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Record of Decision
Operable Units 3, 4, and 5
Lower Fox River and Green Bay, Wisconsin




Record of Decision
Responsiveness Summary

June 2003

Record of Decision
Operable Units 3, 4, and 5

Lower Fox River and Green Bay Site
Wisconsin

June 2003

SUPERFUND RECORD OF DECISION (ROD)
for Operable Units 3, 4, and 5
Wisconsin DNR and U.S. EPA
Lower Fox River and Green Bay
Brown, Door, Marinette, Oconto, Outagamie, Kewaunee, and Winnebago Counties, Wisconsin, and
Delta and Menominee Counties, Michigan
CERCLIS ID: WID000195481
June 2003

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- White Paper No. 20 – Green Bay Modeling Evaluation of the Effects of Sediment PCB Bed Map Revisions on GBTOXe Model Results
- White Paper No. 21 – Green Bay Modeling Evaluation of a Hypothetical Open-Water Disposal Site for Navigational Dredged Material in Southern Green Bay
- White Paper No. 22 – Remedial Decision-Making for the Lower Fox River/Green Bay Remedial Investigation, Feasibility Study, Proposed Remedial Action Plan, and Record of Decision for Operable Units 3 through 5
- White Paper No. 23 – Evaluation of Cost and Implementability of Alternative C2B for Operable Unit 3 and Operable Unit 4

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
µg/kg	micrograms per kilogram
µg/kg-BW/day	micrograms per kilogram of body weight per day
µg/L	micrograms per liter
API/NCR	Appleton Papers, Inc./NCR Corp.
ARAR	applicable or relevant and appropriate requirement
BLRA	Baseline Human Health and Ecological Risk Assessment
BTAG	Biological Technical Assistance Group
CAD	confined aquatic disposal
CDF	confined disposal facility
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	Community Involvement Plan
COC	chemical of concern
COPC	chemical of potential concern
CSF	cancer slope factor
CT	central tendency
CTE	central tendency exposure
CWAC	Clean Water Action Council
cy	cubic yard
DHFS	Department of Health and Family Services (Wisconsin)
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenylene
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
ERA	Ecological Risk Assessment
ESD	Explanation of Significant Difference
FRDB	Fox River Database
FRFood	Fox River Food Chain Model
FRG	Fox River Group
FS	Feasibility Study
GBFood	Green Bay Food Chain Model
GBMBS	Green Bay Mass Balance Study
GBTOXe	Enhanced Green Bay PCB Transport Model (an enhanced version of GBTOX, a water quality model)
GLNPO	Great Lakes National Program Office
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
kg	kilogram
LLBdM	Little Lake Butte des Morts
LMMBS	Lake Michigan Mass Balance Study
LOAEC	Lowest Observed Adverse Effects Concentration
LOAEL	Lowest Observed Adverse Effects Level
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
MNR	Monitored Natural Recovery
NAS	National Academy of Sciences
NCP	National Contingency Plan
NCR	National Cash Register Company (now NCR Corporation)
ng/L	nanograms per liter
NHPA	National Historic Preservation Act

NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observed Adverse Effects Concentration
NOAEL	No Observed Adverse Effects Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NR	Natural Resources (in reference to that part of the WAC that presents NR rules)
NRC	National Research Council
NRDA	Natural Resource Damage Assessment
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAL	preventive action limit
PCB	polychlorinated biphenyl
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PRP	potentially responsible party
RAL	remedial action level
RAO	remedial action objective
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SITE	Superfund Innovative Technology Evaluation
SLRA	Screening Level Risk Assessment
SMDP	Scientific Management Decision Point
SMU	Sediment Management Unit
SQT	sediment quality threshold
SWAC	surface-weighted average concentration
TAG	Technical Assistance Grant
TBC	to be considered
TEF	toxic equivalency factor
TEL	threshold exposure limit
TMDL	total maximum daily load
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WDOT	Wisconsin Department of Transportation
wLFRM	whole Lower Fox River Model
WPDES	Wisconsin Pollutant Discharge Elimination System
WQS	Water Quality Standard

EXECUTIVE SUMMARY
Record of Decision (ROD) for Operable Units 3, 4, and 5 Wisconsin DNR and U.S. EPA

The Lower Fox River and Green Bay Site ("the Site") includes an approximately 39-mile stretch of the Lower Fox River (referred to herein as "the River") as well as the Bay of Green Bay (referred to herein as "the Bay"). The River portion of the Site extends from the outlet of Lake Winnebago and continues downstream to the mouth of the River at Green Bay, Wisconsin. The Bay portion of the Site includes all of Green Bay from the City of Green Bay to the point where Green Bay enters Lake Michigan. A Record of Decision (ROD) for Operable Units (OUs) 1 and 2 of the River was released by the Wisconsin Department of Natural Resources (WDNR) and United States Environmental Protection Agency (EPA) on January 7, 2003. This ROD covers OU 3, OU 4, and OU 5 and addresses some of the human health and ecological risks posed to people and ecological receptors associated with polychlorinated biphenyls (PCBs) that have been released to the Site. Presently these PCBs reside primarily in the sediment in the River and in the Bay, and this ROD outlines a remedial plan to address a certain portion of PCB-contaminated sediment.

For ease of management and administration, as well as because of similar features and characteristics, the Site has been divided into certain discrete areas: the River has been divided into Operable Units 1 through 4 and the Bay constitutes Operable Unit 5. These Operable Units are as follows:

Operable Unit 1 – Little Lake Butte des Morts
Operable Unit 2 – Appleton to Little Rapids
Operable Unit 3 – Little Rapids to De Pere
Operable Unit 4 – De Pere to Green Bay (in some documents, Green Bay Zone 1)
Operable Unit 5 – Green Bay

This ROD selects a remedial action for OUs 3, 4, and 5, and is complementary to the ROD addressing Operable Units 1 and 2, which was released in January 2003. This ROD completes the remedial decision-making process for the entire Site. Significant public comments on the Proposed Plan concerning OUs 3, 4, and 5 were considered in preparation of this ROD.

For many years, a large number of paper mills have been and continue to be concentrated along the River. Some of these mills operated de-inking facilities in connection with the recycling of paper. Others manufactured carbonless copy paper. In both the de-inking operations and the manufacturing of carbonless copy paper, these mills handled PCBs, which were used in the emulsion that coated carbonless copy paper. In the de-inking process and in the manufacturing process, PCBs were released from the mills to the River directly or after passing through local water treatment works. PCBs have a tendency to adhere to sediment and they have contaminated the River sediment. In addition, the PCBs and contaminated sediment were carried downriver and released into the Bay.

Presently, it is estimated that OU 3 contains approximately 1,250 kilograms (kg) (2,750 pounds) of PCBs in 3,030,100 cubic yards (cy) of sediment. This ROD provides for the removal by dredging 586,800 cy of contaminated sediment containing 1,111 kg (2,444 pounds) of PCBs from Operable Unit 3. In addition, this ROD calls for the removal of Deposit DD from OU 2 as part of the OU 3 remedy. Deposit DD adds approximately 9,000 cy of contaminated sediment and 31 kg (68 pounds) of PCB mass to the OU 3 project. It is estimated that OU 4 contains approximately 26,650 kg (58,620 pounds) of PCBs in 8,491,400 cy of sediment. This ROD provides for the removal by dredging 5,880,000 cy of contaminated sediment containing 26,433 kg (58,150 pounds) of PCBs from OU 4. This ROD provides for the removal of about 56 percent of all contaminated sediment from OUs 3 and 4, removing 6.5 million cy out of approximately 11.6 million cy of contaminated sediment.

The dredged material will be “dewatered” and taken to a landfill for permanent disposal. This ROD establishes an “action level” of 1 part per million (ppm) for this cleanup effort. In other words, any sediment found in Operable Unit 3 or 4 which has a concentration of PCBs of 1 ppm or greater will be targeted for removal. The goal of the remedial action in Operable Units 3 and 4 is to reach a surface-weighted average concentration (SWAC) of approximately 0.25 ppm after dredging is completed. Current estimates are that the removal of the contaminated sediment above 1 ppm will result in a SWAC of 0.26 ppm for OU 3 and a SWAC of 0.16 ppm for OU 4. Reducing the concentration of PCBs in Operable Units 3 and 4 to this SWAC level or below will dramatically reduce the risks to human health and ecological receptors. Following implementation of the remedy, monitoring of these OUs will take place. This monitoring will address natural processes such as degradation, dispersion, and burial of contaminant concentrations and will examine various media.

Operable Unit 5 has a selected remedy of Monitored Natural Recovery (MNR) with continued institutional controls. MNR includes the monitoring of processes such as degradation, dispersion, and burial of contaminant concentrations to the point where the contaminants are no longer of concern. In OU 5, it does not appear that burial or degradation are significant factors in the recovery of Green Bay. However, remediation of the River will reduce loading from the River into Green Bay and should contribute to the recovery of the Bay. The MNR alternative for OU 5 includes a monitoring program for measuring PCB levels in various media (e.g., water, sediment, tissue, etc.). Monitoring would continue until acceptable levels of PCBs are reached in sediment, surface water, and fish tissue. In response to comments on the proposed remedy for OU 5, additional sampling will take place near the mouth of the River. Evaluation of the sample results may lead to further dredging in OU 5 near the River mouth.

A monitoring program for OUs 3 through 5 will also be developed to effectively measure achievement of and progress toward the Site’s remedial action objectives. These monitoring plans will be placed in information repositories for the Site (including Administrative Record locations) for public review

The estimated cost for the remedial action in Operable Units 3 and 4 is $284 million; for Operable Unit 5, the estimated cost is $39.6 million.

Declaration for the Record of Decision (ROD) for
Operable Units 3, 4, and 5
Wisconsin DNR and U.S. EPA
Lower Fox River and Green Bay
Brown, Door, Marinette, Oconto, Outagamie, Kewaunee, and Winnebago Counties, Wisconsin, and
Delta and Menominee Counties, Michigan
CERCLIS ID: WID000195481
June 2003

Part 1: Declaration for the Record of Decision

The Lower Fox River and Green Bay Site ("the Site") includes an approximately 39-mile section of the Lower Fox River (referred to herein as "the River"), from Lake Winnebago downriver to the mouth of the River, and all of Green Bay (referred to herein as "the Bay"); the Site totals approximately 2,700 square miles in area. This stretch of the River and Bay flows through or borders Brown, Door, Kewaunee, Marinette, Oconto, Outagamie, and Winnebago Counties in Wisconsin and Delta and Menominee Counties in Michigan. The Site has been divided into discrete areas referred to as Operable Units (OUs). The River portion of the Site comprises OU 1 through OU 4, and the Bay portion of the Site is designated OU 5 for purposes of Site management. The OUs were selected based, in part, on stretches of the River having similar features and characteristics, as well as for ease of Site management and administration. OU 1 (Little Lake Butte des Morts) encompasses the area from the Lake Winnebago outlet to the Appleton dam. OU 2 (Appleton to Little Rapids) is the area from the Appleton dam to the Little Rapids dam. OU 3 (Little Rapids to De Pere) is the area from the Little Rapids dam to the De Pere dam. OU 4 (De Pere to Green Bay) is the area from the De Pere dam to the mouth of the River at Green Bay. OU 5 is the bay of Green Bay.

This Record of Decision (ROD) addresses the risks to people and ecological receptors associated with polychlorinated biphenyls (PCBs) in OUs 3, 4, and 5. PCBs, the primary risk driver, are contained in sediment deposits located in the River and the Bay. The implementation of the remedy selected in this ROD will result in reduced risks to humans and ecological receptors living in and near the Site.

With the exception of continuing releases of PCBs from contaminated sediment, it is believed that the original PCB sources are now essentially controlled. PCBs in the River resulted from historical discharges, primarily related to the manufacturing and recycling of carbonless copy paper.

<u>STATEMENT OF BASIS AND PURPOSE</u>

By agreement with the United States Environmental Protection Agency (EPA), the Wisconsin Department of Natural Resources (WDNR) is the "lead agency" with respect to the Site. EPA has funded the WDNR through a cooperative agreement to prepare a Remedial Investigation and Feasibility Study (RI/FS) and this ROD.

This decision document was developed by WDNR for OUs 3, 4, and 5 of the Site, pursuant to WDNR's authority under Chapter 292, Wisconsin Statutes. EPA has concurred in and has adopted this ROD for the Site, as provided for in 40 Code of Federal Regulations (CFR) § 300.515(e).

This decision document presents the selected remedy for OUs 3, 4, and 5 of the Site and was written in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, with the National Oil and Hazardous Substances Pollution Contingency Plan ("National Contingency Plan" or NCP), 40 CFR Part 300. This decision is based on information contained in the Administrative Record for this Site. This ROD is consistent with the findings of the National Academy of Sciences' (NAS) National Research Council report entitled "A Risk Management Strategy for PCB-Contaminated Sediments" and with EPA policy.

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health, safety, and welfare or the environment from an imminent and substantial endangerment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The objectives of the response actions for this Site are to protect public health, safety, and welfare and the environment and to comply with applicable federal and state laws. The selected remedy specifies response actions that will address PCB-contaminated sediment in OUs 3, 4, and 5. The WDNR and EPA ("the Agencies") believe the remedial actions outlined in this ROD, if properly implemented, will address contaminated sediment in OUs 3, 4, and 5 and will protect human health, safety, and welfare and the environment to the extent practicable. Among the goals for the selected remedy are the removal of fish consumption advisories, the protection of the fish and wildlife that use the River and Bay, and reduction of the transport of PCBs from the River to the Bay.

The major components of the selected remedy include:

- Removal of an estimated 6,475,800 cubic yards (cy) of contaminated sediment containing over 27,575 kilograms (kg) or 60,660 pounds of PCBs from OUs 3 and 4 using environmental dredging techniques that minimize adverse environmental impacts. The selected remedy calls for dewatering the dredged sediment and disposing of it at a new off-site licensed disposal facility, not yet constructed, to be located in the Fox River Valley. Dredge water will be treated prior to discharge. In conducting the design of this remedy, WDNR and EPA may utilize vitrification of dredged contaminated sediment as an alternative to off-site disposal at a licensed facility if this is determined to be practicable and cost-effective. If vitrification is proposed, the Agencies will inform the public and seek public input.

- Monitored Natural Recovery (MNR) of the residual PCB contamination remaining in dredged areas and undisturbed areas until the concentrations of PCBs in fish tissue are reduced to an acceptable level. Fish consumption advisories and fishing restrictions will remain in place until acceptable PCB levels are achieved.

- The use of Monitored Natural Recovery for OU 5.

- A long-term monitoring program covering various media (e.g., water, tissue, and sediment) throughout OUs 3, 4, and 5 to determine the effectiveness of the remedy. A final long-term monitoring plan will be developed as part of the remedial design phase.

STATUTORY DETERMINATIONS

The selected remedy meets the requirements for remedial actions set forth in Section 121 of CERCLA, 42 United States Code (USC) § 9621. It is protective of human health and the environment, complies with federal and state applicable or relevant and appropriate requirements, and is cost-effective. The selected remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. It does not completely satisfy the statutory preference for treatment as a principal element of the remedy, because PCB-contaminated sediment may not be treated prior to disposal.

With respect to the portions of the River addressed in this ROD, some PCB concentrations create a risk in the range of 10^{-3} or more, thus "qualifying" those sediments to be a principal threat waste. The preference for treatment applies to these particular sediments. However, it would be wholly impracticable to closely identify, isolate, and treat these principal threat wastes in a manner different from the other PCB sediment identified for removal and disposal. Typical dredging technology that may be employed may not be capable of distinguishing among such fine gradations of PCB concentrations. Nevertheless, at the conclusion of the OUs 3 and 4 remedy, the principal threat wastes will have been removed from OUs 3 and 4 and deposited in a landfill. In so doing, the mobility of the principal threat wastes will have been greatly reduced. Also, dredge water will be treated prior to discharge.

Because the selected remedy will result in hazardous substances remaining on the Site above levels that allow unlimited use and unrestricted exposure, a statutory review will be conducted every 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. Once all remedial action objectives have been met, a 5-year review will no longer be needed.

DATA CERTIFICATION CHECKLIST

The following information is in the Declaration for the Record of Decision. Additional information is in the Administrative Record file for this Site.

- Chemicals of concern and their respective concentrations – Sections 6 and 8
- Baseline risk presented by the chemicals of concern – Section 8
- Cleanup levels established for the chemical of concern and the basis for these levels – Section 13.3
- How source materials constituting principal threats are addressed – Section 12
- Surface water and land use assumptions used in the baseline risk assessments and ROD – Sections 7 and 8
- Potential land and groundwater uses that will be available at the Site as a result of the Selected Remedy – Section 7
- Estimated capital, operation and maintenance, and total present-worth costs and the time to implement each of the various remedial alternatives – Sections 11 and 13.2
- Key factors that led to selecting the remedy (i.e., best balance of tradeoffs with respect to the balancing and modifying criteria) – Sections 11 and 14

6/30/03
Date

Bruce Baker, Deputy Administrator
Water Division
Wisconsin DNR

By signing this ROD, U.S. EPA Region 5 concurs with the selected remedy.

6/30/03

Date

Wm. E. Muno

William E. Muno, Director
Superfund Division
U.S. EPA – Region 5

Declaration for the Record of Decision (ROD) for Operable Units 3, 4, and 5 Wisconsin DNR and U.S. EPA

Lower Fox River and Green Bay
Brown, Door, Marinette, Oconto, Outagamie, Kewaunee, and Winnebago Counties, Wisconsin, and
Delta and Menominee Counties, Michigan
CERCLIS ID: WID000195481
June 2003

Part 2: Superfund Record of Decision

1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

1.1 Site Name and Location

The Lower Fox River and Green Bay Site ("the Site") is located in northeast Wisconsin in Brown, Door, Marinette, Oconto, Outagamie, Kewaunee, and Winnebago Counties and in the eastern portion of the Upper Peninsula of Michigan in Delta and Menominee Counties. The Lower Fox River (referred to herein as "the River") flows northeast from Lake Winnebago for 39 miles, where it discharges into Green Bay (referred to herein as "the Bay"). The Bay is approximately 119 miles long and is an average of 23 miles wide (Figures 1-1 and 1-2).

The Site has been divided into five discrete Operable Units (OUs) by the Wisconsin Department of Natural Resources (WDNR) and the United States Environmental Protection Agency (EPA). For purposes of the Remedial Investigation and Feasibility Study (RI/FS), the River was divided into four OUs. An OU is a geographical area designated for the purpose of analyzing and implementing remedial actions. OUs are defined on the basis of similar features and characteristics (e.g., physical and geographic properties and characteristics developed in previous investigations) and for ease of Site management and administration. The River and the Bay OUs are:

- OU 1 – Little Lake Butte des Morts
- OU 2 – Appleton to Little Rapids
- OU 3 – Little Rapids to De Pere
- OU 4 – De Pere to Green Bay (referred to in some documents as Green Bay Zone 1)
- OU 5 – Green Bay

The Bay is a single OU and has been divided into four major zones (i.e., zones 2, 3A, 3B, and 4).

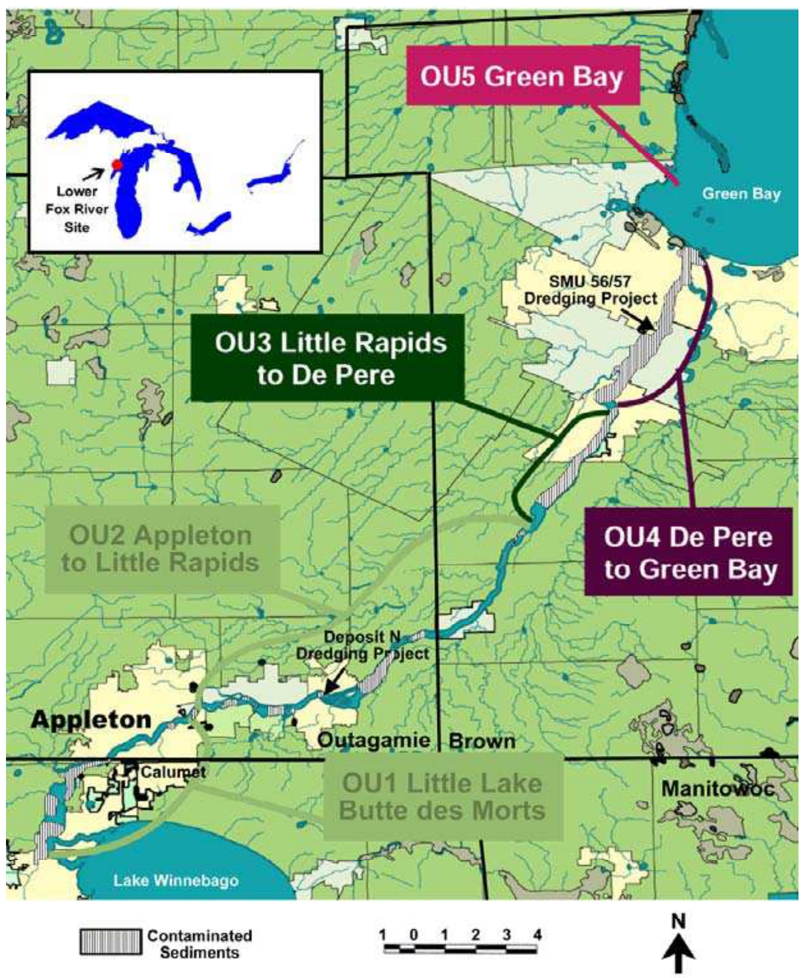
This Record of Decision (ROD) addresses Operable Units 3, 4, and 5. For OUs 3 and 4, active remediation (dredging, dewatering, and off-site disposal) of in-place sediment has been selected. The remediation of OU 3 is to include the dredging of Deposit DD from OU 2. Remediation of OU 4 will include dredging by the mouth of the River. For OU 5, a monitoring program has been selected to evaluate the effectiveness of natural processes that are expected to reduce risk over time. Risk reduction will occur more quickly in OUs 3 and 4 because of the active remediation of those Operable Units. The remedial activity may include a small amount of remediation in the Bay. It is expected that the active remediation in OU 1, OU 3, and OU 4 may contribute to a faster remediation in the Bay.

The remedial action selected herein is to remove and isolate or otherwise ameliorate the threats to human health and the environment in OUs 3 through 5 caused by the release of polychlorinated biphenyls (PCBs) into the River. While the release of PCBs to the environment occurred between 1954 and the late 1970s, the PCB contamination in the sediment continues to act as a source to the water, biota, and air.

1.2 Brief Description

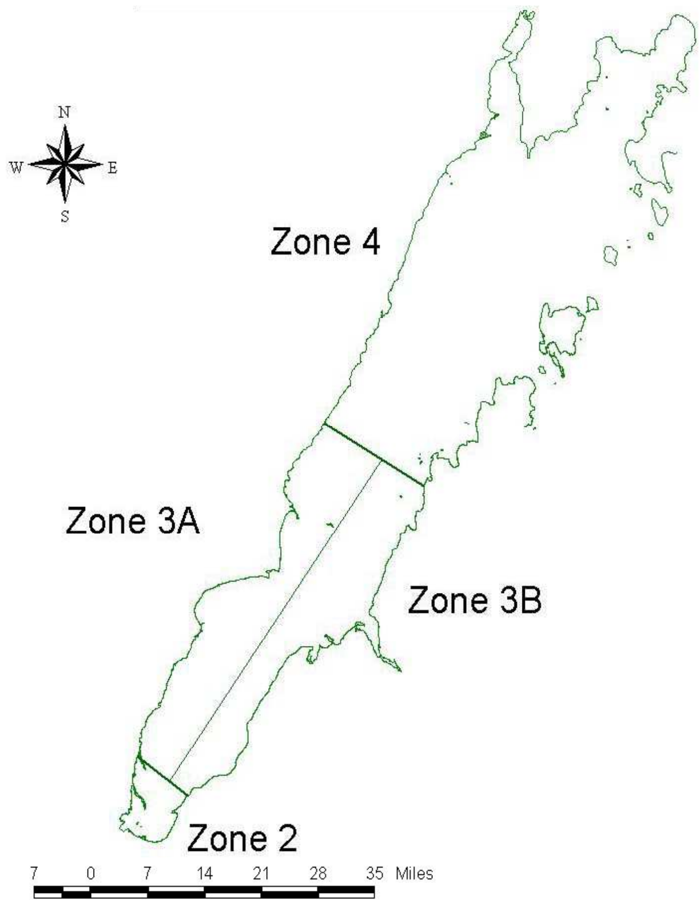
The study area comprises two distinctly different water bodies, the River and Lake Michigan's Green Bay (Figures 1-1 and 1-2). The River flows northeast approximately 39 miles from Lake Winnebago to the River mouth at the southern end of the Bay. The Bay's watershed drains approximately 15,625 square miles. Two-thirds of the Bay basin is in Wisconsin; the remaining one-third is in Michigan's Upper Peninsula.

Figure 1-1 Lower Fox River PCB-Contaminated Sediment Deposits and Operable Units



The River is the primary tributary to the Bay, draining approximately 6,330 square miles. The River's elevation drops approximately 168 feet between Lake Winnebago and the Bay. Twelve dams and 17 locks accommodate this elevation change and allow navigation between Lake Winnebago and the Bay. While the entire River and southern Bay has a federally authorized navigation channel and is navigable by recreational boats, the Rapide Croche lock is permanently closed to restrict upstream migration of the sea lamprey.

Figure 1-2 Green Bay Zones



The River is generally less than 1,000 feet wide over much of its length and is up to approximately 20 feet deep in some areas. Where the River widens significantly, the depth generally decreases to less than 10 feet and, in the case of Little Lake Butte des Morts (LLBdM), water depths range between 2 and 5 feet except in the main channel. The main channel of the River ranges from approximately 6 to 20 feet in depth.

Since 1918, flow in the River has been monitored at the Rapide Croche dam, midway between Lake Winnebago and the River mouth. Mean annual discharge is approximately 4,237 cubic feet per second (cfs). The recorded maximum daily discharge of 24,000 cfs occurred on April 18, 1952; the minimum daily discharge of 138 cfs occurred on August 2, 1936.

OU 3 is identified primarily as the river reach from the Little Rapids dam to the De Pere dam and extends a distance of approximately 6 miles. This reach includes sediment deposits EE through HH. For operational reasons, sediment Deposit DD, which is located in OU 2 immediately upstream of the Little Rapids dam, is also included with OU 3 for remedy consideration. OU 4 extends from the De Pere dam to the River's mouth at Green Bay, a distance of approximately 7 miles, and includes Sediment Management Units (SMUs) 20 through 115. OU 5 is Green Bay, which is roughly 119 miles long by 23 miles wide, and includes zones 2, 3A, 3B, and 4.

1.3 Lead Agency

The WDNR is the lead agency for this project. EPA has worked jointly with WDNR in the development of this ROD and concurs with and has adopted the decision described herein. Through a cooperative agreement, the EPA has funded WDNR to prepare the Site RI/FS and baseline risk assessment, as well as this ROD.

2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Site History

The Fox River Valley is one of the largest urbanized regions in the state of Wisconsin, with a population of approximately 400,000. The Fox River Valley has a significant concentration of pulp and paper industries, with 20 mills located along or near the River. This is one of the largest concentrations of paper mills in the world. Other important regional industries include metal working, printing, food and beverages, textiles, leather goods, wood products, and chemicals. In addition to heavy industrial land uses, the region also supports a mixture of agricultural, residential, light industrial, and conservancy uses, as well as wetlands. For investigative purposes, the Site is defined as the 39 river miles of the River and Bay to a line that extends between Washington Island, Wisconsin, and the Garden Peninsula of Michigan.

Problems related to water quality have been noted and measured in the River and lower Green Bay almost since the area was settled. Water quality studies were initiated in the early 1900s and have been conducted almost annually since. Between the early 1930s and mid-1970s, the population of desirable fish and other aquatic organisms in the system was poor. Recorded fish kills and the increasing predominance of organisms able to tolerate highly polluted conditions were found throughout the Lower Fox River and lower Green Bay. Few people used the River or lower Green Bay for recreation because of the poor water quality and the lack of a sport fishery. During this same time period, dissolved oxygen (DO) levels were often very low (2 milligrams per liter [mg/L] or less). The poor water quality was attributed to many sources, such as the effluent discharged from pulp and paper mills and municipal sewage treatment plants.

Over time, in large part because of the federal Clean Water Act (1972), improved waste treatment systems began operation. As part of this effort, WDNR developed and implemented a Waste Load Allocation system to regulate the discharge of oxygen-demanding pollutants from wastewater treatment plants. Fish and aquatic life in the River and Bay have responded dramatically to the improved water quality conditions. Fishery surveys conducted from 1973 to the present indicate a sharp increase in the sport-fish population. Species sensitive to water quality, such as lake trout, which were absent since the late 1800s or early 1900s, have been found in the River since 1977. These improvements resulted in large part from a substantial reduction in organic wastes discharged into the River.

With the return of sport fishery, human use of the River and Bay has also returned. Recognizing concerns about potential health impacts of PCBs in the environment and their bioaccumulative properties, WDNR began routinely monitoring contamination in fish in the early 1970s. Significantly elevated levels of PCBs were detected in all species of fish and all OUs. Measured concentrations of PCBs in fish were (and remain) above levels that have been shown to be harmful to human health. As a result, fish consumption advisories for the Site were first issued in 1976 and 1977 by WDNR and the State of Michigan, respectively. Fish consumption advisories remain in effect today. WDNR has continued to collect data on contaminant concentrations in fish tissue since that time.

2.1.1 PCB Use in the Lower Fox River Valley

The principal source of PCBs in the River and Bay is the manufacture and recycling of carbonless copy paper. The former National Cash Register Company (NCR) is credited with inventing carbonless copy paper. The method used microcapsules of a waxy material to enclose a colorless dye dissolved in PCBs. This material was manufactured as an emulsion and could be coated onto the back of a sheet of paper. A second reactive coating was then applied to the front of a second sheet of paper. When the two sheets were joined, an impact on the front sheet would rupture the microcapsules and allow the dye to react with the coating on the second sheet, leaving an identical image.

PCB discharges to the River resulted from the production and recycling of carbonless copy paper made with PCB-containing coating emulsions. The manufacture of carbonless paper using the PCB-containing emulsion began in the Fox River Valley in 1954 and continued until 1971. The production of carbonless copy paper increased during the 1950s and 1960s; by 1971, approximately 7.5 percent of all office forms were printed on carbonless copy paper. With the increased production of carbonless copy paper, PCBs began to appear also in many types of paper products made using recycled carbonless copy paper. As documented in an EPA report, nearly all paper products contained detectable levels of PCBs by the late 1960s. During this time period, other Fox River Valley paper mills also began recycling wastepaper laden with PCBs. Evidence of PCBs in paper products includes studies conducted by the Institute of Paper Chemistry to determine the rate at which PCBs migrated from paper container materials to the food products contained in them.

The production of carbonless copy paper was discontinued after 1971 because of increased concern about PCBs in the environment. Technical Memorandum 2d estimates that during the period of use (1954 through 1971),13.6 million kilograms (kg) (30 million pounds) of emulsion were used in the production of carbonless copy paper produced in the Fox River Valley. PCBs were released into the River in discharge water from several facilities. Conservative estimates made from analyzing purchase, manufacturing, and discharge records have shown that approximately 313,600 kg (690,000 pounds) of PCBs were released to the River environment during this time. Ninety-eight percent of the total PCBs released into the River had been released by the end of 1971. Ceasing production of carbonless copy paper and implementing the wastewater control measures put in place by the Clean Water Act were effective in eliminating point sources. No major non-point sources, such as PCB-contaminated groundwater plumes, are known to exist from any of the potentially responsible parties' (PRPs') properties.

2.2 Actions to Date

To date, seven companies have been identified as PRPs with respect to the PCB contamination and formally notified of such by the governmental agencies. These companies are Appleton Paper Company, NCR, P.H. Glatfelter Company, Georgia Pacific (formerly Fort James), WTMI (formerly Wisconsin Tissue), Riverside Paper Co., and U.S. Paper Co. This group is commonly referred to as the Fox River Group (FRG).

The EPA's proposed inclusion of the Site on the National Priorities List (NPL), a list of the nation's hazardous waste sites eligible for investigation and cleanup under the federal Superfund program, defines the Site as the Lower Fox River from the outlet of Lake Winnebago to a point in Green Bay 27 miles from the River mouth. That Site is officially called the Fox River NRDA PCB Releases Site in the proposed NPL listing. However, for the purpose of the RI/FS, the Proposed Remedial Action Plan ("Proposed Plan"), and this ROD, the Site includes the 39 miles of the Lower Fox River and all of Green Bay. The federal trustees conducting a

Natural Resource Damage Assessment (NRDA) have defined the Site somewhat differently to include the Lower Fox River, all of Green Bay, and nearby areas of Lake Michigan.

In 1994, the United States Department of the Interior acting through the United States Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, the Menominee Indian Tribe of Wisconsin, and the Oneida Tribe of Indians of Wisconsin initiated an NRDA for the Site. The state, federal, and tribal trustees are working together to determine what is necessary to address natural resource injuries caused to date by releases of PCBs. This process is separate from, but related to, the remediation discussed in this document.

In January 1997, the WDNR and the FRG signed an agreement dedicating $10 million to fund demonstration projects on the River and other work to evaluate various methods of restoration. This collaborative effort, however, was not completely successful and did not resolve technical issues as initially hoped. At about this same time, the USFWS issued a formal Notice of Intent to sue the paper companies. In June 1997, the EPA announced its intent to list the River and portions of the Bay on the NPL. The state indicated its opposition to listing the River as a Superfund site. Federal, state, and tribal officials subsequently signed an agreement on July 11, 1997, to share their resources in developing a comprehensive cleanup and restoration plan for the River and the Bay. The EPA formally proposed listing of the Site to the NPL in the Federal Register on July 28, 1998.

In October 1997, the FRG submitted an offer to conduct an RI/FS on the River. An RI/FS is the first step in the federal process initiated by EPA to assess current health risks and evaluate potential remediation methods. Following unsuccessful attempts to negotiate this work activity with the FRG, the EPA delegated the lead role for the Site to the WDNR and helped craft a scope of work and cooperative agreement for completing the RI/FS with the WDNR. The WDNR, EPA, USFWS, NOAA, and the Menominee and Oneida Tribes worked in close cooperation to guide, review, and issue the RI/FS.

In February 1999, the WDNR released a draft RI/FS for public review and comment. The draft RI/FS was released to solicit public comment early in the planning process, to better evaluate public acceptance, and to assist the WDNR and EPA in selecting a cleanup alternative having the greatest public acceptance. Comments were received from other governmental agencies, the public, environmental groups, and private-sector corporations. These comments were used to revise and refine the scope of work that led to the RI/FS and Proposed Plan released for public comment in October 2001. Comments received from the PRPs, the public, and independent peer review committees were incorporated into the final RI/FS. In January 2003, the ROD for OUs 1 and 2 was released. That ROD called for active remediation in OU 1 and Monitored Natural Recovery in OU 2.

2.2.1 Documentation of Residual PCB Levels

With the finding that PCBs released into the River were appearing at levels harmful to human health and the environment, several cooperative efforts were initiated to document residual PCBs in the sediment and the fate, transport, and risks of PCBs within the Site. Two mass balance studies were conducted: the Green Bay Mass Balance Study and the Lake Michigan Mass Balance Study, discussed below.

Green Bay Mass Balance Study

In 1989/90, following recommendations made in the Green Bay Remedial Action Plan, the EPA and WDNR began a comprehensive program of sampling sediment, water, and biota in the River and Bay for use in the Green Bay Mass Balance Study (GBMBS).

The GBMBS was a pilot project to test the feasibility of using a mass balance approach for assessing the sources and fates of toxic pollutants spreading throughout the food chain. The objectives of the GBMBS were to:

1. Inventory and map PCB mass and contaminated sediment volume.

2. Calculate PCB fluxes into and out of the River and Bay by evaluating Lake Winnebago, point sources, landfills, groundwater, atmospheric contributions, and sediment resuspension.

3. Increase understanding of the physical, chemical, and biological processes that affect PCB fluxes.

4. Develop, calibrate, and validate computer models for the River and Bay systems.

5. Conduct predictive simulations using computer models to assist in assessing specific management scenarios and selecting specific remedial actions.

The GBMBS confirmed that the primary source (more than 95 percent) of the PCBs moving within the River is the River sediment itself. The contribution of PCBs from wastewater discharges, landfills, groundwater, and the atmosphere is relatively insignificant in comparison to the PCBs originating from the sediment. Furthermore, the GBMBS showed that PCBs released from the sediment were directly linked to the levels of PCBs measured throughout the biological food chain, including fish, birds, and mammals that depend on the River for food.

Inventory and mapping activities showed that PCBs are distributed throughout the entire River. Thirty-five discrete sediment deposits were identified between Lake Winnebago and the De Pere dam. One relatively large, continuous sediment deposit exists downstream of the De Pere dam. Water column sampling indicated that the water entering the River from Lake Winnebago contains relatively low PCB concentrations. However, upon exposure to the contaminated river sediment in Little Lake Butte des Morts, water in the River exceeds state water quality standards. During the GBMBS, the lowest water column concentration (5 nanograms per liter [ng/L]) of PCBs measured in any River sample still exceeded the state water quality standard by a factor of more than 1,500.

As expected, water column concentrations also increased as River flow increased and PCBs attached to River sediment were resuspended into the water column. These higher flows resulted in PCB concentrations that exceeded standards by a factor of almost 40,000. The GBMBS also documented that more than 60 percent of PCB transport occurs during the relatively short time that River flows are above normal. Movement of PCBs in the water column extends throughout the Bay, with some PCBs from the River ultimately entering Lake Michigan proper. The GBMBS also documented that a considerable amount of PCBs is lost to the atmosphere from the surface of the water in the River and Bay.

Lake Michigan Mass Balance Study

The EPA's Great Lakes National Program Office (GLNPO) initiated a similar mass balance study for all of Lake Michigan, the Lake Michigan Mass Balance Study (LMMBS). To accomplish the objectives of this study, which were similar to those of the GBMBS but on a larger scale, pollutant loading (including PCBs) from 11 major tributaries flowing into Lake Michigan was measured. The Lake Michigan Tributary Monitoring Program confirmed the magnitude and significance of the River contribution to pollutant loading in Lake Michigan. It is estimated that on a daily basis, up to 70 percent of the PCBs entering Lake Michigan via its tributaries are from the River.

2.2.2 The Fox River Coalition

In 1993, a group of paper mills approached the WDNR to establish a cooperative process for resolving the contaminated sediment issue. The outcome was formation of the Fox River Coalition, a private-public partnership of area businesses, state and local officials, environmentalists, and others committed to improving the quality of the River. The Coalition focused on the technical, financial, and administrative issues that would need to be resolved to achieve a whole River cleanup.

The Coalition's first project was an RI/FS of several sediment deposits upstream of the De Pere dam. The sediment deposits targeted for the Coalition's RI/FS were selected after all the deposits had been prioritized based on their threat and contribution to the contaminant problems. Previous studies of the River had focused only on the nature and extent of contamination. The Coalition's RI/FS first confirmed the nature and extent of the contamination within each deposit, then evaluated remedial technologies for cleaning up two of the deposits.

The Coalition also undertook a project to more thoroughly inventory and map sediment contamination in the River downstream of the De Pere dam, collecting sediment cores from 113 locations. The sampling was completed in 1995 with technical and funding assistance from both the WDNR and EPA. The resulting data led to a revised estimate of PCB mass and the volume of contaminated sediment in this River reach. The expanded database also made it possible to prioritize areas of sediment contamination, much as had previously been done for areas upstream of the De Pere dam.

Following completion of the Coalition's RI/FS for the upstream sites, the Coalition selected Deposit N as an appropriate site for a pilot project to evaluate remedial design issues. The primary objectives were to determine requirements for implementing a cleanup project and to generate site-specific information about cleanup costs. Although the Coalition initiated the effort, the WDNR, with funding from the EPA, was responsible for implementing the Deposit N pilot project.

2.2.3 Demonstration Projects

Deposits N and O

In 1998 and 1999, the WDNR and EPA-GLNPO sponsored a project to remove PCB-contaminated sediment from Deposit N in the River. This project was successful at meeting its primary objective by demonstrating that dredging of PCB-contaminated sediment can be performed in an environmentally safe and cost-effective manner. Other benefits of the project included the opportunity for public outreach and education on the subject of environmental dredging, as well as the actual removal of PCBs from the River system. Deposit N, located near Little Chute and Kimberly, Wisconsin, covered approximately 3 acres and contained about

11,000 cubic yards (cy) of sediment. PCB concentrations were as high as 186 milligrams per kilogram (mg/kg). Of the 11,000 cy in Deposit N, about 65 percent of the volume was targeted for removal.

Approximately 8,200 cy of sediment were removed, generating 6,500 tons of dewatered sediment that contained 112 total pounds of PCBs. The total included about 1,000 cy of sediment from Deposit O, another contaminated sediment deposit adjacent to Deposit N. Monitoring data showed that the River was protected during the dredging and that wastewater discharged back to the River complied with all permit conditions. The project met the design specifications for the removal, such as the volume of sediment removed, sediment tonnage, and allowed thickness of residual sediment. It should be noted that the project's goals were to test and meet the design specifications and focus on PCB mass removal, not to achieve a concentration-based cleanup, i.e., removal of all PCB-contaminated sediment above a certain cleanup level. A cost analysis of this project indicated that a significant portion of the funds was expended in pioneering efforts associated with the first PCB cleanup project on the River, for the winter construction necessary to meet an accelerated schedule, and for late season work in 1998.

Fox River Group Demonstration Project (SMU 56/57)

As part of the January 1997 agreement between the FRG and the State of Wisconsin, the FRG agreed to make available a total of $10 million for a number of projects. One of these was a sediment remediation project for which the objective was to design, implement, and monitor a project downstream of the De Pere dam. The project was intended to yield important information about large-scale sediment restoration projects in the River. The project, as described in the agreement, had a pre-defined financial limit of $8 million.

The FRG and WDNR agreed on Sediment Management Units 56 and 57 (SMU 56/57) as the project site. Contractors and consultants, under contract to the FRG, designed and implemented the project. Dredging at SMU 56/57 began on August 30, 1999. Dewatered sediment was trucked to a landfill owned and operated by Fort James Corporation (now Georgia Pacific). Because of cold weather and ice, dredging ceased on December 15, 1999, after approximately 31,350 cy of contaminated sediment containing more than 636 kg (1,400 pounds) of PCBs were removed from the River.

At the time this project was halted for the first year, SMU 56/57 had not met the project's dredging objective, which was removal of 80,000 cy of material. The result was that unacceptably high concentrations of PCBs in surface sediment were present in portions of the dredged area. Despite this, the project provided instructive experience concerning hydraulic dredging. Building on the successes of the project, Fort James (now Georgia Pacific) worked cooperatively with the WDNR and EPA in the spring of 2000 to complete the SMU 56/57 project. (See a description of this enforcement agreement in Section 2.3, below.) The sediment volume targeted for removal in 2000 was 50,000 cy.

The additional volume of sediment removed from SMU 56/57 in 2000 was 50,316 cy; following dewatering, the material was transported to the same Fort James landfill. Approximately 304 kg (670 pounds) of PCBs were removed from SMU 56/57 during the 2000 project phase. Overall, the 1999 and 2000 efforts at SMU 56/57 resulted in the removal of approximately 940 kg (2,070 pounds) of PCBs from the River. The 2000 project phase met all goals set forth in the Administrative Order By Consent and also met or exceeded the project's operational goals for removal rates, dredge slurry solids, filter cake solids, and production rates set forth for the original 1999 FRG project.

2.2.4 Green Bay White Perch Analysis

In response to requests from parties interested in expanding commercial harvest of white perch from Green Bay, the WDNR undertook a study in 2001 and 2002 to examine whether PCB concentrations in white perch vary by location in Green Bay, by season, or by length of the fish. This was a more extensive examination of PCB concentrations than the WDNR typically conducts when issuing fish consumption advisories.

White perch, which are not native to Green Bay, were first discovered in the Bay in 1988. As part of the fish advisory monitoring program, skin-on white perch fillets were analyzed for PCBs in 1992, 1994, and 1996 because of the growing presence of the species in the Bay. These early analyses showed that the fish contained more than 2 parts per million (ppm, or mg/kg, representing mg PCBs per kg of fish tissue) of PCBs in skin-on fillets. Based on this work, the WDNR and the Wisconsin Department of Health and Family Services (DHFS) issued a sport-fish consumption advisory recommending that individuals eat no more than six meals of white perch each year from Green Bay or the Lower Fox River (below the De Pere dam). Present sport-fishing regulations have no bag limit or size limit for white perch in Green Bay. The upper limit for PCBs in fish for sale in commercial markets under U.S. Food and Drug Administration rules is 2 ppm. WDNR and DHFS fish consumption advisories for PCBs are based on fish tissue concentrations ranging from less than 0.05 ppm (no-limit-on-consumption advisory) to 2 ppm (do-not-eat advisory).

Sport-fish consumption advisories have been established to inform people how much fish from contaminated waters can be safely eaten. The number of recommended meals that a person may safely eat is based upon the average for a given fish size, species, and location. Fish with PCB concentrations of more than 1.9 mg/kg in their skin-on fillet fall into the "Do Not Eat" category, while there are no advisories for fish with body burdens of less than 0.05 mg/kg PCBs. Advisories are reevaluated and revised when new data are available and changed when warranted.

White perch samples were collected during 2001 and 2002 for analysis as individuals to determine whether PCB concentrations in white perch fillets vary by location in the Bay, by season, and by length of the fish. Individual fish were selected for PCB analysis as the collections were completed. In total, skin-on fillets from 145 individual fish were analyzed for PCB concentrations. The fish analyzed in 2001–2002 ranged in size from 6.1 to 13.0 inches. PCB concentrations in skin-on fillets ranged from 0.13 ppm to a high value of 2.2 ppm. Only three out of 145 individual fish contained PCBs equal to or greater than the 2 ppm standard.

The following relationships were determined to be significant for white perch with skin-on fillets.

- PCB concentration is moderately associated with fat and less so with length and weight. Fattier fish tend to have higher concentrations of PCBs. Length and weight are highly correlated measures of the condition of the fish.

- PCB concentrations in the white perch fillets differed significantly by collection location. Adjusted PCB concentrations in fish collected from the southernmost Bay were significantly higher than concentrations in fish collected from the northern Bay. This is not unexpected, because the River is the major source of PCBs to the Bay.

- PCB concentrations differed significantly by season of collection. Fish collected in the spring had the highest PCB concentrations, followed by fish collected in the fall, and then fish collected in the summer.

Based on this study, the following conclusions were reached:

- Based on the most recent data, the sport-fish consumption advisory will remain at six meals per year.

- The 2001–2002 data suggest that PCBs in white perch fillets reflect the location in which the fish were collected and also the season. To minimize the chance of harvesting an individual fish with a PCB concentration that exceeds 2 ppm, fish should be taken from the northern portion of Green Bay. In addition, the study suggests that fishing during the summer months may minimize the chance of harvesting an individual fish with a PCB concentration that exceeds 2 ppm. However, the seasonal pattern observed in 2001–2002 may not hold true in the future.

- The levels of PCBs and fat in white perch may vary with abundance of white perch, growth rates, and food availability and type, as well as with short-term and long-term changes in PCB exposure. Any of these factors may change in future years and future concentrations cannot be predicted from the 2001–2002 data. Future monitoring is needed.

More information is available from the WDNR's Fisheries Management website at: http://www.dnr.state.wi.us/org/water/fhp/fish/pubs/whiteperch.pdf.

2.3 Enforcement Activities

The work on SMU 56/57 described above was conducted from July to November 2000 under an Administrative Order By Consent (Docket No. V-W-00-C-596) that was entered into by Fort James, the EPA, and the State of Wisconsin. Under its terms, Fort James funded and managed the project in 2000 with oversight from both the WDNR and EPA.

An interim Consent Decree settlement was also reached with Appleton Papers/NCR (API/NCR); the Decree was entered by the Court on December 10, 2001. Under this agreement, API/NCR agrees to provide up to $10 million a year for each of 4 years ($40 million in total) for both remediation and restoration work under the natural resource damage process. The determination of which remedial or restoration projects to fund rests solely with the Intergovernmental Partnership. In return, the Intergovernmental Partnership agrees not to order API/NCR to perform remediation or restoration work on the River for the 4-year life of the agreement.

On January 29, 2003, the WDNR and EPA, along with Georgia Pacific Corporation (formerly Fort James Corporation) signed an agreed administrative order under which Georgia Pacific agreed to provide $4 million toward certain characterization and contaminant delineation work, anticipated primarily in the OU 4 area.

3 COMMUNITY PARTICIPATION

3.1 Public Participation

Community/public participation activities were conducted to support selection of the remedy in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) § 117 and the National Contingency Plan (NCP) § 300.430(f)(3).

More than 100 people were interviewed in late 1998 and early 1999 to support development of the Site's Community Involvement Plan (CIP). Residents, tribal members, elected officials, business organizations, local health staff, and environmental groups from the affected communities discussed their concerns; those discussions are documented in the CIP. In addition, an extensive profile of each municipality and reservation, as well as a history of the River, was completed for the CIP. The CIP was placed in the information repositories for the Site in 2001.

The information repositories are located at the Appleton Public Library, Oshkosh Public Library, Brown County Library in Green Bay, Door County Library in Sturgeon Bay, and Oneida Community Library. Five additional locations (the Kaukauna, Little Chute, Neenah, De Pere, and Wrightstown Public Libraries) maintain a fact sheet file, although they are no longer information repositories.

The EPA awarded a $50,000 Technical Assistance Grant (TAG) to the Clean Water Action Council (CWAC) in 1999, another $50,000 grant was provided in 2001, and another $50,000 grant was provided in 2003. The council has used its TAG to inform the community about the Lower Fox River investigations. To fulfill its obligations, the CWAC developed a website, printed flyers and bumper stickers, paid for newspaper advertisements, and paid technical advisors to review EPA- and WDNR-generated documents.

The WDNR and EPA held numerous public meetings and availability sessions beginning in the summer of 1997 to explain how and why the Site was proposed for the NPL (i.e., Superfund listing). In February 1999, a draft RI/FS (which did not identify a specific selected remedy) was released with a 45-day public comment period, which was later extended an additional 60 days. Prior to and after the release of the draft RI/FS, the WDNR and EPA provided for extensive community and public participation and kept residents, local government officials, environmental organizations, and other interest groups apprised of the steps in the process. Well-attended public meetings, small group discussions, meetings and presentations for local officials, and informal open houses continued through 2001.

The public meetings and availability of the Proposed Plan were announced to the public at a press conference on October 5, 2001, and received extensive television, radio, and newspaper coverage. The draft RI/FS and Proposed Plan were formally presented at public meetings held on October 29, 2001, in Appleton and October 30, 2001, in Green Bay. Additionally, the WDNR and EPA mailed meeting reminders and summaries of the Proposed Plan to the 10,000 names on the Fox River mailing list. Press releases pertaining to the Proposed Plan, the comment period, and the public meetings were sent to newspapers and television and radio stations throughout the Fox River Valley. Display advertisements announcing the Proposed Plan, comment period, and public meetings were also placed in Green Bay and Appleton newspapers. The presentations and question-and-answer sessions at the public meetings, as well as all public comments taken at the meetings, were recorded and transcribed. The written transcripts of the public meetings are available in the information repositories, the Administrative Record, and on the WDNR Lower Fox River web page (http://www.dnr.state.wi.us/org/water/wm/lowerfox/index.html).

More than 20 public meetings and availability sessions have been held regarding the project. Among the topics on which these meetings focused are cleanup and restoration activities, the status of pilot projects, fish consumption advisories, and the February 1999 draft RI/FS released by the WDNR. Additionally, over 15 small group and one-on-one interview sessions have been held. Project staff have also made more than 60 presentations to interested organizations and groups. In addition, the WDNR, EPA, and their intergovernmental partners publish a bimonthly newsletter, the *Fox River Current*, which is mailed to over 10,000 addresses. To date, more than 25 issues of the *Fox River Current* have been published.

Copies of the various supporting reports and the Proposed Plan were made available to the public during a public comment period that began on October 5, 2001, and concluded on January 22, 2002. (Originally, the comment period was for 60 days, ending on December 7, 2001, but it was extended until January 22, 2002. The announcement of this extension was published through newspaper advertisements and news releases on October 25, 2001.) Approximately 4,800 written comments were received via letter, fax, and e-mail. A copy of the Responsiveness Summary for comments that pertain to OU 3, OU 4, and OU 5 is attached to this ROD. Additionally, many comments were addressed in the Responsiveness Summary attached to the ROD issued for OU 1 and OU 2; a number of those comments and responses also pertain to OU 3, OU 4, and OU 5.

Newspaper advertisements announcing the availability of the plan and its supporting documents were placed in the *Green Bay Press Gazette* and the *Appleton Post Crescent*, and a brief summary of the plan was placed in the information repositories. The Proposed Plan, the RI/FS, and other supporting documents containing information upon which the proposed alternative was based were also made available on the Internet at http://www.dnr.state.wi.us/org/water/wm/lowerfox/index.html and at the EPA Region 5 website at http://www.epa.gov/region5/. All documents were also available as part of the Administrative Record housed at WDNR offices in Madison, Wisconsin, and Green Bay, Wisconsin, and at the EPA Region 5 office in Chicago, Illinois.

Following the release of the ROD for OUs 1 and 2, the WDNR and EPA held a public information meeting on January 29, 2003, in Appleton, Wisconsin.

Information Repositories and Administrative Records

Copies of the ROD for OUs 3, 4, and 5 and the associated Responsiveness Summary, as well as other documents related to the Lower Fox River cleanup, are available in reference sections of the following libraries:

- *Appleton Public Library*
  225 N. Oneida Street
  Appleton, Wisconsin
  (920) 832-6170
- *Brown County Library*
  515 Pine Street
  Green Bay, Wisconsin
  (920) 448-4381, Ext. 394
- *Door County Library*
  104 S. Fourth Street
  Sturgeon Bay, Wisconsin
  (920) 743-6578
- *Oneida Community Library*
  201 Elm Street
  Oneida, Wisconsin
  (920) 869-2210
- *Oshkosh Public Library*
  106 Washington Avenue
  Oshkosh, Wisconsin
  (920) 236-5200

An Administrative Record containing detailed information upon which the selection of the cleanup plan was based is available at the WDNR Lower Fox River Basin Team Office, 801 E. Walnut Street, Green Bay; at the WDNR Bureau for Remediation and Redevelopment Office, 3rd Floor, 101 S. Webster Street, Madison; and at the EPA Records Center, 7th Floor, 77 W. Jackson Boulevard, Chicago, Illinois.

4 SCOPE AND ROLE OF RESPONSE ACTION

As with many Superfund sites, the problems at the Site are complex. As a result, the WDNR and EPA organized the Site into five OUs as described in Section 1.1.

The Proposed Plan, issued in October 2001, recommended a remedy for each of the five Operable Units at the Site. In January 2003, the WDNR and EPA released the ROD for OUs 1 and 2. At this time, the WDNR and EPA are issuing a ROD for OUs 3 and 4 in the River and OU 5, Green Bay. With the issuance of this ROD, the WDNR and EPA have completed issuing a final remedial decision for the entire Site.

The primary objective of this ROD is to select the remedy that will address the risks to human health and the environment resulting from PCBs in the in-place sediment of OUs 3 and 4 in the River and OU 5, Green Bay. PCB concentrations remain elevated in River sediment, in the water column, and in the fish. Removal of the PCB-contaminated sediment will result in reduced PCB concentrations in fish tissue, thereby accelerating the reduction of future human health and ecological risks. In addition, by addressing the sediment, the remediation will control the most critical source of PCBs to the water column, which contributes to fish tissue concentrations and transports PCBs into downstream reaches of the River, Green Bay, and eventually to Lake Michigan.

This ROD builds upon work already accomplished (the cleanup actions in deposits N and O and in SMU 56/57, described in Section 2.2.3) and the remedial work to be accomplished in OUs 1 and 2 (as described in the ROD for OUs 1 and 2). Together with the OU 1 and OU 2 ROD, this ROD completes remedial decision making for the entire Site.

5 PEER REVIEW

To ensure the credibility of the scientific work conducted during the RI/FS, the EPA conducted two forms of peer involvement: peer input and peer review. Peer input was conducted through internal WDNR and EPA reviews, as well as reviews by other agencies and tribes. More formal peer review was also conducted, in accordance with EPA guidance outlined in the *Peer Review Handbook* (dated December 1998, updated December 2000). The peer review, which focused on some of the major scientific findings that form the basis for this decision, was conducted by independent experts who were unaffiliated with the EPA, WDNR, FRG, or other Site stakeholders.

Two separate EPA-sponsored peer review panels were convened, one to consider the Remedial Investigation (RI), the other to consider the Feasibility Study (FS). Each panel conducted an independent review by three panel members, with technical and administrative support from an EPA contractor. The EPA contractor was responsible for convening the panels, consistent with the "charge" (a request to address specific questions) given by the EPA for the panel review. The peer review was undertaken without influence by the EPA, WDNR, FRG, or other interested parties to provide an independent analysis of and comment on key documents and issues related to the development of a proposed remedy. Specifically, the panels were asked to evaluate:

- The adequacy of the data considered in the 1999 draft RI relative to quality and quantity (RI Panel).

- Natural recovery and environmental transformation, i.e., biological breakdown of PCBs (FS Panel). Natural recovery was defined by the panel as naturally occurring physical, chemical, or biological processes that reduce the risks associated with contaminants in sediment over time.

Each peer review panel was asked to address specific questions (the "charge") regarding the report being reviewed, including key controversial issues identified by the EPA. The RI and FS Panels issued reports dated October 7, 1999, and September 28, 1999, respectively.

The following summarizes the major findings of the panels:

- The data are adequate to determine the distribution of contaminants (i.e., it can be decided where cleanups should take place) if all data sources are considered (i.e., the RI does not provide a complete compilation of all data).

- The data from all available sources are adequate to support identification and selection of a remedy for those technologies (for example, dredging and capping) that have been used on a large scale at other, similar sites. The data are insufficient for developing *in-situ* bio-technologies that may be applicable to the Site.

- Substantial improvements or additions to the existing data set are not indicated.

- The draft FS should more fully evaluate natural recovery of sediments as a remedial alternative in comparison with other remedial options.

- The technical basis of the natural recovery analysis needs to be described in more detail to permit a review of the methodology used and to assess confidence in natural recovery predictions.

In the 2001 draft RI/FS and the Proposed Plan, the WDNR and EPA considered the recommendations by the peer review panels and, on that basis, made modifications to the draft documents upon which the Proposed Plan was based.

In addition to EPA-sponsored peer reviews, the FRG sponsored peer reviews that were technically consistent with EPA peer review policy, although they may not have conformed to all aspects of the peer review process and documentation. These reviews consisted of the following analysis for the River:

- Fate and transport and bio-uptake modeling evaluations by the WDNR and FRG
- Human health and ecological risk assessments by the WDNR and FRG

Recommendations arising from both the EPA- and FRG-sponsored peer reviews were considered and incorporated into the 2001 draft RI/FS, which was a significant part of the basis for the Proposed Plan.

6 SITE CHARACTERISTICS

6.1 Conceptual Site Model

The conceptual site model for the Site describes the source-to-receptor succession in simple terms and identifies the major contamination sources (discussed in Section 2.1.1), contaminant release mechanisms, secondary sources, pathways, and receptors of concern. Figures 6-1, 6-2, 6-3, and 6-4 show both human health (Figure 6-1) and ecological (Figures 6-2, 6-3, and 6-4) conceptual site models. The design of field investigations and of the human health and ecological risk assessments reflect the basic components of the conceptual site model.

The conceptual site model shows that historical PCB releases were from paper manufacturing and paper recycling facilities that discharged wastewater into the River. Current wastewater releases are considered insignificant. The historical discharges created contaminated sediment "hot spots" — areas where PCBs are concentrated. These contaminated sediment hot spots contribute to the overall PCB load in the River and the Bay.

Once introduced into the River, the PCBs adhere to sediment, with some fraction being carried in the water column. Physical, chemical, and biological release mechanisms allow PCBs in the sediment to become available for redistribution and a source of PCB contamination to the water column. Unless the PCB-contaminated sediment is managed or remediated in some manner, the sediment will continue to release PCB contamination to the water column through these mechanisms. Biological release mechanisms include biotic decomposition, which allows contaminants to cycle through the pelagial, aquatic, and benthic food chains. Physical release mechanisms include boat scour, ice rafting, and bioturbation, which are not easily modeled. In addition, scour from water flowing over sediment during high-flow events will continue to redistribute sediment and reexpose contaminants.

Generally, PCB-laden sediment is not sequestered or stable, because the River is a dynamic system with varying energy regimes. At times, some PCB-contaminated sediment is buried by deposition of cleaner sediment, but in other places and at other times, contaminants are redistributed. This redistribution may be local or more regional, depending on the energy of flow events and/or the physical type or size of the sediment particles. The redistributed sediment releases contamination to the water column. High-flow events (e.g., floods) further increase the bioavailability of contaminants to organisms in the water column. Although scour during high-flow events is an important release mechanism, PCBs in the surface water are also routinely observed during periods of lower flows (see the water column discussion in Section 6.2.3).

The conceptual site model shows that the fish ingestion pathway is a completed exposure route for the Site. Receptors include humans (such as anglers and their families), piscivorous (that is, fish-eating) fish, piscivorous birds (including threatened and endangered species), and mammals. Additional information on the human and ecological receptor populations is provided in Section 8 of this ROD, which summarizes the Site risks.

Figure 6-1 Human Health Conceptual Site Model for the River and Bay

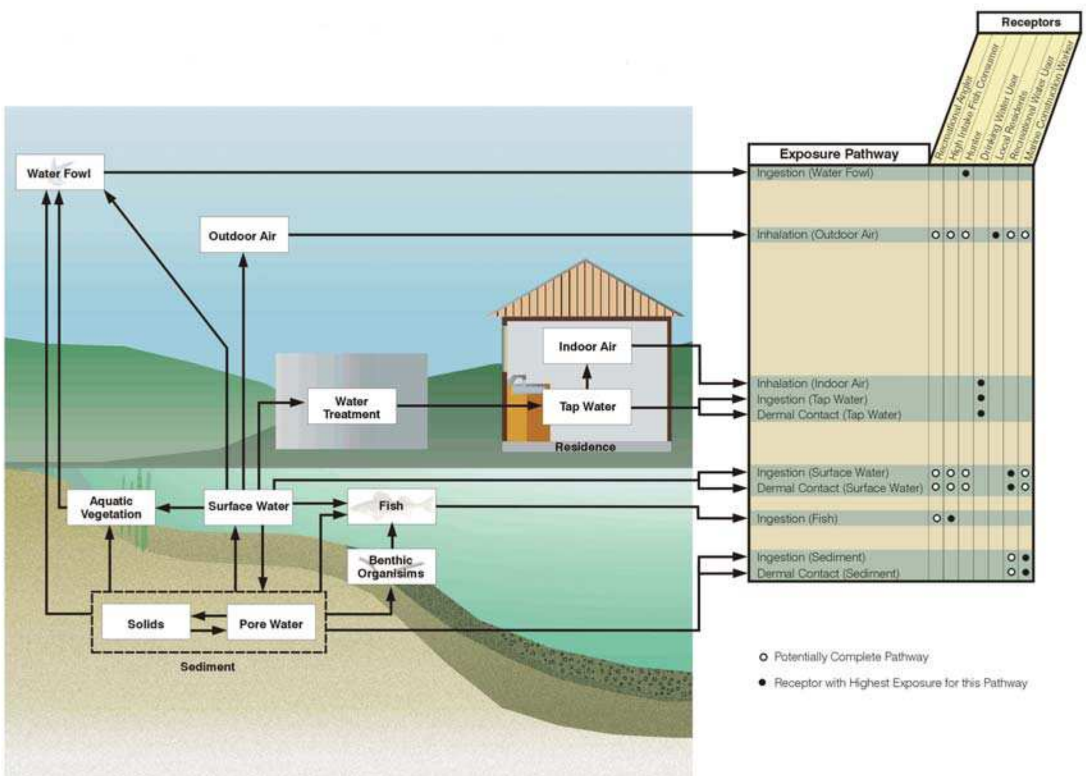


Figure 6-2 Ecological Conceptual Site Model for OU 3

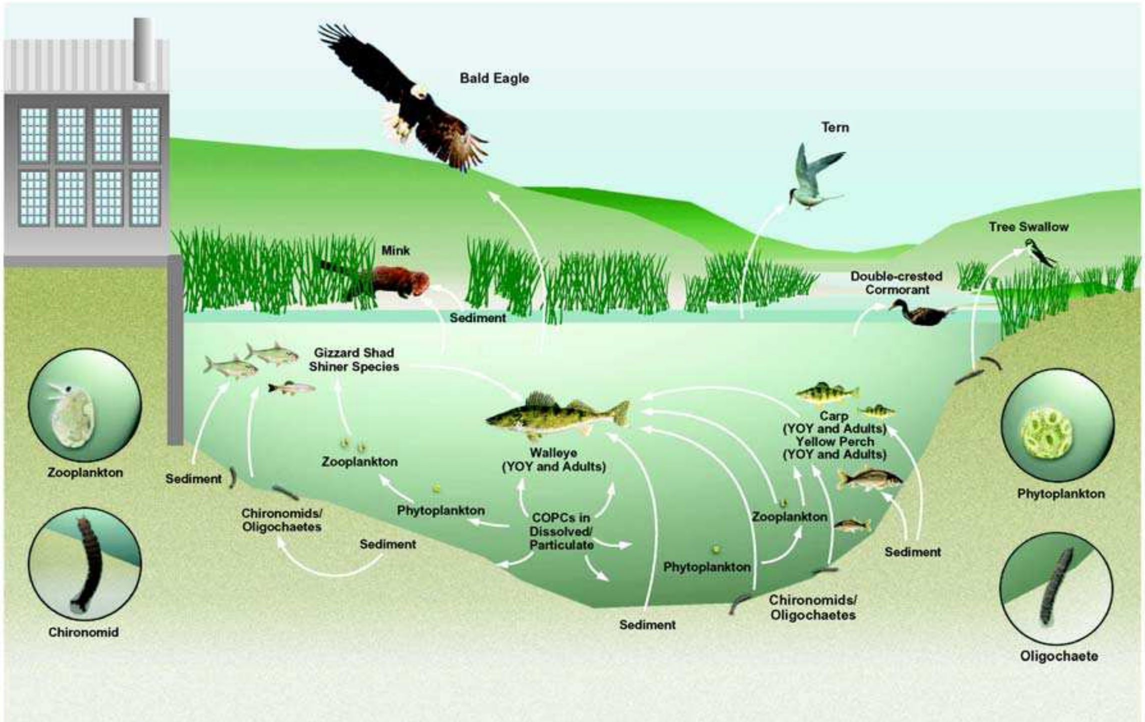


Figure 6-3 Ecological Conceptual Site Model for OU 4 and OU 5 – Zone 2

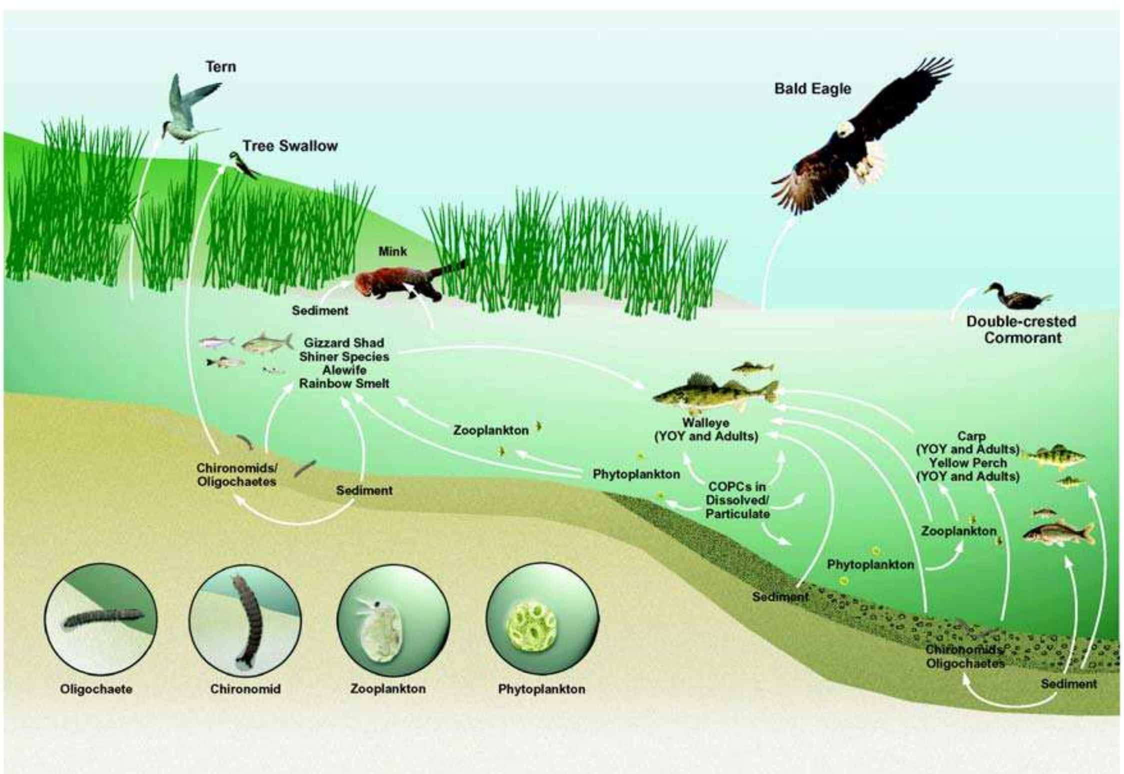
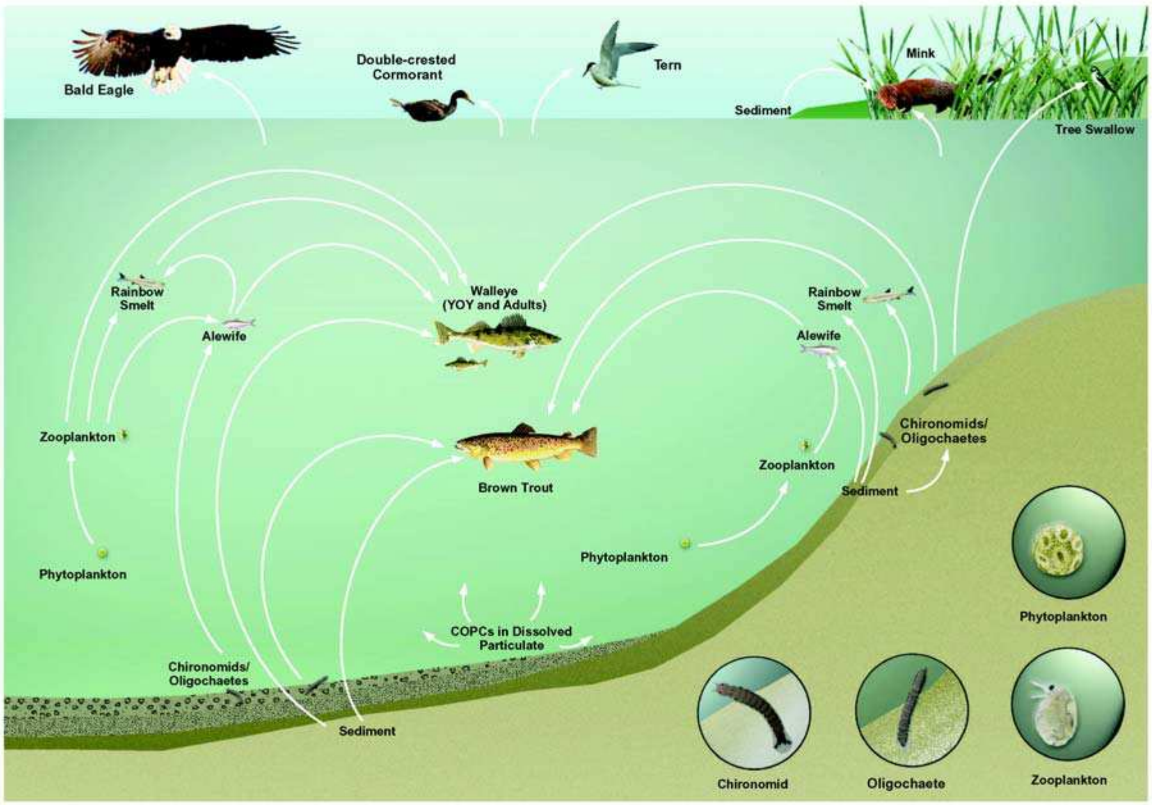


Figure 6-4 Ecological Conceptual Site Model for OU 5 Zones 3A, 3B, and 4



6.2 Results of the Remedial Investigation

6.2.1 Site Overview

The Lower Fox River is a large freshwater river. Green Bay is a large freshwater body of water, roughly 119 miles long with an average width of 23 miles. The southern end of the Bay is a warm water estuary with shallow depths, while the northern half is deeper and has cold water more typical of Lake Michigan. The River and Bay have been contaminated with PCBs for nearly 50 years. The contaminated portions of the River have variations in hydrology and riverbed geology, creating a complex environmental setting. Within this setting, there are varying levels of PCB contamination.

6.2.2 Summary of Sampling Results

The RI/FS evaluated data from numerous prior investigations, some of which had been conducted as early as 1971. These data have been incorporated into a single Fox River Database (FRDB), which is available at the WDNR's Lower Fox River web page (http://www.dnr.state.wi.us/org/water/wm/lowerfox/index.html). The current database contains more than 580,000 analytical records captured since 1971, including every substantial data collection activity from 1989 to the time of the release of this ROD. The FRDB covers analysis of samples of sediment, water, air, and biota (e.g., fish and wildlife tissues). Data received as part of the comments on the Proposed Plan have been added to the database.

6.2.3 Nature of Contamination

Based upon the investigations conducted for this project, it was determined that PCBs are the primary risk driver, and PCB contamination was therefore studied in the RI/FS. PCBs consist of a group of 209 distinct chemical compounds, known as congeners, that contain one to ten chlorine atoms attached to a biphenyl molecule, with the generic formula of $C12H_{(10-x)}Cl_x$, where x is an integer from 1 to 10. PCBs are grouped based on the number of chlorine atoms present (homologous groups). For example, monochlorobiphenyls contain one chlorine atom, dichlorobiphenyls contain two chlorine atoms, and trichlorobiphenyls contain three chlorine atoms. Some PCB congeners are structurally and toxicologically similar to another highly toxic group of compounds known as dioxin. These PCB compounds are sometimes called “dioxin-like” PCBs.

Commercially manufactured PCBs consisted of complex mixtures of congeners that were known under various trade names and marketed under the general trade name “Aroclors.” Approximately 140 to 150 different congeners have been identified in the various commercial Aroclors; about 60 to 90 different congeners were present in each individual Aroclor.

The PCBs used by paper manufacturing facilities on the River in the production of carbonless copy paper from 1954 to 1971 consisted largely of the Aroclor identified as “1242.” Carbonless copy paper produced during this time contained approximately 3.4 percent PCBs by weight.

Other chemicals of potential concern (COPCs) (for example, mercury, lead, arsenic, dieldrin, DDT/DDE/DDD, furan, and dioxin) are also present at the Site. However, these non-PCB contaminants are not significant risk drivers because of their relatively low concentrations. Additionally, some of the other COPCs identified in sediment have fate and transport properties similar to those of PCBs and are generally co-located with PCBs. For this reason, a remedy that effectively addresses PCB exposure will also address the other COPCs (which pose less risk) in the sediment.

Sources

Approximately 20 paper mills are located along the portion of the River included in the Site. Of these companies, six engaged in the production or de-inking of carbonless copy paper containing PCBs and, as a result, discharged PCBs to the River. It is estimated that the wastewater discharged by the paper mills, either directly or indirectly (i.e., through publicly owned treatment works), released an estimated 313,260 kg (690,000 pounds) of PCBs into the River.

Contaminated Media

Sediment

Much of the volume of PCBs discharged into the River has already been transported throughout the Site and is now concentrated in sediment within specific areas. In general, the upper three River reaches can be characterized as having discrete soft sediment deposits within inter-deposit areas (areas between deposits with little or no soft sediment). In contrast, the last River reach from De Pere to Green Bay is essentially one large, continuous soft sediment deposit. Because there were several points of PCB discharge along the entire length of the River, PCB concentrations and mass distributions are highly variable. Table 6-1 summarizes the distribution of PCBs within the sediment of OUs 3, 4, and 5. (Also see Tables 8-1 through 8-6 in Section 8 of this ROD, which summarize PCB contaminant concentration data for OUs 3, 4, and 5.)

Table 6-1 PCB Distribution in the Lower Fox River OUs 3, 4, and 5

River Reaches	Sediment Volume (cy)	PCB Mass (kg)
OU 3 – Little Rapids to De Pere	3,030,100	1,250
OU 4 – De Pere to Green Bay	8,491,400	26,650
OU 5 – Green Bay*	815,210,000	69,330

* The Green Bay mass and volume estimates are from the RI. Please see *White Paper No. 18 – Evaluation of an Alternative Approach of Calculating Mass, Sediment Volume, and Surface Concentrations in Operable Unit 5, Green Bay,* and *White Paper No. 19 – Estimates of PCB Mass, Sediment Volume, and Surface Sediment Concentrations in Operable Unit 5, Green Bay Using an Alternative Approach* for a complete discussion of Green Bay mass and volume estimates.

Transport of PCBs in the Fox River and Green Bay

Contaminant fate and transport in the River and Bay are largely a function of deposition, suspension, and redeposition of the chemicals of concern (COCs) that are bound to sediment particles. The organic COCs (PCBs, pesticides) adhere to organic material in the sediment. The ultimate fate and transport of these organic compounds depend significantly on the rate of flow and water velocities through the River and Bay. During high-flow events such as storms and spring snowmelt, more sediment becomes suspended and transported downstream. High-flow events occur approximately 15 to 20 percent of the time, but can transport more than 50 to 60 percent of the PCB mass that annually moves over the De Pere dam and into the Bay. Other modes of contaminant transport, such as volatilization, atmospheric deposition, and point source discharges, are negligible when compared to this sediment resuspension.

Changes in Sediment Bed Elevation

The River is an alluvial river that exhibits significant changes in bed elevations over time in response to changing volumes of flow during annual, seasonal, and storm events; changes in sediment load; and changes in its base level, which is determined by Lake Michigan. Sediment in the riverbed is dynamic and does not function as discrete layers. Sediment movement in the River is in marked contrast to the sediment dynamics found in a large, quiescent body of water, such as deep lakes or the deeper portions of the Bay.

Scouring of the sediment bed plays a significant role in the quantity of sediment and contaminants transported through the River system. In its comments on the 1999 draft RI/FS, the FRG commented that less than 1 inch of sediment would be resuspended from the riverbed as a result of a 100-year storm event. In response to that comment, the WDNR and EPA investigated changes in sediment bed elevation for the De Pere to Green Bay River reach (OU 4). This work, entitled *Technical Memorandum 2g of the Model Documentation Report*, is relevant to OU 4 and informative regarding movement of River sediments generally. (Technical Memorandum 2g was completed by a group called the FRG/WDNR Model Evaluation Workgroup as part of the 1997 agreement between the FRG and WDNR. The EPA made further evaluations that were consistent with changes documented in Technical Memorandum 2g; see *White Paper No. 3 – Fox River Bathymetric Survey Analysis*, released with the Lower Fox River and Green Bay ROD for OUs 1 and 2.) Monitoring indicates that the River is both erosional and depositional over time, reflecting the fact that the hydrodynamics of the River are very complex. These same results indicate that in the absence of continued point sources contributing PCBs to the system, the continued presence of PCBs in the Lower Fox River is the result of erosion, transport, and redeposition of PCB-contaminated sediment.

These analyses indicate that changes in sediment bed elevation occur in the River over both short- and long-term time frames. Changes in sediment bed elevation were observed both across the channel and downstream profiles, and these changes show little continuity. Since River flows have not significantly changed in recent years, the complexity of the changes in sediment bed elevation reflects the prevailing hydrologic and sediment conditions that occurred over a 22-year period from 1977 through 2000. However, it should be noted that lake levels are at historically low levels and additional declines are projected over the long term. Therefore, the potential for erosion and scour may increase, particularly during large storm events.

The wide range of these discharges and sediment loads continuously reshapes the River sediment bed. Short-term changes (e.g., annual and subannual) in average net sediment bed elevations range from a decrease or scour of over 11 inches to an increase or deposition of over 14 inches. Long-term changes (e.g., over several years) in average net elevations range from a decrease of more than 39 inches to an increase of nearly 17 inches. These documented changes are well supported by sediment volume calculations made by the United States Army Corps of Engineers (USACE) from pre- and post-dredge surveys of sediment bed elevations, as well as by the results of an analysis by the United States Geological Survey (USGS) of bed surveys performed at intermediate time scales (e.g., 8 months to 45 months).

Surveys of the River bottom conducted by several different groups show significant changes in sediment bed elevation. On average, sediment bed elevation data from throughout the De Pere to Green Bay Reach suggest that this River reach is a net depositional zone. It should be noted that during the survey period, there were no large storm events of a 10-year or greater magnitude. It is unknown what the scour would be during larger events.

The Potential for Natural Biodegradation of PCBs

Responding to comments received from the EPA's peer review panel concerning natural recovery, the viability of natural degradation as a potential remedial action for the sediment-bound PCBs in the River and Bay was evaluated and set forth in Appendix F of the Lower Fox River and Green Bay FS.

In summary, two basic degradation processes, anaerobic (without oxygen) and aerobic (in the presence of oxygen), must occur to completely decompose PCBs. Based on evidence in the literature, anaerobic PCB degradation was demonstrated to have occurred under field conditions at almost all the sites studied. However, a reduction in PCB concentrations through anaerobic processes is site-dependent. In the Lower Fox River, University of Wisconsin researchers found only a 10 percent reduction that could be attributed to anaerobic degradation processes in deposits with average PCB concentrations greater than 30 mg/kg. More important, no PCB reductions resulting from anaerobic processes could be accounted for in deposits with average concentrations less than 30 mg/kg.

Other active treatment options might promote dechlorination of the sediment, making the PCBs more amenable to biological destruction. However, a pilot-scale experiment conducted at the Sheboygan River, another site with PCB-contaminated sediment, yielded inconclusive results regarding the viability of enhanced biodegradation. In that study, PCB-contaminated sediment was removed from the river and placed into a specially engineered treatment facility. The sediment was seeded with microorganisms and nutrients, and the sediment was manipulated between aerobic and anaerobic conditions to optimize biological degradation. Even under these conditions, the data were insufficient to conclude that PCB decomposition was enhanced.

Effects of Time

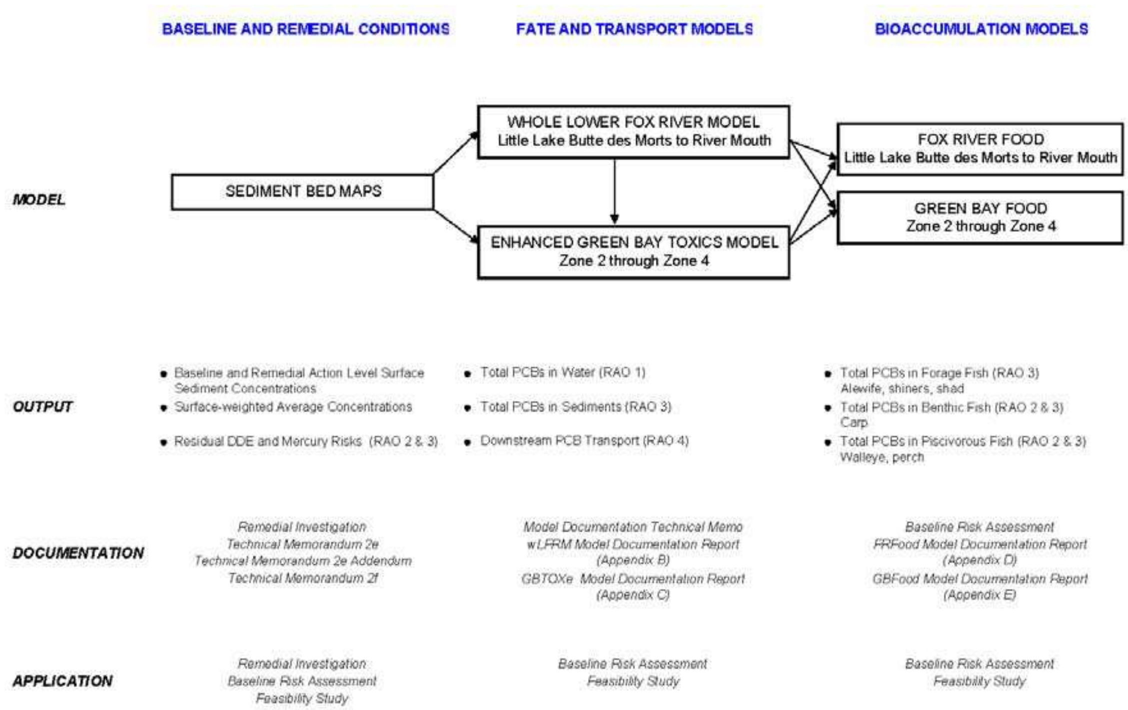
The FRDB includes test results for sediment, water, and tissue samples collected since 1971. During the 1970s, after the use of PCBs in the manufacture of carbonless copy paper had ceased, PCB concentrations in fish tissue showed significantly declining concentrations. Since the mid-1980s, however, changes in PCB levels in fish have slowed, remained constant, or, in some cases, increased. The Time Trends Analysis (see Appendix B to the Remedial Investigation and *White Paper No. 1 – Time Trends Analysis,* December 2002, released with the Lower Fox River and Green Bay ROD for OUs 1 and 2) conducted as part of the RI suggests that the rate of change in PCB concentrations in fish has slowed to unacceptable levels in certain cases or, in some cases, has stabilized and shows no change at all.

Trends in PCB concentrations in the surface layer (i.e., top 4 inches) of River sediment are not consistent, but concentrations generally appear to be decreasing over time as more PCB mass is transported downstream. However, the Time Trends Analysis showed that concentrations in the subsurface sediments do not appear to be declining. This indicates that a considerable amount of PCB mass remains within the sediments of the River. Any changes made to the current lock and dam configuration on the River could result in increased scour and resuspension of those underlying sediments, which could in turn result in increases in PCB concentrations in fish tissue. In addition, soil eroded from the watershed mixes with and may further dilute PCB concentrations in the sediment.

Modeling Effort for the Lower Fox River and Green Bay

Four interrelated models were used in the RI/FS to simulate the fate and transport of PCBs in the River and the Bay (Figure 6-5). The models are mathematical representations of the transport and transfer of PCBs between the sediment, the water, and uptake into the River and Bay food webs. The models are intended not only to provide information on the fate and transport of PCBs in an unremediated river system, but also to compare the potential remedial alternatives detailed in the FS. Although the models tend to estimate concentrations lower than the concentrations actually observed in the River, the relative differences predicted by the models are considered to be reliable.

Figure 6-5 Relationship of Models Used for Risk Projections in the Lower Fox River and Green Bay



The modeling effort included:

- Bed mapping of the River and Bay to define sediment thickness, sediment physical properties (such as total organic carbon and bulk density), and total PCB concentrations
- Use of the whole Lower Fox River Model (wLFRM) to simulate the movement of PCBs in the water column and sediment of the River from Little Lake Butte des Morts to the mouth of the River at Green Bay
- Use of the Fox River Food Chain Model (FRFood) to simulate the uptake and accumulation of PCBs in the aquatic food chain in the River using model results from wLFRM
- Use of the Enhanced Green Bay PCB Transport Model (GBTOXe) to simulate the movement of PCBs in the water column and sediment of Green Bay from the mouth of the Lower Fox River to Lake Michigan, including loading rates to Green Bay based on model results from wLFRM
- Use of the Green Bay Food Chain Model (GBFood) to simulate the uptake and accumulation of PCBs in the aquatic food chain in the lowest reach of the Lower Fox River and in Green Bay

Bed mapping provided the foundation for the modeling inputs. Total PCB concentrations in surface sediment for the baseline and action levels serve as inputs to wLFRM and GBTOXe. This model projects total PCB concentrations in water and sediment. The output from this model is in turn used in the bioaccumulation models, FRFood and GBFood, to project whole fish tissue concentrations of PCBs (see Figures 6-2 to 6-4). The output from all of the models is then compared to the remedial action levels specified in the FS. This information is used in the FS to estimate the length of time it would take for a receptor to achieve the acceptable fish tissue concentration in response to a given action level.

Taken together, these models provide a method for evaluating the long-term effects of different remedial alternatives and different action levels on PCB concentrations in water, sediment, and aquatic biota in the River and Bay. The models are then used to predict PCB concentrations in the aquatic environment over a 100-year period under different remedial alternatives and action levels. The modeling results are discussed in the FS and a more detailed discussion on modeling can be found in the Model Documentation Report. A complete copy of that report is available on the WDNR's Lower Fox River web page, which can be accessed at http://www.dnr.state.wi.us/org/water/wm/lowerfox/index.html.

In summary, in the RI/FS the Agencies evaluated PCB contamination at the Site using a number of tools. These tools included geochemical analyses of the water and sediment, "time trends" (i.e., statistical) analyses, analysis of biological monitoring data, and synthesis of the data by the application of a set of complex mathematical (i.e., computer) models. PCB physical/chemical transport and fate and PCB bioaccumulation models were applied to predict future levels of PCBs in the River and Bay sediment, water, and fish, as discussed below.

Water Column

The dominant current PCB source to the water column is sediment. Average River surface water total concentrations are 54.6 parts per trillion (ppt), with particulates and dissolved concentrations 40.0 ppt and 14.6 ppt, respectively. There are significant seasonal variations, particularly when the water temperature drops below 40 degrees Fahrenheit (°F). For example, during the winter months of December 1994 and February 1995, total PCB concentrations dropped to about 10 percent of their average concentration. See Tables 8-1 through 8-6 in Section 8 of this ROD for data on surface water PCB concentrations for OU 3, OU 4, and OU 5.

Fish and Other Biota

PCB concentrations in fish result from a fish's exposure to PCBs in water and surface sediment through an aquatic food chain and/or a benthic food chain. The WDNR continues to collect and analyze fish tissue data from locations in the River and the Bay. See Tables 8-1 through 8-6 in Section 8 of this ROD for data on fish (walleye) PCB concentrations for OU 3, OU 4, and OU 5.

A wide variety of fish and other species have been collected and analyzed for the River and the Bay from 1971 to present. In general, these data suggest concentrations in biota have declined, although the rate of decline varies depending upon the location and time. However, it is important to note that this does not appear to be true for all cases. For certain fish species evaluated as part of the Time Trends Analysis, it appears that the rate of change in fish PCB concentrations has slowed to unacceptable levels in certain cases or, in some cases, has stabilized and shows no change at all.

Air

PCBs can enter the air via volatilization from PCB-contaminated water and soil, although volatilization of PCBs is generally considered to be limited. Air monitoring during the 1999 SMU 56/57 dredging project demonstrated that volatilization of PCBs does not pose a significant risk to humans or wildlife. Based on previous modeling, PCB loading to the Lower Fox River and Green Bay from atmospheric sources is relatively small, estimated to be a maximum of 5 kg (11 pounds) to the River and 35 kg (77 pounds) to Green Bay.

7 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

As one of Wisconsin's great rivers, the Lower Fox River has played and will continue to play a major role in the history, culture, and economy of the area. Current and reasonably anticipated future land and surface water uses are described below.

7.1 Current and Reasonably Anticipated Future Land Uses

Current land use includes a variety of residential, commercial, agricultural, and industrial activities. Other uses of land along the River and Bay include recreational areas such as parks and woodlands. Future uses of the River and lands surrounding the River are expected to remain consistent with present uses. At this time, no changes in future land use are known, nor are any new uses expected. Table 7-1 summarizes current land uses for OUs 3, 4, and 5, which pass through and border on Brown, Door, Kewaunee, Marinette, Oconto, Outagamie, and Winnebago Counties in Wisconsin and Delta and Menominee Counties in Michigan.

Table 7-1 Predominant Land Uses by Operable Unit

Operable Unit	Predominant Land Uses
OU 3 – Little Rapids to De Pere	Agricultural, residential
OU 4 – De Pere to Green Bay	Residential, industrial, commercial, agricultural, and commercial
OU 5 – Green Bay	Residential, industrial, commercial, agricultural, and commercial

7.2 Surface Water Uses

Human uses of the surface waters of the River and Bay range from the industrial and commercial to the residential and recreational. In addition, surface waters of the River and Bay fill important ecological functions. These uses are briefly described below.

- **Industrial and Commercial:** Uses include electrical power generation, paper mills and related production facilities, heavy and light manufacturing, as well as other industrial and commercial activities.

- **Residential/Domestic:** Because of historical problems in the River, the main water supply sources for human consumption in the areas surrounding OUs 3, 4, and 5 are Lake Michigan and groundwater, not the River. The River is not presently used as a primary source of drinking water source by municipalities.

- **Recreation:** The River and Bay support a variety of water-based recreational activities, including sport fishing, waterfowl hunting, swimming, and boating, both power and non-power. Tourism is popular and important to the local economy.

- **Ecological Resources:** The River and Bay support many species of birds (such as tree swallow, Forster's and common tern, double-crested cormorants, and bald eagles), fish (such as rainbow smelt, alewife, gizzard shad, shiner, yellow perch, carp, brown trout, and walleye), and mammals (for example, mink), including 16 species of state or federally listed threatened or endangered species.

  The River also provides diverse habitats for all trophic levels of the River and Bay ecosystem. Plants, plankton, aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals use the River for feeding, reproduction, and shelter. In addition to the aquatic communities associated with the River, animals living in wetlands, floodplains, and upland communities are also dependent on the River. Both federal and state freshwater wetlands exist in the River region, providing valuable habitat.

8 SUMMARY OF SITE RISKS[1]

Baseline human health and ecological risk assessments were conducted to evaluate the potential for current and future impacts of site-related contaminants on receptors visiting, utilizing, or inhabiting the River and the Bay. The Baseline Human Health and Ecological Risk Assessment (BLRA) for the Lower Fox River and Green Bay was prepared as a companion document to the RI/FS and was finalized in December 2002.

In the BLRA's Human Health Risk Assessment (HHRA), cancer risks and noncancer health hazards were evaluated for the River and Bay. In the BLRA's Ecological Risk Assessment (ERA), ecological risks were evaluated for the River and Bay.

The BLRA concluded that:

- Human health and ecological receptors are at risk in each Operable Unit.

[1] Publication details for references cited in this section can be found in the BLRA and/or RI/FS documents, which appear in the Administrative Record and are also available in the information repositories.

- Fish consumption is the exposure pathway presenting the greatest level of risk for human and ecological receptors.
- The primary contaminant of concern is PCBs.

8.1 Identification of Chemicals of Concern

More than 75 chemicals of potential concern (COPCs) were identified in the Screening Level Risk Assessment (SLRA) conducted to evaluate which chemicals in the system pose the greatest degree of risk to people and ecological receptors. COPCs identified for the Lower Fox River included metals, PCBs, dioxins, pesticides, and polycyclic aromatic hydrocarbons. Based on a further review of the COPCs in fish tissue, the Agencies, along with the Biological Technical Assistance Group (BTAG), made a determination that only the following eight COPCs should be carried forward into the BLRA: PCBs (total and/or Aroclor 1242), dioxins, furans, DDT/DDE/DDD, dieldrin, arsenic, lead, and mercury. The rationale supporting this decision is documented in Appendix A to the BLRA.

Human health and ecological risks associated with those eight COPCs were evaluated in the BLRA. It was concluded that all the COPCs posed risk to at least one receptor group in at least one reach or zone of the River or Bay; however, only PCBs, DDE, and mercury posed risk to all receptors (both human and ecological) in all areas evaluated. Of those, PCBs were the primary chemical of concern (COC). As a result of this process, only PCBs, DDE, and mercury were carried forward for evaluation in the FS as COCs.

PCB Health Effects

Studies on the human health effects and risks associated with exposure to PCBs, including from fish consumption, show:

- *Neurobehavioral and developmental problems, such as impaired responsiveness, short-term memory problems, and reduced mental abilities in the infants and children of mothers exposed to PCBs prior to and during pregnancy (Jacobson, 1984, 1985, 1990; Koopman, 1996; Huisman, 1995; Lonkey, 1996; Rogan, 1985).*
- *Three times the chance of having lower IQ scores; twice the chance of lagging at least 2 years behind in reading comprehension; short-term and long-term memory effects and difficulties paying attention (Jacobson, 1996).*
- *Increased risk of cancer and immune system effects among the general population and workers producing PCB capacitors (Bertazzi, 1987; Brown, 1987; Sinks, 1991; Svensson, 1984; Rothman, 1997).*

Because of the potential health impacts, fish consumption advisories have been in place since 1976 for both the Lower Fox River and Green Bay. These advisories, published regularly by the Wisconsin Department of Natural Resources, warn residents to limit or eliminate locally caught fish (for example, carp and catfish) from their diets. The advisories also provide tips on how to properly clean and cook fish to reduce the risk of PCB exposure.

8.2 Human Health Risk Assessment

8.2.1 Summary of Site Risks

The site-specific HHRA evaluated both cancer risks and noncancer health hazards from exposure to PCBs and other COCs in the Site, as documented in the RI/FS. This discussion emphasizes cancer risks and noncancer health hazards due to PCBs in the River and Bay that exceed the EPA's goals for protection. For cancer effects, regulatory decisions are made ranging from incremental risk levels of one in a million (10^{-6}) to one in 10,000 (10^{-4}). For noncancer effects, a hazard index (HI) of 1 is the most frequent basis for risk management decisions. Cancer risks and noncancer hazard indices in the Bay were calculated to be generally similar to those in the River. For fish consumption, the cancer risks and noncancer hazard indices in the River and Bay are above the EPA's levels of concern for fish consumption, while other exposure media presented significantly lower risks.

Consistent with Superfund policy and guidance, the HHRA is a baseline risk assessment and therefore assumes no actions (e.g., remediation) to control or mitigate hazardous substance releases and no institutional controls, such as the fish consumption advisories and fishing restrictions that are currently in place, intended to control exposure to hazardous substances. As part of the baseline HHRA, cancer risks and noncancer hazard indices were calculated based on an estimate of the reasonable maximum exposure (RME) expected to occur under current and future conditions at the Site. The RME is defined as an upper end exposure that is reasonably expected to occur at a site. The HHRA also estimated cancer risks and noncancer hazard indices based on central tendency (CT), or average, exposures at the Site.

For both the RME and CT exposures, upper-bound and average concentrations of COCs in fish and other exposure media were determined. The HHRA also included a focused evaluation of exposure only to PCBs through the fish ingestion pathway. The following discussion summarizes the HHRA with respect to the basic steps of the Superfund HHRA process: (1) data collection and analysis, (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization.

8.2.2 Data Collection and Analysis

The baseline HHRA utilized documents relating to the nature and extent of PCB contamination at the Site developed as part of the RI/FS. These RI/FS documents provide both current and projected future concentrations of PCBs in source media, including air, fish, sediments, and River water. To calculate cancer risks and noncancer hazard indices, the information on concentrations in these media (Tables 8-1 to 8-6) is combined with other information on exposure (see Section 8.2.3) and toxicity (see Section 8.2.4).

Table 8-1 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 3

<table>
<tr><th rowspan="2">Exposure Point</th><th rowspan="2" colspan="2">Chemical of Concern</th><th colspan="2">Concentration Detected</th><th rowspan="2">Frequency of Detection</th><th rowspan="2">Exposure Point Concentration</th><th rowspan="2">Statistical Measure</th></tr>
<tr><th>Min.</th><th>Max.</th></tr>
<tr><td>Sediments</td><td colspan="2">Total PCBs</td><td>0.003 ppm</td><td>54.0 ppm</td><td>542/652</td><td>2.1 ppm</td><td>mean</td></tr>
<tr><td rowspan="2">Surface Water Direct Contact</td><td rowspan="2">Total PCBs</td><td>particulate</td><td>0.2 ng/L</td><td>96.3 ng/L</td><td>94/98</td><td>29.9 ng/L</td><td rowspan="2">mean</td></tr>
<tr><td>dissolved</td><td>0.2 ng/L</td><td>27.6 ng/L</td><td>97/98</td><td>11.3 ng/L</td></tr>
<tr><td>Fish Tissue (walleye)</td><td colspan="2">Total PCBs</td><td>0.4 ppm</td><td>2.80 ppm</td><td>47/48</td><td>0.5 ppm</td><td>mean</td></tr>
</table>

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-76.
Exposure point concentration for sediments – BLRA Table 5-33.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-76.

Table 8-2 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 4

Exposure Point	Chemical of Concern		Concentration Detected Min.	Concentration Detected Max.	Frequency of Detection	Exposure Point Concentration	Statistical Measure
Sediments	Total PCBs		0.0004 ppm	710.0 ppm	947/1023	2.959 ppm	mean
Surface Water Direct Contact	Total PCBs	particulate	1.4 ng/L	149 ng/L	129/143	44.2 ng/L	mean
		dissolved	2.4 ng/L	45.0 ng/L	142/143	16.6 ng/L	
Fish Tissue* (walleye)	Total PCBs		0.1 ppm	4.6 ppm	124/125	1.3 ppm	mean

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
* Fish concentration data from De Pere to Green Bay (OU 4) and Green Bay Zone 2 are combined.
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-76.
Exposure point concentration for sediments – BLRA Table 5-34.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-76.

Table 8-3 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 5, Zone 2

Exposure Point	Chemical of Concern		Concentration Detected Min.	Concentration Detected Max.	Frequency of Detection	Exposure Point Concentration	Statistical Measure
Sediments	Total PCBs		0.015 ppm	0.8 ppm	48/49	0.212 ppm*	Mean
Surface Water Direct Contact	Total PCBs	particulate	1.3 ng/L	91.7 ng/L	71/71	13.0 ng/L	Mean
		dissolved	1 ng/L	13.7 ng/L	63/63	4.8 ng/L	
Fish Tissue** (walleye)	Total PCBs		0.1 ppm	4.6 ppm	124/125	1.3 ppm	Mean

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
* Concentration is the mean for all Green Bay zones.
** Fish concentration data from De Pere to Green Bay (OU 4) and Green Bay Zone 2 are combined.
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-76.
Exposure point concentration for sediments – BLRA Table 5-35.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-76.

Table 8-4 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 5, Zone 3A

Exposure Point	Chemical of Concern		Concentration Detected Min.	Concentration Detected Max.	Frequency of Detection	Exposure Point Concentration	Statistical Measure
Sediments	Total PCBs		0.004 ppm	1.0 ppm	157/180	0.212 ppm*	mean
Surface Water Direct Contact	Total PCBs	particulate	0.22 ng/L	16.9 ng/L	61/66	2.8 ng/L	mean
		dissolved	0.48 ng/L	5.1 ng/L	60/60	1.6 ng/L	
Fish Tissue (walleye)	Total PCBs		0.16 ppm	5.5 ppm	15/15	1.7 ppm	mean

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
* Concentration is the mean for all Green Bay zones.
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-78.
Exposure point concentration for sediments – BLRA Table 5-35.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-78.

Table 8-5 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 5, Zone 3B

Exposure Point	Chemical of Concern		Concentration Detected Min.	Concentration Detected Max.	Frequency of Detection	Exposure Point Concentration	Statistical Measure
Sediments	Total PCBs		0.002 ppm	1.3 ppm	418/424	0.212 ppm*	mean
Surface Water Direct Contact	Total PCBs	particulate	0.29 ng/L	9.4 ng/L	40/45	2.2. ng/L	mean
		dissolved	0.5 ng/L	3.9 ng/L	40/40	1.4 ng/L	
Fish Tissue (walleye)	Total PCBs		0.5 ppm	8.1 ppm	23/23	2.5 ppm	mean

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
* Concentration is the mean for all Green Bay zones.
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-78.
Exposure point concentration for sediments – BLRA Table 5-35.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-78.

Table 8-6 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 5, Zone 4

Exposure Point	Chemical of Concern		Concentration Detected		Frequency of Detection	Exposure Point Concentration	Statistical Measure
			Min.	Max.			
Sediments	Total PCBs		0.001 ppm	0.8 ppm	199/203	0.212 ppm*	mean
Surface Water Direct Contact	Total PCBs	particulate	0.1 ng/L	2.4 ng/L	66/86	0.9 ng/L	mean
		dissolved	0.3 ng/L	1.3 ng/L	66/66	0.6 ng/L	
Fish Tissue (walleye)	Total PCBs		0.1 ppm	3.5 ppm	30/30	0.7 ppm	mean

Notes:
ng/L – nanograms per liter (ppt)
ppm – parts per million
* Concentration is the mean for all Green Bay zones.
Data Sources:
Concentrations and detections for sediments – RI Table 5-1.
Concentrations and detections for surface water – RI Table 5-16.
Concentrations and detections for fish tissue (walleye) – BLRA Table 5-78.
Exposure point concentration for sediments – BLRA Table 5-35.
Exposure point concentration for surface water – RI Table 5-16.
Exposure point concentration for fish tissue (walleye) – BLRA Table 5-78.

Fish at the Site have been collected by the WDNR for approximately 35 years and fish advisories have been in effect since 1976. Fish samples have been analyzed for PCBs (both total PCBs and selected congeners), dioxins/furans (specifically, 2,3,7,8-TCDD and 2,3,7,8-TCDF), the pesticide DDT (dichlorodiphenyltrichloroethane) and its metabolites (DDD and DDE), the pesticide dieldrin, arsenic, lead, and mercury. The non-PCB contaminants were found to present substantially less risk than the risk presented by PCBs. Additionally, some of the other contaminants identified in sediment have fate and transport properties similar to those of PCBs and are generally co-located with PCBs. For this reason, a remedy that effectively addresses PCB exposure will also address the other COCs (that pose less risk) in the sediment. This is also the basis for including only PCBs in the focused risk assessment.

The conceptual site model identifies potential receptors for COCs and exposure pathways. As discussed above, determination of PCB exposure provides a sound basis for characterizing significant human health risks at the Site. Estimates of the exposures allow a quantitative risk evaluation. This was done for source media including fish, sediment, and drinking/River water. Most Site risks were determined to relate to fish consumption, with only minimal risk associated with other potential exposures (e.g., inhalation, direct contact). This is the basis for including only the fish ingestion pathway in the focused risk assessment.

The quantitative risk calculations for the fish consumption pathway were based on wet-weight PCB concentrations in fish fillets, as generated by the WDNR's bioaccumulation models, Fox River Food (FRFood) and Green Bay Food (GBFood). The fillet represents the portion of the fish most commonly consumed. The fish exposures were derived by weighting the model output by reported angler preference for species consumption (i.e., weighting the modeled PCB concentrations in fish to reflect the species caught and consumed by anglers) and by averaging over location within the study area.

8.2.3 Exposure Assessment

The exposure assessment evaluates exposure pathways by which people are or can be exposed to the COCs in different media (e.g., fish, water, and sediment). Factors relating to the exposure assessment include, but are not limited to, the concentrations that people are or can be exposed to and the potential frequency and duration of exposure.

Conceptual Site Model

Human exposure to PCBs through consumption of fish presented the greatest risk. Other human exposure pathways evaluated in the baseline HHRA presented significantly less risk; these pathways include ingestion of and dermal contact with sediments and water and inhalation of indoor and outdoor air. The human health conceptual site model is shown on Figure 6-1.

Exposed Populations

Recreational anglers and high-intake (i.e., subsistence) fish consumers are the most likely population to have significant PCB exposures. This group consists of approximately 136,000 individuals who have fishing licenses in counties adjacent to the River and Bay. Populations that may have portions of their members engaged in subsistence fishing include Native Americans and Hmong (Laotians), estimated to include 5,000 individuals and their families. Sensitive populations that were quantitatively evaluated include highly exposed (i.e., subsistence) anglers and their families, as well as young children who consume fish. Infants of mothers who ingest fish that are exposed *in utero* and/or through consumption of breast milk are of concern, and these exposures were evaluated qualitatively. With respect to subsistence or highly exposed angler populations in Wisconsin, review of the literature suggests that these populations are likely to be adequately represented in the HHRA. With respect to infants (less than 1 year old), exposure to PCBs *in utero* and via ingestion of breast milk are known exposure routes that pose risks to fetal development in the infant. Several ongoing studies are determining whether it is possible to develop quantitative relationships between fetal/infant PCB exposure and developmental effects. Standard EPA default factors were used for angler body weight (e.g., 72 kg [159 pounds] for an adult).

Fish Ingestion Rate

Several fish consumption surveys were used to evaluate fish intake rates for both recreational and high-intake fish consumers. Specific studies included West et al. (1989, 1993) conducted in Michigan; Fiore et al. (1989) conducted in Wisconsin; Hutchinson and Kraft conducted in Wisconsin (1994), and Hutchinson (1999) conducted in Wisconsin. The RME fish ingestion rate for recreational anglers was determined to be 59 grams per day from the West et al. studies, while 81 grams per day was determined to be the RME for high-intake fishers using the findings from Hutchinson and Kraft (1994). For average or central tendency exposures (CTE) of recreational anglers, a fish intake of 15 grams per day was used based on the average of results from West et al. (1989) and West et al. (1993). For CTE high–intake anglers, a fish intake of 21 grams per day was used based on Hutchinson and Kraft (1994).

Exposure Duration

To derive both RME and CTE exposures, average levels of PCBs in fish (all fish or subgroups such as walleyes) were applied. Fish data from 1989 onward was used in the risk analyses. Values of 30 years for the CTE and 50 years for the RME scenarios were established based on

EPA published estimates of the years persons live in the River and Bay area. For young children, an exposure duration of 7 years was applied.

PCB Cooking Loss

PCB losses during cooking were assumed to be 50 percent, based on studies reported in the literature. Potential PCB loss mechanisms include removing skin and fat, draining cooking fluids from the fish, and grilling to allow oil to drip away from the fish.

Probabilistic Analysis

In addition to the point estimate (i.e., deterministic) analyses, a probabilistic analysis was performed to provide a range of estimates of the cancer risks and noncancer health hazards associated with the fish ingestion pathway. The probabilistic analysis helps to evaluate variability in exposure parameters (e.g., differences within a population's fish ingestion rates, number of years anglers are exposed, body weight, etc.) and uncertainty (i.e., lack of complete knowledge about specific variables). The deterministic risk analyses using point estimates to generate RMEs and risks were found to compare favorably to findings from the probabilistic approach.

8.2.4 Toxicity

The toxicity assessment determines the types of adverse health effects associated with PCB exposures and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Potential health effects for PCBs include the risk of developing cancer over a lifetime. Other noncancer health effects, such as changes in the normal functions of organs within the body (e.g., changes in the effectiveness of the immune system), are also associated with PCB exposure. Some of the 209 PCB congeners are considered to be structurally and mechanistically similar to dioxin and exert dioxin-like effects. The WDNR and EPA have concluded that the use of EPA-derived toxicity criteria is appropriate for the human health risk assessment. These values were developed according to standard methodologies and, therefore, present a relative measure of the potential for adverse effects. Both the cancer slope factor (CSF) and the reference dose (RfD) that were used in the BLRA were also used by the EPA in the Hudson River Risk Assessment, where PCBs were also the primary contaminant of concern. In defense of these values, the EPA prepared papers on PCB Carcinogenicity and Non-Cancer Toxicity as part of EPA work on the Hudson River.

Sources of Toxicity Information

The HHRA used the current consensus toxicity values for PCBs from EPA's Integrated Risk Information System (IRIS) in evaluating the cancer risk and noncancer health effects of PCBs. IRIS provides the primary database of chemical-specific toxicity information used in Superfund risk assessments. More recent toxicity data are provided in Appendix B of the BLRA. These data do not change the EPA's use of IRIS values. For the dioxin-like PCBs, the HHRA used toxicity information for dioxin (2,3,7,8-TCDD) provided in EPA's 1997 Health Effects Assessment Summary Tables coupled with toxic equivalency factors (TEFs) specific to each congener.

Cancer

The EPA has determined that PCBs cause cancer in animals and probably cause cancer in humans (B2 classification or likely to cause cancer in humans). The EPA's CSFs for PCBs represent plausible upper-bound estimates, which means that the EPA is reasonably confident that the actual cancer risks will not exceed the estimated risks calculated using the CSFs. For exposure to total PCBs in fish, sediment, or particulate exposure media, the CSF of 2 (milligrams per kilogram per day [mg/kg-day])$^{-1}$ was used (BLRA Table 5-40). For exposure to total PCBs in water or vapors, a CSF of 0.4 (mg/kg-day)$^{-1}$ was used. For the dioxin-like PCBs, the CSFs were based on toxic equivalency to 2,3,7,8-TCDD.

Noncancer Health Effects

Serious noncancer health effects have been observed in animals exposed to PCBs. Studies of rhesus monkeys exposed through ingestion of PCBs (i.e., Aroclors 1016 and 1254) indicate a reduced ability to fight infection and reduced birth weight in offspring exposed *in utero*. Studies of noncancer health effects, including neurobehavioral effects observed in children of mothers who consume PCB-contaminated fish, were summarized in the BLRA and are being evaluated by the EPA as part of the Agency's IRIS process. The toxicity assessment is an evaluation of the chronic (e.g., 7 years or more) adverse health effects from exposure to PCBs. The chronic RfD represents an estimate (with uncertainty spanning an order of magnitude or greater) of a daily exposure level for the human population, including sensitive populations (e.g., children), that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chemical exposures exceeding the RfD do not predict specific disease. For oral exposure to total PCBs, the oral RfD for Aroclor 1254 of 2×10^{-5} mg/kg-day was used (BLRA Table 5-41). For the dermal exposure to total PCBs, a dermal RfD was extrapolated from the oral RfD for Aroclor 1254. Inhalation exposures were not evaluated for noncancer health effects.

8.2.5 Risk Characterization

This final step in the HHRA combines the exposure and toxicity information to provide a quantitative assessment of Site risks. Exposures are evaluated based on the potential incremental risk for developing cancer and the potential for noncancer health hazards.

8.2.6 Cancer Risks

Cancer risk is expressed as an incremental probability of an individual developing cancer over a lifetime as a result of exposure to a carcinogen. For example, a 10^{-4} cancer risk means a one in 10,000 excess cancer risk, or an increased risk of an individual developing cancer of one in 10,000 as a result of exposure to site contaminants under the conditions used in the exposure assessment. Under Superfund, acceptable RME cancer risks are defined within the range of 10^{-4} to 10^{-6} (corresponding to a one in 10,000 to a one in 1,000,000 excess cancer risk). Excess lifetime cancer risk is calculated from the following equation:

$$Risk = CDI \times CSF$$

where:

Risk = a unitless probability (e.g., 1×10^{-3} of an individual developing cancer)
CDI = Chronic Daily Intake averaged over (mg/kg-day)
CSF = Cancer Slope Factor, expressed as (mg/kg-day)$^{-1}$

The focused risk assessment of exposure to PCBs via fish ingestion at this Site indicates that cancer risks to individuals exposed under RME and CT (average) conditions are above the EPA's acceptable levels. Tables 8-7 to 8-11 summarize key cancer risks from Tables 5-82 (River recreational anglers), 5-83 (Green Bay recreational anglers), 5-86 (River high-intake fish consumers), and 5-87 (Green Bay high-intake fish consumers) in the focused HHRA for the Site. Cancer risks from exposure to dioxin-like PCBs were comparable to the cancer risks from total PCBs for fish ingestion. Differences in exposure assumptions and the resultant cancer risks between RME and CTE groups and recreational and high-intake fish consumers are based upon differences in exposure duration (50 years versus 30 years) and fish intake rates (ranging from 15 to 21 grams per day [CTE] and 59 to 81 grams per day [RME]).

Table 8-7 Cancer Risk from Fish Ingestion – Summary for OU 3

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	3.3×10^{-4} (3.3 in 10,000)	4.9×10^{-5} (4.9 in 100,000)
Walleye	2.9×10^{-4} (2.9 in 10,000)	4.4×10^{-5} (4.4 in 100,000)
High-intake Fish Consumer		
All Fish	4.5×10^{-4} (4.5 in 10,000)	7.1×10^{-5} (7.1 in 100,000)
Walleye	4.1×10^{-4} (4.1 in 10,000)	6.4×10^{-5} (6.4 in 100,000)

Table 8-8 Cancer Risk from Fish Ingestion – Summary for OU 4 and OU 5, Zone 2 (combined)

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	7.3×10^{-4} (7.3 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
Walleye	7.3×10^{-4} (7.3 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
High-intake Fish Consumer		
All Fish	1.0×10^{-3} (1.0 in 1,000)	1.6×10^{-4} (1.6 in 10,000)
Walleye	1.0×10^{-3} (1.0 in 1,000)	1.6×10^{-4} (1.6 in 10,000)

Table 8-9 Cancer Risk from Fish Ingestion – Summary for OU 5, Zone 3A

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	7.4×10^{-4} (7.4 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
Walleye	6.2×10^{-4} (6.2 in 10,000)	9.2×10^{-5} (9.2 in 100,000)
High-intake Fish Consumer		
All Fish	1.0×10^{-3} (1.0 in 1,000)	1.6×10^{-4} (1.6 in 10,000)
Walleye	8.5×10^{-4} (8.5 in 10,000)	1.3×10^{-4} (1.3 in 10,000)

Table 8-10 Cancer Risk from Fish Ingestion – Summary for OU 5, Zone 3B

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	5.6×10^{-4} (5.6 in 10,000)	8.4×10^{-5} (8.5 in 100,000)
Walleye	5.9×10^{-4} (5.9 in 10,000)	8.8×10^{-5} (8.8 in 100,000)
High-intake Fish Consumer		
All Fish	7.8×10^{-4} (7.8 in 10,000)	1.2×10^{-4} (1.2 in 10,000)
Walleye	8.2×10^{-4} (8.2 in 10,000)	1.3×10^{-4} (1.3 in 10,000)

Table 8-11 Cancer Risk from Fish Ingestion – Summary for OU 5, Zone 4

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	5.2×10^{-4} (5.2 in 10,000)	7.7×10^{-5} (7.7 in 100,000)
Walleye	3.7×10^{-4} (3.7 in 10,000)	5.5×10^{-5} (5.5 in 100,000)
High-intake Fish Consumer		
All Fish	7.1×10^{-4} (7.1 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
Walleye	5.1×10^{-4} (5.1 in 10,000)	8.0×10^{-5} (8.0 in 100,000)

8.2.7 Noncancer Health Hazards

The potential for noncancer health effects is evaluated by comparing an exposure level over a specified time period (e.g., 7 years) with an RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ less than 1 indicates that a receptor's dose of a single contaminant is less than the RfD and that toxic noncarcinogenic effects from that chemical are unlikely. A hazard index (HI) represents the sum of the individual exposure levels for different chemicals and different media (e.g., fish, water, sediment) compared to their corresponding RfDs (i.e., HI is the sum of HQs for an individual). The key concept of a noncancer HI is that a threshold level (measured as an HI of 1) exists below which noncancer health effects are not expected to occur. Under the federal Superfund program, the EPA's goal for protection for noncancer health hazards is an HI equal to or less than 1 for the RME individual.

The HQ is calculated as follows:

$$Noncancer\ \ HQ = \frac{CDI}{RfD}$$

where:

CDI = chronic daily intake averaged over the exposure period (mg/kg-day)
RfD = reference dose (mg/kg-day)

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic).

The focused risk assessment of exposure to PCBs via fish ingestion indicates that all noncancer hazard indices to individuals exposed under RME and CT (average) conditions are above the EPA's generally acceptable levels, as shown below (Tables 8-12 to 8-16). Risks to children were calculated for OU 4 and OU 5, Zone 2, combined and are cited in Table 8-13. Based on these hazard indices, it is likely the risk to children would be two to three times higher than those hazard indices for Green Bay zones 3A, 3B, and 4. The tables below summarize key noncancer risks from Tables 5-84, 5-85, 5-88, 5-89, 5-104, and 5-105 from the focused HHRA for the Site. In addition, noncancer hazard indices to the average (CT) individual are above the EPA's generally acceptable levels. Noncancer hazard indices for dioxin-like PCBs were not evaluated quantitatively due to the EPA's ongoing evaluation of dioxin toxicity.

Table 8-12 Noncancer Health Hazard from Fish Ingestion – Summary for OU 3

Pathway	RME Noncancer HI	CT (Average) Noncancer HI
Recreational Angler		
All Fish	12.3	3.0
Walleye	11.0	2.7
High-intake Fish Consumer		
All Fish	17.0	4.4
Walleye	15.2	4.0

Note:
Hazard indices for young children are not listed here. However, based on analogy to OU 4, hazard indices would be two to three times higher than those cited in the table for adults.

Table 8-13 Noncancer Health Hazard from Fish Ingestion – Summary for OU 4 and OU 5, Zone 2 (combined)

Pathway	RME Noncancer HI	CT (Average) Noncancer HI
Recreational Angler		
All Fish	27.4	6.8
Walleye	27.4	6.8
High-intake Fish Consumer		
All Fish	37.8	9.9
Walleye	37.9	9.9
Recreational Child		
All Fish	66.3	16.4
Walleye	66.4	16.5
High-intake Fish Consumer Child		
All Fish	91.6	24.0
Walleye	91.8	24.0

Table 8-14 Noncancer Health Hazard from Fish Ingestion – Summary for OU 5, Zone 3A

Pathway	RME Noncancer HI	CT (Average) Noncancer HI
Recreational Angler		
All Fish	27.7	6.9
Walleye	23.1	5.7
High-intake Fish Consumer		
All Fish	38	10
Walleye	32	8.3

Note:
Hazard indices for young children are not listed here. However, based on analogy to OU 4, HI would be two to three times higher than those cited in the table for adults.

Table 8-15 Noncancer Health Hazard from Fish Ingestion – Summary for OU 5, Zone 3B

Pathway	RME Noncancer HI	CT (Average) Noncancer HI
Recreational Angler		
All Fish	21.2	5.2
Walleye	22.2	5.7
High-intake Fish Consumer		
All Fish	29	7.7
Walleye	31	8

Note:
Hazard indices for young children are not listed here. However, based on analogy to OU 4, HI would be two to three times higher than those cited in the table for adults.

Table 8-16 Noncancer Health Hazard from Fish Ingestion – Summary for OU 5, Zone 4

Pathway	RME Noncancer HI	CT (Average) Noncancer HI
Recreational Angler		
All Fish	19.4	4.8
Walleye	13.8	3.4
High-intake Fish Consumer		
All Fish	27	7
Walleye	19	5

Note:
Hazard indices for young children are not listed here. However, based on analogy to OU 4, HI would be two to three times higher than those cited in the table for adults.

8.2.8 Probabilistic Analysis

In addition to the deterministic calculations discussed above, the EPA calculated risks for ingestion of fish from the River and Bay using a probabilistic analysis, consistent with EPA guidance on probabilistic risk assessments (EPA, 1999). This analysis supports and complements the point estimates of risks and hazard indices calculated in evaluations of exposure to PCBs in fish.

Deterministic RME estimates of risk and hazard index provided in the probabilistic evaluation are generally consistent within the 90^{th} to 95^{th} percentiles of the respective probability distributions of risk and hazard indices. This is consistent with the interpretation provided by the EPA (EPA, 1999) of the RME as a plausible high-end risk or hazard index for the exposed population.

Deterministic CTE estimates of risk and hazard index are generally close to the means of probability distributions of risk and hazard index. This is consistent with the interpretation of the CTE as the average risk or hazard index for the exposed population.

8.2.9 Uncertainty

The process of evaluating human health cancer risks and noncancer hazard indices involves multiple steps. Inherent in each step of the process are uncertainties that ultimately affect the final cancer risks and noncancer hazard indices. Important sources of uncertainty in the HHRA are discussed below.

The uncertainties in the HHRA reflect uncertainties in the historical and trends of PCB concentrations in fish tissue over time, the assumptions relating to fish ingestion rates and PCB body burdens in people eating fish from the Lower Fox River and Green Bay, the assessment of PCB toxicity to humans, and the estimation of future PCB body burdens in fish. Each of these is discussed in more detail below.

Time Trends

Although concentrations in fish may be decreasing over time for some fish species in OU 3, OU 4, and OU 5, these trends were not consistent with all species (*White Paper No. 1 – Time Trends Analysis* (December 2002, released with the Lower Fox River and Green Bay ROD for OUs 1 and 2). In addition, trends in the surficial sediment layer are not consistent and concentrations in deeper sediments are not decreasing. Additionally, events that may scour sediments may cause declining trends currently observed to either slow or reverse.

Fish Ingestion Rate

The uncertainty in the fish ingestion rate was minimized by relying on a number of surveys. These included Michigan angler surveys for recreational anglers by West et al. (1989 and 1993) and a Wisconsin angler survey by Fiore et al. (1989). For high-intake fish consumers, surveys by West et al. (1993), Peterson (1994), Hutchison and Kraft (1994), Hutchison (1994), and Hutchison (1999) were also considered. In addition, the sensitivity/uncertainty analysis conducted for the probabilistic analysis showed that, despite the use of different fish, the overall conclusion of the HHRA – that cancer risks and noncancer hazard indices due to ingestion of fish are above levels of concern – essentially remains the same.

PCB Toxicity

The EPA describes the uncertainty in the cancer toxicity values as extending in both directions (i.e., contributing to possible underestimation or overestimation of cancer slope factors). However, the CSFs were developed to represent plausible upper-bound estimates, which means that the EPA is reasonably confident that the actual cancer risk will not exceed the estimated risk calculated using the CSF. The CSFs used in the HHRA were externally peer reviewed and supported by the panel of expert scientists and are the most current values recommended by the EPA in IRIS.

Noncancer toxicity values also have uncertainty. The current oral RfDs for Aroclor 1016 and 1254, which were used in the HHRA, have uncertainty factors of 100 and 300, respectively, in order to provide for protection of public health. The RfD for Aroclor 1016 was also subjected to peer review and was supported by a panel of scientists. The RfD for Aroclor 1254 was developed using the same methodology as Aroclor 1016 and was also subject to peer review. Since these RfDs were developed, a number of recent national and international studies have reported possible associations between developmental and neurotoxic effects in children from prenatal or postnatal exposures to PCBs. In light of these new studies, the current RfDs are now being evaluated as part of the IRIS process.

PCB Body Burden

The fact that any previous exposures (either background or past consumption of PCB-contaminated fish) may still be reflected in an individual's body burden today is an additional source of uncertainty and may result in an underestimate of noncancer hazard indices and cancer risks.

PCB Bioaccumulation Modeling

A bioaccumulation model was used in the HHRA calculations to generate estimations of future concentrations of PCBs in fish if no action occurs. The Agencies minimized this uncertainty to the extent possible by developing a bioaccumulation model specifically for the River and the Bay (i.e., FRFood and GBFood, respectively), calibrating the model to the extensive database for the River and the Bay. Additionally the model was revised based on a peer review sponsored by the FRG. Based on the model calibration (i.e., the ability of the fish bioaccumulation model to capture the historical observed lipid-normalized PCB measurements in fish), and the feedback received from the peer review, the model uncertainty is not sufficient to change the overall conclusion of the HHRA that cancer risks and noncancer hazard indices due to ingestion of fish are above acceptable levels.

8.3 Ecological Risk Assessment

The Site provides habitat function for a variety of invertebrates, fish, birds, and mammals that inhabit or use this watershed for foraging, reproducing, rearing young, and other life cycle requirements. The Lower Fox River basin and Green Bay show considerable variation in their potential to provide and support different kinds of wildlife habitat and this variability affects the wildlife diversity and populations. The BLRA focuses primarily on aquatic or aquatic-dependent species. Aquatic habitats within the area are wetland (e.g., Lower Fox River and southern Green Bay), riverine (e.g., the River), and lacustrine (Green Bay).

The significant groups of wildlife found within these habitats include:

- Both pelagic and benthic aquatic invertebrate species form the primary prey in the food webs of the River and Bay. Species of oligochaetes and chironomids (e.g., worms and midges) are typically most abundant and are found throughout the River and Bay. Amphipods, crayfish, snails, and mussels are also present in the River and Bay. Zebra mussels, an exotic species, are present throughout the Bay and the River.

- Fish of the region include salmon/trout; game fish, including walleye, yellow perch, and northern pike; and pelagic and benthic non-game fish. A discussion of the significant fish species within the study area is presented later in this section.

- Birds of the region include raptors, gulls/terns, diving birds, migratory waterfowl, passerines, shorebirds, and wading birds. A listing of the significant bird species within the study area is presented later in this section. These animals are found nesting, feeding, and living in both terrestrial and aquatic habitat environments.

- Mammals of the region include large and small game animals that generally live in open or wooded habitat, as well as fur-bearing animals that may forage or live within or near aquatic environments. The small and large game animals include rabbits, squirrels, and deer. The fur-bearing animals include beaver, red fox, mink, raccoon, muskrat, and otter. Additionally, bats feed on insects in the vicinity of Lake Winnebago and near the communities along the River as well as areas around the Bay. Few of the mammals will be discussed in detail within this document. Mink are the principal species discussed in the BLRA.

- Reptiles and amphibians, including snakes, turtles, frogs, and toads, are present in the region (Exponent, 1998). Typically, the frogs and turtles confine themselves to the wetland and nearshore areas while several snake species and toads are found in association with both terrestrial and aquatic habitats. Frogs and toads that dwell in wetlands or nearshore areas are fed upon by wading birds of the region.

Through the mid-1970s, the population levels of fish species, such as walleye and perch, were low within the River and southern Green Bay ecosystems. Contaminants, along with low levels of dissolved oxygen (DO) conditions brought about by uncontrolled and untreated wastewater discharged into the River, were believed to be contributing factors causing low population levels. Principal species found within the system were those that could tolerate these conditions, especially bullhead and carp.

With the institution of water quality controls in the mid-1970s, contaminants and DO conditions improved. The WDNR undertook a program to reintroduce walleye into the River and Bay through a stocking program beginning in 1973. That program was very successful; self-sustaining populations of walleye now exist within the River and Bay. Recent electrofishing catch data for walleye from the De Pere dam to the mouth of the River are shown on Figure 2-15 of the BLRA.

In addition to walleye, a number of other species were reestablished in the River and the Bay, including white and yellow perch, alewife, shad, bass, and other species. Historical anecdotal data from the Oneida Tribe and more recent creel survey data from the WDNR indicate that Duck Creek and Suamico tributaries to southern Green Bay were used by numerous fish species (Nelson, 1998).

The WDNR has completed extensive fish surveys in the River and inner Green Bay. However, due to the numerous factors that may affect fish populations, reliable conclusions simply cannot be made based on reviewing and comparing the population survey results from various years. Year-to-year fish populations do not necessarily indicate whether conditions within the River/Bay are degraded or improving, because other environmental, physical, or biological factors may be impacting select fish species at any given time. Selected fish surveys for the River have been reviewed to provide data on the types of fish present within the system at given points in time. However, no in-depth analysis of whether these population surveys indicate declining or improving conditions is included in this discussion, nor are Bay fish surveys included. Rather, personal observations from WDNR and Michigan Department of Natural Resources personnel familiar with both the commercial and sport fisheries of the Bay are used.

8.3.1 Screening Level Risk Assessment

The SLRA for the River and Bay focused on the potential for ecological risks associated with chemicals in sediments, surface waters, and biota. The SLRA was conducted using conservative exposure and effects scenarios in an effort to identify which of the more than 300 contaminants previously identified potentially posed risks to ecological receptors. Data from 16 separate comprehensive studies conducted on the River and Bay by state, federal, university, and private parties were used to assess risk. The objective of the screening was to identify a smaller list of contaminants that would be carried through to the baseline risk assessment.

As defined in the Superfund Risk Assessment Guidance (EPA, 1997a), following the completion of the SLRA, a Scientific Management Decision Point (SMDP) was necessary to review the results of the SLRA. The technical team of risk managers and risk assessors, collectively referred to as the Biological Technical Assistance Group (BTAG), was assembled during the SLRA process to specifically address SMDPs and provide technical review.

The SMDP was formalized in a memorandum from the WDNR dated August 3, 1998 (BLRA, Appendix A). The memorandum identified and justified which chemicals should be carried forward into the BLRA, based on the potential for either human health or ecological risk. Of the 75 chemicals that were above screening level risk criteria, only those with the most potential for adverse risk were carried forward as BLRA COPCs.

The retained COPCs include PCBs (expressed as total and PCB coplanar congeners), dioxin and furan congeners, DDT and its metabolites DDE and DDD, dieldrin, arsenic, lead, and mercury. Sediment HQs were greatest for PCBs based on both human heath and ecological risk-based screening levels.

8.3.2 Baseline Ecological Risk Assessment

The overall ecological goals of the BLRA for the River and Bay were to:

- Examine how the COPCs carried forward from the SLRA (RETEC, 1998b) move from the sediment and water into ecological receptors within the River and Bay.
- Quantify the current (or baseline) ecological risk associated with the COPCs.
- Distinguish those COPCs that pose the greatest potential for risk to the environment and should be carried forward as COCs in the FS.
- Determine which exposure pathways lead to the greatest risks.
- Support the selection of a remedy that eliminates, reduces, and/or controls identified risks by calculating sediment quality thresholds (SQTs).

Consistent with Superfund policy and guidance, the BLRA assumes no actions (remediation) to control or mitigate hazardous substance releases. The following discussion summarizes the BLRA with respect to the four basic steps of the Superfund Ecological Risk Assessment process: (1) Problem Formulation, (2) Exposure Assessment, (3) Effects Assessment, and (4) Risk Characterization.

Problem Formulation

Chemicals of Concern

PCBs were carried forward in the BLRA as the primary COPC because SLRA-calculated sediment HQs ranged from 1,514 to 5,872, generally several orders of magnitude greater than HQs for other COPCs. Although 2,3,7,8-TCDD is the most toxic dioxin congener, all structurally related dioxin and furan congeners were evaluated for toxicity based on the toxicity equivalency method, further described in Section 6.3.2 of the BLRA. The dioxin and furan congeners evaluated are those that have been measured in Site media and those that have toxic equivalency factors (TEFs). The only PCB congeners that were evaluated for dioxin-like toxicity are those that most structurally resemble dioxin and have the greatest potential for bioaccumulation: congeners 77, 81, 105, 118, 126, and 169, as further discussed in Section 6.3.3 of the BLRA.

The FRDB currently contains more than 580,000 records representing contaminant data from sediment, water, and tissue. Total PCBs are the most frequently found analyte in the database. The cut-off date for inclusion of data for the evaluation of risk was set at 1989 for several reasons: (1) the contribution of these data toward assessing risk was considered to be less advantageous than the greater accuracy obtained by evaluating risk based on more current data; (2) no data collected prior to 1989 were validated; and (3) although data collected in 1989 were not validated, the total number of samples collected in that year is more than 30 percent of all samples collected.

Complete Exposure Pathways

The BLRA determined that the principal source for COPCs is currently the contaminated sediment deposits found throughout the system. The principal transport mechanism is sediment resuspension, with transport occurring by downstream currents in the River and by discrete resuspension transport and deposition events within the Bay (WDNR, 1998b, 1998c). The fate of these contaminants, following their release into the water column, depends on the chemical properties of the contaminant, abiotic factors within the receiving environment (e.g., organic carbon in sediments, pH, surface water hardness), and interaction with the biotic environment. This interaction can result in degradation, transformation, or bioconcentration of the contaminant. The fate of a contaminant is not fixed, and the degree of contaminant exchange between surface water, sediment, sediment pore water, and biota varies.

Aquatic organisms can be exposed to COPCs through the water column, through ingesting sediments, and through consumption of contaminated prey. Water column organisms are exposed to dissolved and particulate-based COPCs through respiration, ingestion, and direct contact. Benthic invertebrates are exposed through direct contact and ingestion of contaminated sediments. Benthic fish, carnivorous birds, and carnivorous mammals can incidentally ingest sediments during feeding on prey species. All of the COPCs have the potential to biomagnify up the food chain (i.e., increase in tissue concentrations as contaminants go up the food chain through two or more trophic levels) except for lead and arsenic, which can bioconcentrate. Therefore, benthic invertebrates, fish, birds, and mammals are all exposed to COPCs by consuming contaminated food.

PCBs in the environment are stable and persistent; cycling rather than degradation represents the predominant fate. PCBs are highly lipophilic and, therefore, more readily bind to sediments or accumulate in tissues rather than remain in the water column. For invertebrates, both aquatic and benthic, exposure to PCBs through contact with the water column or pore water contributes significantly to the total PCB body burden. For most species, however, particularly those in the upper trophic levels, prey consumption is likely the primary route of exposure. Biological uptake of PCBs by aquatic organisms appears to be species-specific. Rates of accumulation vary depending on species, age, sex, and size. Generally, when equally exposed, fish accumulate two to three times more PCBs than do aquatic invertebrates.

Bioaccumulation of non-polar organic compounds occurs as a result of uptake by a receptor, followed by partitioning of the compounds into the receptor's organic carbon compartment – the lipids. Once chemicals are accumulated within an organism's lipid fraction, biomagnification may occur when organisms at lower trophic levels are preyed upon by receptors higher in the food chain. The net result is an aggregate increase in tissue body burdens of the chemicals at higher trophic levels.

Animals and plants living in or near the River and Bay, such as invertebrates, fish, amphibians, and water-dependent reptiles, birds, and mammals, are or can be exposed to PCBs directly and/or indirectly through the food chain. Ecological exposure to PCBs is primarily an issue of bioaccumulation through the food chain rather than direct toxicity, because PCBs bioaccumulate in the environment by bioconcentrating (i.e., being absorbed from water and accumulated in tissue to levels greater than those found in surrounding water) and biomagnifying. As a result, the ecological risk assessment emphasizes indirect exposure at various levels of the food chain to address PCB-related risks at higher trophic levels. The ecological conceptual site models used for this portion of the River and the Bay are provided on Figures 6-2 to 6-4.

Assessment Endpoints

Appropriate selection and definition of assessment endpoints, which focus the risk assessment design and analysis, are critical to the utility of the risk assessment. It is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at the Site. Assessment endpoints were selected based on being representative components of the ecosystem that could be adversely affected by the contaminants present. Eight assessment endpoints were developed to evaluate the risk of contaminants in the River and Bay. These include:

- The functioning of water column and benthic invertebrate populations
- Benthic and pelagic fish survival and reproduction
- Insectivorous, piscivorous, and carnivorous bird survival and reproduction
- Piscivorous mammal survival and reproduction

By evaluating and protecting these assessment endpoints, it is assumed that this ecosystem as a whole would also be protected.

Conceptual Site Model

The ecological conceptual site model identifies where contaminant interactions with biota can occur, describes the uptake of Site contaminants into the biological system (in this case, the water and sediments of the River and Bay), and diagrams key receptor contaminant exposure pathways. Due to the large area being assessed for risk, more than one conceptual site model was necessary. The River, from the mouth of Lake Winnebago to the De Pere dam, was evaluated using the same conceptual site model (Figure 6-2). This includes OU 3. Figure 6-3 represents the conceptual site model for OU 4 (De Pere to Green Bay) and OU 5 – Zone 2 of Green Bay, while Figure 6-4 represents the conceptual site model for the rest of OU 5 (Green Bay zones 3A, 3B, and 4).

It should be noted that Figures 6-2 and 6-3 are not able to adequately show periphyton as part of the ecological conceptual site model. This is an organic, green to brown layer that colonizes hard surfaces (e.g., twigs, rocks) in a body of water. Some researchers believe that this is the organic layer that hydrophobic compounds (e.g., PCBs) would likely adhere to and would be a food source (and contaminant source) for many benthic organisms.

Measurement Endpoints

Risk questions are assessed using measurement endpoints. Types of measurement endpoints used in the risk assessment process fall generally into four categories: (1) comparison of estimated or measured exposure levels of COPCs to levels known to cause adverse effects, (2) bioassay testing of site and reference media, (3) *in-situ* toxicity testing of Site and reference media, and (4) comparison of observed effects on site with those observed at a reference site. Measurement endpoints selected for assessment endpoint evaluation in this risk assessment consistently fell into the first category of measurement endpoints and are presented in Table 6-2 of the BLRA. Only existing data were evaluated as part of this assessment. As such, the measurement endpoints were fashioned around the existing data. Where the data did not already exist to fulfill the measurement endpoint, it was modeled based on the existing data.

Exposure Assessment

The exposure assessment includes a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure parameters; and measurement or estimation of exposure point concentrations. Complete exposure pathways and exposure parameters (e.g., body weight, prey ingestion rate, home range) used to calculate the concentrations or dietary doses to which the receptors of concern may be exposed were obtained from EPA references, from the scientific literature, and directly from researchers. In the FRDB, data were generally lacking for piscivorous and carnivorous birds, and no data were available for piscivorous mammals; therefore, ecological modeling was used to estimate COPC exposure to these receptors.

Description of Groups of Key Species

Invertebrate communities constitute a vast portion of the basis of the food chain in aquatic ecosystems. Since invertebrates process organic material and are prey items for other invertebrates, fish, and birds, they are important in nutrient and energy transfer in an aquatic ecosystem. Alterations in invertebrate functions may consequently affect nutrient and energy transfer and bird and fish populations. In addition, COPCs in invertebrates may be passed along through the food chain. Therefore, upper trophic levels can be affected not only by reduced prey abundance, but also by trophic transfer of accumulated contaminants in invertebrate prey. Examples of important benthic invertebrates in the River system include chironomids (e.g., midges) and oligochaetes (e.g., segmented worms).

Fish have many roles in the aquatic ecosystem, including the transfer of nutrients and energy, and are prey for mammals, birds, and predatory fish. In fact, several predators rely solely or primarily on fish for survival. Fish typically constitute a large proportion of the biomass in aquatic systems. Additionally, fish have social and economic value; impaired fish communities would adversely affect commercial and recreational fishing. Benthic fish are those fish that live in contact with and forage for food directly in the sediments. As such, they represent a unique exposure pathway because of their foraging behavior (i.e., high exposure to sediments) and prey items (i.e., predominately benthic invertebrates). Examples of benthic fish in the River include carp, catfish, and bullhead. Pelagial fish are those species that live and feed principally in the water column (as opposed to being in direct contact with sediment). Pelagial fish represent many trophic levels, with prey items predominately in the water column (e.g., zooplankton and other fish). Examples of important pelagial fish in the River include shiners, shad, alewife, perch, and walleye. Pelagial fish important to Green Bay include the same species as are found in the River, in addition to lake trout and other salmonids in the upper Bay.

Bird populations, in general, present one of the most significant biological components of the River/Bay system and occupy several trophic levels. Given the potential for some contaminants to biomagnify, birds, as upper trophic level receptors, may concentrate and be affected by contaminants in their tissues to a greater degree than lower trophic level species. In addition to their ecological importance, birds are socially valued because of recreational activities and aesthetics. Insectivorous birds rely predominately on insects (e.g., benthic invertebrates) for food. Examples of insectivorous birds in the River and Bay region include swallows and blackbirds. Piscivorous birds rely primarily on fish for food. Of the bird populations present at the Site, piscivorous birds represent a high trophic level and, therefore, are more at risk than insectivores from contaminants transferred through the food chain. Examples of piscivorous birds on the River and Bay include cormorants and terns. Carnivorous birds were selected for evaluation because of their diverse forage, which can include consumption of fish, piscivorous birds, or even small mammals. Examples of carnivorous birds on the River and Bay include eagles, osprey, and other raptors.

Piscivorous mammals represent the upper trophic level of the riverine corridor ecosystem and, therefore, are potentially highly exposed to contaminants that bioaccumulate or biomagnify. Piscivorous mammals rely primarily on fish as food, but may also consume amphibians, invertebrates, crayfish, clams, and mussels. The foraging behavior of these mammals represents a pathway through which energy is transferred from the aquatic to the terrestrial ecosystem. Mink are piscivorous mammals found in the River and Bay area.

A number of different animals have been or are currently on the Wisconsin, Michigan, or federal endangered and threatened species lists. Listed animals that have historically been found in the vicinity of the River or the Bay include osprey, common tern, Forster's tern, Caspian tern, and great egret (Matteson et al., 1998). The osprey, common tern, and Forster's tern have nested along the River as well as at upstream locations in Lake Winnebago, Little Lake Butte des Morts, and Lake Poygan. Osprey have been sighted near Kaukauna and have attempted to nest in the vicinity of Combined Locks, while terns have been observed farther upstream. Additionally, Caspian tern and great egret have nested on some of the islands located in the Bay. Very few nesting pairs have been observed over the past few years and recovery of these populations is slow (Matteson et al., 1998).

In addition to these birds, the WDNR reported a bed of clams or mussels, which may be threatened. The sediment bed, which these clams/mussels inhabit, is approximately 6 meters (20 feet) wide and 30.5 meters (100 feet) long and is located near the mouth of Mud Creek in the River (Szymanski, 1998, 2000).

As mentioned above, populations of both eagles and the double-crested cormorants have recovered to the point where both birds have been removed from the Wisconsin endangered species list. Other populations, specifically wild mink and otter, have been found to be declining around the River and the Bay, yet they are not currently listed by state or federal agencies as threatened or endangered. The endangered and threatened fish and birds of the region are listed in Tables 2-11 and 2-12 of the BLRA. The endangered and threatened mammals of the region are listed in Table 2-14 of the BLRA.

Derivation of Exposure Point Concentrations

All COPCs show the exposure point concentrations for chemicals where risk was indicated (see Tables 8-17 to 8-21). For calculation of exposure values, one-half of the sample quantitation limit was used for undetected values (EPA, 1991b). The 95 percent upper confidence limit (UCL) of the mean is the value that a mean, calculated repeatedly from subsamples of the data population, will not exceed 95 percent of the time. Therefore, there is a 95 percent probability that the true mean of the population does not exceed the 95 percent UCL. The 95 percent UCL was calculated from the sample values depending on whether the data were normally, log-normally, or not normally distributed. When the data distribution fit neither a normal nor log-normal distribution pattern, the 95 percent UCL selected was the greater of the two calculated 95 percent UCLs (normal and log-normal). In cases where data were limited or the variability in the data was high, the calculated 95 percent UCL can exceed the maximum detected concentration. The RME is defined as the lesser of the calculated 95 percent UCL or the maximum detected value.

As an estimate of risk, both the arithmetic mean concentration and the RME concentration are used as exposure point concentrations. The RME is an estimate of the highest average exposure expected to occur at a site. The intent of the RME is to provide an estimate of exposure that is above average, yet still within the range of most exposures. The RME thus provides a degree of protectiveness that encompasses the individual receptors that have a higher likelihood of exposure.

Tissue residue values were available for some of the bird assessment endpoint species. These data included measurements of PCBs in whole body, brain, and eggs. Where tissue data were available, exposure point concentrations were determined. In addition to the exposure point concentration, minimum and maximum exposures are presented along with frequency of detection information. In addition, exposure point concentrations were also determined, where appropriate, based on food chain exposure (water, sediment, and prey ingestion). Since the food chain exposure includes ingestion of a variety of food items, it is not possible to present the minimum and maximum concentrations nor the frequency of detection for each of the items ingested; therefore, these values are indicated as being not applicable in Table 8-20. Since exposure point concentrations for piscivorous mammals are also based solely on food chain exposure, it is also not possible to present the minimum or maximum values (Table 8-21).

Table 8-17 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Water Column Invertebrates

Scenario Time Frame:	Current					
Medium:	Water					
Exposure Medium:	Surface water					
Exposure Point	**Chemical of Concern**	**Concentration Detected (ng/L)**		**Frequency of Detection**	**Exposure Point Concentration (ng/L)**	**Statistical Measure and Source Table from BLRA**
		Min	**Max**			
Operable Unit 3						
Surface Water	Mercury (filtered)	1,260	2,520	2/3	2,520	Max, Table 6-28
	Mercury (unfiltered)	4,490	7,120	2/3	7,120	Max, Table 6-28
Operable Unit 4						
Surface Water	Total PCBs (particulate)	1.4	149	129/143	54.7	95% UCL, Table 6-35
					44.2	Mean, Table 6-35
Operable Unit 5, Zone 2						
Surface Water	Mercury (filtered)	1,150	2,330	2/10	2,300	Max, Table 6-41
	Mercury (unfiltered)	1,520	5,000	2/11	5,000	Max, Table 6-41

Table 8-18 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Benthic Invertebrates

Scenario Time Frame:	Current					
Medium:	Sediment					
Exposure Medium:	Sediment					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure and Source Table from BLRA**
		Min	**Max**			
Operable Unit 3						
Sediment	Lead (mg/kg)	6.2	1,400	20/20	274	95% UCL Table 6-29
					159	Mean, Table 6-29
	Mercury (mg/kg)	0.01	9.8	74/74	4.0	95% UCL, Table 6-29
					3.5	Mean, Table 6-29
	2,3,7,8-TCDD (µg/kg)	3.7E-03	6.8E-03	2/2	6.8E-03	Max, Table 6-29
					5.3E-03	Mean, Table 6-29
	Total PCBs (µg/kg)	37	40,430	203/209	10,543	95% UCL, Table 6-29
	Total PCBs (µg/kg)	0	40,429	37,490/37,490	2,088	95% UCL, Table 6-29
					2,054	Mean, Table 6-29
	Total PCBs (µg/kg)	37.1	40,429	37,060/37,060	2,112	95% UCL, Table 6-29
					2,078	Mean, Table 6-29
	DDE (µg/kg)	6.6	22	4/19	22	Max, Table 6-29
					12.5	Mean, Table 6-29
	DDT (µg/kg)	5.1	20	3/14	20	Max, Table 6-29
					16.5	Mean, Table 6-29
Operable Unit 4						
Sediment	Arsenic (mg/kg)	0.8	386	66/92	16.9	95% UCL, Table 6-36
					10.1	Mean, Table 6-36
	Lead (mg/kg)	4.4	350	92/92	91.2	95% UCL, Table 6-36
					75.7	Mean, Table 6-36
	Mercury (mg/kg)	0.1	7.7	89/92	1.4	95% UCL, Table 6-36
					1.0	Mean, Table 6-36
	Total PCBs (µg/kg)	19.9	99,000	285/290	5,510	95% UCL, Table 6-36
					4,184	Mean, Table 6-36
	DDD (mg/kg)	1.2	4.5	3/22	4.5	Max, Table 6-36
	DDE (mg/kg)	1.9	1.9	1/22	1.9	Max, Table 6-36

Table 8-18 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Benthic Invertebrates (Cont.)

Scenario Time Frame:	Current					
Medium:	Sediment					
Exposure Medium:	Sediment					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure and Source Table from BLRA**
		Min	**Max**			
Operable Unit 5 (Zones 2 through 4)						
Green Bay Zone 2						
Sediment	Mercury (mg/kg)	0.1	1.5	9/11	1.5	Max, Table 6-42
					0.5	Mean, Table 6-42
	Total PCBs (µg/kg)	26.0	799	14/15	720	95% UCL, Table 6-42
					251	Mean, Table 6-42
Green Bay Zone 3A						
Sediment	Total PCBs (µg/kg)	6.0	993	13/15	518	95% UCL, Table 6-54
					376	Mean, Table 6-54
Green Bay Zone 3B						
Sediment	Arsenic (mg/kg)	3.6	15.0	4/4	14.1	95% UCL, Table 6-62
					8.6	Mean, Table 6-62
	Lead (mg/kg)	9.6	50.0	4/4	49.4	95% UCL, Table 6-62
					29.9	Mean, Table 6-62
	Mercury (mg/kg)	0.2	0.2	1/4	0.2	Max, Table 6-62
	Total PCBs (µg/kg)	50.0	1,056	35/40	809	95% UCL, Table 6-62
					542	Mean, Table 6-62
Green Bay Zone 4						
Sediment	Total PCBs (mg/kg)	10.0	264	27/31	117	95% UCL, Table 6-71
					82.9	Mean, Table 6-71

Table 8-19 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Fish

Scenario Time Frame:	Current					
Medium:	Fish					
Exposure Medium:	Fish					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure and Source Table from BLRA**
		Min	**Max**			
Operable Unit 3						
Whole Fish Tissue						
Carp	Mercury (mg/kg)	0.15	0.15	1/1	0.15	Max, Table 6-31
Walleye	Mercury (mg/kg)	0.16	0.16	1/1	0.16	Max, Table 6-31
Gizzard Shad	Total PCBs (µg/kg)	310	370	3/3	370	Max, Table 6-31
					347	Mean, Table 6-31
Golden Shiner	Total PCBs (µg/kg)	1,003	1,036	2/2	1,036	95% UCL, Table 6-31
					1,020	Mean, Table 6-31
Yellow Perch	Total PCBs (µg/kg)	627	627	1/1	627	Max, Table 6-31
Carp	Total PCBs (µg/kg)	604	6,000	20/20	5,800	95% UCL, Table 6-31
					3,919	Mean, Table 6-31
Walleye	Total PCBs (µg/kg)	1,490	4,587	4/4	4,587	Max, Table 6-31
					3,179	Mean, Table 6-31
Operable Unit 4 and Green Bay Zone 2						
Whole Fish Tissue						
Alewife	Mercury (mg/kg)	0.10	0.25	2/5	0.25	Max, Table 6-44
					0.10	Mean, Table 6-44
Rainbow Smelt		0.02	0.04	4/4	0.04	Max, Table 6-44
					0.03	Mean, Table 6-44
Carp		0.12	0.12	1/1	0.12	Max, Table 6-44
Walleye		0.11	0.39	10/11	0.27	95% UCL, Table 6-44
					0.21	Mean, Table 6-44
Alewife	Total PCBs (µg/kg)	990	19,000	51/51	3,182	95% UCL, Table 6-44
					2,599	Mean, Table 6-44
Gizzard Shad		700	4,100	50/50	2,005	95% UCL, Table 6-44
					1,852	Mean, Table 6-44
Rainbow Smelt		280	1,600	33/33	1,152	95% UCL, Table 6-44
					1,049	Mean, Table 6-44

Table 8-19 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Fish (Cont.)

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Fish Fish					
Exposure Point	**Chemical of Concern**	**Concentration Detected Min**	**Concentration Detected Max**	**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure and Source Table from BLRA**
Common Shiner		3,100	4,000	5/5	3,846	95% UCL, Table 6-44
					3,520	Mean, Table 6-44
Emerald Shiner		3,100	4,000	5/5	3,846	95% UCL, Table 6-44
					3,520	Mean, Table 6-44
Golden Shiner		1,326	1,443	2/2	1,443	Max, Table 6-44
Yellow Perch		614	2,151	9/9	1,567	95% UCL, Table 6-44
					1,206	Mean, Table 6-44
Carp		202	22,500	115/115	7,369	95% UCL, Table 6-44
					6,637	Mean, Table 6-44
Walleye		387	19,000	91/91	7,658	95% UCL, Table 6-44
					6,539	Mean, Table 6-44
Carp	DDE (µg/kg)	15	88	3/4	88	Max, Table 6-44
Walleye		64	120	3/3	120	Max, Table 6-44
Operable Unit 5 – Green Bay						
Green Bay Zone 3A						
Whole Fish Tissue						
Alewife	Total PCBs (µg/kg)	280	2,700	18/18	1,271	95% UCL, Table 6-56
					907	Mean, Table 6-56
Gizzard Shad		3,524	3,524	1/1	3,524	Max, Table 6-56
Rainbow Smelt		210	1,300	31/32	735	95% UCL, Table 6-56
					570	Mean, Table 6-56
Walleye		980	7,500	14/14	5,064	95% UCL, Table 6-56
					4,155	Mean, Table 6-56
Brown Trout		1,800	4,400	14/14	3,612	95% UCL, Table 6-56
					3,250	Mean, Table 6-56
Green Bay Zone 3B						
Whole Fish Tissue						
Walleye	Mercury (mg/kg)	0.65	0.65	1/3	0.65	Max, Table 6-64
Alewife	Total PCBs (µg/kg)	536	2,800	8/8	2,375	95% UCL, Table 6-64
					1,821	Mean, Table 6-64

Table 8-19 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Fish (Cont.)

Scenario Time Frame: / Medium: / Exposure Medium:	Current / Fish / Fish					
Exposure Point	**Chemical of Concern**	**Concentration Detected Min**	**Concentration Detected Max**	**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure and Source Table from BLRA**
Gizzard Shad		635	635	1/1	635	Max, Table 6-64
Rainbow Smelt		250	1,500	20/20	861	95% UCL, Table 6-64
					733	Mean, Table 6-64
Walleye		212	20,031	26/26	11,741	95% UCL, Table 6-64
					6,429	Mean, Table 6-64
Brown Trout		75	6,700	26/26	2,697	95% UCL, Table 6-64
					2,223	Mean, Table 6-64
Alewife	DDE (µg/kg)	80	80	1/1	80	Max, Table 6-64
Gizzard Shad		37	37	1/1	37	Max, Table 6-64
Walleye		64	540	2/3	540	Max, Table 6-64
Green Bay Zone 4						
Whole Fish Tissue						
Alewife	Total PCBs (µg/kg)	110	2,000	8/8	1,488	95% UCL, Table 6-73
					1,036	Mean, Table 6-73
Rainbow Smelt		150	1,600	18/18	764	95% UCL, Table 6-73
					526	Mean, Table 6-73
Walleye		620	9,620	36/36	3,294	95% UCL, Table 6-73
					2,546	Mean, Table 6-73
Brown Trout		1,456	3,900	18/18	2,714	95% UCL, Table 6-73
					2,451	Mean, Table 6-73
Walleye	DDE (µg/kg)	235	1,168	20/20	593	95% UCL, Table 6-73
					479	Mean, Table 6-73

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Prey Items Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Operable Unit 3 (from Table 6-33 of the BLRA)						
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	12.7	Mean
					25.3	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	170	Mean
					181	RME
Forster's Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	11.7	Mean
					23.4	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	157	Mean
					167	RME
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	4.9	Mean
					9.8	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	65.6	Mean
					70.0	RME
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	17.4	Mean
					17.5	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	427	Mean
					630	RME
Operable Unit 4 (from Tables 6-38 and 6-39 of the BLRA)						
Tree Swallow	Total PCBs (µg/kg)	510	17,000	22/22	4,505	RME
					3,118	Mean
	DDE (µg/kg)	28	520	22/22	331	RME
					218	Mean
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	49	Mean
					123	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,274	Mean
					1,559	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	10.3	Mean
					28.4	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	51.1	Mean
					70.0	RME

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Prey Items Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Forster's Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	45.2	Mean
					113	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,175	Mean
					1,438	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	9.5	Mean
					26.2	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	47.1	Mean
					64.6	RME
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	18.9	Mean
					47.3	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	492	Mean
					602	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	4.0	Mean
					11.0	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	19.7	Mean
					27.0	RME
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	10.2	Mean
					12.5	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	750	Mean
					842	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	2.7	Mean
					3.8	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	25.8	Mean
					74.0	RME
Operable Unit 5 – Green Bay						
Green Bay Zone 2 (from Tables 6-46 and 6-47 of the BLRA)						
Double-Crested Cormorant Brain	Total PCBs (µg/kg)	1,900	6,000	5/5	5,307	95% UCL
					3,700	Mean
Double-Crested Cormorant Egg		610	74,000	34/34	21,127	95% UCL
					13,944	Mean

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Prey Items Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Double-Crested Cormorant Whole Body		324	63,000	74/74	13,870	95% UCL
					11,026	Mean
Common Tern Egg		2,266	9,011	10/10	5,963	95% UCL
					4,819	Mean
Forster's Tern Egg		1,478	8,092	10/10	6,234	95% UCL
					5,077	Mean
Tree Swallow Whole Body		1,200	4,500	15/15	3,495	95% UCL
					2,980	Mean
Double-Crested Cormorant Brain	Dieldrin (µg/kg)	30	64	5/5	60.5	95% UCL
					48.2	Mean
Double-Crested Cormorant Egg		39	1,300	32/34	445	95% UCL
					224	Mean
Double-Crested Cormorant Whole Body		36	1,300	73/73	243	95% UCL
					196	Mean
Common Tern Egg		29.8	155	5/5	139	95% UCL
					85.0	Mean
Forster's Tern Egg		26.5	84.9	7/7	62.7	95% UCL
					47.6	Mean
Double-Crested Cormorant Brain	DDE (µg/kg)	410	670	5/5	643	95% UCL
					534	Mean
Double-Crested Cormorant Egg		170	11,000	34/34	7,277	95% UCL
					4,132	Mean
Double-Crested Cormorant Whole Body		380	11,000	73/73	3,523	95% UCL
					2,756	Mean
Common Tern Egg		421	942	5/5	893	95% UCL
					666	Mean
Forster's Tern Egg		206	735	7/7	576	95% UCL
					447	Mean

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Prey Items Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	49.1	Mean
					123	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,274	Mean
					1,559	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	10.3	Mean
					28.4	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	51.1	Mean
					70.0	RME
Forster’s Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	45.3	Mean
					114	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,174	Mean
					1,438	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	9.5	Mean
					26.2	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	47.1	Mean
					64.6	RME
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	19.0	Mean
					47.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	492	Mean
					602	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	4.0	Mean
					11.0	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	19.7	Mean
					27.0	RME

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame:	Current					
Medium:	Prey Items					
Exposure Medium:	Prey Items					
Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection	Exposure Point Concentration	Statistical Measure
		Min	Max			
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	10.2	Mean
					12.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	750	Mean
					842	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	2.7	Mean
					3.8	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	25.8	Mean
					74.0	RME
Green Bay Zone 3A (from Tables 6-58 and 6-59 of the BLRA)						
Bald Eagle Egg	Mercury (mg/kg)	0.3	0.3	3/3	0.3	RME
					0.3	mean
	Total PCBs (µg/kg)	13,000	13,000	1/1	13,000	Max
	Dieldrin (µg/kg)	200	200	1/1	200	Max
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	14.7	Mean
					19.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	444	Mean
					623	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	10.5	Mean
					13.5	RME
Forster's Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	13.6	Mean
					18.1	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	410	Mean
					575	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	9.7	Mean
					12.4	RME
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	5.7	Mean
					7.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	172	Mean
					241	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	4.1	Mean
					5.2	RME

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame: **Medium:** **Exposure Medium:**	Current Prey Items Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	2.3	Mean
					4.5	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	334	Mean
					475	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	2.6	Mean
					6.3	RME
Green Bay Zone 3B (from Tables 6-66 and 6-67 of the BLRA)						
Double-Crested Cormorants Whole Body	Total PCBs (µg/kg)	246	15,000	20/21	15,000	Max
					5,384	mean
	DDE (µg/kg)	140	6,500	20/20	4,546	95% UCL
					2,010	Mean
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	12.3	Mean
					24.5	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	892	Mean
					1,164	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	9.3	Mean
					13.4	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	39.2	Mean
					39.2	RME
Forster's Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	11.3	Mean
					22.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	823	Mean
					1,073	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	8.6	Mean
					12.3	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	36.2	Mean
					36.2	RME

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame:	Current					
Medium:	Prey Items					
Exposure Medium:	Prey Items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	4.7	Mean
					9.5	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	345	Mean
					450	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	3.6	Mean
					5.2	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	15.1	Mean
					15.1	RME
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	15.6	Mean
					30.1	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	594	Mean
					823	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	5.1	Mean
					6.4	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	16.1	Mean
					34	RME
Green Bay Zone 4 (from Table 6-75 of the BLRA)						
Common Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	14.7	Mean
					14.7	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	508	Mean
					729	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	7.3	Mean
					7.6	RME
Forster's Tern Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	13.6	Mean
					13.6	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	468	Mean
					672	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	6.7	Mean
					7.0	RME

Table 8-20 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds (Cont.)

Scenario Time Frame:	Current					
Medium:	Prey Items					
Exposure Medium:	Prey Items					
Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection	Exposure Point Concentration	Statistical Measure
		Min	Max			
Double-Crested Cormorant Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	5.7	Mean
					5.7	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	196	Mean
					282	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	2.8	Mean
					3.0	RME
Bald Eagle Ingestion	Mercury (µg/kg-BW/day)	NA	NA	NA	20.2	Mean
					23.3	RME
	Total PCBs (µg/kg-BW/day)	NA	NA	NA	329	Mean
					489	RME
	DDE (µg/kg-BW/day)	NA	NA	NA	91.2	Mean
					119	RME

Notes:
BW – body weight
NA – not applicable
RME – reasonable maximum exposure
Since the food chain exposure includes ingestion of a variety of food items, it is not possible to present the minimum and maximum concentrations nor the frequency of detection for each of the items ingested; therefore, these values are indicated as being not applicable in Table 8-20.

Table 8-21 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Mammals

Scenario Time Frame	Current					
Medium:	Prey items					
Exposure Medium:	Prey items					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Operable Unit 3 (from Table 6-34 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	773	Mean
					1,162	RME
Operable Unit 4 (from Table 6-40 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,290	Mean
					1,437	RME
Operable Unit 5 (Zones 2 through 4)						
Green Bay Zone 2 (from Table 6-52 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	1,271	Mean
					1,413	RME
Green Bay Zone 3A (from Table 6-60 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	507	Mean
					763	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	3.4	Mean
					10.5	RME
Green Bay Zone 3B (from Table 6-69 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	949	Mean
					1,180	RME
	Dieldrin (µg/kg-BW/day)	NA	NA	NA	8.3	Mean
					10.5	RME
Green Bay Zone 4 (from Table 6-76 of the BLRA)						
Mammal Ingestion	Total PCBs (µg/kg-BW/day)	NA	NA	NA	573	Mean
					875	RME

Notes:
BW – body weight
NA – not applicable
RME – reasonable maximum exposure
Since exposure point concentrations for piscivorous mammals are based solely on food chain exposure, it is also not possible to present the minimum or maximum values in Table 8-21.

PCB-Specific Exposure Point Concentrations

Water

Filtered and particulate concentrations of PCBs were detected in all River reaches and Bay zones. These concentrations were summed to give estimated water concentrations of total PCBs. Estimated mean, 95 percent UCL, and maximum total PCB concentrations in water are presented on Figure 6-6 of the BLRA. Estimated mean total PCB concentrations were greatest in OU 4 (60.9 micrograms per liter [μg/L]) and represented an increase of 2.2 times over the estimated mean total PCB concentrations in Little Lake Butte des Morts (27.6 μg/L).

Sediment

Total PCBs were detected frequently in all River reaches and the Bay zones. Total PCBs were reported as both statistical representations of the data in the FRDB (i.e., mean, 95 percent UCL, and maximum concentrations) and as concentrations based upon the interpolated bed maps. In contrast to metals, PCB concentrations generally decreased moving down the River and into the Bay. The mean total PCB concentration ranged from 82.9 micrograms per kilogram (μg/kg) (Green Bay Zone 4) to 10,724 μg/kg (Little Lake Butte des Morts). Mean, 95 percent UCL, and maximum concentrations of PCBs are presented on Figure 6-8 of the BLRA.

Fish

Total PCBs were detected frequently in all River reaches and the Bay zones. The range of detection frequency was 85 to 100 percent. The mean total PCB concentration ranged from 79.8 μg/kg (yellow perch from Green Bay Zone 4) to 6,637 μg/kg (carp from Green Bay zones 1 and 2). Mean, 95 percent UCL, and maximum total PCB concentrations in yellow perch, carp, and walleye are presented on Figure 6-11 of the BLRA. Mean, 95 percent UCL, and maximum total PCB concentrations in forage fish species (gizzard shad, alewife, shiner species, and rainbow smelt) are presented on Figure 6-12 of the BLRA.

Birds

Where they were analyzed, total PCBs were detected at a frequency of 100 percent, except for Green Bay Zone 3B, where they were detected at a frequency of 95 percent. The mean total PCB concentration ranged from 2,135 μg/kg (whole tree swallow from Little Lake Butte des Morts) to 11,026 μg/kg (whole double-crested cormorants from Green Bay Zone 2). Measured total PCB concentrations in birds are presented on Figure 6-15 of the BLRA. As indicated by this figure, the area where the most bird species were sampled was Green Bay Zone 2. This area also contained the highest concentrations of total PCBs, found in double-crested cormorants.

Mammals

Little Rapids to De Pere (OU 3): The mean exposure concentration for total PCBs was estimated to be between 760 and 773 micrograms per kilogram of body weight per day (μg/kg-BW/day).

De Pere to Green Bay (OU 4): The mean exposure concentration for total PCBs was estimated to be between 1,284 and 1,290 μg/kg-BW/day.

Green Bay Zone 2: The mean exposure concentration for total PCBs was estimated to be between 1,271 and 1,275 μg/kg-BW/day.

Green Bay Zone 3A: The mean exposure concentration for total PCBs was estimated to be 507 μg/kg-BW/day.

Green Bay Zone 3B: The mean exposure concentration for total PCBs was estimated to be 949 µg/kg-BW/day.

Green Bay Zone 4: The mean exposure concentration for total PCBs was estimated to be 573 µg/kg-BW/day.

Summary of Field Studies

Within the River and Bay system, there have been numerous field studies on a variety of different species. Many of the species studied were also evaluated in the BLRA as receptor species that represented the assessment endpoints in the BLRA. While not specifically included in the risk characterization, the studies are presented in BLRA Section 6.5.4 to provide the risk managers with an integrated tool for decision-making.

Effects Assessment

Toxic effects of all COPCs were evaluated in the BLRA. Section 6.3 of the BLRA provides details of the effects of all the COPCs on the assessment endpoints. The discussion below focuses on effects of PCBs.

PCBs have been shown to cause lethal and sublethal reproductive, developmental, immunological, and biochemical effects. The BLRA limited its focus to adverse impacts on survival, growth, and reproduction. The ecological effects assessment includes literature reviews, field studies, and toxicity tests that correlate concentrations of PCBs to effects on ecological receptors. Toxic equivalency factors, based on the toxicity of dioxin, have been developed for the dioxin-like PCB congeners. The effects of PCBs on Great Lakes fish and wildlife have been extensively documented. PCB-induced reproductive impairment has been demonstrated for several fish species (Mac, 1988; Ankley et al., 1991; Walker and Peterson, 1991; Walker et al., 1991a, 1991b; Williams and Giesy, 1992), a number of insectivorous and piscivorous birds (Kubiak et al., 1989; Gilbertson et al., 1991; Tillitt et al., 1992), and mink (Aulerich et al., 1973, Aulerich and Ringer, 1977; Bleavins et al., 1980; Wren, 1991; Giesy et al., 1994c; Heaton et al., 1995a, 1995b; Tillitt et al., 1996).

Derivation of Toxicity Reference Values

In order to derive toxicity reference values (TRVs), a comprehensive literature search was performed for all COPCs. A variety of databases were searched for literature references containing toxicological information. Some of these literature sources included Biological Abstracts, Applied Ecology Abstracts, Chemical Abstract Services, Medline, Toxline, BIOSIS, ENVIROLINE, Current Contents, IRIS, the Aquatic Information Retrieval Database (AQUIRE) maintained by the EPA, and the Environmental Residue Effects Database (ERED) maintained by the EPA and USACE. The TRVs selected for this assessment were discussed with and agreed upon by BTAG members. Importantly, the consensus on the TRVs is for Site-specific use only; the TRVs are not intended to be used at other sites (Table 6-5 of the BLRA).

TRVs were used to estimate the potential for ecological risk at the Site. The selected TRVs were either Lowest Observed Adverse Effects Levels (LOAELs) and/or No Observed Adverse Effects Levels (NOAELs) from laboratory and/or field-based studies reported in the scientific literature. LOAELs are the lowest values at which adverse effects have been observed, and NOAELs are the highest values at which adverse effects were not observed.

The PCB and dioxin-like PCB congener TRVs for fish, birds, and mammals are based on effects on survival, growth, and reproduction of fish and wildlife species in the River. Reproductive effects (e.g., egg maturation, egg hatchability, and survival of juveniles) were generally the most sensitive endpoints for animals exposed to PCBs.

Risk Characterization

Hazard Quotient Calculations

Risk characterization for each assessment endpoint was based upon the calculated HQs and, as available, population or field study data. Hazard quotients calculated based on literature values provide one line of evidence for characterizing ecological effects. Field studies were evaluated, where appropriate, as a supplement to the risk evaluation, particularly when the contamination has a historical basis (EPA, 1994b, 1997a).

While HQs and other lines of evidence (i.e., field studies and other data types) cannot be quantitatively combined, each can inform risk managers on the presence of risk and how these risks may be reduced. Therefore, this risk characterization process did not result in the distillation of a single conclusive statement regarding overall risk to each assessment endpoint. Consideration of the magnitude of uncertainty, discussed in Section 6.6 of the BLRA, is also a key component of the risk interpretation process.

For this risk assessment, it was agreed by the BTAG that degree of risk would be determined based on three categories: “no” risk was concluded when both the No Observed Adverse Effects Concentration (NOAEC) and Lowest Observed Adverse Effects Concentration (LOAEC) HQs evaluated were less than 1.0; “potential” risk was concluded when the NOAEC HQ exceeded 1.0 but the LOAEC HQ was less than 1.0; and risk was concluded when both the NOAEC and LOAEC HQs evaluated were greater than 1.0. When constituents were analyzed but not detected, it was concluded that no risk existed.

OU 3 – Little Rapids to De Pere: The results suggest that measured or estimated concentrations of total PCBs are at sufficient levels to cause risk to benthic invertebrates and piscivorous mammals. Potential risks are indicated for benthic and pelagic fish and piscivorous and carnivorous birds. There are no data to evaluate insectivorous birds. Measured or estimated concentrations of mercury are found to be at sufficient concentrations to cause, or potentially cause, risk to aquatic invertebrates, benthic invertebrates, pelagic fish, piscivorous birds, and carnivorous birds. There are persistent risks to benthic infaunal communities in sediments from exposure to lead, mercury, 2,3,7,8-TCDD, total PCBs, p,p'-DDE, and p,p'-DDT. Concentrations of arsenic, dieldrin, all o,p'- isomers of DDT and its metabolites, and p,p'-DDD are not sufficient to pose risk to any assessment endpoint.

OU 4 – De Pere to Green Bay: The results taken in total suggest that measured or estimated concentrations of total PCBs are at sufficient levels to cause risk to benthic invertebrates and piscivorous mammals. Total PCBs are at sufficient levels to potentially cause risk to aquatic invertebrates and insectivorous birds. Concentrations of dieldrin, all o,p'- isomers of DDT and its metabolites, and p,p'-DDT are not sufficient to pose risk to any of the evaluated assessment endpoints. Risks to fish and birds are discussed in the Green Bay Zone 2 summary.

OU 5 – Green Bay Zone 2: The results taken in total suggest that measured or estimated concentrations of total PCBs are at sufficient levels to cause risks to benthic invertebrates, carnivorous birds, and piscivorous mammals. Potential risks are indicated for benthic and pelagial fish and piscivorous birds. Measured or estimated concentrations of mercury are at sufficient concentrations to cause or potentially cause risk to aquatic invertebrates, benthic invertebrates, pelagial fish, piscivorous birds, and carnivorous birds. Measured or estimated concentrations of DDE are at sufficient concentrations to cause or potentially cause risk to benthic fish, pelagic fish, insectivorous birds, piscivorous birds, and carnivorous birds.

OU 5 – Green Bay Zone 3A: The results taken in total suggest that concentrations of total PCBs are at sufficient levels to cause or potentially cause risk to benthic invertebrates, benthic fish, pelagic fish, piscivorous birds, carnivorous birds, and piscivorous mammals. There were no data to evaluate insectivorous birds. Mercury concentrations are potentially causing risk to piscivorous birds. Concentrations of dieldrin are a potential risk for carnivorous birds and piscivorous mammals. Concentrations of arsenic, lead, and all o,p'- and p,p'- isomers of DDT and its metabolites were not found to pose risk to any assessment endpoint.

OU 5 – Green Bay Zone 3B: The results taken in total suggest that measured or estimated concentrations of total PCBs are at sufficient levels to cause or potentially cause risk to benthic invertebrates, pelagial fish, piscivorous birds, carnivorous birds, and piscivorous mammals. There are no data to evaluate insectivorous birds. Mercury concentrations are causing or potentially causing risk to benthic invertebrates, pelagial fish, piscivorous birds, and carnivorous birds. DDE concentrations are causing or potentially causing risk to pelagial fish, piscivorous birds, and carnivorous birds. Dieldrin concentrations are potentially causing risk to piscivorous mammals. Arsenic and lead concentrations are only of risk to benthic invertebrates.

OU 5 – Green Bay Zone 4: These results taken in total suggest that concentrations of total PCBs are at sufficient levels to cause or potentially cause risk to benthic invertebrates, pelagial fish, piscivorous birds, carnivorous birds, and piscivorous mammals. Concentrations of DDE are causing or potentially causing risk to pelagial fish and carnivorous birds. Concentrations of mercury are causing or potentially causing risk to piscivorous and carnivorous birds.

Major Findings

A summary of the risk to each assessment endpoint in each reach and zone is presented in Table 6-134 of the BLRA. OUs 3, 4, and 5 are discussed below and summarized in Table 8-22.

The principal findings of the ecological risk assessment are:

- Total PCBs cause or potentially cause risk to all identified receptors. The exception is insectivorous birds, where the weight of evidence suggests that these receptors are not at risk from PCB concentrations. Not all receptors at risk or potentially at risk from PCBs are at risk in all River reaches or Bay zones.

- Mercury poses a risk in all River reaches and zones, but not to all receptors. Mercury was not identified as a risk for insectivorous birds or piscivorous mammals.

- DDT or its metabolites pose a risk to benthic invertebrates in OUs 3 and 4, benthic and pelagic fish in OUs 4 and 5, and piscivorous and carnivorous birds in OUs 4 and 5. DDT or its metabolites were not identified as a risk to water column invertebrates or to piscivorous mammals.

- Dieldrin poses a risk in either or both OUs 4 and 5 to piscivorous and carnivorous birds as well as piscivorous mammals.

- Arsenic and/or lead pose a risk to benthic invertebrates in OUs 3 and 4 and parts of OU 5. No other receptor is at risk from arsenic or lead.

Table 8-22 Ecological Risk Summary for OUs 3 through 5

OU	Water Column Invertebrates	Benthic Invertebrates	Benthic Fish	Pelagic Fish	Insectivorous Bird	Piscivorous Bird	Carnivorous Bird	Piscivorous Mammal
3	● mercury	● lead, mercury, 2,3,7,8-TCDD, PCBs, DDE, DDT	☼ mercury, PCBs	☼ mercury, PCBs	NA	☼ mercury PCBs	☼ mercury, PCBs	● PCBs
4	☼ PCBs	● arsenic, lead, mercury, PCBs, DDD, DDE	☼ PCBs, DDE	☼ mercury, PCBs, DDE	☼ PCBs	☼ mercury, PCBs, dieldrin, DDE	☼ PCBs, mercury, DDE	● PCBs
OU 5, Zone								
2	● mercury	● mercury, PCBs	☼ PCBs, DDE	☼ mercury, PCBs, DDE	☼ PCBs, DDE	☼ mercury, PCBs, dieldrin DDE	☼ PCBs, mercury, DDE	● PCBs
3A		● PCBs	☼ PCBs	☼ PCBs	NA	☼ mercury, PCBs	● ☼ PCBs, dieldrin	● ☼ PCBs, dieldrin
3B		● arsenic, lead, mercury, PCBs		● PCBs, ☼ mercury, DDE	NA	● PCBs, mercury ☼ dieldrin DDE	☼ PCBs, mercury, DDE	● ☼ PCBs, dieldrin
4		● PCBs	NA	☼ PCBs, DDE	NA	☼ mercury, PCBs	☼ PCBs, mercury, DDE	● PCBs

Notes:
NA – no data available
Risk conclusions based on HQs
= No Risk
● = Risk
☼ = Potential Risk
Risk conclusions based on weight of evidence
[yellow] = Site-specific receptor data suggest that there is no risk.
[cyan] = Because of the federal listing of the bald eagle as threatened, it is concluded that potential risk is actual risk.

Note: In the original table, the Insectivorous Bird symbol cells for OU 4 and OU 5 Zone 2 are shaded yellow; the Carnivorous Bird symbol cells for all rows are shaded cyan.

Uncertainty

The goal of this uncertainty analysis is to both qualitatively and, to the degree possible, quantitatively define the degree of confidence that exists with the estimations of effects from exposure to hazardous chemicals in toxic amounts. EPA's Superfund Ecological Risk Assessment Guidance (EPA, 1997a) and the Guidelines for Ecological Risk Assessment (EPA, 1998b) provide general instructions on what should be addressed in an uncertainty analysis.

Conceptual Site Model

Qualitatively, there is a high degree of certainty that factors such as fate and distribution, downstream transport, biological uptake, effects on field populations, and habitat and life histories of important fish, birds, and mammals within the River and Bay are well understood and adequately characterized in the conceptual site model. There remains, however, some uncertainty as to whether the receptors identified within the conceptual site model adequately represent the ecosystem and other species potentially at risk within the River. The selection of the important receptor species was made in consultation with biologists both within the WDNR and the USFWS. In addition, input on the receptor species was provided by biologists and resource managers within the EPA, NOAA, and the Oneida and Menominee Nations through the EPA BTAG process. However, despite this, there remain a class of organisms and a threatened species that were not addressed in the BLRA. Reptile and amphibian species were not evaluated for risk because there are no data within the FRDB to evaluate this receptor group, and there are no uptake models to estimate risk for frogs or other amphibians. For the fish species sturgeon, listed as a threatened species in Michigan (but not in Wisconsin), there are also too few data points within the FRDB to evaluate potential risks.

Data

The FRDB represents numerous separate data collection efforts with over 580,000 discrete data records of air, water, sediments, and tissue from throughout the River and Bay. A rigorous evaluation of the quality of the data was undertaken, and only data for which at least partial data validation (quality assurance) packages could be reviewed were placed into the FRDB. Of the studies between 1971 and 1991, only partial packages could be reviewed, and so those data were used as supporting evidence in the BLRA. Several studies were completed on the River in the 1990s. All studies conducted after 1992 have fully validated data packages. Given the temporal and spatial density of the data within the River, there are good reasons to assume that the overall quality of the data is high, and, therefore, the related degree of data uncertainty is low. There were no significant biases or gaps observed in the sediment, fish, or bird sample data.

Another data gap in the BLRA is that there are limited measurements of metals and the organochlorine pesticides in surface water. However, this data gap impacts only the ability to assess risks to pelagic invertebrate communities; the remaining assessment endpoints could be addressed through the other media (e.g., bird tissues) for which data were judged adequate. Finally, there are relatively too few data points on all PCB congeners for all media within the River and Bay to make conclusive assessments or predictions of risk. While the FRDB contains numerous congener-specific data points, until relatively recently all of the dioxin-like congeners have not been adequately assessed. For example, while PCB congener 169 has been detected in the fish and birds of the River and Bay, there have been too few measurements taken in sediment or water.

Temporal

A time trends analysis was undertaken specifically to address the question of losses or gains in PCB concentrations over time in sediment and fish (see *White Paper No. 1 – Time Trends Analysis*, December 2002). For sediment, a large fraction of analyses provided little information useful for projecting future trends because of the lack of statistical significance and the wide confidence limits observed. This is especially true for sediment below the top 4 inches; changes in the sediment PCB concentrations cannot be distinguished from zero or no change. Generally over time, however, PCB concentrations in the surface sediment (i.e., top 10 cm) have been steadily decreasing, but the rate of change in surface sediment is both reach- and deposit-specific. The change averages an annual decrease of 15 percent, but ranges from an increase of 17 percent to a decrease of 43 percent. Given these conditions, the sediment data used may over- or under-evaluate the risks, depending on how much older data were used in the point estimates or interpolated bed maps.

Like sediment PCB concentrations, fish tissue PCB concentrations showed a significant but slow rate of change throughout the River and Bay. In all of the reaches of the River and in Zone 2, there were steep declines in fish tissue PCB concentrations from the 1970s, but with significant breakpoints in declines beginning around 1980. After the breakpoint, depending on the fish species, the additional apparent declines were either not significantly different from zero or were relatively low (i.e., 5 to 7 percent annually) or in some cases showed statistically significant increase in PCB concentrations. For example, whole body carp showed a significant increase in 1995 in OU 4. Likewise, gizzard shad in Zone 2 show a non-significant increase of 6 percent per year into 1999. These data, taken collectively, suggest that since the breakpoint for tissue declines occurred in the early 1980s and the changes in fish tissue concentrations were not typically greater than 4 to 7 percent annually, aggregating fish tissue from 1989 does not likely result in any significant biasing of the risk estimations. At worst, the tissue point estimates might overestimate risks by 50 percent (i.e., average of 5 percent per year over 10 years), but given that at least some fish tissue concentrations increased, it is reasonable to suggest that some risks were underestimated by at least an equivalent amount.

<u>Spatial Variability</u>

Uncertainty in the spatial variability refers principally to where sediment samples were collected from within the River and Bay. Within the River, most sampling efforts are concentrated in areas where there were thick sediment deposits (e.g., A, POG, N, GG/HH, and the SMUs below De Pere). There were no systematic sampling efforts to define PCB concentrations throughout the River. Within the Bay, systematic grid sampling was employed, but the spatial uncertainty is higher because of the large distance between sampling points. Sediment concentrations used in the risk assessment were based on both non-interpolated and interpolated concentration estimation methods so that the differences in risk estimates could be compared. The calculations demonstrate that, in general, using the interpolated sediment data yields a lower estimation of sediment-based risk than using the non-interpolated data.

<u>Toxic Exposure</u>

Point estimates of exposure concentrations were compared in the BLRA to point estimates of toxicity in the literature to yield the hazard quotients. While the rationale used to select the most representative value from the literature was presented in Section 6.3 of the BLRA, there remain uncertainties associated with effects concentrations above or below the selected TRV, the selection of TRVs from one species and application to another, interpretation between NOAECs and LOAECs based on application of uncertainty factors, or application of different sets of toxicity equivalent factors from the literature. For PCBs, risk estimation uncertainty was reduced by determining risk potential on a total PCB basis and a PCB congener basis for receptors where both exposure and effects data were available (i.e., fish and birds).

<u>Alternative Exposure Points</u>

The principal exposure point concentration used for risk evaluation in the BLRA was the RME (i.e., the lower of either the 95 percent UCL or the maximum concentration) for all media and receptors evaluated. In order to determine the degree to which risk may have been under- or overestimated, 90th percentile concentrations were estimated and evaluated for risk for two representative species: walleye and double-crested cormorants.

For walleye, results of this comparison indicated that risk evaluation of the 90th percentile concentrations would result in only two changes to the risk conclusions. Hazard quotients for the total PCB NOAEL for walleye in OU 4 increase from 10 to 14 using the 90th percentile. The risk determination for walleye from total PCBs would change from "potential risk" to "likely risk" in Green Bay zones 1 and 2, and risk from mercury in Green Bay Zone 4 would change from "no risk" to "potential risk." The net conclusions of the ecological risk assessment for piscivorous fish would be negligibly affected by using the 90th percentile.

For double-crested cormorants, risk evaluation of the 90th percentile concentrations would result in only one change to the risk conclusions. Risk to double-crested cormorants from p,p'-DDE would change from "potential risk" to "likely risk" in Green Bay Zone 3B. Because of the limited 90th percentile data in fish appropriate as prey for double-crested cormorants, dietary concentrations could not be modeled. However, use of the 90th percentile would not appreciably affect the risk determinations for piscivorous birds.

<u>Population Data</u>

As noted previously, although population level endpoints can be an appropriate tool to assess risk, the population data discussed in the BLRA were not collected specifically for risk assessment. There is some uncertainty introduced given the potential for other confounding environmental factors that may affect the absence or abundance of receptors within the River and Bay. These factors can include such things as immigration, emigration, food availability, habitat suitability and availability, species competition, predation, and weather. For example, while the risk assessment concludes that PCBs are at sufficient concentrations to affect mink reproduction within the River and Bay, Section 2 of the BLRA documented that there is limited habitat for mink, especially along the River. While contaminant conditions exist that potentially would jeopardize mink health along the River corridor, the absence of mink due to an absence of habitat must be considered.

Likewise, the apparent increase in populations of walleye and cormorants suggest little or no current risks to these species. Increases in walleye populations have occurred since the 1980s and are directly linked to improvement in water quality and habitat in the River, not necessarily to decreases in contaminants. That some risks persist is evidenced in the apparent presence of pre-cancerous lesions. Cormorant population increases may be related to decreases in contaminant concentrations, but are also likely tied to increases in available prey (fish). As for walleye, sublethal conditions appear to persist within the cormorant population. Given a shift in food or habitat conditions, those risks could be potentially of greater concern.

<u>Quantitative Analysis</u>

Only the data for benthic infauna for the River were thought to be amenable to a quantitative analysis. This analysis involved use of a range of toxicity values as listed in the literature rather than the single point estimate for toxicity that was used in the main body of the BLRA. This re-analysis was performed for each River reach and Bay zone.

Operable Unit 3 – Little Rapids to De Pere Reach: There is a high probability (80 percent) that PCBs are widely distributed throughout the reach at sufficiently high concentrations to moderately impact benthic infaunal populations and at least a 30 percent probability of encountering sediment concentrations associated with extreme effects.

Operable Unit 4 – De Pere to Green Bay: There is a high probability (95 percent) that PCBs are widely distributed throughout the reach at sufficiently high concentrations to moderately impact benthic infaunal populations and at least a 60 percent probability of encountering sediment associated with extreme effects.

Operable Unit 5 – Green Bay:

- **Green Bay Zone 2.** There is a high probability (40 percent) that PCBs are widely distributed throughout the reach at sufficiently high concentrations to moderately impact benthic infaunal populations and at least a 25 percent probability of encountering sediment associated with extreme effects.

- **Green Bay Zone 3A.** Relative to the other reaches discussed, there is a moderate probability (30 percent) of encountering PCBs at sufficiently high concentrations to moderately impact benthic infaunal populations, but a 0 percent probability of encountering sediment associated with extreme effects.

- **Green Bay Zone 3B.** There is a high probability (60 percent) that PCBs are widely distributed throughout the reach at sufficiently high concentrations to moderately impact benthic infaunal populations, but a 0 percent probability of encountering sediment associated with extreme effects.

- **Green Bay Zone 4.** There is only a very low probability that PCBs are widely distributed throughout the reach at sufficiently high concentrations to impact benthic infaunal populations.

Concluding Statement

The evaluation of uncertainties did not change the general conclusions drawn from the BLRA, which are that:

- Fish consumption by other fish, birds, and mammals is the exposure pathway that represents the greatest level of risk for receptors (other than direct risk to benthic invertebrates).

- The primary COC is PCBs; other COCs carried forward for remedial evaluation and long-term monitoring are mercury and DDE.

8.4 Derivation of Sediment Quality Thresholds

To facilitate the selection of a remedy that would result in decreased risks, it was necessary to establish a link between levels of PCBs toxic to human and ecological receptors and the principal source of those PCBs, the River and Bay sediment. SQTs are estimated threshold concentrations of PCBs in sediment below which risks should not occur. The SQTs themselves are not cleanup criteria, but are a good approximation of protective sediment thresholds and were considered to be “working values” from which a range of remedial action levels could be evaluated. Development of SQTs is consistent with the NCP guidance and the recommendations of the National Research Council (NRC) (*A Risk Management Strategy for PCB-Contaminated Sediment*, 2001).

SQTs were estimated for PCBs with the assumption that a remedy that reduces PCB exposure would also address the other co-located COCs. Risk-based concentrations in fish for human and ecological receptors were determined based on:

- Human health cancer risk levels of 10^{-4}, 10^{-5}, and 10^{-6} and a noncancer hazard index of 1.0 for risk in recreational anglers and high-intake fish consumers

- The NOAECs and LOAECs for species of benthic invertebrates, fish, birds, and riverine mammals found in the River and Bay

8.5 Basis for Action

The excess cancer risk and noncancer health hazards associated with human ingestion of fish, as well as the ecological risks associated with ingestion of fish by birds, fish, and mammals, are above acceptable levels under baseline conditions. The response action selected in this ROD is necessary to protect the public health, safety, or welfare and the environment from actual releases of hazardous substances into the environment.

9 REMEDIAL ACTION OBJECTIVES

Consistent with the NCP and RI/FS guidance, the WDNR and EPA developed remedial action objectives (RAOs) for the protection of human health and the environment. The RAOs specify the contaminants and media of concern, exposure routes and potential receptors, and an acceptable concentration limit or range for each contaminant for each of the various media, exposure routes, and receptors. RAOs were then used to establish specific remedial action levels (RALs) for the Site. Action levels were established after review of both the preliminary chemical-specific applicable or relevant and appropriate requirements (ARARs) and risk-based concentrations and serve to focus the development of alternatives or remedial technologies that can achieve the remedial goals. Although this ROD addresses only remediation of OUs 3, 4, and 5, the RAOs were developed for the entire River and the Bay.

The FS brought together the four major components used to evaluate risk, remedial goals, and alternative technologies in its analysis of remedial options. These components are briefly described below, then discussed in more detail on the following pages.

- **Remedial Action Objectives.** RAOs are site-specific goals for the protection of human and ecological health. Five RAOs were developed; all five apply to the River, while RAOs 1, 2, 3, and 5 apply to the Bay. RAO 4 does not apply to the Bay.

- **Remedial Action Levels.** A range of action levels was considered for the River and Bay; action levels were chosen based in part on SQTs, which link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment. The SQTs were developed in the human health and ecological risk assessments.

- **Operable Units.** Four River reaches (OU 1 through OU 4) and the Bay (OU 5) were identified as Operable Units based on geographical similarities for the purpose of analyzing remedial actions. This ROD encompasses OU 3, OU 4, and OU 5. A previous ROD covered OU 1 and OU 2.

- **Remedial Alternatives.** Following a screening process detailed in the FS, six remedial alternatives (A through F) were retained for the River and seven (A through G) were retained for the Bay.

For each River reach, six possible remedial alternatives were applied to each of five possible action levels and evaluated against each of five RAOs. For the Bay, seven possible remedial alternatives were applied to each of three possible action levels and evaluated against each of four RAOs. The steps in this process are described in more detail below. Cost estimates were also prepared for each remedial alternative and action level.

9.1 Remedial Action Objectives

RAOs address protection of human health and protection of the environment. No numeric cleanup standards have been promulgated by the federal government or the State of Wisconsin for PCB-contaminated sediment. Therefore, site-specific RAOs to protect human and ecological health were developed based on available information and standards, such as ARARs, non-promulgated guidelines referred to as “to be considereds” (TBCs), and risk-based levels established using the human and ecological risk assessments. The following five RAOs have been established for the Lower Fox River and Green Bay Site.

- **RAO 1: Achieve, to the extent practicable, surface water quality criteria throughout the Lower Fox River and Green Bay.** This RAO is intended to reduce PCB concentrations in surface water as quickly as possible. The current water quality criteria for PCBs are 0.003 ng/L for the protection of human health and 0.012 ng/L for the protection of wild and domestic animals. Water quality criteria incorporate all routes of exposure assuming the maximum amount is ingested daily over a person’s lifetime.

- **RAO 2: Protect humans who consume fish from exposure to COCs that exceed protective levels.** This RAO is intended to protect human health by targeting removal of fish consumption advisories as quickly as possible. The WDNR and EPA defined the expectation for the protection of human health as the likelihood for recreational anglers and high-intake fish consumers to consume fish within 10 years and 30 years, respectively, at an acceptable level of risk or without restrictions following completion of a remedy.

- **RAO 3: Protect ecological receptors from exposure to COCs above protective levels.** RAO 3 is intended to protect ecological receptors such as invertebrates, birds, fish, and mammals. The WDNR and EPA defined the ecological expectation as the likelihood of achieving safe ecological thresholds for fish-eating birds and mammals within 30 years following remedy completion. Although the FS did not identify a specific time frame for evaluating ecological protection, the 30-year figure was used as a measurement tool.

- **RAO 4: Reduce transport of PCBs from the Lower Fox River into Green Bay and Lake Michigan.** The objective of this RAO is to reduce the transport of PCBs from the River into the Bay and Lake Michigan as quickly as possible. The WDNR and EPA defined the transport expectation as a reduction in loading to the Bay and Lake Michigan to levels comparable to the loading from other Lake Michigan tributaries. This RAO applies only to River reaches.

- **RAO 5: Minimize the downstream movement of PCBs during implementation of the remedy.** A remedy is to be completed within 10 years.

Remedial Action Levels

PCB remedial action levels were developed based on the SQTs derived in the BLRA for the River and Bay. SQTs are estimated concentrations that link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment (see discussion in Section 8.4). The PCB RALs considered are 0.125, 0.25, 0.5, 1, and 5 ppm for the River and 0.5, 1, and 5 ppm for the Bay.

A range of RALs was considered in order to balance the feasibility of removing PCB-contaminated sediment down to each action level against the residual risk to human and ecological receptors after remediation. For each Operable Unit, all of the sediment with PCB concentrations greater than the selected RAL is to be remediated. One of the outcomes of applying a specific RAL to various remedial alternatives, such as dredging or capping or a combination of those, is the recognition that Monitored Natural Recovery (MNR) may also be a component of the remedy. This was considered because when sediment is removed to a specific action level, some sediment with PCB concentrations above the SQTs will likely be left in place. MNR can also be a standalone remedy if it is determined to achieve sufficient protection within a reasonable time frame. As a result, each action level and each remedial alternative has an MNR component relating to PCBs left in place following active remediation.

9.2 Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121(d) of CERCLA requires that Superfund remedial actions meet ARARs. In addition to applicable requirements, the ARARs analysis considered criteria and relevant and appropriate standards and non-promulgated TBC guidelines that were useful in evaluating remedial alternatives. ARARs are promulgated cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations; TBCs are guidelines and other criteria that have not been promulgated.

Location-specific ARARs establish restrictions on dredging and grading activities and the management of waste or hazardous substances in specific protected locations, such as riverbeds, lakebeds, wetlands, floodplains, historic places, and sensitive habitats.

Action-specific ARARs are technology-based or activity-based requirements or limitations on actions taken with respect to remediation. These requirements are triggered by particular remedial activities that are selected to accomplish the remedial objectives. The action-specific ARARs indicate the way in which the selected alternative must be implemented, as well as specify levels for discharge (see Table 4-2 of the FS).

Chemical-specific ARARs are health- or risk-based numerical values or methodologies that establish concentration or discharge limits, or a basis for calculating such limits, for particular substances, pollutants, or contaminants.

In addition to the water quality criteria, substantive requirements of the National Pollutant Discharge Elimination System (NPDES), as implemented under Wisconsin administrative rules, would also be applicable to wastewaters that are planned to be discharged to the River, which will require treatment. These wastewaters include liquids generated during construction activities, such as dewatering liquids, excavation area liquids, and liquids generated during construction of any on-Site consolidation area. Discharges to publicly owned treatment works (POTWs) may be pursued as an alternative discharge location. However, such discharges must also comply with pretreatment limitations to ensure acceptable discharge from the POTW after treatment. The specific discharge levels will be determined during the design stage in coordination with the WDNR.

Sediments removed from the River may contain PCBs at a concentration equal to or greater than 50 ppm. PCB sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act (TSCA) of 1976 (Appendix E of the FS).

Presently, TSCA compliance would be achieved through the extension of the January 24, 1995, approval issued by the EPA to WDNR pursuant to 40 CFR 761.60(a)(5) under the authority of TSCA. This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500 WAC landfill (a landfill that complies with requirements established under a rule in the Wisconsin Administrative Code referred to as NR [Natural Resources] 500) that is also in compliance with the conditions of the TSCA approval: (1) provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5), and (2) will provide the same level of protection required by EPA Region 5 and therefore is no less restrictive than TSCA. However, should other administrative rules pertaining to disposal under TSCA be in effect at the time that TSCA compliance decisions are made for the River sediment, then compliance with those rules will be achieved.

10 DESCRIPTION OF ALTERNATIVES

Following development of the RAOs, the WDNR and EPA conducted a rigorous screening and evaluation in accordance with CERCLA and the NCP. First, a wide range of potentially applicable remedial technologies or process options for addressing PCB-contaminated sediments were identified and screened (evaluated) based on effectiveness and technical implementability at the Site. Those technologies that were retained after the first screening of potential remedial technologies were then evaluated in a second screening based on effectiveness, implementability, and cost. After the second screening, the following technologies were retained for consideration in the analysis of remedial alternatives: (A) no action, which the NCP requires be evaluated; (B) MNR; (C) dredging with various disposal options, (D) dredging to confined disposal facility, (E) dredging to a vitrification facility, and, (F) capping to the maximum extent practicable with dredging in areas where capping is not appropriate. Alternatives C through F would be followed by MNR once the active remediation was complete.

Process options for treatment and disposal that were retained after the second screening include vitrification and upland and in-water disposal. After the technology screening, the WDNR and EPA developed and screened remedial alternatives. A specified cleanup value or action level for PCBs in sediment was not developed for purposes of evaluating remedial alternatives. Because fish consumption is the major pathway of concern, remedial alternatives were evaluated based on their ability to reduce PCB concentrations in fish. Because PCB concentrations in fish are largely a function of PCB concentrations in both the sediment and the water column, sediment cleanup is considered the means to the goal of protecting human health and the environment.

The criteria identified in Section 6.4.4 of the FS were used to identify locations where the capping alternative was feasible. For excavation and capping alternatives, the WDNR and EPA evaluated the following action levels for the River: PCB concentrations of 0.125 ppm, 0.25 ppm, 0.5 ppm, 1 ppm, 5 ppm, and no action. These results were then compared to the RAOs, particularly RAOs 2 and 3, which deal with protection of human health and the environment. On the basis of that analysis and to achieve the risk reduction objectives using a consistent action level, 1 ppm was agreed upon as the appropriate RAL. In making this determination, the Agencies relied on projections of the time required to achieve the risk reduction, the post-remediation surface-weighted average concentration (SWAC), and cost.

Table 10-1 (derived from FS Tables 8-14 and 8-16) shows the time necessary to achieve acceptable fish tissue concentrations for walleye that are protective of human health at the selected action level of 1 ppm at OU 3. PCB fish consumption advisories are lifted when the contaminant concentration in the fish fillets falls below 50 parts per billion (ppb). Therefore, for the recreational angler, PCB tissue levels in young-of-the-year walleye would be just at or below the level triggering fish consumption advisories about 9 years post-remediation of OU 3. This compares to 92 years under a no action alternative (and MNR), also shown in the table. Additional time (in years) is necessary for older fish to achieve acceptable levels of PCB tissue concentration for potentially removing fish consumption advisories.

Table 10-1 Years to Human Health and Ecological Thresholds for Lower Fox River at 1 ppm PCB Action Level and No Action in OU 3

Fish	Risk Level (and comparative fillet PCB concentration)	Receptor	Estimated Years (for 1 ppm Action Level)	Estimated Years (for No Action/ MNR)
Walleye	RME hazard index of 1.0 (49 ppb)	Recreational angler	9	92
Walleye	RME hazard index of 1.0 (31 ppb)	High-intake fish consumer	17	100+
Walleye	RME 10^{-5} cancer risk level (18 ppb)	Recreational angler	30	100+
Walleye	RME 10^{-5} cancer risk level (12 ppb)	High-intake fish consumer	42	100+
Carp	NOAEC	Carnivorous bird deformity	22	100+
Carp	NOAEC	Piscivorous mammal	43	100+

Notes:
Shaded row represents time to achieve safe tissue concentrations for young-of-the-year fish.
NOAEC – No Observed Adverse Effects Concentration.
RME – Indicates the reasonable maximum exposure.

Table 10-2 (derived from FS Tables 8-14 and 8-16) shows the time necessary to achieve acceptable fish tissue concentrations for walleye that are protective of human health at the selected action level of 1 ppm at OU 4. PCB fish consumption advisories are lifted when the contaminant concentration in the fish fillets falls below 50 ppb. Therefore, for the recreational angler, PCB tissue levels in young-of-the-year walleye would be just at or below the level triggering fish consumption advisories about 20 years post-remediation of OU 4. This compares to over 100 years under a no action alternative (and MNR), also shown in the table. Additional time (in years) is necessary for older fish to achieve acceptable levels of PCB tissue concentration for potentially removing fish consumption advisories.

Table 10-2 Years to Human Health and Ecological Thresholds for Lower Fox River at 1 ppm PCB Action Level and No Action in OU 4

Fish	Risk Level (and comparative fillet PCB concentration)	Receptor	Estimated Years (for 1 ppm Action Level)	Estimated Years (for No Action/ MNR)
Walleye	RME hazard index of 1.0 (49 ppb)	Recreational angler	20	100+
Walleye	RME hazard index of 1.0 (31 ppb)	High-intake fish consumer	30	100+
Walleye	RME 10^{-5} cancer risk level (18 ppb)	Recreational angler	45	100+
Walleye	RME 10^{-5} cancer risk level (12 ppb)	High-intake fish consumer	59	100+
Carp	NOAEC	Carnivorous bird deformity	20	100+
Carp	NOAEC	Piscivorous mammal	45	100+

Notes:
Shaded row represents time to achieve safe tissue concentrations for young-of–the-year fish.
NOAEC – No Observed Adverse Effects Concentration.
RME – Indicates the reasonable maximum exposure.

The SWAC is a measure of the average surface (upper 10 cm) concentration over a given area. In terms of the River and Bay, this would be the average residual contaminant concentration in the upper 10 cm divided by the area of the Operable Unit. The SWAC calculation for a particular OU includes inter-deposit areas. The estimated post-removal SWAC values for OU 3 and OU 4 at an action level of 1 ppm are 264 µg/kg and 156 µg/kg, respectively.

The SWAC value provides a number that can be compared to the SQTs developed in the BLRA. SQTs are estimated concentrations that link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment. Human health and ecological SQTs for carp and walleye are listed in Tables 10-3 and 10-4, respectively.

Table 10-3 Human Health Sediment Quality Threshold (SQT) Values

		Recreational Angler		High-intake Fish Consumer	
		RME µg/kg	CTE µg/kg	RME µg/kg	CTE µg/kg
Cancer Risk at 10^{-5}					
Carp		16	180	11	57
Walleye		21	143	14	75
Noncancer Risk (HI = 1)					
Carp		44	180	28	90
Walleye		58	238	37	119

Notes:
CTE – central tendency exposure.
RME – reasonable maximum exposure.

Table 10-4 Ecological Sediment Quality Threshold (SQT) Values

	NOAEC (µg/kg)
Carp – fry growth and mortality	363
Walleye – fry growth and mortality	176
Common Tern – hatching success	3,073
Common Tern – deformity	523
Cormorant – hatching success	997
Cormorant – deformity	170
Bald Eagle – hatching success	339
Bald Eagle – deformity	58
Mink – reproduction and kit survival	24

Note:
NOAEC – No Observed Adverse Effects Concentration.

The volume of sediment and PCB mass that would be removed, as well as the cost to implement the remedy at the 1 ppm action level, were also considered. For OU 3, an estimated 586,800 cy of contaminated sediments and 1,111 kg (2,444 pounds) of PCBs would be removed. In addition, removal of Deposit DD would add 9,000 cy of sediment containing 31 kg (68 pounds) of PCBs. The cost for remediation of OU 3 (including Deposit DD) is estimated to be $26.5 million. For OU 4, an estimated 5,880,000 cy of contaminated sediments and 26,433 kg (58,150 pounds) of PCBs would be removed. The cost for remediation of OU 4 is estimated to be $257.5 million.

10.1 Description of Alternative Components

Remedial Alternatives

The WDNR and EPA evaluated several alternatives to address contamination in the Lower Fox River (OU 3 and OU 4) and Green Bay (OU 5). Because the level of contamination in the OUs and their size vary, a specific proposed cleanup plan was developed for each OU. The FS outlines the process used to develop and screen appropriate technologies and alternatives for addressing PCB-contaminated sediment and provides detailed discussions of the remedial alternatives, which are briefly described below. The suite of remedial alternatives is intended to represent the remedial alternatives that are available, not to be inclusive of all possible approaches. The proposed alternative for an Operable Unit may consist of any combination of the remedial alternatives. Other implementable and effective alternatives could theoretically be used; however, a ROD amendment, or Explanation of Significant Difference (ESD), would be required before a “fundamental” or ”significant” modification could be made to the selected remedy.

The WDNR and EPA selected six remedial alternatives for detailed analysis for the River and Bay: No Action, Monitored Natural Recovery and Institutional Controls, Dredge and Off-Site Disposal, Dredge to a Confined Disposal Facility (CDF), Dredge and Vitrification, and *In-situ* Capping. For the Bay, a seventh remedial alternative, Dredge to a Confined Aquatic Disposal (CAD) Facility, was also evaluated. These alternatives cover the range of viable approaches to remedial action and include a no action alternative, as required by the NCP.

Alternative A – No Action

A No Action alternative is included for all River reaches and Bay zones. This alternative involves taking no action. The No Action alternative is required by the National Contingency Plan, because it provides a basis for comparison with the alternatives for active remediation.

Alternative B – Monitored Natural Recovery

Similar to Alternative A, the MNR alternative relies on naturally occurring degradation, dispersion, and burial processes to reduce the toxicity, mobility, and volume of contaminants. However, the MNR alternative also includes a long-term monitoring program for measuring PCB levels in various media (e.g., water, sediment, and tissue from sources such as invertebrates, fish, and birds) to effectively determine achievement of and progress toward the RAOs. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish. Until the RAOs are achieved, institutional controls would be necessary to prevent exposure of human and biological receptors to contaminants. Institutional controls include measures that restrict access to or uses of a site. They typically consist of some combination of physical restraints (such as fences to limit access), legal restrictions (such as local ordinances and restrictive covenants that limit land development), and outreach activities (such as public education programs and health advisories). Land and water use restrictions, fishing restrictions, and access restrictions may require local or state legislative action to prevent development or inappropriate use of contaminated areas of the River.

Alternative C – Dredge and Off-Site Disposal

Alternative C includes removing sediment having PCB concentrations greater than the RAL using a hydraulic or mechanical dredge, dewatering the sediment either passively or mechanically, treating the water before discharging it back to the River, and then disposing of the sediment off site, transporting it by truck. It is anticipated that sediment disposal would be at a local landfill (within approximately 40 miles) in compliance with the requirements of NR 500 WAC, which regulates the disposal of waste and the WDNR's TSCA approval issued by the EPA. The EPA issued this approval under the authority of the federal TSCA. This approval allows for the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 mg/kg (ppm) in landfills that are licensed by the WDNR under the NR 500 WAC rule series, provided that certain requirements are met. In this removal alternative, four different dewatering and disposal alternatives were examined for OU 3 and OU 4: C1 – dredging with passive dewatering followed by transport to an NR 500 disposal facility; C2A – dredging to a combined passive dewatering and disposal facility; C2B – dredging to a separate passive dewatering facility followed by disposal in an adjacent landfill; and C3 – dredging with mechanical dewatering and disposal at an NR 500 disposal facility. Alternatives C2A and C2B may rely on a pipeline to transport the dredge slurry directly to the passive dewatering facility.

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

Alternative D includes the removal of sediment having PCB concentrations greater than the RAL to an on-site CDF for long-term disposal. A CDF is an engineered containment structure that provides both dewatering and a permanent disposal location for contaminated sediment. A CDF can be located in the water adjacent to the shore or at an upland location near the shore. Sediment with PCB concentrations equal to or greater than 50 mg/kg are not eligible for disposal in a CDF. Such sediments would be mechanically dredged for solidification and disposal at a solid waste landfill conforming to requirements defined by the state in the NR 500 WAC rule series and the WDNR's TSCA approval. Conceptual nearshore CDF locations were identified in OU 4.

Alternative E – Dredge and Vitrification

This alternative is similar to Alternative C except that all the dewatered sediment would be thermally treated using a vitrification process. Alternative E assumes that the residual material would be available for possible beneficial reuse after vitrification. Vitrification has been used as a representative thermal treatment process option and was included as an alternative after a recently completed pilot-scale evaluation.

Alternative F – *In-Situ* (In-Place) Capping

Alternative F includes primarily sand capping to the maximum extent possible. The maximum extent of the capping action was defined in each River reach on the basis of Site-specific conditions such as water depth, average river current, river current under flood conditions, wave energy, ice scour, and boat traffic. Using these criteria, it was determined that certain areas of the Site are not suited for capping. Therefore, capping alone is not a viable option to achieve the Site RAOs. In the FS, where capping is a viable alternative, the conceptual design included a 20-inch sand cap overlaid by 12 inches of graded armor stone. Sediment that is not capped but still exceeds the action level would be hydraulically dredged to an on-site CDF, similar to Alternative D. In the FS, several cap designs were retained for possible application; design factors that influence the final selection of an *in-situ* cap include an evaluation of capping materials and cap thickness when applied in the field. In general, sandy sediment is a suitable capping material, with the additional option of armoring at locations where there is the potential for scouring and erosion. Laboratory tests developed in the past indicate that a minimum *in-situ* cap thickness of 12 inches (30 cm) is required to isolate contaminated sediment, as indicated in FS Section 7.1, pages 7-4 to 7-5. Full-scale design would require consideration of currents during storm events, wave energy, and ice scour. A minimum river depth of 6 feet was proposed in the FS (FS Section 7.1.1, page 7-5) for any location where a cap is proposed. Institutional controls and monitoring and maintenance are also components of this alternative. Institutional controls may be necessary to ensure the long-term integrity of the cap. Recent climate models indicate that Lake Michigan water levels could decrease by 3 feet by 2050 and 4.5 feet by 2090, below historical low water levels. Therefore decisions concerning capping, should consider potential future declines in Lake Michigan water levels which would in turn affect levels within the Lower Fox River and Green Bay. Monitoring and maintenance would be required in perpetuity to ensure the integrity of the cap and the permanent isolation of the contaminants. As part of the ROD for OU 1 and OU 2, *White Paper No. 6B – In-Situ Capping as a Remedy Component for the Lower Fox River* was prepared. This white paper provides additional criteria that would need to be considered in the design of a remedial cap.

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

Alternative G includes the removal of sediment to a CAD facility for long-term disposal; this alternative is technically feasible only in the Bay (OU 5). A CAD facility is a variation on capping in which the contaminated sediment is placed in a natural or excavated depression or natural deposition area and covered with clean material. Ideal CAD sites are in “null-zones” where circulation patterns create areas with net deposition instead of erosion and scour. Three possible locations were determined in the FS on the basis of water depth and currents. Each location was assumed to provide enough capacity for each action level. Construction of the CAD would involve placing contaminated sediment with a mechanical dredge and covering the sediment at completion with 3 feet of clean sand. Institutional controls and monitoring are also components of this alternative. Institutional controls would be necessary to ensure the long-term integrity of the CAD cap. Monitoring and maintenance of the CAD cap would be required to ensure the integrity of the cap and the permanent isolation of the contaminants. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish.

In evaluating the alternatives, the WDNR and EPA considered the level of protection that would satisfy the concern of the natural resource trustees that future natural resource injuries be minimized. Many of the natural resource trustees cooperated in the development of the Proposed Plan and agreed with the combination of active remediation to a proposed PCB cleanup level of 1 ppm and the use of MNR in areas where active remediation will not occur. Additionally, it is recognized that natural recovery processes would be required to meet RAOs in areas undergoing removal because of residual contaminant concentrations that may remain after active remediation.

10.2 Key/Common Elements

The following discussion applies primarily to the alternatives that involve dredging or dredging and capping.

Phasing of Work and Collection of Additional Data

The first construction season of remedial dredging will include an extensive monitoring program of all operations. Monitoring data will be compared to performance standards developed during remedial design. Performance standards are likely to address (but may not be limited to) resuspension rates during dredging, production rates, residuals after dredging, and community impacts (e.g., noise, air quality, odor, navigation). Data gathered will enable the WDNR to determine whether adjustments to operations are needed in the succeeding phase of dredging or whether performance standards need to be reevaluated. The WDNR will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public.

Institutional Controls

Institutional controls (fish consumption advisories and fishing restrictions) would be utilized with the MNR, capping, and removal alternatives. Institutional controls are considered to be limited action alternatives and therefore are not included in the No Action alternative.

Source Control

Point sources of contaminants have been effectively addressed by water discharge permits for the River. Thus, no additional actions related to source control are necessary. Final closure of Renard Island in southern Green Bay will be undertaken by the USACE, but is not part of this decision.

Monitored Natural Recovery

Natural recovery refers to the beneficial effects of natural processes that reduce surface sediment concentrations of PCBs. These processes include biodegradation, diffusion, dilution, sorption, volatilization, chemical and biochemical stabilization of contaminants, and burial by natural deposition of cleaner sediments. The primary mechanisms for natural recovery in the River and Bay are desorption and dispersion in the water column (i.e., as a dissolved constituent), burial, and sediment resuspension and transport. Biodegradation is a negligible contributor to the lowering of PCB concentrations (and is not a factor for mercury). The relative importance of each of these mechanisms in reducing PCB concentrations in the River and Bay is not easily estimated based on available data. Some or all of these processes may be occurring at varying rates at any given time and location within the River or Bay. During the design phase, a monitoring program will be developed to measure the net effects of the natural attenuation processes after remedial activities are completed until the remediation goals are reached. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish.

Sediment Concentrations

Sediments that may significantly contribute to the PCB levels in fish, both now and in the future, are considered principal threats. The determination of the significance of the sediment contribution to fish is based primarily on model projections, in conjunction with geochemical and statistical analyses. The model projections indicate that the significance of the sediment contribution to PCB fish tissue levels varies by Operable Unit; therefore, the sediment levels that are considered principal threats will correspondingly vary by Operable Unit.

Treatment

Conventional treatment technologies, such as vitrification, are technically feasible; however, the associated costs could be substantially greater than off-site landfill disposal. Because the Agencies believe that vitrification of sediments is feasible, it is considered a possible alternative to the current plans for conventional disposal in an approved, licensed landfill. Dredged sediments processed using vitrification technology could be beneficially reused.

Sediment Processing/Transfer Facilities

It is expected that sediment processing/transfer facilities would be established to handle materials from the environmental dredging process. The locations of these facilities will be determined during the remedial design phase of the remedy considering engineering issues (such as those associated with the type of dredging selected), property issues, noise and air impacts, and other appropriate factors. Although it is projected that these facilities would be based on land, water-based facilities will also be evaluated. Dredged sediment will be dewatered and then disposed of in a licensed engineered landfill.

Water that is separated from the dredged sediment will undergo treatment to remove fine sediment particles and dissolved PCBs. Ultimately, the water will be discharged back into the River in compliance with the substantive requirements of the State of Wisconsin Pollutant Discharge Elimination System, which is an ARAR for this Site. As part of the ROD for OU 1 and OU 2, *White Paper No. 7 – Lower Fox River Dredged Sediment Process Wastewater Quality and Quantity: Ability to Achieve Compliance with Water Quality Standards and Associated WPDES Permit Limits* was prepared. This white paper provides additional direction on wastewater processes, compliance with standards, and Wisconsin Pollutant Discharge Elimination System (WPDES) limits associated with the treatment of wastewater from dredging operations.

Transportation

Dredged materials will likely be transported from the dredging site to the sediment processing facility by river pipeline. Transportation from the sediment processing facility to disposal facilities will likely be by truck, although other means such as a conveyor system will be considered.

Disposal

Disposal of PCB-contaminated sediment from OUs 3 and 4 would be to an existing upland landfill or a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs/TBCs specific to the landfill option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series, WAC.

Sediments removed from the River may contain PCBs equal to or greater than 50 ppm. PCB sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act of 1976 (Appendix E of the FS). Presently, TSCA compliance would be achieved through the extension of the January 24, 1995, approval issued by the EPA to WDNR pursuant to 40 CFR 761.60(a)(5) under the authority of TSCA. This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500 WAC landfill that is also in compliance with the conditions of the TSCA approval: (1) provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5), and (2) will provide the same level of protection required by EPA Region 5 and therefore is no less restrictive than TCSA. However, should other administrative rules pertaining to disposal under TSCA be in effect at the time that TSCA compliance decisions are made for the River sediment, then compliance with those rules will be achieved.

Therefore, this disposal method meets the TSCA regulatory requirement of 40 CFR 761.61(c) that the risk-based method for disposal of PCB remediation waste does not pose an unreasonable risk of injury to health and the environment.

Although off-site landfilling is anticipated, vitrification and beneficial reuse of dredged excavated sediment will be evaluated during the design phase. Value engineering to reduce waste volumes (which will also reduce costs) will be explored and, if appropriate, finalized during remedial design.

Monitoring

Short- and long-term (i.e., pre-, during, and post-construction) monitoring programs will be developed to ensure compliance with performance standards and protection of human health and the environment. The types and frequency of pre-construction monitoring will be developed during remedial design. Plans for monitoring during and after construction will be developed during the remedial design and modified during and after construction as appropriate. This approach is consistent with the NRC report recommendation that long-term monitoring evaluate the effectiveness of the remedial action as well as ensure protection of public health and the environment (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001). Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish.

11 COMPARATIVE ANALYSIS OF ALTERNATIVES[2]

In selecting a remedy for the Site, the WDNR and EPA considered the factors set forth in CERCLA § 121, 42 USC § 9621 by conducting a detailed analysis of the viable remedial alternatives pursuant to the NCP, 40 CFR § 300.430(e)(9), EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies*, OSWER Directive 9355.3-01, and EPA's *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, OSWER 9200.1-23.P. The detailed analysis consists of an assessment of the individual alternatives against each of nine evaluation criteria (two threshold, five primary balancing, and two modifying criteria) and a comparative analysis focusing upon the relative performance of each alternative against those criteria.

Threshold Criteria

1. **Overall Protection of Human Health and the Environment** addresses whether a remedy provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. The selected remedy must meet this criterion.

[2] Publication details for references cited in this section can be found in the BLRA and/or RI/FS documents, which appear in the Administrative Record and are also available in the information repositories, or in the ROD and associated Responsiveness Summary for OU 1 and OU 2.

2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)** addresses whether a remedy will meet applicable or relevant and appropriate federal and state environmental laws and/or justifies a waiver from such requirements. The selected remedy must meet this criterion or a waiver of the ARAR(s) must be attained.

Primary Balancing Criteria

3. **Long-Term Effectiveness and Permanence** refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met.

4. **Reduction of Toxicity, Mobility, or Volume through Treatment** addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

5. **Short-Term Effectiveness** addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed until cleanup levels are achieved.

6. **Implementability** is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. **Cost** includes estimated capital costs, annual operation and maintenance costs (assuming a 30-year time period), and net present value of capital and operation and maintenance costs, including long-term monitoring.

Modifying Criteria

8. **Agency Acceptance** considers whether the support agency, in this instance the EPA, concurs with the lead agency's remedy selection and the analyses and recommendations of the RI/FS and the Proposed Plan. The WDNR is the lead agency for this project with technical support and funding from the EPA.

9. **Community Acceptance** addresses the public's general response to the remedial alternatives and Proposed Plan. The ROD includes a Responsiveness Summary that presents public comments and the WDNR's and EPA's responses to those comments. The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary (see Appendix A). Comments that address issues common to OU 1 and OU 2 as well as to OU 3, OU 4, and OU 5 are discussed in the Responsiveness Summary attached to the OU 1 and OU 2 ROD.

11.1 Operable Unit 3 (Little Rapids to De Pere)

Table 11-1 summarizes the comparative analysis for OU 3 alternatives and how each alternative meets, or does not meet, requirements for each of the nine criteria described above.

Table 11-1 OU 3 – Little Rapids to De Pere Alternatives

Yes = Fully meets criterion Partial = Partially meets criterion No = Does not meet criterion	Alternative A No Action	Alternative B Monitored Natural Recovery	Alternative C1 Dredge with Off-Site Disposal	Alternative C2A Dredge with Off-Site Disposal	**Selected Remedy** Alternative C2B Dredge with Off-Site Disposal	Alternative C3 Dredge with Off-Site Disposal	Alternative D Dredge to a Confined Disposal Facility	Alternative E Dredge and Vitrification	Alternative F *In-Situ* Capping
1. Overall Protection of Human Health and the Environment	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Compliance with Applicable or Relevant and Appropriate Requirements	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Long-Term Effectiveness and Permanence	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Reduction of Toxicity, Mobility, or Volume Through Treatment	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Short-Term Effectiveness	No	No	Yes	Yes	Yes	Yes	Partial	Partial	Yes
6. Implementability	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Partial	Yes
7. Cost (millions of $)	$ 4.5	$ 9.9	$ 95.1	$ 43.9	$ 26.5 *	$ 69.1	$ 52.5	$ 86.2	$ 62.9
8. Agency Acceptance	The WDNR has been the lead agency in developing the RI/FS and Proposed Plan. Both the WDNR and EPA support the selected alternative for this Operable Unit at the 1 ppm action level.								
9. Community Acceptance	The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary.								

* This remedy is combined with Alternative C2B in OU 4. The total cost for this combined remedy is $284 million. Estimated costs for the combined remedy are discussed in *White Paper No. 23 – Evaluation of Cost and Implementability of Alternative C2B for Operable Unit 3 and Operable Unit 4*, which is attached to this ROD. The estimated cost for OU 3 (including Deposit DD) is $26.5 million.

11.1.1 Threshold Criteria for Operable Unit 3

Protection of Human Health and the Environment

The primary risk to human health associated with the contaminated sediment is consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. Protection of human health and the environment were evaluated by residual risk in surface sediment using five lines of evidence:

- Residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy
- Average PCB concentrations in surface water
- The projected number of years required to reach safe consumption of fish
- The projected number of years required to reach a surface sediment concentration protective of fish or other biota
- PCB loadings to Green Bay and total mass contained or removed

Each of these is discussed below.

Residual PCB Concentrations in Surficial Sediment and Surface Water

As shown in Table 11-2, substantial reductions in the average PCB concentration in surficial sediment and in surface water for OU 3 is achieved by Alternatives C1, C2A, C2B, C3, D, E, and F when compared to Alternatives A and B. Implementation of Alternative C1, C2A, C2B, C3, D, E, or F results in reduction in residual PCB concentrations in surface sediment from 2.1 ppm to 0.264 ppm using surface-weighted averaging when compared to Alternatives A and B (No Action and MNR). It is also estimated that surface water concentrations 30 years after remediation will be reduced from 5.37 ng/L to 0.37 ng/L for Alternatives C1, C2A, C2B, C3, D, E, and F relative to Alternatives A and B.

Table 11-2 Post-Remediation Sediment and Surface Water Concentrations in OU 3

Alternative	Post-Remediation SWAC (ppm)	Estimated Surface Water Concentrations 30 Years after Remediation (ng/L)
A, B	2.078	5.37
C1, C2A, C2B, C3, D, E, F	0.264	0.37

Notes:
SWAC – surface-weighted average concentration
Data are from FS Table 8-5B and Table 1 in *White Paper No. 11 – Comparison of SQTs, RALs, RAOs and SWACs for the Lower Fox River* of the OU 1 and OU 2 ROD.

Time Required to Achieve Acceptable Fish Tissue Concentrations

As shown in Table 11-3, substantial reductions in the time when humans could safely consume fish are achieved by Alternatives C1, C2A, C2B, C3, D, E, and F when compared to Alternatives A and B. The implementation of Alternative C1, C2A, C2B, C3, D, E, or F is expected to achieve acceptable fish tissue concentrations for recreational fishers within 9 to 30 years and acceptable tissue concentrations for high-intake fish consumers within 42 years, as compared to

92 to more than 100 years for Alternatives A and B. It should be noted that because of limitations of modeling analysis, this relative comparison for three of the four receptors does not reflect how many years more than 100 would be required for natural recovery.

Table 11-3 Time to Achieve Acceptable Fish Tissue Concentrations for Walleye in OU 3

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C1, C2A, C2B, C3, D, E, F	Alternatives A, B
Walleye	Recreational Angler	RME Hazard Index of 1.0	9	92
Walleye	High-intake Fish Consumer	RME Hazard Index of 1.0	17	>100
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	30	>100
Walleye	High-intake Fish Consumer	RME 10^{-5} cancer risk level	42	>100

Notes:
RME – reasonable maximum exposure
Data are from FS Table 8-14.

Time Required to Achieve Surface Sediment Concentration Protective of Fish or Other Biota

As shown in Table 11-4, substantial reductions in the time required to reach protective levels for ecological receptors are achieved by Alternatives C1, C2A, C2B, C3, D, E, and F relative to Alternatives A and B. For representative ecological receptors, implementation of Alternative C1, C2A, C2B, C3, D, E, or F achieves a protective level in 22 to 46 years as compared to more than 100 years for Alternatives A and B. Because of limitations of the modeling analysis, this relative comparison does not reflect how many years more than 100 would be required for natural recovery.

Table 11-4 Time Required to Achieve Protective Levels in Sediment for Representative Ecological Receptors in OU 3

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C1, C2A, C2B, C3, D, E, F	Alternatives A, B
Carp	Carnivorous bird	NOAEC	22	>100
Carp	Piscivorous mammal	NOAEC	43	>100
Sediment	Sediment invertebrate	TEL	46	>100

Notes:
NOAEC – No Observed Adverse Effects Concentration
TEL – threshold exposure limit
Data are from FS Table 8-16.

PCB Loadings to Downstream Areas and Total Mass Contained or Removed

Reduction of the PCB load transported from the River into Green Bay is a measure of the overall protection of human health and the environment. Reduced PCB loading will ultimately contribute to downstream reduction of concentrations of PCBs in sediment, water, and fish, thereby reducing risk to humans and ecological receptors in the River, the Bay, and Lake Michigan. After implementation of Alternative C1, C2A, C2B, C3, D, E, or F, estimates are that releases from the River to Green Bay would be reduced from the present 77 kg (170 pounds) per year to 1.5 kg (3.2 pounds) per year 30 years after completion of remediation as compared to 21 kg (47 pounds) per year after 30 years for Alternatives A and B. Thus, Alternatives C1, C2A, C2B, C3, D, E, and F would provide a 93 percent reduction in loadings relative to the alternatives of No Action and MNR.

Summary

Alternatives C1, C2A, C2B, C3, D, E, and F provide a substantially more protective remedy than do Alternatives A and B. Alternatives A and B are not protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4). Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provide a basis for invoking a waiver.

The ARAR discussion below is organized by the different operational components of the alternatives (Table 11-5), because various components are utilized in essentially the same manner for some alternatives and apply equally to those alternatives with a common component. There is additional discussion of compliance with ARARs in Section 14.2.

Table 11-5 Operational Components for OU 3 Alternatives

		Alternatives								
		A	B	C1	C2A	C2B	C3	D	E	F
Removal				X	X	X	X	X	X	X
Dewatering	Mechanical						X			
	Passive			X	X	X		X	X	X
Sediment Treatment				*	*	*	*	*	X	*
Water Treatment				X	X	X	X	X	X	X
Transportation	Trucking			X		X**	X		X	X
	Pipeline				X	X				
Disposal	Upland			X	X	X	X			X
	In-water CDF							X		
Beneficial Reuse of Sediments									X	
Capping										X

Notes:
X: Required activity for alternative.
* Possible supplement.
** Trucking would be minimal (disposal location is adjacent to the dewatering facility).

A description of the components listed in Table 11-5 follows.

- **Removal:** The removal technology utilized for Alternatives C1, C2A, C2B, C3, D, E, and F is dredging (although Alternative F also includes capping). The ARARs that directly relate to the removal of sediment from the River and Bay concern the protection of surface water (NR 322, 200, and 220 through 297). The surface water ARARs limit the discharge of PCBs into the receiving water bodies so that water quality is not adversely affected. These ARARs will be achieved by Alternatives C1, C2A, C2B, C3, D, E, and F. Dredge material will be moved to the dewatering facility by pipeline or barge.

- **Dewatering and Water Treatment:**

  - Mechanical dewatering would be utilized for Alternative C3. Discharge requirements (NR 200 and 220 through 297, WAC) are set forth for the discharge of water to POTWs and to navigable waters such as the River (NR 105 and 106, WAC). Discharges from prior remedial activities on the River provide an indication of the treatment requirements for discharging effluent water to the River or to a POTW. Another requirement covers stormwater discharge. A potentially important ARAR (NR 108, WAC) relates to the construction of a wastewater treatment facility specifically to treat water from remedial activities.

  - Passive dewatering ponds would be part of Alternatives C1, C2A, C2B, D, E, and F and would be constructed under the wastewater ARAR (NR 213, WAC), which associated with wastewater treatment lagoons. Based on previous experience gained during the SMU 56/57 pilot dredging project, ARARs associated with passive dewatering lagoons are achievable.

- ***Ex-Situ* (Off-site) Treatment:** ARARs specific to vitrification technology (Alternative E) relate to the air emission and permitting requirements of thermal treatment units (40 CFR 701 and NR 400 through 499). In addition, the thermal unit must meet performance requirements in NR 157 for the efficient treatment of PCB-containing sediment. These ARARs would be met.

- **Transportation:** The likely method for transporting PCB-containing sediment to upland disposal locations for Alternatives C1, C3, and F is by trucking it to the disposal facility, although other transportation methods could be used if it is determined during design that there are better methods. Alternatives C2A and C2B would initially use a pipeline to transport the dredge slurry to the dewatering facility. Alternative C2B would involve moving the dewatered sediment, likely trucking it from the passive dewatering facility to the adjacent disposal site, although other options may be considered during design. Alternative C2A does not require transportation of the sediment after dewatering, because the dredge material would be disposed of in the dewatering facility. Alternative D would not require off-site transportation, because all removed sediments would be disposed on site in a nearshore CDF. Alternative E would require trucking contaminated sediments to a treatment facility and trucking the treated (non-hazardous) materials to a site for beneficial or commercial reuse. ARARs and TBCs important to this process option include the requirements to prevent spills and releases of PCB materials (NR 140 and 157, WAC). Two ARARs applicable only to the trucking method include Wisconsin Department of Transportation (WDOT) requirements for the shipping of PCB materials and NR 157 shipping requirements. ARARs and TBCs related to in-water transportation activities (i.e., piping) include the protection of surface water (NR 322, 200, and 220 through 297, WAC). Alternatives C1, C2A, C2B, E, and F will comply with these ARARs.

- **Disposal:** For Alternatives C1, C2A, C2B, C3, and F, contaminated sediment removed (i.e., dredged) from OU 3 will be disposed of at either an existing upland landfill or in a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs specific to this process option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series, WAC. For contaminated sediments with PCB concentrations equal to or greater than 50 ppm, disposal will comply with TSCA, 40 CFR Part 761. General disposal requirements for PCB-containing sediments are simplified by the EPA's current approval requirements for placing TSCA-level PCB-containing material in a state-licensed landfill. In all cases, for sediment to be disposed of at a local landfill, the landfill must be in compliance with the requirements of the NR 500 WAC series that regulates the disposal of waste and with the WDNR's TSCA approval issued by the EPA. This EPA approval currently allows for the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 mg/kg in landfills licensed under the NR 500 rule series, WAC, provided that certain technical and administrative requirements are met. These ARARs will be met by Alternatives C1, C2A, C2B, C3, and F.

- **Capping:** For Alternative F, some sediments would be capped in place, primarily in the deeper portions of OU 3. This would require compliance with Section 10 of the Rivers and Harbors Act of 1899 (22 CFR 403) and with the Wisconsin Statutes Chapter 30 (defining riparian rights of upland owners which extend to the center of a stream). It is expected that these ARARs would be met.

11.1.2 Primary Balancing Criteria for Operable Unit 3

Long-Term Effectiveness and Permanence

Reduction of Residual Risk

Alternatives A and B result in a continuation of the degraded condition of the sediment and surface water quality of the Little Rapids to De Pere Reach (OU 3) for at least several decades. Alternatives A and B do not eliminate PCBs from the River and do not reduce PCB levels in fish to acceptable levels for the foreseeable future.

Alternatives C1, C2A, C2B, C3, D, E, and F reduce residual risk through removal or containment of 586,800 cy of sediments containing approximately 1,111 kg (2,444 pounds) of PCBs over an area of 330 acres. The reduction in the time required to reach acceptable fish tissue concentrations ranges from a minimum of 58 to 90 percent (see Section 11.1.1 for detailed discussion).

Adequacy of Controls

Alternatives A and B do not produce a reduction in human risk and exposure in the foreseeable future, unlike Alternatives C1, C2A, C2B, C3, D, E, and F. Additionally, fish consumption surveys indicate that 50 percent of anglers do not follow fish advisories. Therefore, existing institutional controls do not adequately reduce human exposure to PCBs from consumption of contaminated fish. In addition, institutional controls are not protective for ecological receptors (e.g., birds, mammals, and fish). Given the survey data, it is unlikely that these types of controls alone would be reliable in the long term to ensure human health and ecological protection. In effect, institutional controls by themselves are not sufficiently effective for OU 3.

Alternatives C1, C2A, C2B, C3, D, and E provide for the removal of PCB-contaminated sediments in OU 3. Alternative F also removes a large portion of PCB-contaminated sediments and provides for an engineered cap over an estimated approximately 40 percent of contaminated deposits in OU 3. Like Alternative B (MNR), Alternative F also requires institutional controls such as Site use restrictions in capped areas (e.g., prohibition of activities that disturb sediment). Although institutional controls would still be required for the removal alternatives, the risk to consumers of fish would be greatly reduced by these alternatives.

All alternatives would require institutional controls, such as fish consumption advisories and fishing restrictions, until remedial action objectives were met at a future date, but they are unlikely to require additional Site use restrictions after removal activities are completed.

All alternatives will require some degree of monitoring. Monitoring programs will be developed, as appropriate, for all phases of the project.

Alternatives C1, C2A, C2B, C3, D, and F rely on engineering controls at the disposal facility. Properly designed and managed landfills provide proven, reliable controls for long-term disposal for Alternatives C1, C2A, C2B, C3, and F (which have off-site landfill disposal). Alternative F would also require a long-term operation and maintenance plan to ensure containment of PCBs in perpetuity. Alternative D would require on-site engineering controls at an in-water disposal facility. Long-term monitoring and maintenance are included in operation of the landfill and confined disposal facility. The final disposition of contaminated sediments is summarized in Table 11-6.

Table 11-6 Final Disposition of Contaminated Sediments in OU 3

	Alternatives (cubic yards)					
	A	B	C1/C2A/C2B/C3	D	E	F
Treated and residual disposal	0	0	0	0	586,788	0
Removed and disposed at upland (off-site) landfill	0	0	586,788	0	0	170,418
Removed and disposed at in-water, on-site CDF	0	0	0	586,788	0	
Capped in place	0	0	0	0	0	416,370

Note:
Data are from FS Table 7-2.

Reliability of Controls

For Alternatives B, C1, C2A, C2B, C3, D, E, and F, fish consumption advisories and fishing restrictions will continue to provide some protection of human health until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or lifted. However, in the interim, these controls will provide only an uncertain measure of protection. Among the active alternatives, sediment capping, sediment removal (dredging and excavation), and off-site disposal/treatment of removed sediments are all established technologies.

The capping portion of Alternative F relies upon proper design, placement, and maintenance of the cap in perpetuity for its effectiveness, continued performance, and reliability. A cap-integrity monitoring and maintenance program would provide reasonable reliability, although there are inherent challenges in monitoring and maintaining a cap in the River environment. The capping portion of Alternative F may not be as reliable as the removal alternatives because of the unknown potential for damage to the cap, potentially exposing PCBs. In addition, the capping component of Alternative F is vulnerable to a catastrophic flow event, such as might be seen during a 500-year flood or a dam failure. However, with proper design and maintenance, these risks can be minimized.

In general, Alternatives C1, C2A, C2B, C3, D, and E are the most reliable, because there is little or no additional long-term, on-site maintenance associated with the remedial work. These alternatives permanently remove the greatest amount of contaminated sediment and PCBs from the River and achieve the greatest reduction of the potential scour-driven resuspension of PCB-contaminated sediments. However, Alternative F is also considered to be sufficiently reliable.

Summary

Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, Alternatives C1, C2A, C2B, C3, D, E, and F are superior to Alternatives A and B because of the greater risk reduction and mass of PCBs removed from the River. Alternatives C1, C2A, C2B, C3, and E are similar to each other in terms of risk reduction being the most effective over time. The Agencies' analysis of residual risk for each alternative is consistent with the NRC report recommendation to consider options to reduce risk and to consider residual risks associated with material left behind (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001).

Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction in toxicity, mobility, or volume of contaminants through treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

Alternatives A and B do not involve any containment or removal of contaminants from OU 3 sediments. Alternatives A and B rely exclusively on natural attenuation processes such as burial by cleaner sediments, biodegradation, bioturbation, and dilution to reduce concentrations of PCBs in sediments and surface water.

Natural degradation processes were not found to be effective in reducing PCB concentrations or toxicity in River sediments (FS, Appendix F, "Dechlorination Memorandum"). Nevertheless, concentrations of PCBs in fish populations will respond slowly over time to slow natural decreases in concentrations in sediments and surface water due primarily to dilution and the burial of contaminated sediments by cleaner sediments.

For Alternative F, the mobility of the PCBs in capped areas (estimated to be approximately 140 acres) would be reduced because these PCBs are sequestered under the cap. However, capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the PCBs under the cap. Under Alternative F, the mass of PCBs and the volume of contaminated sediments within OU 3 are permanently reduced because approximately 170,400 cy of sediment would be removed from the ecosystem either to an upland landfill or a CDF, and approximately 416,400 cy would be contained under a cap in OU 3. A total of approximately 1,111 kg (2,444 pounds) of total PCBs would be removed or isolated from the ecosystem by this alternative. In addition, after construction of the remedy is completed, natural attenuation processes could provide additional reductions in PCB concentrations in the remaining sediments and surface water.

For Alternatives C1, C2A, C2B, C3, D, and E, the approximately 1,111 kg (2,444 pounds) of PCBs and 590,000 cy of contaminated sediments in OU 3 are permanently removed from the ecosystem. As for Alternative F, natural attenuation processes would provide additional reductions in PCB concentrations in the remaining sediments and surface water after construction of the remedy is completed.

Although Alternatives C1, C2A, C2B, C3, D, and F would permanently remove large volumes of PCBs from the River (thereby reducing their mobility), they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal (other than stabilization of the sediments for handling purposes) may not be cost-effective. Vitrification would reduce toxicity, mobility, and volume, and the glass aggregate product would be available for beneficial reuse.

Short-Term Effectiveness

Short-term effectiveness relates to the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation up until the time that remediation levels are achieved.

Length of Time Needed to Implement the Remedy

The implementation times for the active alternatives are approximately 1 to 5 years for Alternatives C1, C2A, C2B, C3, D, E, and F (see Table 11-7). These estimates represent the estimated time required for mobilization, operation, and demobilization of the remedial work, but do not include the time required for long-term monitoring or operations and maintenance. These estimates do take into consideration the fact that winter conditions will not allow for dredging (or capping) operations during the winter season. Alternatives A and B do not involve any active remediation and therefore require no time to implement. Alternative B would require monitoring until acceptable levels of PCBs are achieved in sediment, surface water, and fish.

Table 11-7 Time to Implement Alternatives for OU 3

Alternative	Years to Implement (rounded up to whole number)
A/B	0
C1	5
C2A/C2B	1
C3	5
D	5
E	1
F	2

Protection of the Community and Workers During Remedial Action

No construction activities are associated with the remediation of sediments for Alternatives A and B, so those alternatives neither increase nor decrease the short-term potential for direct contact with or ingestion and inhalation of PCBs from the surface water and sediments.

Community Protection. Access to sediment processing/transfer facilities and process and treatment areas under Alternatives C1, C2A, C2B, C3, D, E, and F will be restricted to authorized personnel. Controlling access to the dredging locations and sediment processing/transfer facilities, along with monitoring and engineering controls developed during the design phase, will minimize potential short-term risks to the community. The design will also provide for appropriate control of air emissions, noise, and light through the use of appropriate equipment that meets all applicable standards. Compliance with these design provisions will be monitored during construction, operation, and demobilization. Vehicular traffic associated with workers and the delivery of supplies will increase at the sediment processing and transfer facilities.

For Alternatives C1, C2A, C2B, C3, D, E, and F, work in the River will also be designed with provisions for control of air emissions, noise, and light. Work areas will be isolated (access-restricted), with an adequate buffer zone so that pleasure craft can safely avoid these areas. Environmental dredging in the River will be conducted at times and in ways to minimize disruption to River traffic. Targeted dredging will be sequenced and directed to ensure minimal impacts to navigation within the River. To help ensure that navigation is not impeded, the WDNR and EPA will consult with local authorities during the remedial design and construction phases regarding issues related to River uses and other remedy-related activities within OU 3. Discrete areas of the River will be subject to dredging and related activities over only short periods of time; once an area is dredged, dredging equipment will move to another area, thereby minimizing locational impacts.

Based on air monitoring for the SMU 56/57 demonstration project, air emissions at dredging sites and at land-based facilities are expected to be minimal. Nevertheless, community and worker protection would be considered relative to potential air monitoring requirements. Action levels will be established, monitoring conducted as required, and appropriate engineering control measures employed to ensure that any air releases do not exceed acceptable levels.

Vehicles used for the transportation of hazardous waste will be designed and operated in conformance with state and local regulations. The WDNR and EPA will provide the community and local government with the opportunity to provide input on plans related to the off-site transportation of hazardous wastes. This approach is consistent with the NRC recommendation to involve the local communities in risk management decisions (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001).

The WDNR and EPA believe that implementation of Alternatives C1, C2A, C2B, C3, D, E, and F would have little, if any, adverse impact on local businesses or recreational opportunities. Indeed, the WDNR and EPA believe that the remedy will have substantial positive economic impacts on local communities and will facilitate enhanced recreational activities in and along the River. To the extent that any adverse local impacts do occur, the WDNR and EPA expect that they will be short term and manageable. Moreover, the Agencies believe that any such impacts will be outweighed by the long-term benefits of the remediation on human health and the environment.

Worker Protection. For Alternatives A and B, occupational risks to persons performing the sampling activities (for the 5-year reviews) will be unchanged from current levels. There is some minimal increase in occupational risk associated with Alternative B because of the degree of sampling involved in the River.

For Alternatives C1, C2A, C2B, C3, D, E, and F, potential occupational risks to Site workers from direct contact, ingestion, and inhalation of PCBs from the surface water and sediments, as well as routine physical hazards associated with construction work and working on water, are higher than for Alternatives A and B. For Alternatives C1, C2A, C2B, C3, D, E, and F, personnel will follow a Site-specific health and safety plan and Occupational Safety and Health Administration (OSHA) health and safety procedures and wear the necessary personal protective equipment; therefore, no unacceptable risks would be posed to workers during implementation of the remedy.

In summary, Alternatives C1, C2A, C2B, C3, D, E, and F would not pose significant risk to the nearby communities or Site workers. A short-term risk to the community and Site workers may be possible as a result of potential air emissions and noise from construction equipment, dewatering operations, and hauling activities. However, as successfully shown during the Lower Fox River demonstration dredging projects, these risks can be effectively managed or minimized by: (1) coordinating with and involving the community; (2) limiting work hours; (3) establishing buffer zones around the work areas; (4) using experienced contractors who would assist project design; and (5) giving consideration to experience gained on other sediment remediation projects and applying that knowledge to this Site's specific circumstances.

Environmental Impacts of Remedy and Controls

Environmental impacts consist of PCB releases from removed sediment into the air and water. As successfully shown during the River demonstration dredging projects, environmental releases will be minimized during remediation by: (1) treating water prior to discharge;

(2) controlling stormwater runon and runoff from staging and work areas; (3) utilizing removal techniques that minimize losses; and through (4) the possible use of silt curtains where necessary to reduce the potential downstream transport of PCBs.

Habitat impacts from Alternatives C1, C2A, C2B, C3, D, E, and F are expected to be minimal, as the benthic community should recover relatively quickly from dredging activities (see *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* attached to the OU 1 and OU 2 ROD). Additionally, dredging remediation can result in collateral benefits in the course of mitigation, including removal of other chemical contaminants (e.g., mercury and ammonia) and nuisance species, reintroduction of native species, aeration of compacted and anaerobic soils, and other enhancements to submerged habitats. For the capping portion of Alternative F, there could be similar effects on aquatic vegetation and benthic invertebrate and fish communities, but recovery of benthic invertebrate communities would likely be slower (relative to recovery from dredging) because of changes in the subaqueous habitat to sand and rock as well as decreases in organic content of the sediment.

Potential Adverse Environmental Impacts During Construction

Alternatives A and B do not involve construction activities associated with the River sediments. Continuing the existing limited sampling activities (under the No Action alternative) or increasing the monitoring program (under the MNR alternative) is not anticipated to have any adverse effect on the environment beyond that already caused by PCB contamination of the sediments and ongoing releases of PCBs from the sediments in OU 3. For Alternatives C1, C2A, C2B, C3, D, E, and F, the release of PCBs from the contaminated sediments into the surface water during construction (dredging and cap placement) will be controlled by operational practices (e.g., control of sediment removal rates, use of environmental dredges, and possible use of sediment barriers). Although precautions to minimize resuspension will be taken, it is likely that there could be a localized, temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens.

Analysis of results from projects at Deposit N and SMU 56/57 and comparison to yearly sediment resuspension rates, as well as resuspension quantities during yearly high-flow events, show the expected resuspension resulting from dredging to be well within the variability that normally occurs on a yearly basis. Analysis of results from other dredging projects indicates that releases from environmental dredging are relatively insignificant. The performance standards and monitoring program developed during design will ensure that dredging operations are performed consistent with the environmental and public health goals of the project. This was readily achieved on the Deposit N and SMU 56/57 projects and is expected to be feasible for other River dredging activities.

Dredging activities may result in short-term, temporary impacts to aquatic and wildlife habitat of OU 3 but, as discussed below and in *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* (attached to the OU 1 and OU 2 ROD), recovery is expected to be rapid.

For Alternatives C1, C2A, C2B, C3, D, E, and F, there is the potential for transient impact from the temporary exposure of deeper, more highly contaminated sediments during excavation activities. This impact would be minimized by the quick completion of removal activities and (if needed) placement of a post-dredging sand cover as soon as practicable after the removal operations are complete.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as the availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Technical Feasibility

Both Alternatives A and B are technically feasible because no active measures other than continued sampling would be taken. Technical feasibility for the active remediation alternatives is discussed below in terms of the main components of the alternatives. Additional information is provided in the FS.

Sediment Processing/Transfer Facilities: Alternatives C1, C2A, C2B, C3, E, and F require sediment processing/transfer facilities. At these facilities, the transfer, dewatering, and stabilization of dredged material would be conducted. Each of these activities is considered a readily implementable, commonly engineered activity. Design of sediment processing/transfer facilities will include requirements for the control of light, noise, air emissions, and water discharges.

The WDNR and EPA have not determined the location of the sediment processing/transfer facilities. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. In preparing the cost estimate in the FS, the WDNR and EPA assumed a number of upland staging and access areas in the cities of De Pere and Green Bay, as well as access for a potential pipeline. These facilities (wherever located) would be temporary and removed after completion of the active remedial activities.

Removal: Alternatives C1, C2A, C2B, C3, D, E, and F require the dredging of contaminated sediments. Dredging of sediments is a readily implementable and environmentally effective engineering activity. Two concerns are relevant to whether sediments can be dredged effectively: (1) resuspension and releases during dredging, and (2) resulting residual contaminant concentrations that may remain in sediments after dredging is completed. Regarding resuspension, environmental dredges have been shown to generally not release significant quantities of contaminants during removal operations. The type of dredging equipment (mechanical and/or hydraulic) will be selected during the remedial design on the basis of what is the most appropriate equipment for the specific conditions in the River. Silt screens or other barriers, as appropriate, could further assist in limiting downstream migration of PCBs and may be used as well. Regarding post-dredging residual contaminant concentrations, comparable projects indicate that the 1 ppm action level in remaining sediments is readily achievable. The Lower Fox River SMU 56/57 dredging project achieved a 96 percent reduction in the average concentration of contaminated sediments targeted for removal. This outcome is consistent with results for other dredging projects having similar site conditions (see Appendix B of the FS and Hudson River White Paper ID 312663, “Post-Dredging PCB Residuals”).

Dewatering: Alternatives C1, C2A, C2B, C3, D, E, and F would require the removal of excess water from dredged sediments. Either mechanical or passive dewatering would be used for this purpose. These are conventional technologies and are readily implementable and effective.

Water Treatment: Conventional water treatment technologies for dredge water have been proven commonly reliable and are readily implementable and effective.

Capping: Alternative F includes capping in areas that are acceptable for capping. Capping is not acceptable in navigation channels, in areas where a cap may interfere with infrastructure (e.g., pipelines, utility easements, bridge piers), in areas where PCB concentrations are equal to or greater than 50 ppm, and in areas with shallower water (e.g., where a cap would result in water depths less than 3 feet). The placement of capping materials is a readily implementable engineering activity. Sand and/or fine-grained materials may be utilized for capping. Clean sand placed over contaminated deposits would result in a new sediment bed surface that is essentially without contamination initially. The type of material (e.g., texture/size and sorting), thickness of the isolation cap, and armoring requirements will need to be determined on a location-specific basis. Recent climate models indicate that Lake Michigan water levels could decrease by 3 feet by 2050 and 4.5 feet by 2090, below historical low water levels. Therefore, decisions concerning capping should consider potential future declines in Lake Michigan water levels which would in turn affect levels within the Lower Fox River and Green Bay.

Post-Dredging Sand Cover: The selected alternative envisions an option of limited backfilling (see the discussion of capping as a contingent remedy in Sections 13.4 through 13.7). The placement of a sand backfill is a readily implementable engineering activity. Sand or other materials, as appropriate, may be utilized for backfill. This “residual cap” is defined as placement of a thin cap layer over a residual sediment contamination left behind following dredging. Residual capping serves to dilute the contaminated sediment and speed up the natural recovery process. Residual caps are not designed as isolation caps. An example of a residual cap is the material placed at the SMU 56/57 demonstration project.

Transportation: Different dredging alternatives have different transportation requirements (see Table 11-5).

For Alternatives C1, C2A, C2B, C3, D, and E, dredged materials may be transported in-River to sediment processing/transfer facilities or a nearshore CDF using barges or pipelines. These are considered readily implementable engineering activities.

For Alternatives C2A and C2B, an on-land pipeline to the dewatering facilities or dewatering/disposal facilities would be necessary. For Alternative C2B, trucks, or possibly some other transportation method, would serve for transferring the dewatered sediments from the dewatering location to the adjacent disposal facility.

For Alternatives C1, C3, E, and F, off-site transportation of dredged materials to disposal facilities would be by truck, rail, and/or barge. These forms of transportation are routine engineering activities that have been employed at many Superfund sites and are technically implementable. The WDNR and EPA will comply with all legal regulatory requirements for transporting both hazardous and non-hazardous wastes.

Disposal: Off-site disposal is a common activity at many Superfund sites. The number and location of off-site disposal facilities will be based on dredged material volume, transportation, and cost considerations. It is expected that appropriate disposal will be in the Fox River Valley area.

Alternatives C1, C2A, C2B, C3, and F all include upland disposal options. Alternative D uses an in-water confined disposal facility for disposal. These are conventional technologies and readily implementable. Under Alternative F, based on the criteria for cap placement, approximately 40 percent of the surface area of the 1 ppm footprint could be capped *in situ*. For the areas that will be capped, it is considered technically achievable. It should be noted that certain areas are not amenable to capping, as noted above in the “Capping” discussion.

Alternative E, the *ex-situ* treatment alternative of vitrification, was determined to be technically feasible. As discussed in the FS, this alternative does require reuse of residual materials after treatment. For purposes of this ROD, it is assumed that there will a beneficial reuse of the residual material and an associated value (range of $2 to $25 per ton) and, as a consequence, there is no disposal cost associated with this alternative.

Treatment: Alternative E includes thermal treatment by vitrification and is technically implementable to meet cleanup goals.

Administrative Feasibility

Alternatives A and B require no active measures. All alternatives except Alternative A include an administrative requirement for fish consumption advisories. Because fish consumption advisories are already in place, this requirement is already met and would continue even under the No Action alternative. Alternatives C1, C2A, C2B, C3, D, E, and F are somewhat more difficult to implement in terms of administrative feasibility because of the need to site a pipeline and the sediment processing/transfer facilities, to address the associated real property issues, and to make arrangements to utilize the River with minimal interruption of boat traffic.

Sediment Processing/Transfer Facilities: For Alternatives C1, C2A, C2B, C3, D, and F, the transfer facilities, constructed on land adjacent to or in the River, are considered “on site” for the purposes of the permit exemption under CERCLA Section 121(e), although any such facilities will comply with the substantive requirements of any otherwise necessary federal or state permits.

Removal: Operations under these alternatives will have to be performed in conformance with the substantive requirements of regulatory programs implemented by the USACE under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. In addition, discharges during remediation will conform to Wisconsin Statutes and substantive WDNR regulations related to dredging and maintaining water quality.

Disposal: Identifying a local landfill for disposal of dredged sediments is feasible. This would have to be coordinated with local authorities, consistent with appropriate ARARs.

Capping and CDF: For Alternatives D and F, consideration of riparian rights would require use/access agreements with property owners of land adjacent to the riverbed. If capping or CDF areas are considered to be a “lake” due to dams, a lakebed grant would have to be approved by the state. Regulations concerning impacts to floodplains and floodways would need to be addressed. These considerations would be addressed during design.

Treatment: Alternative E is administratively feasible. Air emissions permits would be required if sediments are treated off site.

Availability of Services and Materials: For Alternatives A and B, all needed services and materials are available. For Alternatives C1, C2A, C2B, C3, D, E, and F, equipment and personnel related to dredging and materials handling (e.g., sediment dewatering) are commercially available. Technology and associated goods and services for capping or a post-dredging sand cover, upland landfill, or CDF construction are locally available.

Cost

Cost includes estimated capital and annual operation and maintenance costs, as well as total capital cost. Present worth cost is the total capital cost and operation and maintenance costs of an alternative over time in today’s dollar value. Cost estimates are expected to be accurate within a range of –30 to +50 percent. (This is a standard assumption in accordance with EPA CERCLA guidance.)

For Alternatives C1, C2A, C2B, C3, D, E, and F, the estimated costs range from approximately $26.5 million for Alternative C2B to $95.1 million for Alternative C1 at the 1 ppm RAL. The estimated costs of Alternative A (No Action) and Alternative B (MNR) are $4.5 million and $9.9 million, respectively. Capital costs, present worth of operation and maintenance (O&M) costs, and the total costs are listed in Table 11-8.

Table 11-8 Comparison of Costs for OU 3 Alternatives at the 1 ppm RAL

	Estimated Volume Removed or Treated (cubic yards)	Estimated PCB Mass Remediated (pounds)	Capital Cost ($ millions)	O&M Cost ($ millions)	Present Worth Total Cost ($ millions)
A – No Action	0	0	0	4.5	4.5
B – Monitored Natural Recovery	0	0	0	9.9	9.9
C1 – Dredging/Passive Dewatering/Off-Site Disposal	586,788	2,444	90.6	4.5	95.1
C2A – Dredging/Combined Passive Dewatering/Disposal Facility	586,788	2,444	39.4	4.5	43.9
C2B – Dredging/Passive Dewatering/Monofill	586,788	2,444	21.2	4.5	25.7
C2B – DD Incremental Cost	9,000	31	0.8	0.0	0.8
C3 – Dredging/Mechanical Dewatering/Off-Site Disposal	586,788	2,444	64.6	4.5	69.1
D – Dredge to a Confined Disposal Facility	586,788	2,444	48.0	4.5	52.5
E – Dredge and Vitrification	586,788	2,444	81.7	4.5	86.2
F – Dredging and Capping to Maximum Extent Practicable	170,418	2,444	58.4	4.5	62.9

Note:
Data are Table 7-7 of the FS and *White Paper No. 23 – Evaluation of Cost and Implementability of Alternative C2B for Operable Unit 3 and Operable Unit 4.* The white paper impacts only Alternative C2B and these costs were developed assuming capital costs were prorated based on the volume of sediment in OU 3 compared to the total for OU 3 and OU 4 combined (~9 percent) and that 50 percent of the O&M costs are applicable to OU 3.

11.1.3 Agency and Community Criteria for Operable Unit 3

<u>Agency Acceptance</u>

The State of Wisconsin has been actively involved in managing the resources of the River since before there was a federal Superfund law. These efforts have led to significant state knowledge and understanding of the River and Bay and of the contamination problems within those areas. As a result of this expertise, the WDNR has served as the lead agency responsible for assessing risks and conducting the RI/FS, which formed the basis for the Proposed Plan; the ROD for OU 1 and OU 2; and this ROD addressing OU 3, OU 4, and OU 5. As the lead agency, the WDNR has worked closely with the EPA to cooperatively develop this ROD. Both the WDNR and EPA support the selection of this remedy, as is evidenced by their joint issuance of this ROD.

Community Acceptance

Community acceptance considers whether the local community agrees with the EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. Community acceptance of the Proposed Plan was evaluated based on comments received at the public meetings and during the public comment period. More than 4,800 comments were received concerning the Proposed Plan. This ROD includes a Responsiveness Summary (see Appendix A). Comments that address issues common to OU 1 and OU 2, as well as to OU 3, OU 4, and OU 5, are discussed in the Responsiveness Summary attached to the OU 1 and OU 2 ROD.

11.2 Operable Unit 4 (De Pere to Green Bay)

Table 11-9 summarizes the comparative analysis for OU 4 alternatives and how each alternative meets, or does not meet, requirements for each of the nine criteria described above.

Table 11-9 OU 4 – De Pere to Green Bay Alternatives

Yes = Fully meets criterion Partial = Partially meets criterion No = Does not meet criterion	Alternative A No Action	Alternative B Monitored Natural Recovery	Alternative C1 Dredge with Off-Site Disposal	Alternative C2A Dredge with Off-Site Disposal	Selected Remedy Alternative C2B Dredge with Off-Site Disposal	Alternative C3 Dredge with Off-Site Disposal	Alternative D Dredge to a Confined Disposal Facility	Alternative E Dredge and Vitrification	Alternative F *In-Situ* Capping
1. Overall Protection of Human Health and the Environment	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Compliance with Applicable or Relevant and Appropriate Requirements	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Long-Term Effectiveness and Permanence	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Reduction of Toxicity, Mobility, or Volume Through Treatment	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Short-Term Effectiveness	No	No	Yes	Yes	Yes	Yes	Partial	Partial	Yes
6. Implementability	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Partial	Yes
7. Cost (millions of $)	$ 4.5	$ 9.9	$656.4	$169.3	$257.5*	$509.3	$500.9	$350.9	$352.9
8. Agency Acceptance	The WDNR has been the lead agency in developing the RI/FS and Proposed Plan. Both the WDNR and EPA support the selected alternative for this Operable Unit at the 1 ppm action level.								
9. Community Acceptance	The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary.								

* This remedy is combined with Alternative C2B in OU 3. The total cost for this combined remedy is $284 million. Estimated costs for the combined remedy are discussed in *White Paper No. 23 – Evaluation of Cost and Implementability of Alternative C2B for Operable Unit 3 and Operable Unit 4*, which is attached to this ROD. The estimated cost for OU 4 is $257.5 million.

11.2.1 Threshold Criteria for Operable Unit 4

Protection of Human Health and the Environment

The primary risk to human health associated with the contaminated sediment is consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. Protection of human health and the environment were evaluated by residual risk in surface sediment using five lines of evidence:

- Residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy
- Average PCB concentrations in surface water
- The projected number of years required to reach safe consumption of fish
- The projected number of years required to reach a surface sediment concentration protective of fish or other biota
- PCB loadings to Green Bay and total mass contained or removed

Each of these is discussed below.

Residual PCB Concentrations in Surficial Sediment and Surface Water

As shown in Table 11-10, substantial reductions in the average PCB concentration in surficial sediment and in surface water for OU 4 is achieved by Alternatives C1, C2A, C2B, C3, D, E, and F when compared to Alternatives A and B. Implementation of Alternative C1, C2A, C2B, C3, D, E, or F results in reduction in residual PCB concentrations in surface sediment from 3.11 ppm to 0.156 ppm using surface-weighted averaging when compared to Alternatives A and B (No Action and MNR). It is also estimated that surface water concentrations 30 years after remediation will be reduced from 21.08 ng/L to 0.42 ng/L for Alternatives C1, C2A, C2B, C3, D, E, and F relative to Alternatives A and B.

Table 11-10 Post-Remediation Sediment and Surface Water Concentrations in OU 4

Alternative	Post-Remediation SWAC (ppm)	Estimated Surface Water Concentrations 30 Years after Remediation (ng/L)
A, B	3.11	21.08
C1, C2A, C2B, C3, D, E, F	0.156	0.42

Notes:
SWAC – surface-weighted average concentration
Data are from FS Table 8-5B and Table 1 in *White Paper No. 11 – Comparison of SQTs, RALs, RAOs and SWACs for the Lower Fox River* of the OU 1 and OU 2 ROD.

Time Required to Achieve Acceptable Fish Tissue Concentrations

As shown in Table 11-11, substantial reductions in the time when humans could safely consume fish are achieved by Alternatives C1, C2A, C2B, C3, D, E, and F when compared to Alternatives A and B. The implementation of Alternative C1, C2A, C2B, C3, D, E, or F is expected to achieve acceptable fish tissue concentrations for recreational fishermen within 20 to 45 years and acceptable tissue concentrations for high-intake fish consumers within 59 years, as compared to more than 100 years for Alternatives A and B. It should be noted that because of limitations of modeling analysis, this relative comparison does not reflect how many years more than 100 would be required for natural recovery.

Table 11-11 Time to Achieve Acceptable Fish Tissue Concentrations for Walleye in OU 4

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C1, C2A, C2B, C3, D, E, F	Alternatives A, B
Walleye	Recreational Angler	RME Hazard Index of 1.0	20	>100
Walleye	High-intake Fish Consumer	RME Hazard Index of 1.0	30	>100
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	45	>100
Walleye	High-intake Fish Consumer	RME 10^{-5} cancer risk level	59	>100

Notes:
RME – reasonable maximum exposure
Data are from FS Table 8-14.

<u>Time Required to Achieve Surface Sediment Concentration Protective of Fish or Other Biota</u>

As shown in Table 11-12, substantial reductions in the time required to reach protective levels for ecological receptors are achieved by Alternatives C1, C2A, C2B, C3, D, E, and F relative to Alternatives A and B. For representative ecological receptors, implementation of Alternative C1, C2A, C2B, C3, D, E, or F is expected to achieve protective levels within 20 to 45 years as compared to more than 100 years for Alternatives A and B. Because of limitations of the modeling analysis, this relative comparison does not reflect how many years more than 100 would be required for natural recovery.

Table 11-12 Time Required to Achieve Protective Levels in Sediment for Representative Ecological Receptors in OU 4

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C1, C2A, C2B, C3, D, E, F	Alternatives A, B
Carp	Carnivorous bird	NOAEC	20	>100
Carp	Piscivorous mammal	NOAEC	45	>100
Sediment	Sediment invertebrate	TEL	37	>100

Notes:
NOAEC – No Observed Adverse Effects Concentration
TEL – threshold exposure limit
Data are from FS Table 8-16.

<u>PCB Loadings to Downstream Areas and Total Mass Contained or Removed</u>

Reduction of the PCB load transported from the Lower Fox River into Green Bay is a measure of the overall protection of human health and the environment. Reduced PCB loading from OU 4 will ultimately contribute to downstream reduction of concentrations of PCBs in sediment, water, and fish, thereby reducing risk to humans and ecological receptors in the River, Green Bay, and Lake Michigan. Implementation of Alternative C1, C2A, C2B, C3, D, E, or F is expected to reduce the estimates for releases from the River to Green Bay from the present range of 125 kg (276 pounds) to 221 kg (486 pounds) per year to a level of 1.7 kg (3.7 pounds) per year 30 years after completion of remediation, as compared to 75 kg (166 pounds) per year after 30 years for Alternatives A and B. Thus, Alternatives C1, C2A, C2B, C3, D, E, and F would provide a 98 percent reduction in loadings relative to Alternatives A and B.

Summary

Alternatives C1, C2A, C2B, C3, D, E, and F provide a substantially more protective remedy than do Alternatives A and B. Alternatives A and B are not protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4). Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provide a basis for invoking a waiver.

The ARAR discussion below is organized by the different operational components of the alternatives (Table 11-13), because various components are utilized in essentially the same manner for some alternatives and apply equally to those alternatives with a common component. There is additional discussion of compliance with ARARs in Section 14.2.

Table 11-13 Operational Components for OU 4 Alternatives

		Alternatives								
		A	**B**	**C1**	**C2A**	**C2B**	**C3**	**D**	**E**	**F**
Removal	Mechanical			X						
	Hydraulic				X	X	X	X	X	X
Dewatering	Mechanical						X			
	Passive			X	X	X		X	X	X
Sediment Treatment				*	*	*	*	*	X	*
Water Treatment				X	X	X	X	X	X	X
Transportation	Trucking			X		X***	X	X**	X	X
	Pipeline				X	X				
Disposal	Upland			X	X	X	X	X**		X
	In-water CDF							X**		
Beneficial Reuse of Sediments									X	
Capping										X

Note:
X: Required activity for alternative.
* Possible supplement.
** Upland disposal for this alternative includes approximately 3,742,800 cy of sediments with PCB concentrations less than 50 ppm and 240,800 cy of sediments with concentrations equal to or greater than 50 ppm. Due to capacity limitations, 2,136,700 cy of sediments with PCB concentrations less than 50 ppm will be disposed of in an in-water CDF.
*** Trucking would be minimal (disposal location is adjacent to the dewatering facility).

A description of the components listed in Table 11-13 follows:

- **Removal:** The removal technology utilized for Alternatives C1, C2A, C2B, C3, D, E, and F is dredging (although Alternative F also includes capping). The ARARs that directly relate to the removal of sediment from the River and Bay concern the protection of surface water (NR 322, 200, and 220 through 297). The surface water ARARs limit the discharge of PCBs into the receiving water bodies so that water quality is not adversely affected. These ARARs will be achieved by Alternatives C1, C2A, C2B, C3, D, E, and F. Dredge material will be moved to the dewatering facility by pipeline or barge.

- **Dewatering and Water Treatment:**

  - ♦ Mechanical dewatering would be utilized for Alternative C3. Discharge requirements (NR 200 and 220 through 297, WAC) are set forth for the discharge of water to POTWs and to navigable waters such as the River (NR 105 and 106, WAC). Discharges from prior remedial activities on the River provide an indication of the treatment requirements for discharging effluent water to the River or to a POTW. Another requirement covers stormwater discharge. A potentially important ARAR (NR 108, WAC) relates to the construction of a wastewater treatment facility specifically to treat water from remedial activities.

  - ♦ Passive dewatering ponds would be part of Alternatives C1, C2A, C2B, D, E, and F and would be constructed under the wastewater ARAR (NR 213, WAC), which is associated with wastewater treatment lagoons. Based on previous experience gained during the SMU 56/57 pilot dredging project, ARARs associated with passive dewatering lagoons are achievable.

- ***Ex-Situ* (Off-site) Treatment:** ARARs specific to vitrification technology (Alternative E) relate to the air emission and permitting requirements of thermal treatment units (40 CFR 701 and NR 400 through 499). In addition, the thermal unit must meet performance requirements in NR 157 for the efficient treatment of PCB-containing sediment. These ARARs would be met.

- **Transportation:** The likely method for transporting PCB-containing sediment to upland disposal locations for Alternatives C1, C3, D, and F is by trucking it to the disposal facility, although other transportation methods could be used if it is determined during design that there are better methods. Alternative C2B would involve moving sediment from the passive dewatering facility to the adjacent disposal site. Alternative C2A does not require disposal transportation, because the dredge material will be disposed of in the dewatering facility. Alternatives C2A and C2B would require use of a pipeline to convey the dredge slurry to the dewatering/disposal facility or to the dewatering facility. Alternative D would not require off-site transportation, because all removed sediments would be disposed of on site in a nearshore CDF. Alternative E would require trucking contaminated sediments to a treatment facility and trucking the treated (non-hazardous) materials to a site for beneficial or commercial reuse. ARARs and TBCs important to this process option include the requirements to prevent spills and releases of PCB materials (NR 140 and 157, WAC). Two ARARs applicable only to the trucking method include WDOT requirements for the shipping of PCB materials and NR 157 shipping requirements. ARARs and TBCs related to in-water transportation activities (i.e., piping) include the protection of surface water (NR 322, 200, and 220 through 297, WAC). Alternatives C1, C2A, C2B, D, E, and F will comply with these ARARs.

- **Disposal:** For Alternatives C1, C2A, C2B, C3, and F, contaminated sediment removed (i.e., dredged) from OU 4 will be disposed of at either an existing upland landfill or in a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs specific to this process option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series, WAC. For contaminated sediments with PCB concentrations equal to or greater than 50 ppm, disposal will comply with TSCA, 40 CFR Part 761. Alternative D would also have a relatively small portion (i.e., an estimated 2 percent) of dredged materials with concentrations equal to or greater than 50 ppm that would be disposed of at a TSCA-compliant upland landfill.

- **Capping:** For Alternative F, some sediments would be capped in place, primarily in the deeper portions of OU 4 outside of the navigation channel. This would require compliance with Section 10 of the Rivers and Harbors Act of 1899 (22 CFR 403) and with the Wisconsin Statutes Chapter 30 (defining riparian rights of upland owners which extend to the center of a stream). It is expected that these ARARs would be met.

11.2.2 Primary Balancing Criteria for Operable Unit 4

Long-Term Effectiveness and Permanence

Reduction of Residual Risk

Alternatives A and B result in a continuation of the degraded condition of the sediment and surface water quality of the De Pere to Green Bay Reach (OU 4) for at least more than 100 years. Alternatives A and B do not eliminate PCBs from the River and do not reduce PCB levels in fish to acceptable levels for the foreseeable future.

Alternatives C1, C2A, C2B, C3, D, E, and F reduce residual risk through removal or containment of an estimated 5,880,000 cy of sediments containing approximately 26,433 kg (58,150 pounds) of PCBs over an area of 1,030 acres. The implementation of Alternative C1, C2A, C2B, C3, D, E, or F is expected to reduce the time required to reach acceptable fish tissue concentrations for recreational fishermen to 20 to 45 years and for high-intake fish consumers to within 59 years when compared to Alternatives A and B (Table 11-11). It should be noted that because of limitations of modeling analysis, this relative comparison does not reflect how many years more than 100 would be required for natural recovery.

Adequacy of Controls

Alternatives A and B do not produce a reduction in human risk and exposure in the foreseeable future, unlike Alternatives C1, C2A, C2B, C3, D, E, and F. Additionally, fish consumption surveys indicate that 50 percent of anglers do not follow fish advisories. Therefore, existing institutional controls do not adequately reduce human exposure to PCBs from consumption of contaminated fish. In addition, institutional controls are not protective for ecological receptors (e.g., birds, mammals, and fish). Given the survey data, it is unlikely that these types of controls alone would be reliable in the long term to ensure human health and ecological protection. In effect, institutional controls by themselves are not effective for OU 4.

Alternatives C1, C2A, C2B, C3, D, and E provide for the removal of PCB-contaminated sediments in OU 4. Alternative F also removes a large portion of PCB-contaminated sediments and provides for an engineered cap over an estimated 40 percent of the surface area of the 1 ppm footprint of contaminated deposits in OU 4. Like Alternative B (MNR), Alternative F also requires institutional controls such as Site use restrictions in capped areas (e.g., prohibition of activities that disturb sediment). Although institutional controls would still be required for Alternatives C1, C2A, C2B, C3, D, E, and F, the risk to consumers of fish would be greatly reduced by these alternatives.

All alternatives would require institutional controls, such as fish consumption advisories and fishing restrictions, until remedial action objectives were met at a future date, but they are unlikely to require additional Site use restrictions after removal activities are completed.

All alternatives will require some degree of monitoring. Monitoring programs will be developed, as appropriate, for all phases of the project. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish.

Alternatives C1, C2A, C2B, C3, D, and F rely on engineering controls at the disposal facility. Properly designed and managed landfills provide proven, reliable controls for long-term disposal for Alternatives C1, C2A, C2B, C3, and F (which have off-site landfill disposal). Alternative F would also require a long-term operation and maintenance plan to ensure containment of PCBs in perpetuity. Alternative D would require on-site engineering controls at an in-water disposal facility. Long-term monitoring and maintenance are included in operation of the landfill and confined disposal facility. The final disposition of contaminated sediments is summarized in Table 11-14.

Table 11-14 Final Disposition of Contaminated Sediments in OU 4

	Alternatives (cubic yards)					
	A	**B**	**C1/C2A/C2B/C3**	**D**	**E**	**F**
Treated and residual disposal	0	0	0	0	5,879,529	0
Removed and disposed at upland (off-site) landfill	0	0	5,879,529	3,742,758	0	1,909,504
Removed and disposed at in-water, on-site CDF	0	0	0	2,136,771	0	2,136,771
Capped in place	0	0	0	0	0	1,833,253

Note:
Data are from FS Table 7-2.

Reliability of Controls

For Alternatives B, C1, C2A, C2B, C3, D, E, and F, fish consumption advisories and fishing restrictions will continue to provide some protection of human health until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or lifted. However, in the interim, these controls will provide only an uncertain measure of protection. Among these alternatives, sediment capping, sediment removal (dredging and excavation), and off-site disposal/treatment of removed sediments are all established technologies.

The capping portion of Alternative F relies upon proper design, placement, and maintenance of the cap in perpetuity for its effectiveness, continued performance, and reliability. A cap-integrity monitoring and maintenance program would provide reasonable reliability, although there are inherent challenges in monitoring and maintaining a cap in the River environment. The capping portion of Alternative F may not be as reliable as the removal alternatives because of the unknown potential for damage to the cap, potentially exposing PCBs. In addition, the capping component of Alternative F is vulnerable to a catastrophic flow event, such as might be seen during a 500-year flood or a dam failure. However, with proper design and maintenance, these risks can be minimized.

In general, Alternatives C1, C2A, C2B, C3, D, and E are the most reliable, because there is little or no additional long-term, on-site maintenance associated with the remedial work. These alternatives permanently remove the greatest amount of contaminated sediment and PCBs from the River and achieve the greatest reduction of the potential scour-driven resuspension of PCB-contaminated sediments. However, Alternative F is also considered to be sufficiently reliable.

Summary

Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, Alternatives C1, C2A, C2B, C3, D, E, and F are superior to Alternatives A and B because of the greater risk reduction and mass of PCBs removed from the River. Alternatives C1, C2A, C2B, C3, D, E, and F are similar to each other in terms of risk reduction, with Alternatives C1, C2A, C2B, C3, and E likely being the most effective over time. The Agencies' analysis of residual risk for each alternative is consistent with the NRC report recommendation to consider options to reduce risk and to consider residual risks associated with material left behind (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001).

Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction in toxicity, mobility, or volume of contaminants through treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

Alternatives A and B do not involve any containment or removal of contaminants from OU 4 sediments. Alternatives A and B rely on natural attenuation processes such as burial by cleaner sediments, biodegradation, bioturbation, and dilution to reduce concentrations of PCBs in sediments and surface water.

Natural degradation processes were not found to be effective in reducing PCB concentrations or toxicity in River sediments (FS Appendix F, "Dechlorination Memorandum"). Nevertheless, concentrations of PCBs in fish populations will respond slowly over time to slow natural decreases in concentrations in sediments and surface water due primarily to dilution and the burial of contaminated sediments by cleaner sediments.

For Alternative F, the mobility of the PCBs in capped areas (approximately 437 acres) would be reduced because these PCBs are sequestered under the cap. However, capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the PCBs under the cap. Under Alternative F, the mass of PCBs and the volume of contaminated sediments within OU 4 are permanently reduced because approximately 4,050,000 cy of sediment would be removed and approximately 1,830,000 cy would be contained under a cap in OU 4. A total of approximately 26,433 kg (58,150 pounds) of total PCBs would be removed or isolated from the ecosystem by this alternative. In addition, after construction of the remedy is completed, natural attenuation processes could provide additional reductions in PCB concentrations in the remaining sediments and surface water.

For Alternatives C1, C2A, C2B, C3, D, and E at OU 4, approximately 26,433 kg (58,150 pounds) of PCBs and 5,880,000 cy of contaminated sediments are permanently removed from the ecosystem. As for Alternative F, natural attenuation processes would provide additional reductions in PCB concentrations in the remaining sediments and surface water after construction of the remedy is completed.

Although Alternatives C1, C2A, C2B, C3, D, and F would permanently remove large volumes of PCBs from the River (thereby reducing their mobility), they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal (other than stabilization of the sediments for handling purposes) may not be cost-effective. Vitrification under Alternative E would reduce toxicity, mobility, and volume, and the glass aggregate product would be available for beneficial reuse.

Short-Term Effectiveness

Short-term effectiveness relates to the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation up until the time that remediation levels are achieved.

Length of Time Needed to Implement the Remedy

The implementation times are approximately 6 to 8 years for Alternatives C1, C2A, C2B, C3, D, E, and F (see Table 11-15). These estimates represent the estimated time required for mobilization, operation, and demobilization of the remedial work, but do not include the time required for long-term monitoring or operations and maintenance. These time estimates do take into consideration the fact that winter conditions will not allow for dredging (or capping) operations during the winter season. Alternatives A and B do not involve any active remediation and therefore require no time to implement. Alternative B would require monitoring until acceptable levels of PCBs are achieved in sediment, surface water, and fish.

Table 11-15 Time to Implement Alternatives for OU 4

Alternative	Years to Implement (rounded up to whole number)
A/B	0
C1	8
C2A/C2B	7
C3	6
D	8
E	8
F	6

Protection of the Community and Workers During Remedial Action

No construction activities are associated with the remediation of sediments for Alternatives A and B, so those alternatives neither increase nor decrease the short-term potential for direct contact with or ingestion and inhalation of PCBs from the surface water and sediments.

Community Protection: Access to sediment processing/transfer facilities and process and treatment areas under Alternatives C1, C2A, C2B, C3, D, E, and F will be restricted to authorized personnel. Controlling access to the dredging locations and sediment processing/transfer facilities, along with monitoring and engineering controls developed during the design phase, will minimize potential short-term risks to the community. The design will also provide for appropriate control of air emissions, noise, and light through the use of appropriate equipment that meets all applicable standards. Compliance with these design provisions will be monitored during construction, operation, and demobilization. Vehicular traffic associated with workers and the delivery of supplies will increase at the sediment processing and transfer facilities.

For Alternatives C1, C2A, C2B, C3, D, E, and F, work in the River will also be designed with provisions for control of air emissions, noise, and light. Work areas will be isolated (access-restricted), with an adequate buffer zone so that pleasure craft can safely avoid these areas. Environmental dredging in the River will be conducted at times and in ways to minimize disruption to River traffic. Targeted dredging will be sequenced and directed to ensure minimal impacts to navigation within the River. To help ensure that navigation is not impeded, the WDNR and EPA will consult with local authorities during the remedial design and construction phases regarding issues related to River uses and other remedy-related activities within OU 4. Discrete areas of the River will be subject to dredging and related activities over only short periods of time; once an area is dredged, dredging equipment will move to another area, thereby minimizing locational impacts.

Based on air monitoring for the SMU 56/57 demonstration project, air emissions at dredging sites and at land-based facilities are expected to be minimal. Nevertheless, community and worker protection would be considered relative to potential air monitoring requirements. Action levels will be established, monitoring conducted as required, and appropriate engineering control measures employed to ensure that any air releases do not exceed acceptable levels.

Vehicles used for the transportation of hazardous waste will be designed and operated in conformance with state and local regulations. The WDNR and EPA will provide the community and local government with the opportunity to provide input on plans related to the off-site transportation of hazardous wastes. This approach is consistent with the NRC recommendation to involve the local communities in risk management decisions (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001).

The WDNR and EPA believe that implementation of Alternatives C1, C2A, C2B, C3, D, E, and F would have little, if any, adverse impact on local businesses or recreational opportunities. Indeed, the WDNR and EPA believe that the remedy will have substantial positive economic impacts on local communities and will facilitate enhanced recreational activities in and along the River. To the extent that any adverse local impacts do occur, the WDNR and EPA expect that they will be short term and manageable. Moreover, the Agencies believe that any such impacts will be outweighed by the long-term benefits of the remediation on human health and the environment. Alternatives A and B involve sampling of OU 4, which would also have minimal to no impact.

Worker Protection: For Alternatives A and B, occupational risks to persons performing the sampling activities (for the 5-year reviews) will be unchanged from current levels. There is some minimal increase in occupational risk associated with Alternative B because of the greater degree of sampling involved in the River.

For Alternatives C1, C2A, C2B, C3, D, E, and F, potential occupational risks to Site workers from direct contact, ingestion, and inhalation of PCBs from the surface water and sediments, as well as routine physical hazards associated with construction work and working on water, are higher than for Alternatives A and B. For all alternatives, personnel will follow a Site-specific health and safety plan and OSHA health and safety procedures and wear the necessary personal protective equipment; therefore, no unacceptable risks would be posed to workers during the implementation of the remedies.

In summary, Alternatives C1, C2A, C2B, C3, D, E, and F would not pose significant risk to the nearby communities or Site workers. A short-term risk to the community and Site workers may be possible as a result of potential air emissions and noise from construction equipment, dewatering operations, and hauling activities. However, as successfully shown during the River demonstration dredging projects, these risks can be effectively managed or minimized by: (1) coordinating with and involving the community; (2) limiting work hours; (3) establishing buffer zones around the work areas; (4) using experienced contractors who would assist project design; and (5) giving careful consideration to the experience gained on other sediment remediation projects and applying that knowledge to this Site's specific circumstances. Alternatives A and B will also have minimal to no risk to workers or nearby communities.

Environmental Impacts of Remedy and Controls

Environmental impacts consist of PCB releases from removed sediment into the air and water. As successfully shown during the River demonstration dredging projects, environmental releases will be minimized during remediation by: (1) treating water prior to discharge; (2) controlling stormwater runon and runoff from staging and work areas; (3) utilizing removal techniques that minimize losses; and through (4) the possible use of silt curtains where necessary to reduce the potential downstream transport of PCBs.

Habitat impacts from Alternatives C1, C2A, C2B, C3, D, E, and F are expected to be minimal, as the benthic community should recover relatively quickly from dredging activities (see *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* attached to the OU 1 and OU 2 ROD). Additionally, dredging remediation can result in collateral benefits in the course of mitigation, including removal of other chemical contaminants (e.g., mercury and ammonia) and nuisance species, reintroduction of native species, aeration of compacted and anaerobic soils, and other enhancements to submerged habitats. For the capping portion of Alternative F, there could be similar effects on aquatic vegetation and benthic invertebrate and fish communities, but recovery of benthic invertebrate communities would likely be slower (relative to recovery from dredging) because of changes in the subaqueous habitat to sand and rock as well as decreases in organic content of the sediment.

Potential Adverse Environmental Impacts During Construction

Alternatives A and B do not involve construction activities associated with the River sediments. Continuing the existing limited sampling activities (under the No Action alternative) or increasing the monitoring program (under the MNR alternative) is not anticipated to have any adverse effect on the environment beyond that already caused by the PCB contamination of the sediments and the ongoing releases of PCBs from the sediments in OU 4. For Alternatives C1, C2A, C2B, C3, D, E, and F, the release of PCBs from the contaminated sediments into the surface water during construction (dredging and cap placement) will be controlled by operational practices (e.g., control of sediment removal rates, use of environmental dredges, and possible use of sediment barriers). Although precautions to minimize resuspension will be taken, it is likely that there could be a localized, temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens.

Analysis of results from projects at Deposit N and SMU 56/57 and comparison to yearly sediment resuspension rates, as well as resuspension quantities during yearly high-flow events, show the expected resuspension resulting from dredging to be well within the variability that normally occurs on a yearly basis. Analysis of results from other dredging projects indicates that releases from environmental dredging are relatively insignificant. The performance standards and monitoring program developed during design will ensure that dredging operations are performed consistent with the environmental and public health goals of the project. This was readily achieved on the Deposit N and SMU 56/57 projects and is expected to be feasible for other River dredging activities.

Dredging activities may result in short-term, temporary impacts to aquatic and wildlife habitat of Little Lake Butte des Morts, but as discussed in *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* (attached to the OU 1 and OU 2 ROD), recovery is expected to be rapid.

For Alternatives C1, C2A, C2B, C3, D, E, and F, there is the potential for transient impact from the temporary exposure of deeper, more highly contaminated sediments during excavation activities. This impact would be minimized by the quick completion of removal activities and (if needed) placement of a post-dredging sand cover as soon as practicable after the removal operations are complete.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as the availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Technical Feasibility

Both Alternatives A and B are technically feasible because no active measures other than continued sampling would be taken. Technical feasibility for Alternatives C1, C2A, C2B, C3, D, E, and F is discussed below in terms of the main components of the alternatives. Additional information is provided in the FS.

Sediment Processing/Transfer Facilities: Alternatives C1, C2A, C2B, C3, D, E, and F require sediment processing/transfer facilities. At these facilities, the transfer, dewatering, and stabilization of dredged material would be conducted. Each of these activities is considered a readily implementable, commonly engineered activity. Design of sediment processing/transfer facilities will include requirements for the control of light, noise, air emissions, and water discharges.

The WDNR and EPA have not determined the location of the sediment processing/transfer facilities. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. In preparing the cost estimate in the FS, the WDNR and EPA assumed a number of upland staging and access areas in the cities of De Pere and Green Bay. These facilities (wherever located) would be temporary and removed after completion of the active remedial activities.

Removal: Alternatives C1, C2A, C2B, C3, D, E, and F require the dredging of contaminated sediments. Dredging of sediments is a readily implementable and environmentally effective engineering activity. Two concerns are relevant to whether sediments can be dredged effectively: (1) resuspension and releases during dredging, and (2) resulting residual contaminant concentrations that may remain in sediments after dredging is completed. Regarding resuspension, environmental dredges have been shown to generally not release significant quantities of contaminants during removal operations. The type of dredging equipment (mechanical and/or hydraulic) will be selected during the remedial design on the basis of what is the most appropriate equipment for the specific conditions in the River. Silt screens or other barriers, as appropriate, could further assist in limiting downstream migration of PCBs and may be used as well. Regarding post-dredging residual contaminant concentrations, comparable projects indicate that achieving the 1 ppm action level in remaining sediments is readily achievable. The Lower Fox River SMU 56/57 dredging project achieved a 96 percent reduction in the average concentration of contaminated sediments targeted for removal. This outcome is consistent with results for other dredging projects having similar site conditions (see Appendix B of the FS, and Hudson River White Paper ID 312663, “Post-Dredging PCB Residuals”).

Dewatering: Alternatives C1, C2A, C2B, C3, D, E, and F would require the removal of excess water from dredged sediments. Either mechanical or passive dewatering would be used for this purpose. These are conventional technologies and are readily implementable and effective.

Water Treatment: Conventional water treatment technologies for dredge water have been proven commonly reliable and are readily implementable and effective.

Capping: Alternative F includes capping in areas that are acceptable for capping. Capping is not acceptable in navigation channels, in areas where a cap may interfere with infrastructure (e.g., pipelines, utility easements, bridge piers), in areas where PCB concentrations are equal to or greater than 50 ppm, and in areas with shallower water (e.g., where a cap would result in water depths less than 3 feet). The placement of capping materials is a readily implementable engineering activity. Sand and/or fine-grained materials may be utilized for capping. Clean sand placed over contaminated deposits would result in a new sediment bed surface that is essentially without contamination initially. The type of material (e.g., texture/size and sorting), thickness of the isolation cap, and armoring requirements will need to be determined on a location-specific basis. Recent climate models indicate that Lake Michigan water levels could decrease by 3 feet by 2050 and 4.5 feet by 2090, below historical low water levels. Therefore, decisions concerning capping should consider potential future declines in Lake Michigan water levels which would in turn affect levels within the Lower Fox River and Green Bay.

Post-Dredging Sand Cover: The selected alternative envisions an option of limited backfilling (see the discussion of capping as a contingent remedy in Sections 13.4 through 13.7). The placement of a sand backfill is a readily implementable engineering activity. Sand or other materials, as appropriate, may be utilized for backfill. This "residual cap" is defined as placement of a thin cap layer over a residual sediment contamination left behind following dredging. Residual capping serves to dilute this contaminated sediment and speed up the natural recovery process. Residual caps are not designed as isolation caps. An example of a residual cap is the material placed at the SMU 56/57 demonstration project.

Transportation: Different dredging alternatives have different transportation requirements (see Table 11-13).

For Alternatives C1, C2A, C2B, C3, D, and E, dredged materials may be transported in-River to sediment processing/transfer facilities or a nearshore CDF using barges or pipelines. These are considered readily implementable engineering activities.

For Alternatives C2A and C2B, an on-land pipeline to the dewatering facilities or dewatering/disposal facilities would be required. For Alternative C2B, trucks, or possibly some other method, would serve for transferring the dewatered sediments from the dewatering location to the adjacent disposal facility.

For Alternatives C1, C3, E, and F, off-site transportation of dredged materials to disposal facilities would be by truck, rail, and/or barge. These forms of transportation are routine engineering activities that have been employed at many Superfund sites and are technically implementable. The WDNR and EPA will comply with all legal regulatory requirements for transporting both hazardous and non-hazardous wastes.

Disposal: Off-site disposal is a common activity at many Superfund sites. The number and location of off-site disposal facilities will be based on dredged material volume, transportation, and cost considerations. It is expected that appropriate disposal will be in the Fox River Valley area.

Alternatives C1, C2A, C2B, C3, and F all include upland disposal options. Alternative D uses an in-water confined disposal facility for disposal. These are conventional technologies and readily implementable. Under Alternative F, approximately 40 percent of the surface area of the 1 ppm footprint could be capped *in situ*. For the areas that will be capped, it is considered technically achievable. It should be noted that certain areas are not amenable to capping, as noted above in the Capping discussion.

Alternative E, the *ex-situ* treatment alternative of vitrification, was determined to be technically feasible. As discussed in the FS, this alternative does require reuse of residual materials after treatment. For purposes of this ROD, it is assumed that there will a beneficial reuse of the residual material and an associated value (range of $2 to $25 per ton) and, as a consequence, there is no disposal cost associated with this alternative.

Treatment: Alternative E includes thermal treatment by vitrification and is technically implementable to meet cleanup goals.

Administrative Feasibility

Alternatives A and B require no active measures. All alternatives include an administrative requirement for fish consumption advisories. Because fish consumption advisories are already in place, this requirement is already met and would continue even under the No Action alternative. Alternatives C1, C2A, C2B, C3, D, E, and F are somewhat more difficult to implement in terms of administrative feasibility because of the need to site a pipeline and the sediment processing/transfer facilities, to address the associated real property issues, and to make arrangements to utilize the River with minimal interruption of boat traffic.

Sediment Processing/Transfer Facilities: For Alternatives C1, C2A, C2B, C3, D, E, and F, the transfer facilities, constructed on land adjacent to or in the River, are considered “on site” for the purposes of the permit exemption under CERCLA Section 121(e), although any such facilities will comply with the substantive requirements of any otherwise necessary federal or state permits.

Removal: Operations under these alternatives will have to be performed in conformance with the substantive requirements of regulatory programs implemented by the USACE under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. In addition, discharges during remediation will conform to Wisconsin Statutes and substantive WDNR regulations related to dredging and maintaining water quality.

Disposal: Identifying a local landfill for disposal of dredged sediments from OU 4 is feasible. This would have to be coordinated with local authorities, consistent with appropriate ARARs.

Capping and CDF: For Alternatives D and F, consideration of riparian rights would require use/access agreements with property owners of land adjacent to the riverbed. These considerations would be addressed during the design phase.

Treatment: Alternative E is administratively feasible. Air emissions permits would be required if sediments are treated off site.

Availability of Services and Materials: For Alternatives A and B, all needed services and materials are available. For the Alternatives C1, C2A, C2B, C3, D, E, and F, equipment and personnel related to dredging and materials handling (e.g., sediment dewatering) are commercially available. Technology and associated goods and services for capping or a post-dredging sand cover, upland landfill, or CDF construction are locally available.

Cost

Cost includes estimated capital and annual O&M costs, as well as total capital cost. Present-worth cost is the total capital cost and O&M costs of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of –30 to +50 percent. (This is a standard assumption in accordance with EPA CERCLA guidance.)

The estimated costs range from $4.5 million for Alternative A to $656 million for Alternative C1. For Alternatives C1, C2A, C2B, C3, D, E, and F, the estimated cost of the capital and O&M

costs range from approximately $170 million for Alternative C2A to $656 million for Alternative C1. Capital costs, present worth of O&M costs, and the total costs are listed in Table 11-16.

Table 11-16 Comparison of Present Worth Costs for OU 4 Alternatives at the 1 ppm RAL

	Estimated Volume Removed or Treated (cubic yards)	Estimated PCB Mass Remediated (pounds)	Capital Cost ($ millions)	O&M Cost ($ millions)	Present Worth Total Cost ($ millions)
A – No Action	0	0	0	4.5	4.5
B – Monitored Natural Recovery	0	0	0	9.9	9.9
C1 – Dredging/Passive Dewatering/Off-Site Disposal	5,879,529	58,150	651.9	4.5	656.4
C2A – Dredging/Combined Passive Dewatering/ Disposal Facility	5,879,529	58,150	164.8	4.5	169.3
C2B – Dredging/Passive Dewatering/Monofill	5,879,529	58,150	253.0	4.5	257.5
C3 – Dredging/Mechanical Dewatering/Off-Site Disposal	5,879,529	58,150	504.8	4.5	509.3
D – Dredge to a Confined Disposal Facility	5,879,529	58,150	496.4	4.5	500.9
E – Dredge and Vitrification	5,879,529	58,150	346.4	4.5	350.9
F – Dredging and Capping to Maximum Extent Practicable	4,046,276	58,150	348.4	4.5	352.9

Note:
Data are from Table 7-8 of the FS and *White Paper No. 23 – Evaluation of Cost and Implementability of Alternative C2B for Operable Unit 3 and Operable Unit 4.* The white paper impacts only Alternative C2B and these costs were developed assuming total costs were prorated based on the volume of sediment in OU 4 compared to the total for OU 3 and OU 4 combined (~91 percent) and that 50 percent of the O&M costs are applicable to OU 4. Costs listed here exclude costs associated with Bayport closure.

11.2.3 Agency and Community Criteria for Operable Unit 4

Agency Acceptance

The State of Wisconsin has been actively involved in managing the resources of the River since before there was a federal Superfund law. These efforts have led to significant state knowledge and understanding of the River and Bay and of the contamination problems within those areas. As a result of this expertise, the WDNR has served as the lead agency responsible for assessing risks and conducting the RI/FS, which formed the basis for the Proposed Plan; the ROD for OU 1 and OU 2; and this ROD addressing OU 3, OU 4, and OU 5. As the lead agency, the WDNR has worked closely with the EPA to cooperatively develop this ROD. Both the WDNR and EPA support the selection of this remedy, as is evidenced by their joint issuance of this ROD.

Community Acceptance

Community acceptance considers whether the local community agrees with the EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. Community acceptance of the Proposed Plan was evaluated based on comments received at the public meetings and during the public comment period. More than 4,800 comments were received concerning the Proposed Plan. This ROD includes a Responsiveness Summary (see Appendix A). Comments that address issues common to OU 1 and OU 2, as well as to OU 3, OU 4, and OU 5, are discussed in the Responsiveness Summary attached to the OU 1 and OU 2 ROD.

11.3 Operable Unit 5 (Green Bay)

Table 11-17 summarizes the comparative analysis for OU 5 alternatives and how each alternative meets, or does not meet, requirements for each of the nine criteria described above. Although seven alternatives (A through G) were initially considered for the Bay, Alternatives E and F were not carried forward for detailed evaluation because of issues associated with the technology or implementation. Therefore, the alternatives considered for the Bay are A, B, C, D, and G.

Table 11-17 OU 5 – Green Bay Alternatives

Yes = Fully meets criterion Partial = Partially meets criterion No = Does not meet criterion	Alternative A No Action	Selected Alternative Alternative B Monitored Natural Recovery	Alternative C Dredge with Off-Site Disposal	Alternative D Dredge to a Confined Disposal Facility	Alternative G Dredge to a Confined Aquatic Disposal Facility
1. Overall Protection of Human Health and the Environment	No	No	No	No	No
2. Compliance with Applicable or Relevant and Appropriate Requirements	No	Yes	No	No	No
3. Long-Term Effectiveness and Permanence	No	Partial	Yes	Yes	Yes
4. Reduction of Toxicity, Mobility, or Volume Through Treatment	No	No	Yes	Partial	Partial
5. Short-Term Effectiveness	No	Partial	Partial	Partial	Partial
6. Implementability	Yes	Yes	No	No	No
7. Cost (millions of $)	18	39.6	11–507.2	166.5–2,454.1	124–2,107.4
8. Agency Acceptance	The WDNR has been the lead agency in developing the RI/FS and Proposed Plan. Both the WDNR and EPA support the selected alternative of MNR for this OU.				
9. Community Acceptance	The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary.				

11.3.1 Threshold Criteria for Operable Unit 5

Protection of Human Health and the Environment

The primary risk to human health associated with the contaminated sediment is consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. Protection of human health and the environment were evaluated by residual risk in surface sediment using three lines of evidence:

- Residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy
- The projected number of years required to reach safe consumption of fish
- The projected number of years required to reach a surface sediment concentration protective of fish or other biota

Each of these is discussed below.

Residual PCB Concentrations in Surficial Sediment

The estimated SWACs for different Green Bay zones (2, 3A, 3B, and 4; see Figure 1-2) in combination with a 1 ppm PCB action level for the River are summarized in Table 11-18.

Table 11-18 Estimated PCB Surface-Weighted Average Concentrations (SWACs) for OU 5 by Zone

	SWAC Based on Action Levels (ppm)		
Zone	**No Action/MNR**	**5 ppm**	**1 ppm**
2	1.159	1.025	0.476
3A	0.320	0.274	0.274
3B	0.561	0.551	0.551
4	0.073	0.063	0.063

Note:
Data are from FS Table 5-5.

Using the approach outlined in Technical Memorandum 2f, the average surface concentration in the 0- to 2-cm range in all of Green Bay is 0.351 ppm. Based on the alternative method identified in *White Paper No. 18 – Evaluation of an Alternative Approach of Calculating Mass, Sediment Volume, and Surface Concentrations in Operable Unit 5, Green Bay* (attached to this ROD), the overall average concentration in the 0- to 2-cm range for the Bay is 0.353 ppm. While remediating Zone 2 to a 1 ppm remedial action level has the effect of reducing the SWAC in Zone 2 by 60 percent, there appears to be little risk reduction associated with this effort. Remediating zones 3A, 3B, and 4 to a 1 ppm remedial action level has no apparent impact on the average concentrations for those zones.

Time Required to Achieve Acceptable Fish Tissue Concentrations

For both cancer and noncancer risk for recreational anglers and high-intake fish consumers, it would take more than 100 years to reach acceptable human health thresholds for walleye for representative human receptors (see Table 11-19). This is true for all action levels evaluated for Green Bay zones in combination with the River action level of 1 ppm.

Table 11-19 Time to Achieve Acceptable Fish Tissue Concentrations for Walleye in OU 5 at a 1 ppm River RAL

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve Based on Bay Action Levels	
			1 ppm	No Action/ MNR
Walleye	Recreational Angler	RME Hazard Index of 1.0	>100	>100
Walleye	High-intake Fish Consumer	RME Hazard Index of 1.0	>100	>100
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	>100	>100
Walleye	High-intake Fish Consumer	RME 10^{-5} cancer risk level	>100	>100

Notes:
RME – reasonable maximum exposure
Data are from FS Table 8-15.

<u>Time Required to Achieve Surface Sediment Concentration Protective of Fish or Other Biota</u>

As shown in Table 11-20, the estimated time to achieve protective standards for representative receptor mammals (mink) would be more than 100 years for all cleanup levels evaluated for OU 5 (No Action/MNR and 1 ppm) in combination with a River remedial action level of 1 ppm. The estimated time to achieve protective standards for representative receptor bird species (Forster's tern and bald eagle) varies by Bay zone and receptor for cleanup levels evaluated for OU 5 (No Action/MNR and 1 ppm) in combination with a River remedial action level of 1 ppm. These estimated time frames range from less than a year for Forster's tern deformities (LOAEC) in all zones to more 100 years for bald eagle deformities (NOAEC) in all zones.

Table 11-20 Time Required to Achieve Protective Levels in Sediment for Representative Ecological Receptors in OU 5 at a 1 ppm River RAL

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve Based on Bay Action Levels	
			1 ppm	No Action/ MNR
Zone 2				
Alewife	Forster's Tern deformity	LOAEC	< 1	< 1
Alewife	Forster's Tern hatch success	LOAEC	< 1	< 1
Alewife	Forster's Tern hatch success	NOAEC	3	23
Alewife	Forster's Tern deformity	NOAEC	30	> 100
Walleye	Bald Eagle deformity	NOAEC	> 100	> 100
Walleye	Mink	NOAEC	> 100	> 100
Alewife	Mink	NOAEC	> 100	> 100
Zone 3A				
Alewife	Forster's Tern deformity	LOAEC	< 1	< 1
Alewife	Forster's Tern hatch success	LOAEC	< 1	< 1
Alewife	Forster's Tern hatch success	NOAEC	< 1	< 1
Alewife	Forster's Tern deformity	NOAEC	11	43
Walleye	Bald Eagle deformity	NOAEC	> 100	> 100
Walleye	Mink	NOAEC	> 100	> 100
Alewife	Mink	NOAEC	> 100	> 100
Zone 3B				
Alewife	Forster's Tern deformity	LOAEC	NC	< 1
Alewife	Forster's Tern hatch success	LOAEC	NC	< 1
Alewife	Forster's Tern hatch success	NOAEC	NC	< 1
Alewife	Forster's Tern deformity	NOAEC	NC	32
Walleye	Bald Eagle deformity	NOAEC	NC	> 100
Walleye	Mink	NOAEC	NC	> 100
Alewife	Mink	NOAEC	NC	> 100
Zone 4				
Alewife	Forster's Tern deformity	LOAEC	NC	< 1
Alewife	Forster's Tern hatch success	LOAEC	NC	< 1
Alewife	Forster's Tern hatch success	NOAEC	NC	< 1
Alewife	Forster's Tern deformity	NOAEC	NC	5
Walleye	Bald Eagle deformity	NOAEC	NC	> 100
Walleye	Mink	NOAEC	NC	> 100
Alewife	Mink	NOAEC	NC	> 100

Notes:
LOAEC – Lowest Observed Adverse Effects Concentration
NOAEC – No Observed Adverse Effects Concentration
NC – not considered
Data are from FS Table 8-17.

Summary

There is no reduction in time to reach human health representative thresholds for OU 5 for the selected RAL of 1 ppm for the River combined with action levels evaluated for OU 5 (1 ppm and No Action/MNR). There would also be no reduction in time to reach ecological thresholds, except for certain piscivorous birds.

Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP § 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4). Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provide a basis for invoking a waiver.

The ARAR discussion below is organized by the different operational components of the alternatives (Table 11-21), because various components are utilized in essentially the same manner for some alternatives and apply equally to those alternatives with a common component. There is additional discussion of compliance with ARARs in Section 14.2.

Table 11-21 Operational Components for OU 5, Alternatives for Zones 2, 3A, and 3B[1]

		Alternatives				
		A	B	C*	D	G
Removal (mechanical or hydraulic dredging)				X	X	X
Passive Dewatering				X	X	X
Water Treatment				X	X	X
Transportation (trucking)				X		X
Disposal	Upland**			X**		
	In-water CDF				X	
	CAD					X

Notes:
X: Required activity for alternative.
* Alternative C was evaluated only for zones 2 and 3A of OU 5.
** Upland disposal was considered only for a 5 ppm action level for Zone 2 because volumes for lower action levels would be too large for off-site disposal (i.e., 29 million cy, which would be 28 percent of the capacity of all existing Wisconsin landfills).
[1] Only Alternatives A and B were evaluated for Zone 4.

A description of the components listed in Table 11-21 follows.

- **Removal:** The removal technology evaluated for Green Bay zones 2, 3A, and 3B is mechanical dredging. The ARARs that directly relate to the removal of sediment from the River and Bay concern the protection of surface water (NR 322, 200, and 220 through 297). The surface water ARARs limit the discharge of PCBs into the receiving water bodies so that water quality is not adversely affected. These ARARs will be achieved by Alternatives C, D, and G.

- **Transportation:** The likely method for transporting PCB-containing sediment to upland disposal locations under Alternative C (evaluated for zones 2 and 3A) is by trucking it to the disposal facility, although other transportation methods could be used if it is determined during design that there are better methods. ARARs and TBCs important to this process option include the requirements to prevent spills and releases of PCB materials (NR 140 and 157, WAC). Two ARARs applicable only to the trucking method include WDOT requirements for the shipping of PCB materials and NR 157 shipping requirements. ARARs and TBCs related to in-water transportation activities (i.e., piping) include the protection of surface water (NR 322, 200, and 220 through 297, WAC). Alternatives C and G will comply with these ARARs.

- **Disposal:** For Alternative C, contaminated sediment removed (i.e., dredged) from zones 2 and 3B of OU 5 would be disposed of at either an existing upland landfill or in a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs specific to this process option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series as well as NR 157, WAC requirements. For Alternatives D and G, Wisconsin Statutes Chapter 289 on obtaining lakebed and riverbed grants from the Legislature and riparian landowners would be met. Sediment in any of the Green Bay zones is not expected to have PCB concentrations equal to or greater than 50 ppm. Therefore, although TSCA, 40 CFR Part 761 is an ARAR for the River portion of the Site, it is not an ARAR for the Bay.

11.3.2 Primary Balancing Criteria for Operable Unit 5

Long-Term Effectiveness and Permanence

Reduction of Residual Risk

Alternatives A, B, C, D, and G for OU 5 result in a continuation of the existing condition of the sediment and surface water quality for more than 100 years (the limit of modeling estimates).

It is possible that there is upwards of approximately 89,600,000 cy of sediment containing an estimated mass of 36,870 kg (81,100 pounds) of PCBs above the 0.5 ppm Bay RAL in the Bay. It is possible that there is upwards of approximately 29,300,000 cy of sediment with an approximate PCB mass of 29,770 kg (65,500 pounds) at the 1 ppm RAL (FS Tables 7-2 and 7-3). None of the alternatives appears to significantly reduce residual risk through removal or containment. Based on modeling estimates, there is no reduction in time required to reach acceptable fish tissue concentration ranges for any of the alternatives.

Adequacy of Controls

None of the alternatives indicates recovery of OU 5. Alternatives C, D, and G provide for the removal or containment of PCB-contaminated sediments in OU 5.

All alternatives would require institutional controls, such as fish consumption advisories and fishing restrictions, until remedial action objectives were met at a future date, but they are unlikely to require additional Site use restrictions after removal activities are completed; however, Alternative G also requires institutional controls such as Site use restrictions in disposal areas.

All alternatives will require some degree of monitoring. Monitoring programs will be developed, as appropriate, for all phases of the project.

Alternatives C, D, and G rely on engineering controls at the disposal facility. Properly designed and managed landfills provide proven, reliable controls for long-term disposal for Alternative C (which has off-site landfill disposal). Alternative G would also require a long-term operation and maintenance plan to ensure containment of PCBs in perpetuity. Alternative D would require on-site engineering controls at an in-water disposal facility. Long-term monitoring and maintenance are included in operation of the landfill, confined disposal facility, or confined aquatic disposal facility.

Reliability of Controls

For all alternatives, fish consumption advisories and fishing restrictions will continue to provide some protection of human health until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or lifted. However, in the interim, these controls will provide only an uncertain measure of protection.

Summary

Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, and given the limited ability of modeling to estimate recovery times, the alternatives provide effectively the same level of long-term effectiveness and permanence.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction in toxicity, mobility, or volume of contaminants through treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of contamination present.

Alternatives A and B do not involve any containment or removal of contaminants from OU 5 sediment. Alternatives A and B rely exclusively on natural attenuation processes such as burial by cleaner sediments, biodegradation, bioturbation, and dilution to reduce concentrations of PCBs in sediment and surface water.

Natural degradation processes were not found to be effective in reducing PCB concentrations or toxicity in River sediments (FS Appendix F, "Dechlorination Memorandum"). Nevertheless, concentrations of PCBs in fish populations will respond slowly over time to slow natural decreases in concentrations in sediments and surface water due primarily to dilution and, to a lesser degree, the burial of contaminated sediments by cleaner sediments.

For Alternatives C, D, and G, the mass of PCBs and volume of contaminated sediment in OU 5 are permanently reduced in mobility because for action levels of 5 and 0.5 ppm, volumes ranging from 4 million to 90 million cy of contaminated sediment containing a total PCB mass of approximately 6,360 to 36,775 kg (14,000 to 81,000 pounds) would be removed from the ecosystem and contained.

Although Alternatives C, D, and G would permanently remove large volumes of PCBs from the Bay (thereby reducing their mobility), they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material that would be removed, treatment of the dredged material prior to off-site disposal would likely not be cost-effective.

Short-Term Effectiveness

Short-term effectiveness relates to the length of time needed to implement an alternative and the risks the alternative poses to workers, residents, and the environment during implementation up until the time that remediation levels are achieved.

Length of Time Needed to Implement the Remedy

Table 11-22 summarizes estimated implementation times for Alternatives C, D, and G at zones 2, 3A, and 3B in OU 5. (Alternatives C, D, and G were not evaluated for Zone 4.) These estimates represent the estimated time required for mobilization, operation, and demobilization of the remedial work, but do not include the time required for long-term monitoring or operations and maintenance. Alternatives A and B do not involve any active remediation and therefore require no time to implement.

Table 11-22 Time to Implement Alternatives (for 0.5 to 5 ppm Action Levels) for OU 5 Zones 2, 3A, and 3B

Alternative	Years – Zone 2 Action Levels, ppm			Years – Zone 3A Action Levels, ppm			Years – Zone 3B Action Levels, ppm		
	0.5	1	5	0.5	1.0	5.0	0.5	1.0	5.0
A/B	0			0			0		
C	NE	NE	1.1	NE	<1	NE	NE	NE	NE
D	8.2	8.1	1.1	4.5	NE	NE	12	NE	NE
G	10.2	10.1	2.1	6.5	NE	NE	16	NE	NE

Note:
NE – not evaluated

Protection of the Community and Workers During Remedial Action

No construction activities are associated with the remediation of sediments for Alternatives A and B, so those alternatives neither increase nor decrease the short-term potential for direct contact with or ingestion and inhalation of PCBs from the surface water and sediments.

Community Protection: Access to sediment processing/transfer facilities and process and treatment areas for Alternatives C, D, and G will be restricted to authorized personnel. Controlling access to the dredging locations and sediment processing/transfer and on-site disposal facilities, along with monitoring and engineering controls developed during the design phase, will minimize potential short-term risks to the community. The design will also provide for appropriate control of air emissions, noise, and light through the use of appropriate equipment that meets all applicable standards. Compliance with these design provisions will be monitored during construction, operation, and demobilization. Vehicular traffic associated with workers and the delivery of supplies will increase at the sediment processing and transfer facilities. These effects are likely to be minimal, in part because the transportation of sediments for disposal (Alternative C only) will take place within the River area.

For Alternatives C, D, and G, work in the Bay will also be designed with provisions for control of air emissions, noise, and light. Work areas will be isolated (access-restricted), with an adequate buffer zone so that pleasure craft can safely avoid these areas. Environmental dredging in OU 5 would be conducted at times and in ways to minimize disruption to Bay activities or navigation traffic. The WDNR and EPA would consult with local authorities during remedial design and construction phases on issues related to Bay uses and other remedy-related activities within OU 5.

Based on air monitoring for the SMU 56/57 demonstration project, air emissions at dredging sites and at land-based facilities are expected to be minimal. Action levels will be established, monitoring conducted as required, and appropriate engineering control measures employed to ensure that any air releases do not exceed acceptable levels.

Vehicles used for the transportation of hazardous waste will be designed and operated in conformance with state and local regulations. The WDNR and EPA will provide the community and local government with the opportunity to provide input on plans related to the off-site transportation of hazardous wastes. This approach is consistent with the NRC recommendation to involve the local communities in risk management decisions (*A Risk Management Strategy for PCB-Contaminated Sediment*, NRC, 2001).

The WDNR and EPA believe that implementation of Alternatives C, D, and G would have little, if any, adverse impact on local businesses or recreational activities. To the extent that any adverse local impacts do occur, the WDNR and EPA expect they will be short term and manageable. Moreover, the Agencies believe that any such impacts will be outweighed by the long-term benefits of the remediation on human health and the environment.

Worker Protection: For Alternatives A and B, occupational risks to persons performing the sampling activities (for the 5-year reviews) will be unchanged from current levels. There is some minimal increase in occupational risk associated with Alternative B because of the greater degree of sampling involved in the Bay.

For Alternatives C, D, and G, potential occupational risks to Site workers from direct contact, ingestion, and inhalation of PCBs from the surface water and sediments, as well as routine physical hazards associated with construction work and working on water, are higher than for Alternatives A and B. Personnel will follow a Site-specific health and safety plan and OSHA health and safety procedures and wear the necessary personal protective equipment; therefore, no unacceptable risks would be posed to workers during implementation of the remedy. Worker protection for Alternatives A and B would be relatively less than for Alternatives C, D, and G, which involve more construction activities.

In summary, the Alternatives C, D, and G would not pose significant risk to the nearby communities. A short-term risk to the community and Site workers may be possible as a result of potential air emissions and noise from construction equipment, dewatering operations, and hauling activities. However, as successfully shown during the River demonstration dredging projects, these risks can be effectively managed or minimized by: (1) coordinating with and involving the community; (2) limiting work hours; (3) establishing buffer zones around the work areas; (4) using experienced contractors who would assist project design; and (5) giving consideration to experience gained on other sediment remediation projects and applying that knowledge to this Site's specific circumstances.

<u>Environmental Impacts of Remedy and Controls</u>

Environmental impacts consist of PCB releases from removed sediment into the air and water. As successfully shown during the River demonstration dredging projects, environmental releases will be minimized during remediation by: (1) treating water prior to discharge; (2) controlling stormwater runon and runoff from staging and work areas; (3) utilizing removal techniques that minimize losses; and through (4) the possible use of silt curtains where necessary to reduce the potential downstream transport of PCBs.

Habitat impacts from Alternatives C, D, and G are expected to be minimal, as the benthic community should recover relatively quickly from dredging activities. Additionally, dredging remediation can result in collateral benefits in the course of mitigation, including removal of nuisance species, reintroduction of native species, aeration of compacted and anaerobic soils, and other enhancements to submerged habitats. For the in-water disposal portion of Alternatives D and G, habitat would be impacted.

<u>Potential Adverse Environmental Impacts During Construction</u>

Alternatives A and B do not involve construction activities associated with the Bay sediments. Continuing the existing limited sampling activities (under the No Action alternative) or increasing the monitoring program (under the MNR alternative) is not anticipated to have any adverse effect on the environment beyond that already caused by the PCB contamination of the sediments and the ongoing releases of PCBs from the sediments in OU 5. For Alternatives C, D, and G, the release of PCBs from the contaminated sediments into the surface water during construction (dredging and cap placement) will be controlled by operational practices (e.g., control of sediment removal rates, use of environmental dredges, and possible use of sediment barriers). Although precautions to minimize resuspension will be taken, it is likely that there could be a localized, temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens. Analysis of results from projects at Deposit N and SMU 56/57 and comparison to yearly sediment resuspension rates, as well as resuspension quantities during yearly high-flow events, show the expected resuspension resulting from dredging to be well within the variability that normally occurs on a yearly basis. Analysis of results from other dredging projects indicates that releases from environmental dredging are relatively insignificant (substantially less than 1 percent of the mass of contaminants). The performance standards and monitoring program developed during design will ensure that dredging operations are performed consistent with the environmental and public health goals of the project. This was readily achieved on the Deposit N and SMU 56/57 projects and is expected to be feasible for Bay dredging activities.

Dredging activities could result in short-term temporary impacts to aquatic and wildlife habitat of OU 5 but, as discussed below and in *White Paper No. 8 – Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River* (attached to the OU 1 and OU 2 ROD), recovery is expected to be rapid.

For Alternatives C, D, and G, there is the potential for transient impact from the temporary exposure of deeper, more highly contaminated sediments during excavation activities. This impact would be minimized by the quick completion of removal activities and (if needed) placement of a post-dredging sand cover as soon as practicable after the removal operations are complete.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Technical Feasibility

Both Alternatives A and B are technically feasible because no active measures other than continued sampling would be taken. Technical feasibility for Alternatives C, D, and G is discussed below in terms of the main components of the alternatives. Additional information is provided in the FS.

Sediment Processing/Transfer Facilities: Alternative C would require sediment processing/transfer facilities. At these facilities, the transfer, dewatering, and stabilization of dredged material would be conducted. Each of these activities is considered a readily implementable, commonly engineered activity. Design of sediment processing/transfer facilities will include requirements for the control of light, noise, air emissions, and water discharges.

The WDNR and EPA have not determined the location of the sediment processing/transfer facilities. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. In preparing the cost estimate in the FS, the WDNR and EPA assumed a number of upland staging and access areas adjacent to or near Green Bay. These facilities (wherever located) would be temporary and removed after completion of the active remedial activities.

Removal: Alternatives C, D, and G require the dredging of contaminated sediment. Dredging of sediment is a readily implementable and environmentally effective engineering activity. Two concerns are relevant to whether sediment can be dredged effectively: (1) resuspension and releases during dredging and, (2) resulting residual contaminant concentrations that may remain in sediment after dredging is completed. Regarding resuspension, environmental dredges have been shown to generally not release significant quantities of contaminants during removal operations. The use of silt screens or other barriers, as appropriate, could further assist in limiting downstream migration of PCBs and may be used as well.

It should be noted, however, that while removal of contaminated sediment might be theoretically feasible, the volumes removed would be large (see Table 11-23). If removal were performed for all of Green Bay, the volumes would be orders of magnitude greater than has been previously implemented for environmental dredging projects. The exception to these unprecedented volumes would be at a PCB action level of 5 ppm.

Table 11-23 Removal Volumes for Different Action Levels for Green Bay by Zone

Bay Zone	Volume (cy) Based on Action Level		
	0.5 ppm	1 ppm	5 ppm
Zone 2	29,700,000	29,300,000	4,060,000
Zone 3A	16,300,000	14,400	0
Zone 3B	43,600,000	0	0
Zone 4	0	0	0
TOTAL	89,600,000	29,314,400	4,060,000

Note:
Data are adapted from FS Table 5-5.

Dewatering: Alternative C would require removal of excess water from dredged sediment. Dewatering would be conducted primarily on-barge and in upland staging areas. This is a conventional, commonly utilized, proven technology and is readily implementable and effective.

Water Treatment: Conventional water treatment technologies for dredge water have been proven commonly reliable and are readily implementable and effective.

Transportation: For Alternatives C, D, and G, dredged materials would be transported in-river to sediment processing/transfer facilities or a nearshore CDF or CAD using barges. These are considered implementable engineering activities.

For Alternative C, off-site transportation of dredged materials to disposal facilities will be by truck, rail, and/or barge. These forms of transportation are routine engineering activities that have been employed at many Superfund sites and are technically implementable. The WDNR and EPA would comply with all legal regulatory requirements for transporting both hazardous and non-hazardous wastes.

Disposal: Off-site disposal is a common activity at many Superfund sites and would be hypothetically implementable for Alternative C. However, to achieve even relatively minimal risk reduction under Alternative C would require disposal of a volume impracticable to dispose of or treat. For example, a PCB action level of 0.5 ppm would require disposal of about 90 million cy (see Table 11-24), more than double the total existing landfill capacity of 44 million cy estimated for landfills within 40 miles of the River (FS Table 6-10). The next higher PCB action level, 1 ppm, would utilize about 66 percent of the capacity for landfills located in the Fox River Valley and Green Bay area.

Table 11-24 Disposal Volume by Action Level for OU 5 Compared to Landfill Capacity in the Fox River Area

Action Level (ppm)	Total Volume (cy)	Capacity of Existing Landfills* Required for Disposal of Total Volume (%)
0.5	89,560,898	203
1	29,290,778	66
5	4,063,804	9

Notes:
* Total capacity of major landfills within approximately 40 miles of the Lower Fox River is 44,158,706 cy.
Data are from FS Tables 5-5 and 6-10.

Treatment: The large volumes of material that would be dredged and the low concentrations of PCBs make it impracticable to treat sediment dredged from OU 5.

<u>Administrative Feasibility</u>

Alternatives A and B require no active measures. All alternatives except Alternative A include an administrative requirement for fish consumption advisories. Because fish consumption advisories are already in place, this requirement is already met and would continue even under the No Action alternative. Alternatives C, D, and G are somewhat more difficult to implement in terms of administrative feasibility because of the need to site the sediment processing/transfer and disposal facilities and to address the associated real property issues.

Sediment Processing/Transfer Facilities: For Alternatives C, D, and G, the transfer facilities, which would be constructed on land adjacent to or in the general vicinity of Green Bay, are considered on site for the purposes of the permit exemption under CERCLA Section 121(e), although any such facilities will comply with the substantive requirements of any otherwise necessary federal or state permits.

Removal: Operations under Alternatives C, D, and G will have to be performed in conformance with the substantive requirements of regulatory programs implemented by the USACE under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. In addition, discharges during remediation will conform to Wisconsin Statutes and substantive WDNR regulations related to dredging and maintaining water quality.

Disposal: Identifying a local landfill for disposal of sediments dredged from OU 5 is likely not feasible because of the large volumes that would be removed.

Capping and CDF: For Alternatives D and G, a lakebed grant may have to be approved by the state. This would be addressed during the design phase.

Treatment: Treatment would be administratively feasible. Air emissions permits would be required if sediments are treated off site.

Availability of Services and Materials: For Alternatives A and B, all needed services and materials are available. For Alternatives C, D, and G, equipment and personnel related to dredging and materials handling (e.g., sediment dewatering) are commercially available. Technology and associated goods and services for an upland landfill or CDF or CAD construction are locally available.

Cost

Cost includes estimated capital and annual O&M costs, as well as total capital cost. Present worth cost is the total capital cost and O&M costs of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of –30 to +50 percent. (This is a standard assumption in accordance with EPA CERCLA guidance.)

The net present worth of remedial alternatives for OU 5 (Table 11-25) range from $18 million for Alternative A (No Action) to $2.454 billion for Alternative D (Dredge to a Confined Disposal Facility). For Alternatives C, D, and G, which all involve active remediation, the estimated costs range from approximately $124 million to $2.454 billion.

Table 11-25 Cost Comparison of Active Remediation of OU 5 at the 0.5, 1, and 5 ppm Action Levels and MNR, by Zone

	Action Level						
	0.5 ppm		1 ppm		5 ppm		MNR
Zone	Sediment Volume (cy)	Cost (million $)	Sediment Volume (cy)	Cost (million $)	Sediment Volume (cy)	Cost (million $)	Cost (million $)
2	29,700,000	707–825	29,300,000	698–814	4,060,000	124–507	9.9
3A	16,300,000	389–474	14,400	11	—	—	9.9
3B	43,600,000	1,010–1,155	—	—	—	—	9.9
4	—	—	—	—	—	—	9.9
Totals	89,600,000	2,106–2,454	29,314,400	709–825	4,060,000	124–507	39.6

Notes:
Zone 3 is subdivided into zones 3A and 3B on the basis of sediment movement patterns.
There is insufficient volume of PCBs in zones 3A, 3B, and 4 to warrant cost estimates at the 5 ppm action level.
There is insufficient volume of PCBs in zones 3B and 4 to warrant cost estimates at the 1 ppm action level.
There is insufficient volume of PCBs in Zone 4 to warrant cost estimates at the 0.5 ppm action level.

11.3.3 Agency and Community Criteria for Operable Unit 5

Agency Acceptance

The State of Wisconsin has been actively involved in managing the resources of the River since before there was a federal Superfund law. These efforts have led to significant state knowledge and understanding of the River and Bay and of the contamination problems within those areas. As a result of this expertise, the WDNR has served as the lead agency responsible for assessing risks and conducting the RI/FS, which formed the basis for the Proposed Plan; the ROD for OU 1 and OU 2; and this ROD addressing OU 3, OU 4, and OU 5. As the lead agency, the WDNR has worked closely with the EPA to cooperatively develop this ROD. Both the WDNR and EPA support the selection of this remedy, as is evidenced by their joint issuance of this ROD.

Community Acceptance

Community acceptance considers whether the local community agrees with the EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. Community acceptance of the Proposed Plan was evaluated based on comments received at the public meetings and during the public comment period. More than 4,800 comments were received concerning the Proposed Plan. This ROD includes a Responsiveness Summary (see Appendix A). Comments that address issues common to OU 1 and OU 2, as well as to OU 3, OU 4, and OU 5, are discussed in the Responsiveness Summary attached to the OU 1 and OU 2 ROD. While all comments were considered in selecting the final cleanup alternatives for OU 3, OU 4, and OU 5, comments for OU 5 in particular caused the Agencies to revisit issues related to the Proposed Remedy for Green Bay. Because of this reconsideration, additional Green Bay sampling was conducted and further evaluations were completed (see *White Paper No. 18 – Evaluation of an Alternative Approach of Calculating Mass, Sediment Volume, and Surface Concentrations in Operable Unit 5, Green Bay*; *White Paper No. 19 – Estimates of PCB Mass, Sediment Volume, and Surface Sediment Concentrations in Operable Unit 5, Green Bay Using an Alternative Approach*; *White Paper No.20 – Green Bay Modeling Evaluation of the Effects of Sediment PCB Bed Map Revisions on GBTOXe Model Results*; and *White Paper No. 21 – Green Bay Modeling Evaluation of a Hypothetical Open-Water Disposal Site for Navigational Dredged Material in Southern Green Bay*, which are included with this ROD).

12 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats at a site whenever practical. Engineering controls, such as on-site or off-site containment, may be used for wastes that pose a relatively low long-term threat or where treatment is impractical (NCP Section 300.430(a)(1)(iii) and Superfund Publication 9380.3-06FS, November 1991, "A Guide to Principal Threat and Low Level Threat Wastes").

The concept of principal threat and low-level threat wastes is applied on a site-specific basis when characterizing source material. Source material is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, or to air or act as a source for direct exposure. At this Site, the contaminated sediments are source materials.

Principal threat wastes are those source materials considered to be highly toxic or highly mobile that cannot be reliably contained or that would present a significant risk to human health or the environment should exposure occur. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied. Although the EPA has not established a threshold level of toxicity/risk to identify a principal threat waste, generally where toxicity and mobility of source material combine to pose a potential risk of "several orders of magnitude greater" than acceptable, 10^{-3} or greater, the source material is considered principal threat waste.

With respect to the River sediments in OUs 3 and 4, some PCB concentrations create a risk sufficient to be considered a principal threat waste. The preference for treatment outlined above applies to these particular sediments. However, it would be impracticable to closely identify, isolate, and treat these principal threat wastes differently than the other PCB sediments. The dredging technology that will be employed to accomplish this remedy does not distinguish among gradations of contamination in source materials. Nevertheless, at the conclusion of the OU 3 and OU 4 remedy, the source materials (and principal threat wastes) will have been removed from the River, dewatered, and deposited in a state-licensed landfill and in accordance the WDNR's TSCA agreement with the EPA. Dredge water will be treated prior to discharge back to the River. In so doing, the mobility of the principal threat wastes will have been greatly reduced.

13 SELECTED REMEDY

13.1 The Selected Remedy

The selected remedy for OUs 3 and 4 is Alternative C2B, which is a variation of Alternative C, Dredge and Off-Site Disposal. This remedy includes removal, dewatering, and off-site disposal of an estimated 586,800 cy of PCB-contaminated sediment from OU 3 (Little Rapids to De Pere) and removal, dewatering, and off-site disposal of an estimated 5,880,000 cy of PCB-contaminated sediment from OU 4 (De Pere to Green Bay) with PCB concentrations greater than 1 ppm. The sediments in OU 3 are estimated to contain approximately 1,111 kg (about 2,444 pounds) of PCBs, or approximately 89 percent of the total PCB mass in that OU. In addition, Deposit DD (located in OU 2) will be removed as part of the OU 3 remediation. An estimated PCB mass of 31 kg (68 pounds) and a contaminated sediment volume of 9,000 cy from Deposit DD are included in the OU 3 mass, volume, and cost estimates. Therefore, the estimated totals for OU 3 are 1,142 kg (2,512 pounds) of PCB mass and 595,800 cy of contaminated sediment.

The sediments in OU 4 are estimated to contain approximately 26,430 kg (about 58,150 pounds) of PCBs, or approximately 99 percent of the total PCB mass in that OU. As part of the remediation effort for OU 4, the Agencies will, during the design phase of this project, more clearly define the extent of contamination from the River's mouth out into Green Bay. All sediment contaminated with a PCB concentration of greater than 1 ppm extending from the River mouth will also be subject to dredging. Currently, the Agencies do not have a good estimate of the sediment volume or PCB mass in this area, although it is not expected that the volume of material will exceed a few thousand cubic yards.

The selected remedy for OU 5 is Alternative B, Monitored Natural Recovery and Institutional Controls, with limited dredging near the mouth of the River as part of the OU 4 remediation. The Agencies will also conduct additional modeling and evaluation of risks in Green Bay.

Summary and Description of the Rationale for the Selected Remedy

The following sections address the rationale for the remedy selection for OUs 3 and 4 (discussed together) and OU 5, as well as how the selected alternatives would be implemented. Five-year reviews of remedial activities at each OU will be conducted to determine remedy effectiveness.

Operable Unit 3 (Little Rapids to De Pere) and Operable Unit 4 (De Pere to Green Bay) — Alternative C2B

OUs 3 and 4 are discussed together because of the interdependency of the remedy for these two Operable Units. Alternative C2B includes the removal of sediment with PCB concentrations greater than the 1 ppm RAL using an environmental dredge, followed by dewatering and off-site disposal of the sediment. The total volume of sediment with PCB concentrations greater than 1 ppm to be dredged in this alternative is approximately 595,800 cy (including Deposit DD) from OU 3 and 5,880,000 cy from OU 4. The addition of Deposit DD to the OU 3 cleanup does not substantially alter the Comparative Analysis of Alternatives, because the additional volume and increase in cost are relatively small.

- **Site Mobilization and Preparation:** The final decision on the staging area(s) for these Operable Units will be made during the design stage. Site preparation at the staging area(s) will include collecting soil samples, securing the onshore property for equipment staging, and constructing the necessary onshore facilities for sediment management and transportation. A docking facility for dredging and ancillary equipment may need to be constructed and multiple staging areas may be necessary.

- **Sediment Removal:** Sediment removal will be conducted using a dredge (e.g., cutterhead or horizontal auger or other method). Given the volumes and operating assumptions described in the FS, completing the removal effort is estimated to take approximately 1 year for OU 3 and 7 years for OU 4. For dredging removal, in-water pipelines will carry the slurry from the dredging area to the staging area(s). For longer pipeline runs, it may be necessary to utilize in-line booster pumps to pump the slurry to the staging area. If necessary, silt curtains may be used around the dredging area to minimize sediment resuspension downstream of the dredging operation. Buoys and other waterway markers will be installed around the perimeter of the in-water work area.

  From the staging area, the sediment slurry would be pumped, via pipeline, to a passive dewatering facility. Preliminary assumptions are that the pipeline could follow the existing route of the Fox River Trail, although a final decision on the pipeline location will be made during the design phase. Estimates are that four booster pumps would be necessary for the pipeline, although the specifics will be determined during the design phase. Dewatered sediment will be disposed of in an adjacent engineered landfill facility. Other activities associated with sediment removal will be water quality monitoring and post-removal sediment surveys in the River, as well as site restoration of the staging area(s) and pipeline route. The staging area(s) and the dewatering and disposal facilities will be fenced to limit access.

- **Sediment Dewatering and Disposal:** Passive dewatering requires land acquisition and construction of the dewatering cells. At this conceptual design stage, the sediment dewatering system is envisioned to be a multi-cell passive dewatering system designed to accommodate 26 weeks of dredge production, including a maximum water surge capacity for multiple construction seasons to enhance the system's dewatering capability. However, the specifics of the dewatering system will be finalized during the design phase. Ancillary activities include water treatment and disposal of solids as well as decommissioning of the dewatering system and site restoration.

  Disposal of dewatered sediment will be at a dedicated NR 500 engineered landfill, which will be operated as a monofill accepting only Lower Fox River sediments. The landfill will be constructed and operated in accordance with the WDNR's TSCA agreement with the EPA, which is necessary if PCB concentrations in sediment are over 50 mg/kg. The disposal facility will be located adjacent to the dewatering facility.

- An ongoing evaluation by the Agencies has indicated the potential viability of vitrification as an alternative to the disposal of PCB-contaminated sediments in an engineered landfill. If this technology is determined to be an appropriate substitute for sediment disposal, the Agencies would address this modification through a ROD amendment. Criteria for the selection and use of vitrification are identified in Section 13.8 of this ROD.

- **Water Treatment:** Water treatment will require the use of equipment and materials for flocculation, clarification, and sand and carbon filtration. Water treatment will be conducted 24 hours per day, 7 days per week during the dredging season. In the FS, the discharge water for hydraulic dredging is estimated at 570,000 gallons per day for OU 3 and 5,131,000 gallons per day for OU 4 during the term of the water treatment activity. Daily discharge water quality monitoring is included in the cost estimate. Treated water will be sampled and analyzed to verify compliance with the appropriate discharge requirements.

- **Demobilization and Site Restoration:** Demobilization and site restoration will involve removing all equipment from the staging and work areas and restoring the site to, at a minimum, its original condition.

- **Institutional Controls and Monitoring:** Baseline monitoring will include pre- and post-remedial sampling of water, sediment, and tissue. Monitoring during implementation will include air and surface water sampling. Verification monitoring to confirm that PCB contamination has been removed to the RAL will include sediment sampling. Long-term monitoring will include surface water, biological tissue, and surface sediment sampling. Details concerning long-term sampling will be developed in the design of the final Long-term Monitoring Plan. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish. The types and frequency of pre-construction monitoring will be developed during remedial design. Plans for monitoring during and after construction will be developed during the remedial design and modified during and after construction, as appropriate. Until the RAOs have been achieved, institutional controls will have to be maintained to help prevent exposure of human receptors to contaminants. Institutional controls may include access restrictions, land use or water use restrictions, possible dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Land and water use restrictions and access restrictions may require local legislative action and state administrative action to prevent inappropriate use or development of contaminated areas.

- **Achievement of Remedial Action Level (RAL) Objective:** The mass and volume to be remediated will be depend on the dredge elevation that is set to achieve an RAL of 1 ppm. The success of the selected remedy for OU 3 and OU 4 will be evaluated based on removal of all material with a PCB concentration greater than 1 ppm. In addition, a SWAC for each OU will be computed following completion of dredging with samples from 0 to 10 cm depth. If dredging is completed to the dredge elevation representing a 1 ppm removal, based on pre-design sampling data, and post-dredging sampling shows that the 1 ppm RAL has not been achieved, a determination by the Agencies regarding whether the SWAC of 0.26 ppm for OU 3 or a SWAC of 0.25 ppm for OU 4 has been achieved may be used to assess the effectiveness of PCB removal for these Operable Units. A 0.25 ppm SWAC will be deemed acceptable as a level of performance for determining completion. If the appropriate SWAC has not been achieved for either OU 3 or OU 4, then the remedy provides certain options to further reduce risk. The first option is that additional dredging may be undertaken to ensure that all sediments with PCB concentrations greater than the 1 ppm RAL are removed. A second option is to place a sand cover on dredged areas to reduce surficial concentrations such that a SWAC is achieved. This option is discussed further in Section 13.4. These options allow for achievement of the RAL under certain conditions (e.g., obstructions or debris).

<u>Operable Unit 5 (Green Bay) — Alternative B</u>

The selected remedy for OU 5 is Monitored Natural Recovery (MNR) with institutional controls and limited dredging. This remedy includes the following:

- Additional sampling near the mouth of the Lower Fox River to identify sediments with PCB concentrations greater than 1 ppm. Any PCB-contaminated sediments with concentrations greater than1 ppm adjacent to the River mouth will be dredged as an extension of the OU 4 removal. A preliminary (rough) estimate of the volume of material in Green Bay adjacent to the River mouth with PCB concentrations above 1 ppm may be as high as 200,000 cy. This area will be more precisely delineated in design activities.

- Additional evaluation of the contaminant distribution and associated risks in Green Bay, including fate and transport and biological modeling. Estimates regarding recovery times would be developed similar to those completed in the Alternative-Specific Risk Assessment, summarized in Section 8 in the FS.

- Monitoring to confirm long-term recovery of Green Bay, relying on natural processes, primarily dispersion. Neither biodegradation nor burial is expected to occur at a significant rate.

OU 5 is expected to recover eventually through natural processes in combination with removal of the major sources of PCBs to the Bay (i.e., the removal of PCBs from the River sediment and, in part, removal of sediments adjacent to the River mouth). A monitoring program for measuring PCB and possibly mercury levels in water, tissue (e.g., invertebrates, fish, birds), and sediment will be developed as discussed in the FS to measure progress toward and achievement of Site RAOs for the Bay. In summary, the monitoring program will include:

- Surface water quality sampling at several stations in Green Bay to determine the transport of PCB mass within Green Bay and into Lake Michigan

- Fish and possibly waterfowl tissue sampling to determine the residual risk of PCBs and possible mercury consumption to human receptors

- Fish, bird, and zebra mussel tissue sampling to determine the residual risk of PCB uptake to environmental receptors

- Possible avian population studies of bald eagles and double-crested cormorants to assess the residual effects of PCBs and mercury on reproductive viability

- Possible surface sediment sampling to assess potential recontamination from upstream sources and the status of natural recovery

Types and frequency of monitoring to occur during pre-design, construction, and post-remediation will be developed as part of a comprehensive Site monitoring program. Monitoring would continue until acceptable levels of PCBs are reached in sediments, surface water, and fish. Plans will be developed as part of the

Explanation of Remedial Action Level, Surface-Weighted Average Concentration, and Sediment Quality Threshold

The term Remedial Action Level (RAL) refers to a PCB concentration in sediment used to define an area or volume of contaminated sediment that is targeted for remediation. In other words, the RAL in this ROD calls for the removal by dredging of all sediment in OU 3 and OU 4 that has a PCB concentration of greater than 1 ppm. If all sediment with a concentration greater than the 1 ppm RAL is removed, it is expected that the residual Surface-Weighted Average Concentration (SWAC) of sediment will be approximately 0.26 ppm in OU 3 and 0.16 ppm in OU 4. The SWACs in this instance are less than the RAL because a SWAC is calculated as an average concentration over the entire Operable Unit, after the removal of sediment from discrete areas (deposits) that are above the RAL, and includes averaging over areas in which there are surface concentrations less than the RAL. SWAC calculations are discussed in Section 5 of the FS.

The term Sediment Quality Threshold (SQT) refers to the PCB concentration in the sediment that is protective of specified human and ecological receptors. SQTs vary depending on the sensitivity of the particular receptor (such as recreational anglers, high-intake fish consumers, walleye, mink, etc.). Put another way, if the remediation called for in this ROD results in a sediment concentration at or below the SQT, then the risk to specified human and ecological receptors will have been reduced to a safe level. It is important to understand that it is not expected that the SQT will be achieved immediately upon completion of the dredging; rather, the estimated SWAC will be met. For example, the estimated post-dredging SWAC for OU 3 is 0.26 ppm, whereas the SQT for unlimited walleye consumption is 0.049 ppm and would take an estimated 9 years to achieve. It is contemplated that the SQT will be met only after the River is allowed a certain amount of time to "recover" through natural processes following active dredging.

remedial design and modified during and after the upstream remedial construction in OUs 3 and 4, as appropriate.

Until the RAOs have been achieved, existing institutional controls will have to be maintained to help prevent exposure of human receptors to contaminants. Institutional controls may include access restrictions, land use or water use restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Land and water use restrictions and access restrictions may require local legislative action and state administrative action to prevent inappropriate use or development of contaminated areas. At the current time, the only institutional control in place for Green Bay is fish consumption advisories.

13.2 Summary of the Estimated Costs of the Selected Remedy

The total estimated present-worth cost of the selected remedy is $284 million for OUs 3 and 4 and $39.6 million for OU 5 for a total of $323.6 million. The estimated increase in cost to remediate Deposit DD is approximately $0.8 million when remediated with OU 3. This is based on a unit cost developed from the total cost ($283,200,000) for remediation of the volume of contaminated sediment within OUs 3 and 4 (6,466,800 cy). This is an engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost (based on year 2001 dollars). Changes in the cost elements are likely to occur as a result of new information and data collected during the remedial design. Major changes may be documented in a memorandum in the Administrative Record, an ESD, or a ROD amendment.

13.3 Cleanup Standards and Outcomes for the Selected Remedy

The selection of a remedy was accomplished through the evaluation of the nine criteria as specified in the NCP. A remedy selected for a site must be protective of human health and the environment, comply with ARARs (or justify a waiver), and offer the best balance of tradeoffs with respect to the balancing and modifying criteria in the NCP.

Through the analyses conducted for the RI/FS, the WDNR and EPA have determined that there is an unacceptable risk to human health and the environment from the consumption of fish from the River. It has also been determined that the unacceptable risk will continue for many decades without active remediation of the PCB-contaminated sediment in OU 3 and OU 4. For OU 5, it has been determined that risks will continue for decades under all alternatives, with there being no effective difference between alternatives. Additional modeling of OU 5 will further evaluate this matter.

13.3.1 Achieving Cleanup Standards

The WDNR and EPA believe that the removal of sediment in OU 3 and OU 4 with PCB concentrations greater than the 1 ppm RAL is important to achieving the timely reduction of risks to an acceptable level (i.e., fish can be safely consumed by human or ecological receptors). The WDNR and EPA envision that all sediment in OU 3 and OU 4 contaminated at concentrations above the RAL will be removed. However, this ROD also provides that under certain circumstances a sand cover may be used to supplement the primary dredging remedy in order to reach the risk reduction targets. Pre-remediation sampling and characterization efforts will define a spatial “footprint” (both horizontally and vertically) of the sediment in both Operable Units that has a concentration of PCBs greater than 1 ppm. It is this footprint that is targeted for removal by dredging. If dredging is able to achieve this result (i.e., remove all sediments with PCB concentrations greater than 1 ppm), the active remediation portion of the OU 3 and OU 4 remedy will be complete.

However, if sampling after dredging is completed for OUs 3 and 4 shows that the 1 ppm RAL has not been achieved, a SWAC of 0.26 ppm for OU 3 and of 0.25 ppm for OU 4 may be used to assess the effectiveness of PCB removal. If the SWAC has not been achieved for either OU 3 or OU 4, then the remedy provides certain options to further reduce risk. One option is that additional dredging may be undertaken to ensure that all sediments with PCB concentrations greater than the 1 ppm RAL are removed throughout the particular deposit. Another option would be to place a sand cover on dredged areas to reduce surficial concentrations. The determination of the appropriate option will be made by the Agencies.

13.3.2 Expected Outcomes of Selected Remedy and RAL Rationale

Remedial Action Objectives were developed to provide relative comparisons for different remedial alternatives. RAO 1 relates to achieving surface water quality standards. RAOs 2 and 3 relate to protectiveness for human and ecological receptors. RAO 4 evaluates long-term relative releases to Green Bay and Lake Michigan. RAO 5 considers short-term releases from the potential remedies themselves.

RAO 1 may not be achieved in the foreseeable future because of the stringent regulations for acceptable PCB concentrations in surface waters. Nevertheless, significant risk reduction will occur. Recovery times estimated for RAO 2 (protection of human health) and RAO 3 (protection of ecological receptors) indicate that they will be met well within the defined goals. RAO 4 relates to PCB movement from the River to Green Bay and Lake Michigan. Reductions of loadings as a result of the removal of contaminants in OU 3 and OU 4 will reduce contaminant migration downstream and will therefore contribute to achieving RAO 4. Although the time to recover for Green Bay is not known (because of the time limitations of the models), the substantive reduction of contaminant loading from the River to Green Bay resulting from implementation of the remedy for OU 3 and OU 4 should assist in Bay recovery. RAO 5 is achievable with conventional environmental removal technologies for OU 3 and OU 4 and does not apply directly to the remedy for OU 5.

RAOs 2 and 3 are evaluated in the Alternative-Specific Risk Assessment in the FS by estimating the time required to reach the protectiveness criteria for human health (i.e., removal of fish advisories) and the time required to reach the protectiveness criteria for ecological receptors. This analysis was performed for each of the different remedial action levels and for the alternatives that do not involve contaminant removal, Alternatives A and B.

A PCB concentration of 1 ppm has been selected as the appropriate RAL based on its ability to achieve RAOs for human health and ecological receptors within a reasonable time frame relative to the anticipated costs. This RAL will also reduce the PCB concentration in surface water. Exposures to PCB sediment concentrations above 1 ppm must be eliminated in order to achieve a protective SWAC within a reasonable time frame. This RAL will also reduce and minimize surface water concentrations and the release of contaminants to downstream areas of the River. Studies conducted as part of the Lower Fox River and Green Bay RI/FS indicate that a 1 ppm RAL shows the greatest decrease in projected surface water concentrations relative to the other action levels.

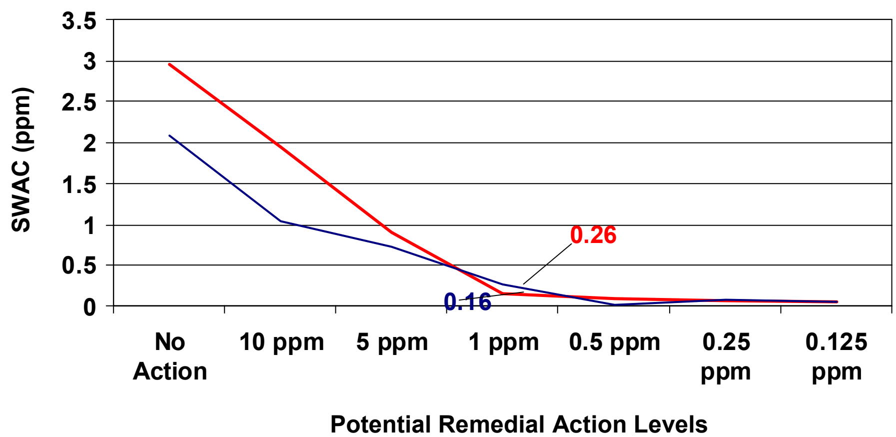
PCB RALs of No Action, 5 ppm, 1 ppm, and 0.5 ppm, were also evaluated. However, those RALs greater than 1 ppm would require a significant amount of additional time to achieve the RAOs for the Site. For those RALs of less than 1 ppm, the RAOs would not necessarily be achieved sooner than they would using the 1 ppm RAL. The RAOs considered in determining the RAL are discussed below for OUs 3, 4, and 5. It is important to note that while absolute numbers are inherently uncertain because of uncertainties in modeling, the relative differences among the RALs are reliable. Furthermore, it should be noted that the Agencies expect that the

Bay may recover more rapidly as a result of the reduction of PCB loading that will occur with the removal of PCBs from the Lower Fox River (OU 1, OU 3, and OU 4). Modeling results may not clearly show this improvement because of the model's time limitations (a maximum of 100 years).

Rationale for Operable Units 3 and 4 – Remedial Action Level of 1 ppm

Figure 13-1 shows the modeling analysis of sediment RALs in comparison with the SWACs, which will result from cleanup to the selected 1 ppm RAL. Modeling suggests that a 1 ppm RAL can achieve an estimated 0.26 ppm PCB SWAC for OU 3 and a 0.16 ppm SWAC for OU 4. A sediment RAL of 1 ppm is the most effective RAL, because the risk declines significantly in a reasonable time period (see Figures 13-2 and 13-3), which will result in achieving risk reduction in the number of years estimated in Table 13-1.

Figure 13-1 Remedial Action Levels and Estimated SWACs for Evaluated RALs for OUs 3 and 4 (from FS Table 5-4 and BLRA Tables 5-33 and 5-34)



As shown in Table 13-1, modeling suggests that a sediment RAL of 1 ppm will lead to fairly rapid declines in PCB fish tissue concentrations. Using the 1 ppm RAL, Table 13-1 projects the number of years until the risk of fish ingestion/consumption declines to acceptable levels for different consumers.

Table 13-1 Estimated Years to Reach Human Health and Ecological Thresholds to Achieve Risk Reduction for Operable Units 3 and 4 at an RAL of 1 ppm

Fish	Receptor	Risk Level Goal	Estimated Years
Operable Unit 3			
Walleye	Recreational Angler	RME Hazard Index of 1.0	9
Walleye	High-intake Fish Consumer	RME Hazard Index of 1.0	17
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	30
Walleye	High-intake Fish Consumer	RME 10^{-5} cancer risk level	42
Carp	Carnivorous Bird	NOAEC	22
Carp	Piscivorous Mammal	NOAEC	43
Operable Unit 4			
Walleye	Recreational Angler	RME Hazard Index of 1.0	20
Walleye	High-intake Fish Consumer	RME Hazard Index of 1.0	30
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	45
Walleye	High-intake Fish Consumer	RME 10^{-5} cancer risk level	59
Carp	Carnivorous Bird	NOAEC	20
Carp	Piscivorous Mammal	NOAEC	45

Notes:
NOAEC – No Observed Adverse Effects Concentration
RME – reasonable maximum exposure

A 1 ppm RAL shows the greatest decrease in projected surface water concentrations in OU 3 and OU 4. Figure 13-2 shows model estimates for PCB surface water concentration 30 years after remediation for OU 3, and Figure 13-3 shows model estimates for PCB surface water concentrations 30 years after remediation for OU 4. Further decline for projected surface water concentrations for an RAL of less than 1 ppm are relatively small in both Operable Units. In other words, selection of an RAL of less than 1 ppm would marginally reduce the SWAC and surface water concentrations. A comparison of various RALs shows the 1 ppm RAL has the greatest relative post-remediation decrease in surface water concentrations.

Figure 13-2 Estimates of Surface Water PCB Concentrations for the Evaluated RALs 30 Years After Completion of Remedial Activities for OU 3

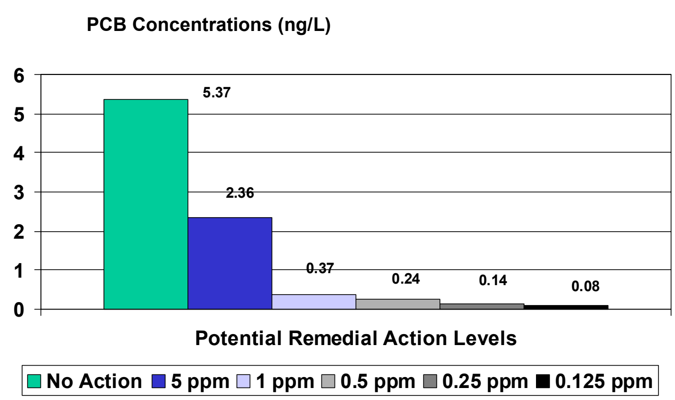
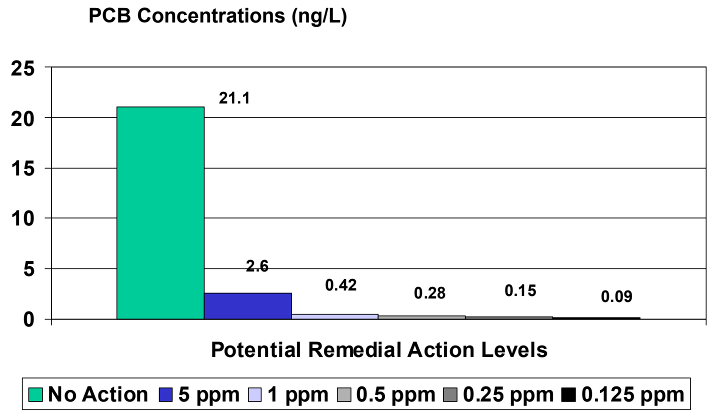


Figure 13-3 Estimates of Surface Water PCB Concentrations for the Evaluated RALs 30 Years After Completion of Remedial Activities for OU 4



RAO 1 relates to achieving surface water quality standards. A comparison of the reduction expected 30 years after completion of the proposed alternative at the 1 ppm RAL to the No Action alternative is presented in Table13-2.

Table 13-2 RAO 1: Surface Water PCB Concentrations 30 Years After Completion of the Proposed Alternative

River Reach	No Action	1 ppm Action Level	% Difference
OU 3	5.37 ng/L	0.37 ng/L	93
OU 4	21.08 ng/L	0.42 ng/L	98

"Acceptable fish tissue concentrations" are levels that would allow unlimited consumption of young-of-the-year fish, recognizing it would take longer for fish (about 5 years for walleye) to become large enough to be legally caught and eaten. "Acceptable risks" assume an acceptable cancer risk less than 10^{-4} (within the EPA's acceptable risk range of 10^{-4} to 10^{-6}) and a hazard index of less than 1. As shown on Figures 13-4 and 13-5, a 1 ppm RAL shows similar relative decreases in relation to acceptable fish tissue concentrations for walleye. Figures 13-4 and 13-5 show that for RAL concentrations greater than 1 ppm, significantly more years will elapse before the risk of fish consumption declines to acceptable levels. Other species of fish show similar reductions and are discussed in detail in Section 8 of the FS. Figures 13-4 and 13-5 clearly show that there is limited additional risk reduction achieved by selecting an RAL of less than 1 ppm.

Figure 13-4 Time to Achieve Acceptable Fish Tissue Concentrations for OU 3

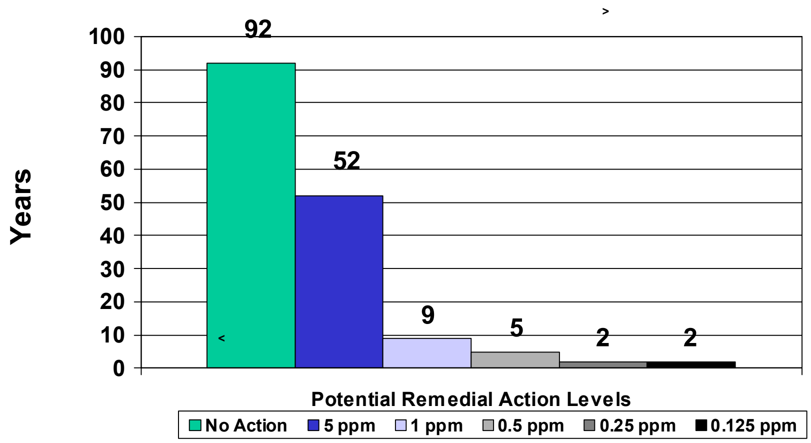
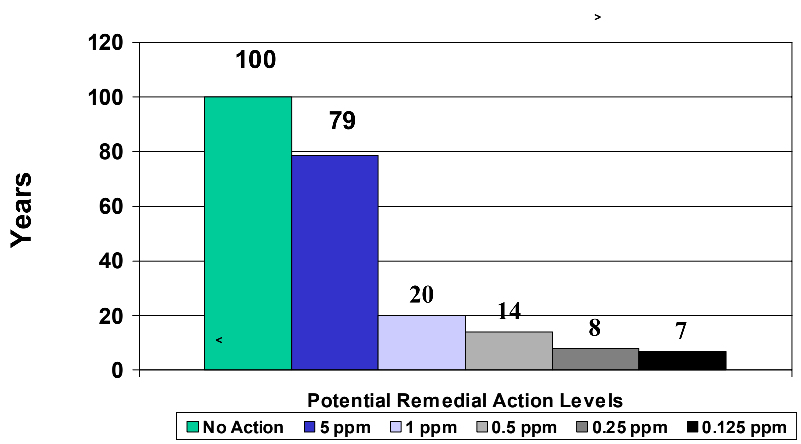


Figure 13-5 Time to Achieve Acceptable Fish Tissue Concentrations for OU 4



Safe fish consumption by birds showed similar relative reductions for the 1 ppm RAL versus other potential cleanup levels (Figures 13-6 and 13-7). Thus, the 1 ppm RAL provides the greatest relative reduction of time required for ecosystem recovery.

Figure 13-6 Time to Safe Fish Consumption by Birds in OU 3

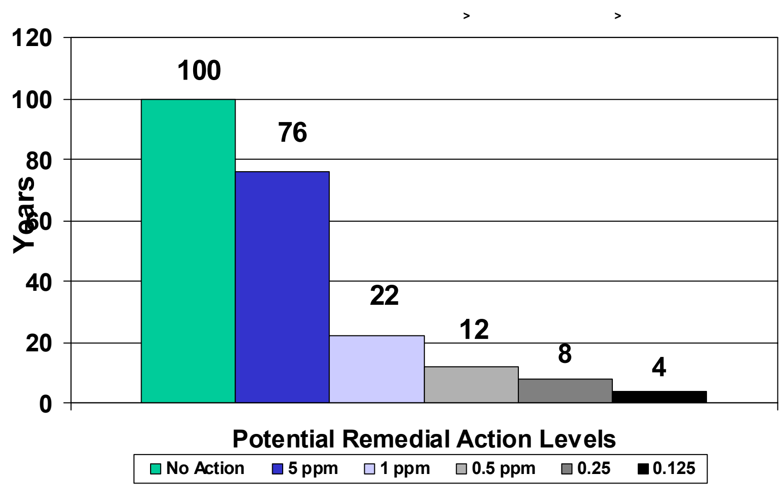
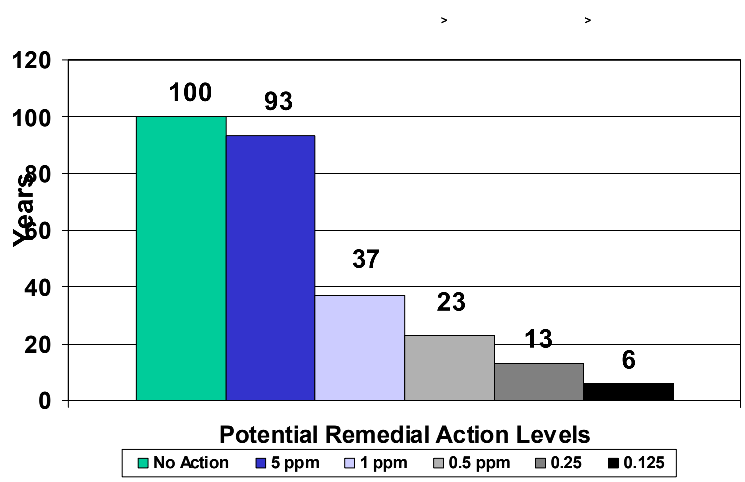
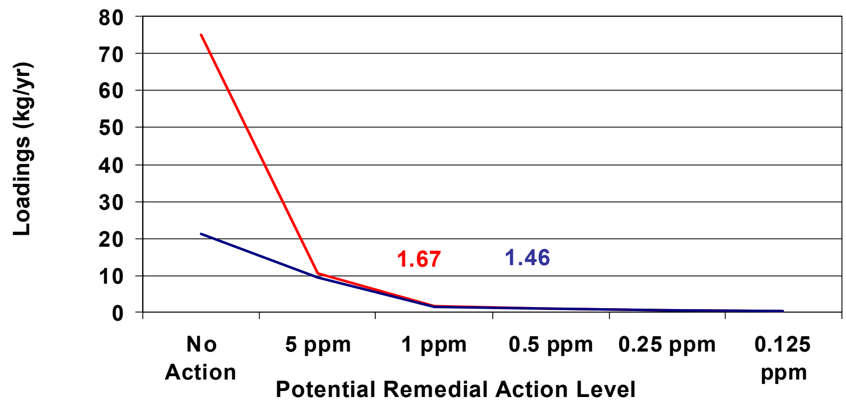


Figure 13-7 Time to Safe Fish Consumption by Birds in OU 4



A 1 ppm RAL is also the most protective based on estimates of downstream loadings (i.e., movement and migration of PCBs into OU 4 of the River and into Green Bay). Downstream loadings of PCBs from OUs 3 and 4 relative to remedial activities are shown on Figure 13-8 for OU 3 and OU 4. The RAL of 1 ppm provides the greatest decrease in downstream loadings relative to the other RALs. Figure 13-8 shows that, with respect to downstream loadings, the 1 ppm RAL level achieves the most reduction when compared to time and cost.

Figure 13-8 RALs and Downstream Loadings in OU 3 and OU 4



A tabular comparison of the reduction expected 30 years after completion of the proposed alternative at the 1 ppm RAL to the No Action alternative is presented in Table 13-3.

Table 13-3 RAO 4: Annual Sediment Loading Rates 30 Years After Completion of the Proposed Alternative

Operable Unit	No Action	1 ppm Action Level	% Difference
OU 3	21.25 kg/yr	1.46 kg/yr	93
OU 4	75.27 kg/yr	1.67 kg/yr	97

In summary, the 1 ppm RAL shows the most significant relative improvement for all the pertinent RAOs, resulting in a protective and cost-effective cleanup level for OU 3 and OU 4.

Rationale for Operable Unit 5 — Monitored Natural Recovery

Green Bay has a water surface area of approximately 2,700 square miles and a water volume of 20 cubic miles. The mean depth of the Bay is approximately 65 feet; the maximum depth is 176 feet. PCB concentrations in the sediment are typically low (i.e., less than 1 ppm) because of the vast sediment volume. Of the total sediment volume in the Bay, the RI estimated only about 2 percent has PCB concentrations greater than 1 ppm and less than 0.2 percent has PCB concentrations above 5 ppm, representing 2.6 and 0.2 percent of the sediment mass, respectively.

The BLRA identifies the risks associated with the OU 5 zones. It appears there is not a significant difference in the human and ecological health endpoints between an aggressive remedial approach throughout the Bay and Alternatives A and B (No Action and MNR), in which no active remediation is undertaken for the Bay. In other words, because of the enormous quantity of Bay sediment contaminated at low levels (PCB concentrations less than 1 ppm), any large-scale Bay remediation would add substantially to remedial costs without significantly reducing risks in the Bay. Costs for active remediation in Green Bay were developed for each Bay zone at 0.5, 1, and 5 ppm action levels. Costs and related issues are discussed in Section 11.3. The cost to implement the MNR alternative in the Bay is $39.6 million.

13.4 Contingent Remedy – *In-Situ* Capping (i.e., "Partial Capping" or "Supplemental Capping")

The WDNR and EPA have selected Alternative C as identified in the Proposed Plan and the RI/FS as the *selected* alternative. However, during the RI/FS public comment period, the Agencies received numerous comments relating to the viability of capping as a possible remedy. An analysis of these comments (discussed in *White Paper No. 5A – Responses to the API Panel Report*, *White Paper No. 5B – Evaluation of API Capping Costs Report*, *White Paper No. 5C – Evaluation of Remedial Alternatives for Little Lake Butte des Morts Proposed by WTMI and P.H. Glatfelter*, *White Paper No. 6A – Comments on the API Panel Report*, and *White Paper No. 6B – In-Situ Capping as a Remedy Component for the Lower Fox River*, attached to the ROD for OU 1 and OU 2) evaluated the viability of a capping-only remedy. This evaluation indicated that a capping-only remedy would not be protective, and would be technically and administratively difficult to implement. The evaluation also indicated that capping would only be technically feasible in some areas. Based on these public comments, the WDNR and EPA have developed a contingent remedy that may supplement the selected remedy in certain circumstances. This capping contingency is different than Alternative F presented in the FS. Alternative F included capping in all areas where certain technical and engineering requirements were met. The pre-design sampling results, the engineering requirements outlined below, and costs would provide the basis for determining whether capping would be appropriate to implement for a particular deposit or subset of deposits. Design considerations would be the basis for determination of the exact deposits that would be capped. This contingent remedy may only be implemented if it meets the following requirements:

1. The contingent remedy, consisting of a combination of dredging and capping, must provide the same level of protection to human health and the environment as the selected remedy. To demonstrate that a cap would provide the same level of protectiveness as the selected remedy, the following would have to be addressed: (a) the potential for PCB releases from flooding and ice scour, as well as advective and diffusional processes; and (b) the potential for a breach of the cap and how that or other potential cap failures mechanisms would be monitored.

2. The contingent remedy must be less costly to implement than the selected remedy.

3. The contingent remedy must not take more time to implement than the selected remedy.

4. The contingent remedy must comply with all necessary regulatory, administrative, and technical requirements, discussed below.

5. The capping contemplated in the contingent remedy will not be permitted in certain areas of OUs 3 and 4:

    - No capping in areas of navigation channels (with an appropriate buffer zone to ensure no impacts to maintenance of the navigation channel)

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

    - No capping in areas with PCB concentrations exceeding TSCA levels (50 ppm)

    - No capping in areas that do not have sufficient load-bearing capacity

- ♦ No capping in shallow-water areas (bottom elevations that would result in a cap surface at elevation greater than –3 feet chart datum without prior dredging to allow for cap placement

In addition to other controls, institutional controls unique to capping would be required to ensure the integrity and protectiveness of capped areas, including restrictions on anchoring or dredging.

Because capping relies on long-term integrity of the cap in a dynamic river environment, long-term monitoring would need to ensure that the cap would remain physically intact and chemical contaminants were contained. For example, in addition to other monitoring requirements, if there were a large storm or other event that could impair a cap's ability to retain contaminants, additional monitoring would likely be required.

Assuming the above criteria are met, capping is considered a viable and protective alternative for OU 3 and OU 4 and may be implemented. The specific areas where caps could be placed will be determined during design. Design will be based, in part, on considerations included in *White Paper No. 6B – In-Situ Capping as a Remedy Component for the Lower Fox River*, attached to the ROD for OU 1 and OU 2. To ensure the permanence of an OU 3 cap, permanent maintenance of the De Pere dam would be required.

13.5 Basis for Implementing the Contingent Remedy (OUs 3 and 4)

The contingent remedy may be employed in OUs 3 and 4 to supplement the selected dredging remedy if one or both of the following criteria are satisfied. The decision as to whether one or both of the criteria have been satisfied will be made solely by the EPA and WDNR.

1. It can be predicted with a high degree of certainty based on sampling results (taken after a sufficient amount of contaminated sediment in OUs 3 and 4 has been dredged) that a PCB SWAC of 0.26 ppm for OU 3 and 0.25 ppm for OU 4 would not be achieved by dredging alone, <u>or</u>

2. Capping would be less costly than dredging and would provide the same level of protection to human health and the environment as the selected remedy, as evaluated in accordance with the protectiveness provisions and the nine criteria in the NCP (40 CFR 300.430).

The selected dredging remedy would still be completed in areas not capped. Based on estimates in the FS, and because of limitations on where capping could be performed, capping would be limited to about 40 percent of the total volume of contaminated sediments in OU 3 and OU 4. Selection and implementation of this contingency would be documented in an ESD.

It should be noted that if dredging alone achieves cleanup standards, and the contingent remedy is not shown to be more cost-effective than dredging alone, then capping would not be implemented.

13.6 Description of Contingent Remedy

The contingent remedy, which may supplement the selected remedy, consists of the following components:

- **Cap Design:** Cap construction specifications would be determined during design. Although the FS envisioned a cap composed of 20 inches of sand overlaid with 12 inches of large cobble "armor" to provide erosion protection, the final cap design would be based on predicted performance. The final cap design must have sufficient thickness to ensure containment of contaminants, resistance to burrowing organisms, and "armoring" to provide sufficient permanence and resistance to erosion and scour.

- **Demobilization and Site Restoration:** Demobilization and site restoration would require removing all capping-related equipment, fencing, facilities, etc., from staging and work areas.

- **Monitoring:** Operations and maintenance monitoring would be required to ensure proper placement, maintenance of cap integrity, and isolation and containment of contaminants. For this type of capping, monitoring would be performed to ensure that the cap is placed as intended, the necessary capping thickness is maintained, and contaminants are contained and do not become bioavailable. In addition to other dredging-related monitoring, cap monitoring would include bathymetric or side-scan sonar profiling, sediment and cap sampling, and capture and analysis of pore water that may migrate through the cap, as well as diver inspections to ensure that the cap is intact and containing contaminants. Additionally, provisions would have to be made for cap repair should that be necessary.

- **Institutional Controls:** Institutional controls may include deed restrictions, Site access and anchoring limitations, and continuation of fish and waterfowl consumption advisories, as appropriate. Access restrictions could include limitations on the use or development of capped areas, possibly requiring local legislative action and state administrative action. These controls and limitations are intended to ensure the permanence of the cap and to minimize reexposure and/or migration of contaminants. Deed and access restrictions, dredging moratoriums, and other limitations (e.g., no anchor zones) on the use or development of capped areas would continue in perpetuity or until contaminants were removed or rendered nontoxic. Fish consumption advisories would continue until fish contaminant concentrations reach levels protective for human health and the environment. Monitoring in perpetuity would likely also be required, as the cap would need to permanently contain contaminants.

13.7 Estimated Costs of the Contingent Remedy

Costs would be determined prior to implementation of capping. Estimates of capping costs would be documented in an ESD.

13.8 Use of Vitrification Technology

The Agencies have selected land disposal as the technology for managing dewatered dredged material from the Lower Fox River. In Section 10.2 of this ROD, an option to use vitrification is identified. This section discusses vitrification and provides the basis upon which it can be used as part of the remedy for OUs 3 and 4. If successfully implemented, vitrification is an effective technology, has the added benefit of destruction of PCBs, and would allow beneficial reuse of dredged sediment. However, if vitrification is used instead of disposal of contaminated sediments, the Agencies would issue a ROD Amendment, consistent with the requirements of the NCP.

Certain criteria must be considered prior to the use of vitrification. These criteria include the ability of vitrification technology to treat the chemicals of concern, the cost of constructing and operating a vitrification facility, the amount of dredged material that would be managed at the vitrification facility, and issues related to siting a facility.

- **Vitrification Technology.** As part of the evaluation of technologies in Section 6 of the FS, vitrification was evaluated as the representative process option for thermal treatment. Vitrification is a high-temperature process (2,500 to 3,000 °F) that destroys organic compounds (e.g., PCBs) while melting the contaminated sediment into glass aggregate material. Inorganic contaminants (e.g., most heavy metals) are contained in the glass matrix of the aggregate. Vitrification units can be operated to achieve the 99.9999 percent destruction removal efficiency requirement for PCBs. In cooperation with and supported by funding from the WDNR and EPA Great Lakes National Program Office, Minergy Corporation has undertaken a multi-phase study to evaluate the feasibility of vitrification technology, based on glass furnace technology, to treat PCB-contaminated sediment. The EPA's Superfund Innovative Technology Evaluation (SITE) program has also participated in this study and conducted an independent evaluation of the cost and treatment effectiveness of the technology. Reports prepared by Minergy and submitted to the WDNR and EPA did demonstrate the effectiveness of the technology and provided initial cost information. While the SITE report is not yet final, initial indications are that vitrification using glass furnace technology has been demonstrated to be successful at treating PCB-contaminated sediment.

- **Amount of Dredged Material to be Managed.** Estimated quantities to be dredged are 595,800 cy from OU 3 (including Deposit DD) and 5,880,000 cy from OU 4, for a total quantity of approximately 6.5 million cy. Once dewatered to 55 percent solids, this quantity is equivalent to approximately 3.6 million wet tons of filter cake. When converted to dry tons for comparison with the tables presenting unit cost estimates in the Minergy report, this quantity is approximately 1.98 million dry tons.

- **Cost to Construct and Operate.** As part of a contract with the WDNR, Minergy Corporation prepared a study entitled *Revised Unit Cost Study for Commercial Scale Sediment Meter Facility – Glass Furnace Technology*. This study provides additional information on capital and operating costs of a vitrification facility. Various parameters influence the unit cost of a vitrification facility, such as the amount of dredge material processed, the water content of the dredge material, the size of the plant needed to process the dredge material, the amount of glass produced, annual days of operation, and the assumed value of the glass, as well as initial capital construction costs and operating costs. Based on work documented in the FS, the following values were developed for these parameters:

Amount of dredge material	3,600,000 wet tons
Water content of dredge material	55%
Plant size	750 to 1,125 tons/day
Project life	7 to 10 years
Annual operating days	240 to 350 days
Amount of glass produced	180,000 to 270,000 tons
Assumed value of the glass	$2 to $25 per ton

  Following these assumptions, the unit cost ranges from $32.21/ton to $53.04/ton on a wet ton basis. Consequently, the cost to manage all the dredge material from OU 3 and OU 4 using vitrification could range upwards to $191 million. Note that the unit costs increase as the amount of material managed at a vitrification facility decreases. Also note that this cost does not include dewatering.

- **Siting of a Disposal Facility.** Siting a location to construct a passive dewatering facility and a monofill to dispose of all the dredged material from OUs 3 and 4 presents several challenges. The passive dewatering and monofill disposal facilities are key features in the cost-effectiveness of the selected remedy. The challenges to siting these facilities include finding a site with the necessary geophysical characteristics, such as favorable geology; the need for a large land area to place these facilities; and the need to go through the state's siting process for the disposal facility. Current land area estimates are approximately 327 acres for the dewatering cells and approximately 121 acres for the disposal facility, for an approximate total of 448 acres. Although it may be possible to restore the area used for the dewatering cells to an alternative use or to the previous use, the disposal facility will be permanent. Such parcels of land are available in southern Brown County, but these parcels would still have to be procured. Part of the site evaluation process will be to determine whether existing properties having the necessary physical characteristics are available and whether there are concerns related to wetlands, sensitive habitat, or archaeological or historical matters. The state's siting law requires that the owners of a proposed landfill negotiate a host agreement with the community in which the landfill will be located. These negotiations can place limits on the size and operation of a landfill and the type of materials accepted, can lead to negotiation of a host community fee, and can be time consuming. An inability to successfully negotiate an agreement may result in the need to seek an alternative location for the proposed disposal facility or to seek a means to manage the dredge material, such as vitrification.

In summary, vitrification is a potentially viable technology for the management of dredge material for the Lower Fox River. The Agencies will allow for vitrification technology to be used on all or part of the contaminated sediment dredged from the River under any of the following circumstances. The decision as to whether the following criteria have been satisfied will be made solely by the EPA and WDNR.

1. **Protection of Human Health and the Environment.** Vitrification must provide the same level of protection to human health and the environment as the selected remedy as evaluated in accordance with the protectiveness provisions and the nine criteria in the NCP (40 CFR 300.430).

2. **Lack of Disposal Capacity.** If, following attempts to secure land and site a monofill disposal facility for dredge material management, there is either no disposal capacity or insufficient disposal capacity.

3. **Costs.** In the event that costs to site, construct, and operate a disposal facility are unacceptable to the responsible parties or the incremental increase in cost to permanently destroy PCBs is unacceptable, the responsible parties can use vitrification as an alternative means of disposal.

It is also important to note that given the need for a higher percent solids in the dewatered material, it is likely that mechanical dewatering would have to be used in lieu of passive dewatering. If this happens, it may lead to higher costs to implement the remediation of OUs 3 and 4. In the event that use of vitrification technology is proposed, the public would be informed and public input would be sought on the proposal to use this technology, as well as on the rationale concerning its selection, implementation, and cost, through a ROD amendment.

14 STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the remedies that are selected for Superfund sites are required to be protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), be cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

14.1 Protection of Human Health and the Environment

Implementation of the selected remedy will adequately protect human health and the environment through the removal and off-site disposal of PCB-contaminated sediment and the monitoring of the natural recovery of PCB-contaminated sediment that is left in place. The selected remedy will target a sediment cleanup level of 1 ppm in OUs 3 and 4. The residual risk posed by this action level in OUs 3 and 4, expressed in years to reach human health and ecological thresholds, is presented in Table 13-1. This table indicates that for the selected action level of 1 ppm, acceptable fish tissue concentrations in young-of-the-year walleye would be achieved in 9 to 42 years for OU 3 and in 20 to 59 years for OU 4.

Reduced reliance on fish consumption advisories is an overall objective of all cleanup alternatives. For that reason, fish consumption advisories are not considered to be part of the remedial alternatives presented to protect public health. It is expected, however, that once the selected remedy is implemented, the fish consumption advisories will continue to be an important part of the human health risk reduction strategy for years to come. Efforts to improve advisory awareness and voluntary compliance with advisories will be ongoing during both remedial design, implementation, and long-term monitoring of remedy effectiveness.

The SWAC value in OU 5 will be 0.352 ppm. Implementation of the selected alternative in OU 3, OU 4, and OU 5 will result in PCB concentrations within acceptable risk ranges over time. The selected remedy does not pose unacceptable short-term risk.

14.2 Compliance with ARARs

Section 121(d) of CERCLA requires that Superfund remedial actions meet ARARs. The selected remedy will comply with the ARARs summarized in Table 14-1 and discussed below.

14.2.1 Potential Chemical-Specific ARARs

Toxic Substances Control Act (TSCA)

TSCA establishes requirements for the handling, storage, and disposal of PCB-containing materials equal to or greater than 50 ppm. TSCA is an ARAR at the Site with respect to any PCB-containing materials with PCB concentrations equal to or greater than 50 ppm that are removed from the Site.

Clean Water Act

Federal surface water quality standards are adopted under Section 304 of the Clean Water Act where a state has not adopted standards. These federal standards, if any, are ARARs for point discharges to the River. Related to these standards are the federal ambient water quality criteria. These criteria are non-enforceable guidelines that identify chemical levels for surface waters and generally may be related to a variety of assumptions, such as use of a surface water body as a water supply. While these criteria are not ARARs, they may be TBCs for this Site.

Groundwater Quality Standards

State groundwater quality standards for various substances are set forth in Chapter NR 140, WAC. In general, Sections NR 140.24 and NR 140.26 require preventive action limits (PALs) to be achieved to the extent it is technically and economically feasible to do so. In the remediation context, the NR 140 groundwater quality standards are to be achieved within a reasonable time frame. Natural attenuation is allowed as a remedial method where source control activities have been undertaken and where groundwater quality standards will be achieved within a reasonable period of time. The groundwater quality standards constitute an ARAR.

Soil Cleanup Standards

The State of Wisconsin has adopted generic, site-specific, and performance-based soil cleanup standards in the NR 700 series, WAC. These regulations allow the party conducting the remedial action to select which approach to apply. The generic soil standards are divided into those necessary to protect the groundwater quality and those necessary to prevent unacceptable, direct contact exposure. Generic soil standards, based on conservative default values and assumptions, have been adopted only for a few substances, none of which is relevant to the Site. Site-specific soil standards depend upon a variety of factors, including local soil conditions, depth to groundwater, type of chemical, access restrictions, and current and future use of the property. These site-specific soil standards also may be adjusted based on an assessment of the site-specific risk presented by the chemical constituents of concern. With respect to the Site, the soil standards constitute an ARAR.

Surface Water Quality Standards

The State of Wisconsin has promulgated water quality standards that are based on two components: (1) use designation for the water body and (2) water quality criteria. These standards, designations, and criteria are set forth in Chapters NR 102 to NR 105, WAC. The State also has rules for applying the water quality standards when establishing water quality-based effluent limits (Chapters NR 106 and NR 207, WAC). The state water quality standards are used in making water management decisions and controlling municipal, business, land development, and agricultural activities (Section NR 102.04, WAC). In the remediation context, surface water quality standards are applicable to point source discharges that may be part of the remedial action. Further, to the extent that the remedial work is conducted in or near a water body, such work is to be conducted so as to prevent or minimize an exceedance of a water quality criterion (in Chapters NR 102 to 105, WAC).

As recognized in the WDNR's sediment guidance (1995), the water quality standards are goals to be used in guiding the development of the sediment remediation work. As a goal, but not a legal requirement, the water quality standards as applied to the remediation of sediment contamination constitute a TBC.

In addition, the NCP states that, in establishing RAOs, water quality criteria established under the Clean Water Act (Water Quality Standards [WQSs] in Wisconsin), shall be attained where "relevant and appropriate under the circumstances of the release" (40 CFR 300.430(e)(2)(I)(E)).

The WDNR and EPA have determined that WQSs, while relevant to sediment cleanup RAOs, are not appropriate for direct application at this time. Calculating a site-specific sediment quality standard from a WQS using current scientific methods such as equilibrium partitioning is very uncertain. Moreover, the EPA's 1996 Superfund PCB cleanup guidance directly addresses sediment cleanup targets using water quality criteria. The guidance suggests using equilibrium partitioning to develop a sediment criterion and then compare it to risk-based cleanup numbers for establishing an RAO. If the guidance considered a derived sediment quality number to be an ARAR, it would be directly applied to each alternative as a threshold criterion. Therefore, WQSs are not ARARs and are not threshold criteria for selecting an alternative for the Site.

14.2.2 Potential Action- and Location-Specific ARARs

Wisconsin Statutes Chapter 30

Chapter 30 of the Wisconsin Statutes requires permits for work performed in navigable waterways or on or near the bank of such a waterway. For remediation that is conducted under CERCLA, only the substantive provisions set forth in Chapter 30 (but not the procedural requirements for obtaining a permit) must be satisfied. In general, the substantive provisions address minimizing any adverse effects on the waterway that may result from the work. This includes Chapter NR 116, Wisconsin's Floodplain Management Program. The substantive provisions are action-specific ARARs.

Section 10 – Rivers and Harbors Act; Section 404

Section 404 of the Clean Water Act requires approval from the U.S. Army Corps of Engineers for discharges of dredged or fill material into waters of the United States, and Section 10 of the Rivers and Harbors Act requires approval from the USACE for dredging and filling work performed in navigable waters of the United States. As the River is a water of the United States, these statutes might dictate action-specific ARARs for dredging/filling work that may be conducted in the River. Under the Fish and Wildlife Coordination Act, the USACE must coordinate with the USFWS regarding minimization of effects from such work. The work would be subject to the substantive environmental law aspects of permits under these statutes, which would be ARARs. Permits are not required for remediation that is implemented under the authority of CERCLA.

Floodplain and Wetland Regulations and Executive Orders 11988 and 11990

The requirements of 40 CFR § 264.18(b) and Executive Order 11988, Protection of Flood Plains, are relevant and appropriate to action on the Site. Executive Order 11990 (Protection of Wetlands) is an applicable requirement if there are any wetlands present in the areas to be remediated.

National Historic Preservation Act (NHPA), 16 USC 470 *et seq.*

The NHPA provides protections for historic properties (cultural resources) on or eligible for inclusion on the National Register of Historic Places (see 36 CFR Part 800). In selecting a remedial alternative, adverse effects to such properties are to be avoided. If any portion of the Site is on or eligible for the National Historical Register, the NHPA requirements would be ARARs.

Endangered Species

Both State and federal law have statutory provisions that are intended to protect threatened or endangered species (i.e., the federal Endangered Species Act and s. 29.604, State Statutes). In general, these laws require a determination as to whether any such species (and its related habitat) reside within the area where an activity under review by governmental authority may take place. If the species is present and may be adversely affected by the selected activity, where the adverse effect cannot be prevented, the selected action may proceed. If threatened or endangered species exist in certain areas of the River and Bay, these laws may constitute an action-specific ARAR. At the Site, the queen snake as well as several plant species were noted by the WDNR to be endangered or rare resources occurring within or near the Site.

Management of PCBs and Products Containing PCBs

Wisconsin regulations (i.e., Chapter NR 157, WAC, "Management of PCBs and Products Containing PCBs" that was adopted pursuant to Section 299.45. Wisconsin Statutes) that establish procedures for the storage, collection, transport, and disposal of PCB-containing materials also apply to remedial actions taken at the Site.

Solid Waste Management Statutes and Rules (Chapter 289, Wisconsin Statutes and Chapters NR 500 to 520 and NR 600 to 685, WAC) establish standards that apply to the collection, transportation, storage, and disposal of solid and hazardous waste.

It is not expected that federal Resource Conservation and Recovery Act (RCRA) or State regulations governing hazardous waste management will be applicable at this Site.

TSCA – Disposal Approval

TSCA regulations for the disposal of PCB remediation waste (40 CFR 761.61) are applicable to the selection of the cleanup alternative for remediation of PCBs in sediments at the Site and to the disposal of removed sediments at a state-licensed landfill. These regulations provide cleanup and disposal options for PCB remediation waste. The three options include self-implementing, performance-based, and risk-based disposal approvals. The risk-based disposal approval option is allowed if it will not pose an unreasonable risk of injury to health and the environment.

The current situation in the River and Bay, as described in the risk assessment conducted as part of the RI/FS, is that PCB-contaminated sediment poses an unacceptable level of risk in the River at this time. Remediation of PCB-contaminated sediment via the selected remedy will reduce risks to human health and the environment.

Sediment removed from the River may contain PCBs equal to or greater than 50 ppm. PCB-contaminated sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB-contaminated sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act of 1976 (Appendix E of the FS). Presently, TSCA compliance would be achieved through the extension of the January 24, 1995, approval issued by the EPA to WDNR pursuant to 40 CFR 761.60(a)(5) under the authority of TSCA.

This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500 WAC landfill that is also in compliance with the conditions of the TSCA approval provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5) and will provide the same level of protection required by EPA Region 5 and therefore is no less restrictive than TSCA. However, should other administrative rules pertaining to disposal under TSCA be in effect at the time that TSCA compliance decisions are made for the River sediment, then compliance with those rules will be achieved.

14.2.3 Additional To Be Considered Information

Section 303(d), Clean Water Act

Under Section 303(d) of the federal Clean Water Act, states are required, on a periodic basis, to submit lists of “impaired waterways” to the EPA. In December 1996, the WDNR submitted its first list of impaired waters under Section 303(d). The Fox River was included on the initial list. The WDNR has taken no further action with respect to the listing, nor has it developed a total maximum daily load (TMDL) for the River. Currently, a state-wide watershed committee is advising WDNR on the steps to be taken in this process, and the listing process is being reviewed by the Wisconsin Natural Resources Board. The listing of the Fox River under Section 303(d) is a TBC.

Great Lakes Water Quality Initiative, Part 132, Appendix E

The Great Lakes Water Quality Initiative set forth guidance to the states bordering the Great Lakes regarding their wastewater discharge programs. For remedial actions, the guidance states that any remedial action involving discharges should, in general, minimize any lowering of water quality to the extent practicable. The concepts of the guidance have been incorporated into Chapters NR 102 to NR 106, WAC. The Great Lakes Water Quality Initiative constitutes a TBC.

Sediment Remediation Implementation Guidance

Part of the Strategic Directions Report of the WDNR approved by Secretary Meyer in 1995 addressed the sediment remediation approach to be followed by the WDNR. This approach includes meeting water quality standards as a goal of sediment remediation projects. In developing a remedial approach, the guidance calls for use of a complete risk management process in consideration of on-site and off-site environmental effects, technological feasibility, and costs. The guidance constitutes a TBC.

Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement calls for the identification of “Areas of Concern” in ports, harbors, and river mouths around the Great Lakes. Remedial goals to improve water quality are to be established in conjunction with the local community. In the case of the Lower Fox River and lower Green Bay, a Remedial Action Plan (RAP) has been prepared and finalized. The RAP lists a series of recommendations ranging from addressing contaminated sediments to controlling non-point source runoff. This RAP is a TBC.

Fox River Basin Water Quality Management Plan

This plan was developed by the WDNR and lists management objectives for improving water quality in the Fox River Basin. The Fox River Basin Water Quality Management Plan is a TBC.

Table 14-1 Fox River ARARs

Act/Regulation	Citation
Federal Chemical-Specific ARARs	
TSCA	40 CFR 761.60(a)(5)-761.79 and EPA Disposal Approval
Clean Water Act – Federal Water Quality Standards	40 CFR 131 (if no Wisconsin regulation) and 33 CFR 323
Federal Action-/Location-Specific ARARs	
Fish and Wildlife Coordination Act	16 USC 661 *et seq.* 33 CFR 320-330 – Rivers and Harbors Act 40 CFR 6.304
Endangered Species Act	16 USC 1531 *et seq.* 50 CFR 200 50 CFR 402
Rivers and Harbors Act	33 USC 403; 33 CFR 322, 323
National Historic Preservation Act	15 USC 470; *et seq.* 36 CFR Part 800
Floodplain and Wetlands Regulations and Executive Orders	40 CFR 264.18(b) and Executive Order 11988
State Chemical-Specific ARARs	
TSCA-Disposal Approval	EPA Approval
Surface Water Quality Standards	NR 102, 105 (*To Be Considered*), and 207 NR 722.09 1–2
Groundwater Quality Standards	NR 140
Soil Cleanup Standards	NR 720 and 722
Hazardous Waste Statutes and Rules	NR 600–685
State Action-/Location-Specific ARARs	
Management of PCBs and Products Containing PCBs	NR 157
Wisconsin's Floodplain Management Program	NR 116
Solid Waste Management	NR 500–520
Navigable Waters, Harbors, and Navigation	Chapter 30 – Wisconsin Statutes
Fish and Game	Chapter 29.415 – Wisconsin Statutes

14.3 Cost-Effectiveness

The WDNR and EPA have determined that the selected remedy is cost-effective. Section 300.430(f)(1)(ii)(D) of the NCP requires that all the alternatives that meet the threshold criteria (protection of human health and the environment and compliance with ARARs) must be evaluated by comparing their effectiveness to the three primary balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness). The selected remedies meet these criteria by achieving a permanent protection of human health and the environment at low risk to the public and provide for overall effectiveness in proportion to their cost.

The Superfund program does not mandate the selection of the least costly cleanup alternative. The least costly effective remedy is not necessarily the remedy that provides the best balance of tradeoffs with respect to the remedy selection criteria, nor is the least costly alternative necessarily both protective of human health and the environment and ARAR-compliant. Cost-effectiveness is concerned with the reasonableness of the relationship between the effectiveness afforded by each alternative and its costs compared to other available options.

The total net present worth of the selected remedy for OU 3, OU 4, and OU 5 is $323.6 million.

14.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The WDNR and EPA believe that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the Site. The selected remedy does not pose excessive short-term risks. There are no special implementability issues that set the selected remedy apart from the other alternatives evaluated.

14.5 Preference for Treatment as a Principal Element

Based on current information, the WDNR and EPA believe that the selected remedy is protective of human health and the environment and utilizes permanent solutions to the maximum extent possible. The remedy, however, does not satisfy the statutory preference for treatment of the hazardous substances present at the Site as a principal element because such treatment was not found to be practical or cost-effective.

14.6 Five-Year Review Requirements

The NCP, at 40 CFR § 300.430(f)(4)(ii), requires a 5-year review if the remedial action results in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure. Because this remedy will result in hazardous contaminants remaining on site above levels that allow for unlimited exposure, a statutory review will be conducted within 5 years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

15 DOCUMENTATION OF SIGNIFICANT CHANGES FROM PREFERRED ALTERNATIVE OF PROPOSED PLAN

To fulfill the requirements of CERCLA 117(b) and the NCP (40 CFR § 300.430(f)(5)(iii)(B) and 300.430(f)(3)(ii)(A)), a ROD must document and discuss the reasons for any significant changes made to the Proposed Plan.

The Proposed Plan was released for public comment in October 2001. It identified a PCB sediment cleanup target of 1 ppm in OUs 3 and 4 with Monitored Natural Recovery in OU 5.

In the selection of the remedy for OU 3, OU 4, and OU 5, the WDNR and EPA considered information submitted during the public comment period and reevaluated portions of the proposed alternative.

New Information Obtained During the Public Comment Period

The WDNR and EPA considered alternative proposals for OUs 3 and 4 submitted as comments. As a result, the following elements were incorporated into this ROD: (1) If dredging is unable to reduce exposed contaminant PCB concentrations, a sand cover will be employed to further reduce risks rather than continuing with dredging removal operations (Section 13.3); and (2) if it is predicted that concentrations may not sufficiently reduce risks, or if capping is shown to be less costly than complete dredging and as protective of human health and the environment, then capping may be employed for some areas not yet dredged (Sections 13.4 through 13.7).

These proposals may be given further consideration prior to implementation of remedial actions. However, if these proposals cause a fundamental change to the alternatives described in this ROD (e.g., changing the remedy from removal to containment), then the WDNR and EPA will issue a new, revised Proposed Plan and have a public comment period, after which a ROD amendment would be finalized. If the change is not "fundamental," but is "significant" (e.g., modification of volumes to be removed), then an Explanation of Significant Difference would be issued, and there would be limited public comment.

The Agencies conducted a comprehensive reconsideration of Green Bay largely due to the numerous comments and concerns expressed, including the appropriateness of the proposed remedy and the need for additional data. To this end, the Agencies performed the following:

1. Additional sampling and analysis in Green Bay Zone 2 in areas not previously sampled and believed to have the greatest potential for relatively high PCB concentrations.

2. Modeling to determine the effects of a hot spot remediation and to determine alternative mass and volume numbers for the Bay.

3. Reevaluation of the techniques used to estimate sediment volume and PCB mass and preparation of bed maps with alternative mass and volume estimates.

White Papers Nos. 18, 19, 20, and 21, which are included with this ROD, present the new data and modeling information regarding evaluation of new and existing Green Bay data. These are:

- *White Paper No. 18 – Evaluation of an Alternative Approach of Calculating Mass, Sediment Volume, and Surface Concentrations in Operable Unit 5, Green Bay*

- *White Paper No. 19 – Estimates of PCB Mass, Sediment Volume, and Surface Sediment Concentrations in Operable Unit 5, Green Bay Using an Alternative Approach*

- *White Paper No. 20 – Green Bay Modeling Evaluation of the Effects of Sediment PCB Bed Map Revisions on GBTOXe Model Results*

- *White Paper No. 21 – Green Bay Modeling Evaluation of a Hypothetical Open-Water Disposal Site for Navigational Dredged Material in Southern Green Bay*

The additional sampling data provide revised estimates of average PCB concentrations, mass, and volume of contaminated sediments and revised mapping interpolations (discussed in White Papers Nos. 18, 19, 20, and 21 and summarized in Table 15-1). It should be noted that in addition to the consideration of the July 2002 Bay data, these evaluations also used an "alternative" method for calculating Green Bay PCB mass and contaminated sediment volumes.

Table 15-1 Summary of Green Bay SWAC, Volume, and PCB Mass Calculations

	PCB SWAC (ppm)	Mass		Volume	
		Kilograms	Pounds	Cubic Meters	Cubic Yards
RI/FS[1]	0.351	69,955	154,600	622,353,000	806,182,830
White Paper No. 18	0.353	14,600	32,120	242,543,000	316,204,200
White Paper No. 19	0.246	14,565	32,190	266,228,000	344,765,120

Note:
[1] Discussed in White Paper No. 18.

Results of these new calculations in White Papers Nos. 18 and 19 demonstrate that the RI/FS mass and volume estimates are high. Using the alternative method of calculating PCB mass and volume with the additional Green Bay data gives a lower estimate for the Bay SWAC and less PCB mass and volume of contaminated sediments. For example, the SWAC in the revised calculation from White Paper No. 19 is 0.246 ppm, less than the SWAC goal of 0.250 ppm, considered protective for the Lower Fox River. This compares to an estimated PCB SWAC of 0.351 ppm originally calculated in the RI/FS and 0.353 ppm for White Paper No. 18. These new data also confirm that the only area known to have PCB concentrations significantly above 1 ppm is located near the mouth of the Lower Fox River in the extreme southern portion of Green Bay.

Therefore, information developed in the RI/FS and the new information and evaluations provide the basis for the decision for OU 5 as described in Section 13.1. However, if additional evaluations indicate that it is appropriate, an Explanation of Significant Difference or a ROD amendment will be developed.