APPENDIX I

LOWER FOX RIVER REMEDIAL DESIGN
100 PERCENT DESIGN REPORT

LONG-TERM MONITORING PLAN

Prepared for

Appleton Papers Inc.

Georgia-Pacific Consumer Products LP

NCR Corporation

For Submittal to

Wisconsin Department of Natural Resources

U.S. Environmental Protection Agency

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LOWER FOX RIVER LONG-TERM MONITORING PLAN

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AOC	Administrative Order on Consent
CERCLA	Comprehensive Environmental Response, Compensation, Liability Act
CFR	Code of Federal Regulations
CLP	contract laboratory program
COC	chain-of-custody
COMMP	Cap Operations, Maintenance, and Monitoring Plan
CQAPP	Construction Quality Assurance Project Plan
CUL	Cleanup Levels
CV	coefficient of variation
DGPS	differential global positioning system
DQO	data quality objective
EDD	electronic data deliverable
EDL	estimated detection limit
FCR	field change request
HSP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HRGC/MS	high-resolution gas chromatography/mass spectrometry
LCS	laboratory control sample
LIMS	laboratory information management system
LMMBS	Lake Michigan Mass Balance Study
LOAEC	lowest observed adverse effects concentration
LTMP	Long-term Monitoring Plan
MDL	method detection limit
mg/kg	milligrams per kilogram
MDRD	minimum detectable relative difference
MNR	monitored natural recovery
ng/L	nanograms per liter
OU	Operable Unit
PCB	polychlorinated biphenyl
PE	performance evaluation
PM	project manager
ppm	part per million
QA	quality assurance

QAM	quality assurance manager
QAPP	quality assurance project plan
QC	quality control
RA	remedial action
RAL	remedial action level
RAO	remedial action objective
RD	remedial design
RG	Remediation Goals
RI/FS	remedial investigation/feasibility study
RM	river mile
ROD	Record of Decision
RPD	relative percent difference
RM	river mile
SDG	sample delivery group
SOP	standard operating procedure
SOW	statement of work
SWAC	surface-weighted average concentration
TBD	to be determined
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WDNR	Wisconsin Department of Natural Resources
WOE	weight-of-evidence
WSLH	Wisconsin State Lab of Hygiene
YOY	young-of-year

1 PROJECT MANAGEMENT AND OBJECTIVES

1.1 Introduction

The Lower Fox River extends 39 miles from the outlet of Lake Winnebago over a series of locks and dams to the mouth of the river where it discharges into Green Bay (Figure 1-1). The Lower Fox River is the most industrialized river in Wisconsin; since the early 1900s, water quality has been degraded by expanding industries and communities discharging sewage and industrial wastes into the river. Polychlorinated biphenyls (PCBs) were discovered in the Lower Fox River in the 1970s. Due to their persistence in the environment, PCBs remain the focus of current remedial design (RD) and remediation efforts in the river.

This Long-term Monitoring Plan (LTMP) presents a program for monitoring the post-remediation recovery of surface water and biota in Operable Units (OUs) 1 through 5 and sediment in OUs 2 and 5 of the Lower Fox River and Green Bay. Long-term monitoring will be performed to assess progress toward achieving the remedial action objectives (RAOs) specified in two Records of Decision (RODs) and a ROD Amendment issued in December 2002, June 2003, and June 2007, respectively, by the U.S. Environmental Protection Agency (USEPA) and the Wisconsin Department of Natural Resources (WDNR) (collectively, the "Response Agencies") under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended.

This LTMP was prepared pursuant to the RD Administrative Order on Consent (AOC) for OUs 2 to 5, originally executed in March 2004 and amended by the October 2007 revised Administrative AOC and Order on Consent. The requirement to implement the LTMP in OUs 2 through 5 is set forth in the Response Agencies' 2007 Administrative Order for Remedial Action (RA) ("Order") and the accompanying Phase 2B Scope of Work. The respondents to the order include Appleton Papers Inc.; CBC Coating, Inc. (formerly known as Riverside Paper Corporation); Georgia-Pacific Consumer Products, LP (formerly known as Fort James Operating Company, Inc.); Menasha Corporation; NCR Corporation; P.H. Glatfelter Company; U.S. Paper Mills Corp; and WTM I Company (formerly known as Wisconsin Tissue Mills, Inc.) (collectively the "Respondents"). Implementation of RD/RA and long-term monitoring activities in OU 1 is being addressed under a separate agreement between the Response Agencies and the WTM I Company.

Active remediation (dredging and capping) of Lower Fox River sediments began in OU 1 in 2004 and was completed in May 2009. A Phase 1 removal action in OU 4 was performed in 2007. The remaining dredging and capping actions in OUs 2 through 4 began in April 2009 and are expected to be completed in 2017. This LTMP, in conjunction with the baseline monitoring program conducted in 2006-2007, is designed to monitor improvements in water, fish tissue, and sediment quality in the Lower Fox River and Green Bay as a result of these sediment RAs. Long-term monitoring of sediment quality in capped areas is also described in this LTMP; however, monitoring of the physical integrity of capped areas is described separately in the accompanying Cap Operations, Maintenance, and Monitoring Plan (COMMP).

1.2 Project Organization

This section describes the project organization, responsibilities, authorities, and lines of communication. The roles and responsibilities of key project personnel are described below.

1.2.1 Respondent Technical Team

1.2.1.1 Respondent Team Project Coordinator

The duties of the Respondent Team Project Coordinator include:

- Administration and management of long-term monitoring activities, including schedule and budget control
- Authorization and coordination of subcontractors
- Authority to stop work based on quality control (QC) issues, health and safety issues, or other deficiencies that may compromise the safety of the field crew or the integrity of the long-term monitoring program
- Ongoing communication with USEPA and WDNR regarding project status, problems encountered and recommended solutions, deviations from scope of work, and other related issues
- Coordination and resolution of key technical issues with Respondent and Response Agency Teams
- Coordinate document production
- Prepare and submit progress reports

1.2.1.2 Respondent Team Project Manager

The duties of the Respondent Team Project Manager (PM) include:

- Management of preparation of LTMPs and Data Reports
- Coordination and trouble-shooting of field activities, including recommendations for scope modifications as needed based on field conditions
- Review and assessment of corrective action procedures in consultation with Project Coordinator
- Oversight of water, fish tissue, and sediment quality data analysis and interpretation
- Assignment of fish compositing groups in consultation with WDNR and USEPA PMs

1.2.1.3 Field Quality Assurance Manager

The duties of the Field Quality Assurance Manager (QAM) include:

- Auditing of field activities to ensure compliance with LTMP requirements
- Review of all field documentation for consistency, accuracy, and completeness, and to ensure any procedural modifications are appropriately documented and communicated
- Reporting of deficiencies in field procedures or documentation to the PM to initiate corrective action procedures

1.2.1.4 Data Quality Assurance Manager

The duties of the Analytical QAM include:

- Direct the review of quality assurance (QA) plans and procedures
- Schedule and coordinate the analytical laboratories and data validators
- Oversee the tracking of samples and data from the time of field collection through laboratory reporting and database entry
- Review laboratory data for compliance with LTMP requirements

1.2.1.5 Long-Term Monitoring Field Supervisors

The duties of the Field Supervisors include:

- On-site coordination and direction of field activities and personnel

- Coordination of field and laboratory schedules
- Oversight of field activities to ensure they are conducted in accordance with this LTMP and the Health and Safety Plan (HSP)
- Authority to stop work based on QC issues, health and safety issues, or other deficiencies that may compromise the safety of the field crew or the integrity of the long-term monitoring program
- Communication of field conditions and progress, problems encountered, and recommended scope modifications (if needed) to the project team
- Oversee sampling subcontractors

1.2.1.6 Corporate Health and Safety Manager

The duties of the Corporate Health and Safety Manager include:

- Remote supervision of field activities to ensure adherence to the HSP
- Final authority on HSP issues and approval of significant modifications to the HSP, if needed, based on changed field conditions

1.2.2 Subconsultants/Subcontractors

All subconsultants and subcontractors will be identified to the Response Agencies for review and approval prior to the beginning of field work.

1.2.2.1 Analytical Laboratory Project Managers

The duties of the Analytical Laboratory PMs include:

- Oversee laboratory QA/QC requirements for the project
- Convey project requirements and objectives to laboratory staff and analysts
- Provide technical guidance to the Consultant Team
- Review laboratory data for compliance with LTMP requirements

1.2.2.2 Laboratory Quality Assurance Managers

The duties of the Laboratory QAMs include:

- Evaluate compliance with laboratory standards of practice and ensure that systems are in place to provide QA/QC as defined in this LTMP
- Initiate and oversee audits of corrective action procedures
- Perform laboratory data quality reviews

- Maintain laboratory documentation

1.2.2.3 Data Quality Validator

The duties of the Data Quality Validator include:

- Provide independent third-party data validation at the following frequency:
  - One hundred percent of each media will be validated in the first week of sampling during each monitoring event, and when a substantive modification is made to the sampling method or analytical laboratory
  - If initial validation is acceptable, a minimum of 10 percent of each media will continue to be validated on an ongoing basis
- Evaluate compliance with laboratory QA/QC criteria and other project requirements as defined in this LTMP
- Qualification of analytical data as needed to identify noncompliance with QA/QC criteria, and assessment of acceptability of data to fulfill project objectives

1.2.3 Wisconsin Department of Natural Resources (WDNR)

As one of the lead Response Agencies, WDNR and its consultants will observe, review, and provide regulatory and technical comments to ensure the long-term monitoring program fulfills the requirements of the ROD and provides data necessary to evaluate attainment of RAOs in the Lower Fox River and Green Bay. WDNR and USEPA have sole approval authority over any modifications to this Plan, including modifications to the frequency or intensity of sampling and the need for corrective action.

1.2.3.1 WDNR Project Coordinator

The duties of the WDNR Project Coordinator include:

- Review all project plans and data reports, and provide input to development of overall project strategies and technical approaches
- Indicate the appropriate time to evaluate fish consumption advisories
- Ensure LTMP meets the requirements of the ROD, and assist Consultant Team and WDNR staff in interpreting the intent of the ROD
- Final review and approval of LTMPs and Data Reports
- Ongoing communication with Consultant Team Project Coordinator and PM

1.2.3.2 WDNR Project Manager

The duties of the WDNR PM include:

- Scheduling and coordination of WDNR reviews and approvals of LTMPs and Data Reports
- Coordination of technical resources for WDNR and its consultants, and application of these resources to help support the design and implementation of the LTMP
- Assist WDNR Project Coordinator with project administrative duties
- Review progress reports detailing work accomplished

1.2.3.3 WDNR Quality Assurance Manager

The duties of the WDNR QAM include:

- Review LTMP for technical accuracy and completeness
- Provide technical assistance to the WDNR PM and Project Coordinator regarding analytical methods and QC procedures
- Review of data validation results, data quality, and the need for and scope of corrective actions, if any

1.2.4 U.S. Environmental Protection Agency (USEPA)

As one of the lead Response Agencies, USEPA and its consultants will observe, review, and provide regulatory and technical comments to ensure the long-term monitoring program fulfills the requirements of the ROD and provides data necessary to evaluate attainment of RAOs in the Lower Fox River and Green Bay. USEPA and WDNR have sole approval authority over any modifications to this LTMP, including modifications to the frequency or intensity of sampling and the need for corrective action.

1.2.4.1 USEPA Remedial Project Manager

The duties of the USEPA Remedial PM include:

- Review all project plans and data reports, and provide input to development of overall project strategies and technical approaches
- Ensure LTMP meets the requirements of the ROD
- Final review and approval of LTMPs and Data Reports
- Ongoing communication with Consultant Team Project Coordinator and PM

1.2.4.2 USEPA Quality Assurance Manager

The duties of the USEPA QAM include:

- Review LTMPs for technical accuracy and completeness
- Provide technical assistance to the USEPA Remedial PM

1.3 Communication Plan

1.3.1 Monthly Progress Reports

During periods of long-term monitoring activity (i.e., data collection, evaluation, and reporting), the Respondent Team Project Coordinator will provide written monthly progress reports to the Response Agencies by the 10th day of every month. These progress reports will describe the status of long-term monitoring activities.

1.3.2 Monthly Meetings

During periods of long-term monitoring activity, the Project Coordinators will hold monthly progress report meetings or telephone conferences unless it is deemed unnecessary by the Response Agencies. Such meetings will begin 1 to 2 months prior to the beginning of field work. Briefings on the status of long-term monitoring activities and preliminary results, as available, will be provided during the meetings.

1.3.3 Long-Term Monitoring Work Group

In an effort to develop a coordinated and cost-effective long-term monitoring program that is consistent with the intent of the ROD, representatives and consultants from the Respondent Team and the Response Agencies formed the Long-Term Monitoring Work Group. From October 2004 to May 2009, the Long-Term Monitoring Work Group held periodic meetings and conference calls to discuss monitoring objectives, field and analytical methods, data evaluation tools and techniques, and the design and implementation of the baseline monitoring program. Draft notes from these meetings are maintained in the Response Agency project files. The Long-Term Monitoring Work Group may continue to meet on a mutually agreeable schedule as needed to implement the long-term monitoring program. It is expected that meetings will be held to discuss the following:

- Adaptive management of field sampling, laboratory analysis, and data validation procedures

- Review and evaluation of long-term water, fish tissue, and sediment analytical results as they become available
- Ongoing assessment of the effects of sediment remediation, and progress toward achieving RAOs in the Lower Fox River and Green Bay

1.3.4 Electronic Data Transmittal

Technical documents, reports, data, comments, schedules, meeting notices, and general project communications related to long-term monitoring activities will be distributed electronically to designated members and consultants of the Response Agencies. Documents that are too large to send via email will be posted on a shared access website. In such cases, an e-mail notification will be sent to the same persons with information on how to access those documents. Electronic copies (CD-ROM) of laboratory analytical data packages (in pdf format) will be provided to the Response Agencies upon receipt from the laboratory. Once the data have been checked and verified, they will also be provided to the Response Agencies in an electronic file format that can be loaded into a database for relational queries and numerical analysis.

1.3.5 Hard Copy Data Transmittal

For documents requiring hard copy distribution, one copy will be sent to each of the following Response Agency personnel:

- USEPA Remedial PM
- WDNR Project Coordinator
- WDNR PM
- WDNR QAM
- WDNR Oversight Consultant PM
- Other personnel, as appropriate

1.3.6 Notification Procedures

Requirements for periodic progress reports and meetings between the Respondent Team, WDNR, and USEPA are described in Sections 1.3.1 and 1.3.2. At least 15 days of notice shall be given to the WDNR Project Coordinator and the USEPA Remedial PM prior to beginning sampling.

1.3.7 Modifications to the Long-Term Monitoring Plan

Significant modifications to the LTMP will be provided to USEPA and WDNR for review and approval via revisions to the LTMP or Addenda to the LTMP. Modifications that will require USEPA and WDNR approval include the following:

- Major changes/revisions to the monitoring design
- Major changes/revisions to the sampling or analytical methods
- Major changes to project team personnel
- Major changes/revisions to the statistical procedures for data quality assessment presented in Section 4.2

Modifications may be required as a result of unexpected or changed field conditions; extreme weather or hydrologic events; or due to the results of ongoing discussions of monitoring strategies, techniques, and procedures during the CERCLA 5-year reviews.

1.4 Problem Definition

1.4.1 Problem Statement

Data collected during the remedial investigation/feasibility study (RI/FS) and related investigations were used to define RAOs, Remediation Goals (RGs), and Cleanup Levels (CULs) for the Site (see USEPA 2005). The RAOs, RGs, and CULs for the Lower Fox River are set forth in the RODs for OUs 1 and 2 and OUs 2 through 5 signed by the Response Agencies in December 2002 and June 2003, respectively.

As with other CERCLA sites, the ROD described the overall goals and objectives, and selected a specific remedy that the Response Agencies believe will achieve the goals and objectives. Specifically, the RODs require that the remedies for the Site be designed to achieve CULs (i.e., addressing sediments above 1 part per million [ppm] or, if that is not achieved, a surface-weighted average concentration [SWAC] of 0.26 and 0.25 ppm in OU 3 and OU 4, respectively). The RODs concluded that achieving the CULs will result in achieving the RGs (target fish tissue concentrations) and RAOs (human and ecological risk reduction and surface water PCB load reductions to Green Bay). This translates into two types of remedy success measures: 1) remedy effectiveness success (whether the CULs are met); and 2) achievement of risk reduction targets (whether the RA leads to the desired levels of risk reduction).

1.4.1.1 Remedy Effectiveness Success

A sediment verification sampling program has been developed and approved by the Response Agencies as part of the Construction Quality Assurance Project Plan (CQAPP) and COMMP to ensure that the CULs have been achieved at the completion of the RA. Additional long-term monitoring of sediment quality will be conducted as part of this LTMP to verify that natural recovery processes in OUs 2 and 5 continue during the 30-year post-construction period. Long-term sediment monitoring also includes a focused sampling and analysis program to supplement the COMMP, providing further verification that sediment caps continue to provide effective chemical isolation of underlying contaminants. Long-term monitoring of water quality will be conducted in all OUs to verify that short-term and long-term improvements in sediment quality result in commensurate improvements in the water column. In a weight-of-evidence (WOE) evaluation, the combined verification and monitoring activities outlined in the CQAPP, COMMP, and LTMP will be used to determine whether RAs at the Site (i.e., dredging, capping, cover, and monitored natural recovery [MNR]) have successfully implemented best reasonably available technology in order to achieve successful remedy effectiveness.

1.4.1.2 Achievement of Risk Reduction Targets

The primary objective of this LTMP is to develop a monitoring program to evaluate achievement of risk reduction targets. The human and ecological receptors exposed to bioaccumulation pathways are the most sensitive endpoints for monitoring risk reduction success. Fish tissue concentrations will be monitored throughout the Site and compared to levels below which human fish consumption advisories may be relaxed or eliminated, and target RGs for ecological risk are being addressed. In conjunction with the remedy effectiveness determinations described in the preceding section, the results of the long-term monitoring program will be used in a WOE evaluation to determine whether the combination of RAs approved by the Response Agencies have achieved risk reduction targets.

1.4.2 Long-term Monitoring Objectives

Long-term monitoring data will be collected to evaluate progress toward achieving the RAOs of reduced risk to humans and the environment, as presented in the RODs

(WDNR and USEPA 2002, 2003). The data collection effort is focused on water, fish tissue, and sediment, these being critical components of all major bioaccumulation risk pathways. Water and sediment are media of concern through which many aquatic organisms, including benthic and pelagic fish, may be exposed to PCBs at the Site. Water and sediment are also the media through which contaminants in the Lower Fox River are entrained and transported out into Green Bay. Fish are the medium of exposure for bioaccumulation risk in higher-level organisms, including humans, mammals, and birds, as well as the fish themselves.

1.4.2.1 Remedy Effectiveness Objectives

In addition to construction monitoring activities, such as sediment confirmation sampling, the long-term monitoring objectives associated with remedy effectiveness success include:

- **Monitor Reductions in Sediment Contaminant Concentrations in MNR Areas.** Verify that sediment RAs in the Lower Fox River result in continued improvements in sediment quality in OUs 2 and 5 in the 30-year post-construction period.
- **Verify Chemical Isolation Properties of Sediment Caps.** In conjunction with the physical integrity monitoring activities specified in the COMMP, verify that sediment caps in the Lower Fox River provide effective long-term isolation of underlying contaminants.

1.4.2.2 Risk Reduction Objectives

The long-term monitoring objectives associated with risk reduction success include:

- **Monitor Reductions in Water and Fish Tissue Concentrations.** Verify that sediment RAs in the Lower Fox River result in substantive reductions in water column and fish tissue PCB concentrations. The RODs identified water and fish tissue as key exposure media through which bioaccumulation occurs.
- **Monitor Progress toward Achieving Human Health Risk Goals.** Verify progress toward achieving human health risk goals through a WOE analysis of recovery trends in water and fish tissue monitoring data. As described in the RODs, one of the goals of the RA is removal or relaxation of fish

consumption advisories for recreational and high-intake fish consumers. The results of the long-term monitoring program will be submitted to WDNR's Fish Consumption Advisory Program for their consideration in determining if and when modification or removal of advisories is warranted.

- **Monitor Progress toward Achieving Ecological Risk Goals.** Verify progress toward achieving ecological risk goals through a WOE analysis of recovery trends in water and fish tissue monitoring data. A primary goal of the RA is achievement of safe ecological thresholds for fish-eating birds and mammals. The results of the long-term monitoring program will be evaluated using the risk assessment framework described in the RODs, in consultation with WDNR and USEPA risk assessors, to determine if and when ecological thresholds are achieved.
- **Monitor Reductions in PCB Loadings to Green Bay.** Verify that sediment RAs in the Lower Fox River result in substantive reductions of PCB loadings to Green Bay. Decreased loadings from the Lower Fox River will help facilitate natural recovery processes in Green Bay.

1.4.3 Relationship to Other Monitoring Activities

Other related short-term and long-term monitoring activities in the Lower Fox River and Green Bay are described in the documents listed below.

1.4.3.1 Baseline Monitoring Data Report

Baseline fish tissue and water quality monitoring data in the Lower Fox River and Green Bay were collected to characterize existing (pre-remediation) conditions, and to provide an initial point of comparison for determining the magnitude and extent of PCB concentration reductions over the long term (Anchor QEA et al. 2009). The combined baseline and long-term monitoring data sets will allow the Response Agencies to determine whether or to what degree the implemented remedy meets risk reduction success criteria. The baseline monitoring program characterized the statistical variability of fish tissue and water data to help evaluate the statistical power of long-term monitoring decisions and to help estimate appropriate sample sizes. Unless otherwise noted, field and analytical techniques and procedures used

in the long-term monitoring program will be consistent with those used in the baseline monitoring program to ensure comparability of data.

1.4.3.2 Construction Quality Assurance Project Plan

Water column monitoring during construction activities, including dredging, capping, and dredged material disposal activities are described in the CQAPP (see Appendix D of the 100 Percent Design Report Volume 1). These monitoring activities are designed to ensure construction best management practices are being properly implemented to prevent construction activities from impacting the river or bay. One of the objectives of the CQAPP is to achieve RAO 5, as specified in the RODs: "Minimize the downstream movement of PCBs during implementation of the remedy." The sediment verification sampling program specified in the CQAPP will be used to confirm the attainment of remedial action levels (RALs) in sediments. If RALs are not met at the completion of construction, a range of contingency response actions will be implemented.

1.4.3.3 Cap Operations, Maintenance, and Monitoring Plan

Long-term maintenance and monitoring of capped areas are described in the COMMP (see Appendix H of the 100 Percent Design Report Volume 2). The COMMP specifies maintenance and monitoring activities to ensure the caps remain physically stable (i.e., do not erode) and chemically protective. Similar to the CQAPP, the COMMP provides a range of possible contingency response actions that may be implemented if post-construction monitoring data indicate the engineered caps have not met their RA criteria. In conjunction with the physical integrity monitoring activities specified in the COMMP, this LTMP describes the monitoring plan for sampling and analysis of the cap material to confirm the effectiveness of the chemical isolation properties of the cap.

1.4.3.4 Wisconsin Fish Consumption Advisory Program

Field surveys and chemical monitoring of contaminant levels in fish tissue in the Lower Fox River and Green Bay are ongoing activities performed by the State Fish Consumption Advisory Program. The monitoring activities of the State Fish

Consumption Advisory Program will continue during and after the long-term monitoring program has fulfilled its objectives.

1.5 Background Information

The design of the long-term monitoring program has benefited from the data collected during the baseline monitoring program, as well as from ongoing review and discussion of the baseline monitoring data in the Long-Term Monitoring Work Group. The baseline monitoring program was conducted between August 2006 and July 2007. The results are compiled in the Baseline Monitoring Data Report (Anchor QEA et al. 2009), and summarized briefly in this section. Unless otherwise noted, field and analytical methods used in the baseline monitoring program will be carried forward in the long-term monitoring program to ensure comparability of data and to minimize statistical errors caused by inconsistent sampling and analytical methods.

1.5.1 Site Description

The Lower Fox River is divided into five OUs (Figure 1-1):

- OU 1 is also known as Little Lake Butte des Morts. The Neenah and Menasha Dams control the pool elevation of Lake Winnebago and the discharge to the upstream end of OU 1 at river mile (RM) 39. The remediation of OU 1 is being addressed under a separate statement of work (SOW) and Consent Order from that of OUs 2 through 5.
- OU 2 extends from the Appleton Locks at RM 31.9 to the Little Rapids Dam at RM 13.1. This unit contains the majority of locks and dams in the Lower Fox River system and the greatest elevation drop and gradient. Sediments have a very patchy distribution in this reach with extensive intervening bedrock exposures. MNR is the selected remedy for OU 2, except for Deposit DD just upstream of Little Rapids Dam, which is planned for active remediation.
- OU 3 extends from the Little Rapids Dam to the De Pere Dam at RM 7.1. Soft sediment covers most of this unit.
- OU 4 extends from the De Pere Dam to the river mouth at Green Bay. This unit contains a federal navigation channel. The federal channel is currently maintained by the U.S. Army Corps of Engineers downstream of the Fort James

Turning Basin, but the section above here is unmaintained. The area around OU 4 is highly urbanized, including the City of Green Bay metropolitan area.

- OU 5 begins at the river mouth, and includes the entirety of Green Bay. Except for a relatively small PCB deposit on the river-mouth delta, MNR is the selected remedy for OU 5.

1.5.2 Site Water Quality

Chapter 4 of the Baseline Monitoring Data Report provides a summary and evaluation of water quality in the Lower Fox River, Green Bay, and Lake Winnebago (Anchor QEA et al. 2009). Water samples were collected on a monthly basis from 10 sampling stations (weather permitting) over a period of 1 year, from August 2006 through July 2007. The baseline water quality investigation is summarized briefly below.

1.5.2.1 Water Quality Summary Statistics

Summary statistics of blank-corrected total PCB concentrations (congener analysis by EPA Method 1668A), sorted by OU/subunit, are presented in Table 1-1. This table includes nonparametric statistics (minimum, maximum, median, and other percentiles) and parametric statistics (arithmetic mean, standard deviation, and coefficient of variation [CV]).

1.5.2.2 Spatial Distribution of Water Column PCB Concentrations

Average annual total PCB concentrations generally increase downstream in the Lower Fox River, from 4 nanograms per liter (ng/L; or parts per trillion [ppt]) in OU 1 to 28 ng/L in OU 4. Total PCB concentrations decrease beyond the mouth of the river in Green Bay, dropping from an average PCB concentration of 2 ng/L in OU 5A to 0.4 ng/L in OU 5C. In addition, there is a pronounced spatial gradient in the congener composition, from a mid-weight composition in the Lower Fox River, presumably associated with Aroclor 1242 contamination, to an increasingly heavier composition moving into the deeper waters of Green Bay, especially OU 5C. The lowest concentrations were observed in Lake Winnebago, with a mean concentration of 0.2 ng/L, representing upstream "background" concentrations unaffected by site activities and inputs.

1.5.2.3 Seasonal Trends in PCB Concentrations

Baseline water samples were collected on a monthly basis for a period of 1 year. These data show a pronounced seasonality in total PCB concentrations in the Lower Fox River (see Anchor QEA et al. 2009, Figure 4-3). Based on the observed seasonality, the data are stratified into winter months (December through March) and warm-weather months (April through November). Peak concentrations in the summer months of July and August are typically an order of magnitude or more higher than concentrations in the winter months throughout the Lower Fox River. However, seasonality is less pronounced in Lake Winnebago and Green Bay. Seasonal changes in ambient water temperature appear to be the primary cause the observed of seasonality in total PCB concentrations.

1.5.2.4 Seasonal Trends in PCB Loads

Estimated PCB loads (concentration times flow in mass/day) at the mouth of the Lower Fox River exhibit a seasonality that mimics the annual distribution of water concentrations (Anchor QEA et al. 2009; Appendix J). In particular, it is estimated that the PCB load during the combined 4 winter months, including December through March, when total PCB concentrations are lowest, amounts to only approximately 10 percent of the total annual PCB load to Green Bay.

1.5.3 Fish Tissue Quality

Chapter 3 of the Baseline Monitoring Data Report provides a summary and evaluation of fish tissue quality in the Lower Fox River, Green Bay, and Lake Winnebago (Anchor QEA et al. 2009). At least five different fish species were collected from nine sampling stations in late summer/fall 2006, with limited follow-up sampling in June 2007 to fill some data gaps in the program. The five fish species included a primary and secondary species for monitoring human health risk (walleye and bass, respectively), a primary and secondary species for monitoring ecological risk (carp and drum), and a young-of-year (YOY) forage fish to provide an early indication of ecosystem recovery (gizzard shad).

1.5.3.1 Fish Tissue Summary Statistics

Summary statistics of total PCB concentrations (Aroclor analysis by EPA method 8082), sorted by OU/subunit and species, are presented in Table 1-2. This table includes nonparametric statistics (percent detection, minimum, maximum, median, and other percentiles) and parametric statistics (arithmetic mean, standard deviation, and CV).

1.5.3.2 Fish Consumption Advisories

In the Lower Fox River and southern Green Bay, fish consumption advisories are in effect for 19 species. All species are listed for PCBs. The species restricted by consumption advisories are summarized in Table 1-3.

1.5.3.3 PCB Concentration by Species

The highest total PCB concentrations are generally associated with ecological and YOY index species—carp, drum, and gizzard shad. In OU 4, the average fish tissue PCB concentrations for these species are 4,600 μg/kg, 1,347 μg/kg, and 938 μg/kg, respectively. In contrast, somewhat lower PCB concentrations are associated with human health index species—walleye and bass—with average fish tissue PCB concentrations of 671 μg/kg and 442 μg/kg in OU 4, respectively.

1.5.3.4 Spatial Distribution of PCBs in Fish Tissue

Similar to the spatial patterns observed in water quality data, mean PCB concentrations in fish tissue generally increase downstream to peak concentrations in OU 4. For example, mean PCB concentrations in walleye increase from 135 μg/kg in OU 1 to 671 μg/kg in OU 4. Fish tissue PCB concentrations decrease beyond the mouth of the river into Green Bay. For example, walleye tissue concentrations decrease to 494 μg/kg in OU 5A and further decrease to 296 μg/kg in OU 5B. Similar trends were observed in other species, although the absolute magnitude of the tissue concentrations may differ. The lowest fish tissue concentrations are observed in Lake Winnebago, which represents upstream "background" concentrations unaffected by site activities and inputs, and with mean tissue concentrations typically one to two orders of magnitude lower than those in the river.

1.5.4 Conceptual Site Model

It was recognized in the RODs that bioaccumulation of PCBs in fish tissue and subsequent ingestion by higher-level organisms (humans, mammals, birds, and the fish themselves) is the primary risk pathway of concern in the Lower Fox River and Green Bay. A conceptual site model has been developed to better understand the relationship between sediments, water, fish, and fish-eating animals, including humans. The conceptual site model will be used to help interpret long-term monitoring data for water and tissue.

1.5.4.1 Predicted Reduction in SWAC due to Cleanup Action

The RODs estimated that the sediment RA in the Lower Fox River will result in an approximate 90 percent reduction of the SWAC for PCBs (WDNR and USEPA 2002, 2003). Remediating the in-water sources of PCBs in sediments is expected to result in substantive reductions in PCB water column concentrations, PCB loadings to Green Bay, PCB concentrations in YOY fish, and eventually, PCB concentrations in adult fish. However, there will likely be a lag period of several years before improvements in the tissue quality of adult organisms (i.e., fish of harvestable size) will be evident.

1.5.4.2 Predicted Reduction in Water Concentrations

As reported in the RODs and RI/FS, the RA in the Lower Fox River is expected to result in order-of-magnitude reductions in both water column PCB concentrations and PCB loads to Green Bay. Model predictions referenced in the RODs suggest that over the long term (i.e., roughly 30 years), post-RA PCB concentrations in the Lower Fox River are expected to decline by 90 percent or more compared to pre-remedial baseline values. Over shorter time frames (i.e., from one monitoring event to the next), concentrations are expected to decline by about 50 percent every 5 years, on average. These changes are predicted based on the combined effects of the remedy and subsequent long-term natural recovery processes.

1.5.4.3 PCB Concentrations vs. PCB Loads

The PCB load to Green Bay (mass/time) is the product of PCB water column concentration (mass/volume) times river flow (volume/time). Because the PCB load may be confounded by annual variations in flow (i.e., year-to-year changes in

weather and river hydraulics), PCB concentration is expected to provide a more accurate indicator of trends in water quality, and surface-water PCB concentrations in OU 4 will be used as a surrogate for monitoring PCB loadings to Green Bay. PCB concentrations in surface water represent the part of the PCB load that will be directly affected by the RA. However, differences in PCB concentration may also be confounded by the effects of flow conditions and temperature, so these variables will be controlled using appropriate statistical methods, including multiple regression techniques, during long-term data analysis.

1.5.4.4 Seasonal Effects on Water Quality

Water temperature exerts a seasonal influence on PCB concentrations in the Lower Fox River, with the highest PCB concentrations and loads occurring in the warm weather months from April through November. In contrast, less than 10 percent of the annual PCB load is discharged during the cold weather months from December through March, as estimated from baseline monitoring data (Anchor QEA et al. 2009). This is consistent with previous studies that estimated 4 to 12 percent of the annual PCB load, 8 percent on average, is discharged during this time period (Velleux and Endicott 1994; USEPA 2002a and 2004b; LTI 2002). Total suspended solids (TSS) concentrations are also correlated with PCB concentrations. The correlation between PCB concentration and flow appears to be weak but this relationship will be explored further during analysis of long-term monitoring data (Anchor QEA et al. 2009; Appendix J).

1.5.4.5 Bioaccumulation Exposure Pathways

As determined in the Baseline Risk Assessment (Retec 2002), the primary exposure pathway for humans and wildlife to become exposed to PCBs in the Lower Fox River is through consumption of PCB-contaminated fish. Therefore, the focus of the LTMP is to monitor risk reduction to humans and wildlife (including fishermen as well as fish-eating mammals and birds) by monitoring PCB concentrations in an appropriate selection of fish species, sizes, ages, and preparation methods which are relevant to these receptors.

1.6 Project Description

The long-term monitoring program is designed to assess long-term (i.e., decadal) recovery trends and conditions in water, fish tissue, and sediment quality in the Lower Fox River and Green Bay following the sediment RA.

1.6.1 Benchmarks and Criteria

1.6.1.1 Remedial Action Levels

The RAL for the Lower Fox River is:

- Remediation of sediments with PCB concentrations above 1 ppm

If post-dredge residual PCB concentrations remain above 1 ppm following the RA, the contingent cleanup level becomes:

- Attainment of SWACs in sediments of 0.25, 0.28, and 0.25 ppm in OU 1, OU 3, and OU 4, respectively
- Further SWAC reductions caused by more limited RAs in OU 2 and OU 5A, which are otherwise designated for MNR

Through achievement of the RAL or SWAC, the RA is expected to greatly improve sediment quality conditions in the Lower Fox River. In response, it is expected that first water and then fish tissue PCB concentrations will decline. Measuring the rate and magnitude of this decline in water and fish tissue, over a representative set of stations, seasons, and species, is a key objective of the LTMP.

1.6.1.2 SWAC Reduction Criteria

As a measure of remedy effectiveness, the Response Agencies expect that SWAC reductions achieved in sediments as a result of the RA will propagate into commensurate reductions in PCB concentrations in the water column, YOY forage fish, and eventually adult fish. SWAC reduction criteria will therefore be used in the evaluation of water and YOY fish tissue monitoring data.

The SWAC reductions that are expected to result from the sediment RAs in OUs 1, 3, and 4 range from 86 to 93 percent, averaging 90 percent, as summarized below (WDNR and USEPA 2002, 2007):

Unit	Pre-Remediation PCBs (mg/kg)	Post-Remediation PCBs (mg/kg)	Percent Reduction
OU 1	3.70	0.25	93%
OU 2	0.61	N/A	N/A
OU 3	2.00	0.28	86%
OU 4	3.20	0.25	92%
OU 5	0.25	N/A	N/A

N/A = Not applicable (i.e., no substantive RAs)

As a result, approximately 90 percent reductions in PCB concentrations may be similarly realized in the water column and in YOY fish in response to the sediment RAs in OUs 1, 3, and 4. However, similar estimates cannot be made in OUs 2 and 5 because these are predominantly MNR areas that have not been substantially affected by sediment RAs. Predicted reductions in these MNR areas may be lower than 90 percent because they are indirectly affected by upstream actions and they are starting at considerably lower sediment concentrations.

1.6.1.3 PCB Mass Loading Reduction in OU 4

One of the RAOs specified in the ROD for OUs 3, 4, and 5 is to "reduce transport of PCBs from the Lower Fox River into Green Bay and Lake Michigan" (WDNR and USEPA 2003). The ROD expectation is that PCB loadings to Green Bay and Lake Michigan will be reduced "to levels comparable to the loading from other Lake Michigan tributaries." To characterize what magnitude of reduction would be needed to make the PCB load from the Lower Fox River comparable to other Lake Michigan tributaries, a review of PCB loadings from the 1994-1995 Lake Michigan Mass Balance Study (LMMBS; USEPA 2009) and a follow-up study conducted by the U.S. Geological Survey (USGS) in 2005-2006 (USGS 2009) is provided below.

Tributary	1994-95 PCB Load (kg/year)	2005-2006 PCB Load (kg/year)
Lower Fox	216	167
Grand Calumet	40	17
Kalamazoo	38	20
Sheboygan	12	NA
Milwaukee	11	NA
Grand	10	6
St. Joseph	10	7

Based on these loading estimates, the PCB load from the Lower Fox River (OU 4) to Green Bay should be reduced by approximately 90 percent to be commensurate with the PCB loads from other Lake Michigan tributaries. This reduction is consistent with the magnitude of the SWAC reduction described in the previous section.

1.6.1.4 Background Criteria

PCB concentrations in Site areas are not expected to decline below concentrations observed in relatively unimpacted background locations, given the effects of ambient low-level contamination from regional and global sources such as atmospheric deposition and stormwater runoff unrelated to Lower Fox River sediments. Lake Winnebago provides an upstream background reference station for water and fish tissue quality for comparison to the Lower Fox River, and Station OU 5C in central Green Bay provides a water quality reference station for comparison to OUs 4, 5A, and 5B (note that the PCB signature at this deep-water location does not appear to be substantially influenced by inputs from the Lower Fox River) (Anchor et al. 2009). Fish contaminant databases in state monitoring programs in Wisconsin (http://dnr.wi.gov/fish/consumption/) and Michigan (http://www.deq.state.mi.us/fcmp/) will be consulted to determine appropriate Great Lakes background levels of PCBs in fish tissue.

Background criteria may be defined using the 90 percent confidence, upper prediction limit on the mean concentration to avoid unreasonable false positive error rates (i.e., concluding a Site is significantly more contaminated than background when in fact it is not) (Bhaumik and Gibbons 2004). Upper prediction limits were calculated using a bootstrapping method in which random samples of a specified size are drawn, with replacement, from the empirical data set and the distribution of sample means is analyzed after a large number of repetitions are completed (Cressie 1993).

Background criteria (90 percent upper prediction limit on the mean) for water and fish tissue are provided below, based on the results of the baseline monitoring program (Anchor QEA et al. 2009). In addition, preliminary Great Lakes background concentrations for walleye (skin-on fillet) and carp (whole fish) are

provided based on a review of Michigan's fish contaminant database, including samples from Lake Michigan and the Menominee, Muskegon, Manistique, Grand, and St. Joseph Rivers (Michigan DEQ 2005). For consistency with the baseline monitoring data, Aroclor analyses were used to characterize background PCB concentrations in Great Lakes fish tissue, rather than congeners.

Medium	Units	LTMP Sample Size	Lake Winnebago		Great Lakes	
			Mean	90% Upper Prediction Limit	Mean	90% Upper Prediction Limit
Water (Jan-Dec)	ng/L-bc	8	0.19	0.48	0.37*	0.54*
Water (Apr-Nov)	ng/L-bc	8	0.24	0.70	0.42*	0.61*
Walleye	µg/kg-ww	15	24	27	~220**	~440**
Carp	µg/kg-ww	7	36	41	~700**	~1,200**
Drum	µg/kg-ww	5	175	221	TBD	TBD
Gizzard Shad	µg/kg-ww	7	25	30	TBD	TBD

* Calculated using Green Bay Station OU 5C

** Calculated using Michigan DEP fish contaminant database, 1995 to present.
bc = blank-corrected (water) per modified Ferrario method; see Section 4.2.2
ww = wet weight (tissue)

1.6.1.5 Human Health Target Tissue Goals

As stated in the Lower Fox River RODs, the human health RAO is removal or relaxation of fish consumption advisories for recreational and high-intake fish consumers. If PCB concentrations in fish tissue reach levels that indicate fish consumption advisories may be relaxed, then progress toward the human health risk-reduction goal is being achieved. The following table provides benchmarks for fish consumption advisory levels. Note that these benchmarks, used to evaluate long-term monitoring data, do not take into account the independent process that WDNR must go through to actually change the advisory.

Fish Consumption Advisory	PCB Concentration (µg/kg-ww)
Do Not Eat	> 2,000
6 meals/yr	1,000 – 2,000
12 meals/yr	220 – 2,000
52 meals/yr	50 - 220
Unlimited	< 50

1.6.1.6 Ecological Target Tissue Goals

As stated in the Lower Fox River RODs, the ecological RAO is achievement of safe ecological thresholds for fish-eating birds and mammals, which are among the most sensitive ecological receptors to PCB contamination. Ecological risk will be evaluated using lowest observed adverse effects concentrations (LOAECs) as developed in the Ecological Risk Assessment for the Lower Fox River. LOAECs are listed below.

Species	Effect (LOAEC)	Whole Fish PCB Concentration (ug/kg-ww)
Walleye	Fry growth & mortality	7,600
Carp	Fry growth & mortality	7,600
Common Tern	Hatching success & deformity	4,055
Foster's Tern	Hatching success & deformity	3,879
Double-crested Cormorant	Hatching success & deformity	1,317
Bald Eagle	Hatching success & deformity	1,147
Mink	Reproduction & kit survival	500

1.6.2 Overview of Long-Term Monitoring Activities

Water and fish tissue will be periodically monitored at a number of stations from upstream Lake Winnebago, through the Lower Fox River, and out into Green Bay.

1.6.2.1 Water Quality Monitoring Plan

The water monitoring plan includes systematic monthly sampling of 10 stations during the 8-month non-winter season between April and November (10 x 8 = 80 water samples, plus QC samples, during a given monitoring year). Water monitoring stations are sited near the downstream boundaries of Lake Winnebago (upstream background) and each of the OUs such that the net PCB contribution from each OU, and the effectiveness of the remedy in each OU, can be evaluated. Multiple water quality monitoring stations are sited in OU 2 (including OU2A, OU2B, and OU2C) and OU 5 (including OU5A, OU5B, and OU5C) to provide increased coverage in these large MNR areas with more diverse environments. The water quality monitoring locations are the same as those used in the baseline monitoring program.

1.6.2.2 Fish Tissue Monitoring Plan

The fish tissue monitoring plan includes sampling of four different types of species – walleye (human health index species), carp and drum (ecological index species), and gizzard shad (YOY forage fish species). In addition, substitute human health species may be added to the program after walleye achieves its risk-reduction goal to further support fish consumption advisory evaluations. The fish will be sampled at 9 different stations in Lake Winnebago, Lower Fox River, and Green Bay; they will be located in the general vicinity of all water stations except OU5C. Each walleye station (or substitute human health species) will be comprised of 15 individual fish; each carp station (in the Lower Fox River) will be comprised of seven composite samples of five fish in each composite; each drum station (in OU 4 and Green Bay) will be comprised of five composite samples of five fish in each composite; and each gizzard shad station will be comprised of seven composite samples of 25 fish in each composite. It is expected that different fish species will be collected from different parts of the OUs because of varying habitat preferences, feeding and migration patterns. Recommended fish sampling locations are presented in Section 2.2.2 based on lessons learned during the baseline monitoring program; however, exact locations may be adjusted in response to the local field conditions at the time of sampling.

1.6.2.3 MNR Sediment Sampling Plan

Sediment monitoring will be conducted in representative MNR areas of OUs 2 and 5. Sediment monitoring of MNR areas will provide a secondary line of evidence to document natural recovery success, with the primary line of evidence being based on fish tissue and water monitoring results. Approximately 10 sampling stations in OU 2, and 15 to 20 sampling stations in OU 5 will be monitored, focusing on those areas that were reported in the RI/FS as containing surface sediment PCB concentrations above 1 milligram per kilogram (mg/kg). To the extent possible, sediment MNR sampling stations will be co-located with surface water and fish monitoring stations. At each sediment sampling station, a 5-point composite surface sample will be collected from the top 6 inches (15 centimeters) of the sediment to track reductions in average PCB concentrations over time. The details of sediment monitoring locations, along with field and analytical protocols, will be finalized

toward the conclusion of RAs in OUs 2 through 5, and will be approved by the Agencies as an addendum to this LTMP.

1.6.2.4 Cap Chemical Isolation Monitoring Plan

Cap chemical isolation monitoring will be performed in representative areas with "Type B" caps to verify basic cap design assumptions (i.e., proper installation of the cap and resistance to chemical diffusion through from underlying contaminated sediments). "Type B" caps contain a basal layer of mixed cap material and sediment overlain by a clean chemical isolation layer and a final armor layer; these types of caps are installed over mid-range sediment PCB concentrations (between 10 and 50 ppm). Cap chemical isolation monitoring will provide a secondary line of evidence to document cap effectiveness, with the primary line of evidence being a comprehensive survey of the physical integrity of capped areas, as described in the Agency-approved COMMP (including bathymetry, sub-bottom profiling, poling, and potentially other methods to verify that the caps and armor layers remain intact). Diver cores will be used to collect samples of the chemical isolation layer in 15 to 20 representative locations, taking care not to create sampling-induced carry-down or cross-contamination of the cap samples. The details of cap chemical isolation monitoring locations, along with field and analytical protocols, will be finalized toward the conclusion of RAs in OUs 2 through 5, and will be approved by the Agencies as an addendum to this LTMP.

1.6.3 Equipment and Personnel Requirements

1.6.3.1 Equipment Requirements

Equipment required for water quality monitoring activities includes:

- Sampling boat with echo sounder
- Water quality monitoring probe (temperature and turbidity)
- Water quality field forms
- Sampling pump (peristaltic), tubing, and accessories (Lower Fox River and Lake Winnebago)
- Water column sampler (Niskin bottle or equivalent) (Green Bay)
- Differential Global Positioning System (DGPS)
- Safety and personal protective equipment (per HSP)

Equipment required for fish sampling activities includes:

- Sampling boat with echo sounder
- Support boat
- Electrofishing equipment
- Other fish collection equipment as needed (e.g., rod/reel, nets, trawls)
- Fish collection field forms
- Scale and ruler to size fish
- GPS
- Safety and personal protective equipment (per HSP)

The field crew will need to obtain a fish collection permit prior to beginning fish sampling activities.

Equipment requirements for MNR sediment monitoring and cap chemical isolation monitoring activities will be subsequently provided in an addendum to this LTMP.

1.6.3.2 Personnel Requirements

Field Supervisors will be experienced in conducting water and/or fish sampling activities at hazardous waste cleanup sites as necessary to implement the tasks required in this Plan in accordance with the field and laboratory quality assurance requirements of this Plan. Field personnel will be trained in the safe and proper use of the above-listed equipment. During sediment sampling activities, all field personnel will have completed 40-hour HAZWOPER training with up-to-date, annual 8-hour refresher training. This training is recommended, although not required, for fish and water sampling activities.

The project team will include a fisheries biologist, a database manager, and a chemist experienced in PCB congener analysis and evaluation. Subcontract analytical laboratories must be qualified to perform the required analyses (see Section 2.6) at the required levels of QA/QC (see Section 2.7), and will be subject to review and approval by the Response Agencies.

1.6.4 Preliminary Long-Term Monitoring Schedule

An overview of the projected schedule of long-term monitoring activities is presented on Figure 1-3. This schedule is of a conceptual nature, given the uncertainties in the schedule for completion of sediment RAs in the different OUs that trigger the initiation of long-term monitoring activities.

The key concepts of the long-term monitoring schedule include the following:

- Remediation of OU 1 began in 2004 and was completed in May 2009. An initial Phase 1 removal action in OU 4 was performed in 2007. The main phase of sediment remediation in OUs 2 to 4 began in April 2009 and is projected to be completed in 2017. Remediation will be completed in OUs 2 and 3 first, then the majority of the construction period will be spent working in OU 4.
- Post-construction monitoring of water and fish in Lake Winnebago and OU 1 will begin in 2010, with water monitoring from April through November 2010 and fish sampling from August 15 through September 15, 2010.
- Post-construction monitoring in the remaining OUs will begin at or near the completion of remediation: in 2012 for Lake Winnebago through OU 3 (including continued monitoring in OU 1), and in 2017 for Lake Winnebago through OU 5.
- Initially, the monitoring will be scheduled on 5-year intervals. The monitoring is planned to occur 1 year prior to the scheduled CERCLA 5-year reviews. This provides for periodic reassessment of the scope of the monitoring program in light of progress achieved toward environmental recovery. Based on the results of the 5-year review, the path forward could include: 1) continued monitoring at 5-year intervals; 2) continued monitoring at less frequent intervals (e.g. 10-year intervals); 3) continued monitoring of fish and phasing out of other media because progress is being made toward risk-reduction goals; and 4) termination of monitoring because risk-reduction goals have been achieved.
- During each designated monitoring year, water sampling will be conducted on a monthly basis from April through November. Fish sampling will occur between August 15 and September 15. Sediment monitoring will be conducted concurrently with fish sampling.

1.7 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that define the objectives of the project, identify the most appropriate types of data and data collection procedures, and specify acceptable error limits for decision making. The DQOs for this project were developed in accordance with *USEPA Guidance for Data Quality Objectives Process*, EPA QA/G-4 (USEPA 2000b) and *USEPA Region 5 Instructions on the Preparation of the Superfund Division Quality Assurance Project Plan, Revision 0* (USEPA 2000a). Once approved, any proposed additions or changes to methods and procedures of this LTMP will be documented in addenda to the Plan subject to the review and approval by WDNR and USEPA.

The DQO Process for Long-Term Monitoring is presented below.

1.7.1 Step 1: State the Problem

The overall objective of the LTMP is to characterize long-term, post-remediation, water, fish tissue, and sediment quality in the Lower Fox River and Green Bay. The combined baseline and long-term monitoring data will provide the Response Agencies with information to determine whether the implemented remedy meets RAOs, including remedy effectiveness criteria and risk reduction targets.

As stated in the ROD (WDNR and USEPA 2002, 2003; see also Section 1.4.3), the RAOs for this project which are relevant to the long-term monitoring program include:

- Reduction of water column PCB concentrations
- Removal of human health fish consumption advisories
- Achievement of safe ecological thresholds for fish-eating birds and mammals, and other ecological receptors
- Reduction of Lower Fox River PCB loadings to Green Bay

These objectives are expected to be met through completion of the sediment RA (which was recently completed in OU 1 and is currently underway in OUs 2 through 5) and achievement of sediment RALs as specified in the RODs.

1.7.2 Step 2: Identify the Decisions

1.7.2.1 Risk Reduction Decisions

A key objective of the long-term monitoring program is to determine whether the RA has been successful at reducing risk to humans, fish and wildlife. In addition, reductions in sediment contaminant concentrations resulting from the RA (i.e., dredging, capping, and cover) are expected to bring about similar levels of reduction in water and YOY fish as well as long-term improvements in MNR areas. The LTMP is designed to answer the following questions:

- Are fish tissue concentrations declining to levels that will allow human consumption at recreational and high intake rates?
- Are fish tissue concentrations declining to levels that will not impair fish and wildlife?
- Are fish tissue concentrations declining at rates that will achieve human health and ecological goals within 30 years?
- Are water and YOY fish tissue PCB concentrations declining in response to sediment RAs, and at levels commensurate with the sediment quality improvements brought about by the RAs?
- Are the PCB loadings from the Lower Fox River to Green Bay declining to levels comparable to other Lake Michigan tributaries?
- Are water and fish tissue concentrations declining to levels comparable to relatively unimpacted background areas?
- Are water concentrations declining to levels comparable to field and laboratory blank contamination levels, indicative of ubiquitous low-level PCB contamination in the regional or global environment?

1.7.2.2 Remedy Effectiveness Decisions

A second objective of the long-term monitoring program is to monitor the effectiveness of the RA. The LTMP is designed to answer the following questions:

- Are natural recovery processes in OUs 2 and 5 progressing at rates comparable to or better than expected (i.e., based on recovery rates predicted in the RI/FS and ROD)?
- Are sediment caps providing an effective chemical barrier for the underlying contaminated sediments?

These decisions will be evaluated, reevaluated, and adaptively managed as more and more long-term monitoring data become available. The monitoring data will be evaluated on an OU-by-OU basis, allowing management and monitoring decisions to be made on an OU-by-OU basis. In OUs 2 and 5, both of which include multiple monitoring stations due to their substantially greater extent and environmental complexity, management decisions will be further subdivided into portions of the OUs.

Ultimately, the achievement of human health and ecological risk-reduction goals will be based on fish tissue concentrations. However, water represents a medium through which fish are exposed to PCBs, and will therefore be used as an indicator of bioaccumulation, an indicator that potentially responds more quickly to the effects of the RA. Water is also a medium through which PCBs are transported from the Lower Fox River to Green Bay. YOY fish serve a similar role as an early indicator of ecosystem recovery. Sediment will be monitored primarily for informational purposes, to help track natural recovery processes, and to provide a secondary line of evidence for management decisions.

1.7.2.3 Exit Criteria

The decisions outlined in the previous section are structured into a series of exit criteria to help determine when long-term monitoring goals have been achieved and monitoring may be reduced or eliminated. These exit criteria are also expressed as hypothesis statements that will be amenable to statistical testing. The default condition in the hypothesis statements is that the remedy has had no effect unless the preponderance of data indicates that it has. In other words, rejection of the null hypothesis provides evidence of remedial success.

1. **Comparison to Background Concentrations (All Media).** This criterion will be satisfied when it can be shown that Site contaminant concentrations are equivalent to ambient background contamination in relatively unimpacted reference areas. Lake Winnebago serves as the upstream reference area for fish tissue and water quality for the Lower Fox River (applicable to OUs 1 through 3); OU 5C serves as the Green Bay reference area for water quality

(applicable to OUs 4, 5A, and 5B), and Great Lakes reference concentrations for fish tissue quality will be determined from a review of Wisconsin and Michigan fish contaminant databases in Lake Michigan and in relatively unimpacted tributaries of Lake Michigan representing a range of rural and urban land uses. Background criteria are established using the 90 percent upper prediction limit on the mean of the background data, as presented in Section 1.6.1.4.

- *Null Hypothesis 1.* Water and fish tissue contaminant concentrations are higher than reference areas.
- *Alternative Hypothesis 1.* Water and fish tissue contaminant concentrations are less than or equivalent to reference areas.

Alternative Hypothesis 1 will be accepted when it can be shown that Site monitoring data from a particular OU is equivalent to background data with an appropriate level of statistical confidence.

2. **Comparison to Risk-based Target Concentrations (Human Health and Ecological Fish Species).** This criterion will be satisfied when it can be shown that Site concentrations have achieved levels that indicate fish consumption advisories may be reduced or eliminated and are protective of wildlife. Human health and ecological evaluation criteria are presented in Sections 1.6.1.5 and 1.6.1.6, respectively. The average fish tissue concentration is the metric that will be compared to human health and ecological risk-reduction criteria, given that bioaccumulation exposures are represented by long-term average concentrations in the food source.
   - *Null Hypothesis 2a.* Fish tissue concentrations in human health index species are higher than risk-based goals for recreational and high-intake fish consumption.
   - *Alternative Hypothesis 2a.* Fish tissue concentrations in human health index species have achieved risk-based goals for recreational and high-intake fish consumption.
   - *Null Hypothesis 2b.* Fish tissue concentrations in ecological index species are higher than LOAECs for protection of fish, birds, and mammals.

- *Alternative Hypothesis 2b.* Fish tissue concentrations in ecological index species have achieved LOAECs for protection of fish, birds, and mammals.

Alternative Hypotheses 2a or 2b will be accepted when it can be shown that the mean fish tissue concentration in a particular OU is below the risk-based target concentration with an appropriate level of statistical confidence.

3. **Comparison to SWAC-Reduction Targets (Water and YOY Species).** This criterion will be satisfied when it can be shown that PCB concentrations in water and YOY fish tissue have achieved the SWAC-reduction targets presented in Sections 1.6.1.2. In addition, water in OU 4 must meet the PCB load reduction target presented in Section 1.6.1.3. To fulfill these criteria, water and YOY fish tissue concentrations should achieve a 90 percent reduction relative to baseline conditions. Note that somewhat lower reductions may be expected in MNR areas (see Section 1.6.1.2). While there are no specific reduction targets for sediment, sediment will be monitored until fish and water monitoring is discontinued.
   - *Null Hypothesis 3.* PCB concentrations in water and YOY fish have not been reduced to 10 percent of their initial baseline concentrations.
   - *Alternative Hypothesis 3.* PCB concentrations in water and YOY fish are less than or equal to 10 percent of their baseline concentrations.

   Alternative Hypothesis 3 will be accepted when it can be shown that the mean water or YOY fish tissue concentrations in a particular OU are at or below their SWAC reduction targets with an appropriate level of statistical confidence.

4. **Evaluation of Recovery Rate, i.e. Slope (All Fish Species and Water).** After a minimum of three sampling events, the rate of post-construction PCB concentration reductions will be analyzed based on an exponential decay function. If the PCB reduction rate indicates risk-based concentrations, SWAC-reduction goals, or background conditions will be achieved within 30

years after remediation (while controlling for co-variables as necessary), the monitoring schedule may be adjusted to more cost-effectively document this condition.

- *Null Hypothesis 4.* Water and fish tissue concentrations will not achieve risk-based goals, SWAC-reduction criteria, or background conditions within 30 years.
- *Alternative Hypothesis 4.* Water and fish tissue concentrations will achieve target concentrations within 30 years, indicating the RA has been successful.

Alternative Hypothesis 4 will be accepted when it can be shown, through extrapolation of temporal regression models, that target concentrations (whether based on acceptable risk levels, background, or SWAC reduction criteria) will be achieved in post-remediation Year 30 with an acceptable level of statistical confidence. Then, a follow-up confirmation sampling event will need to be scheduled to confirm the model predictions.

5. **Evaluation of Laboratory Blank Contamination Levels (Water).** If mean sample concentrations are less than three times the laboratory method blank concentrations, analytical method performance will be evaluated to determine whether additional optimization is practicable, or alternatively, it will be concluded that concentrations have reached the limit of analytical capabilities for reliable determinations. If concentrations fall within this range of method blank contamination, the LTMP goals will be determined to be met to the extent practicable using best available technology. The background contamination levels in field rinseate blanks should also be considered in this evaluation.
   - *Null Hypothesis 5.* PCB concentrations in water are above the range of method blank contamination and can be reliably quantified.
   - *Alternative Hypothesis 5.* PCB concentrations in water are within the range of method blank contamination and cannot be reliably quantified.

Alternative Hypothesis 5 will be accepted when it can be shown that the mean PCB concentration in a particular OU is less than three times the mean concentration in laboratory method blanks, provided further control of laboratory blank contamination is not practicable.

1.7.2.4 Weight-of-Evidence Evaluation

In addition to the exit criteria listed in the preceding section, a WOE evaluation of LTMP results will be conducted in consultation with WDNR and USEPA during each CERCLA 5-year review to determine whether the preponderance of data indicates risk-reduction goals are or are not being achieved. This provides for adaptive management of LTMP goals and objectives using the knowledge gained during the course of the monitoring program. Based on the WOE evaluation, the monitoring intensity may be increased, decreased, or eliminated in certain OUs. The WOE evaluation will consider the following:

- Achievement of significant progress toward risk reduction goals, including achievement of intermediate goals and relaxation of fish consumption advisories, even if high-intake fish consumption may not be achieved for all areas and all species.
- Evaluation of percent PCB concentration reductions in adult fish tissue compared to observed reductions in other media (e.g., water and YOY fish, which may respond more quickly to the RA), and whether further reductions over time would or would not be expected.
- Comparison of measured PCB reductions over time with predictions summarized in the RI/FS and RODs, and whether observed reductions are progressing faster or slower than expected.
- Stabilization of concentrations in a particular medium, with no significant change from one monitoring event to the next, indicating natural recovery processes associated with the RA have run their course and further monitoring would be of limited value (i.e., "flat line" condition).

1.7.3 Step 3: Identify Inputs to the Decision

1.7.3.1 Baseline Monitoring Data

A comprehensive baseline monitoring data set was collected between August 2005 and June 2007 to characterize current environmental conditions at the Site. These data were analyzed to help develop a statistically based long-term monitoring program, to estimate sample sizes for long-term monitoring, and to define a baseline level of contamination for evaluating the recovery of water, fish tissue, and sediment concentrations in the years following the completion of the sediment RA.

Water Quality Summary. Summary statistics of blank-corrected total PCB concentrations in water (congener analysis by EPA Method 1668A), sorted by OUs, are presented in Table 1-1. Water quality data are tested for conformance with standard normal and lognormal distributions in Table 1-4.

Water column data have a bi-modal distribution, with higher concentrations during the warm weather months of April through November, and much lower concentrations during the winter, often ice-covered months of December through March. Stratification of the data therefore improves the statistical characteristics of the data. Water quality data from the warm weather months are well described by standard normal distributions (i.e., data are normally distributed at seven out of 10 monitoring stations) whereas the year-round data set shows more significant deviations from normality (normally distributed at only three out of 10 monitoring stations). The CVs in the Lower Fox River during the warm weather months (0.56 to 0.70) are also lower than the CVs for the year-round data set (0.79 to 1.04), indicating stratification of the warm-weather data helps to control statistical variability.

Also included in Table 1-1 is the standard error on the mean water concentration, expressed as a percentage of the mean, for use in estimating statistical confidence levels for hypothesis testing of exit criteria (see Section 4.2.3.4). For the warm-weather data set, the standard error on the mean total PCB concentration in water ranges from 9 to 25 percent, depending on the OU.

Fish Tissue Summary. Summary statistics of total PCB concentrations in fish tissue (Aroclor analysis by EPA method 8082), sorted by OUs and species, are presented in Table 1-2. Fish tissue data are tested for conformance with standard normal and lognormal distributions in Table 1-5. Distribution test results show that fish tissue concentrations are well described by standard normal distributions in a majority of cases. The data are also well described by lognormal distributions; however, in general lognormal distributions do not improve the goodness-of-fit over normal distributions.

Also included in Table 1-2 are the standard errors on the mean fish tissue concentrations, expressed as a percentage of the mean, for use in estimating statistical confidence levels for hypothesis testing of exit criteria (see Section 4.2.3.4). The range of standard errors on the mean total PCB concentrations in fish tissue are summarized below:

- Walleye: 8 to 22 percent
- Bass: 8 to 19 percent
- Drum: 8 to 18 percent
- Carp: 10 to 42 percent
- Shad: 5 to 32 percent

1.7.3.2 Existing Monitoring Guidance

Federal and State guidance documents were consulted in preparing the LTMP, including the following:

- EPA 2000, Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis
- Great Lakes Sport Fish Advisory Task Force 1993, Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory
- EPA 2005, Contaminated Sediment Remediation Guidance for Hazardous Waste Sites

1.7.3.3 Key Inputs to Monitoring Plan Design

A number of important considerations and monitoring strategies have been discussed in the LTMP Work Group and have helped to guide the design of this LTMP. General programmatic monitoring strategies include the following:

- Archiving of Samples. Fish tissue and sediment samples will be archived (in frozen storage) in case additional or repeat analyses are called for during data review and evaluation. Samples will be archived for a minimum of one CERCLA 5-year review cycle. The status of the samples will be considered during the 5-year review process, at which time the samples may be designated for continued archiving over another review cycle, or else discarded.
- Expanded Baseline Monitoring Activities. The baseline monitoring program was designed to be more broad-based than the long-term monitoring program; this strategy will provide flexibility to accommodate changing environmental conditions in the decades ahead, such as changes in fish species availability. For example, an expanded list of fish species was sampled during the baseline monitoring program, including primary as well as secondary contingency species. During long-term monitoring, the primary fish species will be the main focus of the monitoring program. However, secondary species may also be analyzed in certain circumstances, for example: 1) if the primary species are sparse or unavailable; 2) to provide further support for human health fish consumption advisories; or 3) if the variability of the data for the primary species is higher than expected, compared to the baseline monitoring data, or if the statistical power is compromised by confounding variables or trends.
- State-of-the-Art Detection Limits. Because PCBs are difficult to detect in water at concentrations of environmental concern, a highly sensitive analytical method with ultra-low detection limits has been selected to carry the program forward into the future, in anticipation of declining concentrations in the future. Specifically, PCBs in water will be analyzed using high-resolution gas chromatography/mass spectrometry (HRGC/MS) by EPA Method 1668A which provides the lowest commercially achievable detection limits at the present time. It should be noted, however, that

analytical sensitivity is not just a function of instrument detection capabilities, it is also affected by sample volumes and blank contamination levels. Double (2 liter) sample volumes are being collected (see Section 2.6.1), and lab and field blank contamination levels are being monitored and evaluated (see Sections 2.7.1 and 4.2.2) to help control and optimize all aspects of analytical sensitivity.

- Control of Confounding Variables. The assessment of river recovery, as measured by decreasing water and fish tissue contaminant concentrations, may be confounded by random or systematic changes in other controlling variables. For example, PCB concentrations in water are affected by river temperature and turbidity, and possibly flow, and PCB concentrations in fish tissue are affected by fish type, age, length, and fat content. As a result, field sampling and data analysis techniques will be utilized to control for the effects of confounding variables to the extent possible, thus providing a more accurate assessment of river recovery rates and magnitudes.
- General Strategy for Sampling Locations. Post-remediation management decisions will be made on the basis of OUs. Therefore, fish and water sampling stations are allocated to each of the OUs on the Lower Fox River. More detailed monitoring will be conducted in the MNR areas, OUs 2 and 5; these OUs are characterized by multiple fish and water stations due to their greater spatial extent and habitat complexity. The rationale for selection of water and fish monitoring locations is summarized in Table 1-6.
- Timing of Fish Sampling. Fish sampling will occur in late summer (August 15 to September 15) for the following reasons: 1) fish lipid content, which tends to concentrate PCBs, is typically highest in late summer and early fall after heavy spring and summer feeding, and therefore fish are expected to carry some of their highest PCB burdens during that time of year; 2) recreational fishing is popular at that time of year; 3) fish spawning periods are avoided; and 4) the state conducts many of its fish sampling programs and fish population surveys during that time, allowing for coordinated data collection activities.
- Timing of Water Sampling. Water samples will be collected monthly during the eight non-winter months from April through November. The four winter

months are excluded from the monitoring program for the following reasons: 1) winter sampling from December through March presents a safety concern for the field crew due to severe weather conditions; 2) PCB concentrations in the Lower Fox River are at their annual lowest concentrations in winter, such that the four winter months combined contribute less than 10 percent of the annual PCB mass load; 3) the lower PCB concentrations during the winter months are more difficult to quantify in the analytical lab, and therefore have greater uncertainty; and 4) PCB concentrations in winter are so low, relative to the rest of the year, that they result in a data set with a higher variance and non-normal statistical distributions, such that sampling the four additional months does not increase the statistical power for decision making. Samples will be collected systematically each month, at regular sampling intervals, to provide an unbiased and representative sample of the water year. Although "storm chasing" will not be practiced, the systematic sampling design is expected to capture a representative range of flow conditions during a particular monitoring year.

- Human Health Fish Species. Walleye were selected as the primary human health fish species because: 1) they are a regionally important and popular recreational fishery; 2) they were reliably present and relatively easily harvested in most of the OUs and in most of the target size ranges during the baseline monitoring program; and 3) walleye are widely distributed throughout the Lower Fox River and Green Bay. Consistent with the State Fish Advisory Program, individual walleye will be analyzed as skin-on fillet over a range of legal, harvestable sizes.
- Ecological Fish Species. Different ecological species are selected for monitoring in the Lower Fox River (carp) and Green Bay (drum), and to ensure overlapping coverage, both species will be monitored in OU 4. Carp was selected as the primary ecological species in the Lower Fox River because: 1) carp exhibit some of the highest PCB concentrations of the fish species sampled; 2) carp are a prey species for higher-order predators, such as eagles; 3) carp have an affinity for mud bottoms and may have more intimate contact with PCB-contaminated sediments; and 4) carp are easily and reliably harvested from most of the OUs in the range of target fish sizes.

Drum was selected as the primary ecological species in Green Bay because: 1) PCB concentrations in drum are typically higher than carp in Green Bay, whereas the reverse is generally true in the Lower Fox River; and 2) drum are easily and reliably harvested in these OUs and in the range of target fish sizes.

- YOY Fish Species. Gizzard shad was selected as the YOY fish species based on: 1) monitoring a juvenile life stage that does not carry a legacy PCB burden, and which may therefore respond more quickly to improving water quality conditions in the Lower Fox River; 2) its representativeness as a prey species for higher-order predators (i.e., fish-eating birds and mammals, as well as predatory fish); and 3) ease and reliability of harvesting.
- Fish Compositing Design. Ecological fish species will be composited for analysis because bioaccumulation is caused by the cumulative effects of long-term average dietary exposures. Fish composite groupings will be selected in consultation with the Response Agencies, and in accordance with the following general guidelines. Compositing will be performed using strict fish-length windows (typically 2-inch windows) to control for the effects of size and age on PCB concentration. To preserve site fidelity, grouping of fish into composite samples will be kept within individual OUs, or subunits in the case of OU 2 and OU 5, and will not cross OU or subunit boundaries.
- Comparability of Background Stations. Procedures used for sampling background water and fish in Lake Winnebago and OU 5C will be the same as those used throughout the Lower Fox River and Green Bay to ensure comparability of data and accurate statistical comparisons. Ambient fish contaminant monitoring data from other Great Lakes sites and programs, when used to develop estimates of Great Lakes background concentrations, will be reviewed to ensure species, preparation methods, and analytical methods are comparable to those used in the LTMP.
- Location Control Requirements. Accurate sample location control is essential for ensuring quality data and reproducibility between field sampling events. More accurate and precise control is needed for water and sediment monitoring activities to be able to reoccupy monitoring stations and depths along the designated cross-sections every month and from one monitoring

event to the next. A reduced level of accuracy is appropriate for the fish monitoring program because fish are transient and migratory. Therefore, water and sediment stations will be located to within a target accuracy of two meters; fish stations will be located to within a target accuracy of ten meters.

Additional details of the water and fish monitoring plans are provided in Sections 2.1 and 2.2, respectively. Additional details of the MNR sediment monitoring plan and cap chemical isolation monitoring plan will be submitted as addenda to this LTMP.

1.7.4 Step 4: Define the Boundaries of the Study

The study area for the long-term monitoring program is bounded spatially and temporally by the terms of the ROD.

1.7.4.1 Geographic Boundaries

The study area encompasses the following (see Figure 1-1):

- Upstream Reference Site – Lake Winnebago
- RA Areas – OU 1 through OU 4, and a small portion of OU 5
- Downstream Receiving Water Body – OU 5
- Downstream Reference Site (water only) – OU 5C

1.7.4.2 Temporal Boundaries

Long-term monitoring will be conducted for 30 years following completion of all remedial dredging, capping, and cover actions at the Site unless it can be demonstrated to the satisfaction of the Agencies that risk-reduction goals have been or are being achieved, and monitoring may be modified or terminated earlier. Based on RI/FS predictions as well as experience at other sediment cleanup sites, the effects of the RA are expected to be fully realized within 30 years. The time frames estimated by the Response Agencies for achievement of the RAOs or significant progress toward RAOs is:

- Recreational anglers: 10 years
- High-intake anglers: 30 years
- Fish-eating birds and mammals: 30 years

Given the current understanding of the RA schedule (see Section 1.6.4) long-term monitoring in OUs 1 through 3 is expected to occur from 2012 through 2042 (plus an additional monitoring event in OU 1 in 2010), and long-term monitoring in OUs 4 and 5 is expected to occur from 2017 through 2047. However, WDNR will continue monitoring the Lower Fox River and Green Bay as part of the State Fish Consumption Advisory Program even after the LTMP requirements have been fulfilled.

1.7.5 Step 5: Develop Decision Rules

Long-term monitoring will be conducted in accordance with the decision frameworks (flow charts) depicted on the following figures:

- Figure 1-4. Human health fish species
- Figure 1-5. Ecological fish species
- Figure 1-6. Young-of-year fish species
- Figure 1-7. Water quality
- Figure 1-8. Sediment quality

1.7.5.1 General Rules

The collection and evaluation of long-term monitoring data is based on the following general rules:

1. **OU-by-OU Decisions**. Long-term monitoring decisions will be made at the scale of individual OUs. As a result, some OUs may fulfill exit criteria and be removed from the monitoring program sooner than others. OUs 2 and 5 contain multiple fish, water, and sediment stations and will therefore generate data at a subunit level, allowing for smaller-scale decision units in the MNR areas.
2. **Maximum 30-Year Program Duration**. Monitoring will be conducted for 30 years after the RA unless it can be demonstrated that risk-reduction goals are being achieved to the satisfaction of the Agencies at an earlier period. Based on RI/FS predictions as well as experience at other sediment cleanup sites, the effects of the RA are expected to be fully realized within 30 years. WDNR will continue to monitor the Lower Fox River as part of the State Fish Consumption Advisory Program even after the LTMP requirements have been fulfilled.

3. **Confirmation Sampling Requirement**. Monitoring data will be evaluated using the exit criteria listed in Section 1.7.2.3. If the average site contaminant concentration meets the exit criterion in a particular medium, this provides a minimum line of evidence that LTMP targets have been achieved. Statistical certainty will be improved and WOE more clearly achieved if the average site contaminant concentration meets the exit criterion a second consecutive time in a follow-up confirmation sampling round.
4. **Trend Analysis will not be used for Final Confirmation**. Exit criterion no. 4 (Evaluation of Recovery Rate) can be used as evidence to proceed to confirmation sampling, but cannot be used to establish final confirmation nor to justify termination of the monitoring program.

1.7.5.2 Fish Monitoring Rules

The collection and evaluation of fish monitoring data is based on the following:

1. **Minimum of 3 Events**. A minimum of 3 fish monitoring events (Years 0, 5, and 10) are required before a confirmation monitoring event can be scheduled for either human health or ecological risk.
2. **Walleye is Index Species for Human Health**. Walleye will be used as the primary sentinel species for evaluating human health risk.
3. **Consideration of Substitute Human Health Species**. After walleye have fully recovered to allow recreational and high-intake consumption by humans, consumption advisories may continue to be in effect for other fish species. WDNR and USEPA will review the long-term monitoring record as well as the State fish advisory database to determine whether one or more human health index species should be substituted for walleye in the monitoring program to further support fish consumption advisory evaluations.
4. **Lifting of Fish Consumption Advisories for PCBs**. If the WDNR removes all fish consumption advisories for PCBs for an individual OU or OUs at the Site during implementation of the LTMP, then all fish tissue monitoring for human health risk may be terminated in that OU or OUs.
5. **Carp and Drum are Index Species for Ecological Risk**. Carp will be used as the sentinel species for ecological risk in the Lower Fox River (OU 1 through OU 4),

and drum will be used as the sentinel ecological species in the lowest river reach and in Green Bay (OU 4 and OU 5).

1.7.5.3 Young-of-Year Monitoring Rules

The collection and evaluation of YOY fish monitoring data is based on the following:

1. **Minimum of 1 Event**. At a minimum, YOY fish will be collected and analyzed in Year 0 to help support the WOE evaluation.
2. **Adaptive Management of YOY Monitoring Requirements**. WDNR and USEPA will review the monitoring data to determine whether significant progress toward SWAC-reduction goals is being achieved, relative to baseline concentrations, and whether monitoring should be continued, modified, or terminated.

1.7.5.4 Water Monitoring Rules

The collection and evaluation of water monitoring data is based on the following:

1. **Minimum of 2 Events**. A minimum of 2 water monitoring events (Years 0 and Year 5) are required before a confirmation monitoring event can be scheduled.
2. **Linked with Achievement of Fish Goals**. Water monitoring will be terminated when target fish tissue concentrations have been achieved for humans and wildlife, even if water monitoring goals have not yet been achieved, given that fish tissue quality provides a more direct and accurate measure of bioaccumulation risk.
3. **Surrogate for PCB Loadings to Green Bay**. Surface water concentrations in OU 4 will be used as a surrogate for monitoring PCB loadings to Green Bay. Achievement of the SWAC-reduction goal (90 percent reduction target) in OU 4 will also satisfy the PCB load reduction goal for the Lower Fox River.

1.7.5.5 Sediment Monitoring Rules

The collection and evaluation of sediment monitoring data is based on the following:

1. **Sediment Monitoring is for Informational Purposes**. Sediment monitoring will be conducted for informational purposes, and as a secondary line of evidence to support WOE evaluations, as long as fish monitoring is being conducted.

2. **Linked with Achievement of Fish Goals**. Sediment monitoring will be terminated when target fish tissue concentrations have been achieved for humans and wildlife.

If water or fish tissue concentrations are not declining, or are declining at a rate that indicates risk-reduction goals will not be achieved within the ROD-predicted time frames, then project assumptions will be reassessed, i.e., are the ROD-predicted recovery rates realistic, achievable, or necessary in light of the knowledge gained during the monitoring program? If project goals and assumptions remain valid, the data will be evaluated to determine the likely cause(s) of the delayed recovery, and whether revisions to the monitoring program (i.e., increased sampling intensity, improved characterization of ambient background conditions, etc.) should be considered. Such revisions would be discussed during the CERCLA 5-year reviews.

1.7.6 Step 6: Specify Limits on Decision Errors

The goal of the long-term monitoring program is to meet the statistical criteria in Sections 1.7.6.1 and 1.7.6.2. The monitoring program is expected to provide an appropriate level of statistical confidence for Site management decisions.

1.7.6.1 Minimum Detectable Relative Difference

The specified minimum detectable relative difference (MDRD) between two consecutive monitoring rounds is 50 percent. The monitoring program should be able to detect with statistical significance a 50 percent reduction in water or fish tissue concentrations over relatively short time periods (i.e., 5 years, from one monitoring event to the next).

In response to the anticipated 90 percent reduction in average surface sediment PCB concentrations following completion of the RA, combined with ongoing natural recovery processes in the river and bay, order-of-magnitude reductions in water and fish tissue concentrations are expected to occur. One order-of-magnitude reduction is approximately equal to three 50-percent reductions. Therefore, an MDRD of 50 percent provides an appropriate level of sensitivity for monitoring the cumulative

concentration reductions that are expected to result from the RA over the entire monitoring program (i.e., 30 years).

1.7.6.2 Statistical Confidence and Power

The goal of the long-term monitoring program is to collect water and fish tissue data that will achieve the following levels of statistical significance to support Site management decisions:

- Alpha = 0.1 (90 percent confidence)
- Beta = 0.2 (80 percent power)

1.7.7 Step 7: Optimize the Design

To achieve the DQOs specified for this project, a sufficient number of water and fish tissue samples will be collected and analyzed using field and laboratory methods which provide adequate sensitivity for detection and quantitation of PCBs. Although there are no explicit exit decisions associated with sediment monitoring data, a sufficient number of sediment samples will be collected in MNR areas to track PCB concentration reductions over time; the sediment sampling design will be described in more detail in a future addendum to this LTMP.

1.7.7.1 Number of Samples

The estimated number of water and fish samples required for Site management decisions is based on the desired MDRD, the desired level of statistical confidence and power (see Section 1.7.6.2), and an estimate of the variability of the data (as described by the CV of historical monitoring data). This analysis is based on a comparison of two populations (i.e., one monitoring event compared to a subsequent event), with each population or event having an associated variance. Such an approach is expected to provide a conservatively high estimate of sample size requirements for all types of Site management decisions because of the following considerations:

- If data from one monitoring event is compared to a fixed numerical criterion (e.g., a human health or ecological target concentration), fewer samples will be required to achieve the same confidence level.

- After three post-construction monitoring events are completed, two-sample comparisons will be augmented with regression-based analysis. As the size of the data set grows with each successive monitoring event, greater statistical power will generally be achieved (provided the variance of the data does not increase over the length of the monitoring record).
- Sample size estimates are based on a MDRD of 50 percent between two monitoring events. As the length of the monitoring record grows, larger reductions totaling 90 percent or more are expected over the long term. Larger reductions are more easily discerned using statistical methods.
- The sample size estimates developed for this LTMP do not consider ancillary variables that may influence PCB concentrations (e.g., fish length and lipid content, water temperature, and suspended solids content). If correlations can be established between PCB concentrations and ancillary variables, a larger proportion of the sample variance may be predicted and controlled through the use of multivariate statistical techniques, such as multiple regression (see also Section 4.2.3.6).

The relationship between sample size and statistical power follows USEPA 1998 (section 9.3.3):

$$N = (Z_{\alpha} + Z_{2\beta})^2 (CV/MDRD)^2$$

where [N] = number of samples, [Z_{α} and $Z_{2\beta}$] are Z statistics at the specified alpha and beta levels, [CV] is the coefficient of variation of water or fish tissue data, and [MDRD] is the minimum detectable relative difference (see Section 1.7.6.1).

The estimated sample size as a function of CV for either water or fish tissue data is provided in Table 1-7. For comparison purposes, a range of confidence levels (alpha = 0.2, 0.1, and 0.05) is provided. The estimated sample sizes are based on an assumed normal distribution; both fish tissue data and seasonally stratified water data are reasonably described by normal distributions, as shown in Tables 1-4 and 1-5.

The statistical characteristics of the data collected in the baseline monitoring program (see Tables 1-1 and 1-2) can be used to estimate the sample sizes for the long-term monitoring program. The estimated level of statistical confidence provided by the baseline monitoring data, based on the sample size and the observed CV of these data, is summarized in Table 1-8. In a majority of cases, the baseline monitoring data consistently met or exceeded expectations for statistical power, as described below. For gizzard shad and carp, however, some of the OUs did not meet their statistical goals, generally due to outlier concentrations or reduced sample sizes.

Water Sample Sizes. When monthly water samples are evaluated as a year-round data set, statistical power expectations are generally not met. Water column data in only 3 out of 10 OUs showed statistical confidence levels of 90 percent or higher.

Without considering the effects of controlling variables, statistical power was improved by removing the winter months (December through March) from the data set. Statistical confidence levels of 90 percent or higher were observed in seven out of 10 OUs, in spite of having fewer samples in the data set. Two of the remaining OUs showed confidence levels greater than 80 percent. Lake Winnebago showed the lowest confidence levels (greater than 75 percent) compared to all other OUs, likely due to the extremely low PCB concentrations and higher analytical uncertainty associated with this upstream background location.

In summary, the 8-month warm-weather data set exhibited better statistical power for detecting long-term reductions in PCB concentrations compared to the year-round data set. Expected levels of statistical confidence were met in a majority of cases in the 8-month data set. It is therefore recommended that long-term monitoring of the water column should be performed on a monthly basis from April through November. Additional sampling in the winter months is not likely to improve and may actually degrade statistical performance.

Fish Sample Sizes. The statistical confidence levels associated with human health fish species—walleye and bass—were uniformly excellent and typically exceeded 95

percent (Table 1-8). Statistical confidence levels associated with ecological fish species—carp and drum—were also excellent, with a few localized exceptions. Sub-optimal confidence levels were associated with carp data in OU 1 (greater than 80 percent), OU 2A and OU 5B (greater than 70 percent). OU 2A and OU 5B are each affected by an outlier, and are probably better described by lognormal distributions (see Table 1-5). Drum performance was only slightly below expectations in OU 2C (greater than 80 percent), but exceeded expectations (greater than 95 percent) in a majority of the other OUs. Overall, these comparisons validate the continued use of the sample sizes specified in the baseline monitoring program for all of the adult fish species except carp. In order to increase the statistical power of the carp data, the sample size will be increased from five to seven composite samples (comprised of 35 total fish) during the long-term monitoring program.

Statistical confidence goals were only sometimes met in the gizzard shad data, the YOY species intended to serve as an early indicator of ecosystem recovery. Five of the OUs showed excellent power of discrimination, with over 95 percent confidence, whereas the other four OUs showed only modest power, with 80 to 90 percent confidence. Therefore, the gizzard shad sample size will be increased from five to seven composite samples during the long-term monitoring program to improve statistical power, especially in the Lower Fox River (see Table 1-7).

1.7.7.2 Analytical Sensitivity

To achieve the DQOs for this project, analytical methods must be sensitive enough to:

- Quantify upstream "background" concentrations in Lake Winnebago
- Quantify future PCB concentrations based on anticipated order-of-magnitude reductions

Water is the more difficult medium and requires greater analytical sensitivity because PCBs are extremely hydrophobic, i.e., they tend to concentrate in the fatty tissue of fish but are poorly soluble in water. The method specified for water analysis in the long-term monitoring program is PCB congener analysis by HRGC/MS using EPA Method 1668A. The laboratory used in the baseline monitoring program

(TestAmerica Knoxville) achieved estimated detection limits (EDLs) for individual congeners ranging from 0.0005 to 0.003 ng/L, and reporting limits ranging from 0.02 to 0.03 ng/L. The PCB congener EDLs and reporting limits were enhanced by extraction of double sample volumes (2 liters per sample) as well as by installation of upgraded electronics for the mass spectrometer, resulting in state-of-the-art sensitivity for a commercial laboratory.

Minimum Number of Detected Congeners. Water column PCB data is expressed as total PCBs, which is the sum of all detected congeners using zero for undetected congeners below the EDL, and using estimated values between the EDL and the reporting limit. The congener compositions of the most highly contaminated samples in the baseline monitoring program (i.e., those samples with the fewest number of undetected congeners and the least amount of "censoring") were evaluated to determine how many of the 209 possible congeners make up the bulk of the PCB mass. Water samples from August and September in OU 3 and OU 4 were analyzed for this purpose. It was determined that the top 20 to 25 congeners contributed 80 percent of the total PCB mass (see Section 4.2.1.2).

Based on this evaluation, the goal for the long-term monitoring program is to detect and quantify 25 congeners in each sample. With this level of detection, a majority of the PCB mass will be positively quantified. When PCB concentrations are very low, there may be too few congeners detected. Detections of fewer numbers of congeners may tend to bias results low because a larger fraction of the PCB mass would be undetected or "censored". If and when this occurs, it will be addressed collaboratively through adaptive management (see also Section 4.2.1.4).

Analytical Sensitivity in Water. A review of the water data from the baseline monitoring program shows EPA Method 1668A is sufficiently sensitive to meet the objectives of the long-term monitoring program, at least during the initial monitoring rounds. During the warm-weather months from April to November, between 49 and 132 congeners were detected in water samples from the Lower Fox River; 33 to 99 congeners were detected in water samples from Green Bay; and 31 to 61 congeners were detected in Lake Winnebago (all statistics based on blank-

corrected data). Good detection frequencies were achieved for total PCB concentrations as low as 0.1 ng/L. This level of sensitivity exceeded the expectations of the Baseline Monitoring Plan, which assumed accurate quantitations would be achievable down to about 1 ng/L.

In winter months, fewer numbers of congeners were detected overall. In Lake Winnebago, the number of detected congeners dropped below the minimum recommended detection frequency (less than 25 congeners) for 2 months.

Given the order of magnitude reductions in PCB concentrations which are predicted to occur in the decades following the RA, the sensitivity of the PCB analytical methods may need to be evaluated at some point in the future of the long-term monitoring program. However, data collected during the baseline monitoring program indicates high-quality data should be obtained during the initial monitoring rounds using EPA Method 1668A, with the modifications as recommended in this plan.

Further improvements in sensitivity may be limited by trace levels of PCBs in the global and regional atmosphere, evidenced by ambient PCB concentrations in laboratory method blanks (approximately 0.1 to 0.3 ng/L) and field rinseate blanks (approximately 0.1 to 0.9 ng/L). Ongoing monitoring and evaluation of field and laboratory blank contamination is therefore a critical component of the long-term monitoring program (see Sections 2.7.1 and 4.2.2). To this end, laboratory blank contamination will be controlled as practicable to 0.2 ng/L total PCBs or lower during the long-term monitoring program. This should be an achievable control limit based on the analytical laboratory's performance during the second half of the baseline monitoring program, after a source of laboratory contamination was diagnosed and eliminated. As with other elements of the long-term monitoring program, adaptive management may be used to update this control limit if further reductions in PCB blank contamination can be reasonably achieved by the laboratory.

Analytical Sensitivity in Fish Tissue. PCB concentrations in fish tissue from the Lower Fox River and Green Bay range from about 0.1 to 10 mg/kg (Aroclor basis), depending on the particular species and river reach. The detection limit achieved in the baseline monitoring program for PCBs in fish tissue was 0.019 mg/kg. All fish species were at or near 100 percent detection in all parts of the Lower Fox River and Green Bay. In Lake Winnebago, more frequent non-detects were observed, especially in the human health species (50 percent nondetect for walleye, 40 percent nondetect for bass). Because PCB concentrations in the Lower Fox River and Green Bay are typically about an order of magnitude higher than those in Lake Winnebago, additional analytical sensitivity in Lake Winnebago does not appear to be warranted at this time.

1.8 Documentation and Records

Complete and accurate records of sample collection, sample analysis, QA, data corrections, and data analysis will be maintained. Integrity of this information must be maintained throughout all data transfers and manipulations. Procedures used to generate, transform, and validate data are critical for effective data management. A summary of the data management procedures is provided below.

1.8.1 Data Tracking

When samples are processed and the appropriate sample identification is given, the sample tracking process will be initiated. Every sample will be tracked individually from its collection through receipt of the analytical results and final validation. The date collected, laboratory receipt, data receipt, status of data validation, and status of database entry for each sample will be tracked and recorded in a sample tracking database.

1.8.2 Electronic Data Management

Technical data, including field observations, laboratory analytical results, and data validation results, will be stored in a relational database. The Database Administrator will be responsible for uploading sample collection data into the database under the supervision of the Data QAM. Data received from analytical labs in electronic data deliverable (EDD) format will be checked for completeness by comparing them to the

sample collection forms before appending them into the database. At this point, the analytical data will be marked as "unvalidated" but will be available for preliminary queries. Data checks will be completed, including a comparison of the electronic data against the hard copy reports received from the laboratory. Finally, the Database Administrator will upload validation qualifiers as they are received from the Data Validator, validation qualifiers will be checked, and the data will be marked as "validated".

In addition to analytical data, the database will be used to organize field observation data, and field parameter measurements. These data will be transcribed by field personnel into electronic files (spreadsheets), where they will be uploaded into the database.

1.8.3 Evidence File

The final evidence file will be the central repository for all documents that constitute evidence relevant to sampling and analysis activities. The Respondent Team Project Coordinator or his/her designee will be the custodian of the evidence files and will maintain the contents of the evidence files for the long-term monitoring program, including all relevant records, reports, field logbooks, field forms, pictures, contractor reports, and data reviews in a secured, limited access area.

All records will be kept by the Respondent Team until the monitoring program is completed. As necessary, records may be transferred to an offsite records storage facility which provides secure, access-controlled storage. Raw analytical laboratory data, including chain-of-custody (COC) forms, analytical bench sheets, instrument printouts and chromatograms, certificates of analyses, and QA/QC report summaries will be stored in electronic format (pdf files). The subcontract laboratory will retain its raw analytical data and QA data for a minimum of 10 years after completion of a given monitoring event. The Response Agencies will be notified prior to the disposal of any laboratory data.

2 DATA GENERATION AND ACQUISITION

This section presents the anticipated sampling strategies to be employed during each monitoring event, including sample numbers, monitoring locations, sampling schedules, and field and laboratory procedures. These sampling strategies may be adjusted or modified through adaptive management and the CERCLA 5-year review process. For example, environmental media or fish species may be added, reduced, or discontinued based on an ongoing evaluation of progress toward risk reduction goals.

2.1 Water Quality Monitoring Plan

2.1.1 Number of Water Samples

Monthly water samples will be collected at all monitoring stations during the 8 warm-weather months (April through November) during each monitoring year (eight samples at each of 10 stations). Sampling may not always be possible at all stations due to unforeseen field conditions; therefore, the "completeness" objective for the water quality sampling program will be a minimum of seven out of eight possible sampling events at each station.

2.1.2 Water Quality Monitoring Stations

In general, water monitoring stations are sited near the downstream boundaries of the OUs such that the net PCB contribution from each OU, and the effectiveness of the remedy in each OU, can be evaluated. In addition, multiple water quality monitoring stations are sited in OU 2 and OU 5 to provide more detailed coverage in MNR areas.

Water column samples will be collected and analyzed at one upstream reference location in Lake Winnebago, six stations along the Lower Fox River (OUs 1 through 4), and 3 stations in Green Bay (OU 5), for a total of 10 stations. The stations recommended for the long-term monitoring program are identical to those occupied during the baseline monitoring program.

The water monitoring stations are shown on Figures 2-2 through 2-9, and listed below (see also Figure 2-1 for an index map):

- *Lake Winnebago (upstream reference station).* Just above Neenah and Menasha Channels (Figure 2-2)

- *OU-1.* Downstream of LLBDM and above the first Appleton Dam (Figure 2-3)
- *OU-2.* Three sampling stations:
  - *OU-2A.* Reach between Lock 4 and Cedars Lock (Figure 2-4)
  - *OU-2B.* Reach between Lock 5 and Rapide Croche Lock (Figure 2-5)
  - *OU-2C.* Above Little Rapids Dam (Figure 2-6)
- *OU-3.* Above De Pere Dam (Figure 2-7)
- *OU-4.* Near the USGS stream gage (Oil Depot gage); approximately 1,300 meters upstream from the mouth, and largely beyond the influence of bay water under seiche conditions (Figure 2-8).
- *OU-5 (Green Bay).* Three sampling stations (Figure 2-9):
  - *OU-5A.* Zone II/Zone III Boundary
  - *OU-5B.* Zone III South
  - *OU-5C.* Zone III North

Three stations have been specified for both OU 2 and OU 5 (Green Bay). MNR is the selected remedy for these areas. The rationale for selecting water sampling stations in OU 2 is as follows:

- *OU-2A.* To provide information in a reach of OU 2 having a steeper gradient and faster water velocities, as well as to provide information on natural recovery processes due to Deposit N removal
- *OU-2B.* To provide information in a reach of OU 2 with gentler gradients and slower water velocities (i.e., more likely to be depositional)
- *OU-2C.* To provide information on natural recovery processes due to removal of Deposit DD, and data regarding the PCB mass loading from OU 2 to OU 3

The water sampling stations in OU 5 were sited to characterize the concentration gradient in Green Bay between the mouth of the Lower Fox River and Lake Michigan.

2.1.3 Water Quality Monitoring Schedule

Sampling will be performed on a monthly basis from April through November in a given monitoring year (eight sampling events total). Sampling will be "systematic" in design, to provide representative and unbiased coverage. Specific runoff events will not be targeted but a random and representative range of flows is expected to be captured

during the course of the monitoring program. Water sampling will be scheduled during the first 2 weeks of each month. The six river water samples will be collected in order from upstream to downstream over as short a period of time as practical, typically 3 to 4 days.

2.1.4 Water Quality Sample Identification

Water quality samples will be coded as follows (see also Table 2-1):

AAAA-YY-MMDD

where "AAAA" is a 3 to 4 letter code that identifies the OU (OU1) or subunit (OU2B); "YY" is the two-digit year (e.g., -05 for 2005, -10 for 2010, etc.); and "MMDD" is the month and day of the sample collection. For example, "OU4-05-0912" is a water sample from the OU 4 station collected on September 12, 2005. This sample identification scheme is designed to sort alphabetically in time and space.

Field replicates will be coded in the initial letter string (e.g., OU1D or OU2BD) in order to preserve the time stamp at the end of the name. The code for field rinseate blanks will replace the OU designation at the beginning of the sample code and will retain the time stamp. For peristaltic pump and Niskin bottle rinseate blanks, respectively, the codes are as follows:

RBP-YY-MMDD
RBN-YY-MMDD

Field replicates and field rinseate blanks are discussed further in Section 2.7.1.

Each of the water quality samples will be composited from six separate aliquots from different distances and depths along the channel transect, as described below (Section 2.1.5.1). Each aliquot will be labeled with a consecutive letter (A, B, C, D, E, and F) progressing from top to bottom and west to east, in the following format:

AAAA-YY-MMDD-**B**

The six aliquots will be submitted separately to the analytical laboratory for compositing.

2.1.5 Water Quality Sampling Procedures

Water quality sampling procedures are described below.

2.1.5.1 Location Control

Water quality monitoring stations will be located to within a target accuracy of 2 meters using a DGPS calibrated to known shoreline benchmarks before and after each sampling transect. Water depths will be determined using either a lead line or a calibrated echo sounder recorded to the nearest 0.1 foot. Project-specific location control requirements, calibration protocols, and quality indicators are described in the standard operating procedure (SOP) *Location Control*.

2.1.5.2 "Quarter Point" Sampling Procedures

Area-weighted composite samples will be collected on specified transects to obtain representative water concentrations averaged over the cross-section of flow. Water quality sampling transects are located to the extent possible in relatively straight reaches with simple, U-shaped cross-sections, avoiding areas with shallow benches or protrusions that could cause eddies, wind waves, or other hydraulic complications. It is assumed that the flow in these sections is relatively uniform and well mixed. In a uniform, well-mixed cross-section, an area-weighted sampling design provides a reasonable approximation of a flow-weighted design.

Representative transects of the Lower Fox River, Lake Winnebago, and Green Bay will be sampled in general accordance with USGS "quarter point" sampling procedures. The channel cross-sections are divided into 3 equal areas based on bathymetric data. Water sampling stations are positioned at the midpoint of each of the three flow areas; the coordinates of these stations are listed in Table 2-2. In the Lower Fox River and Lake Winnebago, discrete water samples will be collected at 0.2 and 0.8 times the depth of the water column.

In Green Bay, a surface-water sample will be collected from one meter below the surface, and a deep water sample will be collected from the mid-point of the water column. It should be noted that during the baseline monitoring program, Green Bay transects were stratified into two layers – shallow and deep layers, above and below the thermocline; however, it was determined that PCB concentrations in the shallow and deep layers were not statistically different and as a result, sample stratification will not be required in the long-term monitoring program.

2.1.5.3 Sample Compositing

Discrete water subsamples will be collected at each of the six "quarter point" locations and depths (i.e., two depths x three stations = six subsamples for each transect), then shipped to the analytical laboratory where the compositing will be performed under clean laboratory conditions. A 1-liter bottle will be collected at each of the six subsampling locations/depths (six bottles total) and a second, redundant set of bottles will be collected and held in refrigerated storage near the sampling site until it has been determined that the original bottle set arrived safely at the analytical laboratory.

2.1.5.4 Field Equipment

Samples in the Lower Fox River will be collected using a peristaltic pump with expendable tubing (i.e., used only once for each transect). Samples in Green Bay will be collected with a pre-cleaned, dedicated Niskin bottle (or equivalent). Each Niskin bottle will be dedicated to a specific Green Bay monitoring station.

2.1.5.5 Field Parameters

The following field parameters will be measured at each of the "quarter-point" locations on each sampling transect:

- Temperature
- Turbidity

These field parameters will be monitored in continuous casts from water surface to river bed to assess water column stratification and spatial heterogeneity in each cross section of the river or bay at the time of sampling.

2.2 Fish Tissue Monitoring Plan

2.2.1 Number of Fish Samples

Optimum Completeness Goal. The following number of fish samples will be targeted at each sampling station (i.e., in each OU, or part of an OU):

- *Walleye (human health index species):* 15 individual fish
- *Carp (ecological index species for Lake Winnebago through OU 4):* 35 individual fish, to be composited into seven groups of five fish each
- *Drum (ecological index species for OU 4 and OU 5):* 25 individual fish, to be composited into five groups of five fish each
- *Gizzard shad (YOY forage fish):* 175 individual fish, to be composited into seven groups of 25 fish each

Minimum Completeness Goal. Reasonable efforts will be made to obtain the optimum numbers of target species, according to the field sampling decision framework detailed in Section 3.4.2 and Figure 3-1. However, if sufficient numbers of fish cannot be collected at certain sampling stations, after consideration of alternate fish sizes and other contingency actions to improve the harvest, the following minimum numbers of fish will be collected to satisfy project completeness goals, while still providing a reasonable level of statistical power:

- *Walleye (human health index species):* Minimum of eight individual fish
- *Carp (ecological index species for Lake Winnebago through OU 4):* Minimum of seven individual fish, to be analyzed separately (no compositing)
- *Drum (ecological index species for OU 4 and OU 5):* Minimum of five individual fish, to be analyzed separately (no compositing)
- *Gizzard shad (YOY forage fish):* Minimum of 25 individual fish, to be composited into five groups of five fish each

2.2.2 Fish Monitoring Stations

There are nine fish monitoring stations, including an upstream reference site (Lake Winnebago), six stations in the Lower Fox River (OU 1 through OU 4), and two stations in Green Bay (OUs 5A and 5B). One sampling station is assigned to each OU, except OU 2 which has three sampling stations and OU 5 which has two stations. The fish monitoring stations are shown on Figures 2-2 through 2-9, and listed below:

- *Lake Winnebago.* Upstream reference station. (Figure 2-2).
- *OU-1.* Little Lake Butte de Morts (Figure 2-3).
- *OU-2.* Three sampling reaches:
  - *OU-2A.* Reach between Lock 4 and Cedars Lock (Figure 2-4).
  - *OU-2B.* Reach between Lock 5 and Rapide Croche Lock (Figure 2-5).
  - *OU-2C.* Reach above Little Rapids Dam (Figure 2-6).
- *OU-3.* Reach above De Pere Dam (Figure 2-7).
- *OU-4*. Reach from De Pere Dam to the mouth of the Lower Fox River (Figure 2-8).
- *OU-5.* Two sampling reaches (Figure 2-9):
  - *OU-5A.* Shallow, inner portion of Green Bay
  - *OU-5B.* Deeper, central portion of Green Bay, and the eastern shore from around Dyckesville to Little Sturgeon Bay

Recommended fish collection sites, based on the catches obtained during the baseline monitoring program, are provided on these figures. However, fishing locations may be adjusted as needed in the field based on species availability, habitat, river or bay conditions, seasonal migration patterns, or other field conditions. Because of these variables and habitat preferences, it is assumed that different species will be collected from different parts of the OUs. However, fish have free access within the entire OU or subunit that they represent; therefore, they should be representative of the general environmental conditions in the OU.

2.2.3 Fish Collection Schedule

Fish will be collected in late summer/early fall, between August 15 and September 15. Every fish sampling event will target this same seasonal sampling window to control for seasonal variability in the monitoring data. Sample collection activities may be extended an additional month (through October 15) if necessary to fill data gaps.

If the walleye catch is found to be deficient and bass are substituted for the human health index species, bass fishing in certain OUs (Lake Winnebago, OU 4 and OU 5) should be conducted in the following month of June to be consistent with the bass collection schedule used in the baseline monitoring program.

2.2.4 Target Fish Species and Size Ranges

Target fish species were selected based on the following criteria:

- Presence of fish consumption advisories (human health index species)
- Popular recreational fishery (human health index species)
- Key species evaluated in Human Health or Ecological Risk Assessments (Retec 2002c)
- Common food source for upper-level animals, e.g., fish-eating mammals and birds (ecological index species)
- Availability in the Lower Fox River and Green Bay based on recommendations from State fish biologists and experience during baseline monitoring program

Target fish species are summarized in Table 2-3. A total of five fish species were analyzed during the baseline monitoring program to provide greater flexibility during long-term monitoring. Four fish species will be analyzed during the long-term monitoring program, including a human health index species, two ecological index species, and a YOY forage fish species. The YOY forage fish species is intended to provide an early indication of recovery in the river and bay because these fish best represent current conditions unburdened by legacy contaminants. The four primary species that will be targeted during the long-term monitoring program are:

- Walleye (human health index)
- Carp (ecological index for Lower Fox River)
- Drum (ecological index for Green Bay)
- Gizzard Shad (YOY forage fish)

The following secondary species may be considered if the corresponding primary species are difficult to obtain or unavailable during a particular monitoring event:

- Smallmouth Bass (human health index)
- Drum (ecological index for Lower Fox River)
- Carp (ecological index for Green Bay)

It is recommended that all secondary species be retained and archived during field collection activities until the entire catch is evaluated and it can be determined that the completeness objectives for the primary species are fulfilled.

In addition, substitute human health species may be selected for monitoring after walleye have achieved their monitoring goals, to better support the evaluation of fish consumption advisories (see Section 1.7.5.2).

2.2.5 Fish Tissue Sample Identification

With the exception of gizzard shad, each individual fish will be given a unique sample ID, as follows (see also Table 2-4):

LLLL-YY-SP-NN

where [LLLL] is the location code describing the OU or subunit (OU1, OU2A, OU2B, etc.), [YY] is the two-digit year (i.e., 08 is 2008), [SP] is the species identification code (WA = walleye, SB = smallmouth bass, CA = carp, and DR = drum), and [NN] is a sequential number assigned to each individual fish in a given OU. For example, OU4-08-WA-23 is the twenty-third walleye collected in OU 4 during a monitoring event in 2008. Gizzard shad from a particular sampling location will be bagged in groups of 25 fish or less and each bag of fish will be assigned a sample number in accordance with this convention (with the species code GS = gizzard shad).

Composite sample IDs will follow a similar convention as the IDs assigned to individual fish, except the last two characters will be changed to identify a composite sample:

LLLL-YY-SP-C#

where C# represents composite samples C1, C2, C3, etc. These IDs will be assigned in the laboratory where the compositing will be performed at the direction of the Respondent PM or his/her designee, in consultation with the Response Agencies.

Field replicate samples will be coded in the initial letter string (e.g., OU1D or OU2BD).

2.2.6 Fish Sampling and Preparation Methods

Fish sampling procedures are described below.

2.2.6.1 Location Control

The beginning, end, and turning points of fishing transects will be located to within a target accuracy of 10 meters using a GPS as well as references to shoreline landmarks. Project-specific location control requirements for fish sampling activities are described in the *Location Control* SOP. Because fish migrate freely within an OU or subunit, location control requirements are less stringent for fish collection.

2.2.6.2 Fish Sampling Methods

Primary and secondary target fish species are listed in Section 2.2.4. It is recommended that all secondary species be retained and archived during field collection activities until the entire catch is evaluated and it can be determined that the completeness objectives for the primary species are fulfilled. The following fish collection methods are recommended based on the experience gained during the baseline monitoring program (see Table 2-5):

- Electrofishing (all species)
- Trawls (all species)
- Seine nets (gizzard shad)
- Rod and reel (bass and potentially other species)

Rod and reel techniques were found to be productive for bass fishing in June but may also be productive for other species during the fall. Fyke nets and set lines were not generally productive. Methods may be modified as needed based on field conditions at the time of sampling.

The coordinates, time, and water depth of the starting point, ending point, and turning points of each fishing run will be recording in field logs. Start and end times will also be marked on the hard copy print out from the echosounder. The coordinates, water depth, and time of deployment and recovery will be logged for stationary equipment, if used, such as set lines, fixed nets, etc.

The following data will be recorded for each individual fish (with the exception of gizzard shad):

- Unique individual sample ID

- Time of collection
- Length
- Weight
- Abnormalities (i.e., tumors, lesions)

Because of their small size and large numbers, YOY gizzard shad will not be logged individually. All gizzard shad fingerlings from a particular fishing location will be combined in a plastic bag and forwarded to the analytical lab for compositing. Fish collection, handling and preservation techniques are provided in the *Fish Collection* SOP.

2.2.6.3 Compositing

The Respondent PM or his/her designee, in consultation with the Response Agencies, will select the fish to be used for composite samples and will direct the laboratory in their preparation. See *Laboratory Tissue Preparation* SOP for further details on laboratory methods of preparing composite samples.

Carp and drum (ecological index species), and gizzard shad (YOY forage fish species) will be analyzed as composite samples. Carp composites will consist of seven composites with five individuals in each composite (i.e., 35 fish total), drum composites will consist of five composites with five individuals in each composite (i.e., 25 fish total), and gizzard shad composites will consist of seven composites with 25 individuals in each composite (i.e., 175 fish total). To the extent possible, fish will be collected that are representative of the size classes listed in Table 2-3. Ideally, composites would be prepared for each of the five 2-inch classes in the target length window. However, some compositing classes may be represented by two or more samples, whereas other classes may contain no samples, depending on the catch.

The individual fish will be archived (frozen) until the fishing season is completed and the entire catch may be evaluated. Then the fish will be assigned to compositing groups. Similarly sized individuals (within 2-inch size classes, if possible) will be grouped together for compositing. To the extent possible, gizzard shad composites will be prepared using fish obtained from a single fishing site. Carp and drum

composites, on the other hand, may be combined from multiple fishing sites; the primary consideration for these larger and older fish is preparing composites based on a relatively narrow range of fish lengths. In no case will fish be composited across OUs, or across subunits in OU 2 or OU 5.

2.2.6.4 Fish Tissue Preparation

Walleye (and bass, if analyzed) will be prepared as skin-on fillets. These human health species will be analyzed on an individual basis to be consistent with methods used in the State Fish Consumption Advisory Program. Carp and drum (ecological species) and gizzard shad will be analyzed as composite samples of whole fish (see *Biological Tissue Preparation* SOP).

2.2.6.5 Tissue Archiving

Aliquots of all homogenized fish tissue samples (including both individual and composited samples) will be set aside and archived (frozen) for possible future analysis. Fish tissue samples will be archived for a minimum of one CERCLA 5-year review cycle. The status of the samples will be considered during the 5-year review process, at which time the samples may be designated for continued archiving over another review cycle, or else discarded.

For human health species (i.e., walleye or bass), one fillet will be analyzed and the other side will be archived. For ecological species (i.e., carp and drum), each fish will be individually homogenized, then equal masses of tissue will be drawn from the individual samples to prepare the composite sample. The remainder of the individual samples will be archived for possible future analysis in case it is later determined that analysis of individual fish would be useful. For gizzard shad, an aliquot of each composited and homogenized sample will be set aside and archived.

2.3 MNR Sediment Sampling Plan

Sediment monitoring will be conducted in representative MNR areas of OUs 2 and 5. Sediment monitoring of MNR areas will provide a secondary line of evidence to document natural recovery success, with the primary line of evidence being based on fish tissue and water monitoring results. Approximately 10 sampling stations in OU 2 and 15 to 20

sampling stations in OU 5 will be monitored, focusing on those areas that were reported in the RI/FS as containing surface sediment PCB concentrations above 1 mg/kg. To the extent possible, sediment MNR sampling locations will be co-located with surface water and fish monitoring stations. At each sampling station, a five-point composite surface sample will be collected from the top 6 inches (15 centimeters) of the sediment to track reductions in average PCB concentrations over time. The details of sediment monitoring locations, along with field and analytical protocols, will be finalized toward the conclusion of RAs in OUs 2 through 5, and will be approved by the Agencies as an addendum to this LTMP.

2.4 Cap Chemical Isolation Monitoring Plan

Cap chemical isolation monitoring will be performed in representative areas with "Type B" caps to verify basic cap design assumptions (i.e., proper installation of the cap and resistance to chemical diffusion through from underlying contaminated sediments). "Type B" caps contain a basal layer of mixed cap material and sediment overlain by a clean chemical isolation layer and a final armor layer; these types of caps are installed over mid-range sediment PCB concentrations (between 10 and 50 ppm). Cap chemical isolation monitoring will provide a secondary line of evidence to document cap effectiveness, with the primary line of evidence being a comprehensive survey of the physical integrity of capped areas, as described in the Agency-approved COMMP (including bathymetry, sub-bottom profiling, poling, and potentially other methods to verify that the caps and armor layers remain intact). Diver cores will be used to collect samples of the chemical isolation layer in 15 to 20 representative locations, taking care not to create sampling-induced carry-down or cross-contamination of the cap samples. The details of cap chemical isolation monitoring locations, along with field and analytical protocols, will be finalized toward the conclusion of RAs in OUs 2 through 5, and will be approved by the Agencies as an addendum to this LTMP.

2.5 Sample Handling and Custody Requirements

The following sections describe the procedures for sample handling, preservation, transportation, and storage (see *Shipping and Packaging of Non-hazardous Samples* SOP). Sample COC procedures are also described (see *COC Documentation* SOP).

2.5.1 Sample Handling, Preservation, Transportation, and Storage

Table 2-6 lists the required sample containers, preservation requirements, and holding times for the specified analytical methods and sample matrices. Sample bottles will be provided by the laboratory and prepared in accordance with *The Samplers Guide to the CLP Program* (USEPA 2001b). Sample containers will be purchased by the laboratory pre-cleaned to requirements of the USEPA Office of Solid Waste and Emergency Response Directive 9240.05A. Sample containers will be kept closed and in a cooler until used.

Vendor certificates of cleanliness for sampling supplies will be accepted and on file at the analytical laboratories. For PCB congener analysis by EPA 1668A, ultra-low level detection limits are required, and there is increased risk of cross-contamination; therefore, additional precautions are necessary. Procedures for tracking, lot checking, and ensuring clean sample containers are delivered to the field crew are specified in the *Lot Checking Sample Containers SOP*.

2.5.1.1 Sample Packaging

Sample packaging and shipping procedures are designed to ensure that the samples and their accompanying COC will arrive at the laboratory intact. A temperature blank is required in all coolers. Packaging, marking, labeling, and shipping of samples will comply with the regulations of the U.S. Department of Transportation in 49 CFR 171-177.

2.5.1.2 Shipping Airbills

If samples are shipped, airbills will be retained to provide a record of sample shipment to the laboratory. Completed airbills will accompany shipped samples to the laboratory and will be forwarded along with data packages. Airbills will be kept as part of the data packages in the project files.

2.5.2 Chain of Custody

Proper sample and data custody procedures will be followed during the long-term monitoring program. Custody is addressed during field sample collection, during data analyses in the laboratory, and through proper handling of project files. Persons will

have custody of samples when samples are in their physical possession, in their view after being in their possession, or in their possession and secured to prevent tampering. In addition, when samples are secured in a restricted area accessible only to authorized personnel, they will be deemed to be in the custody of such authorized personnel.

COC forms will provide the record of responsibility for sample collection, transport, and submittal to the laboratory. Field personnel designated as responsible for sample custody will fill out COC forms at each sampling site, at a group of sampling sites, or at the end of each day of sampling. Original COC forms will accompany samples to the laboratory, and copies will be forwarded to the project files.

2.5.2.1 Field Custody Procedures

COC forms will be required for all samples. The sample processing team will initiate COC forms. COC forms will contain the sample's unique identification number, sample date and time, sample description, sample type, preservation (if any), and analyses required. Original COC forms, signed by the field team, will accompany the samples to the laboratory. A copy of relinquished COC forms will be retained with the field documentation. COC forms will remain with the samples at all times. Samples and signed COC forms will remain in the possession of the field team until samples are delivered to the express carrier (e.g., Federal Express), hand delivered to the laboratory, or placed in secure storage (S=see *COC Documentation* SOP).

2.5.2.2 Laboratory Sample Receipt and Storage

Upon sample receipt, the laboratory sample custodian will verify package seals, open the packages, check temperature blanks (and record temperatures), verify sample integrity, and inspect contents against COC forms. Note that samples requiring preservation at 4°C may be recorded as "received on ice" if solid ice is present in the cooler at the time the samples are received, in lieu of temperature measurements, per NR 149.11(4). The laboratory PM will be contacted to resolve any discrepancies between sample containers and COCs. After confirming the shipment and COC are in agreement, the sample custodian will initiate an internal COC as well as supply the Laboratory QAM with a sample acknowledgement letter. If the

sample temperatures are outside the required range, the laboratory will contact the Laboratory QAM to determine the proper course of action.

Samples will be logged into the Laboratory Information Management System (LIMS), which assigns a unique laboratory number to each sample. LIMS will be used by all laboratory personnel handling samples to ensure all sample information is tracked and recorded.

After the laboratory labels the samples, they will be moved to secured refrigerators where they will be maintained at 4 degrees Celsius (°C) or frozen, as appropriate. Access to refrigerators and freezers will be limited to authorized laboratory personnel.

2.6 Laboratory Analytical Methods

The analytical parameters and methods specified for water and fish tissue analysis are the same as those used in the baseline monitoring program, as described in Sections 2.6.1 and 2.6.2, below. In water, PCB congeners will be analyzed using EPA Method 1668A to achieve ultra-low level detection limits. In fish, PCB Aroclors will be extracted and analyzed using Wisconsin State Lab of Hygiene (WSLH) modifications to EPA Method 8082 to ensure consistency with historical fish monitoring data and the state fish consumption advisory program.

2.6.1 Water Analysis

Eight rounds of water column samples (once a month from April through November) will be collected at 10 stations, for a total of 80 samples, plus the specified number of QC samples for each sampling round and monitoring event.

2.6.1.1 Analytical Parameters

All water column samples will be analyzed for the following:

- PCB Congeners (209 total) by EPA Method 1668A (HRGC/MS)
- TSS by EPA Method 160.2
- Total Organic Carbon by EPA Method 415.1

2.6.1.2 Methods and Reporting Limits

Analytical methods and reporting limits for water analysis are summarized in Table 2-7. EDLs and reporting limits for PCB congeners by Method 1668A are listed in Table 2-8. Two-liter samples will be analyzed to improve reporting limits.

2.6.1.3 Order of Analysis

To minimize cross-contamination within a sample batch, the analytical laboratory will be directed to analyze the water samples in order from the least to the most contaminated:

- Lake Winnebago (analyze first)
- OU 5C
- OU 5B
- OU 5A
- OU 1
- OU 2A
- OU 2B
- OU 2C
- OU 3
- OU 4 (analyze last)

The data validation process will verify that the designated analysis order was followed, and if it is not, the potential effect on the data of the out-of-order analysis will be assessed.

2.6.2 Fish Tissue Analysis

For the human health indicator species (walleye, bass, or other substitute species), 15 individual fish will be analyzed from nine stations (135 analyses total) if all completeness goals are met. For carp, five composite samples from seven stations will be analyzed (35 analyses total). For drum, five composite samples from four stations will be analyzed (20 analyses total). For gizzard shad, seven composite samples from nine stations will be analyzed (63 analyses total). In all, as many as 253 fish tissue samples will be analyzed, considering the various species and the numbers of individual or composite analyses for each species, plus QC samples.

2.6.2.1 Analytical Parameters

Fish tissue samples will be analyzed using the following methods:

- Tissue Extraction (WSLH Method)
- PCB Aroclors (EPA Method 8082)
- Lipid Content (Randall et al. 1991)

2.6.2.2 Methods and Reporting Limits

Analytical methods and reporting limits for fish tissue analysis are summarized in Table 2-7.

Detected values above the method detection limit (MDL) but below the reporting limit (also known as the limit of quantitation) will be reported by the laboratory as estimated values with a "J" qualifier to indicate that the reported value is less accurate in this region of measurement. Matrix effects should be considered in assessing the laboratory's compliance with MDLs and reporting limits. The laboratory will provide a discussion of all failures to meet sensitivity specifications in the data package narrative. If a sample dilution results in non-detected values for analytes that had been detected in the original analysis, the results of the original run and the dilution will be reported with the appropriate notations in the case narrative.

2.6.3 Sediment Analysis

The details of the sediment analytical protocols, to be used in the monitoring of MNR areas as well as sediment caps, will be finalized toward the conclusion of RAs in OUs 2 through 5, and will be approved by the Agencies as an addendum to this LTMP.

2.7 Quality Control Requirements

The overall QA objective for this project is to collect data of a known and high level of quality through the specification and implementation of QC procedures during field sampling, sample handling, laboratory analysis, and data management.

Location Control. Field sampling locations must be determined to within known accuracy specifications. Water quality monitoring stations will be located to a target accuracy of within 2 meters using a DGPS calibrated to known shoreline benchmarks before and after

each sampling transect. The beginning, end, and turning points of fishing transects will be located to a target accuracy of within 10 meters using a GPS as well as references to shoreline landmarks (see *Location Control* SOP).

Analytical Control. Analytical specifications, reporting limits, QC procedures, assessment criteria, and corrective actions are summarized in the following tables:

- *Table 2-7*. Laboratory Analytical Methods and Reporting Limits
- *Table 2-8*. PCB Congener Reporting Limits
- *Table 2-9*. Quality Control Procedures, Criteria, and Corrective Actions—PCB Aroclors and Conventionals
- *Table 2-10*. Quality Control Procedures, Criteria, and Corrective Actions—PCB Congeners

The identification of analytical laboratories to perform the required work in the LTMP must be provided to the Response Agencies for approval at least 3 months before sampling is initiated. It is acknowledged that laboratories may need to be changed, with Response Agency approval, over the duration of the multi-decadal monitoring program.

The QA program is designed to generate data of known and acceptable *precision, accuracy, representativeness, comparability,* and *completeness*, as described below.

2.7.1 Precision

Precision is a measure of reproducibility of sample results. All work will adhere to the established protocols presented in this Plan. Checks for field and analytical precision will include the analysis of field replicates for water and fish, as well as matrix spike/matrix spike duplicates.

Field Replicates for Water. To provide an overall assessment of the field and analytical precision associated with PCB congener analysis, field duplicate samples will be collected from two different OUs during each of the 8 monitoring months (16 duplicates total). Four duplicates will be collected from Lake Winnebago and four will be collected from OU 4, systematically distributed throughout the 8-month monitoring period. One duplicate sample will be collected from each of the other eight monitoring stations

during the 8-month monitoring period. No more than one duplicate will be collected from Green Bay (OU 5A, 5B, and 5C) in any given month. This distribution will ensure that assessment of field replicate errors will be evaluated over the entire range of observed PCB concentrations, with particular emphasis in areas of lowest (i.e., Lake Winnebago, the background reference area) and highest concentration (i.e., OU 4).

Field Rinseate Blanks for Water. To provide an assessment of ambient field contamination caused by low but ubiquitous levels of PCBs in the regional background of the Site, field rinseate blanks will be collected. Two rinseate blanks will be collected each month, one from a clean unused section of Teflon tubing and the second from a decontaminated Niskin bottle, to assess both of the water sampling techniques. The laboratory will provide ultra-pure water to the field crew for use in preparing rinseate blanks for high-resolution congener analysis.

In the lake and the river, all six sampling points on the transect (A through F) will be sampled, then a second circuit of the sampling points will be made to collect the six aliquots for the field replicate sample. In Green Bay, the field replicate sample will be collected from a second, separate deployment of the Niskin bottle.

Field Replicates for Fish. Field replicate samples will be collected and prepared for both individual and composite samples of fish, as indicated in Table 2-4. For those species analyzed on an individual basis (i.e., walleye or bass), a pair of fish specimens from the same haul, and nearly identical in size (i.e., within 1 inch in length, if possible), will be designated as a primary specimen and a replicate specimen. For those species analyzed on a composited basis (i.e., carp, drum, and gizzard shad), a replicate composite grouping will be prepared from a second group of fish in the same size class. For carp and drum, replicate composite groups may be prepared from multiple hauls, but they must be from the same monitoring event (i.e. within a 30 to 60 day collection period). For gizzard shad, replicate composite groups should be prepared from the same haul as the original sample, to the extent possible.

One replicate sample of each species in each OU should be targeted for the long-term monitoring program. The minimum completeness goal is to obtain a replicate sample in at least half of the OUs for each species.

Evaluation and Response. Field replicate data will be evaluated during the CERCLA 5-year reviews. If significant discrepancies are evident in field replicate results, the field documentation will be reviewed to determine whether the discrepancies are potentially caused by field sampling error or alternatively, natural heterogeneities in environmental media which are beyond the control of the sampling crew. Note that it may not always be possible to differentiate these two potential sources of sampling variability. Appropriate modifications to the long-term monitoring program, if warranted, will be discussed in the 5-year reviews.

2.7.2 Accuracy

Accuracy is a measure of how close a measured result is to the true value. Both field accuracy (i.e., temperature and turbidity measurements) and analytical accuracy will be monitored through initial and continuing calibration of instruments. In addition, internal standards, matrix spikes, blank samples, laboratory control samples (LCSs), and surrogate standards will be used to assess the accuracy of the analytical data.

Accuracy will be calculated in terms of percent recovery, as follows:

$$\%\text{Recovery} = \frac{(A-X)}{B} \times 100$$

where:

A = Value measured in spiked sample or standard

X = Value measured in original sample

B = True value of amount added to sample or true value of standard

This formula uses an assumption of constant accuracy between the original and spiked measurements.

2.7.3 Representativeness

Representativeness is the degree to which sampling data accurately and precisely represent site conditions. Representativeness is dependent on sampling and analytical variability and the variability of environmental media at the site.

2.7.3.1 Representativeness in Space

Accurate and precise location control is a fundamental requirement for obtaining representative water and sediment samples (see *Location Control* SOP). Because fish swim freely within OUs/subunits, and may congregate in different locations from season-to-season and year-to-year, lower levels of accuracy and precision for location control can be tolerated for fish collection.

Water Representativeness. Representativeness of water samples will be achieved through the use of modified USGS "quarter-point" sampling procedures which provide systematic characterization of water quality over the depth and across the width of the river, lake, and bay. Representativeness will be further assessed by analyzing the spatial variability of field parameter measurements (i.e., temperature and turbidity) at the time of sample collection. Whereas Green Bay samples were stratified into shallow and deep water layers during the baseline monitoring program, it was determined that the PCB concentrations in these two layers, which are seasonally separated by a thermocline, were not statistically different. Therefore, Green Bay transects will be composited into a single sample at each monitoring station.

Fish Representativeness. Representativeness of fish samples will be achieved by collecting specimens from a range of sizes and a cross-section of habitats that are frequented by the target fish species in the various OUs of the Lower Fox River. Because fish are migratory, they provide spatial integration of contaminant exposures over the extent of their home range. A goal of the monitoring program is to characterize each fish station with fish specimens collected from at least three separate fishing sites within the OU or subunit. Collecting specimens from multiple fishing sites will help to provide representative geographic coverage of particular river reaches or bay areas. If possible, depending on species availability, some

specimens should be collected using a second, complementary fishing method (e.g., electrofishing and rod-and-reel) to evaluate the potential for field sampling bias (i.e., potential for one type of fishing gear to preferentially sample a particular habitat or size class).

Subdivision of OU 2 and OU 5. To provide better representation of the range of environmental conditions in a long and fragmented reach of the Lower Fox River, three sampling stations were assigned to OU 2 (OU 2A, 2B, and 2C). Similarly, to provide better representation of the physical and environmental transition from the mouth of the Fox River into Green Bay, two sampling stations were assigned to OU 5 (OU 5A and 5B).

2.7.3.2 Representativeness in Time

Representativeness of water samples will be achieved through the use of systematic monthly sampling over the eight-month monitoring period (April through November) when greater than 90 percent of the annual PCB load is discharged. Representativeness of fish samples will be achieved by targeting a late summer (August 15 to September 15) sampling window, as recommended by USEPA (2000), and maintaining this same sampling window throughout all baseline and long-term monitoring events to minimize seasonal variability in fish lipid content and contaminant levels.

If walleye are relinquished in favor of bass, bass samples should be collected during the same late summer window, to the extent they are available. Bass samples should also be collected in Lake Winnebago, OU 4, OU 5A, and OU 5B during the following June, to be consistent with the baseline monitoring program. If possible, complementary data sets should be collected from these four stations in both the late summer window and the June window to better characterize seasonal differences in PCB and lipid concentrations. If seasonal differences are not significant or are controllable using appropriate statistics, and if bass can be successfully obtained in the fall, the spring sampling event may be phased out.

2.7.4 Comparability

Comparability is the degree of confidence with which one data set can be compared to another, as discussed below.

Comparability between Baseline and Long-Term Monitoring Programs. Internal consistency will be achieved by occupying the same sampling stations and performing the same field and analytical methods in the baseline monitoring program and the long-term monitoring program. Specifically, comparability between baseline and long-term monitoring events will be ensured by:

- Occupying the same water monitoring stations and the same general fishing areas during all baseline and long-term monitoring events
- Utilizing the same or similar field sampling and analytical techniques during all monitoring events
- Collecting water data according to the same systematic monthly sampling schedule during all monitoring events (i.e., monthly sampling from April through November)
- Adhering to a fish sampling window between August 15 and September 15 during all monitoring events to minimize seasonal variations in tissue concentrations and fish lipid content

Tissue Performance Evaluation Sample. Comparability of PCB Aroclor analysis between baseline and long-term monitoring programs will be further evaluated by preparing tissue performance evaluation (PE) samples from representative composite groupings of fish collected during the baseline monitoring program with a typical site-specific Aroclor composition. Although a PE sample was not available for the baseline monitoring program, two PE samples will be prepared for long-term monitoring. One PE sample will be prepared for the Lower Fox River and another PE sample will be prepared for Green Bay. The PE samples will be analyzed five times by the contract laboratory used in the baseline monitoring program, then archived in the freezer for future use in the long-term monitoring program. When long-term monitoring activities are initiated, the selected contract laboratory (whether the same or a different laboratory) will also be required to analyze each of the tissue PE samples five times, and

a statistical comparison of Aroclor results will be performed to assess comparability of labs and analytical methods.

Comparability with Historical Data. Historical data will be used in a more qualitative than quantitative manner because monitoring stations, field and analytical methods specified in this Plan are not always comparable to those used in historical studies of the Lower Fox River and Green Bay. Comparability with historical data will need to be determined on a case-by-case basis. Comparability issues may arise due to station positioning methods, sampling and processing methods, analytical methods, and the level of data quality review.

Comparability with past and ongoing studies will be improved by:

- Utilizing sample preparation and analytical methods which are comparable to past and ongoing studies, to the extent possible (e.g., use of WSLH fish tissue extraction and tissue analysis methods)
- Occupying sampling stations which are coincident with stations occupied during past and ongoing studies to the extent possible (e.g., collocation with the USGS Oil Depot station at the mouth of the Lower Fox River)
- Collecting fish species (e.g., walleye, carp, gizzard shad) that have been routinely collected in past monitoring studies, to the extent possible

2.7.5 Completeness

2.7.5.1 Field Completeness

Field completeness is the percentage of stations or monitoring events successfully completed during the field program. For example, some samples may be lost, certain fish species may be sparse or unavailable in particular river reaches, and water sampling may be precluded at one or more stations because of severe weather or safety issues (e.g., wind, unstable ice, etc.).

The completeness of the field data is calculated using the following equation:

$$\% \text{ Completeness} = [(\# \text{ Samples Collected}) / (\# \text{ Samples Planned})] \times 100$$

Minimum Field Completeness Goals. The overall completeness goal for the water column sampling program is collection of valid water samples in at least 7 out of 8 warm-weather months (i.e., 88 percent). The overall completeness goal for the human health fish species (walleye) is collection of eight out of 15 specimens at a given sampling station (i.e., 53 percent). The overall completeness goal for ecological fish species (carp and drum) is collection of five individual fish as opposed to five composites of five fish each (i.e., 20 percent of the fish and 100 percent of the laboratory analyses). The overall completeness goal for gizzard shad is collection of five composites of five fish each as opposed to seven composites of 25 fish each (i.e., 14 percent of the specimens and 71 percent of the laboratory analyses).

These reduced numbers of samples should still provide sufficient statistical power to assess progress toward meeting RAOs, as discussed in Section 1.7.7. If completeness goals are not met for water, additional sampling may be required; if completeness goals are not met for fish, alternate species may need to be collected and analyzed. In the event completeness goals are not met for water or fish, appropriate contingency actions are described in Section 3.4.1 and Section 3.4.2/Figure 3-1, respectively.

Completeness Goal for Water Transects. The minimum completeness goal for any individual water sampling transect is collection of four out of six aliquots along the transect. For example, it is possible that the sampling crew could be driven off the water partway through a sampling transect due to foul weather. If at least four aliquots were obtained from the transect, these existing aliquots should be submitted to the analytical lab for compositing. If fewer than four aliquots were obtained on a particular sampling day, the aliquots should be discarded and the transect should be completely resampled on a later day when the field crew can remobilize.

2.7.5.2 Laboratory Completeness

Laboratory completeness is a measure of the percentage of data that were successfully collected and analyzed as planned and not rejected during the validation process. Data qualified as estimated values using qualifiers such as "J" are still deemed acceptable and can still be used to make project decisions.

The completeness of the analytical data is calculated using the following equation:

$$\% \text{ Completeness} = [(\# \text{ Valid Sample Results}) / (\# \text{ Samples Collected})] \times 100$$

The overall completeness goal for the laboratory is 90 percent. All valid and usable data must have accompanying location control and field documentation.

2.8 Instrument Testing, Inspection and Maintenance

2.8.1 Field Instruments Calibration

Field instruments will be calibrated daily in accordance with manufacturers' specifications before the beginning of daily sampling activities (see *Water Quality Meter* SOP). Standards used to calibrate the field instruments will be traceable to the standards of the National Institute of Standards and Technology whenever possible. The DGPS system will be checked against known benchmarks before and after each water sampling transect. Location control requirements, calibration protocols, and quality indicators are described in the *Location Control* SOP.

2.8.2 Cleanliness Testing of Water Sampling Equipment

Field rinseate blanks will be collected from Niskin bottles and peristaltic pump equipment prior to water sampling to evaluate the potential for field blank contamination. Field rinseate blanks are described further in Section 2.7.1.

2.8.3 Laboratory Instruments Calibration

Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing QC activities. These records will be filed at the location where the work is performed and will be subject to QA audit. The frequency and QC limits for the analytical instrument calibrations are provided in the relevant Laboratory SOPs.

2.9 Data Management

2.9.1 Field Documentation

2.9.1.1 Field Logbooks

Field logbook entries will be described in as much detail as possible so that persons going to the site could reconstruct a particular situation without reliance on memory. Modifications to field sampling protocols must be documented in the field logbook. The Field Supervisor is responsible for ensuring that modifications to sampling protocols are documented in the field logbook (see *Field Logbook* SOP).

2.9.1.2 Field Forms

Additional detailed sampling information may be recorded on separate field forms and referenced in the field logbook. The field team members will manage the raw data during field activities as overseen by the Field Supervisor. Periodically, the QAM will collect and compile the field data to maintain a current summary of field activities and measurements. All field sampling forms must include the project name, OU, date and time, sample location and sample number(s), and name and signature of the person completing the form.

2.9.1.3 Photographs

Photographs will be taken as needed to document field activities. Digital photograph files will be downloaded from the field camera to the project directory. The information listed below will be linked to each photograph.

- Name of person who took the picture
- Date and time photograph was taken
- Location and direction toward which the photograph was taken
- Description of the photograph

2.9.2 Laboratory Documentation

2.9.2.1 Laboratory Logbooks

Workbooks, bench sheets, instrument logbooks, and instrument printouts will be used to trace the history of samples through the analytical process and document important aspects of the analytical work, including QC metrics. As such, all

logbooks, bench sheets, instrument logs, and instrument printouts will be part of the permanent record of the laboratory.

Each page or entry will be dated and initialed by the analyst at the time of entry. Errors in entry will be crossed out in indelible ink with a single stroke, corrected without obliterating or overprinting the erroneous entry, and initialed and dated by the individual making the correction. Lining out unused portions and initialing by the person lining out the page will complete pages of logbooks that are not used.

The analyst will record information about the sample, analytical procedures, and results on laboratory forms or notebook pages and enter this information in LIMS. These notes will be dated and will also identify the analyst; instruments used, and instrument conditions.

Sufficient raw data records must be retained to permit reconstruction of initial instrument calibrations (e.g., calibration date, test method, instrument, analysis date, each analyte name, concentrations and responses, calibration curves, response factors, or unique equations or coefficients used to reduce instrument responses into concentrations).

Laboratory notebooks will be reviewed periodically by the laboratory group leaders for accuracy, completeness, and compliance with the requirements of this Plan. The laboratory group leader will verify all entries and calculations. If all entries on the pages are correct, the laboratory group leader will initial and date the pages. Corrective action will be taken for incorrect entries before the laboratory group leader signs the notebook.

2.9.2.2 Laboratory Project File

In accordance with analytical laboratory's records information management, documentation will be placed in secured project files which will be maintained by the laboratory records manager. These files will include the following:

- Agreements
- Correspondence

- Memos
- Notes and data
- Special instructions

Filed materials may only be removed by authorized personnel on a temporary basis, at which time the name of the person removing the file will be recorded. Laboratories will retain project files and data packages for a minimum of 10 years unless otherwise specified.

2.9.2.3 Electronic Data Storage

The analytical laboratories will provide the full data package, including chromatograms and raw data, in pdf format on a CD-ROM. These electronic data will be archived in project files for the duration of the long-term monitoring program. Laboratory instrument files and instrument software, including quantification program(s), will be archived at the analytical laboratories for a minimum of 10 years, which surpasses the NELAC standard for data storage. The laboratory will provide notice to the QAM or Project Coordinator before purging any instrument files or instrument software at the end of the archiving period.

2.9.3 Data Reporting

2.9.3.1 Field Data Reporting

Information collected in the field through visual observation, manual measurement, or field instrumentation will be recorded in field logbooks, data sheets, and/or field forms, then entered into an electronic database or spreadsheet. Data will be reviewed by the Field Supervisor for adherence to the requirements of this Plan. Any concerns identified as a result of this review will be discussed with the QAM, corrected if possible, and incorporated into the data evaluation process.

The Field QAM will review the accuracy and completeness of the field documentation, logbook entries, and field forms. The field documents will be checked for the following:

- Completeness and readability

- Use of Plan-specified procedures, with any modifications appropriately documented and communicated
- Instrument calibration and maintenance records
- Correctness of sample locations
- Correctness of reporting units, calculations, and interpretations

Where appropriate, field data forms and calculations will be processed and included in appendices to the appropriate data report. Original field logbooks and supporting documents will be kept in the project file.

2.9.3.2 Laboratory Data Reporting

Full "contract laboratory program (CLP)-equivalent" reporting is required for all water and fish tissue analyses. Whenever possible, analytical data will be transferred directly from the instrument to a computerized data system. Electronic data storage will be utilized. All electronic data will be maintained in a manner that prevents inadvertent loss, corruption, and inappropriate alteration. Per the requirements of the AOC, electronic data will be accessible and retrievable for a period of 10 years after project completion and the Response Agencies will be notified prior to destruction of any data files (USEPA 2004).

Raw data will be examined to assess compliance with QC guidelines. Surrogate and matrix spike sample recoveries will be checked. Samples and laboratory blanks will be checked for possible contamination or interferences. Chromatograms and concentrations will be checked to ensure that sample results are within the calibration range; if necessary, dilutions will be performed when the sample concentration of a constituent exceeds the initial calibration range of instrument.

Deviations from guidelines will call for corrective action. Deviations determined to be caused by factors outside the laboratory's control, such as matrix interference, will be noted with an explanation in the report narrative. Calculations will be checked, as specified in the referenced analytical methods, and the report reviewed for discrepancies, errors or omissions.

The laboratory data report will be submitted to the Laboratory PM for review and approval. The Laboratory PM will review the package, conduct a forms review on 100 percent of definitive data, and ensure that any necessary corrections are made and that the package is complete. A copy of the data package will be maintained in the project file. Data packages will be made available, upon request, to the Response Agencies.

Laboratory data reports will include, at a minimum:

Case Narrative. Summary of activities that took place during the course of sample analysis, including the following information:

- Laboratory name and address
- Date of sample receipt
- Laboratory ID number cross-referenced to contractor ID number.
- Analytical methods
- Deviations from specified protocol, if any
- Corrective actions taken
- Sample handling documents including; field and internal COC forms, air bills, or bills of lading from couriers

Chemical Analytical Results. The following information, as applicable, will be reported with the analytical results:

- Sample results with laboratory sample and client sample identification
- Detection and reporting limits
- Extraction and analysis times
- Sample volume
- Percent moisture
- Dilution factor
- Surrogate recovery
- LCS/LCD accuracy and precision summary
- matrix spike/matrix spike duplicate accuracy and precision summary
- Method blank summary

- Initial calibration summary–including concentration levels, retention times, response factors, and linearity demonstration
- Calibration blank summary
- Continuing calibration summary–including unique instrument/column identification, retention times, retention time windows, calibration factors, percent difference, or drift as appropriate to method
- Internal standard recoveries
- Degradation summary
- Analytical sequence
- Compound identification summary

2.9.3.3 Electronic Data Deliverable Format

An EDD file will be generated by the laboratory for every sample delivery group (SDG). These files will be incorporated into the Long-Term Monitoring Database. Each file will be named "*.txt," where "*" represents the batch SDG number. The USEPA Region 5 valid value list will be used for field and parameter names (see http://www.epa.gov/region5superfund/edman/download/EDD%20V1_05.pdf).

3 ASSESSMENT AND OVERSIGHT

Assessment and oversight activities are performed to determine whether the QC measures identified in this LTMP are implemented and documented as required. The Respondent Team Project Coordinator, PM, and Field Supervisors will perform assessment and oversight to check conformance to this LTMP. For example, during a review, the Field Supervisor may check that a sample has been processed and labeled correctly or that the field QC samples were collected at the appropriate frequency. The need for a check can be determined independently by the Project Coordinator or PM, or assigned by these persons to another team member.

Response Agency oversight activities may be performed by USEPA and WDNR. At all reasonable times, USEPA and WDNR personnel and their authorized representatives shall have the authority to enter and freely move about all on-site and off-site areas where work, if any, is being performed, for the purposes of inspecting conditions, activities, the results of activities, records, operating logs, field notes, and data related to these monitoring activities, provided project health and safety requirements are followed.

Aspects of the LTMP may be adaptively managed by the Respondents, Response Agencies, and their respective technical consultants. Using an adaptive management approach, information collected during the early stages of the monitoring program may be used to guide or improve the performance of later field or analytical tasks.

3.1 Field Audits

Planning, scheduling, and conducting QA audits and surveillance are required to verify that site activities are being performed in conformance with approved plans, standards, federal and state regulatory requirements, sound scientific practices, and contractual requirements. Planned and scheduled audits may be performed to verify compliance with aspects of the QA program and to evaluate the effectiveness of the QA program. Audits include an objective examination of work areas, activities, processes, review of documents and records, interviews with project personnel, and review of plans and standards.

Internal review of the sampling program will be conducted on a regular basis during the field activities. Reviewers will pay particular attention to the sampling program with

respect to representativeness, comparability, and completeness of the specified measurements.

Field documentation (e.g., COC forms, field sampling forms, and logbooks) will be reviewed as it is generated, by the Field Supervisor or designee, for accuracy, completeness, and compliance with the requirements of this LTMP. The Field QAM, PM, or Project Coordinator will audit field sampling procedures periodically for compliance with LTMP procedures. The auditor will check that the following procedures are being properly implemented:

- Sampling protocols are being followed.
- Samples are placed in appropriate containers.
- Samples are stored and transported properly.
- Field documentation is complete, accurate, and legible.

Internal field audits will be conducted by one of the individuals listed above at the beginning of each new field activity (i.e., fish sampling; water sampling) and during a significant crew change (i.e., replacement of Field Supervisor). Additional field audits may be conducted on an as-needed basis if potential data quality issues are identified by field staff or during senior review of field reports and field documentation.

In addition to internal field audits, the USEPA and WDNR oversight team may also conduct field audits. At least 15 days of notice shall be given to the WDNR and USEPA Project Coordinators prior to beginning sampling. If necessary, corrective action shall be performed as provided in Section 3.4 of this Plan.

3.2 Laboratory Audits

The Laboratory QAM may conduct internal system audits. An internal audit is a qualitative evaluation of all components of the laboratory QC measurement system. The audit serves to determine whether measurement systems are being used appropriately. The system audits are conducted to evaluate the following:

1. Sample handling procedures
2. Calibration procedures
3. Analytical procedures

4. QC results
5. Safety procedures
6. Recordkeeping procedures
7. Timeliness of analysis and reporting

The Laboratory QAM will evaluate laboratory precision and accuracy by comparing results of duplicate samples, QC samples, spikes, and blanks. When a beyond-control limit situation is encountered, analytical results will be checked by the Laboratory PM prior to distribution.

In addition, laboratories are subject to external audits. The focus of these audits is to assess general laboratory practices and conformance to the requirements of this LTMP. Laboratory audits may be performed by the Data QAM prior to the start of analyses for this project and at any time during the course of the project as deemed necessary.

External reviews of laboratory performance may also be conducted based on an evaluation of QC check samples analyzed as part of the USEPA and/or Wisconsin state certification requirements. In addition, performance audits may be conducted by sending double-blind PE samples (samples that are not discernable from routine field samples) to the analytical laboratory.

The USEPA and WDNR may also perform laboratory audits in addition to routine certification audits or PE sample results. Any discrepancies will be remedied as described in this Plan.

3.3 Corrective Actions

3.3.1 Field Corrective Action

Any project team member may initiate a field corrective action process. The corrective action process consists of identifying a problem, acting to eliminate the problem, monitoring the effectiveness of the corrective action, verifying that the problem has been eliminated, and documenting the corrective action.

Corrective actions include correcting COC forms; correcting problems associated with sample collection, packaging, shipping, or field record keeping; or additional training in sampling and analysis. Additional approaches may include re-sampling or evaluating and amending sampling procedures. The Field Supervisor will summarize the problem, establish possible causes, and designate the person responsible for a corrective action. The Field Supervisor will verify that the initial action has been taken, that it appears to be effective, and then follow up at a later date to verify that the problem has been resolved.

Technical staff and field personnel will be responsible for reporting suspected technical or QA nonconformances or suspected deficiencies to the Field Supervisor. The Field Supervisor will assess suspected problems in consultation with the Project Coordinator, PM, and/or Field QAM, as appropriate, and reach a coordinated decision based on the potential for the situation to impact data quality. If it is determined that the situation warrants a reportable nonconformance requiring corrective action, a nonconformance report will be initiated by the Field Supervisor.

3.3.2 Stop Work Order

The Project Coordinator has the authority to stop work based on QC, health and safety, or other serious deficiencies that may compromise the integrity of the long-term monitoring program or the safety of the field crew. The decision to stop work will be determined on a case-by-case basis in consultation with the PM, Field QAM, Field Supervisor, and as appropriate, the WDNR Project Coordinator and USEPA Remedial PM. Stop work decisions may also be made on the basis of hazardous field conditions by the Field Supervisor, Corporate H&S Manager, or the boat captain.

3.3.3 Laboratory Corrective Action

Corrective actions are required whenever an out-of-control event or potential out-of-control event is identified at the analytical laboratory during sample handling and preparation, instrument analysis, or data generation, or during the Respondent Team's oversight of these activities (see Tables 2-9 and 2-10). The investigative and corrective actions taken are somewhat dependent on the severity of the problem and its potential

to adversely impact data quality. Corrective actions may be necessary if the following situations occur:

- QC data are outside control limits for precision and accuracy
- Blanks contain target analytes above acceptable levels
- Undesirable trends are detected in spike recoveries or relative percent difference (RPD) between duplicates
- Unusual changes in detection limits occur
- Deficiencies are detected by the Laboratory QAM during internal or external audits or from results of PE samples

Corrective action procedures are often handled at the bench level by the analyst who reviews preparation or extraction procedures for possible errors, and checks instrument calibrations, spike and calibration mixes, and instrument sensitivity. If problems persist or cannot be identified, matters are referred to the Laboratory QAM or Laboratory PM for further investigation. Full documentation of the corrective action procedures is filed with the Laboratory QAM after discussion with and approval by the Data QAM. If corrective actions are insufficient, the Project Coordinator or the Data QAM may issue a stop-work order. Corrective action may include the following:

- Re-analyzing the samples, if sample or extract volume is adequate and holding times have not lapsed
- Performance of additional cleanup steps
- Re-sampling and analyzing
- Evaluating and amending sampling or analytical procedures
- Accepting data and acknowledging a higher level of uncertainty

If re-sampling is deemed necessary due to laboratory problems, the Respondent Team's Project Coordinator and PM will coordinate collection of additional sample material, and if appropriate, pursue cost recovery from the laboratory for the additional sampling effort. If a proposed corrective action results in a significant change or modification to the procedures defined in this LTMP, review and approval by the WDNR and USEPA may be required prior to implementing the recommended procedural modifications.

3.4 Field Contingency Plans

3.4.1 Water Sampling Contingency Plan

It is possible severe weather conditions (e.g., ice, high winds, etc.) or other safety concerns will preclude water sampling at one or more locations during the monitoring year (April through November). Water sampling will be targeted for the first 2 weeks of each month. If severe weather or other difficult field conditions delay sampling, sampling will be performed as soon as possible during the month. If sampling cannot be completed at all during the month, the monthly sampling event will be lost.

The overall completeness goal for the water column sampling program is collection of valid water samples in at least 7 out of 8 monitoring months (see also Section 2.1.3). If this completeness goal is not met, the Respondents and Response Agencies will review the data and determine an appropriate corrective action. Corrective action may include:

- Acceptance of fewer than the required number of sampling events at certain stations for the monitoring year
- Assignment of two sampling events in one month to make up for the deficiency
- Extension of the monitoring program into the winter or the following spring

3.4.2 Fish Sampling Contingency Plan

It is possible that a sufficient number of appropriately sized fish may not be obtainable for all species and all OUs during the August 15 though September 15 sampling window. Figure 3-1 summarizes the steps that will be taken to optimize fish collection efforts, and a decision framework that will be followed to ensure that the most complete and representative fish data are obtained during each monitoring event.

At the outset of the sampling effort, two days will be allocated for fish collection at each station. Electrofishing will be the primary fishing method, as it was consistently productive for nearly all of the target species during the baseline monitoring program. Trawling, seine netting, and rod-and-reel may also be used at the discretion of the Field Supervisor or Field Biologist. Recommended fishing areas, based on experience gained during the baseline monitoring program, are shown on Figures 2-2 through 2-9. Fishing methods and locations may be modified as necessary to target the species and sizes needed at each station, and to adapt to field conditions and fish occurrence. All primary

(walleye, carp, drum, gizzard shad) and secondary (bass) species within the Plan-specified size ranges (Table 2-3), as well as 2 inches shorter and 2 inches longer than the specified size ranges, will be collected and archived in the event that all target species and sizes are not obtainable.

The sampling crew will move to the next station as soon as the requisite species and sizes have been collected or after two days are spent at any station. During the baseline monitoring program, a third fishing day was not generally productive. The sampling crew will complete the circuit of nine stations in this manner, with a maximum of 2 days at each station. If some stations still lack the full complement of target species and sizes, then a field contingency strategy will be implemented, as described below, to optimize follow-up sampling efforts.

1. *Resample Incomplete Stations.* Once the circuit of nine fishing stations has been completed, the sampling crew will circle back and resample any stations where additional species or sizes are needed, on the premise that it may be helpful to let the water "rest" for a few weeks, especially during the transition from summer to fall. An additional 1 to 2 days will be allocated to any incomplete stations. Different fishing techniques may need to be tried. If necessary, the fishing season may be extended as late as October 15.
2. *Expand Target Size Ranges.* If all sizes and species have not been collected after the second attempt, the target size ranges will be expanded plus or minus 2 inches to achieve the requisite numbers of fish to prepare the individual and composite samples.
3. *Reduce Sample Sizes.* If the requisite numbers of fish cannot be achieved even after expanding the target size ranges, then fewer fish will be analyzed for human health species, and fewer fish will be used to prepare the composite samples for ecological species. Sampling will be considered complete if each fishing station contains at least eight walleye (or bass), at least five carp or drum, and at least five composites of five gizzard shad each (i.e., at least 25 gizzard shad).
4. *Use Alternate Species.* If there are still insufficient numbers of target fish species, consideration will be given to the use of alternate species, especially if alternate species were collected and archived during sampling. Bass is the alternate species for walleye; drum is the alternate species for carp in the Lower Fox River,

and carp is the alternate species for drum in Green Bay. If an alternate species is needed to replace gizzard shad, it would be an opportunistic decision at the time of sampling based on the availability of another small, YOY species (e.g., emerald shiner, walleye fingerlings, etc.).

4 DATA VALIDATION AND DATA ANALYSIS

Data validation is the process by which data generated in support of this project are evaluated according to the QA/QC requirements of this LTMP. The data are evaluated for precision and accuracy against analytical protocol requirements. Nonconformance or deficiencies that could affect the precision or accuracy of the reported result are identified and noted, followed by an assessment of whether the result is sufficient to achieve project DQOs.

Data analysis includes procedures for summing total PCB concentrations, blank-correcting PCB congener results, and statistically analyzing the resultant data in space and time. Statistical analysis procedures include statistical distribution testing, correlations with controlling variables, trend analysis and regression, and PCB loading calculations.

4.1 Data Review and Validation

The data validation process is conducted to assess the effect of the overall sampling and analysis process on the usability of the data. There are two areas of review: laboratory PE, and the effect of matrix and sampling interference. Evaluation of laboratory performance is a check for compliance with the method requirements and is a straightforward examination: the laboratory either did or did not analyze the samples within the QC limits of the analytical method and according to protocol requirements. For this project, holding time exceedances for PCBs will be qualified, rather than invalidated. The assessment of potential matrix and sampling effects consists of a QC evaluation of the sample analytical results as well as the results of blank, duplicate, and matrix spike samples; and assessing whether, or how much, the usability of the data could be affected.

All analytical data will be provided in a data package with supporting QC information (see Section 2.7.3 for laboratory deliverable requirements). Before the laboratory releases each data package, the Laboratory QAM will carefully review the sample and laboratory performance QC data to verify sample identity, the completeness and accuracy of the sample and QC data, and compliance with method specifications.

4.1.1 Field Screening Data

Field screening data include measurements of water temperature and turbidity, fish length and weight. These data will be validated by checking the completeness and

accuracy of field measurements, field documentation, and location control. The calibration records for the water probe will be reviewed for accuracy, completeness, and adherence to the calibration schedule.

4.1.2 Data Validation and Verification

One hundred percent of the PCB laboratory data will undergo a forms review by the laboratory consistent with the procedures specified in this LTMP. Independent third-party data validation will be provided for 100 percent of each media in the first week of sampling, for each monitoring event, and when a substantive modification is made to the sampling method or analytical laboratory. This initial validation effort will allow for the early implementation of any corrective actions, if needed. If the initial validation is acceptable, a minimum of 10 percent of each media will continue to be validated on an ongoing basis unless problems are encountered that warrant increasing the data validation requirements.

Third-party data validation will follow USEPA's Contract Laboratory Program National Functional Guidelines for Organic Data Review (USEPA 1999) and USEPA's Contract Laboratory Program National Functional Guidelines for Inorganic Review (USEPA 2002b) (the "National Functional Guidelines"). This is consistent with USEPA Region 5 QAPP guidance (USEPA 2000a) which cites the National Functional Guidelines as appropriate for use in data validation at Superfund sites in this region.

Forms Review. One hundred percent of the laboratory data collected during the long-term monitoring program will undergo a forms review by the laboratory prior to submitting the results to the Data QAM and subsequently to the Data Validator. The data package supplied by the laboratory will be validated through the forms review process for compliance with the following:

- Holding times and sample temperature
- Surrogate recovery
- matrix spike/matrix spike duplicate precision and accuracy
- LCS precision and accuracy
- Initial calibration and continuing calibration precision and accuracy
- Instrument tuning criteria (where applicable)

- Blank contamination
- Field duplicate precision and accuracy

The QC criteria to be implemented during the forms review process are presented in Table 2-9 and Table 2-10.

Data Validation. The laboratory data packages will be sent directly to the Data QAM by the subcontract laboratories. The Data QAM will select 10 percent of the data (or 100 percent of the data during the first week of sampling) to be validated by an independent, third-party Validation Subcontractor. The Data QAM will provide the Validation Subcontractor with copies of the selected data packages. Once validated, the Validation Subcontractor will make copies of the data validation report as well as the summary forms and submit them to the Data QAM, then they will be forwarded to the USEPA PM, and the WDNR Project Coordinator. The acceptance criteria for data validation are those listed in Table 2-9 and Table 2-10 of this Plan. The QC requirements specified in this Plan shall take precedence over the requirements of the National Functional Guidelines.

Data validation is at times based upon professional judgment. In order to achieve consistent data validation, data worksheets will be completed for each data validation effort. A data review worksheet is a summary form on which the data validator records data validation notes and conclusions specific to each analytical method. The worksheets will help the validator track and summarize the overall quality of the data. Sample results will then be assigned a degree of usability based upon the overall data quality. The Consultant Team will review the data validation results and assess how the data, as qualified by the data validation process, can be used to fulfill project objectives, i.e. to evaluate progress toward achieving RAOs in the Lower Fox River and Green Bay.

Data Verification. After validation, the data will be compiled in an electronic database and the data will be verified to confirm:

- The correct samples were analyzed and the correct parameters were reported
- EDDs and hard copy data deliverables are consistent

- Results are consistent with expectations based on Baseline Monitoring results or the results of previous Long-Term Monitoring events.

In the first two instances, the laboratory will be directed to correct any omissions or inconsistencies in reporting. If the data obtained from the laboratories are not consistent with expectations, based on prior sampling data, a more in-depth evaluation of the results will be performed to determine if the deviation is a real environmental phenomenon or an artifact of the sampling and analysis process.

Project-Specific Qualifiers. While maintaining consistency with the National Functional Guidelines, the Region 5 QAPP guidance also allows for the definition of additional project-specific data qualifiers. For this program, a project-specific data qualifier will be used for total PCB concentrations in water (using EPA Method 1668A) for which the summation of total PCBs is based on too-few congener detections. A "Q##" flag will be assigned to blank-corrected total PCB concentrations that have been quantified using fewer than 25 detected congeners, where ## is a number less than 25 that represents the number of detected congeners in each flagged sample. For example, "Q15" indicates the total PCB concentration for that sample is based on the sum of only 15 detected congeners. These summations are qualified because the PCB profile may be censored by the limits of analytical sensitivity, and therefore the total PCB concentration may be biased low. The specific procedures for data qualification in these circumstances are discussed further in Section 4.2.1.2.

4.1.3 Reconciliation with Data Quality Objectives

The goal of the data collection effort is to acquire enough information and data to verify that sediment RAs in the Lower Fox River result in substantive reductions in water column and fish tissue PCB concentrations and loadings to Green Bay. Field and laboratory data will be evaluated in accordance with the DQOs established in Section 1.7. Progress toward achieving RAOs will be evaluated using the data analysis methods and statistical procedures described in Section 4.2 below. Determining whether the data are sufficient to achieve project objectives will be the collective responsibility of the Respondents and the Consultant Team, the Response Agencies and the Oversight Team.

4.2 Data Analysis

4.2.1 PCB Summation

In water samples, total PCB concentrations will be summed using zero for congeners undetected at the EDL. In tissue samples, total PCB concentrations will be summed using zero for Aroclors undetected at the MDL. Estimated (J-flagged) values between the EDL/MDL and the reporting limit will be included in the summation at full value.

4.2.1.1 Aroclors versus Congeners

It should be noted that total PCB concentrations that are summed using congener data are not generally comparable to total PCB concentrations that are summed using Aroclors. These different analytical techniques and quantitation methods respond differently to matrix interference, PCB weathering, and instrument sensitivity. Therefore, comparing water quality data that is reported as PCB congeners, as specified in this Plan, with historical data reported as PCB Aroclors is problematic, unless the bias between the two different analytical methods is adequately understood. As a result, historical data prior to the baseline monitoring event will generally not be used to assess time trends in water quality.

4.2.1.2 Analytical Sensitivity (Minimum Detected Congeners)

Based on an evaluation of the PCB congener compositions in the river reaches (OUs 3 and 4) and monitoring months (August and September) with the highest PCB concentrations during the baseline monitoring program, it was determined that the top 25 congeners contributed at least 80 percent of the total PCB mass (see Section 1.7.7.2). Based on this evaluation, the goal for the long-term monitoring program is to detect and quantify 25 congeners in each sample. With this level of detection, a majority of the PCB mass will be positively quantified. Detections of fewer numbers of congeners may tend to bias results low because a larger fraction of the PCB mass would be undetected or "censored". In addition, highly contaminated samples should be diluted such that 25 individual congeners continue to be detected in the diluted sample. In addition to these minimum congener requirements, Site water samples also need to be discernible from field and laboratory blank contamination, in which low levels of PCB congeners from the global and regional atmosphere are ubiquitously present (see Section 1.7.2.3[5]).

Given the order of magnitude reductions in PCB concentrations which are predicted to occur in the decades following the RA, the sensitivity of the PCB analytical methods may need to be evaluated at some point in the future of the program. If fewer than 25 congeners are detected in some samples (after blank correction), the Respondents and Response Agencies will convene to determine whether some type of corrective action is warranted to improve the estimate of total PCBs. Possible corrective actions may include:

- Qualify the PCB summation as "estimated" and report the number of detected congeners that contribute to the total value
- Develop a correction factor to account for undetected PCB mass in the "censored" part of the data
- Modify the field and/or analytical procedures in an attempt to achieve lower detection limits; the need for lower detection limits, and the ability to achieve lower detection limits, must be determined in consideration of ambient PCB levels in laboratory method blanks and field rinseate blanks.

4.2.2 Blank Correction for PCB Congeners

The lowest PCB congener concentrations in water samples from the baseline monitoring program were found at the upstream reference area (Lake Winnebago) and at the outermost station in Green Bay. At times, the concentrations in these areas approach the sensitivity of the HRGC/MS 1668A method, as well as ambient background levels of PCB contamination in the global and regional atmospheres. Following the sediment RA, PCB concentrations are expected to decline further. As a result, blank correction of the PCB congener data must be carefully performed, especially in OUs with background or near-background concentrations.

During the baseline monitoring program, blank correction was evaluated using three different correction procedures: 1) standard method following National Functional Guidelines (in which congener concentrations less than five times the method blank concentrations are corrected to nondetect); 2) blank subtraction method of Ferrario et al. 1997, also referenced in Section 17.6.1.4.4 of EPA Method 1668A (in which blank correction is based on the mean plus two standard deviations of the method blank data set during the period of analysis); and 3) a nonparametric modification of Ferrario et al.

1997 method (in which blank correction is based on the 95th percentile of the method blank data). In discussions of the Long-Term Monitoring Work Group, the Ferrario method was determined to be superior to the standard method because the standard method resulted in too few congener detections and fragmented and unrealistic congener fingerprints after blank correction.

The Ferrario method is described in Section 17.6.1.4.4 of EPA Method 1668A:

> *Blank corrected results may be reported in addition to reporting of separate results for samples and blanks. The recommended procedure for blank correction is that a result is significantly above the blank level, and the level in the blank may be subtracted, if the result is greater than the mean plus 2 standard deviations of results of analyses of 10 or more blanks for a sample medium.*

The Long-Term Monitoring Work Group decided that a nonparametric modification of the Ferrario method was appropriate due to concerns regarding treatment of censored values (i.e., non-detects) in the method blank data set, and the determination of means and standard deviations from censored data. As a result, the Long-Term Monitoring Work Group decided to blank correct using the 95th percentile of the method blank data, rather than the mean plus two standard deviations. The percentile approach provides an equivalent level of statistical certainty but is unaffected by high percentages of undetected values in the method blank data set. In practice, the Ferrario method and the nonparametric modification of the Ferrario method showed very little difference in terms of blank-corrected total PCB concentrations in the baseline data set (typically less than a few percent RPD between the two calculations).

The blank correction procedures to be used in the long-term monitoring program will be the nonparametric modification of the Ferrario subtraction method. The procedure for nonparametric blank subtraction is described below:

1. Compile laboratory method blank data for EPA Method 1668A during the period of laboratory analysis corresponding to the 8 month monitoring period (April through November), plus 3 months before and 3 months after the monitoring period
2. Prepare a time-series graph of the method blank data to determine whether there are any significant trends in blank concentrations, especially abrupt changes in

blank concentrations that may be traceable to a change in laboratory procedures or equipment

3. Determine whether there were any changes in chromatographic columns during the period of analysis, and ascertain the exact date of column replacement
4. The method blank data set, and the associated statistical calculations and blank subtraction terms, must be calculated separately for any analysis periods in which different chromatographic columns were used, and for periods in which procedural modifications had a significant effect on method blank results, as per items 2 and 3 above
5. It is preferable to have at least 10 to 20 method blank results in every analysis period for which blank subtraction terms are being calculated. If there are fewer than ten results, two options are available: a) use the maximum blank concentration in the data set as the blank subtraction term; or b) consider pooling together some of the analysis periods, if appropriate, to provide more blank results in each period.
6. For each analysis period, calculate the 95th percentile concentration of the method blank data: [k=0.95(n+1)] where k is the rank of the sample corresponding to the 95th percentile concentration, and n is the number of method blank samples in the analysis period. Fractional, non-integer ranks will be interpolated between the two closest data points. The 95th percentile method blank concentrations become the blank subtraction terms.
7. Subtract the 95th percentile method blank concentrations from the raw PCB concentrations for all samples analyzed during the corresponding period. The resultant values are the blank-corrected PCB concentrations. If the sample congener concentration is less than the corresponding 95th percentile blank values, the congener will be corrected to an undetected value. Undetected congeners do not contribute to the summation of total PCB concentrations.

Blank-corrected total PCB concentrations will be used in the statistical analyses described in the following section.

4.2.3 Statistical Analysis of Monitoring Data

Water, fish tissue, and sediment data will be statistically analyzed to assess the performance of the monitoring program and the more fundamental objective of monitoring progress toward achieving the RAOs. Descriptive statistics (Section 4.2.3.1), distribution tests (Section 4.2.3.2), and correlation tests (Section 4.2.3.3) will be performed. Long-term monitoring data will be compared to numerical target concentrations, including ecological and human health risk goals and background criteria, and confidence levels will be assessed (Section 4.2.3.4). Time trend analysis will be performed by comparing mean concentrations and percent reductions between baseline and long-term monitoring events (i.e., two-sample comparisons) and by using simple or multiple regression techniques (Section 4.2.3.5). Finally, PCB mass loadings to Green Bay, and at various upstream locations in the Lower Fox River, will be calculated (Section 4.2.3.6).

4.2.3.1 Descriptive Statistics

For each round of long-term monitoring, descriptive statistics will be calculated for each OU and each fish species. Descriptive statistics will include mean, median, minimum and maximum, 10th, 25th, 50th, 75th, and 90th percentiles, percent nondetects, standard deviation and CV. These statistics will be used to verify the assumptions underlying the sampling design and to confirm that the expected level of statistical power is being achieved. These statistics will also be used to evaluate the achievement of human health and ecological target tissue goals, background criteria, and SWAC reduction targets (see Section 1.6.1).

4.2.3.2 Statistical Distribution Tests

Water and fish data will be subjected to statistical distribution tests to assess conformance with standard normal or lognormal distributions. Conformance with these distributions will allow the data to be analyzed using parametric testing procedures which are generally more powerful than nonparametric procedures. Distribution testing will utilize either numerical procedures (e.g., Shapiro-Wilk or D'Agostino Tests) or graphical procedures (e.g., normal probability plots).

4.2.3.3 Correlations with Controlling Variables

The data will be tested for statistical correlations between PCB concentrations and potential controlling variables. In particular, aqueous PCB concentrations will be tested for correlations with flow, temperature, and TSS concentrations. Fish tissue PCB concentrations will be tested for correlations with lipid content and fish length (a surrogate for fish age, as well as the primary basis for fish consumption advisories).

4.2.3.4 Estimating Statistical Confidence of Exit Decisions

This section provides guidance on estimating statistical confidence levels associated with achieving specified target concentrations, including risk-based concentrations, background criteria, and SWAC reduction targets. The compound probability associated with the LTMP requirement to achieve exit criteria in two successive monitoring rounds is also discussed.

Comparison to Target Concentrations. The statistical confidence associated with achieving a specified target concentration in a particular OU (whether it is a risk-based, background-based, or percent reduction target) is a function of the standard error of the mean concentration and the percent difference between the mean and the target concentration. If the mean concentration is equal to the target concentration, there is a 50 percent chance that the mean is at or below the target concentration. Statistical confidence improves as the mean concentration drops below the target concentration, and the greater the difference, the higher the confidence. Statistical confidence also improves as the standard error on the mean is reduced—a smaller standard error provides greater power of discrimination between the mean and the target concentration.

Table 4-1 provides the estimated statistical confidence as a function of the standard error on the mean of the monitoring data (expressed as a percent of the mean) and the percent difference between the target concentration and the mean. Three tables are provided for three different sample sizes, including data sets with five samples (approximately representing composite samples for ecological fish species), 15 samples (representing individual samples for human health fish species), and an

ideal, infinitely large data set. Standard errors for total PCB concentrations in most OUs and media typically range from approximately 5 to 25 percent of the mean, as summarized in Tables 1-1 and 1-2.

Compound Probability of Confirmation Monitoring. The statistical confidence of exit decisions is improved by requiring exit criteria to be achieved in two consecutive monitoring events (i.e., an initial event and a follow-up confirmation event; see Section 1.7.5 and Figures 1-4, 1-5, and 1-7). The compound probability of achieving exit criteria in two successive monitoring events will be considered in the evaluation of statistical confidence for exit decisions. For example, if exit criteria are met with 70 percent confidence (alpha = 0.3) in each of two successive monitoring events, the compound confidence level is 91 percent (alpha = 0.3 x 0.3 = 0.09).

4.2.3.5 Time Trend Analysis

A primary objective of the baseline and long-term monitoring programs is to evaluate risk reduction success as measured by declining PCB concentrations in water and fish tissue. The essence of this analysis is determining the significance and magnitude of decreasing trends in the monitoring data.

Comparison of Means. A simple test of significance is a comparison of mean PCB concentrations between two monitoring events to determine if the mean value of the later event is significantly lower than the earlier event. If a decreasing trend is present, the power of this type of test will tend to increase as the time between monitoring events increases (i.e., the length of the monitoring record increases). Using this type of analysis, the estimated percent reduction and statistical significance of PCB concentration reductions between the baseline event and each successive monitoring event can be calculated. The results will be used to infer the magnitude and statistical significance of the combined effects of active remediation and natural recovery on reducing PCB concentrations.

Simple Linear Regression. The data will be analyzed to determine an appropriate trend model. The default assumption is that PCB concentration reductions will follow an exponential decay model. This model can be tested by fitting a linear

regression through a plot of log PCB concentrations (in water, tissue, or sediment) versus time. A minimum of three rounds of post-construction monitoring data (i.e., Years 0, 5, and 10) will be needed to estimate the time rate of recovery in this way. Once the data are sufficient to estimate a model of PCB concentrations over time, the model can be used to predict future concentrations and compare predictions to risk reduction goals and other exit criteria. Time regressions will be performed separately for each OU and each fish species. For fish data, it may be appropriate to either stratify the data by size classes or normalize the data using lipid content or fish length, to reduce the effects of confounding variables. Nonparametric trend analysis may be considered if the data are poorly described by standard statistical distributions (see Section 4.2.3.2).

Multiple Regression. If warranted, more complex, multivariate statistical analysis procedures may be considered. In particular, multiple regression techniques may be useful if significant correlations are established with multiple controlling variables (LTI 2002, 2005).

Multiple linear regression provides a way to estimate the effects of an independent variable on water column PCB concentrations, such as the effect of sediment remediation, while controlling for the effects of other variables known to affect PCBs (such as flow, suspended solids, and seasonal temperature changes in water; or lipid content and fish length in tissue). As required for simple linear regression, a minimum of three rounds of post-construction monitoring data are also required for multiple regression. These data would be pooled to estimate the coefficients of an equation predicting PCB concentrations as a function of the independent variables mentioned above. Another independent variable would be a digital indicator to denote post-remediation conditions, equal to 0 for the baseline data and 1 for post-remediation data. The regression coefficient for this indicator would provide an estimate of the effect of remediation, after controlling for the effects of the other variables. A test of the hypothesis of "no effect of remediation" could be structured as a t-test of the null hypothesis that this coefficient is equal to zero.

A finding of a "significant effect" requires rejection of the null hypothesis at a given level of statistical confidence (i.e., probability of Type I error, which is the rejection of the hypothesis if it is true). The smaller the prediction error of the regression equation and the larger the number of data points in the monitoring program, the more accurately the effect of remediation can be estimated, thereby expanding the range of scenarios that can be judged "significantly different from zero." Similarly, smaller prediction errors and larger sample sizes also reduce the likelihood of accepting a null hypothesis of "no effect" if it is false, increasing the statistical power of the test.

Variations in the specification of the regression equation can be made, depending on what variables are known to affect PCB concentration and whether their effects are linear, nonlinear, or interactive. One important variation which is a commonly observed relationship in environmental data assumes the natural logarithm of PCB concentration is a linear function of its determinants. The inclusion of variables and their functional forms should be dictated by scientific understanding of cause and effect relationships, supplemented by comparisons of goodness-of-fit of alternative forms of the equation. Variables should be retained in the regression equation if the hypothesis of "no effect" for each independent variable can be rejected at a high level of significance.

4.2.3.6 PCB Loading Calculations

One of the RAOs for the RA is to achieve a reduction of PCB loadings to Green Bay to accelerate natural recovery of bay sediment, water, and fish. To address this objective, PCB loads will be calculated at the mouth of the Lower Fox River at the USGS Oil Depot gage (OU 4). PCB loads will also be calculated at several upstream reference locations to monitor the natural recovery of the river system as a whole in response to sediment RAs in various parts of the river. Specifically, PCB loads will be calculated at the downstream ends of the following reaches:

- Lake Winnebago (background loading to Lower Fox River)
- OU 1
- OU 2C
- OU 4 (discharge to Green Bay)

Loadings will be estimated using Beale's ratio estimator method. The Beale's method uses daily flow measurements and less frequent concentration measurements to estimate the average daily load. This estimate is computed as the average of loads for all days that both flow and concentration are measured, with a bias correction that accounts for higher- or lower-than average flows on the days when concentration was sampled. Richards (1999) provides formulas for the estimate of the average daily load and its root mean squared error (RMSE). Daily gaged flows are available at Rapide Croche, and can be scaled according to watershed area ratios to estimate daily flows at the four stations for which loads are to be estimated.

Analysis of baseline monitoring data (LimnoTech 2008) indicates the aggregate PCB load discharged in the winter months from December through March contributes less than 10 percent of total annual load in the river, although these months represent one-third of the year. This study also showed that stratifying the data into the non-winter months from April through November provided more accurate loading estimates and lower RMSEs compared to loading estimates calculated over the entire year. Because only a small fraction of the PCB load is missed in the winter months, because the error on the loading estimate increases when winter months are included, and because field crews often face severe weather safety hazards during these months, winter sampling from December through March will not be performed during the long-term monitoring program. Therefore, the assessment of PCB loads will be based on the eight-month monitoring period from April through November. Baseline monitoring data will be truncated accordingly to conform to this monitoring period. If necessary, total annual PCB loads can also be estimated based on the proportion of the annual load that is discharged from December through March, as observed during the baseline monitoring program.

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TABLES

Table 1-1
Water Quality Summary Statistics

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	OU5C	ALL
Whole Year (12 months)											
Total PCBs (ng/L - blank corrected)											
Count (No. Samples)	11	12	12	10	12	12	12	24	20	20	145
No. Nondetects	1	0	0	0	0	0	0	0	0	0	0
Percent Nondetects	9%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mean	0.19	3.98	3.83	4.77	4.48	5.34	27.97	1.97	1.03	0.37	4.64
Median	0.13	2.50	2.76	4.24	2.69	4.17	15.07	1.59	0.67	0.31	1.38
Minimum	0.00	0.16	0.13	0.23	0.24	0.32	1.72	0.85	0.41	0.15	0.00
Maximum	0.80	10.77	11.59	12.54	14.51	14.88	81.74	3.72	3.26	1.02	81.74
10th Percentile	0.03	0.17	0.19	0.92	0.61	0.67	2.05	1.12	0.43	0.16	0.17
25th Percentile	0.09	0.51	0.50	1.94	0.94	1.28	6.63	1.35	0.52	0.19	0.44
50th Percentile	0.13	2.50	2.76	4.24	2.69	4.17	15.07	1.59	0.67	0.31	1.38
75th Percentile	0.19	6.27	6.03	7.10	6.59	8.08	46.98	2.70	0.99	0.43	3.68
90th Percentile	0.70	9.97	10.20	7.98	10.29	11.09	60.54	3.05	2.01	0.68	10.60
Standard Deviation	0.22	4.03	4.00	3.78	4.53	4.77	27.15	0.87	0.87	0.23	10.76
Coefficient of Variation	1.18	1.01	1.04	0.79	1.01	0.89	0.97	0.44	0.84	0.64	2.32
Std Error (as % of Mean)	0.35	0.29	0.30	0.25	0.29	0.26	0.28	0.09	0.19	0.14	0.19
TSS (mg/L)											
Count (No. Samples)	11	12	12	10	12	12	12	24	20	20	145
Mean	16.4	17.2	18.3	18.9	19.5	16.4	24.6	5.2	2.6	1.6	12.0
Median	17.0	9.7	16.5	22.5	20.5	17.5	16.5	5.8	2.2	1.3	6.1
Minimum	1.3	1.8	1.8	1.8	1.3	1.5	1.4	0.9	0.8	0.4	0.4
Maximum	40	63	57	40	42	33	66	10	7.4	4.2	66
Standard Deviation	11.5	17.1	16.4	12.4	14.6	11.4	23.1	2.67	1.93	1.11	14.0
Coefficient of Variation	0.70	0.99	0.90	0.65	0.75	0.70	0.94	0.51	0.73	0.70	1.17
TOC (%)											
Count (No. Samples)	11	12	12	10	12	12	12	24	20	20	145
Mean	9.8	9.7	9.3	9.4	9.8	9.7	9.5	5.0	4.3	3.7	7.3
Median	9.1	9.5	9.5	8.9	9.7	9.7	8.9	4.6	3.7	3.0	7.7
Minimum	6.9	7.4	5.7	6.2	6.6	6.1	6.7	2.6	2.4	2.1	2.1
Maximum	14.0	13.0	12.0	13.0	14.0	13.0	15.0	8.5	8.9	7.4	15.0
Standard Deviation	2.10	1.73	1.48	1.93	2.05	2.02	2.12	1.25	1.74	1.53	3.13
Coefficient of Variation	0.21	0.18	0.16	0.21	0.21	0.21	0.22	0.25	0.40	0.41	0.43

Table 1-1
Water Quality Summary Statistics

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	OU5C	ALL
Warm Weather (April through November)											
Total PCBs (ng/L - blank corrected)											
Count (No. Samples)	8	8	8	8	8	8	8	16	16	16	104
No. Nondetects	0	0	0	0	0	0	0	0	0	0	0
Percent Nondetects	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mean	0.24	5.82	5.61	5.81	6.38	7.59	40.12	2.36	1.13	0.42	6.11
Median	0.15	5.16	4.72	5.73	5.28	7.72	41.03	2.48	0.77	0.33	2.14
Minimum	0.08	1.38	1.53	1.89	1.93	2.24	10.99	1.35	0.41	0.15	0.08
Maximum	0.80	10.77	11.59	12.54	14.51	14.88	81.74	3.72	3.26	1.02	81.74
10th Percentile	0.10	1.80	1.99	2.03	1.93	2.28	11.50	1.45	0.43	0.19	0.28
25th Percentile	0.10	2.76	3.04	3.36	3.07	5.11	16.74	1.59	0.52	0.27	0.63
50th Percentile	0.15	5.16	4.72	5.73	5.28	7.72	41.03	2.48	0.77	0.33	2.14
75th Percentile	0.23	9.30	7.31	7.28	8.75	9.18	56.44	2.92	1.28	0.56	6.10
90th Percentile	0.80	10.29	10.93	8.99	11.72	12.43	67.34	3.37	2.56	0.69	11.53
Standard Deviation	0.24	3.71	3.78	3.49	4.45	4.27	25.47	0.81	0.94	0.24	12.39
Coefficient of Variation	1.01	0.64	0.67	0.60	0.70	0.56	0.63	0.34	0.83	0.57	2.03
Std Error (as % of Mean)	0.36	0.23	0.24	0.21	0.25	0.20	0.22	0.09	0.21	0.14	0.20
TSS (mg/L)											
Count (No. Samples)	8	8	8	8	8	8	8	16	16	16	104
Mean	17.2	23.1	23.8	22.5	25.9	21.9	33.8	6.6	3.0	1.8	14.7
Median	18.5	19.5	24.5	23.5	29.0	22.5	26.0	6.5	2.2	1.5	7.9
Minimum	4.8	8.0	4.2	4.1	3.4	3.0	5.1	3.6	1.0	0.9	0.9
Maximum	25	63	57	40	42	33	66	9.8	7.4	4.2	66
Standard Deviation	6.7	18.3	17.1	11.0	13.4	9.7	23.3	1.61	1.95	1.09	15.0
Coefficient of Variation	0.39	0.79	0.72	0.49	0.52	0.45	0.69	0.24	0.64	0.59	1.02
TOC (%)											
Count (No. Samples)	8	8	8	8	8	8	8	16	16	16	104
Mean	9.7	9.7	9.4	9.3	9.8	9.7	9.6	4.8	4.5	4.0	7.2
Median	8.8	9.6	9.7	8.9	9.7	9.7	8.9	4.4	3.5	3.7	7.4
Minimum	6.9	7.4	5.7	6.2	6.6	6.1	6.7	2.6	2.4	2.5	2.4
Maximum	14.0	12.0	12.0	13.0	14.0	13.0	15.0	8.5	8.9	7.4	15.0
Standard Deviation	2.45	1.53	1.75	2.08	2.52	2.41	2.54	1.42	1.93	1.56	3.21
Coefficient of Variation	0.25	0.16	0.19	0.22	0.26	0.25	0.27	0.30	0.43	0.39	0.45

Table 1-2
Descriptive Summary Statistics for Fish Tissue Data

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	ALL
Walleye										
Total PCBs (µg/kg)										
Count (No. Samples)	17	16	18	16	16	15	16	15	16	145
No. Nondetects	8	0	0	1	0	0	0	0	0	9
Percent Nondetects	47%	0%	0%	6%	0%	0%	0%	0%	0%	6%
Mean	24	135	317	144	579	677	671	494	296	365
Median	20	140	300	130	380	450	575	400	290	280
Minimum	<19	21	97	21	130	250	240	180	160	<19
Maximum	36	340	800	480	1,800	2,000	1,400	1,300	450	2,000
10th Percentile	19	45	128	84	195	284	330	274	180	27
25th Percentile	19	68	175	106	238	325	453	355	225	130
50th Percentile	20	140	300	130	380	450	575	400	290	280
75th Percentile	24	165	388	150	703	860	800	525	363	460
90th Percentile	34	225	482	170	1,350	1,360	1,135	772	415	784
Standard Deviation	6	84	175	97	503	524	336	277	93	363
Coefficient of Variation	0.26	0.62	0.55	0.68	0.87	0.77	0.50	0.56	0.31	1.00
Std. Error (as % of Mean)	0.06	0.16	0.13	0.17	0.22	0.20	0.13	0.14	0.08	0.08
Mercury (mg/kg)										
Count (No. Samples)	17	-	-	-	16	-	-	-	-	n/c
No. Nondetects	9	-	-	-	0	-	-	-	-	n/c
Percent Nondetects	53%	-	-	-	0%	-	-	-	-	n/c
Mean	0.043	-	-	-	0.233	-	-	-	-	n/c
Median	0.045	-	-	-	0.225	-	-	-	-	n/c
Minimum	0.021	-	-	-	0.110	-	-	-	-	n/c
Maximum	0.080	-	-	-	0.380	-	-	-	-	n/c
10th Percentile	0.027	-	-	-	0.130	-	-	-	-	n/c
25th Percentile	0.027	-	-	-	0.178	-	-	-	-	n/c
50th Percentile	0.045	-	-	-	0.225	-	-	-	-	n/c
75th Percentile	0.052	-	-	-	0.293	-	-	-	-	n/c
90th Percentile	0.062	-	-	-	0.315	-	-	-	-	n/c
Standard Deviation	0.017	-	-	-	0.078	-	-	-	-	n/c
Coefficient of Variation	0.39	-	-	-	0.33	-	-	-	-	n/c
Lipids (percent)										
Count (No. Samples)	17	16	18	16	16	15	16	15	16	145
Mean	1.0	0.5	0.8	0.6	1.1	1.4	1.6	1.4	1.6	1.1
Median	0.8	0.4	0.8	0.5	1.0	1.2	1.5	1.2	1.5	1.0
Minimum	0.4	0.2	0.2	0.2	0.3	0.8	0.7	0.7	0.7	0.2
Maximum	2.0	1.0	2.1	2.2	2.7	3.5	3.0	3.3	2.6	3.5
Standard Deviation	0.49	0.18	0.49	0.48	0.67	0.68	0.75	0.62	0.50	0.67
Coefficient of Variation	0.50	0.39	0.61	0.82	0.60	0.50	0.48	0.45	0.32	0.62
Fish Length (inches)										
Count (No. Samples)	17	16	18	16	16	15	16	15	16	145
Mean	14.2	11.4	15.8	12.7	16.3	17.2	16.6	16.7	18.0	15.4
Median	14.5	10.5	16.0	11.9	15.9	17.5	16.3	16.3	18.3	15.5
Minimum	10.8	8.5	10.5	10.0	11.0	13.3	12.8	14.0	16.0	8.5
Maximum	16.3	16.8	20.0	17.5	21.8	20.5	21.0	20.0	19.8	21.8
Standard Deviation	1.68	2.43	2.75	2.36	3.60	2.31	2.10	1.81	8.21	3.08
Coefficient of Variation	0.12	0.21	0.17	0.19	0.22	0.13	0.13	0.11	0.46	0.20

Table 1-2
Descriptive Summary Statistics for Fish Tissue Data

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	ALL
Smallmouth Bass										
Total PCBs (µg/kg)										
Count (No. Samples)	15	15	16	15	16	15	19	8	19	138
No. Nondetects	6	0	0	0	0	0	0	0	2	8
Percent Nondetects	40%	0%	0%	0%	0%	0%	0%	0%	11%	6%
Mean	29.6	212	255	208	187	197	442	319	360	250
Median	20	160	200	210	140	190	400	320	320	210
Minimum	<19	20	96	110	71	66	140	150	<19	<19
Maximum	70	540	530	320	470	370	950	460	1,200	1,200
10th Percentile	<19	53	120	124	76	107	194	199	53	27
25th Percentile	<19	89	140	160	79	150	325	235	180	110
50th Percentile	20	160	200	210	140	190	400	320	320	210
75th Percentile	27	335	310	260	285	225	460	405	515	360
90th Percentile	59	394	480	272	345	304	754	453	592	470
Standard Deviation	17	156	143	63	128	81	221	117	281	196
Coefficient of Variation	0.58	0.74	0.56	0.30	0.68	0.41	0.50	0.37	0.78	0.78
Std. Error (as % of Mean)	0.15	0.19	0.14	0.08	0.17	0.11	0.11	0.13	0.18	0.07
Lipids (percent)										
Count (No. Samples)	15	15	16	15	16	15	19	8	19	138
Mean	0.9	0.9	0.9	1.1	1.2	0.8	0.8	0.7	0.9	0.9
Median	1.0	0.7	0.8	1.2	1.1	0.8	0.8	0.6	0.8	0.8
Minimum	0.2	0.3	0.2	0.7	0.6	0.3	0.3	0.4	0.3	0.2
Maximum	1.7	2.0	2.9	1.8	2.2	1.4	2.3	1.2	2.4	2.9
Standard Deviation	0.40	0.53	0.63	0.24	0.58	0.32	0.46	0.31	0.53	0.48
Coefficient of Variation	0.43	0.60	0.72	0.21	0.50	0.41	0.56	0.44	0.58	0.52
Fish Length (inches)										
Count (No. Samples)	15	15	16	15	16	15	19	8	19	138
Mean	13.9	13.0	13.6	14.0	13.7	12.8	13.5	12.4	15.6	13.7
Median	14.3	13.0	13.4	14.0	13.9	12.8	13.1	12.2	16.7	13.5
Minimum	10.0	9.2	10.8	10.0	10.3	10.3	10.5	9.8	10.5	9.2
Maximum	16.5	18.0	18.0	18.5	16.8	15.5	18.7	16.1	19.5	19.5
Standard Deviation	1.97	2.45	2.07	2.37	1.93	1.58	2.20	1.81	2.35	2.24
Coefficient of Variation	0.14	0.19	0.15	0.17	0.14	0.12	0.16	0.15	0.15	0.16

Table 1-2
Descriptive Summary Statistics for Fish Tissue Data

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	ALL
Carp										
Total PCBs (µg/kg)										
Count (No. Samples)	6	6	5	5	6	6	6	6	5	51
No. Nondetects	0	0	0	0	0	0	0	0	0	0
Percent Nondetects	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mean	36	1,917	4,120	1,200	988	972	4,600	780	337	1,648
Median	36	1,750	2,400	1,200	930	970	4,600	805	240	1,000
Minimum	28	300	2,100	800	670	590	2,800	480	72	28
Maximum	46	3,600	11,000	1,500	1,500	1,600	6,400	980	950	11,000
10th Percentile	29	900	2,140	920	685	595	3,100	600	73	46
25th Percentile	31	1,525	2,200	1,100	740	685	3,575	723	74	595
50th Percentile	36	1,750	2,400	1,200	930	970	4,600	805	240	1,000
75th Percentile	38	2,425	2,900	1,400	1,150	1,075	5,625	888	350	2,000
90th Percentile	42	3,100	7,760	1,460	1,350	1,350	6,100	935	710	3,600
Standard Deviation	7	1,113	3,858	274	319	373	1,404	178	362	1,981
Coefficient of Variation	0.18	0.58	0.94	0.23	0.32	0.38	0.31	0.23	1.07	1.20
Std. Error (as % of Mean)	0.08	0.24	0.42	0.10	0.13	0.16	0.12	0.09	0.48	0.17
Lipids (percent)										
Count (No. Samples)	6	6	5	5	6	6	6	6	5	51
Mean	4.2	6.7	6.6	3.9	5.3	3.3	4.6	4.1	4.5	4.8
Median	4.3	6.6	6.2	3.7	5.0	3.5	4.2	4.1	4.4	4.4
Minimum	3.5	1.4	5.9	3.5	4.4	1.5	3.5	2.9	2.5	1.4
Maximum	5.0	10.2	7.8	4.9	6.6	4.8	6.2	5.1	6.9	10.2
Standard Deviation	0.59	3.10	0.80	0.56	0.93	1.35	1.03	0.74	1.97	1.75
Coefficient of Variation	0.14	0.46	0.12	0.14	0.17	0.41	0.23	0.18	0.44	0.37
Fish Length (inches)										
Count (No. Samples)	19	26	23	25	30	30	26	16	9	204
Mean	15.1	19.7	19.8	18.9	19.6	18.1	19.7	13.6	13.7	18.2
Median	15.3	20.5	19.5	19.3	19.5	18.1	20.0	13.6	13.5	19.0
Minimum	13.0	13.0	18.0	16.5	18.0	15.5	15.5	11.8	11.5	11.5
Maximum	17.0	21.8	21.5	20.0	22.0	20.0	21.5	15.3	17.5	22.0
Standard Deviation	1.15	2.40	1.01	1.05	1.02	1.29	1.54	0.74	1.98	2.58
Coefficient of Variation	0.08	0.12	0.05	0.06	0.05	0.07	0.08	0.05	0.14	0.14

Table 1-2
Descriptive Summary Statistics for Fish Tissue Data

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	ALL
Drum										
Total PCBs (µg/kg)										
Count (No. Samples)	6	6	5	5	5	5	6	6	5	49
No. Nondetects	0	0	0	0	0	0	0	0	0	0
Percent Nondetects	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Mean	175	450	1,268	728	1,082	1,292	1,347	1,392	1,490	1,010
Median	170	445	1,100	580	1,100	1,400	1,250	1,450	1,300	940
Minimum	110	160	770	310	590	460	740	950	750	110
Maximum	250	650	2,300	1,300	1,700	2,000	2,300	1,700	2,100	2,300
10th Percentile	130	265	810	406	602	516	840	1,075	930	196
25th Percentile	153	383	870	550	620	600	955	1,250	1,200	550
50th Percentile	170	445	1,100	580	1,100	1,400	1,250	1,450	1,300	940
75th Percentile	195	590	1,300	900	1,400	2,000	1,575	1,575	2,100	1,400
90th Percentile	225	640	1,900	1,140	1,580	2,000	1,950	1,650	2,100	2,000
Standard Deviation	47.6	181.2	612.5	382.5	484.5	739.1	574.5	276.4	594.1	625.1
Coefficient of Variation	0.27	0.40	0.48	0.53	0.45	0.57	0.43	0.20	0.40	0.62
Std. Error (as % of Mean)	0.11	0.16	0.22	0.23	0.20	0.26	0.17	0.08	0.18	0.09
Lipids (percent)										
Count (No. Samples)	6	6	5	5	5	5	6	6	5	49
Mean	9.9	4.0	4.6	4.3	7.2	7.2	4.6	5.2	7.3	6.0
Median	10.2	3.5	4.5	3.8	7.9	5.4	4.8	5.1	7.4	5.2
Minimum	3.8	0.9	2.2	1.9	2.4	2.5	0.1	3.7	3.8	0.1
Maximum	17.2	8.9	7.4	7.2	11.7	11.9	8.5	6.7	10.3	17.2
Standard Deviation	5.50	2.92	1.84	1.93	3.41	4.12	2.98	1.01	2.90	3.53
Coefficient of Variation	0.56	0.74	0.40	0.45	0.47	0.57	0.64	0.20	0.39	0.59
Fish Length (inches)										
Count (No. Samples)	29	20	25	25	23	21	28	28	15	214
Mean	16.6	15.2	15.3	16.4	17.4	15.9	15.7	13.8	16.1	15.8
Median	17.0	15.0	15.0	16.3	17.0	15.6	16.0	13.8	15.8	15.5
Minimum	12.5	12.3	12.0	12.3	12.0	12.3	12.3	10.8	12.3	10.8
Maximum	22.0	20.3	20.0	20.3	22.0	21.0	18.5	16.8	20.5	22.0
Standard Deviation	3.48	2.49	2.49	2.40	2.80	2.50	1.85	1.57	2.69	2.65
Coefficient of Variation	0.21	0.16	0.16	0.15	0.16	0.16	0.12	0.11	0.17	0.17

Table 1-2
Descriptive Summary Statistics for Fish Tissue Data

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	ALL
Gizzard Shad										
Total PCBs (µg/kg)										
Count (No. Samples)	6	2	3	7	5	6	6	6	6	47
No. Nondetects	1	0	0	0	1	0	0	0	0	2
Percent Nondetects	17%	0%	0%	0%	20%	0%	0%	0%	0%	4%
Mean	25	895	343	102	114	427	938	325	283	342
Median	26	895	300	98	100	400	845	335	285	250
Minimum	19	790	180	89	19	190	250	260	230	19
Maximum	33	1,000	550	130	190	870	1,800	360	350	1,800
10th Percentile	20	811	204	90	47	195	420	285	235	28
25th Percentile	21	843	240	92	90	243	630	313	250	99
50th Percentile	26	895	300	98	100	400	845	335	285	250
75th Percentile	28	948	425	105	170	483	1,210	350	305	365
90th Percentile	31	979	500	118	182	685	1,550	355	330	822
Standard Deviation	5.4	148.5	188.8	14.4	68.4	250.0	548.4	37.3	44.6	361.9
Coefficient of Variation	0.21	0.17	0.55	0.14	0.60	0.59	0.58	0.11	0.16	1.06
Std. Error (as % of Mean)	0.09	0.12	0.32	0.05	0.27	0.24	0.24	0.05	0.06	0.15
Lipids (percent)										
Count (No. Samples)	6	2	3	7	5	6	6	6	6	47
Mean	4.9	5.1	2.0	2.1	1.5	2.3	1.7	1.4	4.7	2.7
Median	5.7	5.1	2.1	2.0	1.2	2.3	1.6	1.5	4.7	2.0
Minimum	0.6	3.9	0.9	0.9	0.8	1.5	0.7	1.1	4.4	0.6
Maximum	7.0	6.3	3.1	3.8	2.2	3.4	3.1	1.7	5.3	7.0
Standard Deviation	2.38	1.63	1.12	0.90	0.59	0.81	0.79	0.24	0.35	1.74
Coefficient of Variation	0.49	0.32	0.55	0.43	0.40	0.35	0.47	0.17	0.07	0.64
Fish Length (inches)										
Count (No. Samples)	149	9	37	174	70	111	138	148	117	953
Mean	4.5	4.5	2.8	3.1	3.3	3.7	2.7	2.5	4.5	3.4
Median	4.5	4.5	2.5	2.5	2.5	4.5	2.5	2.5	4.5	2.5
Minimum	2	3	2	2	2	2	2	2	3	2
Maximum	6	6	6	6	6	6	6	3	6	6
Standard Deviation	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Coefficient of Variation	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c

Notes:

n/c = not calculated

Table 1-3
Fish Consumption Advisories

Species	OU1 to OU3	OU4	Southern Green Bay
Brown Trout	---	---	12 meals/year to DNE; size dependent
Black Crappie	---	12 meals/year	---
Bluegill	---	12 meals/year	---
Carp	DNE	DNE	DNE
Channel Catfish	---	DNE	6 meals/year; size dependant
Chinook Salmon	---	---	6 to 12 meals/year; size dependent
Northern Pike	12 meals/year	6 to 12 meals/year; size dependant	12 meals/year; size dependent
Rainbow Trout	---	---	12 meals/year
Rock Bass	---	12 meals/year	---
Sheepshead	---	6 to 12 meals/year to DNE; size dependent	12 meals/year
Smallmouth Bass	12 meals/year	12 meals/year	12 meals/year
Splake	---	---	6 to 12 meals/year to DNE; size dependent
Sturgeon	---	---	DNE
Walleye	12 meals/year	6 to 12 meals/year to DNE; size dependent	6 to 12 meals/year to DNE; size dependent
White Bass	12 meals/year	DNE	DNE
White Perch	12 meals/year	6 meals/year	6 meals/year
White Sucker	---	6 meals/year	12 meals/year
Whitefish	---	---	6 meals/year
Yellow Perch	12 meals/year	12 meals/year	52 meals/year

Notes:

DNE = Do Not Eat

Table 1-4
Statistical Distribution Test Results – Water

Normal Goodness-of-Fit Test (Probability Plot Regression)

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	OU5C
Year-round (12 months)	NON-PARA 0.658	(NORMAL) 0.871	(NORMAL) 0.864	NORMAL 0.929	(NORMAL) 0.863	NORMAL 0.904	(NORMAL) 0.886	NORMAL 0.902	NON-PARA 0.691	(NORMAL) 0.835
Warm Weather (Apr. to Nov.)	NON-PARA 0.640	NORMAL 0.929	NORMAL 0.904	NORMAL 0.918	NORMAL 0.924	NORMAL 0.950	NORMAL 0.952	NORMAL 0.926	NON-PARA 0.746	(NORMAL) 0.876

Normal Test Results (12 Months)	
3	NORMAL
5	NEAR NORMAL
2	NONPARAMETRIC

Normal Test Results (8 months)	
7	NORMAL
1	NEAR NORMAL
2	NONPARAMETRIC

Lognormal Goodness-of-Fit Test (Probability Plot Regression)

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B	OU5C
Year-round (12 months)	NON-PARA 0.768	LOGNORM 0.905	LOGNORM 0.920	LOGNORM 0.901	LOGNORM 0.976	LOGNORM 0.941	LOGNORM 0.940	LOGNORM 0.951	(LOGNORM) 0.877	LOGNORM 0.943
Warm Weather (Apr - Nov)	(LOGNORM) 0.887	LOGNORM 0.938	LOGNORM 0.966	LOGNORM 0.947	LOGNORM 0.965	(LOGNORM) 0.889	(LOGNORM) 0.920	LOGNORM 0.925	LOGNORM 0.900	LOGNORM 0.970

Lognormal Test Results (12 Months)	
8	LOGNORMAL
1	NEAR LOGNORMAL
1	NONPARAMETRIC

Lognormal Test Results (8 months)	
8	LOGNORMAL
2	NEAR LOGNORMAL
0	NONPARAMETRIC

Notes:

R^2 value provided below each distribution determination

NORMAL or LOGNORM = R^2 value greater than 0.9

(NORMAL) or (LOGNORM) = R^2 value greater than 0.8 and less than 0.9

NON-PARA = R^2 value less than 0.8 = nonparametric

Table 1-5
Statistical Distribution Testing of Fish Tissue Concentrations

Normal Goodness-of-Fit Test (Probability Plot Regression)

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B
Walleye	NORMAL 0.93	NORMAL 0.92	NORMAL 0.91	*NORMAL 0.91*	(NORMAL) 0.80	NON-PARA 0.78	NORMAL 0.92	*NORMAL 0.93*	NORMAL 0.97
Bass	NON-PARA 0.66	NORMAL 0.94	(NORMAL) 0.88	NORMAL 0.97	(NORMAL) 0.86	NORMAL 0.96	(NORMAL) 0.87	NORMAL 0.92	(NORMAL) 0.88
Carp	NORMAL 0.92	NORMAL 0.96	*Small Sample*	NORMAL 0.97	NORMAL 0.94	NORMAL 0.91	NORMAL 0.98	NORMAL 0.92	(NORMAL) 0.80
Drum	NORMAL 0.98	NORMAL 0.94	(NORMAL) 0.83	NORMAL 0.94	NORMAL 0.94	(NORMAL) 0.88	NORMAL 0.92	NORMAL 0.96	NORMAL 0.90
Gizzard Shad	NORMAL 0.95	*Small Sample*	*Small Sample*	(NORMAL) 0.84	NORMAL 0.95	(NORMAL) 0.88	NORMAL 0.98	(NORMAL) 0.88	NORMAL 0.97

Normal Test Results	
29	NORMAL
11	NEAR NORMAL
1	NONPARAMETRIC

Lognormal Goodness-of-Fit Test (Probability Plot Regression)

	LWB	OU1	OU2A	OU2B	OU2C	OU3	OU4	OU5A	OU5B
Walleye	NORMAL 0.93	LOGNORM 0.94	LOGNORM 0.97	NON-PARA 0.78	LOGNORM 0.96	LOGNORM 0.91	LOGNORM 0.99	LOGNORM 0.96	LOGNORM 0.95
Bass	NON-PARA 0.73	LOGNORM 0.96	LOGNORM 0.96	LOGNORM 0.94	LOGNORM 0.90	LOGNORM 0.95	LOGNORM 0.95	LOGNORM 0.92	(LOGNORM) 0.87
Carp	LOGNORM 0.93	(LOGNORM) 0.82	*Small Sample*	LOGNORM 0.93	LOGNORM 0.97	LOGNORM 0.93	LOGNORM 0.97	(LOGNORM) 0.87	LOGNORM 0.93
Drum	LOGNORM 0.98	(LOGNORM) 0.85	LOGNORM 0.92	LOGNORM 0.97	LOGNORM 0.92	(LOGNORM) 0.87	LOGNORM 0.96	LOGNORM 0.92	LOGNORM 0.91
Gizzard Shad	LOGNORM 0.95	*Small Sample*	*Small Sample*	(LOGNORM) 0.87	(LOGNORM) 0.83	LOGNORM 0.94	LOGNORM 0.96	(LOGNORM) 0.85	LOGNORM 0.97

Lognormal Test Results	
34	LOGNORMAL
8	NEAR LOGNORMAL
1	NONPARAMETRIC

Notes:

R^2 value provided below each distribution determination

NORMAL or LOGNORMAL = R^2 value greater than 0.9

NORMAL or LOGNORMAL = R^2 value greater than 0.9 w/ one outlier removed

(NORMAL) or (LOGNORMAL) = R^2 value greater than 0.8 and less than 0.9

NON-PARA = R^2 value less than 0.8 = nonparametric

Table 1-6
Sample Location Rationale

Station	General	Water	Fish
All Stations	Characterize effectiveness of LFR remedial actions and natural recovery processes. Collocate fish and water sampling stations to characterize bioaccumulation pathways. OU 2 and OU 5 are subsampled on a finer scale to provide more detailed characterization of monitored natural recovery areas.	Preference for locations in relatively straight reaches with simple U-shaped cross-sections and relatively uniform flow. Preference for locations near downstream OU boundaries, to monitor cumulative impacts from the entire OU, and net contributions (contaminant loadings) to the next OU.	Preference for known productive fishing sites based on Baseline Monitoring results. Preference for tailwater locations below dams where upstream-migrating species (i.e., walleye) may congregate. Preference for matching habitat of target species. It is assumed fish migrate freely between dams, and provide spatial representativeness of an entire OU. OU 2 is further subdivided because of length, dam interruptions, and variable riffle and pool habitats. OU 5 is further subdivided because of areal extent.
Lake Winnebago	Characterize ambient background conditions upstream of LFR remediation areas.	Characterize ambient background PCB concentrations upstream of LFR remediation areas. Estimate background PCB loading to OU 1.	Characterize ambient background PCB concentrations upstream of LFR remediation areas.
OU-1	Characterize effectiveness of OU 1 remedial action.	Characterize water column PCB concentrations at the downstream end (exit point) of OU 1 remedial action area. Estimate downstream PCB loading to OU 2.	Characterize fish tissue PCB concentrations in OU 1 remedial action area. Assume fish migrate freely within OU 1 below Neenah and Menasha dams.
OU-2A	Characterize natural recovery processes in OU 2, along with the effectiveness of prior remedial action in Deposit N. Characterize environmental conditions in a reach with steep gradients and swift water velocities.	Characterize water column PCB concentrations in upstream reach of OU 2 natural recovery areas. Characterize environmental conditions in a reach with steep gradients and swift water velocities. Available boat access.	Characterize fish tissue PCB concentrations in the upstream reach of OU 2 natural recovery areas. Characterize environmental conditions in a reach with steep gradients and swift water velocities. Available boat access.
OU-2B	Characterize natural recovery processes in OU 2, along with the effectiveness of prior remedial action in Deposit N. Characterize environmental conditions in a reach with gentler gradients and slower water velocities (i.e., more likely depositional).	Characterize water column PCB concentrations in central reach of OU 2 natural recovery areas. Characterize environmental conditions in a reach with gentler gradients and slower water velocities (i.e., more likely depositional). Available boat access.	Characterize fish tissue PCB concentrations in the central reach of OU 2 natural recovery areas. Characterize environmental conditions in a reach with gentler gradients and slower water velocities (i.e., more likely depositional). Available boat access.
OU-2C	Characterize natural recovery processes in OU 2, along with the effectiveness of prior remedial action in Deposit N, and pending remedial action in Deposit DD.	Characterize water column PCB concentrations at the downstream end (exit point) of OU 2 natural recovery areas. Estimate downstream loading to OU 3. Available boat access.	Characterize fish tissue PCB concentrations at the downstream end of OU 2 natural recovery areas. Available boat access.
OU-3	Characterize effectiveness of OU 3 remedial action.	Characterize water column PCB concentrations at the downstream end (exit point) of OU 3 remedial action areas.	Characterize fish tissue PCB concentrations in OU 3 remedial action areas. Assume fish migrate freely within OU 3 below Little Rapids dam.
OU-4	Characterize effectiveness of OU 4 remedial action.	Characterize water column PCB concentrations at the downstream end (exit point) of OU 4 remedial action areas. Estimate downstream loading to Green Bay. Collocate with historical and ongoing USGS monitoring near Oil Depot gage. Beyond the influence of upstream migration of bay water under seiche conditions.	Characterize fish tissue PCB concentrations in OU 4 remedial action areas. Assume fish migrate freely within OU 4 downstream of DePere dam. Anticipate congregation of walleye in DePere dam tailwaters; popular fishing area.
OU-5A	Characterize natural recovery processes in Green Bay, downstream of Lower Fox River remedial actions.	Characterize longitudinal PCB gradient in Green Bay water column near the mouth of the Lower Fox River (Zone II)	Characterize fish tissue concentrations in shallow, inner reaches of Green Bay subject to discharges from the mouth of the Lower Fox River.
OU-5B	Characterize natural recovery processes in Green Bay, downstream of Lower Fox River remedial actions.	Characterize longitudinal PCB gradient in Green Bay water column (Zone III-South)	Characterize fish tissue concentrations in depositional areas along eastern shoreline of Green Bay where highest sediment PCB concentrations have occurred
OU-5C	Characterize natural recovery processes in Green Bay, downstream of Lower Fox River remedial actions.	Characterize longitudinal PCB gradient in Green Bay water column (Zone III-South) with increasing water depth and influence from Lake Michigan and other external sources	No fish samples in this zone. This area is too far removed from Fox River inputs and thus subject to contaminant contributions from other confounding external sources

Table 1-7
Estimated Sample Sizes for Water and Fish Tissue Monitoring

Confidence (alpha)	Power (beta)	Coefficient of Variation							
		0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.2	0.2	1	2	2	3	5	6	8	10
0.1	0.2	2	3	5	7	9	12	15	19
0.05	0.2	3	5	7	10	14	18	23	29

Note:

Minimum Detectable Difference: 50%

Table 1-8
Estimated Statistical Confidence for Detecting 50 Percent Reduction in PCB Concentration

	n	LWB	OU 1	OU 2A	OU 2B	OU 2C	OU 3	OU 4	OU 5A	OU 5B	OU 5C
Water											
Year-Round	12	>75%	>80%	>80%	>90%	>80%	>80%	>80%	>95%	>80%	>95%
Apr. to Nov.	8	>75%	>90%	~90%	>90%	>80%	>90%	>90%	>95%	>80%	>90%
Fish											
Walleye	15	>95%	>95%	>95%	>95%	>90%	>90%	>95%	>95%	>95%	---
Bass	15	>95%	>90%	>95%	>95%	>95%	>95%	>95%	>95%	>90%	---
Carp	5	>95%	>80%	>70%	>95%	>95%	>95%	>95%	>95%	>70%	---
Drum	5	>95%	~95%	>90%	~90%	>90%	>80%	~95%	>95%	~95%	---
Gizzard Shad	5	>95%	>95%	>80%	>95%	>80%	>80%	>80%	>95%	>95%	---

Table 2-1
Water Sampling and Analysis Plan

	Number of Monthly Samples	Number of Field Replicates	Total Number of Analyses[1]	Field Parameters [Temp, Turbidity]	Total Suspended Solids [EPA 160.2]	Total Organic Carbon [EPA 415.1]	PCB Congeners [EPA 1668A]
LWB-yy-mmdd	8	4	12	X	X	X	X
OU1-yy-mmdd	8	1	9	X	X	X	X
OU2A-yy-mmdd	8	1	9	X	X	X	X
OU2B-yy-mmdd	8	1	9	X	X	X	X
OU2C-yy-mmdd	8	1	9	X	X	X	X
OU3-yy-mmdd	8	1	9	X	X	X	X
OU4-yy-mmdd	8	4	12	X	X	X	X
OU5A-yy-mmdd	8	1	9	X	X	X	X
OU5B-yy-mmdd	8	1	9	X	X	X	X
OU5C-yy-mmdd	8	1	9	X	X	X	X
TOTAL	80	16	96				

Note:

[1] Does not include field rinseate blank samples; see Section 2.7.1 for further discussion

Table 2-2
Water Sampling Locations

Transect	Position	X_WTM27	Y_WTM27	Latitude	Longitude	X_WTM8391	Y_WTM_8391
LW	W	625,571	392,512	44.1770	-88.4293	645,559	412,726
	M	626,486	393,942	44.1897	-88.4175	646,474	414,157
	E	627,390	395,354	44.2022	-88.4058	647,378	415,569
OU1	W	624,544	399,939	44.2440	-88.4403	644,531	420,154
	M	624,583	399,885	44.2435	-88.4399	644,571	420,100
	E	624,618	399,838	44.2431	-88.4394	644,606	420,053
OU2A	W	632,719	404,099	44.2800	-88.3369	652,707	424,314
	M	632,733	404,036	44.2794	-88.3368	652,721	424,251
	E	632,749	403,969	44.2788	-88.3366	652,736	424,184
OU2B	W	642,374	408,027	44.3135	-88.2149	662,362	428,242
	M	642,413	407,981	44.3131	-88.2145	662,400	428,197
	E	642,452	407,936	44.3127	-88.2140	662,440	428,151
OU2C	W	649,030	415,114	44.3759	-88.1295	669,017	435,329
	M	649,070	415,075	44.3756	-88.1290	669,057	435,290
	E	649,103	415,044	44.3753	-88.1286	669,090	435,259
OU3	W	653,989	422,665	44.4428	-88.0650	673,977	442,881
	M	654,035	422,628	44.4425	-88.0645	674,022	442,844
	E	654,090	422,584	44.4421	-88.0638	674,077	442,799
OU4	W	658,157	432,421	44.5297	-88.0097	678,144	452,637
	M	658,219	432,409	44.5296	-88.0089	678,206	452,625
	E	658,268	432,400	44.5295	-88.0083	678,255	452,615
OU5A	W	661,674	447,915	44.6683	-87.9606	681,661	468,130
	M	665,240	445,525	44.6460	-87.9164	685,227	465,741
	E	668,193	443,546	44.6275	-87.8798	688,180	463,762
OU5B	W	677,043	470,189	44.8651	-87.7591	697,029	490,405
	M	680,385	468,332	44.8475	-87.7175	700,371	488,548
	E	684,551	466,018	44.8257	-87.6657	704,538	486,234
OU5C	W	694,097	493,040	45.0661	-87.5347	714,083	513,255
	M	700,719	488,883	45.0269	-87.4523	720,705	509,099
	E	705,334	485,986	44.9995	-87.3950	725,319	506,202

Notes:
Quarter-point sampling location code: W = west, M = middle, E = east location in water sampling transect
All Wisconsin Transverse Mercator (WTM) coordinates are in meters

Table 2-3
Target Fish Species, Size Classes, and Compositing Plan

		2 - 4"	4 - 6"	6 - 8"	8 - 10"	10 - 12"	12 - 14"	14 - 16"	16 - 18"	18 - 20"	20 - 22"	22 - 24"	Skin-on Fillet	Whole Fish	No. Individuals (Target)	No. Individuals (Minimum)	No. Composites	No. Fish per Composite (Target)	No. Fish per Composite (Minimum)
Primary Species	**Objective**																		
Walleye	Human Health												X		15	8	0	n/a	n/a
Carp (OUs 1-4)	Ecological													X	35	7	7	5	1
Drum (OUs 4-5)	Ecological													X	25	5	5	5	1
Gizzard Shad	Young of Year													X	175	25	7	25	5
Alternate Species	**Objective**																		
Smallmouth Bass	Human Health												X		15	15	0	n/a	n/a
Drum (OUs 1-3)	Ecological													X	25	5	5	5	1
Carp (OU 5)	Ecological													X	35	7	7	5	1

Notes:

Target Size Class

Alternate Size Class

n/a = Walleye and Bass will not be composited

Table 2-4
Fish Tissue Sampling and Analysis Matrix

	Number of Composites	No. Fish / Composite	No. Individual Fish	Total Number Analyses	No. Field Replicates	Minimum Size (inches)	Maximum Size (inches)	Preparation Method	PCB Aroclors [8082/SLOH]	Lipid Content [EPA 2000]	Mercury [EPA 7471]	Archive [Freeze]
Walleye												
LWB-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X	X	X
OU1-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU2A-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU2B-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU2C-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X	X	X
OU3-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU4-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU5A-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
OU5B-YY-WA-000	n/a	n/a	15	15	1	12	22	SOF	X	X		X
WALLEYE SUBTOTAL:			**135**	**135**	**9**							
Carp												
LWB-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU1-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU2A-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU2B-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU2C-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU3-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
OU4-YY-CA-000	7	5	35	7	1	12	22	WF	X	X		X
CARP SUBTOTAL:			**245**	**49**	**7**							
Drum												
LWB-YY-DR-000	5	5	25	5	1	12	22	WF	X	X		X
OU4-YY-DR-000	5	5	25	5	1	12	22	WF	X	X		X
OU5A-YY-DR-000	5	5	25	5	1	12	22	WF	X	X		X
OU5B-YY-DR-000	5	5	25	5	1	12	22	WF	X	X		X
DRUM SUBTOTAL:			**100**	**20**	**4**							
Gizzard Shad												
LWB-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU1-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU2A-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU2B-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU2C-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU3-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU4-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU5A-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
OU5B-YY-GS-000	7	25	175	7	1	2	4	WF	X	X		X
GIZZARD SHAD SUBTOTAL:			**1,575**	**63**	**9**							

SUBTOTAL FISH ANALYSES (ALL SPECIES):	**267**	**29**
GRAND TOTAL FISH ANALYSES:	**296**	

Notes:
SOF = Skin-On Fillet
WF = Whole Fish
WA = Walleye
CA = Carp
DR = Drum
GS = Gizzard Shad
See Section 2.2.5 for key to sample identification system

Table 2-5
Fish Habitat and Collection Methods

	Species	General Habitat Description	Electrofish	Trawl	Rod and Reel	Seine Net	Other
Lower Fox River (LWB, OU 1 - OU 4)	Walleye	Below dams, near discharges, submerged weed beds, hard rocky substrates, bridge pillars and abutments	X	X	X		
	Carp	Muddy flats and bays, aquatic vegetation and weed beds, below dams, near discharges, bridge pillars, creek mouths	X	X			
	Drum	Diverse and wide-ranging habitat, aquatic vegetation and weed beds, along reefs, below dams, near discharges, boulders, bridge pillars	X	X	X		
	Gizzard Shad	Nearshore areas, aquatic vegetation and weed beds, along reefs, below dams, near discharges, bridge abutments, creek mouths	X	X		X	
	Smallmouth Bass	Aquatic vegetation and weed beds, rocky substrates, below dams, near discharges, deep holes with structure (instream logs, rocks, outcrops), docks, bridge abutments	X	X	X		
Green Bay (OU 5)	Walleye	Aquatic vegetation and weed beds, rocky shorelines, near boat launches	X	X	X		
	Carp	Weedy, muddy, flats and bays along shorelines	X	X			
	Drum	Near shore to 30' of water, all substrates, near boat launches	X	X			
	Gizzard Shad	Near shore, near boat launches	X	X		X	
	Smallmouth Bass	Aquatic vegetation and weed beds, rocky shorelines; deep holes with structure	X	X	X		

Table 2-6
Sample Containers, Holding Times, and Preservation Requirements

Parameter	Analytical Method	Matrix	Container	Preservation	Minimum Sample	Maximum Holding
TOC - water	EPA 415.1	Water	Polyethylene / Glass	4˚C, H2SO4 OR H3PO4 TO pH <2	100 mls	28 days
TSS	EPA 160.2	Water	1 Liter Polypropylene. Certified Clean	None	1,000 mls	7 days
PCB Congeners	EPA 1668	Water	2 Liter Amber Glass with Teflon lined cap. Certified clean	4˚C. Residual chlorine will be tested at the lab upon receipt. If residual chlorine present, add 80 mg. Sodium Thiosulfate	1,000 mls	1 year
PCB Aroclors	SW 8082	Fish	Clean glass container or polyethylene bags	Stored frozen	20 grams	Stored frozen until extraction and analyzed within 40 days of extraction

Table 2-7
Analytical Methods, Detection Limits, and Control Limits

Analytical Parameter	Matrix	Proposed Laboratory	Analysis Methods	Laboratory SOP Number	Reporting Limit	Units
Aroclor 1016	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1221	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1232	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1242	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1248	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1254	Tissue	TBD	Method 8082	TBD	50	ug/kg
Aroclor 1260	Tissue	TBD	Method 8082	TBD	50	ug/kg
Lipids	Tissue	TBD	EPA 2000	TBD	0.1	%
TOC	Water	TBD	EPA 415.1	TBD	2	mg/L
TSS	Water	TBD	EPA 160.2	TBD	1	mg/L
PCB Congeners	Water	TBD	EPA 1668A	TBD	0.020 – 0.031 [See Table 2-8]	ng/L

Table 2-8
PCB Congener Reporting Limits

CAS Registry	Congener Number	Average EDL (ng/L)	Reporting Limit (ng/L)	Precision (%RPD) [1]	Accuracy (%R)
2051-60-7	1	0.00128	0.02	NA	50-150
2051-61-8	2	0.00114	0.02	NA	
2051-62-9	3	0.00105	0.02	NA	50-150
13029-08-8	4	0.01263	0.0314	NA	50-150
16605-91-7	5	0.0079	0.02	NA	
25569-80-6	6	0.00726	0.02	NA	
33284-50-3	7	0.00759	0.02	NA	
34883-43-7	8	0.0073	0.0269	NA	
34883-39-1	9	0.00763	0.02	NA	
33146-45-1	10	0.00783	0.02	NA	
2050-67-1	11	0.00755	0.0239	NA	
2974-92-7	12	0.0073	0.0259	NA	
2974-90-5	13	0.00729	0.0259	NA	
34883-41-5	14	0.00719	0.02	NA	
2050-68-2	15	0.00637	0.02	NA	50-150
38444-78-9	16	0.00731	0.02	NA	
37680-66-3	17	0.00589	0.02	NA	
37680-65-2	18	0.00487	0.0224	NA	
38444-73-4	19	0.00636	0.02	NA	50-150
38444-84-7	20	0.00216	0.02	NA	
55702-46-0	21	0.00223	0.02	NA	
38444-85-8	22	0.00234	0.02	NA	
55720-44-0	23	0.0024	0.02	NA	
55702-45-9	24	0.00427	0.02	NA	
55712-37-3	25	0.00203	0.02	NA	
38444-81-4	26	0.00224	0.02	NA	
38444-76-7	27	0.00416	0.02	NA	
7012-37-5	28	0.00216	0.02	NA	
15862-07-4	29	0.00224	0.02	NA	
35693-92-6	30	0.00487	0.0224	NA	
16606-02-3	31	0.0022	0.02	NA	
38444-77-8	32	0.00382	0.02	NA	
38444-86-9	33	0.00223	0.02	NA	
37680-68-5	34	0.00233	0.02	NA	
37680-69-6	35	0.00231	0.02	NA	
38444-87-0	36	0.00216	0.02	NA	
38444-90-5	37	0.00193	0.02	NA	50-150
53555-66-1	38	0.00221	0.02	NA	
38444-88-1	39	0.00205	0.02	NA	
38444-93-8	40	0.00226	0.02	NA	
52663-59-9	41	0.00226	0.02	NA	
36559-22-5	42	0.0025	0.02	NA	
70362-46-8	43	0.00207	0.02	NA	
41464-39-5	44	0.00203	0.02	NA	
70362-45-7	45	0.00236	0.02	NA	
41464-47-5	46	0.00275	0.02	NA	
2437-79-8	47	0.00203	0.02	NA	
70362-47-9	48	0.00226	0.02	NA	
41464-40-8	49	0.00193	0.02	NA	
62796-65-0	50	0.00227	0.02	NA	
68194-04-7	51	0.00236	0.02	NA	
35693-99-3	52	0.00217	0.02	NA	
41464-41-9	53	0.00227	0.02	NA	
15968-05-5	54	0.00342	0.02	NA	50-150

Table 2-8
PCB Congener Reporting Limits

CAS Registry	Congener Number	Average EDL (ng/L)	Reporting Limit (ng/L)	Precision (%RPD) [1]	Accuracy (%R)
74338-24-2	55	0.0017	0.02	NA	
41464-43-1	56	0.00168	0.02	NA	
70424-67-8	57	0.00167	0.02	NA	
41464-49-7	58	0.00163	0.02	NA	
74472-33-6	59	0.00164	0.02	NA	
33025-41-1	60	0.00165	0.02	NA	
33284-53-6	61	0.00158	0.02	NA	
54230-22-7	62	0.00164	0.02	NA	
74472-34-7	63	0.00156	0.02	NA	
52663-58-8	64	0.00164	0.02	NA	
33284-54-7	65	0.00203	0.02	NA	
32598-10-0	66	0.00155	0.02	NA	
73575-53-8	67	0.00146	0.02	NA	
73575-52-7	68	0.00151	0.02	NA	
60233-24-1	69	0.00193	0.02	NA	
32598-11-1	70	0.00158	0.02	NA	
41464-46-4	71	0.00226	0.02	NA	
41464-42-0	72	0.00161	0.02	NA	
74338-23-1	73	0.00207	0.02	NA	
32690-93-0	74	0.00158	0.02	NA	
32598-12-2	75	0.00164	0.02	NA	
70362-48-0	76	0.00158	0.02	NA	
32598-13-3	77	0.00145	0.02	NA	50-150
70362-49-1	78	0.00161	0.02	NA	
41464-48-6	79	0.00136	0.02	NA	
33284-52-5	80	0.00145	0.02	NA	
70362-50-4	81	0.0016	0.02	NA	50-150
52663-62-4	82	0.00358	0.02	NA	
60145-20-2	83	0.00371	0.02	NA	
52663-60-2	84	0.00362	0.02	NA	
65510-45-4	85	0.00256	0.02	NA	
55312-69-1	86	0.00257	0.02	NA	
38380-02-8	87	0.00257	0.02	NA	
55215-17-3	88	0.00319	0.02	NA	
73575-57-2	89	0.00346	0.02	NA	
68194-07-0	90	0.00268	0.02	NA	
68194-05-8	91	0.00319	0.02	NA	
52663-61-3	92	0.00324	0.02	NA	
73575-56-1	93	0.00313	0.02	NA	
73575-55-0	94	0.00342	0.02	NA	
38379-99-6	95	0.00313	0.02	NA	
73575-54-9	96	0.00238	0.02	NA	
41464-51-1	97	0.00257	0.02	NA	
60233-25-2	98	0.00318	0.02	NA	
38380-01-7	99	0.00255	0.02	NA	
39485-83-1	100	0.00313	0.02	NA	
37680-73-2	101	0.00268	0.02	NA	
68194-06-9	102	0.00318	0.02	NA	
60145-21-3	103	0.00293	0.02	NA	
56558-16-8	104	0.00231	0.02	NA	50-150
32598-14-4	105	0.00141	0.02	NA	50-150
70424-69-0	106	0.00157	0.02	NA	
70424-68-9	107	0.00139	0.02	NA	
70362-41-3	108	0.00154	0.02	NA	

Table 2-8
PCB Congener Reporting Limits

CAS Registry	Congener Number	Average EDL (ng/L)	Reporting Limit (ng/L)	Precision (%RPD) [1]	Accuracy (%R)
74472-35-8	109	0.00257	0.02	NA	
38380-03-9	110	0.00227	0.02	NA	
39635-32-0	111	0.00218	0.02	NA	
74472-36-9	112	0.00255	0.02	NA	
68194-10-5	113	0.00268	0.02	NA	
74472-37-0	114	0.00125	0.02	NA	50-150
74472-38-1	115	0.00227	0.02	NA	
18259-05-7	116	0.00256	0.02	NA	
68194-11-6	117	0.00256	0.02	NA	
31508-00-6	118	0.00131	0.02	NA	50-150
56558-17-9	119	0.00257	0.02	NA	
68194-12-7	120	0.0021	0.02	NA	
56558-18-0	121	0.00229	0.02	NA	
76842-07-4	122	0.00162	0.02	NA	
65510-44-3	123	0.0013	0.02	NA	50-150
70424-70-3	124	0.00154	0.02	NA	
74472-39-2	125	0.00257	0.02	NA	
57465-28-8	126	0.00159	0.02	NA	50-150
39635-33-1	127	0.00143	0.02	NA	
38380-07-3	128	0.0022	0.02	NA	
55215-18-4	129	0.00225	0.02	NA	
52663-66-8	130	0.00286	0.02	NA	
61798-70-7	131	0.00288	0.02	NA	
38380-05-1	132	0.00281	0.02	NA	
35694-04-3	133	0.00264	0.02	NA	
52704-70-8	134	0.00288	0.02	NA	
52744-13-5	135	0.00405	0.02	NA	
38411-22-2	136	0.003	0.02	NA	
35694-06-5	137	0.00215	0.02	NA	
35065-28-2	138	0.00225	0.02	NA	
56030-56-9	139	0.00242	0.02	NA	
59291-64-4	140	0.00242	0.02	NA	
52712-04-6	141	0.00256	0.02	NA	
41411-61-4	142	0.00283	0.02	NA	
68194-15-0	143	0.00288	0.02	NA	
68194-14-9	144	0.00396	0.02	NA	
74472-40-5	145	0.00307	0.02	NA	
51908-16-8	146	0.00232	0.02	NA	
68194-13-8	147	0.00233	0.02	NA	
74472-41-6	148	0.00404	0.02	NA	
38380-04-0	149	0.00233	0.02	NA	
68194-08-1	150	0.00294	0.02	NA	
52663-63-5	151	0.00405	0.02	NA	
68194-09-2	152	0.0029	0.02	NA	
35065-27-1	153	0.00198	0.02	NA	
60145-22-4	154	0.00347	0.02	NA	
33979-03-2	155	0.00281	0.02	NA	50-150
38380-08-4	156	0.00175	0.02	NA	50-150
69782-90-7	157	0.00175	0.02	NA	50-150
74472-42-7	158	0.00172	0.02	NA	
39635-35-3	159	0.00181	0.02	NA	
41411-62-5	160	0.00201	0.02	NA	
74472-43-8	161	0.00188	0.02	NA	
39635-34-2	162	0.00181	0.02	NA	

Table 2-8
PCB Congener Reporting Limits

CAS Registry	Congener Number	Average EDL (ng/L)	Reporting Limit (ng/L)	Precision (%RPD) [1]	Accuracy (%R)
74472-44-9	163	0.00225	0.02	NA	
74472-45-0	164	0.00215	0.02	NA	
74472-46-1	165	0.00205	0.02	NA	
41411-63-6	166	0.0022	0.02	NA	
52663-72-6	167	0.00154	0.02	NA	50-150
59291-65-5	168	0.00198	0.02	NA	
32774-16-6	169	0.00174	0.02	NA	50-150
35065-30-6	170	0.00198	0.02	NA	
52663-71-5	171	0.00255	0.02	NA	
52663-74-8	172	0.00258	0.02	NA	
68194-16-1	173	0.00255	0.02	NA	
38411-25-5	174	0.00239	0.02	NA	
40186-70-7	175	0.00229	0.02	NA	
52663-65-7	176	0.00182	0.02	NA	
52663-70-4	177	0.00256	0.02	NA	
52663-67-9	178	0.00246	0.02	NA	
52663-64-6	179	0.0018	0.02	NA	
35065-29-3	180	0.00167	0.02	NA	
74472-47-2	181	0.00239	0.02	NA	
60145-23-5	182	0.00232	0.02	NA	
52663-69-1	183	0.00229	0.02	NA	
74472-48-3	184	0.00169	0.02	NA	
52712-05-7	185	0.00229	0.02	NA	
74472-49-4	186	0.00184	0.02	NA	
52663-68-0	187	0.00217	0.02	NA	
74487-85-7	188	0.00176	0.02	NA	50-150
39635-31-9	189	0.0016	0.02	NA	50-150
41411-64-7	190	0.00185	0.02	NA	
74472-50-7	191	0.0018	0.02	NA	
74472-51-8	192	0.00195	0.02	NA	
69782-91-8	193	0.00195	0.02	NA	
35694-08-7	194	0.00209	0.02	NA	
52663-78-2	195	0.00229	0.02	NA	
42740-50-1	196	0.00313	0.02	NA	
33091-17-7	197	0.00229	0.02	NA	
68194-17-2	198	0.00311	0.02	NA	
52663-75-9	199	0.00311	0.02	NA	
52663-73-7	200	0.00229	0.02	NA	
40186-71-8	201	0.00228	0.02	NA	
2136-99-4	202	0.00241	0.02	NA	50-150
52663-76-0	203	0.00287	0.02	NA	
74472-52-9	204	0.00235	0.02	NA	
74472-53-0	205	0.00146	0.02	NA	50-150
40186-72-9	206	0.00146	0.02	NA	50-150
52663-79-3	207	0.00132	0.02	NA	
52663-77-1	208	0.00127	0.02	NA	50-150
2051-24-3	209	0.00096	0.02	NA	50-150

Notes:

[1] MS/MSD or LCS/LCSD not required by method

NA = Not applicable.

RPD = Relative percent difference.

Table 2-9
Quality Control Criteria – Standard Analyses

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
EPA Method 8082 w/ WSLOH Modification	Aroclors 1016/1260	Five-point initial calibration (ICAL)	Initial calibration prior to sample analysis	Calibration factor of each peak < 20 % RSD	Correct problem, then repeat initial calibration
	Aroclors, 1221, 1232, 1242, 1248, 1254	One point midrange calibration standard	With each Aroclor 1016/1260 initial calibration	Calibration is acceptable if Aroclor 1016 and 1260 meet acceptance criteria.	None, use response factor from mid-range standard to quantify Aroclor if present
	All Aroclors	Qualitative match for Aroclor Identification	Every sample	Minimum 5 peak match for all Aroclors except Aroclor 1221 (3 peak match)	None, do not report as detected Aroclor
	All Aroclors	Retention time window	Each calibration verification	ICAL mean RT + 0.03 minutes	Correct problem, then reanalyze all samples analyzed since the last retention time check
	Aroclors 1016/1260	Calibration verification	After every 10 samples	Average RF of > 5 peaks < 15 % difference from ICAL mean RF	Correct problem, then repeat initial calibration verification and reanalyze all samples since last successful calibration verification
	Aroclors 1016/1260	Ending calibration verification	After all samples analyzed	Average RF of > 5 peaks < 15 % difference from ICAL mean RF	If sensitivity increased > 15 %, no reanalysis of undetected samples needed. If sensitivity decreased > 15 %, reanalyze samples.
	All Aroclors	Method blank (MB)	One per analytical batch of 20 samples or less	No analytes detected > RL	Correct problem, then repeat prep and analysis of method blank and all samples with detects < 20 X MB processed with the contaminated blank
	Aroclors 1254	LCS	One LCS per analytical batch of 20 samples or less	40-128%	Assess all other batch QC for same bias, if consistent bias present, repeat prep and analysis of LCS and all samples in the affected analytical batch
	All Aroclors	Surrogate spikes (TCMX, DCB)	Every sample, spiked sample, standard, and method blank	TCMX 40-136% DCB 47-145%	If both TCMX and DCB out of limit, re-extract and re-analyze sample
	Aroclor 1254	MS/MSD	One MS/MSD per every 20 project samples	43-130% recovery 56% RPD	If recovery is out of limit, qualify data and note in case narrative suspected matrix problem
	All Aroclors	Field Duplicates	Submitted blind to lab	< 35 % RPD	May request analysis of additional aliquot(s), data qualified as estimated during validation

Table 2-9
Quality Control Criteria – Standard Analyses

Method	Applicable Parameter	QC Check	Minimum Frequency	Acceptance Criteria	Corrective Action
EPA Method 415.1	TOC (water)	Method Blank	1 with each batch of samples processed not to exceed 20 samples	Absolute value < RL of 2 mg/L, if sample level > 20 x MB, no action	Rerun all samples associated with unacceptable blank. If MB > MDL < RL, qualify sample levels < 20 x MB with "A"
	TOC (water)	Laboratory Control Sample	1 with each batch of samples processed not to exceed 20 samples	Percent recovery must be within laboratory control limits 80-120%	If not within laboratory control limits, rerun all associated samples
	TOC (water)	MS/MSD	1 per 10 samples, minimum of one per batch of samples processed	Percent recovery must be within laboratory control limits 80 -120% RPD < 20%	Flag data outside of limit
	TOC (water)	Update calibration factor with 3 standard plus blank.	Initially and as needed when calibration failures occur	See instrument manual	Correct problem, then repeat initial calibration
	TOC (water)	ICV	1 mid-level at beginning of every analytical run	± 10% of true value	Correct problem, then repeat calibration verification and reanalyze all samples not bracketed by an acceptable ICV
	TOC (water)	ICB	Immediately after ICV	Absolute value < RL of 2 mg/L	Correct problem, then repeat calibration verification and reanalyze all samples not bracket by acceptable ICB
	TOC (water)	CCV	1 mid-level every 10 samples	± 10% of true value	Correct problem, then reanalyze all samples not bracketed by an acceptable CCV
	TOC (water)	CCB	Immediately after CCV	Absolute value < RL of 2 mg/L. If sample level >10 x CCB, no action	Correct problem, then reanalyze all samples not bracketed by an acceptable CCB
	TOC (water)	Field Duplicate	Submitted blind to lab	<30% RPD	May request analysis of additional aliquot(s), data qualified as estimated during validation
EPA Method 160.2	Total suspended solids	Method Blank	1 with each batch of samples processed not to exceed 20 samples	< + RL	Reanalyze all samples associated with unacceptable MB
	Total suspended solids	Laboratory Control Sample	1 with each batch of samples processed not to exceed 20 samples	80-120%	Reanalyze all samples associated with unacceptable LCS
	Total suspended solids	Duplicate	1 with each batch of samples processed not to exceed 10 samples	< 10% RPD when results >5xs RL	Flag Parent result with appropriate qualifier

Table 2-10
Quality Control Criteria – PCB Congeners

Analytical Method	Calibration/ QC Check	Frequency	Acceptance Criteria	Corrective Action
EPA Method 1668, Revision A	Check of mass resolution mass accuracy (PFK) and gc performance	Every 12 hours	1) > 10,000 resolving power 2) < 5 ppm deviation from reference mass 3) < 40 % valley between PCBs 34 and 23 4) < 40 % valley between PCBs 187 and 182	1) Retune or service GC/MS system 2) Repeat check
	Initial 6-point calibration	Initially and as needed	1) %RSD for CCCs calculated by isotope dilution - < 20% 2) %RSD for CCCs calculated by internal standard - < 35% 3) %RSD for Labeled congeners calculated by internal standard - < 35%	1) Identify the root cause 2) Perform corrective action 3) Repeat the initial calibration
	Continuing calibration verification (CCV):	Every 12 hours	1) > 10,000 resolving power 2) < 5 ppm deviation from reference mass % D <20% for CCCs 3) Ion abundance ratios within limit in 1668A Table 8. 4) S/N > 10 for all targets and internal standards 5) %D for all target PCBs < 30% 6) % D for labeled internal standards < 50%	1) If %D > 30% for non-toxic/locs, but is < 60%, use shift response factor 2) Evaluate system, service as required 3) Repeat calibration check 4) Perform new initial calibration 5) Reanalyze affected samples
	Labeled congeners/internal standards	Twenty-eight 13C-labeled congeners added to every sample, QA sample, standard	1) %Recovery 30-140% on LCSs 2) %Recovery > 25% on samples, blanks	1) Check all calculations for error 2) Ensure that instrument performance is acceptable 3) Recalculate the data and/or reanalyze if either of the above checks reveal a problem 4) If any recovery is < 25%, evaluate labeled congener S/N and EDLs. If S/N > 10 and EDL< EML, report with qualifiers and discuss in narrative
	Method blank	One per batch of not more than 20 samples	1) Control method blank contamination to <0.2 ng/L total PCBs 2) Individual target compounds should be: - Less than the RL, or - Less than 10% of measured concentration in the associated sample, or - Not present in the associated sample 3) Verify that samples were analyzed in order from anticipated low to high concentrations [See Section 2.6.1.3 of the Plan] [Note: Blank correction procedures described in Section 4.2.2 of the Plan]	1) Service system/glassware to reduce lab contamination 2) Notify Data Quality Assurance Manager (QAM) 3) Reanalyze blank and all affected samples as directed by Data QAM and A/OT
	Ongoing Precision and Recovery (OPR)	One per batch of not more than 20 samples	1) All criteria specified in Table 6 of Method 1668A	1) Corrective action required may include: Re-extraction and Re-analysis of LCS and associated samples If batch is not re-extracted reasons for acceptance must be clearly presented in the project records and report If re-extraction and reanalysis of the batch is not possible due to limited sample volume or other constraints the OPR is reported and the failure is documented in the project narrative

Table 4-1
Estimated Statistical Confidence Levels for Achievement of Risk Targets

N = 5		Standard Error (as Percent of Mean)							
		5%	10%	15%	20%	25%	30%	35%	40%
Difference: Risk Goal - Sample Mean	-10%	6%	19%	27%	32%	35%	38%	39%	41%
	-5%	19%	32%	38%	41%	43%	44%	45%	45%
	0%	50%	50%	50%	50%	50%	50%	50%	50%
	5%	81%	68%	62%	59%	57%	56%	55%	55%
	10%	94%	81%	73%	68%	65%	62%	61%	59%
	15%	98%	90%	81%	75%	71%	68%	65%	64%
	20%	99%	94%	87%	81%	77%	73%	70%	68%
	25%	100%	97%	91%	86%	81%	77%	74%	72%
	30%	100%	98%	94%	90%	85%	81%	78%	75%
	35%	100%	99%	96%	92%	88%	85%	81%	78%
	40%	100%	99%	97%	94%	91%	87%	84%	81%
	45%	100%	99%	98%	96%	93%	90%	87%	84%
	50%	100%	100%	99%	97%	94%	91%	89%	86%

N = 15		Standard Error (as Percent of Mean)							
		5%	10%	15%	20%	25%	30%	35%	40%
Difference: Risk Goal - Sample Mean	-10%	3%	17%	26%	31%	35%	37%	39%	40%
	-5%	17%	31%	37%	40%	42%	44%	44%	45%
	0%	50%	50%	50%	50%	50%	50%	50%	50%
	5%	83%	69%	63%	60%	58%	56%	56%	55%
	10%	97%	83%	74%	69%	65%	63%	61%	60%
	15%	100%	92%	83%	77%	72%	69%	66%	64%
	20%	100%	97%	90%	83%	78%	74%	71%	69%
	25%	100%	99%	94%	88%	83%	79%	76%	73%
	30%	100%	100%	97%	92%	87%	83%	80%	77%
	35%	100%	100%	98%	95%	91%	87%	83%	80%
	40%	100%	100%	99%	97%	93%	90%	86%	83%
	45%	100%	100%	100%	98%	95%	92%	89%	86%
	50%	100%	100%	100%	99%	97%	94%	91%	88%

N = ∞		Standard Error (as Percent of Mean)							
		5%	10%	15%	20%	25%	30%	35%	40%
Difference: Risk Goal - Sample Mean	-10%	2%	16%	25%	31%	34%	37%	39%	40%
	-5%	16%	31%	37%	40%	42%	43%	44%	45%
	0%	50%	50%	50%	50%	50%	50%	50%	50%
	5%	84%	69%	63%	60%	58%	57%	56%	55%
	10%	98%	84%	75%	69%	66%	63%	61%	60%
	15%	100%	93%	84%	77%	73%	69%	67%	65%
	20%	100%	98%	91%	84%	79%	75%	72%	69%
	25%	100%	99%	95%	89%	84%	80%	76%	73%
	30%	100%	100%	98%	93%	88%	84%	80%	77%
	35%	100%	100%	99%	96%	92%	88%	84%	81%
	40%	100%	100%	100%	98%	95%	91%	87%	84%
	45%	100%	100%	100%	99%	96%	93%	90%	87%
	50%	100%	100%	100%	99%	98%	95%	92%	89%

FIGURES

Legend

Urban Areas

Dams and Locks

20000 0 20000 Feet

5 4 3 2 1 0 5 Miles

N W E S

Lower Fox River Study Area

160 0 160 Miles

GREEN BAY

OU5B

OU5A

41

141

PULASKI

HOWARD

FORT JAMES TURNING BASIN (UPPER LIMIT OF FEDERALLY MAINTAINED NAVIGATION)

GREEN BAY

141

43

ONEIDA

ASHWAUBENON

ALLOUEZ

OU4

DE PERE

DE PERE

BLACK CREEK

SHIOCTON

41

LITTLE RAPIDS

OU3

LOWER KAUKAUNA

KAUKAUNA

RAPIDE CROCHE

OU2C

COMBINED LOCKS

KIMBERLY

WRIGHTSTOWN

DENMARK

57

32

LOWER APPLETON

MIDDLE APPLETON

UPPER APPLETON

OU2B

OU2A

KAUKAUNA

MARIBEL

APPLETON

441

MENASHA

10

MENASHA

OU1

NEENAH

SHERWOOD

BRILLION

WHITELAW

REEDSVILLE

NEENAH

HILBERT

POTTER

45

41

LAKE WINNEBAGO

STOCKBRIDGE

VALDERS

OSHKOSH

CHILTON

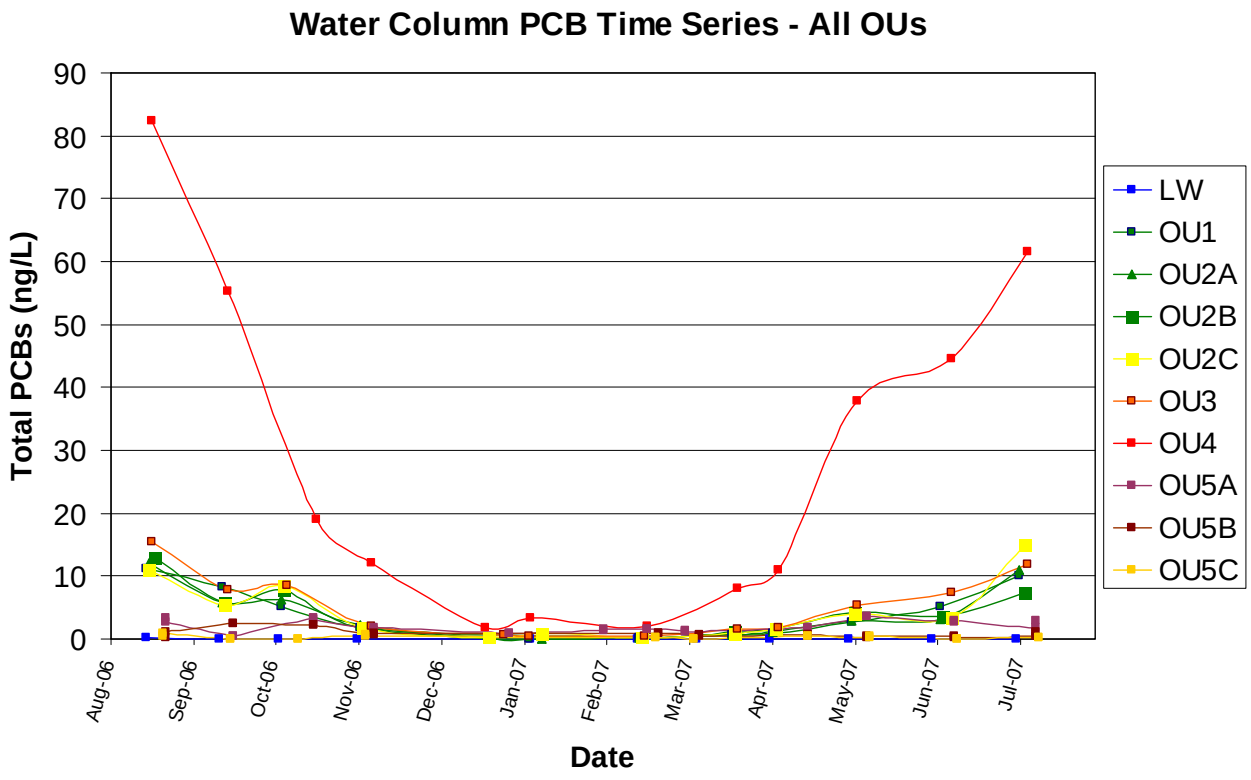
151

NEW HOLSTEIN

Figure 1-1
Site Location Map
Long-Term Monitoring Work Plan

Shaw Shaw Environmental, Inc.

ANCHOR QEA



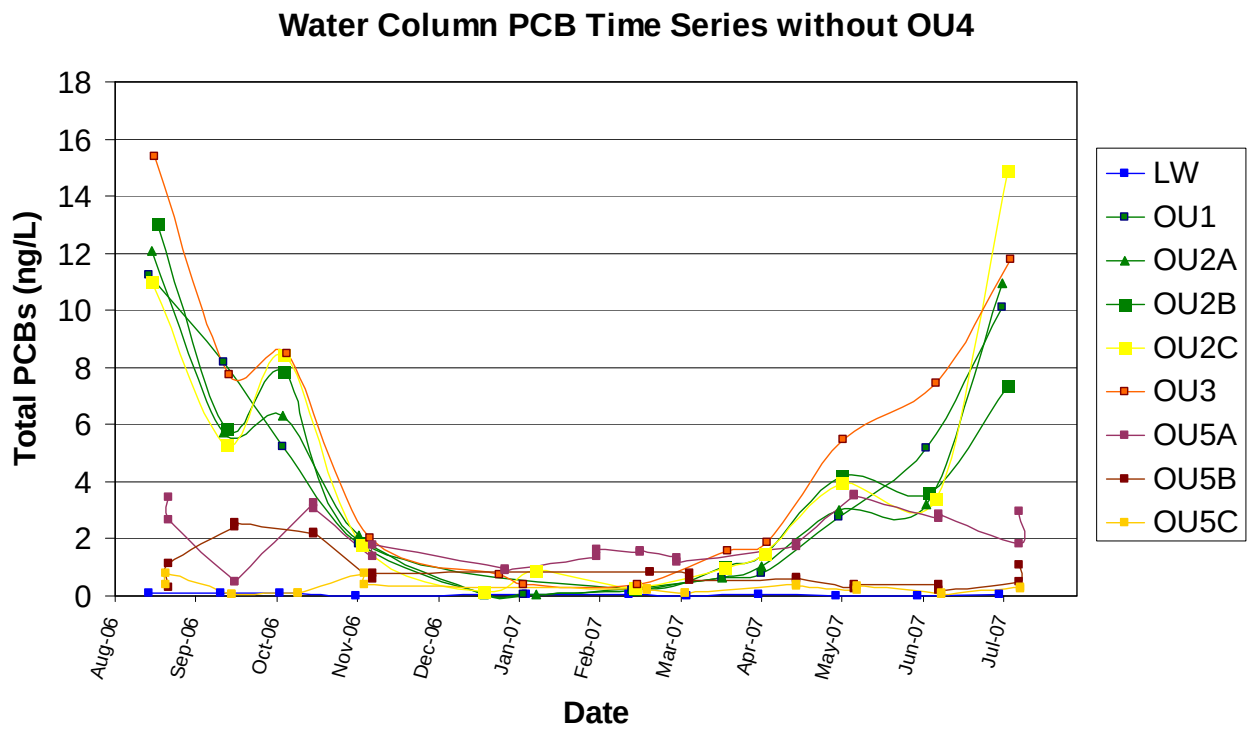
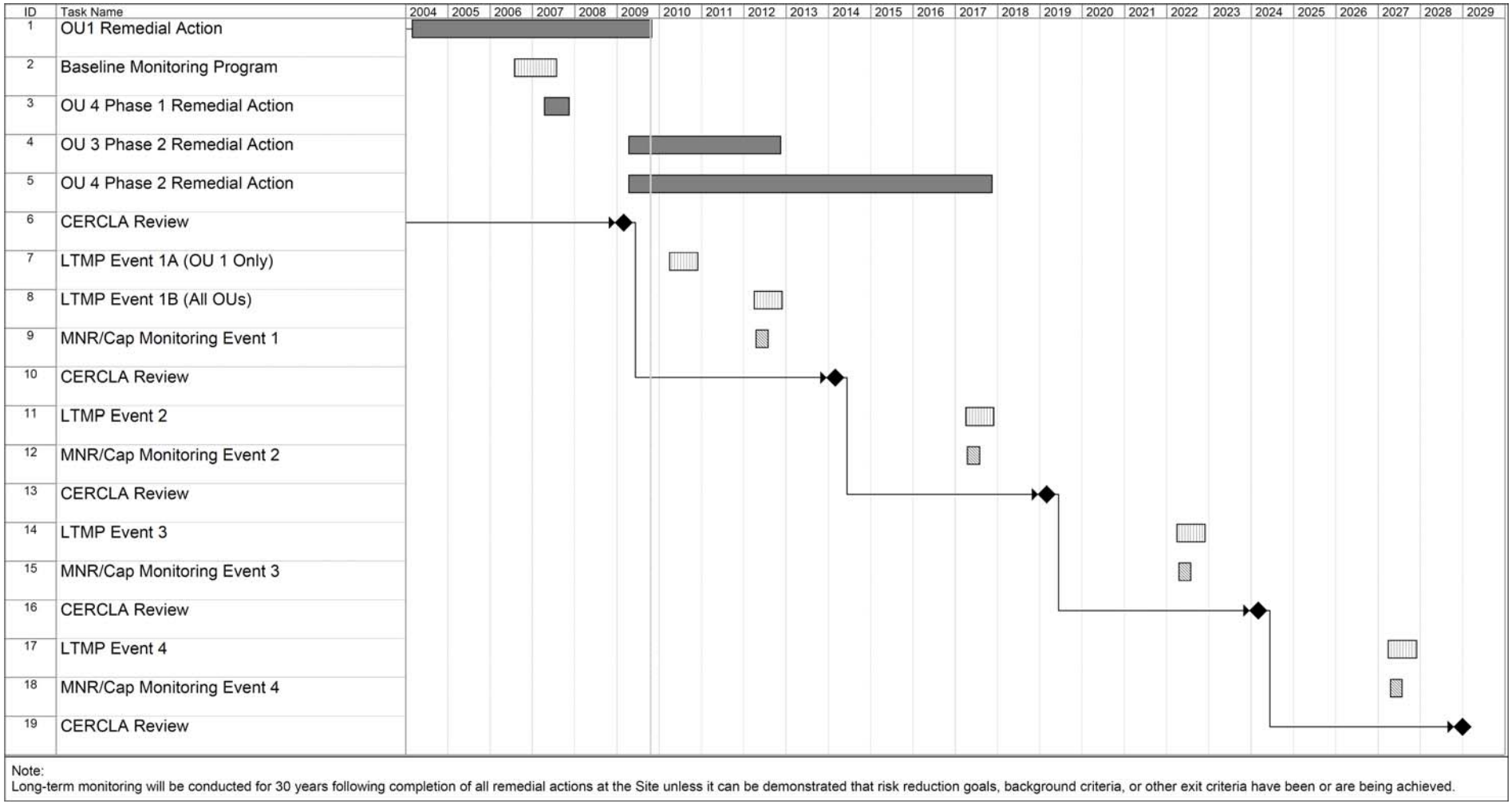


Figure 1-2
Seasonal Variation in Water Column PCB Concentrations
Long-term Monitoring Plan
Lower Fox River Remedial Design

ANCHOR QEA



Note:
Long-term monitoring will be conducted for 30 years following completion of all remedial actions at the Site unless it can be demonstrated that risk reduction goals, background criteria, or other exit criteria have been or are being achieved.

Figure 1-3
Long-term Monitoring Project Schedule (Through 2029)
Long-term Monitoring Plan
Lower Fox River Remedial Design

ANCHOR QEA

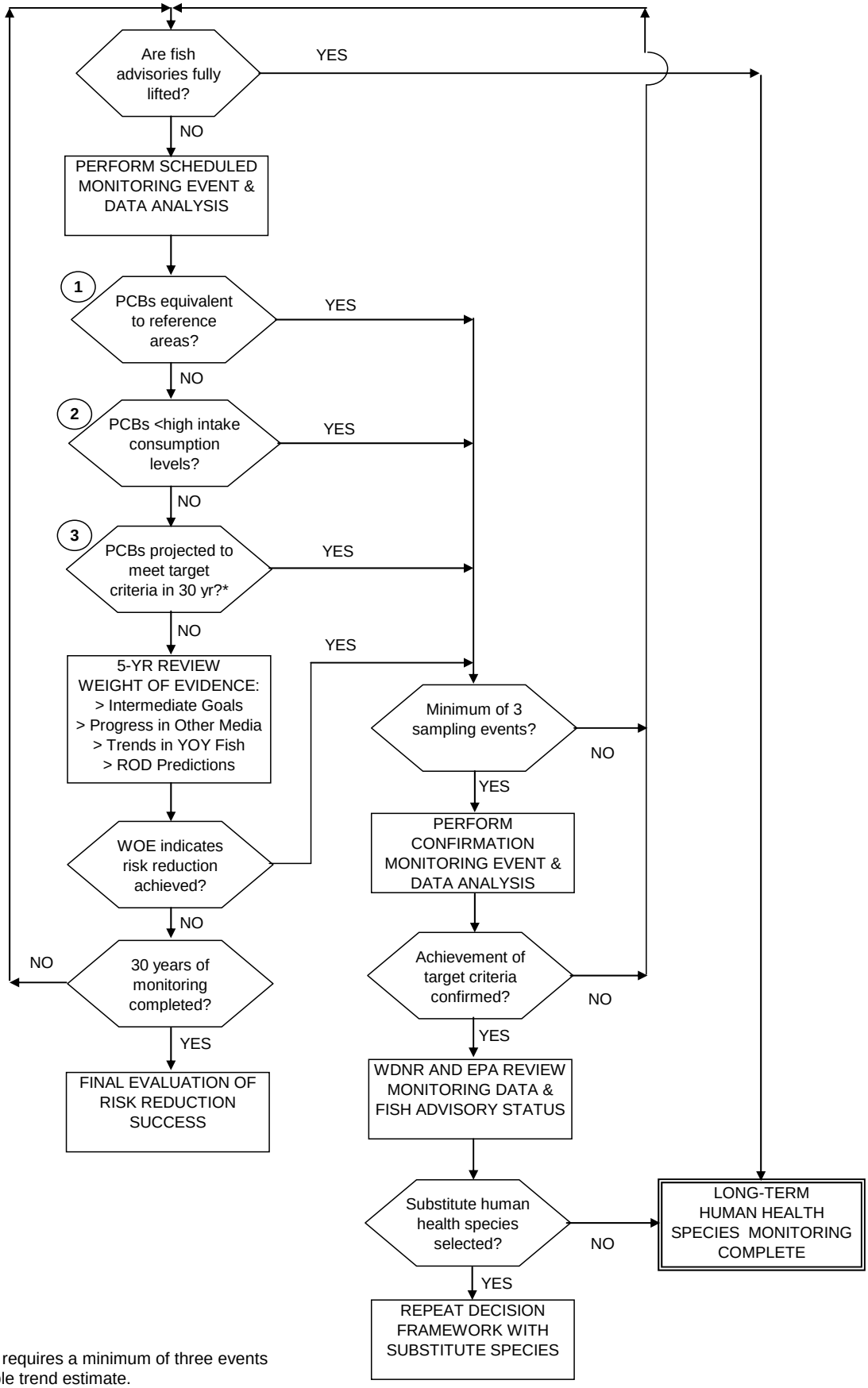
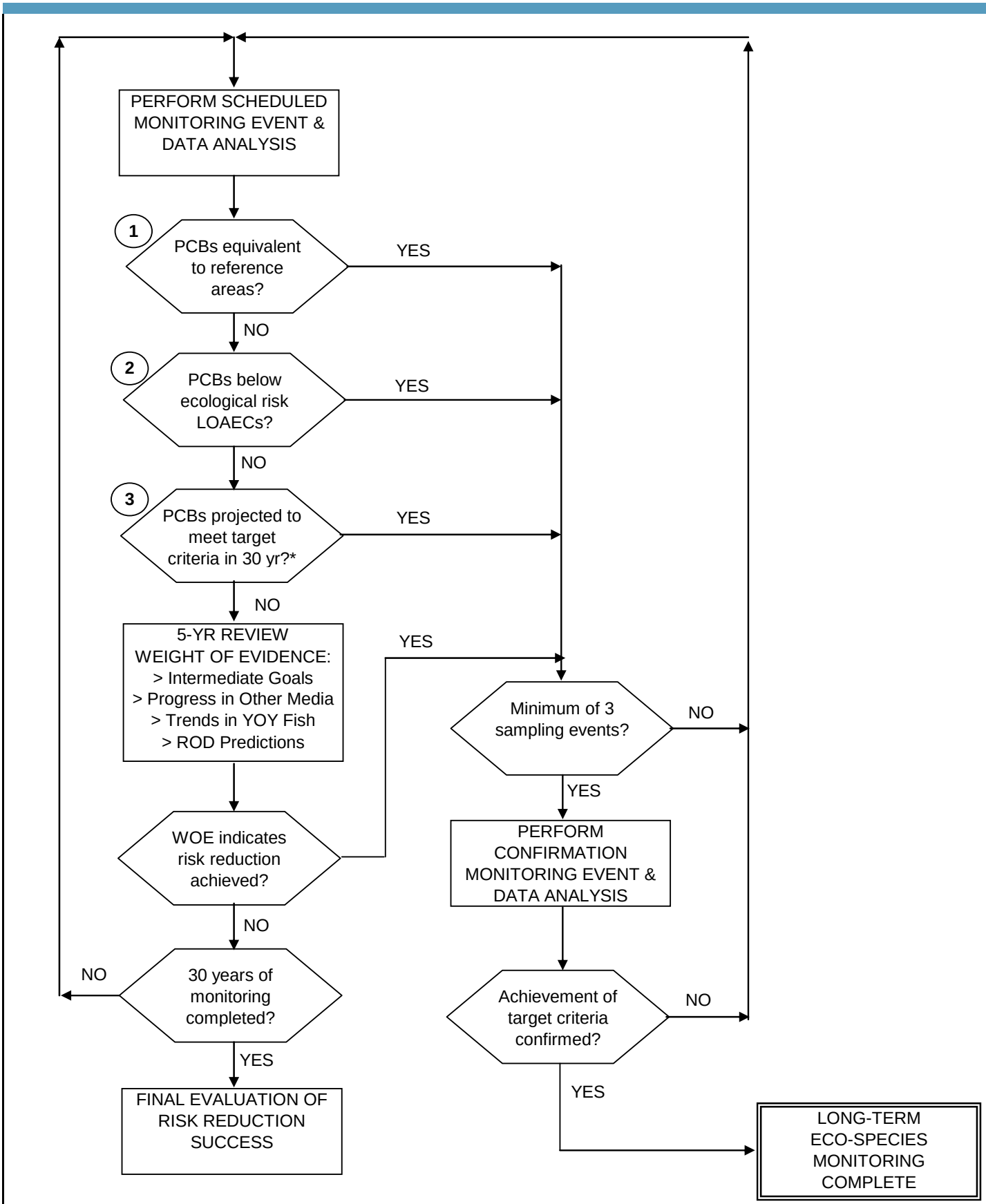


Figure 1-4
Decision Framework for Human Health Fish Species
Long-term Monitoring Plan
Lower Fox River

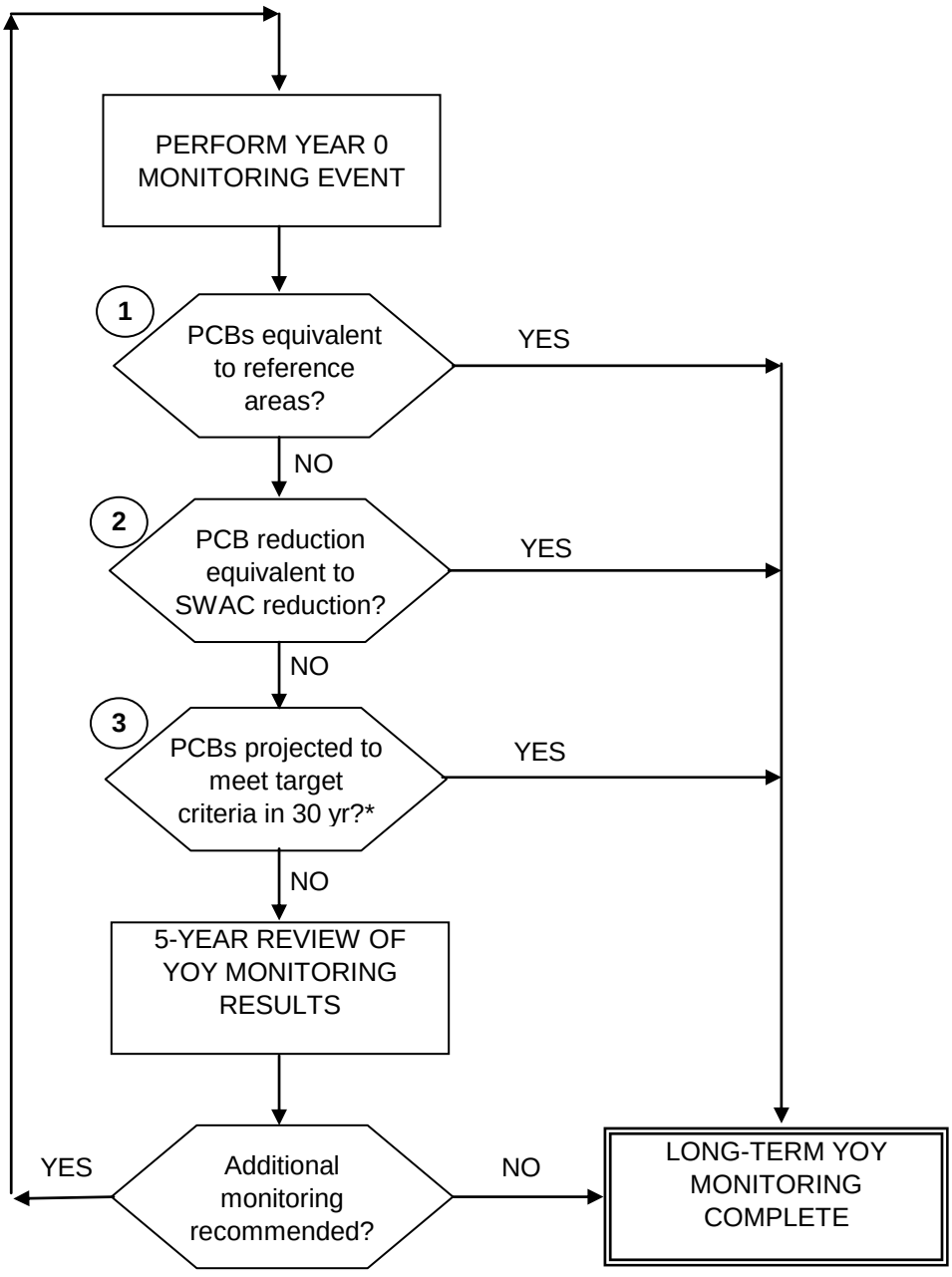
ANCHOR QEA



* Decision No. 3 requires a minimum of three events to obtain a reliable trend estimate.

Figure 1-5
Decision Framework for Ecological Fish Species
Long-term Monitoring Plan
Lower Fox River

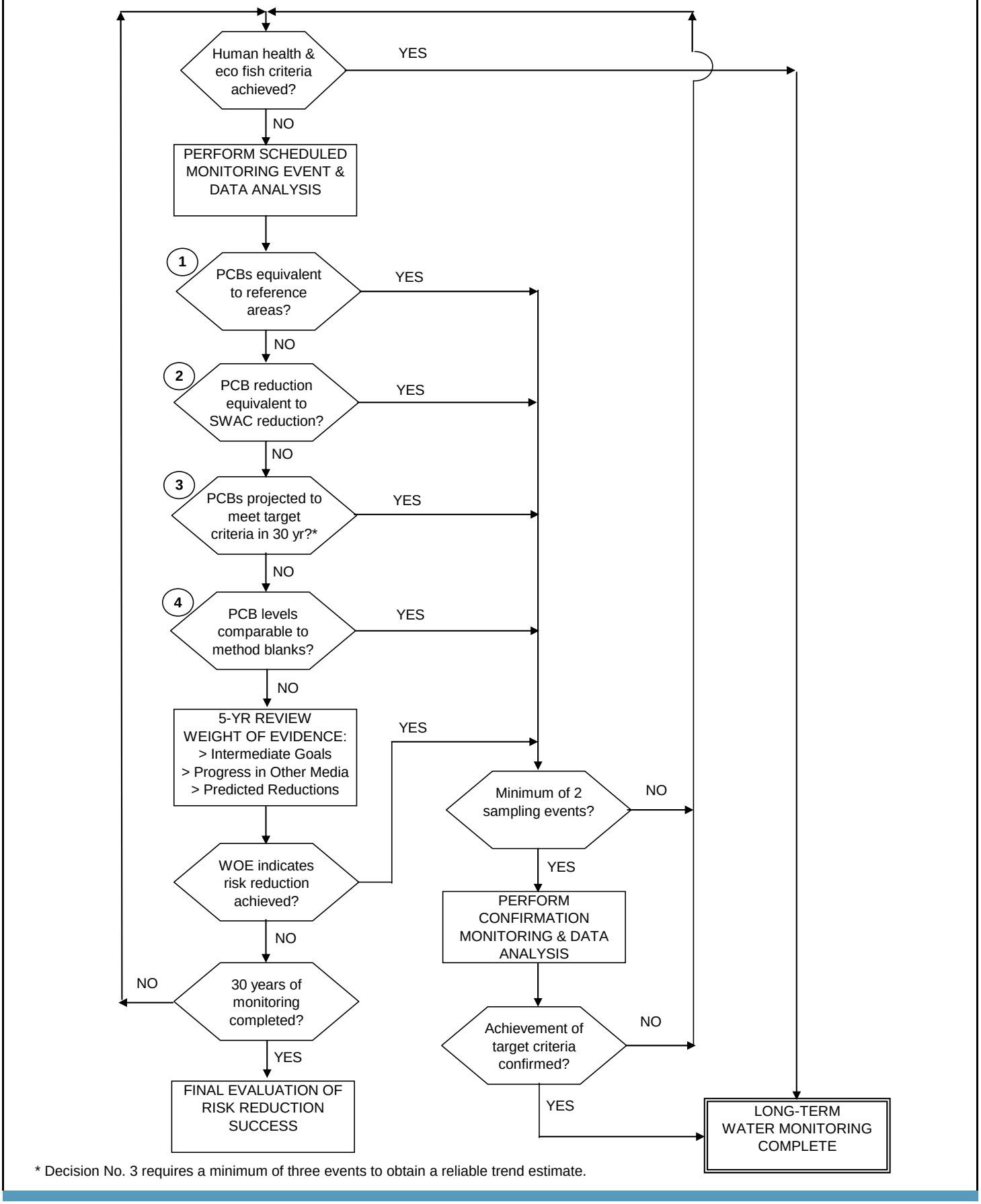
ANCHOR QEA



* Decision No. 3 requires a minimum of three events to obtain a reliable trend estimate.

Figure 1-6
Decision Framework for Young-of-Year Fish Species
Long-term Monitoring Plan
Lower Fox River

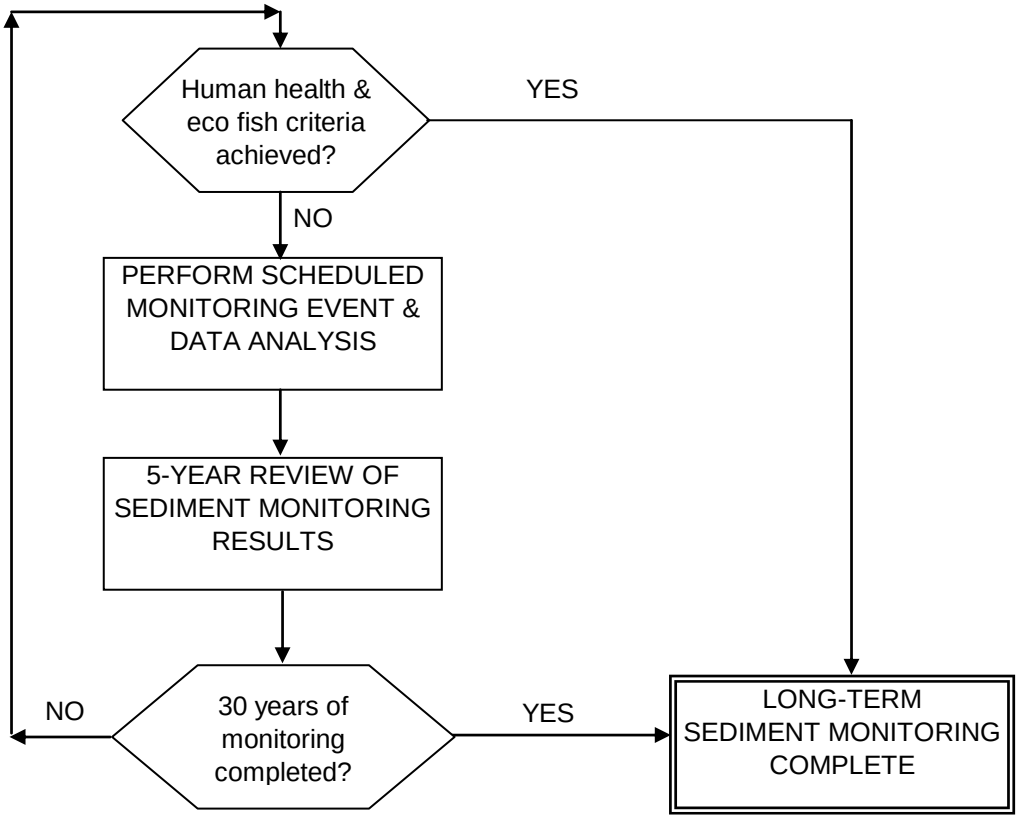
ANCHOR QEA



* Decision No. 3 requires a minimum of three events to obtain a reliable trend estimate.

Figure 1-7
Decision Framework for Water Quality
Long-term Monitoring Plan
Lower Fox River

ANCHOR QEA



* Decision No. 3 requires a minimum of three events to obtain a reliable trend estimate.

Figure 1-8
Decision Framework for Sediment Quality
Long-term Monitoring Plan
Lower Fox River

ANCHOR QEA

Legend

Urban Areas

Map Boundary

Dams and Locks

20000 0 20000 Feet

5 4 3 2 1 0 5 Miles

N W E S

Lower Fox River Study Area

160 0 160 Miles

GREEN BAY

OU5B

OU5A

PULASKI

HOWARD

Figure 2-8

GREEN BAY

ONEIDA

ASHWAUBENON

ALLOUEZ

OU4

Figure 2-9

BLACK CREEK

DE PERE

DE PERE

SHIOCTON

LITTLE RAPIDS

Figure 2-7

OU3

LOWER KAUKAUNA

Figure 2-6

KAUKAUNA

RAPIDE CROCHE

WRIGHTSTOWN

COMBINED LOCKS

KIMBERLY

OU2C

LOWER APPLETON

OU2B

Figure 2-5

MIDDLE APPLETON

UPPER APPLETON

KAUKAUNA

Figure 2-3

APPLETON

OU2A

Figure 2-4

MENASHA

MENASHA

OU1

Figure 2-2

NEENAH

NEENAH

SHERWOOD

BRILLION

WHITELAW

REEDSVILLE

HILBERT

POTTER

LAKE WINNEBAGO

STOCKBRIDGE

VALDERS

OSHKOSH

CHILTON

NEW HOLSTEIN

Figure 2-1
Index to Sampling Maps
Long-Term Monitoring Work Plan

Shaw™ Shaw Environmental, Inc.

ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998

Boat Landing

USACE Channel Definition

Dams

Shoreline

Water Depth Contour - 10-Foot Interval

Water Depth Contour - 2-Foot Interval

12000 0 12000 Feet

N W E S

OU1
JEFFERSON PARK
C
LW
DOTY PARK
PARK AVENUE
w,b,d
OSH-O-NEE
w,d
LAKE WINNEBAGO
SHERMAN ROAD
MURDOCK AVENUE
D,C,G
MILL STREET
FUGLEBURG
24TH AVENUE
G
W,D
D,C,G
b
b,d
NAGY PARK
COUNTY LINE ROAD
G
10
41
45
151
12
18
6

Figure 2-2
Lake Winnebago Sampling Stations
Long-Term Monitoring Work Plan

Shaw Shaw Environmental, Inc.
ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998

Boat Landing

USACE Channel Definition

Dams

Shoreline

Water Depth Contour - 10-Foot Interval

Water Depth Contour - 2-Foot Interval

2000 0 2000 Feet

N W E S

LUTZ PARK
B,D,C
OU1
47
10
W,C
NINTH STREET
FRITZE PARK
W,D,C
B,C
114
LOCK STREET
JEFFERSON PARK
MENASHA DAM
TAYCOST
Lake Winnebago
W,B,D,C,G
DOTY PARK
NEENAH DAM
WINNECONNEAVE

Figure 2-3
Operable Unit 1 Sampling Stations
Long-Term Monitoring Work Plan

Shaw Shaw Environmental, Inc.
ANCHOR QEA

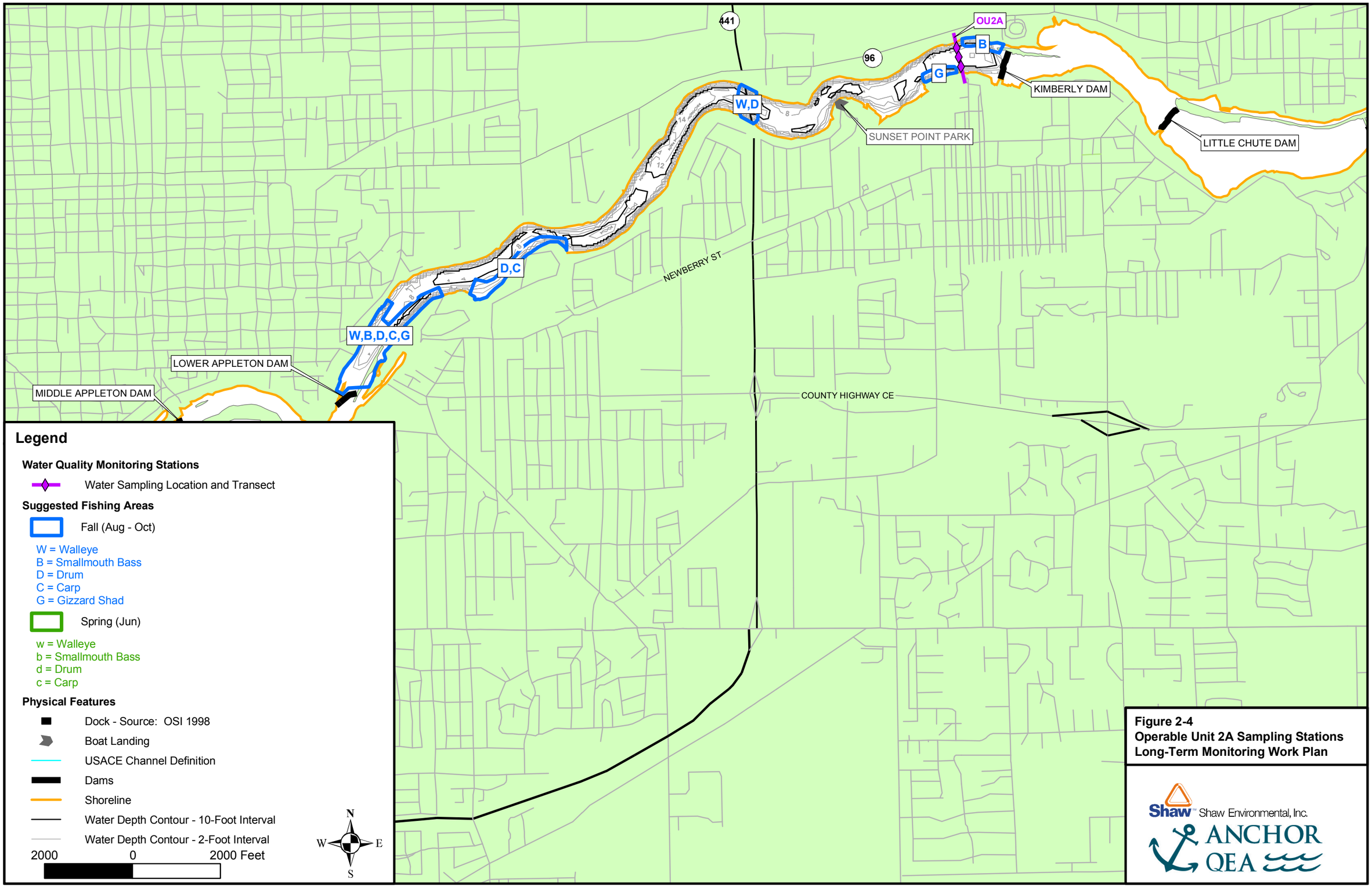


Figure 2-4
Operable Unit 2A Sampling Stations
Long-Term Monitoring Work Plan

Shaw™ Shaw Environmental, Inc.
ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998

Boat Landing

USACE Channel Definition

Dams

Shoreline

Water Depth Contour - 10-Foot Interval

Water Depth Contour - 2-Foot Interval

2000 0 2000 Feet

N W E S

RAPIDE CROCHE DAM
OU2B
96
41
96
NEW RD
AUGUSTINE STREET
COUNTY HIGHWAY ZZ
PLANK RD
KAUKAUNA LOCKS
G
B,D,C
W,B,D,C,G

Figure 2-5
Operable Unit 2B Sampling Stations
Long-Term Monitoring Work Plan

Shaw Shaw Environmental, Inc.
ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998

Boat Landing

USACE Channel Definition

Dams

Shoreline

Water Depth Contour - 10-Foot Interval

Water Depth Contour - 2-Foot Interval

2000 0 2000 Feet

N W E S

41

LITTLE RAPIDS DAM

OU2C

GOLDEN GLOWRD

COUNTY ROAD D

COUNTY ROAD ZZ

WRIGHTSTOWNRD

MEADOWLARKRD

ELMRORD

C,B,D

MAINST

96

WRIGHTSTOWN PARK

RAPIDE CROCHE DAM

C,D

W,B,D,C,G

Figure 2-6
Operable Unit 2C Sampling Stations
Long-Term Monitoring Work Plan

Shaw™ Shaw Environmental, Inc.

ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998
Boat Landing
USACE Channel Definition
Dams
Shoreline
Water Depth Contour - 10-Foot Interval
Water Depth Contour - 2-Foot Interval

2000 0 2000 Feet

N W E S

STATE HIGHWAY 32
41
BROADWAY
DE PERE DAM
FOX RIVER DRIVE
OU3
FOX RIVERDR
COUNTY ROAD PP
BROADWAY
GREENLEAFRD
COUNTY ROAD D
57
G
C,G
D,C,G
W,B,D,C,G
LITTLE RAPIDS DAM

Figure 2-7
Operable Unit 3 Sampling Stations
Long-Term Monitoring Work Plan

Shaw™ Shaw Environmental, Inc.
ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998
Boat Landing
USACE Channel Definition
Dams
Shoreline
Water Depth Contour - 10-Foot Interval
Water Depth Contour - 2-Foot Interval

2000 0 2000 Feet

Green Bay
GREEN BAY YACHT CLUB
I-43
141
WALNUT ST
29
57
BROADWAY
172
32
BROWN COUNTY FAIRGROUNDS
FOX POINT
DE PERE DAM
FORT JAMES TURNING BASIN
OU4
W
G
B
C,G
w,b
W,D
b
N
S
E
W

Operable Unit 4A

Operable Unit 4B

Figure 2-8
Operable Unit 4 Sampling Stations
Long-Term Monitoring Work Plan

Shaw Environmental, Inc.
ANCHOR QEA

Legend

Water Quality Monitoring Stations

Water Sampling Location and Transect

Suggested Fishing Areas

Fall (Aug - Oct)

W = Walleye
B = Smallmouth Bass
D = Drum
C = Carp
G = Gizzard Shad

Spring (Jun)

w = Walleye
b = Smallmouth Bass
d = Drum
c = Carp

Physical Features

Dock - Source: OSI 1998
Boat Landing
USACE Channel Definition
Dams
Shoreline
Water Depth Contour - 10-Foot Interval
Water Depth Contour - 2-Foot Interval

20000 0 20000 Feet

5 4 3 2 1 0 5 Miles

N W E S

RED ARROW
LITTLE RIVER
OU5C
MURPHY PARK
PESHTIGO HARBOR
OCONTO PARK II
OCONTO PARK I
OCONTO HARBOR
B
OU5B
STONE QUARRY
POTAWATOMI STATE PARK
SHERWOOD POINT
RILEY POINT
C
b
STEVENSON PIER ROAD
PENSAUKEE RIVER
SUGAR CREEK COUNTY PARK
CHAUDOIR DOCK PARK
J
S
OU5B FISHING STATION
GREEN BAY
OU5A
RED RIVER COUNTY PARK
W,D,G,C
BAY SHORE PARK
VOKE'S LANDING
SUAMICO RIVER
w
LONG TAIL POINT
HOWARD MEMORIAL
WINDJAMMER CLUB
b
W,B,D,C,G
GREEN BAY YACHT CLUB
GREEN BAY SAILING CLUB
OU5A FISHING STATION
5
10
15
20
25
30
141
41
57
I-43

Figure 2-9
Lower Green Bay Sampling Stations
Long-Term Monitoring Work Plan

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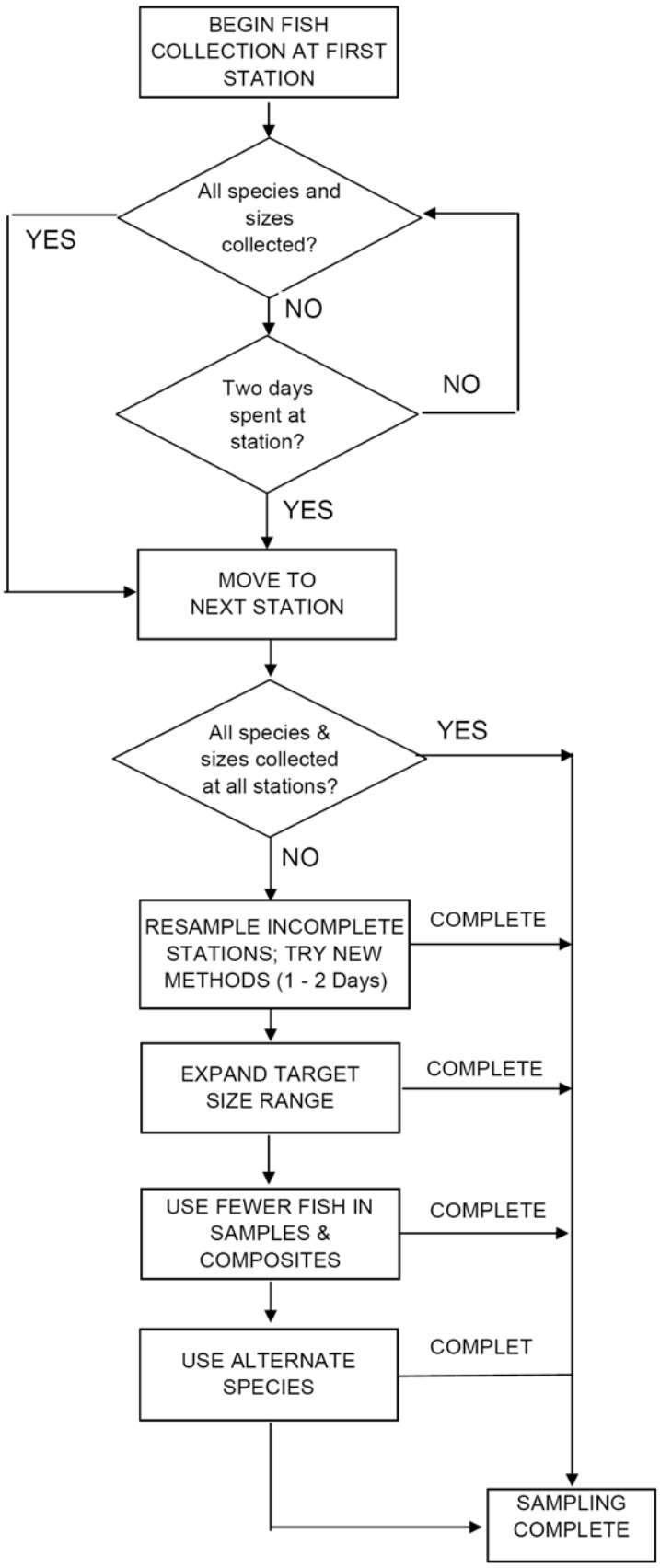

Figure 3-1
Field Decision Flow Chart for Fish Sampling
Long-term Monitoring Plan
Lower Fox River Remedial Design

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