1 Introduction

This Feasibility Study Report (FS) develops and evaluates a range of remedial alternatives for contaminated sediments in the Lower Fox River and Green Bay (Wisconsin). The FS Report was prepared by The RETEC Group, Inc. (formerly known as ThermoRetec Consulting Corporation [ThermoRetec]), on behalf of the Wisconsin Department of Natural Resources (WDNR). WDNR directed the project and received both funding and technical assistance from the United States Environmental Protection Agency (EPA) Region 5.

The FS completes the remedial investigation and feasibility study (RI/FS) program for the Lower Fox River and Green Bay Superfund site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP). Preparation of the FS conformed to procedures outlined in the EPA guidance document: *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA RI/FS Guidance) (EPA, 1988). This RI/FS report is consistent with the findings of the National Academy of Sciences National Research Council report entitled *A Risk Management Strategy for PCB-Contaminated Sediments* (NRC, 2001).

This FS develops remedial alternatives exclusively for the cleanup of contaminated sediments in the Lower Fox River and Green Bay for the long-term protection of human health and the environment. The following major components of the RI/FS program supported preparation of the FS:

- **Data Management (DM).** DM involved the development of a usable database produced through the identification, acquisition, review (validation), catalog, classification and archive of known available data sources (electronic and hard copy) pertinent to the Lower Fox River/Green Bay Risk Assessment (RA) and RI/FS. Usable data includes water, sediment, and fish tissue chemistry data. DM procedures and results are provided in the *Data Management Summary Report* prepared by EcoChem, Inc. under subcontract to ThermoRetec (EcoChem, 2000).

- **Remedial Investigation (RI).** The RI provided a compilation, review, and organization of physical, chemical and biological characteristics of the Lower Fox River and Green Bay. These characteristics provide the framework for a site conceptual model describing the magnitude and extent of chemicals of concern (COCs) in both sediment and water, and in the valued biological resources within the Lower Fox River and Green

Bay. Relevant physical and chemical characteristics of the Lower Fox River and Green Bay such as geology, surface water hydrology, sedimentation, chemical distribution, and fish/bird habitats are presented in the *Remedial Investigation for the Lower Fox River* (RI Report) (RETEC, 2002a). A summary of the RI is presented in Section 2 of this FS Report.

- **Risk Assessment (RA).** The RA involved the identification of COCs and risk-based sediment cleanup goals based upon realistic assessments of potential risks to ecological and human receptors. The RA provides an assessment of risks to human health and the environment that will support selection of a remedy to eliminate, reduce, or control those risks. The RA is presented in two documents: *Screening Level Human Health and Ecological Risk Assessment* (SLRA) (RETEC, 1998) and *Baseline Human Health and Ecological Risk Assessment* (BLRA) (RETEC, 2002b). A summary of the RA is presented in Section 3 of this FS Report.

- **Model Documentation Report (MDR).** The MDR compiled the fate and transport and bioaccumulation models used to estimate and forecast the movement of contaminated PCB sediment in the Lower Fox River and Green Bay. This report provides a "concise" compilation of the models used in the RI/FS including the Whole Lower Fox River Fate and Transport Model (wLFRM) developed by WDNR, the Lower Fox River Food Web Model (FRFood) developed by ThermoRetec, the Enhanced Green Bay Toxics Model (GBTOXe) developed by HydroQual, and the Green Bay Food Web Model (GBFood) developed by QEA. These models were used to predict long-term risk reduction in surface water and fish tissue levels over time after remedy completion.

1.1 Site Description

The project study area includes the Lower Fox River and Green Bay aquatic systems. The Lower Fox River is located in northeastern Wisconsin within the eastern ridges and lowlands of the state. The Lower Fox River is defined as the 39-mile portion of the Fox River, beginning at the outlet of Lake Winnebago and terminating at the mouth of the river into Green Bay, Lake Michigan (Figure 1-1). The river flows north and drains approximately 6,330 square miles, making it a primary tributary to Green Bay and a part of the Great Lakes system. Green Bay is a freshwater system approximately 120 miles long which drains into Lake Michigan (Figure 1-2), and is located on the state border between Wisconsin and Michigan along a northeast- to southwest-trending axis.

Historic discharges from municipal, industrial, and agricultural sources in the Lower Fox River region have degraded sediment and water quality and adversely impacted the ecology of the river and bay. The SLRA identified a list of chemicals of potential concern (COPCs) which included: polychlorinated biphenyls (PCBs) (total and Aroclors), dioxins/furans, 4,4'-dichlorodiphenyl trichloroethylene (DDT) and its metabolites, dieldrin, and several metals (arsenic, lead, and mercury). The BLRA concluded that the chemicals of concern (PCBs, mercury, DDE) represented the potential risks to human health and ecological receptors.

PCBs in the Lower Fox River pose the major potential threat to human health and ecological receptors due to their tendency to sorb to sediments, persist in the environment, and bioaccumulate in aquatic organisms. Contaminated sediments acting as "sinks" for PCBs and other contaminants are also subject to physical and chemical processes that affect the overlying water column and adjoining water bodies in natural (uncontrolled) environments. For example, PCBs from sediment in the Lower Fox River are discharged into Green Bay at the mouth of the river through sediment transport and PCB dissolution in the water column. The RA and RI should be referred to for a complete description of human and ecological impacts as well as the fate and transport of PCBs and other COCs, respectively.

1.2 Feasibility Study Process

The FS develops and evaluates a range of remedial alternatives for the Lower Fox River and Green Bay. This analysis provides the basis for selection of an appropriate cleanup remedy that meets site-specific remedial action objectives. While this is a state-lead (WDNR) effort, the overall assessment follows the procedures and paradigms developed as part of CERCLA and the NCP. The primary steps of the FS process include:

- Establishment of remedial action objectives (RAOs),
- Identification and screening of general response actions (GRAs) and remedial technologies that address the GRAs, and
- Development and detailed analysis of remedial alternatives.

Figure 1-3 illustrates how each section of this FS Report relates to fundamental steps of the FS process. By following EPA RI/FS guidance, a list of potential remedial alternatives for the Lower Fox River and Green Bay was developed and evaluated. The remedial alternatives provide the basis for the development of a Record of Decision (ROD). The following subsections describe the organization and contents of this FS Report.

1.2.1 Summary of the Remedial Investigation - Section 2

Section 2 summarizes the RI Report in terms of the hydrological, physical, chemical, and biological characteristics of the river. The summary describes the following elements of the river system that are pertinent to the FS process:

- **Environmental Setting:** a chronology of major developments and regulatory actions in the Lower Fox River region that have impacted the quality of the river and the river/bay ecosystem;

- **Physical Characteristics:** a detailed description of the four reaches comprising the Lower Fox River and the four zones of Green Bay;

- **Soft Sediment Thickness:** a summary of soft sediment thicknesses and distribution in the Lower Fox River and Green Bay;

- **Nature and Extent of Contaminants of Concern:** a summary of sediment chemical concentrations and vertical distributions across the four reaches and four zones;

- **Fate and Transport:** a generalized description of the processes by which chemical compounds are transported from their source(s) to potential human and environmental receptors; and

- **Time Trends:** a description of statistical changes in PCB concentrations in sediments, birds, and fish in both the river and bay over time.

1.2.2 Summary of the Baseline Human Health and Ecological Risk Assessment - Section 3

Section 3 summarizes the assessment of potential risks to ecological and human receptors that live, feed, and recreate in the Lower Fox River and Green Bay. Results of the risk assessment provide the basis for setting risk-based sediment cleanup goals and determining an appropriate remedial alternative that will eliminate, reduce, or control those risks. The summary describes the following elements of the RA that are pertinent to the FS process:

- **Overview of the Risk Assessment:** a description of potential risks associated with the Lower Fox River and the primary components (i.e., COPCs, sediment quality thresholds [SQTs], etc.) that are identified as part of the process;

- **Human Health Risk Assessment:** a brief discussion of the general methodology used for assessing potential risks posed to human health, including a summary of the results;

- **Ecological Risk Assessment:** a description of the general methodology used for assessing potential risks posed to ecological receptors, including a summary of the results; and

- **Sediment Quality Thresholds:** a summary of the assumptions and methods used to develop an array of SQTs with varying degrees of protectiveness to human health and the environment.

Sections 2 and 3 precede Sections 4 through 10 in this FS Report since they were integral to the direction of the FS process described in the following subsections.

1.2.3 Development of Remedial Action Objectives and General Response Actions - Section 4

The first step in the FS process involves establishing RAOs by integrating data from three key sources: site characteristics, human health and ecological risk, and applicable or relevant and appropriate requirements (ARARs).

Section 4 presents the RAOs and discusses the basis for establishing the RAOs for the Lower Fox River and Green Bay. This section also lists the ARARs and information that is "to be considered" (TBC) that constitute the regulatory/ guidance body for the project.

The GRAs selected to address the RAOs were developed from eight primary remediation strategy categories:

- No Action,
- Institutional Controls,
- Monitored Natural Recovery,
- Containment,
- Removal,
- *In-situ* Treatment,
- *Ex-situ* Treatment, and
- Disposal.

These GRAs were used to identify and screen appropriate action levels in Section 5 and remedial technologies in Section 6.

1.2.4 Development of PCB Action Levels for the Lower Fox River and Green Bay - Section 5

Prior to the development of remedial alternatives, the extent (volumes and areas) of contaminated sediments are identified, to which the GRAs apply. This task was accomplished by identifying areas of contaminated sediment based on analytical data and modeling. Action levels were used to define volumes and potential areas for remediation. These action levels, coupled with monitored natural recovery processes, will be used to determine the relative time frame expected for attainment of the project RAOs and residual SQT concentrations.

Section 5 identifies volumes and areas of impacted sediment and defines the extent of contaminated sediments to be addressed in the remedial alternatives.

1.2.5 Identification and Screening of Technologies - Section 6

A master list of remedial technology types and process options applicable to remediation of the Lower Fox River and Green Bay sediments was compiled for each GRA. An initial screening was performed to determine which technology types and process options were technically practicable and implementable. A second and final screening was performed to evaluate the various process options representing technology types that were retained from the initial screening. These were evaluated based on effectiveness, cost, and administrative (i.e., permitting issues, equipment availability, etc.) implementability.

Section 6 presents a description of the screening process and results of the screening. Additional criteria and other considerations that influence the development and analysis of remedial alternatives for the Lower Fox River and Green Bay are also presented in Section 6.

1.2.6 Reach-specific Remedial Alternatives - Section 7

Technology types and process options that were retained after completion of the screening were combined to develop remedial alternatives for each of the four river reaches and four Green Bay zones. A range of alternatives was developed as follows:

- No action as a baseline to which other remedial options are compared.
- Monitored natural recovery in which sediments will attenuate over time without active remediation. Provide institutional controls until remedial action objectives are met.

- Contain the COCs in place to reduce and/or eliminate exposure to human and ecological receptors.

- Remove and treat contaminated sediments to reduce the risk of human and ecological exposure to COCs.

- Remove and contain contaminated sediments within an on-site or off-site disposal facility to reduce risk to human and ecological receptors and minimize long-term management.

Section 7 presents potential remedial alternatives for the four river reaches and four zones of Green Bay. Section 7 also provides a discussion of the basis for development of the remedial alternatives, considerations for implementation of the different process options incorporated into each remedial alternative, and costs associated with implementation of each remedial alternative.

1.2.7 Alternative-specific Risk Assessment - Section 8

The reach-specific remedial alternatives are further evaluated in terms of risk reduction and residual risks. This evaluation identifies residual ecological or human health risks based on estimates of the effective reduction of the concentrations of COCs in the Lower Fox River and Green Bay attributable to a selected alternative.

Section 8 presents the alternative-specific risk assessment. This evaluation is intended to support a risk-based remedial alternative selection for the Lower Fox River and Green Bay. An alternative-specific risk assessment provides further comparative data on each remedial alternative that can be used as an additional decision-making tool in the ROD.

1.2.8 Detailed Analysis of Remedial Alternatives - Section 9

Each of the remedial alternatives was evaluated using criteria specified in the EPA RI/FS guidance. The criteria are divided into three categories as follows:

- Threshold Criteria
  - Overall Protection of Human Health
  - Compliance with ARARs

- Balancing Criteria
  - Long-term Effectiveness and Permanence
  - Reduction of Toxicity, Mobility, and Volume Through Treatment
  - Short-term Effectiveness

  - Implementability
  - Cost

- Regulatory/Community Criteria
  - State Acceptance
  - Community Acceptance

The regulatory/community criteria are typically addressed in the ROD and will be considered in the FS process during review by WDNR. WDNR will hold public meetings during the public comment period and will solicit comments on the contents of the RI and FS reports.

Section 9 presents a detailed analysis of each remedial alternative developed for the four reaches and four zones.

1.2.9 Comparative Analysis of Alternatives - Section 10

A comparative analysis focused on synthesizing the detailed analysis of Section 9 into a readily accessible decision-making tool will be performed in Section 10. This comparison is in contrast with the detailed analysis conducted in Section 9 in which each alternative is analyzed independently without a consideration of other alternatives. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another, so that the key tradeoffs the decision-maker must weigh can be identified. To accomplish this, numerical measures are used to evaluate how each alternative compares relative to all others with respect to addressing each of the following questions:

- What is the residual human health risk after implementation of an alternative?

- What is the residual ecological risk after implementation of an alternative?

- What is the level of disruption to local communities associated with the construction of each alternative?

- What is the administrative effort necessary to implement each alternative?

- What is the volume of contaminated sediment removed from the Lower Fox River and Green Bay?

- What is the cost of implementing each alternative?
- What is the incremental cost of reducing risk for each alternative?

Section 10 presents a synoptic comparison of the predicted performance of each of the reach-specific alternatives in relation to specific decision-making evaluation criteria.

1.2.10 References - Section 11

This section is a compilation of references cited in the FS. These references will be included in the administrative record for the project.

1.3 Application of NRC Findings and Recommendations

Based on national and growing concern regarding the long-term management of PCB-contaminated sediments, the National Academy of Sciences (NAS) was mandated by the United States Congress, via the National Research Council (NRC), to address the complexities and risks associated with managing PCB-contaminated sediments. The NRC was tasked with reviewing the availability, effectiveness, cost, and effects of technologies used for the remediation of sediments containing PCBs. The results of their findings were published in a document titled *A Risk Management Strategy for PCB-Contaminated Sediments* (NRC, 2001). Based on their review of PCB effects at several sites nationally, the NRC concluded that PCBs in sediment pose a chronic risk to human health and the environment, and that these risks must be managed. The NRC recommended that remedies should be site-specific and risk-based, and that no one remedy (dredging, capping, or monitored natural recovery) is applicable or preferred for all sites.

The recommendations of the NRC were adapted by the United States Environmental Protection Agency (EPA) in a document titled *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (EPA, 2002). EPA used the guiding principals defined by the NRC to develop a set of 11 risk management principles for application at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Resource Conservation and Recovery Act (RCRA) sediment sites. The EPA guidance principles specify use of scientific, risk-based, site-specific remedy decisions using an iterative decision process, as appropriate, which evaluates the short-term and long-term risks of all potential cleanup alternatives. These principles are consistent with the nine remedy selection criteria defined in the National Contingency Plan (NCP) (40 CFR Part 300.430) and application of these principles does not affect existing

statutory and regulatory requirements. A comparison of the NRC-developed and the EPA sediment management principals is given in the white paper titled *Applicability of the NRC Recommendations and EPA's 11 Management Principles* in the Responsiveness Summary.

The Lower Fox River and Green Bay RI/FS followed the guidance set forth by both the EPA and the NRC. These included:

- Using EPA risk assessment frameworks (EPA, 1989b for human health risk; 1997 and 1998b for ecological risk) that were based on the framework developed by NRC in 1983 which recommended a tiered and iterative approach;

- Using an extensive body of site-specific scientific information and data to bound the problem;

- Defining the problem in a site-specific manner through review of all existing scientific information in a preliminary assessment;

- Calibrating and defining the uncertainty of models that were used in the assessment; and by

- Structuring the documents so that a range of site-specific risks to human health and the environment were delineated, and articulating RAOs around which to structure potential remedial alternatives.

EPA's 11 risk management principles also are covered by the above bullet, as well as through public involvement; development of sophisticated fate, transport, and bioaccumulation models; early involvement of trustee groups; and implementation of three demonstration projects to test potential remedial technologies. These are discussed throughout the FS.

1.4 Section 1 Figures

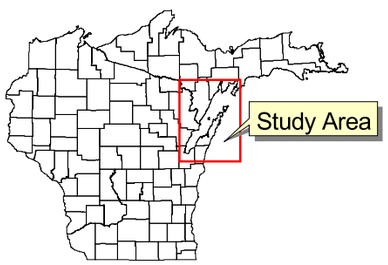
Figures for Section 1 follow this page and include:

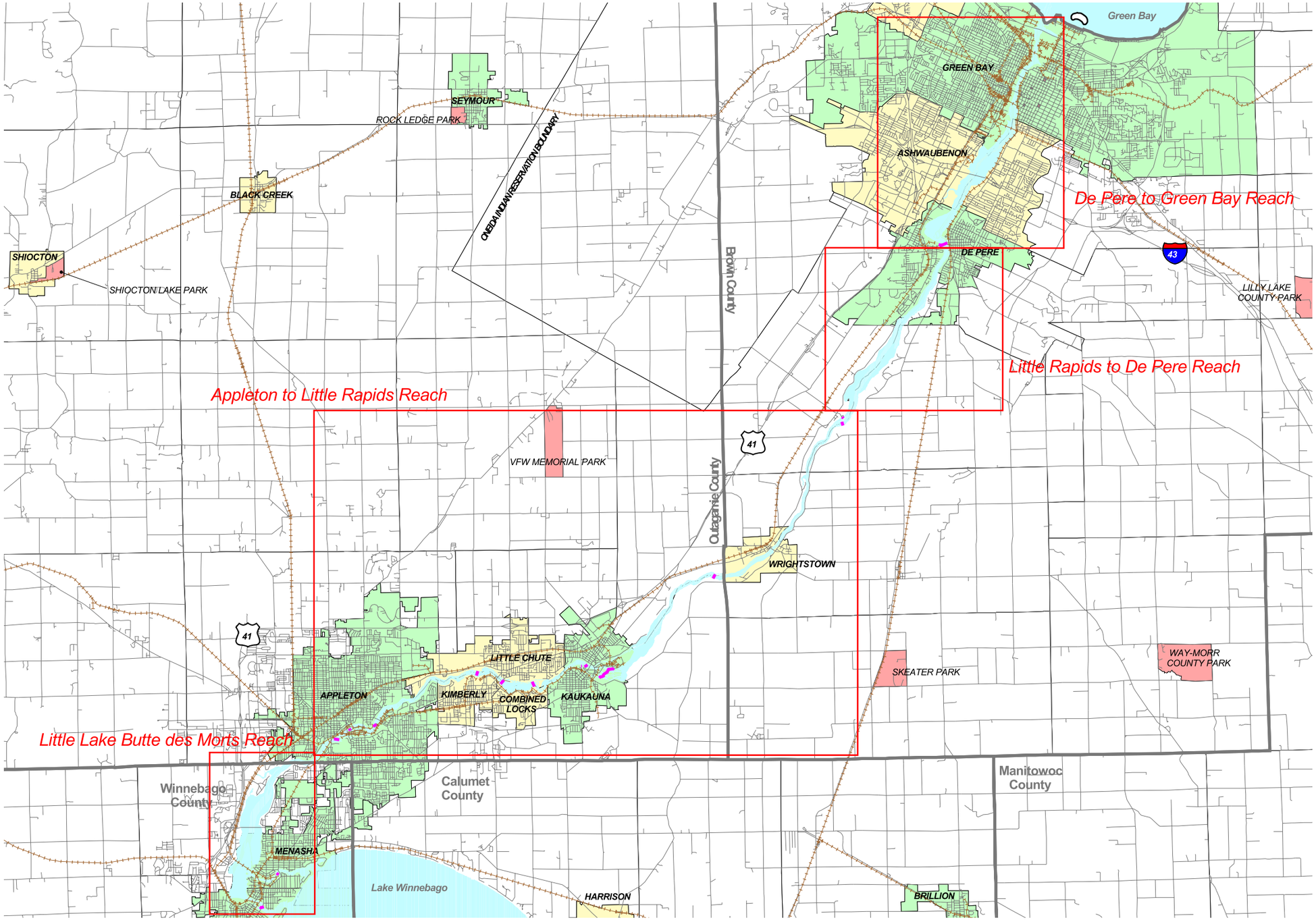
Figure 1-1 Lower Fox River Study Area
Figure 1-2 Green Bay Study Area
Figure 1-3 Overview of Feasibility Study Process

N
W E
S

County Boundaries
Dam Locations
Railroads
Roads
Wisconsin State Parks
Water

Civil Divisions
City
Township
Village
Reach Boundary





3 0 3 6 Kilometers

3 0 3 6 Miles

NOTE:
Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER Census data, 1995.

ThermoRetec
Smart Solutions. Positive Outcomes.

Natural Resource Technology

Lower Fox River & Green Bay Feasibility Study

Lower Fox River Study Area

FIGURE 1-1

REF NO:	FS-14414-535-1-1
CREATED BY:	SCJ
PRINT DATE:	3/9/01
APPROVED:	AGF

N
W E
S

Delta County
Big Bay de Noc
Stonington Peninsula
Garden Peninsula
GLADSTONE
ESCANABA
Little Bay de Noc
Little Summer Island
Summer Island
Poverty Island
Gravelly Island
Gull Island
St. Martin Island
GREEN BAY
ROCK ISLAND STATE PARK
Rock Island
Washington Island
Detroit Island
Plum Island
ZONE 4
STEPHENSON
WAUSAUKEE
Menominee Riv
Menominee County
Chambers Island
Sister Island
ELLISON BAY VILLAGE
Horseshoe Island
SISTER BAY
EPHRAIM
WI
MI
MENOMINEE
Strawberry Islands
FISH CREEK
PENINSULA STATE PARK
Peshtigo R
Green Island
Hat Island
MARINETTE
POUND
PESHTIGO
Marinette County
BAILEY'S HARBOR
EGG HARBOR
LENA
Oconto County
ZONE 3A
ZONE 3B
Door County
POTAWATOMI STATE PARK
STURGEON BAY
Lake Michigan
FORESTVILLE
DYCKESVILLE
Kewaunee County
ALGOMA
ZONE 2A
ZONE 2B
Brown County
Kidney Island
CASCO
LUXEMBURG
GREEN BAY
2
35
41
42
54
57

County Boundaries
Railroads
Roads
Wisconsin State Parks
Water
Civil Divisions
City
Township
Village

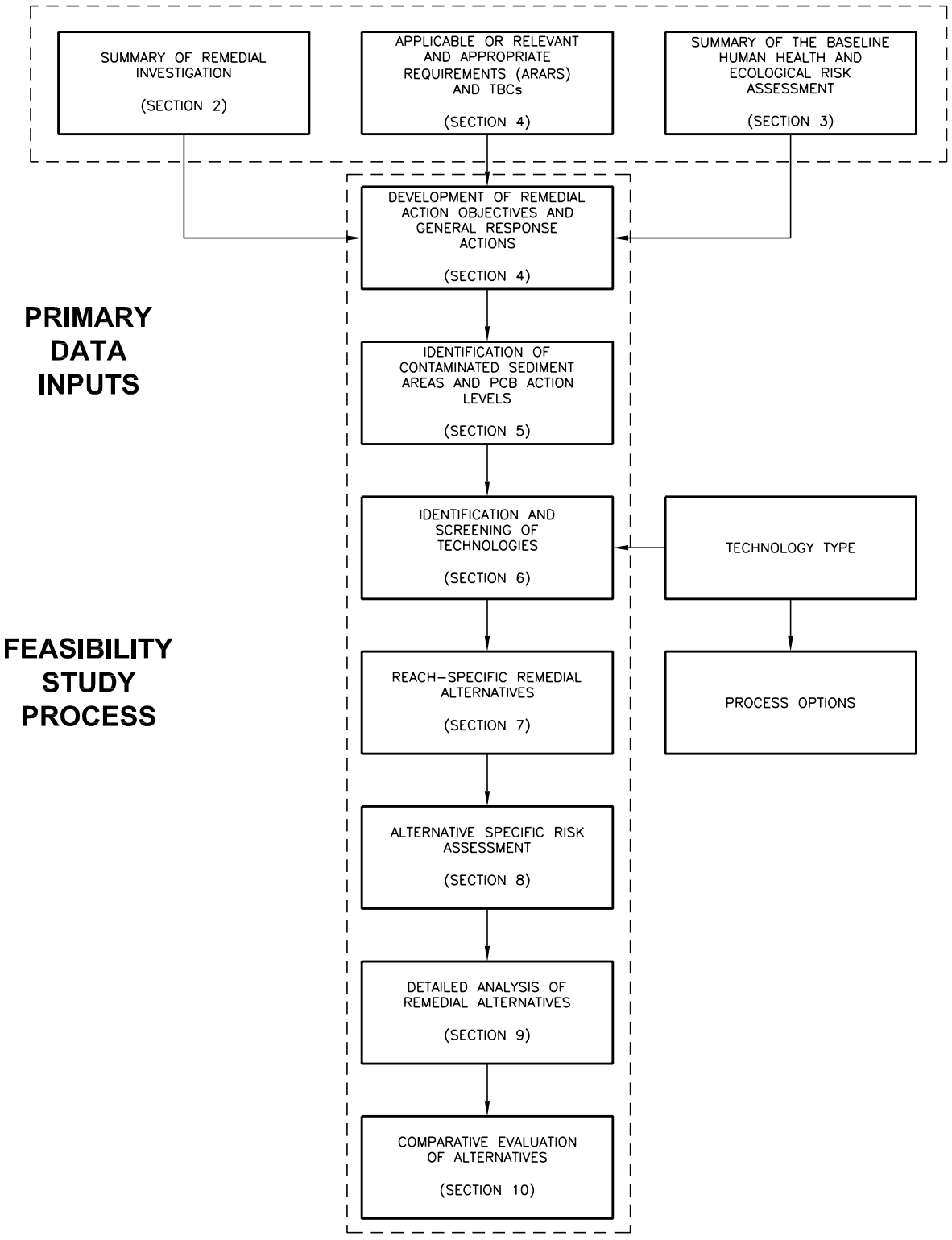
Study Area

5 0 5 10 15 Kilometers

5 0 5 10 Miles

NOTE:
Basemap generated in ArcView GIS, Version 3.2, 1998, and from TIGER Census data, 1995.

ThermoRetec Smart Solutions. Positive Outcomes.	Natural Resource Technology	Lower Fox River & Green Bay Feasibility Study	Green Bay Study Area	REF NO: FS-14414-535-1-2
				CREATED BY: SCJ
				PRINT DATE: 3/9/01
			FIGURE 1-2	APPROVED: AGF



ThermoRetec

LOWER FOX RIVER AND GREEN BAY FEASIBILITY STUDY

WISCN-14414-535

OVERVIEW OF FEASIBILITY STUDY PROCESS

DATE: 01/16/01	DRWN: N.S.	FILE: 14414s017		**FIGURE 1-3**