Fox, R., P.F. LANDRUM, and L. McCrone. 1994. Chapter 1: Introduction. In *Assessment and Remediation of Contaminated Sediments (ARCS) Program: Assessment Guidance Document.* U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL, EPA 905-B94-002, August 1994, 1-9.

1. INTRODUCTION

This document provides guidance on procedures for assessing the nature and extent of sediment contamination as applied to areas in the Great Lakes region. It was prepared under the Assessment and Remediation of Contaminated Sediments (ARCS) Program, administered by the U.S. Environmental Protection Agency's (USEPA) Great Lakes National Program Office (GLNPO) in Chicago, Illinois.

BACKGROUND

Although toxic discharges into the Great Lakes and elsewhere have been reduced in the last 20 years, persistent contaminants in sediments continue to pose a potential risk to human health and the environment. Elevated concentrations of contaminants in bottom sediments and associated adverse effects have been found throughout the Great Lakes and connecting channels. The extent of sediment contamination and its associated adverse effects have been the subject of considerable concern and study in the Great Lakes community and elsewhere. For example, contaminated sediments can have direct toxic effects on aquatic life, such as the development of cancerous tumors in bottom-feeding fish exposed to polynuclear aromatic hydrocarbons (PAHs) in sediments (Myers et al. 1990). In addition, the bioaccumulation of toxic contaminants in the food chain can also pose a risk to humans, wildlife, and aquatic organisms. As a result, advisories against consumption of fish are in place in many areas of the Great Lakes. These advisories have had a negative economic impact on the affected areas.

To address concerns about the adverse effects of contaminated sediments in the Great Lakes, Annex 14 of the Great Lakes Water Quality Agreement (1978) between the United States and Canada (as amended by the 1987 Protocol) stipulates that the cooperating parties will identify the nature and extent of sediment contamination in the Great Lakes, develop methods to assess impacts, and evaluate the technological capability of programs to remedy such contamination. The 1987 amendments to the Clear Water Act, in § 118(c)(3), authorized GLNPO to coordinate and conduct a 5-year study and demonstration projects relating to the appropriate treatment of toxic contaminants in bottom sediments. Five areas were specified in the Act as requiring priority consideration in conducting demonstration projects: Saginaw Bay, Michigan; Sheboygan Harbor, Wisconsin; Grand Calumet River, Indiana; Ashtabula River, Ohio; and Buffalo River, New York. To fulfill the requirements of the Act, GLNPO initiated the ARCS Program. In addition, the Great Lakes Critical Programs Act of 1990 amended the section, now § 118(c)(7), by extending the program by 1 year and specifying completion dates for certain interim activities. ARCS is an integrated program for the development and testing of assessment techniques and remedial action alternatives for contaminated

sediments. Information from ARCS Program activities will help address contaminated sediment concerns in the development of Remedial Action Plans (RAPs) for all 43 Great Lakes Areas of Concern (AOCs, as identified by the United States and Canadian governments), as well as similar concerns in the development of Lakewide Management Plans (LaMPs).

To accomplish the ARCS Program objectives, the following work groups were established:

- The **Toxicity/Chemistry Work Group** was responsible for assessing the current nature and extent of contaminated sediments in three of the five priority AOCs (i.e., Buffalo River, Indiana Harbor Canal, and Saginaw River; Figures 1-1, 1-2, and 1-3, respectively) by studying the chemical, physical, and biological characteristics of contaminated sediments, and for demonstrating cost-effective assessment techniques that can be used at other Great Lakes AOCs and elsewhere. Superfund activities have provided good characterizations of Ashtabula River and Sheboygan Harbor, so the ARCS Program focused the assessment activities on the other three priority AOCs.
- The **Risk Assessment/Modeling Work Group** was responsible for assessing the current and future risks presented by contaminated sediments to human and ecological receptors under various remedial alternatives (including the no-action alternative).
- The **Engineering/Technology Work Group** was responsible for evaluating and testing available removal and remedial technologies for contaminated sediments, for selecting promising technologies for further testing, and for performing field demonstrations at each of the five priority AOCs.
- The **Communication/Liaison Work Group** was responsible for facilitating the flow of information from the technical work groups and the overall ARCS Program to the interested public and for providing feedback from the public to the ARCS Program on needs, expectations, and perceived problems.

OVERVIEW OF SEDIMENT ASSESSMENT METHODS

Sediments are associated with impairment of beneficial uses at 42 of the 43 Great Lakes AOCs. Prior to addressing the potential need for remediation of those sediments, it is necessary to answer the following questions:

- Are the sediments sufficiently "contaminated" to warrant consideration for remediation? In this context, "contaminated" refers to the presence of chemicals in the sediments that have the potential to cause adverse effects in humans or ecological receptors.

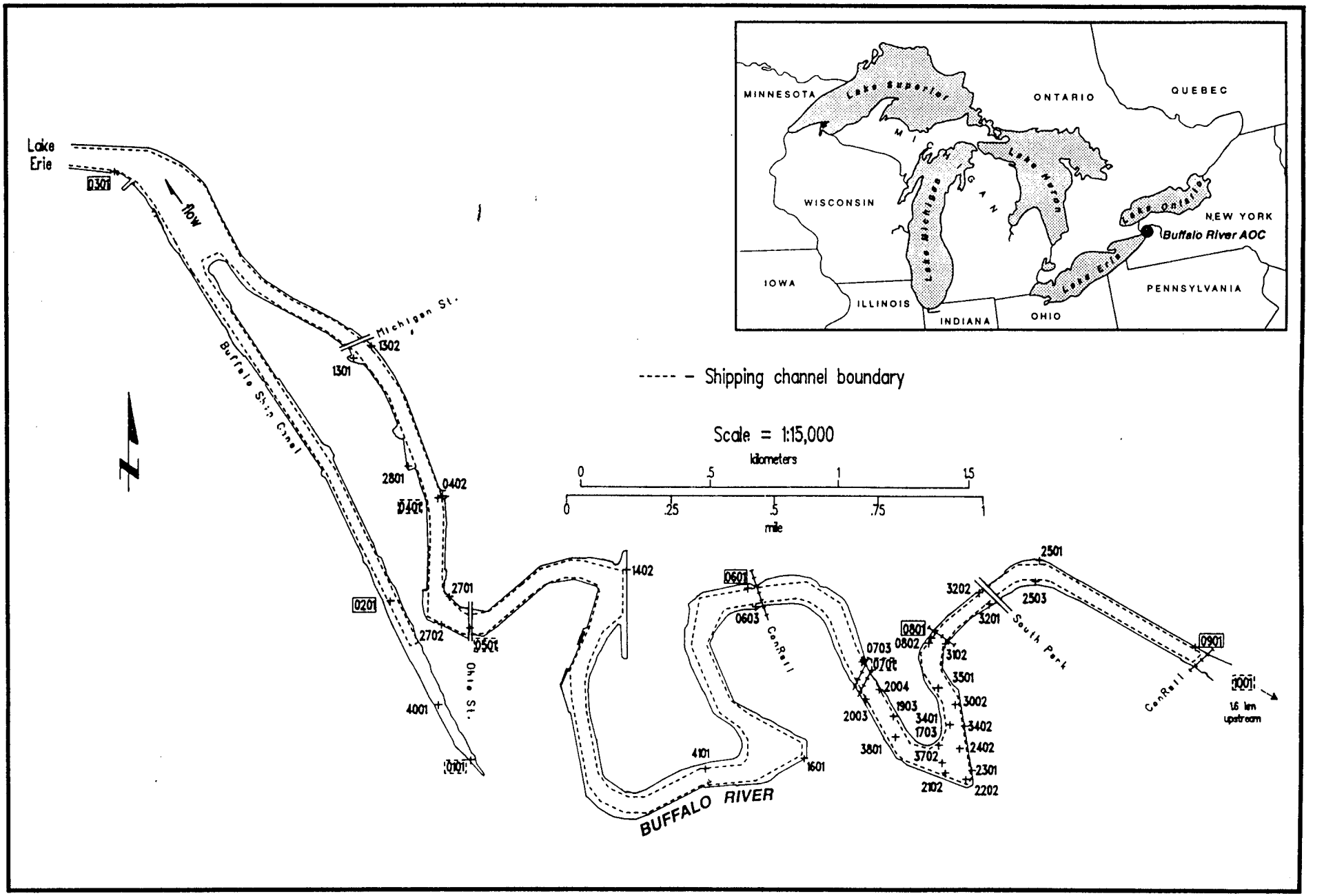

Figure 1-1. Buffalo River Area of Concern, New York.

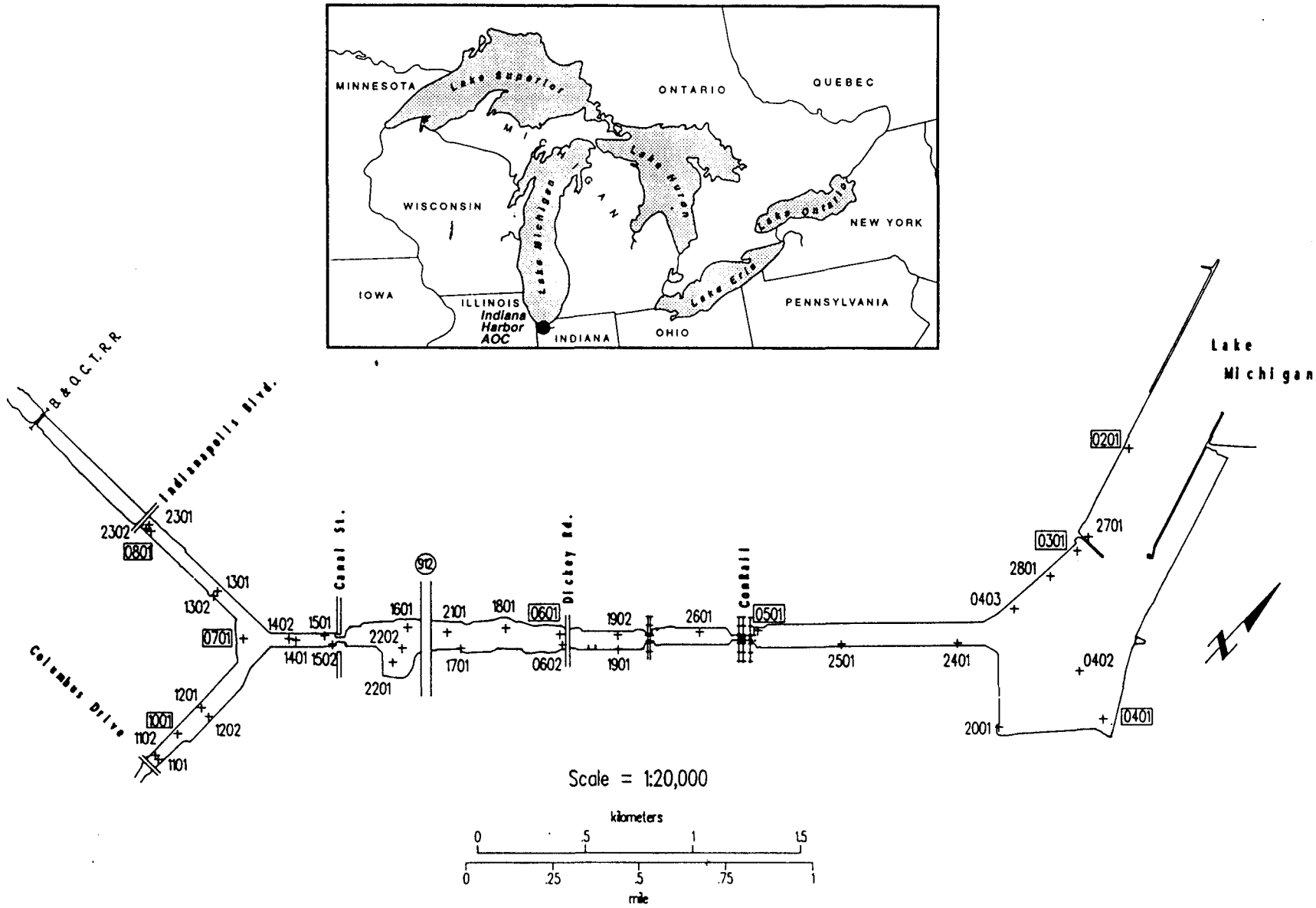

Figure 1-2. Indiana Harbor Area of Concern, Indiana.

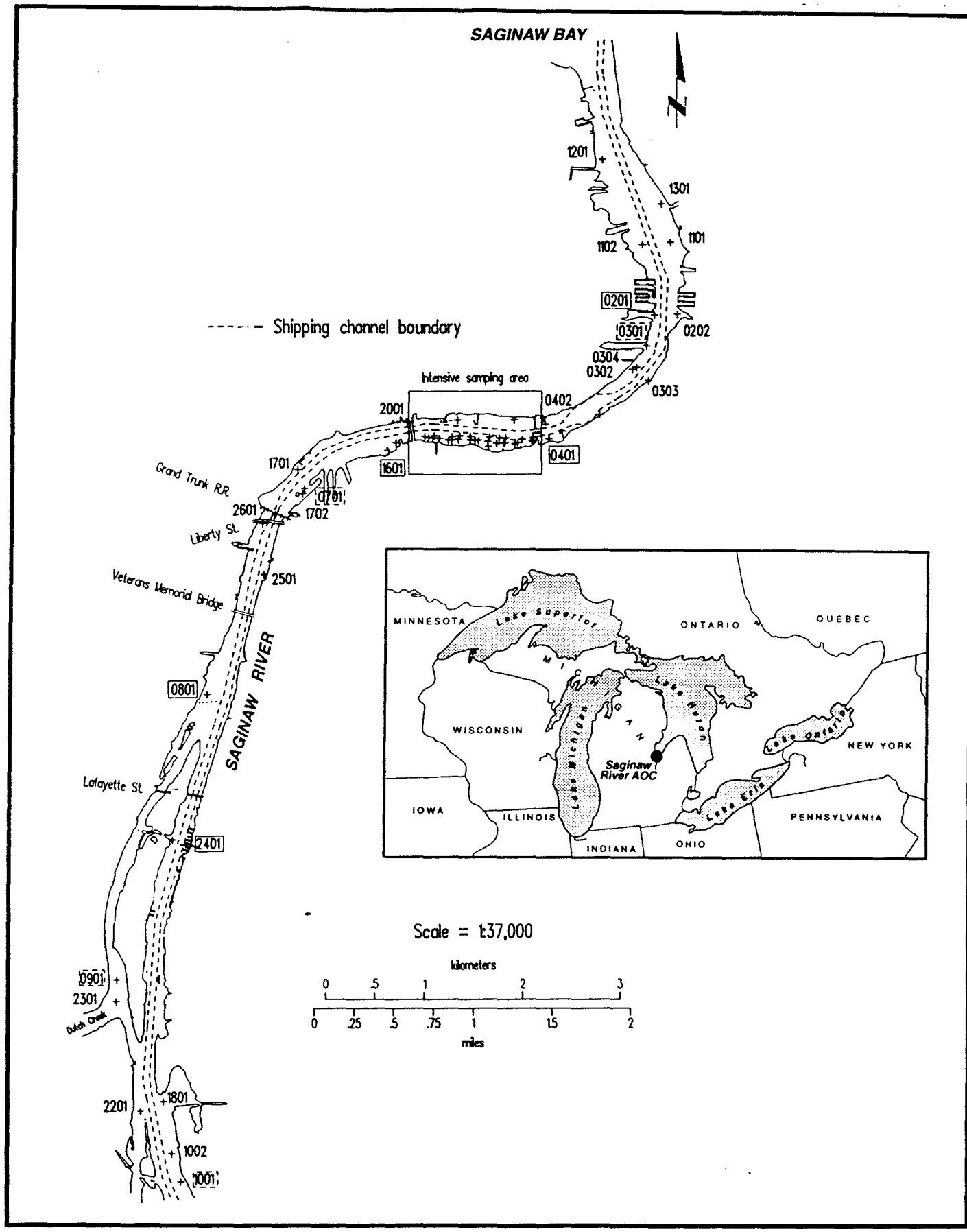

Figure 1-3. Saginaw River Area of Concern, Michigan.

- Is there evidence indicating that existing concentrations of sediment contaminants are adversely affecting ecological receptors? In other words, can it be shown that the presence of contaminants in the sediments is causing adverse effects in organisms, either organisms naturally occurring in the environment, or those exposed to sediments in controlled, laboratory toxicity tests?
- Are ecological receptors exposed to the sediments bioaccumulating chemical contaminants to the extent that the resultant body burdens are adversely affecting the organisms themselves or other organisms higher in the food chain, including humans?
- If the sediments are judged to be sufficiently contaminated to be causing such effects, what is the spatial extent (i.e., both horizontal and vertical) of the contamination, and what are the implications of the distribution of contaminants on possible remedial alternatives?

One of the main goals of the Toxicity/Chemistry Work Group was the selection of methods for answering these sediment assessment questions. Early in the ARCS Program, it was recognized that the current state of sediment assessment methods was rapidly evolving. Whereas in the past the focus had been primarily on measuring physical and chemical characteristics of the sediments, the emphasis over the last decade has been on the development of a suite of assessment methods that also incorporate a number of biological measures and indicators of sediment quality. The sediment assessment methods currently available consider a wide variety of endpoints and effects, which differ in their suitability and sensitivity for investigating sediment contamination. It is therefore vitally important that the assessment methods selected reflect site- and program-specific objectives of the study being conducted.

It was not the intent of the Toxicity/Chemistry Work Group to develop new sediment assessment methods, but rather to survey existing methods and select those methods that show the most promise for addressing the aforementioned questions at the Great Lakes AOCs. The selected sediment assessment methods were then applied in demonstration studies at several of the Great Lakes AOCs. There was a consensus among the work group members that the sediment assessment methods selected for demonstration should include an integration of physical, chemical, and biological information. This consensus reflects the common thinking of the scientific and regulatory communities that is succinctly summarized in the USEPA's *Sediment Classification Methods Compendium* (USEPA 1992) as follows:

> Unfortunately, there simply is no single method that will measure all contaminated sediment impacts at all times and to all biological organisms. This is the result of a number of factors, including environmental heterogeneity and associated sampling problems, variability in the laboratory exposures, analytical variability, differing sensitivities of different organisms to different types of contaminants, the confounding effects caused by the presence of unmeasured contaminants, the synergistic and antagonistic effects of contaminants, and the

physical processes of sediments. While one method will suffice for some circumstances, it is often advisable to use several complementary methods rather than a single one. When several of these approaches are used together, they can provide additional insights into the nature and degree of sediment contamination problems. The use of complementary assessment methods can provide a kind of independent verification of the degree of sediment contamination if the conclusions of the different approaches agree. If the conclusions differ, that difference indicates a need for caution in interpreting the data since some unusual site-specific circumstances may be at work. The importance of this type of verification increases with the significance of the decisions that must be made using the information obtained.

The integrated application of different sediment assessment methods is therefore valuable because decisions can be made on the basis of a preponderance of evidence.

As noted by USEPA (1992), there may be a regulatory requirement for the application of specific sediment testing procedures (e.g., the Toxicity Characteristic Leaching Procedure under the Resource Conservation and Recovery Act; the analysis of polychlorinated biphenyls [PCBs] under the Toxic Substances Control Act), criteria (e.g., the limitations in the London Dumping Convention), and evaluation procedures (e.g., risk assessment guidance under the Comprehensive Environmental Response, Compensation and Liability Act). It is not the intent of this document to describe the sediment assessment methods that might be required under such specific regulatory programs. Instead, this document describes sediment assessment methods that might be applied more generally in investigations of the nature and extent of sediment contamination. While the methods described herein are based on the experience of the ARCS Program and are intended primarily for application in the Great Lakes AOCs, they may be applicable in other aquatic environments as well. Some of the methods described (e.g., the sediment toxicity tests) are applicable only to freshwater environments, while others are more generally applicable.

Sediment assessment methods may be categorized as either numeric or descriptive (USEPA 1992). Numeric methods are chemical-specific and can be used to generate numerical sediment quality criteria for individual chemicals. Descriptive methods are not chemical-specific, but may be used to directly assess the overall impact of all chemicals that may be present in the sediment (e.g., through the use of sediment toxicity tests). A disadvantage of most numeric methods is that they cannot be used to predict the combined effect of several chemicals. The toxic units approach, however, does predict the combined effects of chemicals (Enserink et al. 1991). Descriptive methods, on the other hand, have the disadvantage that they cannot be used alone to generate numerical sediment quality criteria for specific chemicals.

Assessments of the nature and extent of sediment contamination focus on the measurement of the concentrations of chemicals of concern in the sediments, on the measurement of biological impacts, or, more commonly, on a combination of the two. Ultimately, an understanding of the causes of biological impacts can only come through synoptic surveys

that include measurement of chemical and biological parameters on the same sediment samples.

OVERVIEW OF THE ASSESSMENT GUIDANCE DOCUMENT

The remaining chapters of this guidance document address specific topics pertaining to the assessment of contaminated sediments. These chapters include:

- **Chapter 2. Quality Assurance and Quality Control**—Provides guidance on the necessary elements of a quality assurance and quality control (QA/QC) program, including the development of data quality objectives (DQOs) and measurement quality objectives (MQOs), the use of QA/QC samples, contents of quality assurance plans, development of a laboratory audit program, database requirements, and data verification/validation methods.
- **Chapter 3. Sediment Sampling Surveys**—Describes methodology for conducting field surveys of contaminated sediments, including the design of sediment sampling vessels, field positioning methods, sediment sampling procedures, field processing of sediment samples, and sediment characterization by remote sensing.
- **Chapter 4. Screening-Level Analyses**—Describes the use of relatively rapid, low-cost assays that can be applied either in the field or in the laboratory to focus comprehensive analyses on "hot spots" likely to require remediation or on "grey" areas where the integrated sediment assessment approach should be applied to evaluate the need for remediation.
- **Chapter 5. Chemical Analyses**—Provides guidance on the selection of appropriate chemical analytical techniques for sediment samples, including methods for conventional sediment variables, organic compounds, organometallic compounds, and metals.
- **Chapter 6. Evaluation of Sediment Toxicity**—Provides guidance on the selection of appropriate toxicity tests for assessing the biological impacts of sediment contamination.
- **Chapter 7. Assessment of Benthic Invertebrate Community Structure**—Provides guidance on the use of assessments of benthic invertebrate community structure as an indicator of *in situ* biological impacts of contaminated sediments.
- **Chapter 8. Fish Tumors and Abnormalities**—Describes the use of surveys of fish tumors and abnormalities as indicators of *in situ* biological impacts of contaminated sediments.
- **Chapter 9. Data Presentation and Interpretation**—Provides guidance on the application of several different methods of interpreting sediment quality

data, including procedures for mapping sediment quality data, sediment classification methods, and approaches to numerical ranking of contaminated sediments to prioritize sites for remedial action.

- **Chapter 10. Conclusions**—Provides an overall summary of this document.

In addition to describing usable alternatives within each chapter, recommendations are made for selecting appropriate sediment assessment methods, using the experience gained by the ARCS Toxicity/Chemistry Work Group to illustrate key issues. It is intended that the guidance on appropriate sediment assessment methods provided herein may be applied to other Great Lakes AOCs.

United States
Environmental Protection
Agency

Great Lakes
National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

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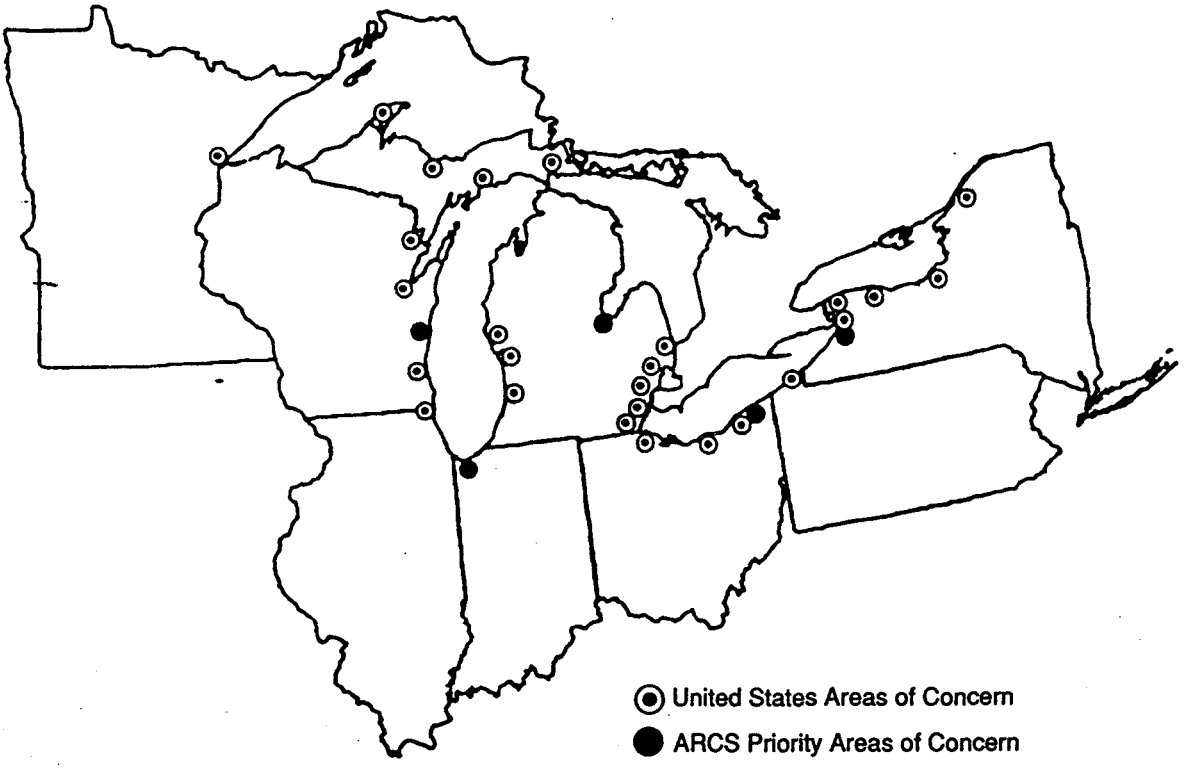

FINAL

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Edited by

PTI Environmental Services
15375 SE 30th Place, Suite 250
Bellevue, Washington 98007
(206) 643-9803

Under Contract to

BATTELLE OCEAN SCIENCES
397 Washington Street
Duxbury, Massachusetts 02332
(617) 934-0571

ASSESSMENT AND REMEDIATION OF CONTAMINATED SEDIMENTS
(ARCS) PROGRAM

ASSESSMENT GUIDANCE DOCUMENT

Great Lakes National Program Office
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

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Contributors to this report included:

Chapter 1. *Rick Fox*, USEPA, GLNPO, Chicago, Illinois

Peter Landrum, National Oceanic and Atmospheric Administration, Ann Arbor, Michigan

Lawrence McCrone, PTI Environmental Services, Bellevue, Washington

Chapter 2. *Brian Schumacher*, USEPA, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada

Rick Fox, USEPA, GLNPO, Chicago, Illinois

J.C. Filkins, USEPA, Environmental Research Laboratory, Large Lakes Research Station, Grosse Ile, Michigan

Bob Barrick, PTI Environmental Services, Bellevue, Washington

Chapter 3. *V.E. Smith* and *S.G. Rood*, AScI Corporation, Dearborn, Michigan

Chapter 4. *J.E. Rathbun, L.L. Huellmantel, M. Tracy,* and *K.A. Ahlgren*, AScI Corporation, Dearborn, Michigan

Chapter 5. *Eric Crecelius, Brenda Lasorsa, Lisa Lefkovitz*, Battelle, Pacific Northwest Division, Marine Sciences Laboratory, Sequim, Washington

Peter Landrum, National Oceanic and Atmospheric Administration, Ann Arbor, Michigan

Bob Barrick, PTI Environmental Services, Bellevue, Washington

Chapter 6. *G. Allen Burton, Jr.*, Wright State University, Dayton, Ohio

Christopher G. Ingersoll, National Biological Survey, Columbia, Missouri

Chapter 7. *Timothy Canfield*, National Biological Survey, Columbia, Missouri

Thomas La Point, Clemson University, Clemson, South Carolina

Michael Swift, University of Minnesota, Monticello, Minnesota

Chapter 8. *Mary Ellen Mueller*, National Biological Survey, Washington, DC

Michael Mac, National Biological Survey, Office of Research Support, Washington, DC

Chapter 9. *S.G. Rood* and *V.E. Smith*, AScI Corporation, Dearborn, Michigan

J.C. Filkins, USEPA, Environmental Research Laboratory, Large Lakes and Rivers Research Branch, Grosse Ile, Michigan

Mark L. Wildhaber and *C.J. Schmitt*, National Biological Survey, Columbia, Missouri

Chapter 10. *Lawrence McCrone*, PTI Environmental Services, Bellevue, Washington

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ABSTRACT

This document provides guidance on procedures for assessing the nature and extent of sediment contamination as applied to areas in the Great Lakes region. The document was prepared by the Toxicity/Chemistry Work Group as part of the Assessment and Remediation of Contaminated Sediments (ARCS) Program, administered by the U.S. Environmental Protection Agency's (USEPA) Great Lakes National Program Office (GLNPO), in Chicago, Illinois.

Assessment of sediment contamination is intended to determine whether chemical concentrations in the sediments are sufficient to cause adverse effects on either aquatic organisms or organisms higher in the food chain, including humans. One of the main goals of the Toxicity/Chemistry Work Group was the selection of scientifically sound methods for assessing sediment quality. The selected sediment assessment methods were then applied in demonstration studies at several of the Great Lakes Areas of Concern (AOCs).

The sediment assessment methods described in this document include an integration of physical, chemical, and biological information. Decisions regarding the possible need for sediment remediation could therefore be made on the basis of a preponderance of evidence.

The chapters of this guidance document focus on various topics related to the assessment of contaminated sediments. Included is guidance on the necessary elements of a quality assurance and quality control (QA/QC) program, considerations for the conduct of field surveys, screening-level analyses (i.e., relatively rapid, low-cost tests to focus subsequent comprehensive analyses on the more contaminated sediments), chemical analyses, toxicity tests for assessing biological impacts, assessments of benthic invertebrate community structure, surveys of fish tumors and abnormalities, and data presentation and interpretation techniques. In addition to descriptions of the available options within each chapter, recommendations are made to guide the selection of appropriate sediment assessment methods, using the experience gained by the Toxicity/Chemistry Work Group to illustrate key issues. It is intended that the guidance on appropriate sediment assessment methods provided herein may be applied to other Great Lakes AOCs as they undergo investigation by Great Lakes Remedial Action Plan (RAP) personnel at the Federal, State, and local levels.

This report should be cited as follows:

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