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ARCS

Assessment and Remediation of Contaminated Sediments

1991 Work Plan

U.S Environmental Protection Agency
Great Lakes National Program Office
Chicago, Illinois

Foreword

On November 16, 1990, President Bush signed into law the Great Lakes Critical Programs Act of 1990 (GLCPA). The GLCPA extends the ARCS program by one year, and stipulates a number of activities to be conducted immediately. As this Work Plan was prepared prior to the passage of this Act, it does not reflect the changes mandated in the Act. Future revisions of the ARCS Work Plan will reflect these changes.

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I. Overall Program Scope

1.0 Introduction

The 1987 amendments to the Clean Water Act, in Section 118(c)(3), authorize the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO) to coordinate and conduct a 5-year study and demonstration project relating to the control and removal of toxic pollutants in the Great Lakes, with emphasis on removal of toxic pollutants from bottom sediments. Five areas were specified in the Clean Water Act as requiring priority consideration in locating and conducting demonstration projects: Saginaw Bay, Michigan; Sheboygan Harbor, Wisconsin; Grand Calumet River, Indiana; Ashtabula River, Ohio; and Buffalo River, New York (Figure 1). In response, GLNPO has initiated the Assessment and Remediation of Contaminated Sediments (ARCS) program. ARCS is an integrated program for the development and testing of assessment and remedial action alternatives for contaminated sediments. Information from ARCS program activities will be used to guide the development of Remedial Action Plans (RAPs) for the 42 Great Lakes Areas of Concern (AOCs, as identified by the International Joint Commission), as well as Lakewide Management Plans.

Although GLNPO is responsible for administering the ARCS Program, it is a multi-organization endeavor. Other participants in ARCS include the U.S. Army Corps of Engineers (ACE), the U.S. Fish and Wildlife Service (FWS), the National Oceanic and Atmospheric Administration (NOAA), EPA headquarters offices, EPA Regions II, III and V, Great Lakes State Agencies, numerous universities, and public interest groups.

The management framework for the ARCS Program is depicted in Figure 2. The Management Advisory Committee provides overall advice on ARCS Program activities. The Management Advisory Committee is made up of representatives from the organizations noted above. Three technical Work Groups identify and prioritize tasks to be accomplished in their areas of expertise. These are the Toxicity/Chemistry, Risk Assessment/Modeling, and the Engineering/Technology Work Groups. The Communication/Liaison Work Group oversees technology transfer, public information, and public participation activities. The Activities Integration Committee coordinates the technical aspects of the work groups' activities.

2.0 Objectives

The overall objectives of the ARCS program are:

- *To assess the nature and extent of bottom sediment contamination at selected Great Lakes Areas of Concern,*
- *To evaluate and demonstrate remedial options, including removal, immobilization and advanced treatment technologies, as well as the "no action" alternative, and*
- *To provide guidance on the assessment of contaminated sediment problems and the selection and implementation of necessary remedial actions in the Areas of Concern and other locations in the Great Lakes.*

The primary aim of the ARCS Program is to develop guidelines that can be used at sites throughout the Great Lakes. Site-specific factors at the five priority consideration areas will need to be considered in

Figure 1. Map of ARCS Priority Areas of Concern

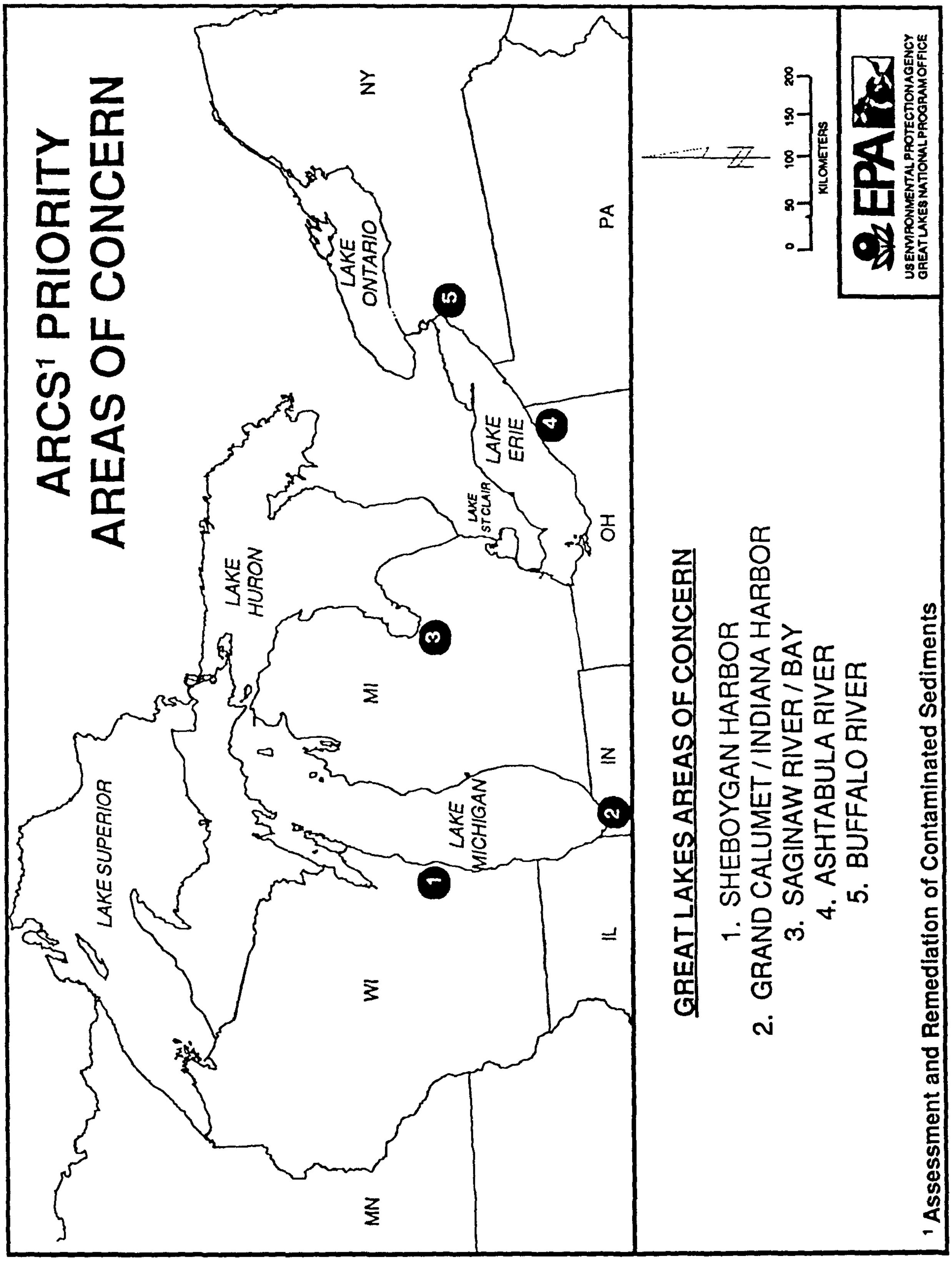


Figure 2. ARCS Management Structure

conducting assessments and choosing appropriate remedial alternatives for those locations. The varying characteristics at the five areas should provide a range of conditions applicable to other sites. The five sites are to be viewed as case studies of the application of the procedures developed under ARCS.

Another important aim of the ARCS Program is that the procedures developed and demonstrated be scientifically sound, and technologically and economically practical. The intent is to provide the environmental manager with methods for making cost-effective, environmentally sound decisions. As a result, application of existing techniques is stressed over basic research into new ones. Some developmental work is, however, being undertaken.

To completely assess the causes and effects of contaminated sediments and to fully evaluate the remedial options available, a mass balance of each of the priority areas, including quantification of contaminant loadings from point and non-point sources, would be desirable. Unfortunately, such characterizations could cost several millions of dollars for each priority area. The ARCS Program intends to use the available resources to develop a basic framework for site characterization. More in-depth evaluations could be performed if additional funds became available.

It is important to stress at the outset that ARCS is not a cleanup program, and will not solve the contaminated sediment problems at the five priority consideration areas. The Program will, however, provide valuable experience, methods, and guidance that could be used by other programs to actually solve the identified problems.

There are several important aspects of the management of contaminated sediments that will not be fully addressed by the ARCS Program because they were felt to be outside the main objectives of the study. Regulatory requirements and socioeconomic factors in decision-making are two such aspects that will be critical in the choice of a remedial alternative (or whether to remediate at all). While not addressing such issues in depth, the ARCS Program will identify issues that need to be resolved before sediment cleanups can go forward.

3.0 Activities

Many complicated issues need to be addressed in order to accomplish the objectives of this Program. These include:

- *Are the sediments contaminated with substances that are impairing or injuring biota (aquatic, mammalian, avian or human)?*
- *Is the injury of such magnitude or quality that remedial action is needed?*
- *Will remedial actions be effective in reducing or eliminating the impairment or injury?*
- *What remedial action alternatives are available, what are their limitations and how effective are they likely to be?*
- *What are the possible adverse impacts of the remedial action itself?*
- *What are the costs of taking remedial action?*

The three technical Work Groups are responsible for answering these questions. The general responsibilities of the Work Groups are as follows:

Toxicity/Chemistry Work Group. To assess the current nature and extent of contaminated sediment problems by studying the chemical, physical and biological characteristics of contaminated sediments and their biotic communities, to demonstrate cost-effective assessment techniques at the priority consideration areas that can be used at other Great Lakes Areas of Concern, and to produce three dimensional maps showing the distribution of contaminated sediments in the priority areas.

Risk Assessment/Modeling Work Group. To assess the current and future hazards presented by the contaminated sediments to all biota (aquatic, terrestrial and human) under the "no action" alternative and other remedial alternatives at the priority consideration areas, and to develop a ranking scheme for inter-site comparison.

Engineering/Technology Work Group. To evaluate and test available removal and remedial technologies for contaminated sediments, to select promising technologies for further testing, and to perform field demonstrations of as many of the promising technologies as possible.

Communication/Liaison Work Group. To facilitate the flow of information from the technical Work Groups and the overall ARCS Program to the interested public and to provide feedback from the public to the ARCS Program on needs, expectations and perceived problems.

Activities Integration Committee. The Activities Integration Committee has oversight over the ARCS Program, including the activities of each of the Work Groups. To aid in consistency in Program activities, the Activities Integration Committee is responsible for coordinating Quality Assurance/Quality Control (QA/QC) and data management activities of the ARCS Program. This involves ensuring that proper QA/QC measures are integrated into Work Group activities through the development and peer review of quality assurance and sampling and analysis plans.

More detailed descriptions of each Work Group's objectives and activities are provided in individual Work Group work plans presented in the following chapters.

Many of the activities performed by one work group will be useful to, or needed by, the other work groups. For example, physical, chemical and biological information obtained by the Toxicity/Chemistry Work Group will be needed by both the Risk Assessment/Modeling and the Engineering/Technology Work Groups. The Work Groups will interact with each other on a regular basis to ensure that needed information is obtained in a timely manner. The work plan identifies where information exchanges are expected.

While the Clean Water Act specifies that priority consideration should be given to the Ashtabula River, Buffalo River, Grand Calumet River, Saginaw Bay and Sheboygan Harbor, it does not preclude considering other areas in the Great Lakes. The ARCS Program will take advantage of ongoing sediment-related activities in these other locations where it would be beneficial. Some of the priority consideration areas are the sites of intensive work by other programs. Both the Ashtabula River and the Sheboygan River are being addressed under the U.S. EPA Superfund Program. Rather than duplicate efforts in these areas, ARCS will follow these activities to utilize the information gained, and will focus *its resources only on factors that are not being addressed by Superfund activities. This is felt to be the most cost-effective way to utilize ARCS funds.*

4.0 Products

Ten documents are foreseen as products of the ARCS Program. The tentative title of each document and a brief description of its anticipated focus are given below:

Volume I	*Executive Summary Document. A comprehensive overview of the ARCS Program, its objectives, activities and outcome.*
Volume II	*Layman's Guide to Contaminated Sediments. A non-technical overview of the contaminated sediments problem, which would focus on education of the public to enable their effective participation in local sediment-related issues.*
Volume III	*Contaminated Sediments Assessment Guidance. The primary technical document discussing techniques for the assessment of contaminated sediments, as demonstrated in the ARCS Program.*
Volume IV	*Contaminated Sediments Remediation Guidance. The primary technical document discussing techniques for the remediation of contaminated sediments, as demonstrated in the ARCS Program.*
Volume V	*Contaminated Sediments Management Document. A management document discussing how to deal with contaminated sediment issues from cleanup of existing contaminated sediments problems to preventing problems from developing in the first place. This document would discuss non-technical issues that need to be addressed in managing sediments, including socioeconomic factors and regulatory requirements. Much of this document will be developed by EPA Headquarters as part of the national contaminated sediment program.*
Volumes VI-X	*Each of the five priority consideration areas will be presented as a case study in the VI- implementation of the guidance contained in Volumes III through V.*

In addition to these products, each individual study funded by will be written up as a technical document.

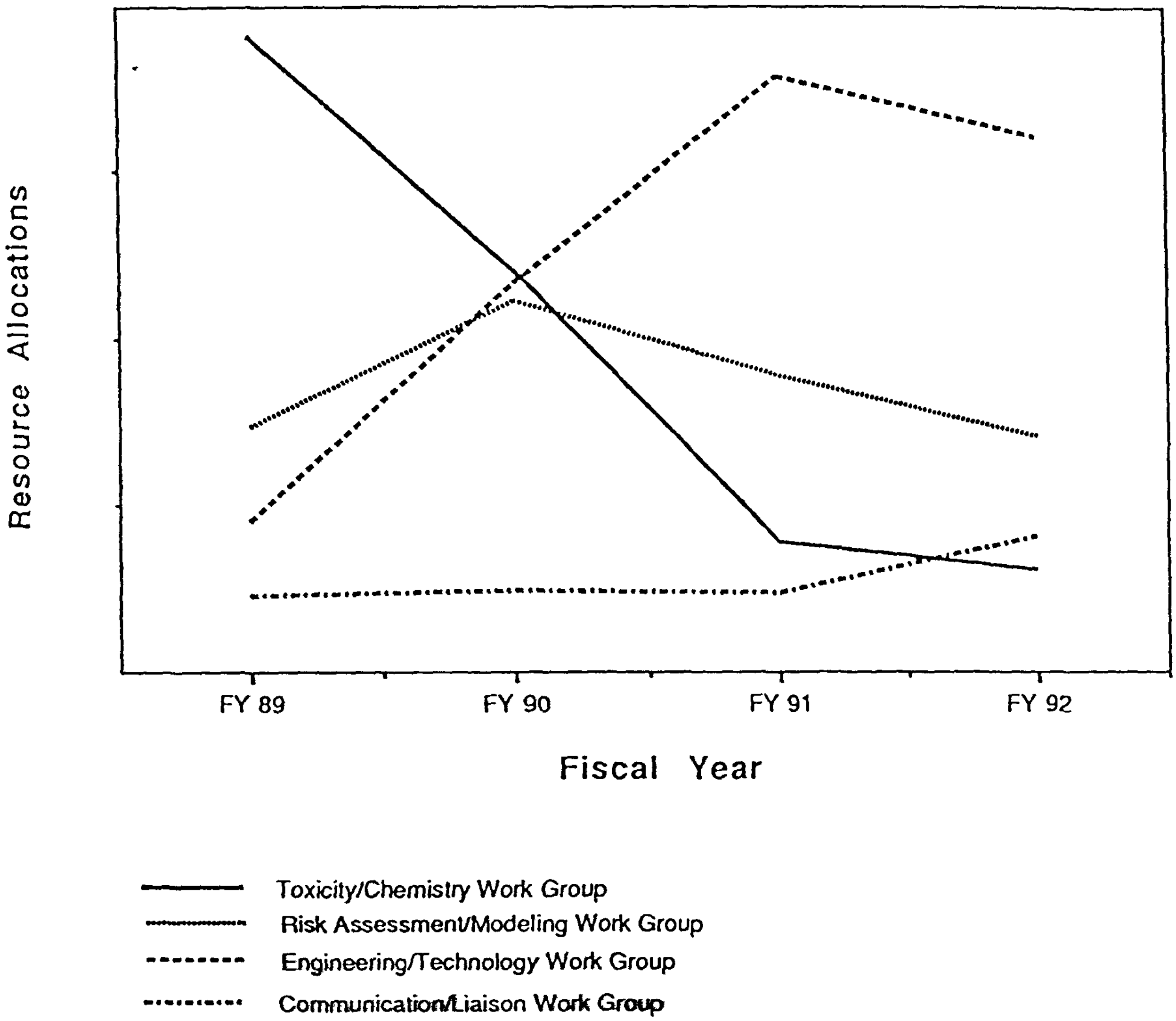
5.0 Timeline

Summary schedules of the activities for each of the work groups are presented within the chapters for the respective Work Groups. Figure 3 depicts the overall key activities and the level of effort and funding required by the Work Groups for the duration of the Program.

6.0 Quality Assurance/Quality Control

It is U.S. EPA policy that all environmental sampling and testing be done in accordance with a Quality Assurance Project Plan (QAPP). Therefore, all participating laboratories and investigators are

Figure 3. Relative Resource Allocations for Each of Four Work Groups



required to comply with strict quality assurance requirements through compliance with quality assurance special conditions in grants and Interagency Agreements (IAG). The purpose of the QAPP is to specify the policies, organization, objectives, and the quality assurance (QA) and quality control (QC) activities needed to achieve data of a "known and acceptable" quality for the ARCS project and that meets the overall ARCS objectives. These specifications are used to assess and control measurement errors that may enter the system at various phases of the project, e.g., during sediment sampling, preparation, and analysis. Adherence to an overall Quality Assurance/Quality Control (QA/QC) program is essential for a large, multi-participant program such as ARCS, to ensure that the data collected by individual investigators will be comparable and congruous.

To achieve the goal of obtaining data of "known and acceptable" quality for the ARCS Program the ARCS Activities Integration Committee (AIC) has oversight responsibility for the ARCS QA/QC program. The EPA Environmental Monitoring and Systems Laboratory in Las Vegas, Nevada (EMSL-LV), which is supported by Lockheed Engineering and Sciences Company (Lockheed-ESC), is responsible for the implementation and daily operation of the ARCS QA/QC program. The primary tasks of EMSL-LV and Lockheed-ESC are to: 1) assist in the development of program and project Data Quality Objectives (DQOs); 2) review QAPPs submitted by the principal investigators (PI); 3) develop a laboratory and field audit program; 4) develop a QA/QC evaluation scale for historical datasets; 5) prepare a Quality Assurance Management Program (QAMP); 6) act as an intermediate data repository for the ARCS program; and 7) prepare a final QA report. Each of these tasks will be discussed in more detail in the following paragraphs.

Upon initial entry into the ARCS program, a list of pertinent questions relating to the DQOs of the ARCS project was developed and distributed to the ARCS management and each of the technical work groups. The DQO questions were formulated to stimulate the program participants into thinking about the objectives of the ARCS Program and how their individual projects would fit in. The questions also made the PIs think about what type of data would be generated , whether it is relevant to the ARCS Program, and how much error was allowable in their measurements (i.e., develop Measurement Quality Objectives - MQOs) such that their data would not compromise the objectives of the ARCS Program.

Once the DQOs are established, the participating PIs are required to prepare QAPPs for their projects to satisfy the DQOs and have their QAPPs reviewed and approved by the QA staff at EMSL-LV prior to starting sample analysis. At EMSL-LV, the review process consists of the following steps:

1) Initial review by three scientists with at least one specializing in the area of quality assurance and one in the area of the principal type of analyses tat are being performed (i.e., inorganic or organic chemistry, bioassay, etc.).

2) Return of review comments to the PI for QAPP revision, if necessary.

3) Additional reviews by the same three scientists to ensure appropriate modifications and clarifications have been made.

4) If acceptable, the QAPP is then reviewed by the EMSL-LV QA officer for compliance with U.S. EPA policy and for completeness of the document.

5) If approved by the EMSL-LV QA officer, the document is started through the approval signature cycle.

6) Upon receipt of the completely signed QAPP, copies are made and distributed to the PI, ARCS Program Manager, EMSL, and Lockheed-ESC.

The review of the QAPP includes checking for the inclusion and discussion of the sixteen general requirements of a QAPP as specified by Stanley and Verner (1985). Specific checking for conformity of the laboratory-specified MQOs to the ARCS-defined MQOs is also performed. This review includes checking for acceptable instrument detection limits, appropriate acceptance limits and frequency of use of accuracy, precision, blank, and spiked samples, suitable calibration procedures, initial and on-going comparable analytical methodology, viable sample preservation techniques, and the correct sample holding times for given sample types.

To ensure that the QAPPs are being followed properly by the analytical laboratories, EMSL-LV has developed and will perform periodic on-site system audits at the laboratories. By the end of fiscal year (FY) 1990, four analytical laboratory audits and one field sampling audit will have been performed as part of the audit program. In addition, EMSL-LV will periodically distribute pre-award audit samples and routine audit samples to participating laboratories in an appropriate matrix (i.e., water or sediment/soil) will be prepared by the Lockheed-ESC staff and distributed to the analytical laboratory as single-blind samples (i.e., the sample identity is known to the laboratory but the analyte concentration is not). By the end of FY 90, one set of pre-award samples has been prepared and distributed covering nearly the entire range of analytes to be quantified as specified in the laboratory's QAPP. In FY 91, several sets of pre-award and routine audit samples may be prepared.

EMSL-LV has created and distributed to members of the Risk Assessment/Modeling Work Group and the ARCS management a final QA/QC evaluation scale for historical datasets. The evaluation scale will help establish the confidence level that the work group can place in the resulting baseline hazard evaluations and may also be used to possibly explain some of the data outliers that may result from their modeling efforts. A point system in which all essential QA/QC practices are given numerical values by parameter group, such as inorganic metals, pesticides/PCBs, and PAHs was selected. The historical data are then rated on the sum total of various categories. Categories include accuracy, precision, spiked samples, detection limits, blank usage, calibration procedures, sampling techniques, holding times, and other properties that might influence the integrity of the sample or the quality of the resultant data. Where deficiencies in the received data are noted, additional QA/QC data are requested from the analytical laboratory. If the deficiencies remain, flags are attached to the parameter groupings. The flags allow the data user to assess the value of the received data as is (actual rating) and the potential value of the data (assuming that if the flag indicates missing information that the analytical laboratory properly informed the missing QA/QC evaluation). By the end of FY 90, five databases will have undergone evaluation using this scale.

The development of the two reports for the ARCS Program, the QAMP and the final QA report, are in various phases of preparation. Outlines for the QAMP and the QA final report have been submitted to ARCS management for review. The QAMP will include an introduction, project description, as well as discussions of sampling strategy, field and laboratory operations, quality assurance objectives, quality assurance implementation, data quality assessment and reporting, QA/QC of historical databases, and the data management system. The final QA report will provide discussions of the project organization, QA program, audit program, data verification, and overview of the database structure and tracking, assessment of the success of the QA/QC protocols for detectability, accuracy, precision, representativeness, and comparability, as well as include a conclusion and recommendation section which addresses how well the program did from a QA/QC standpoint, and provide guidelines for future improvements on projects similar to those in the ARCS Program.

EMSL-LV will act as an intermediate database repository for the ARCS Program. This *responsibility will include the collection of all data fromthe analytical laboratories, creating computer programs to perform QA/QC checks on the data, conversion of the data from the received format to one acceptable in the Ocean Data Evaluation System (ODES), development of a cross-referencing system to track hardcopy data to its corresponding computer file, and to submit the final database on floppy disk to ODES personnel for uploading onto the mainframe computer at the National Computer Center (NCC) in Research Triangle Park, Raleigh, North Carolina. A more complete discussion of the data management and ODES system is provided in the following section.*

7.0 Data Management

The ARCS Activities Integration Committee will have overall oversight responsibility for the ARCS data management program. As mentioned in the previous section, EPA's Office of Marine and Estuarine Protection's ODES database will be the ARCS data repository. Data entry into this repository will be according to the requirements specified by the data management program. The principal investigators will provide their data to EMSL-LV before entry into ODES. This will assure the quality of the data going into the system. Data entry requirements will be a component of the participating investigators' QAPPs and a special condition of their receiving grant or IAG funds.

The ARCS Program will be using a Geographic Information System (GIS) for data analysis, output and mapping. The ARCS data minimum reporting requirements will include the data necessary for use in a GIS system. The data management program will be responsible for maintenance of the GIS system, as well as for fulfilling requests from study participants and report authors for particular outputs from the ARCS data base. The ARCS Activities Integration Committee will have oversight responsibility for the GIS system implementation.

8.0 Publication Policy

All publications that will result from work funded to support the ARCS Program must comply with the EPA peer and administrative review process. This review process helps ensure that published materials are scientifically valid and reflect EPA policy or that appropriate disclaimers to the contrary are included in the published work. The peer and administrative review process requires that all materials be submitted to the EPA Project Officer for review and comment prior to release to the public. EPA will then return its comments and suggestions for revisions to the principal investigator. If the principal investigator and EPA project officer can agree on the necessary revisions, then the publication will carry a statement to the effect that the document has been approved for publication as an EPA document. If they cannot reach agreement, then any publications must carry a disclaimer stating that the document does not necessarily reflect the views of EPA and no EPA endorsement of the document should be inferred. Articles published in refereed journals are exempt from the EPA review process, since the journal's peer review process will serve the same purpose. In such cases, the principal investigators are required to furnish copies of the article when it is submitted for publication and when it is eventually published. However, the article must still carry a disclaimer stating that it does not have EPA endorsement, since it has not gone through the EPA peer and administrative review process. A detailed explanation of these requirements can be found in 40 CFR Section 30.518.

II. Toxicity/Chemistry Work Group Work Plan

1.0 Introduction

The Toxicity/Chemistry Work Group is responsible for developing and testing sediment assessment methods. This Work Group will assess the nature and extent of contaminated sediment problems by studying the chemical, physical and biological characteristics of contaminated sediments and their biotic communities. The Work Group will demonstrate effective assessment techniques for aquatic life at the priority consideration areas. Finally, it will use the information obtained to produce contamination maps of the areas.

2.0 Objectives

The primary objectives of the Toxicity/Chemistry Work Group are:

1. *Contamination Survey Guidance. To develop guidance on the performance of assessment surveys of contaminated sediments through the development of a methodology for such surveys; and*

2. *Performance of Contamination Surveys. To implement contamination survey techniques at the priority consideration areas.*

3.0 Activities

The tasks needed to accomplish these objectives are:

1) *General characterization, sampling and mapping of sediment deposits,*

2) *Toxicity testing of sediment samples,*

3) *Chemical analysis of sediment and fish samples,*

4) *Broader spectrum toxicity testing on a selected subset of sediment samples,*

5) *Fish tumor and abnormality surveys,*

6) *Fish Bioaccumulation Assays.*

These tasks primarily address Objective 2. Objective 1 will be accomplished by summarizing and interpreting the results of the assessment activities undertaken in support of Objective 2 in preparing Volume III of the ARCS outputs, the Contaminated Sediments Assessment Guidance.

3.1 General Characterization, Sampling and Mapping of Sediment Deposits

In order to properly evaluate the nature and extent of sediment contamination in the priority consideration areas, each of the areas will be characterized for physical, chemical and biological parameters, including mapping the distribution of bottom sediments and sediment contaminants. It is desirable to have information on the physical and spatial characteristics of the sediments and some basic indicator parameters to help select the stations that will be subjected to more intensive testing and characterization.

There are four kinds of sampling stations being used for ARCS sediment testing:

- *Reconnaissance Stations,*
- *Master Stations,*
- *Priority Master Stations, and*
- *Extended Priority Master Stations.*

Table 1 shows the types of tests done at stations in each category. Surveys are conducted in 5 phases, described below. The sequence presented below is the recommended order of operations. Due to funding constraints and delays in equipment acquisitions, this order was not precisely followed in the ARCS surveys undertaken to date. The actual sequence achieved in studies to date is summarized in Section 4.0. Nevertheless, the ideal order is still the following:

1) *a pre-survey phase,*
2) *a reconnaissance survey phase,*
3) *an inter-survey phase,*
4) *a supplemental survey, and*
5) *a post-survey phase.*

3.1.1 Pre-Survey Phase

In the pre-survey phase, existing information on sediment contamination at each priority consideration area was obtained and reviewed. Based on this and discussions with investigators who have previously worked in the area, a transect/station grid was prepared to guide sampling and sediment profiling throughout the site. A first set of ten Master Station surficial sediment samples are then collected using a Ponar grab sampler or box corer. More detailed analyses were performed on these samples (Table 1) and then correlated with the results of the Reconnaissance Stations (described in Section 3.1.2) where only the indicator parameters are run. The pre-survey phase has been completed for all ARCS study areas

Reference points are located for deploying microwave transmitters in the positioning system used for mapping the area. Maps of the priority consideration areas are included in the last section of this document. Note that one of the Superfund Potentially Responsible Parties (PRPs) for the Sheboygan Harbor PCB contamination has done very extensive sampling in the Sheboygan River and Harbor for sediment, soil and water contamination. Through Fiscal Year (FY) 1989, this PRP has collected 20 soil samples of soils in the river's floodplain and nearly 200 sediment samples and has conducted 5 rounds of water column sampling under various flow conditions. As a result, the ARCS Program utilizes the existing data base, supplementing it only when appropriate to fill in missing information. The PRP's sampling sites covered the entire River and Harbor in a dense pattern from Sheboygan Falls to the mouth (actual stations are not plotted due to space limitations).

Table 1. Toxicity/Chemistry Analysis Matrix

	TYPES OF SAMPLING STATIONS			
TYPES OF ANALYSES	*Reconnaissance Stations*	*Master Stations*	*Priority Master Stations*	*Extended Priority Master Stations*
INDICATOR PARAMETERS				
BENTHIC COMMUNITY				
DETAILED CHEMISTRY				
TIERED BIOASSYAS o *Photobacterium* o *Selenastrum* o *Daphnia* o *Chironomus riparius* o *Hyalella* o *Pimephales*				
AMES AND MUTATOX				
COMPARATIVE BIOASSAYS o *Photobacterium* o *Selenatrun* o *Daphnia* o *Hyalella* o *Ceriodaphnia* o *Lemna* o *Pimephales* o *Hydrilla* o *Diaporeia* o *Hexagenia* o *Panagrellus* o *Bacterial enzymes*				
BIOACCUMULATION				

3.1.2 Reconnaissance Survey Phase

During the reconnaissance survey, acoustical soundings are used to map the physical distribution of sediments to aid in selecting sampling sites. Numerous sediment core samples (100 to 200 per area) are collected at this time to be tested for a set of "indicator parameters" which can be run relatively inexpensively on large numbers of samples. The core horizons are also visually characterized and photographed. The samples are homogenized and transported to laboratories for biological and chemical analyses as described below. The series of ARCS Reconnaissance Surveys were completed in December, 1990.

3.1.3 Inter-Survey Phase

The core samples obtained during the reconnaissance survey are analyzed for the following indicator parameters:

- *Sediment Grain Size Fractions,*
- *Wet Weight,*
- *Dry Weight,*
- *Ash Weight,*
- *Organic Carbon,*
- *Solvent Extractables,*
- *Organically-bound Chlorine, Bromine and Iodine,*
- *Inductively Coupled Plasma (ICP) Analysis of Selected Metals, and*
- *Microtox Bacterial Luminescence Assay Response.*

Figure 4 shows the procedures that will be used in the analyses. In principle, the indicator parameters will correlate with other measurements of contamination and toxicity. Therefore, use of the indicator parameters will allow the detailed analyses from the few Master Stations to be extrapolated throughout the site, based on correlations between Reconnaissance and Master Station data. Information from this analysis and from profiling data obtained during the reconnaissance survey will be used to prepare three-dimensional contamination maps (Figure 5). Maps of bottom topography and sediment layer thickness are also prepared. Based on these, the remaining ten Master Station sites per area are identified for sampling during the supplemental survey (resources permitting). The inter-survey phase will be completed in early Fiscal Year 1991.

3.1.4 Supplemental Survey

Sediments from the remaining ten Master Station sites are collected, homogenized and shipped to laboratories for chemical and biological characterization. Additional deep vibra-cores are collected at this stage, if required. Supplemental surveys at Saginaw and Buffalo have been conducted.

Figure 4. Sediment Sample Analysis Schematic

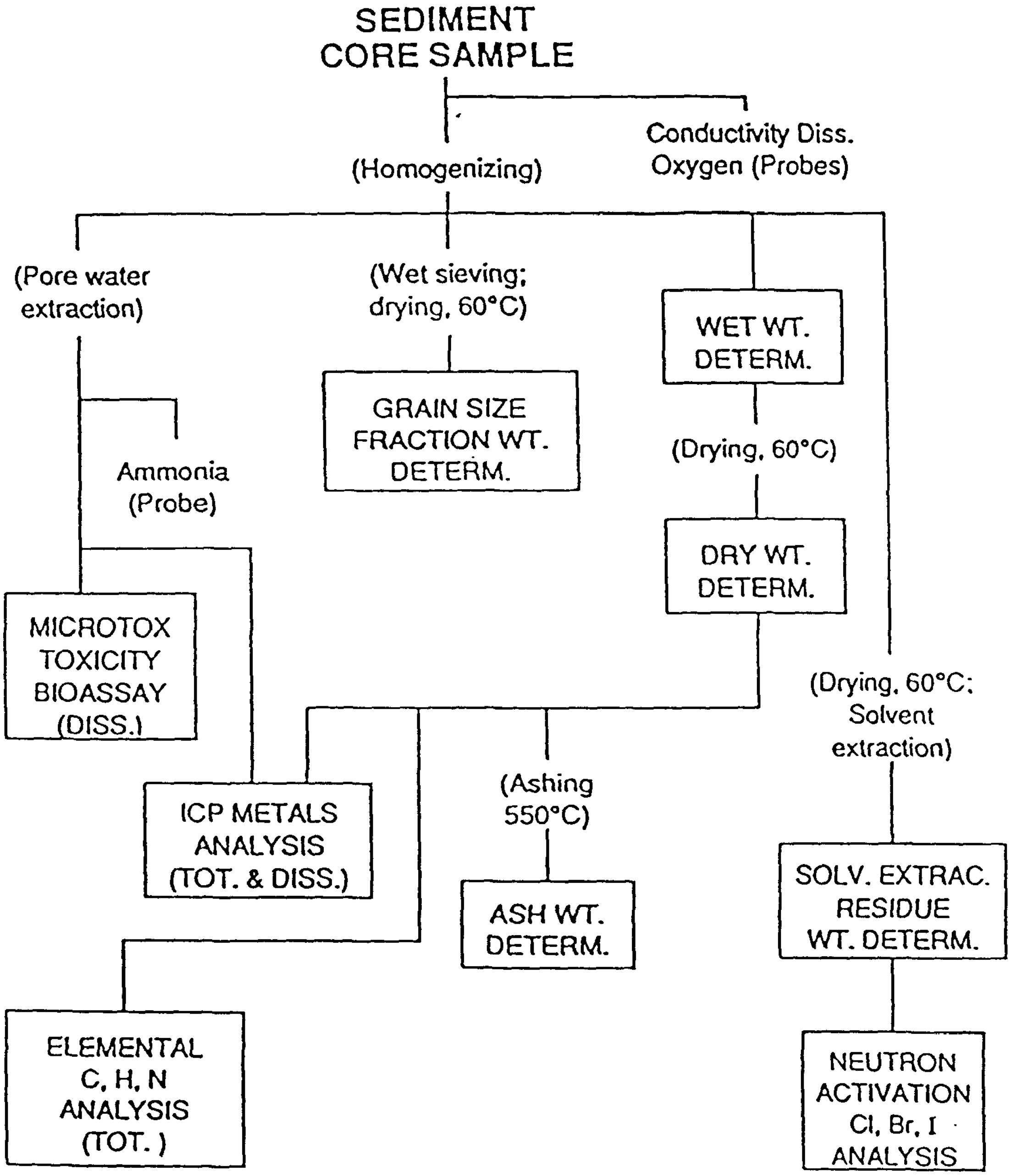
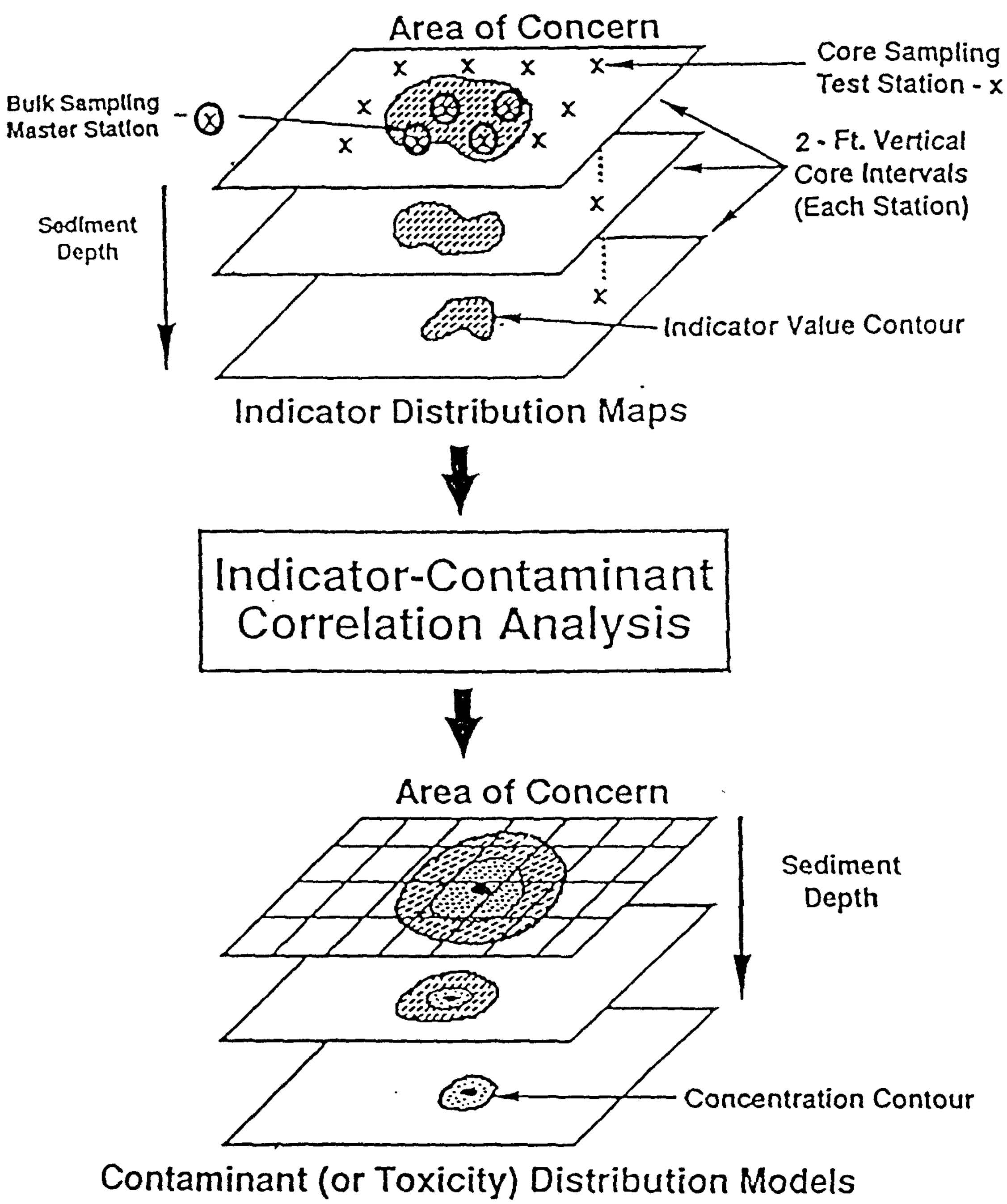


Figure 5. Process of Mapping Sediment Contamination and Toxicity



3.1.5 Post-Survey Phase

Preparation of the three-dimensional sediment, toxicity and contamination distribution maps are completed, using correlated data from Reconnaissance and Master Stations. These maps will be made available to both the Engineering/Technology and the Risk Assessment/Modeling Work Groups for use in their activities. The post-survey phase will be completed in January, 1991.

3.2 Sediment Biological Assessment

Laboratory toxicity testing of the Master Station sediments follows a tiered approach to make efficient use of analytical resources. The results of analyses at one tier are used to select which samples will undergo testing at the next tier. Fewer samples are analyzed in each successive tier since the tests become increasingly more time-consuming and costly. Tier I testing focuses on acute toxicity testing, benthic community structure and mutagenicity testing; Tier II focuses on partial life-cycle toxicity and Tier III on full life-cycle toxicity, sediment dilution and bioaccumulation.

Information on benthic community structure obtained in Tier I is combined with physical, chemical and other biological characteristics of sediment quality as part of an overall description of the contamination and its impacts. All Master Station samples undergo Tier I testing, using the following methods on elutriates of the sediment samples:

- *Daphnia magna, 48-hr mortality test.*
- *Microtox (Photobacterium phosphoreum) luminescence test.*
- *Selenastrum capricornutum, 24-hr carbon-14 uptake test.*

Approximately one-half of the Master Station samples undergoing Tier I testing are selected for Tier II testing, which consists of the Hyalella azteca, 7-14 day (whole sediment) growth test. Up to about one-quarter of the samples undergoing Tier I testing also go to Tier III testing, which consists of the Hyalella azteca 28-day (whole sediment) growth test and the fathead minnow (Pimephales promelas) flow-through bioassay (whole sediment). Selection of samples for Tiers II and III are made to satisfy two conditions. Sediments with low acute toxicity form the majority of the selections, while some with moderately acute and highly acute toxicity are included to provide an appropriate range over which to evaluate the tiered testing system. Other bioassays may be added, as deemed necessary by the Toxicity/Chemistry Work Group.

3.3 Chemical Analysis of Sediment and Fish Samples

Samples of sediments, sediment extracts and fish flesh (from the bioaccumulation assays) collected in the ARCS Program are subjected to chemical analyses. The analyses include a wide variety of inorganic and organic chemicals important to understanding sediment contamination problems in the priority consideration areas. Chemical parameters include:

- *Sediment Organic Carbon,*
- *Free and Acid Volatile Sulfides,*
- *Extractable Metals,*

- *Metals (silver, arsenic, cadmium, chromium, copper, mercury, manganese, nickel, lead, selenium, and zinc) in pore water, elutriates and bulk sediments,*
- *Organo-metals (methyl mercury and butyl tin),*
- *Polyaromatic Hydrocarbons (approximately 16 compounds),*
- *Polychlorinated Biphenyls (approximately 20 congeners),*
- *Chlorinated Pesticides,*
- *Chlorinated Benzenes,*
- *Chlorinated Naphthalenes,*
- *Chlorinated Dioxin and Furan congeners, and*
- *Semi-Volatile Chlorinated Compounds.*

3.4 Broader Spectrum Toxicity Testing of Selected Sediment Samples

The bioassays to be performed at the selected Master Stations are limited in number, due to constraints of cost, space and personnel. In order to provide guidelines for future contamination surveys, it is necessary to compare the results of the limited suite of bioassays to a larger set of bioassay methods. A cost-effective method of making such a comparison is to perform a more complete suite of bioassays on a reduced number of samples. To implement this, a consortium of university and government laboratories with recognized expertise in numerous other testing methods has been assembled. Sediments from selected Master Stations (Priority Master Stations) at each study area are distributed to these investigators for broader bioassay testing. The resulting information obtained from this effort is compared with the results of the limited suite of bioassays. Several of these bioassays also yield dose-response information, which will be useful in the Risk Assessment/Modeling Work Group's assessment efforts. This broader-spectrum testing on a limited number of samples also provides a check on the effectiveness of the tiered testing system. Table 2 gives an overview of all bioassay systems evaluated, by organism, exposure route, endpoint type, and duration.

3.5 Fish Tumor and External Abnormality Survey

Existing information on the incidence of external abnormalities and internal tumors in fish is sought at each priority consideration area. In addition, surveys to determine the incidence were undertaken in the Buffalo, Ashtabula and Saginaw Rivers. In these cases, one hundred individual fish were collected and targeted for field necropsy and histopathological examination at each area. Brown bullhead (Ictalurus nebulosus) is the primary study species, with the white sucker (Catostomus commersoni) serving as a secondary option.

3.6 Fish Bioaccumulation Assays

At a very limited number of Master Stations, the Extended Priority Master Stations, a 10-day fathead minnow (Pimephales promelas) bioaccumulation assay is conducted using bulk sediment samples. Chemical analyses of the fish tissue are conducted as described in Section 3.3.

Table 2. ARCS Biological Test Matrix

TEST SYSTEM	MEDIUM	ENDPOINT	DURATION
1) TOXICITY TESTS			
Photobacterium phosphoreum	Elutriate	Function	15 min
Selenastrum capricornutum	Elutriate	Function	24 h
	Elutriate	Growth	48 h
Daphnia magna	Elutriate	Mortality	96 h
	Sediment	Mortality	48 h
	Sediment	Reproduction	7 d
Chironomus tentans	Sediment	Mortality	10 d
	Sediment	Growth	10 d
Chironomus riparius	Sediment	Mortality	14 d
	Sediment	Growth	14 d
Hyalella azteca	Sediment	Mortality	7 d; 14 d; 28 d
	Sediment	Growth	14 d; 28 d
	Sediment	Reproduction	14 d; 28 d
Ceriodaphnia dubia	Elutriate	Mortality	48 h
	Elutriate	Reproduction	7 d
	Sediment	Mortality	48 h
	Sediment	Reproduction	7 d
Lemna minor	Sediment	Growth	48 h
	Sediment	Structure	48 h
Pimephales promelas	Sediment	Mortality	7 d
	Sediment	Growth	7 d
	Sediment	Terata	7 d
Hydrilla verticulata	Sediment	Growth	14 d
	Sediment	Function	4 d; 7d
	Sediment	Structure	4 d
Diporeia sp.	Sediment	Mortality	28 d
Hexagenia limbata	Sediment	Growth	28 d
	Sediment	Mortality	28 d
Panagrellus redivivus	Elutriate	Growth	4 d
Bacterial enzymes	Sediment	Function	2 h
Artificial Substrates	Sediment	Structure	28 d
2) OTHER TESTS			
Salmonella typhimurium	Org. extract	Mutation	72 h
Photobacterium phosphoreum	Org. extract	Mutation	12 h
Pimephales promelas	Sediment	Bioaccumulation	10 d
Ictalurus nebulosus	Sample	Tumors	Collection
Benthic community	Sample	Comm. structure	Collection

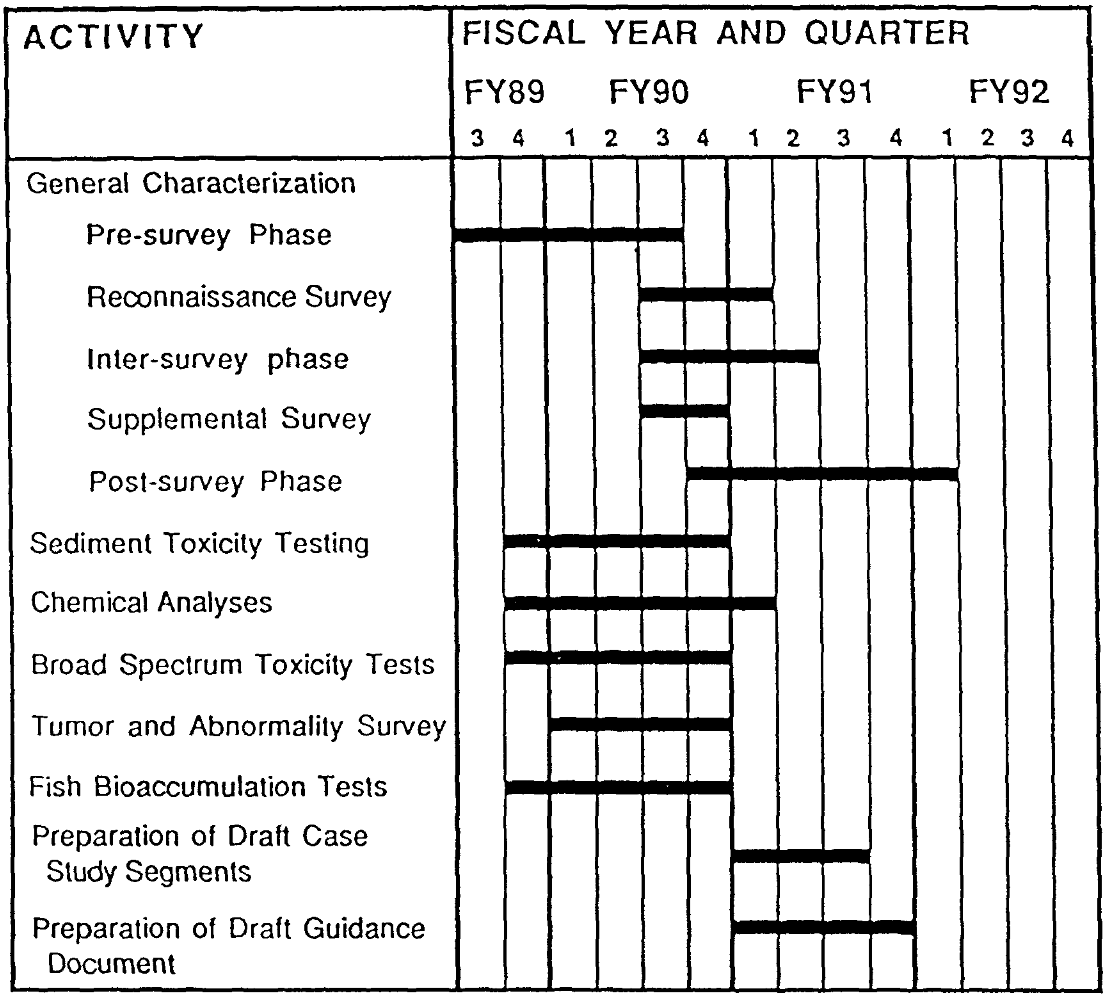
4.0 Products

The products of the Toxicity/Chemistry Work Group will consist of the development of technical documents for each discrete work unit (e.g., chemical analysis of sediments, toxicity testing of sediments) and the detailed maps of sediment deposits. In addition, the Toxicity/Chemistry Work Group will have a key role in the development of the Contaminated Sediments Assessment Guidance Document, Volume III of the final ARCS guidance, which will recommend a much abbreviated, less expensive suite of tests that can be performed to evaluate contaminated sediment. The writing of these documents will be done by a small group of Work Group members and funded investigators, coordinated by the Work Group Chairperson. GLNPO staff will oversee all phases of the document development.

5.0 Progress on Assessment Surveys

Although five surveys were originally planned, two of the priority Areas of Concern (Sheboygan Harbor and Ashtabula River - Fields Brook) are also designated as Superfund National Priority List sites. Due to ongoing activities related to Superfund at those sites, it was premature and potentially redundant to proceed immediately with ARCS surveys at those sites. The pre-survey phase was first conducted at the remaining three sites (Buffalo River, Indiana Harbor and Saginaw River). According to the original plan (see Section 3.1) the next step would have been reconnaissance surveys, followed by the work of the inter-survey phase, at each site. As the reconnaissance survey involved new equipment and methods, there were unforseen delays in equipment acquisition and installation. Consequently, the choice of ten more Master Stations for the supplemental surveys had to be made on the basis of pre-survey phase information. Furthermore, due to limited resources, the supplemental survey phase was limited to one area, the Saginaw Bay and River. Finally, the reconnaissance surveys were undertaken in Saginaw, Buffalo, and Indiana.

6.0 Timeline - Toxicity/Chemistry Work Group



III. Risk Assessment/Modeling Work Group Work Plan

1.0 Introduction

The Risk Assessment/Modeling Work Group is responsible for the evaluation of environmental and human health impacts resulting from contaminated sediments, and the development of techniques for assessing the environmental impacts resulting from the implementation of remedial alternatives. A mini-mass balance approach will be taken to provide the predictive capabilities necessary to determine such impact. The assessments will serve to identify and develop techniques and tools for performing sediment-related hazard evaluations. Assessments will consider the difficult task of separating the effects of sediments from those of the water column or other sources. A system for prioritizing sites with contaminated sediments will be developed and applied to the five priority consideration areas to provide a comparative framework for assessing multiple sites in need of remediation.

2.0 Objectives

The primary objectives of the RAM Work Group are:

1. *Hazard Evaluation: To evaluate exposures to, and impacts resulting from, contact with contaminated sediments and media contaminated by sediment contaminants, incurred by all receptors of concern under the "no action" alternative and other remedial alternatives. This evaluation will draw upon the development and integration of predictive tools to describe future hazards and risks.*

2. *Prioritization System Development: To develop and apply a numerically-based system for use as a decision tool to aid in the prioritization of sites for remedial action;*

3. *Development of Assessment Guidance: To develop guidance on the methods of assessing environmental and human health impacts of contaminated sediments.*

3.0 Activities

The tasks needed to accomplish these objectives are:

1) *Hazard Evaluation*

   - *Mini-mass Balance Approach*
     - *Exposure Model Development*
     - *Field Surveys to Calibrate Model*

   - *Risk/Hazard Assessments*
     - *Human*
     - *Aquatic Life*
     - *Wildlife*

2) *Site Prioritization*

Tasks under section 3.1 address Objective 1; tasks under section 3.2 address Objective 2. Objective 3 will be accomplished by the implementation and interpretation of activities under Objectives 1 and 2, in overall ARCS guidance documents.

3.1 Hazard Evaluation

As used here, the phrase "hazard evaluation" refers to the overall evaluation of impacts to all receptors of concern resulting from exposure to sediment contaminants, and consists of several discrete assessments. The ultimate purpose of the hazard evaluation is to determine the existing and future health risks and effects (e.g., carcinogenic, reproductive or systemic effects, community structure impacts, etc.) presented to human and environmental receptors (aquatic, avian, mammalian) from direct or indirect contact with sediment contaminants under different remedial options. The hazard evaluation is comprised of 1) an exposure assessment, 2) a human health risk assessment, 3) an aquatic hazard assessment and 4) a wildlife hazard assessment. Strictly speaking, the exposure assessment is an integral part of the human health risk assessment and the aquatic and wildlife hazard assessments, and is not usually separated out as such. However, since the activities involved in performing the exposure assessment are different than those involved in performing a risk or hazard assessment, this work plan makes a distinction between them.

Two levels of evaluation are proposed in this work plan: baseline and comprehensive hazard evaluations (Table 3). Baseline human health hazard evaluations will be performed for all five priority demonstration areas, and will be developed from available site-specific information. The baseline hazard evaluations will describe the hazards to receptors under present site conditions, or the "no action" alternative. This baseline assessment will examine all potential pathways that humans may incur risk from exposure to sediments for a given location. Comprehensive hazard evaluations will be performed for the Buffalo River and Saginaw Bay areas. These evaluations will describe the hazards to receptors under different remedial alternatives. These two areas were chosen based upon anticipated impacts from sediments, lack of other on-going activities (such as Superfund remedial activities), and lack of complicating factors (such as complicated ground water/surface water interactions, multiple sources of contaminant inputs, etc.). Information will be obtained through modeling exercises and field studies (described below). A variety of remediation scenarios will be examined as part of the comprehensive evaluation. These will include examining selective removal or capping of hot spots, source control, or dredging of an entire river, among others. Additionally, the comprehensive risk assessment will examine risk from losses of selected remedial alternatives. The following remedial alternatives may be considered in this phase of the comprehensive evaluation:

- *Capping*
- *Immobilization/Stabilization*
- *Extraction*
- *Chemical Treatment*
- *Biological Treatment*
- *Confined Disposal*

These remedial alternatives are being considered by the Engineering/Technology Work Group, which will determine the input of contaminants presented by each alternative. The RAM Work Group will use these contaminant loading estimates to estimate exposure and hazards to receptors and compare them to the "no action" alternative.

3.1.1 Exposure Assessment

As a component of both the human health risk assessment and the aquatic and wildlife hazard assessments, the exposure assessment strives to describe or predict the receptor's exposure to sediment-related contaminants. The assessment of direct or indirect exposure to sediment contaminants by receptors of concern will vary with the type of receptor considered (human, aquatic, avian,

Table 3. Hazard Evaluations to be Performed

	Types of Hazard Evaluation					
	Baseline			Comprehensive		
Priority Area	Aquatic Life	Wildlife	Human	Aquatic Life	Wildlife	Human
Ashtabula River			✓			
Buffalo River	✓	✓	✓	✓	✓	✓
Grand Calumet River	✓		✓			
Saginaw Bay	✓	✓	✓	✓	✓	✓
Sheboygan Harbor			✓			

mammalian), the exposure route (ingestion, inhalation, dermal uptake) and the exposure parameters (exposure magnitude, duration and frequency).

Probable human exposure routes which may need to be addressed in this assessment include 1) intake of sediment contaminants through the consumption of aquatic and avian wildlife into which sediment contaminants have bioaccumulated, 2) intake of sediment contaminants through ingestion of sediments (particularly in children between the ages of two to eight), and 3) dermal uptake of sediment contaminants resulting from recreational use of nearshore contaminated areas. Other exposure routes, such as inhalation of volatile contaminants in sediments or ingestion or inhalation of contaminants from drinking water supplies tainted by sediment contaminants may also be important, and may be considered if important on a site-specific basis.

Exposure assessments for aquatic biota will be evaluated in part by work being performed for the Toxicity/Chemistry Work Group. A suite of bioassays on the toxicological effects of sediment contaminants are planned by the Toxicity/Chemistry Work Group, including those to provide dose-response information. These data, along with existing information, will be the basis for the aquatic biota hazard assessment.

Exposure assessments for piscivorous avian and mammalian wildlife will focus mainly on the uptake of sediment contaminants through the consumption of biota into which sediment contaminants have bioaccumulated. Other routes of exposure may also be of importance, such as intake of contaminated suspended particles in whole water, or direct uptake of sediment contaminants dermally. The feasibility of analyzing these routes will be considered.

The input needed to perform the exposure assessments will be provided by existing information, information obtained from the Toxicity/Chemistry Work Group, through modeling and through the performance of selected field exposure studies.

3.1.1.1 Exposure Modeling

The purpose of exposure modeling is to provide a predictive tool to evaluate future exposures (and consequently hazards) if present conditions are maintained ("no action") or if cleanups are undertaken. The development and validation of models will proceed in two phases (Table 4). Phase I will focus on developing modeling tools using existing information.

Phase II will validate the approaches developed in Phase I by obtaining current synoptic information about the area via five to six sampling days on the river. Data will be collected on flows, contaminant loadings and concentrations in the water column of both the particulate and dissolved phases. This work will be conducted in September to November, 1990 for the Buffalo River, and March to May 1991, for the Saginaw River. To support the food chain model, fish species will also be collected and analyzed. For the Buffalo River, the food chain model will concentrate on carp, while for the Saginaw River, the walleye fishery and other forage fish will be sampled and analyzed. These data will then be used to calibrate the exposure models. Without calibration, there would be little confidence in the exposure model results.

Due to resource limitations, the Phase II field work to support the mini mass balance modeling

Table 4. Components of Phase I and Phase II Exposure Modeling Efforts

Phase I

1) Compilation, review and analysis of all pertinent environmental information.

2) Development of a sediment transport, deposition and resuspension model.

3) Use of Toxicity Identification Evaluation (TIE) approach where the cause(s) of toxicity (e.g., the particular chemicals) have not been identified.

4) Development of load/response relationships for the chemicals of concern based on existing information about loadings to the system.

Phase II

1) Measures contaminant loadings to the system, such as:

   - o Upstream loadings
   - o Tributary loadings
   - o Combined sewer overflows
   - o Hazardous waste site discharges.

2) Sample fish.

3) Measure flow characteristics of river.

4) Measure conventional parameters.

5) Characterize sediment deposits.

6) Perform a Toxicity Identification Evaluation (TIE) on selected Samples.

studies will only be conducted at two priority consideration areas: Buffalo River and Saginaw Bay. The contaminants to be mass balanced for the Buffalo River include:

PCBs	*lead*
DDT	*copper*
dieldrin	*benzo(a)anthracene*
chlordane	*benzo(b/k)fluoranthene*
benzo(a)pyrene	*chrysene*

The contaminants to be modeled for the Saginaw River are:

PCBs	*copper*
zinc	*lead*

The above contaminants were chosen based on fish advisories, concerns cited in the respective Remedial Action Plans, and results obtained from Toxicity Identification Evaluation work. These are also the two areas where comprehensive hazard evaluations will be conducted. The primary objectives of these mass balance modeling studies include the demonstration of available mass balance techniques and how they may be used as an aid in addressing management questions concerning the remediation of contaminated sediments. The mass balance studies are designed to allow estimates of the effects of remedial alternatives, using information provided from other ARCS projects, in order to estimate the response of the AOCs to these alternative remedial actions in terms of toxicity and concentrations of contaminants in the water, sediments and biota.

In the mass balance approach, the law of conservation of mass is applied in the evaluation of the sources, transport, and fate of contaminants. The approach requires that the quantities of contaminants entering the system, less quantities stored, transformed, or degraded in the system, must equal the quantities leaving the system. Once a mass balance budget has been established for each pollutant of concern, the approach can be used to provide quantitative estimates of the effects of changes in that budget.

A mass balance model is the means by which the mass balance approach is applied to a natural system. The application of the mass balance method involves the quantification of the sources, transport, and fate of contaminants. The specific components of the exposure modeling study are described below.

1) <u>Hydrodynamic Model Application</u>: The complex interaction of flows in the Great Lakes (due to upstream inflows and changes in lake elevation) requires that a hydrodynamic model be applied in order to estimate flows. For the systems of concern in the ARCS modeling studies, the model will be multidimensional in order to provide resolution of lateral as well as possibly vertical gradients in addition to longitudinal gradients in transport characteristics.

2) <u>Sediment Transport Model</u>: A model of cohesive sediment transport will be applied in order to predict the interactions between transport, deposition and resuspension processes under various meteorological and hydrological conditions. This model will provide predictions for use in the transport of sorbed contaminants and resuspension of toxic sediments. The model will aid in assessing the no-action alternative by providing estimates of burial rates and the effects of dredging on the system by providing estimates of sediment transport and times required to refill dredged areas. The application of a sediment transport model is of particular importance in these studies due to lack of historical sediment data.

3) Contaminant Exposure Model: Time variable exposure models will be applied in order to predict the effects of water and sediment transport, as well as the effects of sorption and kinetic processes such as volatilization and degradation, on the concentrations of certain critical contaminants. Modeling studies will be conducted concurrently of the riverine portions of the systems, and affected bays or lakes. The contaminant exposure model will assess the effects of loadings and various remedial alternatives on the system. The models will be applied to estimate load/response/uncertainty relationships, which will aid in addressing the study objectives. The models will also provide information that will be used by the Food Chain Model to estimate the contaminant body burdens in fish species due to varying exposure concentrations in water and sediment.

4) Toxicity Model: Since it may not be possible to relate exposure concentrations to toxic effects, it will be necessary to construct a toxic unit model of the system in order to estimate the probability of toxicity in response to various meteorological and hydrological conditions as well as to evaluate the impacts of proposed remedial alternatives. The toxic unit model will utilize information from the hydrodynamic and sediment transport models as well as data from sediment transport models to estimate the probability of toxic events.

5) Food Chain Model: A model of the food chain will be utilized to estimate the response of varying exposure concentrations on contaminant concentrations in the biota. The model will use data collected as part of the study in order to construct a simple food chain model as well as evaluate certain hypothetical food chains (due to reintroduction of some species) using information obtained from the other studies.

The study will utilize existing models and methods. The model which will be used as a framework for the study is Water Quality Analysis Program, WASP4 (Ambrose et al. 1988). This model will be used to integrate predictions from other models (e.g. hydrodynamic and sediment transport) in order to estimate contaminant concentrations in the water sediment and biota. The WASP4 model provides a consistent modeling framework for eutrophication, toxics transformation and transport, bioaccumulation, and food chain effects. It is maintained and distributed by the Center for Exposure Assessment Modeling at Athens and has been widely distributed around the world. It is presently the framework used for modeling studies in Green Bay, Lake Michigan, as well as studies on Lake Ontario and elsewhere on the Great Lakes.

3.1.1.2 Synoptic Surveys

Field sampling programs were designed to provide information required for the application of mass balance models. Synoptic surveys are planned for six sampling days for the lower Buffalo and Saginaw Rivers. Data will be collected on two low flow days, representative of low flow steady-state conditions. Samples will also be collected during an event lasting 3-4 days. The sampling stations were selected to allow estimates of pollutant influxes to, and effluxes from, the AOCs. Samples will be integrated over the width of the system and possibly over depth. Where significant stratification is encountered, samples will be taken at discrete depths at several locations. The data collected during the synoptic surveys will include flows, loading and concentration data for solids and chemicals in both water and suspended solids. Studies of selected conventional parameters will be collected at a greater frequency in order to aid in calibration of the hydrodynamic and sediment transport model, and in order to aid in estimating yearly loadings. Data on sediment contamination will be collected as part of studies *of other ARCS Work Groups. The types of data to be obtained are briefly described below.*

1) Hydrodynamic Data: Data for the calibration of the hydrodynamic model will include historical data as well as data collected as part of the field studies. Historical data are available on flows, water surface elevations at the mouth of the Buffalo and Saginaw Rivers, meteorological data, and concentrations of some conventional constituents such as temperature, conductivity, etc. The above data will also be obtained concurrently with field studies. In addition, water surface elevation data, velocity and discharge measurements, and wind velocity and direction data will be obtained.

2) Sediment Transport Data: Data for the calibration of the sediment transport model will also rely on historical data, such as U.S. ACE dredging records. Data on sediment characteristics (e.g. grain size, water content, etc.) will be collected during the sediment surveys. Also, bathymetry surveys will be conducted to estimated changes in the system's morphometry. Data on suspended solids will be collected concurrently with the river sampling, and suspended solids data will be collected either during high flow events (Buffalo River) or hourly during certain periods (Saginaw) in order to support the sediment transport model. Finally, "shaker" studies will be conducted to estimate the resuspension characteristics of the sediments.

3) Contaminant Exposure Data: Ambient water, sediment, loading, and food chain data for the calibration of the exposure model will use, whenever possible, historical data. In addition, surveys will be conducted to identify spatial variability in the system during certain low flow periods in the fall of 1990. Further studies will be conducted to identify pollutant loadings and ambient pollutant concentrations in water and sediments, and biota.

a. Pollutant Loadings: Pollutant loadings will be estimated and/or measured from point and non-point sources. Historical data will be assessed to estimate loadings from point sources as well as measurements acquired concurrently with the ambient water quality studies during the fall of 1990. Loadings from Combined Sewer Overflows (CSOs) will be estimated based on a limited field sampling program (24 samples at 10 CSOs) and storm water modeling in the Buffalo River study (CSOs were not identified as significant sources and will not be sampled in Saginaw). Loadings for contaminants and suspended solids from upstream tributaries will be based on 6 daily averaged measurements taken during the fall of 1990. Historical contaminant, suspended solids and flow data, as well as data from the suspended solids survey, will be used to extrapolate these measurements to annual loading rates. An analysis of the uncertainty of these estimates will also be performed.

b. Ambient Water Concentrations: Ambient data for particulate and dissolved contaminants as will as conventional parameters will be obtained over six sampling days during the fall of 1990.

c. Sediment Data: Data for sediment concentrations will be collected as part of separate sampling studies planned for the spring of 1990.

4) <u>Food Chain Data</u>: Data will be collected for carp in the Buffalo River and their stomach contents analyzed in order to establish a relationship between carp contaminant concentrations and their benthic forage. Carp were selected for analyses for two reasons. First, there are presently advisories in effect for consumption of carp in the Buffalo River. Second, the available resources limit the possibility of collection data to support an evaluation of fish species with a more complex food chain. Data will be collected for nine carp (divided into three age classes) for analysis. Sampling in the Saginaw River will concentrate on walleye and its food chain due to the importance of the walleye fishery in this area.

The final phase of this approach will be to verify and calibrate the models in Phase I using the site-specific data collected in Phase II.

3.1.2 Risk and Hazard Assessments

The activities involved in the preparation of the individual Risk and Hazard Assessments vary depending upon the area evaluated, the receptors and the endpoints considered. It is primarily a paper exercise, combining information on exposure to, and toxicity of, sediment contaminants. The Baseline Assessments will use existing data, while the Comprehensive Assessments will use the results obtained from the exposure modeling work to predict future risk.

3.1.2.1 Human Health Risk Assessment

Cancer risks and non-cancer hazards potentially incurred resulting from direct and indirect exposure to sediment contaminants, will be considered. Risks and hazards will be calculated using methods recommended by the U.S. EPA Risk Assessment Guidelines of 1986 and other generally recognized risk assessment procedures. Uncertainties in the risk assessment will be stated, as will the assumptions, and discussion on the overall meaning of the risk assessment will be developed. Toxicological information required to calculate risks or hazards may not be available for all chemicals found in the demonstration areas. Therefore, the baseline risk assessment will identify information which is required for the evaluation but not available, and such needs will be recommended to the Activities Integration Committee for resolution. As part of the comprehensive evaluations planned for the Buffalo River and Saginaw Bay, target sediment concentrations (i.e., chemical concentrations below that associated with unacceptable risks and hazards) will be calculated for chemicals identified as responsible for the majority of the risk or hazard.

One of the more potentially important impacts of some chlorinated organic compounds, such as PCBs, are their potential adverse development effects upon infants and children. Recent epidemiological evidence exists that suggests developmental effects have occurred in young children whose mothers were heavy consumers of Great Lakes fish. Given the relationship between sediment and fish contamination, this toxicological endpoint should be assessed in the ARCS program. However, this endpoint is not easily assessed in a quantitative fashion using the existing risk assessment methodology commonly employed by the U.S. EPA. This arises from the hypothesis that the contaminants, to which the infant or child is exposed through placental transfer and breast-feeding, is a result of the mother's body burden of the chemical. This maternal body burden is the result of her lifetime of contaminant intake, not only that occurring during pregnancy. Assessment would require complex pharmacokinetic modeling, an approach which is not well developed in the environmental assessment field.

Given the difficulties which exist in quantifying this hazard, it is beyond the scope of the ARCS program to address this issue in any great depth. However, ARCS would be remiss if it did not address the issue at all. Therefore, the Risk Assessment/Modeling Work Group is pursuing the option to develop an issue or problem identification paper on the subject. It is envisioned that the paper would summarize the existing epidemiological information, discuss the relationship between sediments, fish consumption, human body burden, and human-to-human chemical transfer, and discuss the inadequacies of present assessment techniques to describe the problem.

3.1.2.2 Aquatic Life Hazard Assessment

Aquatic life hazard assessment is an emerging discipline which differs fundamentally from assessments of human health effects. Current approaches for assessing the hazards to aquatic life (such as endangerment of health and viability of populations and communities) focus on existing ecological toxicity, as determined by field or laboratory studies. This type of information will be available from the Toxicity/Chemistry Work Group. Other types of descriptors of toxicity, based on chemical, physical and biological factors, such as the Equilibrium Partitioning Approach to calculating numerical sediment criteria from water quality criteria, the Apparent Effects Threshold and the Sediment Quality Triad, will also be part of the Toxicity/Chemistry Work Group output, and will be used to express and estimate future exposures and effects under the various remedial alternatives. To predict impacts on aquatic life under various remedial alternatives, toxicological information describing dose-response relationships will be used. All of this information will also be used to identify concentrations of chemicals in sediments in the Buffalo River and Saginaw Bay, which, if reached through remediation, will not result in unacceptable hazards. Baseline aquatic life hazard evaluations will be performed for at least three of the priority consideration areas (Buffalo River, Grand Calumet River, and Saginaw Bay). Comprehensive assessments will only be performed for the Buffalo River and Saginaw River.

3.1.2.3 Wildlife Hazard Assessment

Hazards to piscivorous avian and mammalian species are of primary concern for areas within the Great Lakes System. Adverse health effects, such as reproductive impairment and structural deformities, resulting from intake of contaminants in food, have been documented. Description of such effects are generally an outcome of field studies; prospective hazard assessments are not commonly performed. However, since the primary route of contaminant intake is through the consumption of contaminated food (fish), a rough prospective hazard evaluation can be performed in a manner similar to human food chain concerns. As above, the baseline hazard assessment will be based on existing information on impacts upon wildlife in the area, with an emphasis on the degree of hazard attributable to contaminated sediment, as compared with other "sources" of contaminants to wildlife. For the comprehensive assessment, future impacts will be based upon modeled exposures. Limitations of performing such an assessment will be discussed. Baseline and comprehensive wildlife hazard evaluations will be performed at two of the priority consideration areas (Buffalo River and Saginaw Bay).

3.2 Site Prioritization for Remedial Action and Development of Decision Support Tools

A numerically-based ranking system which synthesizes assessment variables and produces objective priorities will be designed to allow remedial priorities to be set for each of the Great Lakes Areas of Concern. Development of numerically-based ranking will provide a method for integrating hazard and risk assessments within and between individual Areas of Concern. The result will be a prioritization procedure that can be used in a comprehensive strategy for the management of contaminated sediments by Federal, State and Provincial governments to guide the development of Remedial Action Plans and Lakewide Management Plans.

During this Program, a database for each of the 5 priority consideration areas will be obtained, and will contain assessment variables which range from site-specific factors (e.g., measurements and/or predictions of heavy metal and organic contaminants, acute and chronic toxicity, mutagenicity, bioaccumulation potential, benthic species composition, and resuspension potential) to broad scale factors (e.g., fish tumor incidence rates, fish and waterfowl consumption advisories, loadings to receiving waters, beach closings, drinking water hazards, human risk from fish consumption, and socioeconomic considerations). These factors will be integrated for use in a decision-making framework to determine which site(s) should be targeted for remedial action. As much as possible, this assessment will be based on a minimum data set common to all five priority consideration areas obtained by the three technical Work Groups.

For the decision-making process, assessment factors will be synthesized to evaluate the sites with regard to remediation. For remedial evaluation, a ranking system will be used which 1) is numerically-based, 2) accommodates a multi-disciplinary database (chemical concentrations, ecotoxicity, model predictions, human risk, cost, etc.), 3) synthesizes and reduces the database to an understandable context, 4) produces objective output, 5) illustrates quantifiable differences between sites, and 6) establishes remedial priorities. The priorities established by the ranking system will then be viewed in terms of remedial goals, the likelihood of successful remediation, cost-benefit, and the technologies available to achieve these goals.

The following are tasks anticipated for this activity to provide site ranking and integration of information about individual sites or areas of concern:

- *Investigate methods of ranking and decision support analysis to determine what other approaches should be incorporated for the ARCS program;*
- *Develop a ranking method to integrate measures of hazard, risk and cost;*
- *Develop a method of ranking sites which can be applied to the Great Lakes Region, by State and Provincial jurisdictions, or smaller sub-regions (i.e., individual lake watersheds);*
- *Calibrate and test the ranking procedure and integration procedure on the five priority consideration areas being investigated during the ARCS Program.*

This work will be closely coordinated with the data collection and assessment activities of the Toxicity/Chemistry Work Group. All data collection and toxicology studies should be specifically designed to provide information for the integration and ranking system selected.

4.0 Products

The products of the Risk Assessment/Modeling Work Group will consist of the development of technical documents for each discrete work unit (e.g., the baseline and comprehensive hazard evaluations). In addition, much of the work performed for this Work Group will be an integral part of the Contaminated Sediments Assessment Guidance and the Contaminated Sediments Remediation Guidance, discussed in Part I, and members will have direct input into the development of these guidance documents.

5.0 Accomplishments in Fiscal Year 1990

1) *Toxicity Identification Evaluation (TIE) work completed on the Buffalo and Saginaw Rivers.*

2) *Draft of Buffalo River Baseline Human Health Risk Assessment.*

3) *Development of field sampling programs to support modeling efforts on the Buffalo and Saginaw Rivers;*

   - *A Buffalo River team was established and included SUNY at Buffalo, Buffalo State University, New York Department of Environmental Conservation, and the U.S. Army Corps of Engineers-Buffalo District;*

   - *The Saginaw River team includes University of Michigan, Michigan State University, Saginaw Valley State University, and U.S. Geological Survey.*

4) *Hydrodynamic modeling started on Buffalo River using existing data.*

5) *To support sediment transport model, field shaker tests were conducted on Buffalo River sediments to determine resuspension of the sediments.*

6) *Aquatic Life Hazard Assessment begun on Buffalo River.*

7) *Wildlife Hazard Assessments begun on Buffalo and Saginaw Rivers.*

6.0 Timeline - Risk Assessment/Modeling Work Group

ACTIVITY	FISCAL YEAR AND QUARTER FY89 3	4	FY90 1	2	3	4	FY91 1	2	3	4	FY92 1	2	3	4
Hazard Evaluation (Baseline)														
Wildlife	■	■	■	■	■	■	■							
Human	■	■	■	■	■	■	■	■						
Aquatic	■	■	■	■	■	■	■	■						
TIE Studies		■	■	■	■									
Synoptic Surveys														
Field Work and Analysis														
Buffalo				■	■	■	■	■						
Saginaw				■	■	■	■	■						
Exposure Model Development and Application			■	■	■	■	■	■	■	■				
Site Prioritization			■	■	■	■	■	■	■	■				
Hazard Evaluation (Comprehensive)					■	■	■	■	■	■				
Report Preparation									■	■	■	■	■	■

IV. Engineering/Technology Work Group Work Plan

1.0 Introduction

The primary responsibilities of the Engineering/Technology Work Group are to evaluate and test available removal and remedial technologies for contaminated sediments, to select promising new technologies for further testing, to demonstrate alternatives at priority consideration areas, and to estimate contaminant losses during remediation. The Engineering/Technology Work Group will seek technologies that are available, implementable, and economically feasible. Both removal and in situ alternatives will be considered.

2.0 Objectives

The primary objectives of the Engineering/Technology Work Group are:

1. Evaluation of existing technologies: To evaluate the effectiveness, technical feasibility and cost of existing technologies to remediate contaminated sediments and estimate contaminant losses during remediation;

2. Demonstration of effectiveness: To demonstrate the effectiveness of sediment remedial technologies through the performance of bench-scale tests, and pilot-scale demonstration projects at selected priority consideration areas;

3. Options Development: To develop options for the remediation of contaminated sediments at the five priority consideration areas; and

4. Development of Remediation Guidance: To develop guidance on the selection and implementation of contaminated sediment remedial alternatives.

3.0 Activities

The tasks needed to accomplish the Work Group objectives are:

1) Review of technical literature;

2) Evaluation of applicability of technologies for bench-scale studies;

3) Develop recommendations for pilot-scale demonstration;

4) Estimate contaminant losses during remediation;

5) Collection of sediments for bench-scale testing;

6) Sediment storage and analysis;

7) Bench-scale testing of selected treatment technologies;

8) Treatment technologies for inorganic contaminants;

9) Workshop on bioremediation technologies;

10) Evaluation of solidification/stabilization technologies;

11) Conduct pilot-scale demonstrations; and

12) Development of options for priority consideration areas.

3.1 Review of Technical Literature

Existing literature on contaminated sediment treatment technologies has been reviewed for the ARCS Program by the U.S. Army Corps of Engineers' Waterways Experiment Station (WES), focusing on the updating of present knowledge on the selection and use of technologies for removal and transport of contaminated sediments, placement/disposal of material at disposal sites, treatment technologies, as well as in situ techniques. The final report is completed. Previous technology assessments and field demonstration studies conducted by the U.S. EPA, U.S. Army Corps of Engineers and others were reviewed for applicability.

3.2 Evaluation of Applicability of Technologies for Bench-Scale Studies

The applicability of treatment technologies to priority consideration areas were evaluated based upon the nature and degree of contamination at the site. Treatment technologies identified in Task 1 were matched with the contaminants present and the level of contamination and volume of sediments to which each technology can be applied. Each technology was evaluated based on costs, effectiveness, volume of material to be handled, level of existing contamination and levels of cleanup required. Table 4 shows treatment technologies selected for each Priority Consideration area.

3.3 Develop Recommendations for Pilot-Scale Demonstrations

Ideally, the Engineering/Technology Work Group would complete its bench-scale evaluations and the products of the other work group studies would be reviewed before any final decisions about sites and technologies for pilot-scale demonstrations were made. However, in order for the demonstrations to occur during FY 1991/92, the decision on sites and technologies must be made no later than the fourth quarter of FY 1990 and detailed preparations begun immediately thereafter. WES has completed a draft strategy for proposed demonstration projects including recommendations for the selection of sites and technologies.

The selection of technologies which are available for pilot-scale demonstration in this timeframe is limited. There is not enough time to scale-up developmental technologies which require elaborate physical or mechanical plants. Some proprietary vendors already have portable pilot-scale plants available for demonstration. A few other technologies can be demonstrated using commercially available equipment. The only technology which has full-scale facilities operational now is incineration.

The availability of sites for demonstrations is even more limiting than the availability of technologies. As a result, site availability will probably be the major determinant as to which technologies can be demonstrated during the ARCS Program. Most pilot-scale demonstrations are performed at the site of contamination. The site of a demonstration must be secure, so that accidents, spills or emissions can be controlled. Land acquisition and site preparation for demonstrations are beyond the resource and time limitations of the ARCS Program. As a result, the use of existing, operational confined disposal facilities (CDFs) appears to be the most viable option for siting demonstrations. Other options, such as close collaboration with Superfund projects and/or Superfund's SITE program will also be explored.

If ARCS demonstrations at these sites are to be implemented, some or all of the following actions will have to be completed:

- *Preparation of plans and specifications;*
- *Reviews of biddability/constructability;*
- *Contract bidding or sole source contracting;*
- *Review of contractor submittals;*
- *NEPA documentation;*
- *Preparations for monitoring programs; and*
- *Obtaining any local, State or federal permits needed.*

These actions will require considerable time, effort and coordination, and they must be completed by December, 1990, in order to prepare for pilot-scale demonstrations during FY 1991/92.

3.4 Estimate Contaminant Losses During Remediation

Contaminant inputs which may occur to the environment during and after implementation of the remedial alternative will be assessed. Models available to calculate losses during dredging, volatilization losses, leaching losses, run-off and effluent concentrations will be reviewed. Models will be selected to calculate the annual losses to the environment resulting from each treatment technology evaluated. These contaminant loads to the environment will be supplied to the Risk Assessment/Modeling Work Group who will assess the human and environmental health impacts associated with each of the remedial alternatives. These tasks will be accomplished by WES and USEPA's Environmental Research Laboratory in Athens, Georgia (ERL/Athens). Coordination between WES and ERL/Athens is underway. The schedule is as follows:

		Start Date	Scheduled Completion Date
A)	Phase I, Briefing to Work Group	6/89	9/89
B)	Phase II, Draft Report	10/90	3/91
C)	Phase III, Draft Report	4/91	12/91
D)	Publish Final Report	1/92	6/92

3.5 Collection of Sediments for Bench-Scale Testing

The bench-scale tests (discussed below) require sediments for testing from the five priority consideration areas. The same or similar sediment samples will be used to evaluate and compare similar demonstration projects. Therefore, it was necessary to collect, characterize, and preserve large-volume sediment samples from each of the areas. Sediment samples consist of homogenized, moist composites of samples from a contaminated region within the area. Sediments were collected for all five (5) areas for Bench-Scale Studies. Sediments were collected by bucket at the following sites: 1) off Buffalo Color Corporation in the Buffalo River (100 gallons), 2) from three (3) sites in the Saginaw River (100 gallons), and 3) from a potential hot spot near General Motors in the Saginaw River (50 gallons). In the Ashtabula River, 100 gallons were collected by boring at various locations and depths. Two gallons were collected from Sheboygan. Additional samples will be collected for the pilot demonstration projects.

3.6 Sediment Storage and Analysis

The sediment samples were homogenized and split into representative subsamples (wet). The wet subsamples are being provided in a variety of convenient sizes for use by the various investigators. The procedure that will be used has been previously applied to sediments from Lake Ontario and the Fox River/Green Bay, and has been validated for organic carbon and organochlorine contaminant homogeneity. Wet samples will be stored in a cold-room at 4°C.

The basic characterization of the sediment includes the following parameters:

- *total organic carbon;*
- *total inorganic carbon;*
- *particle size analysis (wet sieve analysis from 710 to 63 μm, detailed analysis below 63 μm);*
- *density of dry material;*
- *total sulfur content;*
- *acid volatile sulfides;*
- *oil and grease;*
- *total PCBs;*
- *PAHs (at least 10 compounds);*
- *metals (ICAP); and*
- *mercury.*

3.7 Bench-Scale Tests of Selected Treatment Technologies

Particular promising technologies identified in Task 3 will be evaluated in bench-scale tests using sediments from the priority consideration areas. As used here, bench-scale tests mean ones that are done on a few grams to kilograms of sediment. The selection of which technology to use on which priority consideration area will depend upon matching-up the characteristics of each (i.e., a PCB treatment method will be matched with a location having PCB contamination problems).

Bench-scale testing will provide preliminary feasibility data and design data for pilot-scale demonstrations of selected technologies. As used here, pilot-scale tests are those that involve up to several cubic meters of sediments. Treatment technologies have been evaluated in bench-scale tests and the sediments tested are shown in Table 4.

A contract for bench-scale testing of sediments treatment technologies is in with SAIC Corporation. A kickoff meeting for the work plan was held in Cincinnati in August, 1990. Eight bench-scale tests will be completed by February, 1991, and the final report will be ready in August, 1991. Depending upon results, some of these bench-scale tests may be and several new tests will be initiated.

Sheboygan River sediment was tested by USEPA, Cincinnati Laboratory, using the Base Catalyzed Decomposition (BCD) process. All Aroclor congeners were reduced to below 2 ppm. Samples from the Ashtabula River and the Grand Calumet Harbor were also sent to the laboratory.

Sheboygan River sediment was sent to ECO Logic for testing with their hazardous waste destructor. The ECO Logic process requires heat (about 800 C), but the breakup of contaminants is achieved by the injected reducing agent, free hydrogen.

Sediments from Buffalo, Saginaw, Grand Calumet and Ashtabula were sent to Chemical Waste Management, Inc. Their process is solvent extraction. Arrangements were made for preparation of a QAPP by CWM.

3.8 Treatment Technologies for Inorganic Contaminants

This task will examine the treatment options that are available for inorganic contaminants including metals. Treatment options will be evaluated using sediment samples from three of the priority consideration areas with metals contamination problems: Buffalo River, Grand Calumet River, and Saginaw Bay. Techniques used for extraction and recovery of metals from ores and wastes will be evaluated on contaminated sediments. These include physical separation processes using gravity and magnetic properties, and flotation processes.

An interagency agreement has been entered into with the Bureau of Mines with the U.S. work to be carried out at their Salt Lake City Research Facility. A kickoff meeting was held with the Engineering/Technology Work Group. Initial characterization tests were performed on sediments from the Buffalo, Saginaw, and Grand Calumet Rivers. A QAPP has been prepared and approved. Testing of the sediments will be completed in March, 1991, and a final report is due in June, 1991.

3.9 Workshop on Bioremediation

A workshop was held July 17-19, 1990, in Manitowoc, Wisconsin. More than 60 scientists from state and federal agencies, academia, and the private sector from the United States, Canada, and the Netherlands, participated.

During the workshop, presentations were made describing site characteristics of the five ARCS priority U.S. Areas of Concern and for Hamilton Harbour, Ontario. Major contaminants within these and other areas include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and various heavy metal species.

The remainder of the workshop was devoted to discussing related laboratory and field studies and the applicability of biological remediation processes for these contaminants. Workshop presentations and discussions underscored the fact that biological remediation technologies for these classes of compounds are in rapid development, and in some situations may warrant evaluation as a component(s) in remediation strategies, especially when confined disposal options are leading alternatives. For PCB mixtures (Aroclors), anaerobic reductive dechlorination, shown by several investigators to occur in both historically contaminated sediments at various sites and in laboratory spiked sediments, results in the same molar concentration of PCBs with fewer average chlorines per molecule. While this process reduces toxicity alone, further aerobic treatment, believed to be partially a cometabolic process, may result in complete mineralization. For PAH compounds, aerobic microbial and fungal decomposition is fairly well documented, whereas biological treatment of sediments for the remediation of metal species has been considered only recently. In related areas, however, microbially mediated precipitation and/or dissolution reactions of metal species have been effectively utilized.

Proceedings from the workshop will be available in October, 1990.

3.10 Evaluation of Chemical Solidification/Stabilization Technologies

Besides removal and disposal, chemical solidification/stabilization (CSS) techniques are probably the most proven techniques for remediation of contaminated sediments. CSS techniques were *investigated for the Buffalo River. The scope of the study involves laboratory preparation of CSS samples using Buffalo River sediment and one of the following binders/additives: Portland Cement, lime/fly ash, kiln dust, and Portland cement with powdered activated carbon. A range of binder-to-sediment rations were screened and an optimum ratio was selected for detailed evaluation. Effectiveness was measured by comparing leaching results, unconfined compressive strength, and durability under wet/dry and freeze/thaw cycles.*

A draft report was prepared in June, 1990. A final report will be available in January, 1990.

3.11 Pilot-Scale Demonstration Projects

Pilot-scale demonstrations are scheduled to start in FY 1991 and continue through FY 1992. The scale of the pilot demonstrations will be several hundred cubic yards of sediment. Full-scale demonstrations would address in the range of 5,000 to 10,000 cubic yards of sediment. Pilot-scale demonstrations will only demonstrate the unit process (e.g., extraction). They will not include the full treatment train (e.g., dredging, storage, sorting, dewatering, extraction, destruction of extract, solidification, final disposal) that a full-scale demonstration would include. Pilot-scale demonstrations could be performed either on-site or at an off-site location.

3.12 Development of Options for Priority Consideration Areas

Based upon the information gained in the earlier tasks, concept plans for sediment remedial options will be developed for each priority consideration area. The costs of applying the selected options will be calculated. In addition, estimates will be made on the losses of contaminants that might result from applying the remedial actions. The Risk Assessment/Modeling Work Group will use this and other information to evaluate the hazards associated with each remedial option. These plans will also serve to identify data gaps that need to be filled in order to complete the process of selecting the best remedial options for each priority consideration area. Because it would be premature to select the single best remedial option for each area, the concept plans will present three different remediation scenarios for each priority consideration area. These plans will provide very useful information to the State and local groups responsible for the development of sediment remediation plans.

A kickoff meeting was held with the Engineering/Technology Work Group in August, 1990. Draft reports from the Buffalo and Saginaw Rivers are due in February, 1991, with a second progress briefing in March, 1991, and the final report due in May, 1991. Concept plans for the Ashtabula, Grand Calumet and Sheboygan Rivers will start in 1991.

3.13 Summaries of Treatment Technologies

The following are short descriptions of each of the technologies listed in Table 5:

- o *<u>Solidification/Stabilization</u>: The addition of binding materials to produce a more stable solid material that is more resistant to the leaching of contaminants. Typical binding material used include portland cement, fly ash, kiln dust, blast furnace slag, and proprietary additives.*

Table 5. Treatment Technologies to be Demonstrated by ARCS

TECHNOLOGIES	PRIORITY CONSIDERATION AREAS and Scale of Demonstration				
	ASHTABULA RIVER	BUFFALO RIVER	GRAND CALUMET RIVER	SAGINAW BAY	SHEBOYGAN HARBOR
Solidification/ Stabilization		Bench[c]	Bench[e]		
Inorganic Treatment/ Recovery		Bench[b]	Bench[b]	Bench[b]	
Bioremediation					Bench[d] Pilot[d]
KPEG Nucleophilic Substitution	Bench[a]		Bench[a]		Bench[a]
B.E.S.T. Extraction Process		Bench[a]	Bench[a,e]	Bench[a]	
CF Systems Solvent Extraction			Bench[a]	Bench[a]	
Incineration			Bench[a]		
Low Temperature Thermal Stripping		Bench[a]			
Wet Air Oxidation		Bench[a]	Bench[e]		
Eco-Logic Destruction Process					Bench[f]
In-Situ Stabilization					Bench[d] Pilot[d]
Acetone Extraction (Rem-Tech)					Bench[d]
Aqueous Surfactant Extraction					Bench[d]
Taciuk Thermal Extraction					Bench[d]
Sediment Dewatering Methods					Bench[d]

Legend: a = performed for ARCS Program by contractor
b = performed for ARCS Program by Bureau of Mines
c = performed for ARCS Program by Army Corps of Engineers/Waterways Experiment Station (WES)
d = performed by Superfund Potentially Responsible Parties
e = performed for U.S. Army Corps of Engineers by Indiana University - N.W. or Corps' WES
f = performed for Canada

- *Inorganic Treatment/Recovery:* The physical or chemical separation of sediments into different fractions that may be more or less contaminated. Since sediment contaminants usually associate themselves with fine-grained particles like silts and clays, their separation from the bulk of the sediments could significantly reduce the volume of material requiring advanced treatment.

- *Bioremediation:* The use of microorganisms such as bacteria to reduce the toxicity of sediment contaminants by degrading them through biological action. Used in the treatment of waste waters and contaminated soils.

- *(Based Catalyzed Decomposition (BCD) Process formerly called KIEG Nucleophilic Substitution):* A chemical process that reduces the toxicity of chlorinated hydrocarbons (such as PCBs) by removing chlorine atoms and replacing them with alkali metals (such as potassium).

- *Basic Extraction Sludge Technology (BEST) Extraction Process:* Separates contaminated sediments into three fractions: a solid fraction that contains the inorganic contaminants (such as heavy metals); an oil fraction that contains the organic contaminants (such as PCBs); and a water fraction that may contain residual amounts of the original sediment contaminants. By itself, BEST does not destroy any contaminants, but may significantly reduce the volume of material requiring advanced treatment.

- *Critical Fluids (CF) Systems Solvent Extraction:* Performs the same functions as the BEST process, but instead of the solvent used by BEST, the CF System's process utilizes gases at critical temperatures and pressures (propane and carbon dioxide), which reduces the cross-contamination of the end products with the solvent (the propane is simply exposed to normal pressures and temperatures where it turns back into a gas).

- *Incineration:* The high temperature destruction of organic contaminants in a furnace. Used for the disposal of municipal and hazardous wastes.

- *Low Temperature Thermal Stripping:* Removes volatile organic contaminants (such as polynuclear aromatic hydrocarbons, or PAHs) by heating the sediments to temperatures lower than those used in the destructive incineration process. Not intended to permanently destroy contaminants, but may result in a sediment that can be more easily disposed of.

- *Wet Air Oxidation:* Organic contaminants are destroyed by exposing them to elevated temperatures and pressures. This process was developed over 30 years ago and has been successfully used to treat municipal sewage sludge.

- *Low Energy Extraction:* Separates contaminated sediments into fractions as described for the BEST process. Uses a combination of solvents to remove PCBs and other organic contaminants from the sediment.

- *Eco-Logic Destruction Process:* A thermochemical process that uses high temperatures and hydrogen gas to destroy organic contaminants.

- *In-Situ Stabilization:* The covering or armoring of sediment deposits with geotextiles, plastic liners, or graded stone. Prevents the disturbance and resuspension of contaminated sediments, which could lead to a release of sediment contaminants back into the water column.

- *<u>Acetone Extraction (Rem-Tech)</u>: Acetone is used as a solvent to extract PCBs from contaminated sediments.*

- *<u>Aqueous Surfactant Extraction</u>: Similar to the Low Energy Extraction process. Instead of applying acetone, however, this process uses aqueous surfactant to remove PCBs. Ultrasonics may be employed to improve extraction efficiencies.*

- *<u>Taciuk Thermal Extraction</u>: A thermal separation process similar to Low Temperature Thermal Stripping. The sediments are heated in an oxygen-free atmosphere, which aids in the removal of organic contaminants.*

  <u>Sediments Dewatering Methods</u>: Techniques to remove the water from contaminated sediments, such as air drying, consolidation, and filter presses. May be necessary prior to the application of a treatment technology that works inefficiently in the presence of water.

4.0 Products

The products of the Engineering/Technology Work Group will consist of the development of technical documents for each discrete work unit (e.g., bench-scale testing, pilot-scale testing). One key product of this Work Group is a matrix of monetary costs versus contaminant losses from the technologies tested. This information will be provided to the Risk Assessment/Modeling Work Group for use in evaluating the impacts of alternative remedial options. Table 4 summarizes the match-up of technologies and locations planned for the ARCS demonstrations. The table also includes technology demonstrations that have been or are being done under other programs, including the U.S. Army Corps of Engineers, Superfund PRPs and Canada. The Engineering/Technology Work Group will make use of the results of these other demonstrations along with the ones being done specifically for ARCS.

In addition, much of the work performed for this Work Group will be an integral part of the Contaminated Sediments Remediation Guidance Document, discussed in Part I, and members will have direct input into the development of this guidance document.

5.0 Accomplishments in Fiscal Year 1990

Sediments were collected from all five (5) areas for Bench-Scale Studies. Sediments were collected by bucket at the following sites: 1) off Buffalo Color Corporation in the Buffalo River (100 gallons); 2) from three sites in Saginaw (100 gallons); 3) from a potential hot spot near General Motors in the Saginaw River (50 gallons); and 4) from a site just downstream of the Columbus Drive Bridge in the Indiana Harbor Canal (100 gallons). In Ashtabula, 100 gallons were collected by boring at various locations and depths. Two gallons were collected from the Sheboygan River.

Sediment samples were homogenized and characterized for physical and chemical properties by the EPA's Duluth Laboratory.

Sheboygan River sediment was tested by EPA, Cincinnati Laboratory, using the Base Catalyzed Decomposition (BCD) process. All Aroclor congeners were reduced to below 2 ppm. Samples from the Ashtabula River and the Grand Calumet Harbor were also sent to the laboratory.

Sheboygan River sediment was sent to ECO Logic for testing with their hazardous waste distributor. The ECO Logic process requires heat (about 800 C), but the breakup of contaminants is achieved by the injection of the reducing agent, free hydrogen.

Sediments from Buffalo, Saginaw, Grand Calumet and Ashtabula were sent to Chemical Waste Management,Inc (CWM). Their process is solvent extraction. Arrangements were made for preparation of a QAPP by CWM.

A Workshop on Biological Remediation of Contaminated Sediments was held in July, 1990. The following topics were covered: 1)Pathways of Biological Degradation of PCBs and PAHs; 2) Biological Transformation/Complexation of Metal Species, 3) Bioremediation Technologies - Pilot or Full Scale Field Studies; and 4) Relevance to the preparation of Remedial Action Plans for the 42 AOCs.

Four members of the work group made presentations at a Workshop on Innovative Technologies for Treatment of Contaminated Sediment, held in June, 1990, by EPA's Risk Reduction Engineering Laboratory in Cincinnati, Ohio.

The Corps' Waterways Experiment Station (WES) completed the laboratory studies to stabilize and solidify Buffalo River sediment. A draft report has been prepared.

WES completed the literature review of technologies to treat contaminated sediments. The final report is in preparation.

Technologies identified in the literature were selected for bench-scale testing in Buffalo, Grand Calumet, Saginaw, Sheboygan and Ashtabula.

WES completed (August, 1990) a draft "Recommendations for Proposed Demonstration Projects Including Selection of Sites And Technologies".

Concept plans for Buffalo and Saginaw were initiated July, 1990.

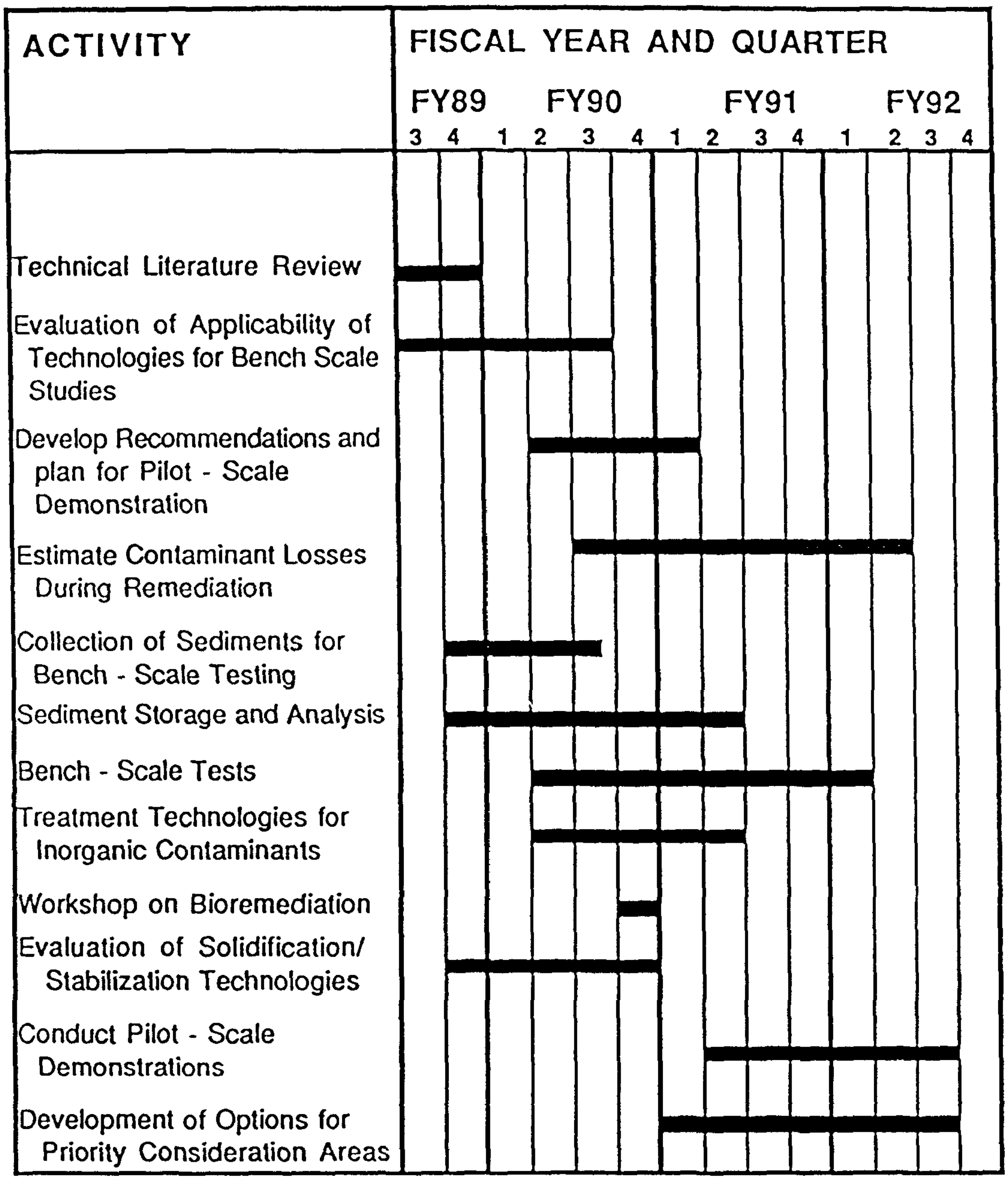
A contract for Bench-Scale Testing of Sediment Treatment Technologies was made with SAIC Corporation. A kickoff meeting for the work plan was held in Cincinnati in August, 1990.

An interagency agreement has been entered into with the U.S. Bureau of Mines (BOM). The BOM Salt Lake City Research Facility will investigate treatment options that are available for inorganic contaminants. These include physical separation processes using gravity and magnetic properties, and flotation processes. Initial characterization tests on sediments from Buffalo, Saginaw and Grand Calumet have been performed.

Buffalo River sediments have been sent to the EPA Athens, Georgia Laboratory. They will investigate the use of surfactant for biological degradation of PAHs.

WES and the EPA Athens Laboratory have begun work on a study to estimate contaminant losses during remediation.

6.0 *Timeline - Engineering/Technology Work Group*



V. Communication/Liaison Work Group Work Plan

1.0 Introduction

The Communication/Liaison Work Group was established to disseminate up-to-date information regarding the ARCS Program and related activities to elected officials, government agencies, and the interested public. The group will also provide feedback from those interested parties to the technical work groups and other ARCS committees.

Ongoing communication between the technical work groups and the Communications/Liaison Work Group regarding research and field work is critical to the ongoing success of this work group. In part, this will be accomplished through weekly conference calls with the AIC, and work group members' attendance at other work group meetings.

Timely notice of upcoming events to our work group members and interested citizens is essential in ensuring our goal of full public scrutiny of ARCS.

The work group's communication efforts will continue to stress that ARCS is not a clean-up program, but is designed to assess the contaminated sediments problem, to identify practical remedial options, and to test new technologies on bench and pilot scales.

2.0 Objectives

The primary objectives of the Communication/Liaison Work Group are:

1. *Track Program Operations in order to keep Work Group members informed of the overall status of the ARCS Program and ongoing efforts of each technical work group.*

2. *Disseminate Information about the program regularly to the public, other agencies, and elected officials in the U.S., as well as to Canadian Federal and Provincial agencies involved in contaminated sediment issues.*

3. *Solicit Feedback from the public and elected officials on the progress and scope of the ARCS Program, and communicate the substance of this feedback to the other work group chairs, the ARCS Management Advisory Committee and GLNPO Management.*

4. *Encourage Public Participation. During all phases of the project, the Work Group seeks to encourage and maintain strong public interest in the ARCS Program through public meetings, news releases, informal information exchange, and other activities.*

5. *Develop Guidelines for Public Participation in future contaminated sediment demonstration projects. These guidelines are to be developed by the conclusion of the ARCS program as part of an overall set of documents prepared by project work teams.*

3.0 Activities

The tasks needed to accomplish these objectives are the following:

1) *Continual work group interaction;*

2) Preparation and dissemination of general and site-specific information materials on the ARCS Program and on contaminated sediments in general;

3) Mailing list compilation and maintenance;

4) Solicitation of public input through news updates, press releases, questionnaires, public meetings and informal dialogue;

5) Development and maintenance of library repositories for contaminated sediment and ARCS Program materials in the five priority areas;

6) On-site coordination of public meetings and press briefings;

7) Slide-show preparation and dissemination;

8) Video preparation and dissemination; and

9) Guidelines for public participation and community outreach plans when appropriate.

3.1 Work Group Interaction

Frequent contact with members of other work groups is maintained, and interviews are scheduled as appropriate to obtain information on planned or ongoing work. The Communication/Liaison Work Group will receive summaries of other work group meetings and work plan revisions on a regular basis.

3.2 Preparation of Information Materials

The Communication/Liaison Work Group prepares press releases, fact sheets and other such materials for dissemination to interested Federal and State agencies, elected officials, and the public at regular intervals.

Quarterly ARCS updates will be produced and published. They will provide information not only on ARCS Program activities, but also on cooperative efforts and information sharing with other projects (such as EPA's Superfund Program, Environment Canada's contaminated sediment research, etc.) and on more general topics such as current scientific research that relates contaminated sediments to ecological impacts on the Great Lakes.

Updates on activities specific to the priority consideration areas will be included in the Fact Sheets or produced and disseminated separately as needed. Press releases will be coordinated and issued by the Communications/Liaison Work Group member representing U.S. EPA's Office of Public Affairs.

3.3 Mailing List Compilation

A mailing list has been compiled and will be maintained and updated regularly to disseminate information gathered in the tasks above to the appropriate interested parties.

3.4 *Soliciting Public Input*

Ongoing and regular feedback will continue to be sought from environmental groups, elected officials and the general public, and will be communicated to the other work groups, GLNPO staff, and the Management Advisory Committee.

3.5 *Development and Maintenance of Library Repositories*

Repositories have been established for all of the five priority areas. They are:

Ashtabula River

Ashtabula County District Library
Attn: Bill Tokarczyk
335 West 44th
Ashtabula Ohio 44004

Phone: 216-997-9341

Buffalo River

Buffalo and Erie County Public Library
ATTN: Science Department
Lafayette Square
Buffalo, New York 14203

Phone 716-823-7101

State University College at Buffalo
Attn: Butler Library
1300 Elmwood Avenue
Buffalo, New York 14222

Phone: 716-878-6331

J.P. Dudley Branch Library
Attn: Marjorie Piegay
2010 South Park Avenue
Buffalo, New York 14220

Phone: 716-823-1858

Grand Calumet River

Gary Public Library
ATTN: Mrs. Watkins
220 West 5th Street
Gary, Indiana 46202

Phone: 219-886-2484

East Chicago Public Library
Attn: Adena Fitzgerald
2401 E. Columbus Dirve
East Chicago, Indiana 46312

Phone: 219-397-2453

Indiana University-Northwest
Attn: Government Documents
3400 Broadway
Gary, Indiana 46408

Phone: 219-980-6580

Saginaw River

Hoyt Library
Attn: Michigan Room
505 Janes Street
Saginaw, Michigan 48605

Phone: 517-775-0904

Bay City Branch Library
Attn: Barbara Fisher
708 Center Avenue
Bay City, Michigan 48708

Phone: 517-893-9566

Saginaw Valley State University
Attn: Zahnow Library (reference)
2250 Pierce Road
University Center, Michigan 48710

Phone: 517-790-4240

Sheboygan River

Mead Public Library
Attn: Sue Mathews
710 Plaza 8
Sheboygan, Wisconsin 53081

Phone: 414-459-3432

Additional Repositories

U.S. Environmental Protection Agency
Great Lakes National Program Office, 5GL
Attn: Librarian
230 South Dearborn Street
Chicago, Illinois 60604

Phone: 312-353-7932

Lake Michigan Federation
59 East Van Buren
Chicago, Illinois 60605

Phone: 312-939-0838

International Joint commission
Great Lakes Regional Office
Attn: Pat Murray
100 Ouellette Avenue
Windsor, Ontario N9A 6T3

Phone: 313-226-2170

3.6 On-Site Coordination and Public Meetings

Representatives from the Communication/Liaison Work Group will travel to the priority consideration sites to inform the public and media about the ARCS Program, ongoing field work, research activities and results. Public meetings have already been held at three of the five sites (Saginaw, Buffalo, and Indiana Harbor) and will be held in the other two locations in Fiscal Year 1991.

3.7 Slide Show Preparation

A slide show is being developed to aid in the discussion of contaminated sediments. Discussions of current contaminated sediment problems, pollutants, ARCS objectives, and remedial options are being explored.

3.8 Video Preparation

A video will be produced to provide a general understanding of the contaminated sediments problem, including information about the extent of the problem in the Great Lakes, assessment techniques and disposal technologies. Video footage is being taken as the project proceeds, and will be completed during advanced stages of the ARCS Program. In the interim, short segments of the material may be provided to the media or others upon request.

3.9 Guidelines for Public Participation

Based on the experience gained from the five priority consideration areas, the Communication/Liaison Work Group will produce guidelines for public involvement for future contaminated sediment demonstration projects.

4.0 Products

The products of the Communication/Liaison Work Group will consist of the fact sheets, press releases, slide show, video and other forms of communication forms discussed above. Much of the work performed by this Work Group will be an integral part of the Contaminated Sediments Management Documents, discussed in Part I. Members will have direct input into the development of these guidance documents.

5.0 Accomplishments in Fiscal 1990

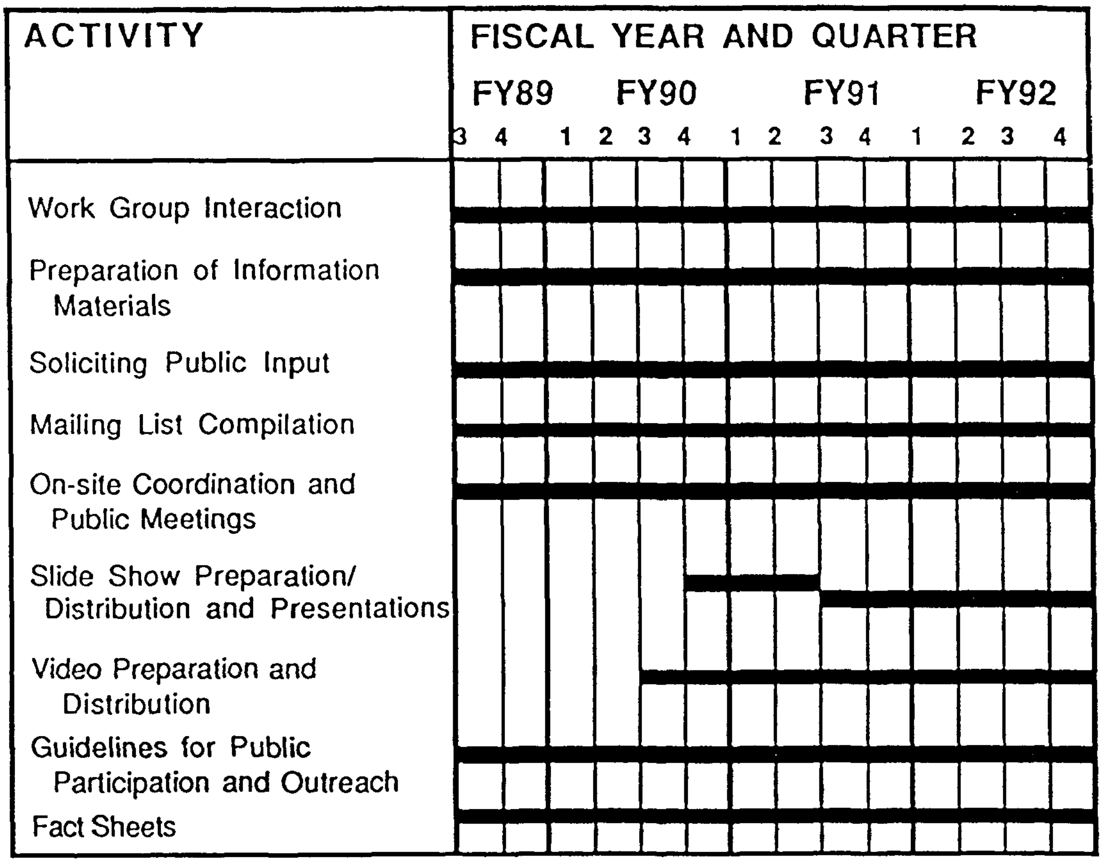
In Fiscal 1990, the Communications/Liaison Work Group produced one general program Fact Sheet and several site-specific fact sheets and news releases. A draft slide show was developed and preliminary footage for an ARCS video was collected.

The members of the work group scheduled and coordinated public meetings in Buffalo, New York; Bay City, Michigan; and Gary, Indiana, as well as presenting talks to community leaders in Kenosha, Wisconsin; at Indiana Dunes National Lakeshore, the University of Wisconsin at Milwaukee, Green Bay, Wisconsin, Gary, Indiana and White Lake/Muskegon Lake, Michigan. Presentations were also made to Citizen's Advisory Committees of Remedial Action Plans, which convened in Stella Niagara, New York.

The Work Group developed a mailing list of some 500 people. It also fielded requests for information and collected feedback on the program from the public for dissemination to and evaluation by the project managers.

Library repositories for ARCS material and other information on contaminated sediment have been designated in the five priority areas. Materials will be distributed to those repositories beginning in fiscal year 1991.

6.0 Timeline - Communications/Liaison Work Group



ARCS PROGRAM COMMITTEE MEMBERSHIP

MANAGEMENT ADVISORY COMMITTEE		
NAME	AFFILIATION	TELEPHONE
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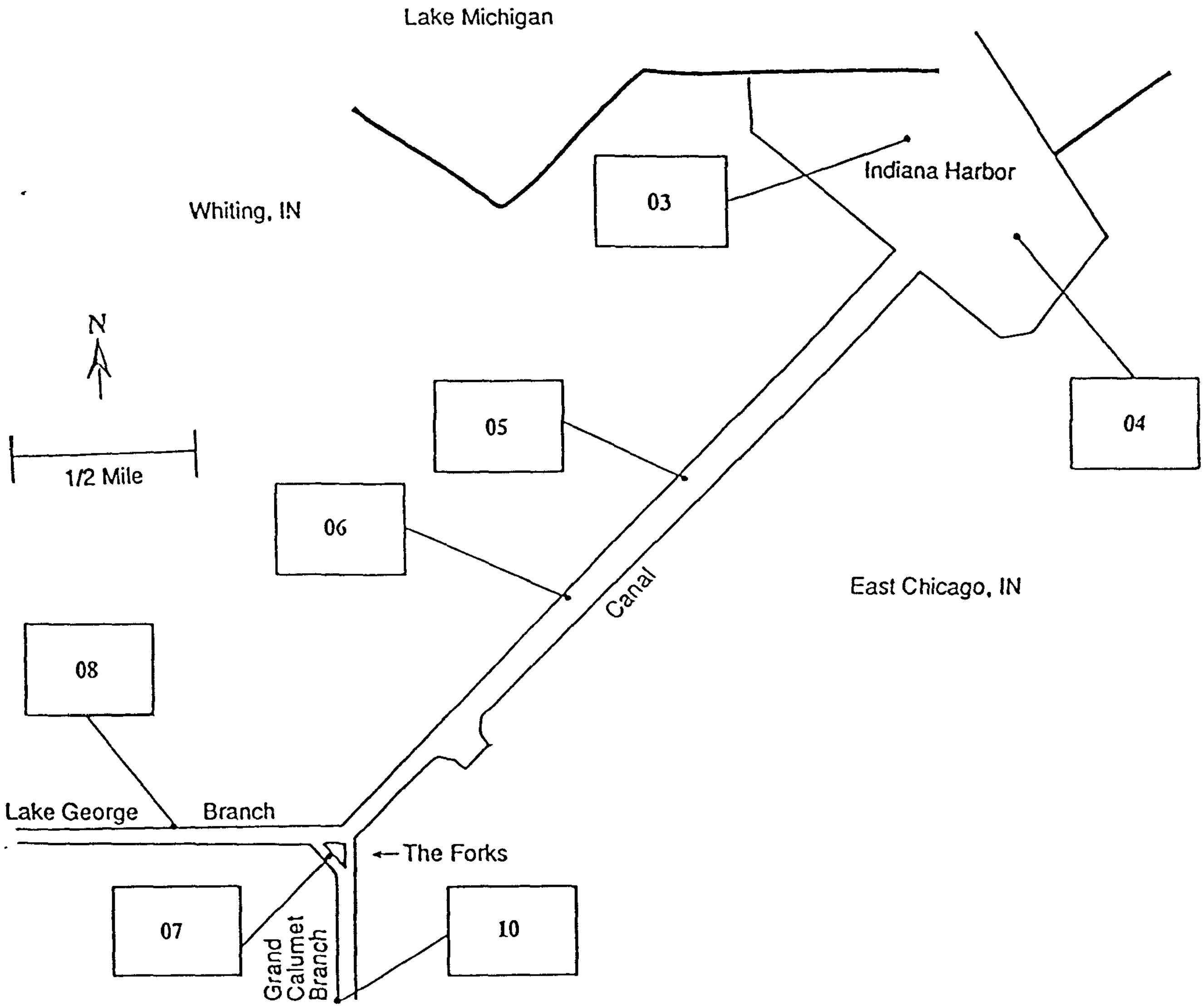
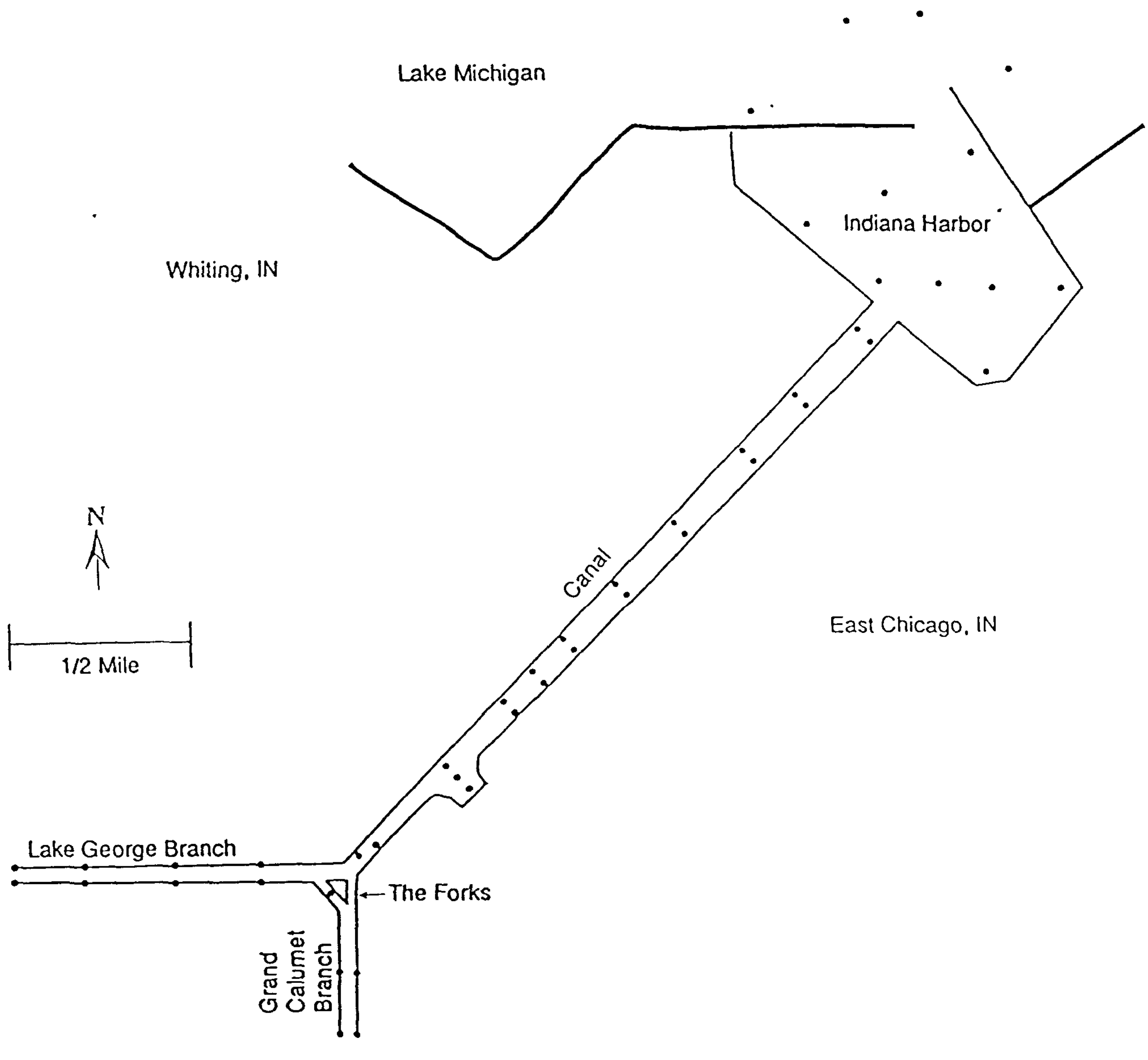
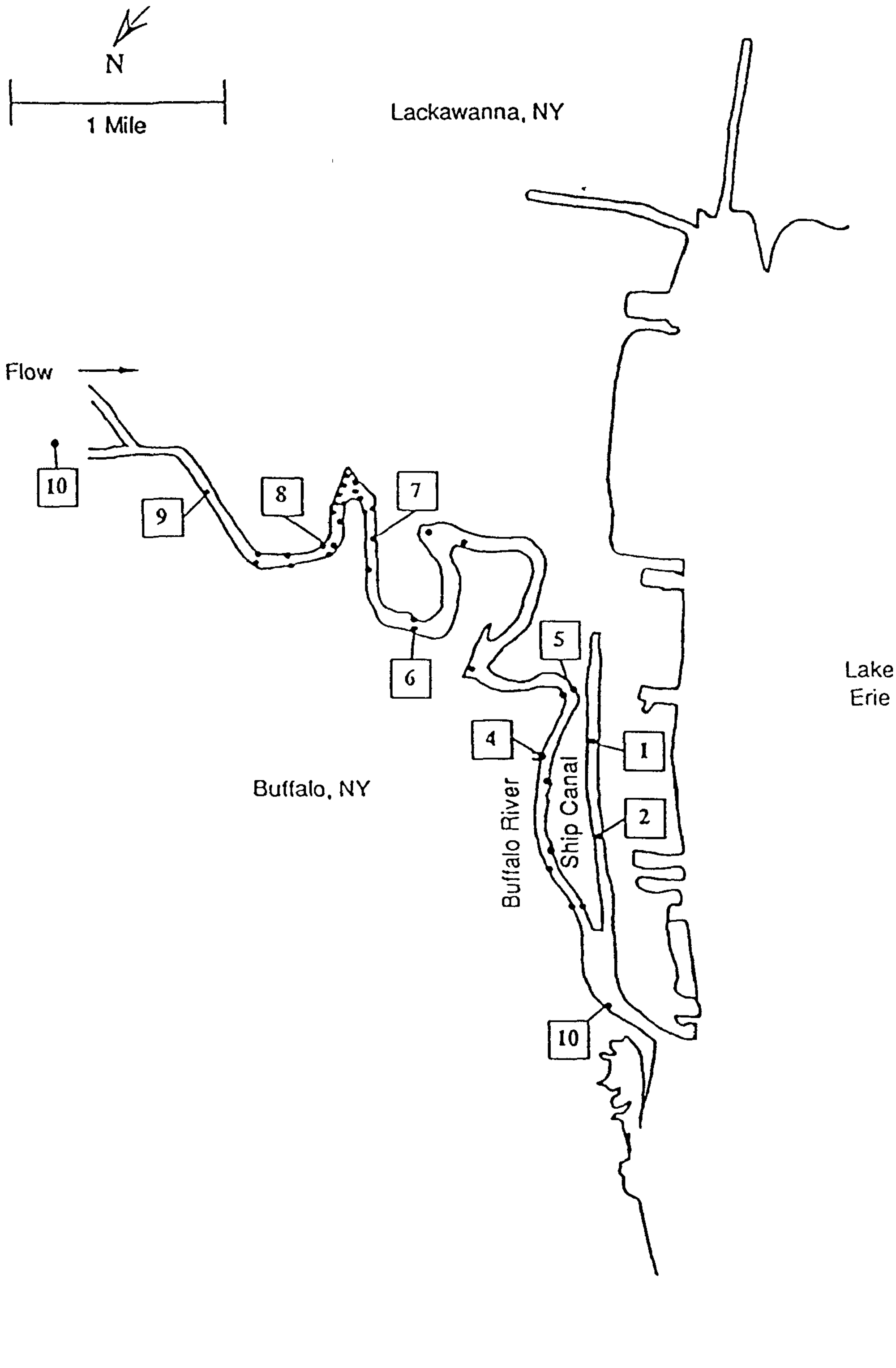
Indiana Harbor Master Station Location



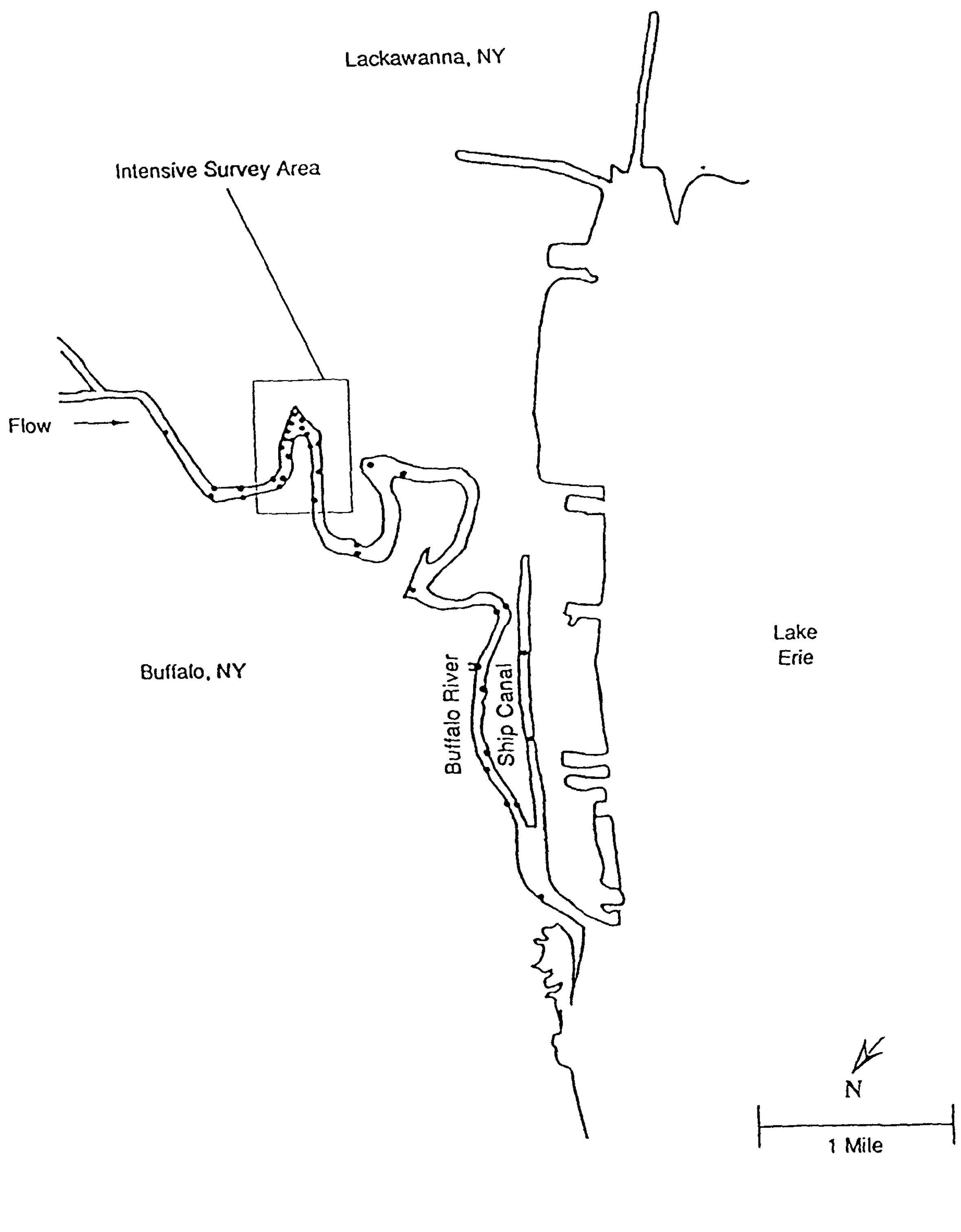
Indiana Harbor Core Station Locations



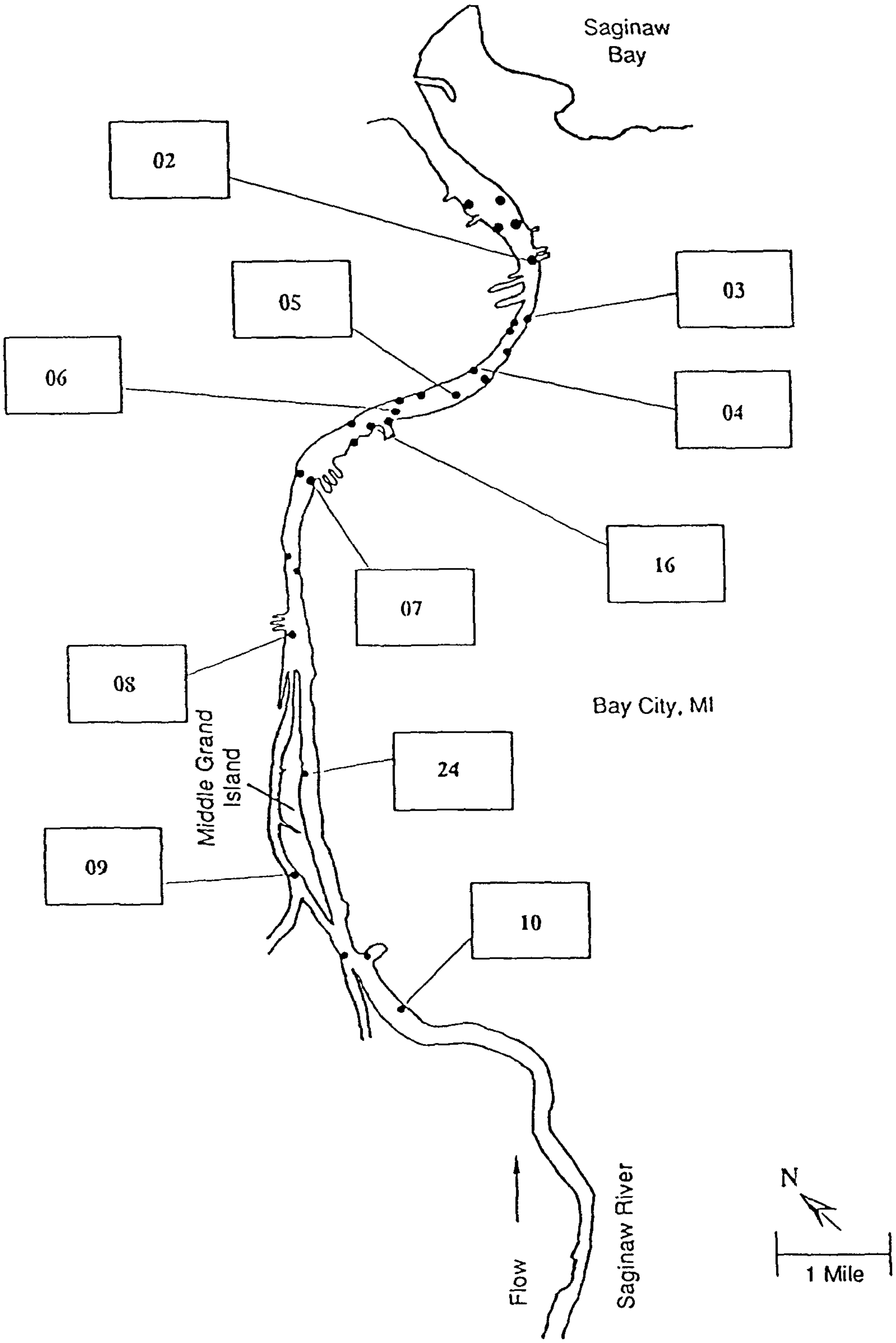
Buffalo River Master Station Locations



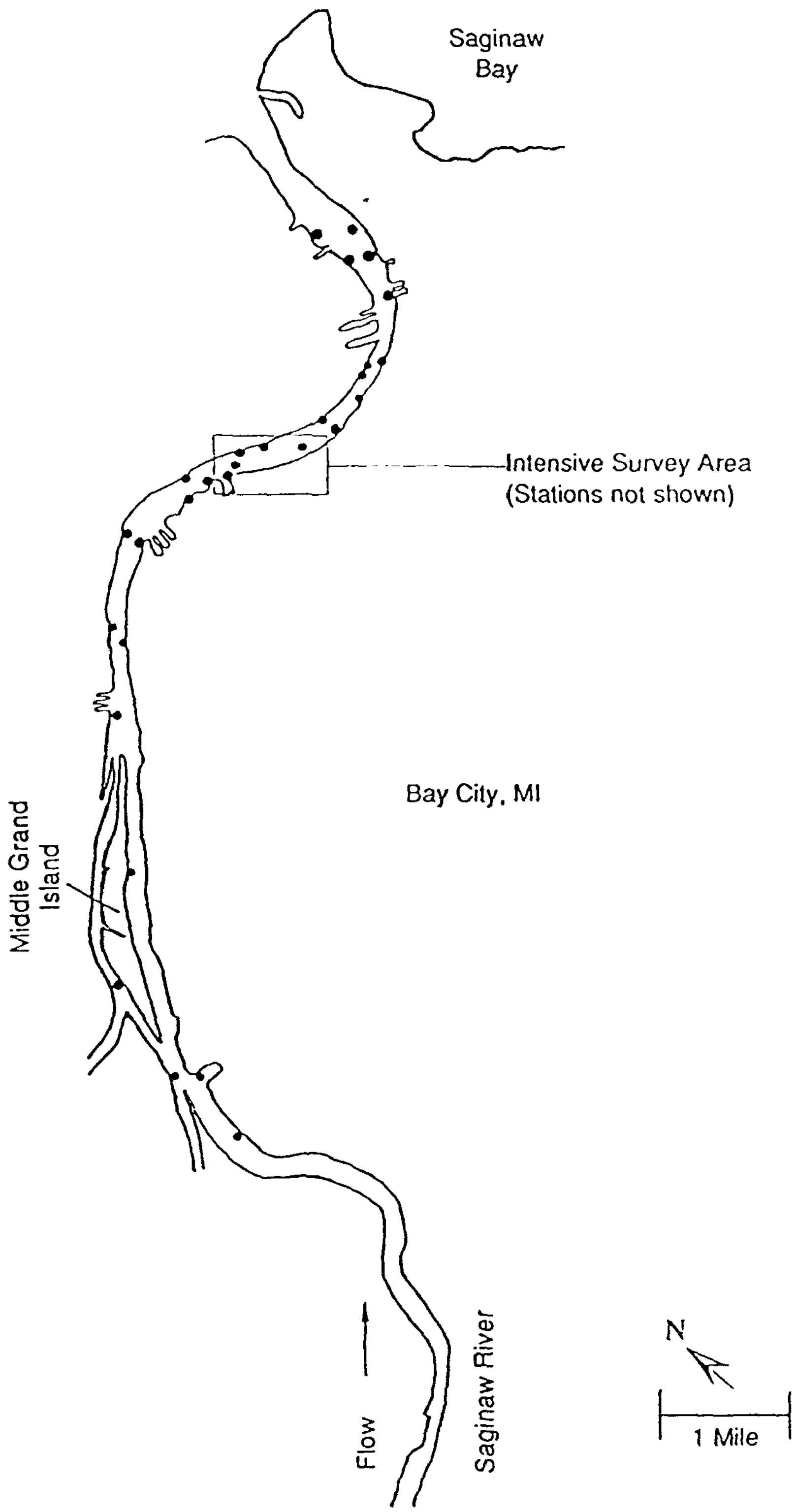
Buffalo River Core Station Locations



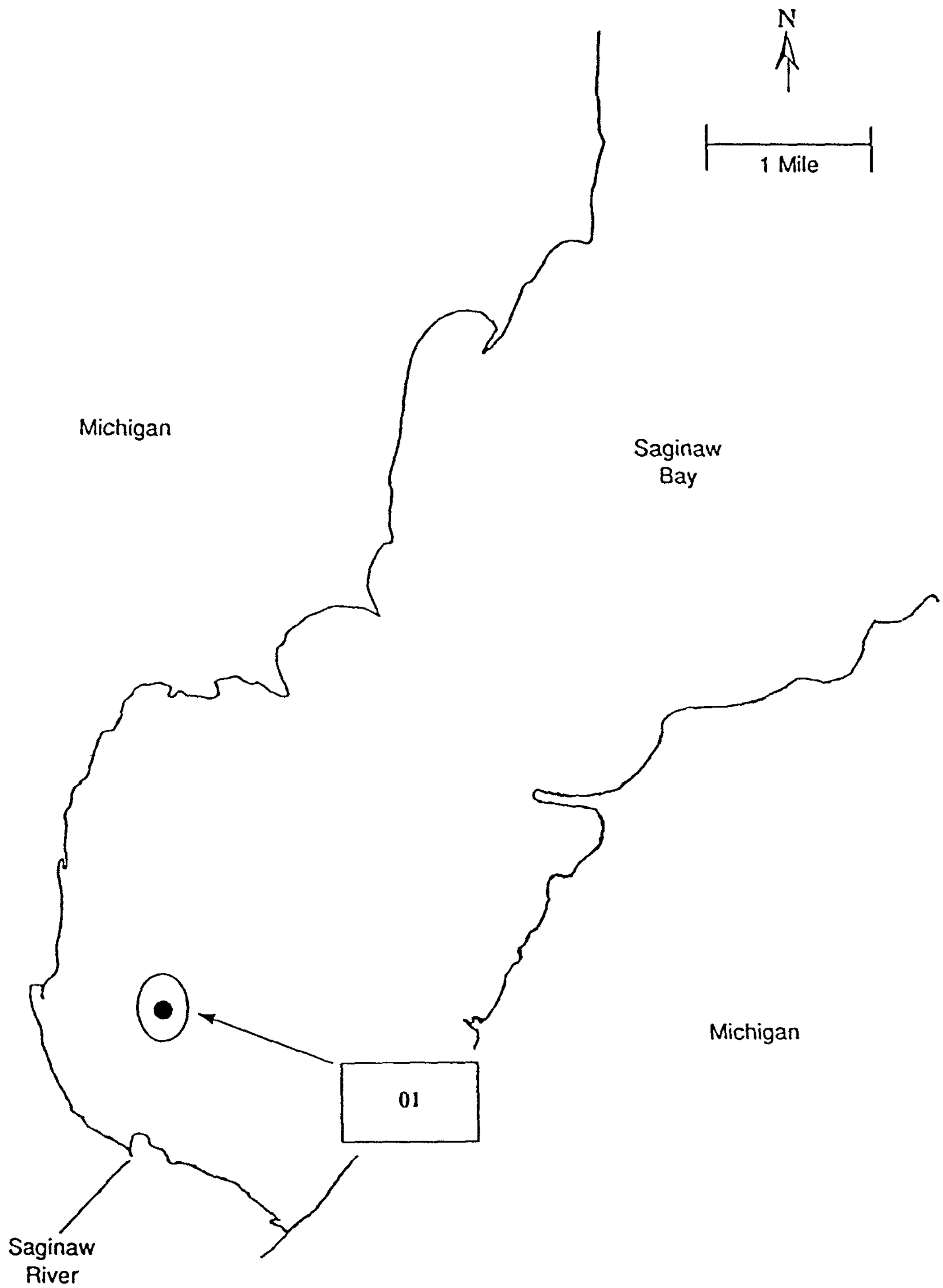
Saginaw River Master Station Locations



Saginaw River Core Station Locations

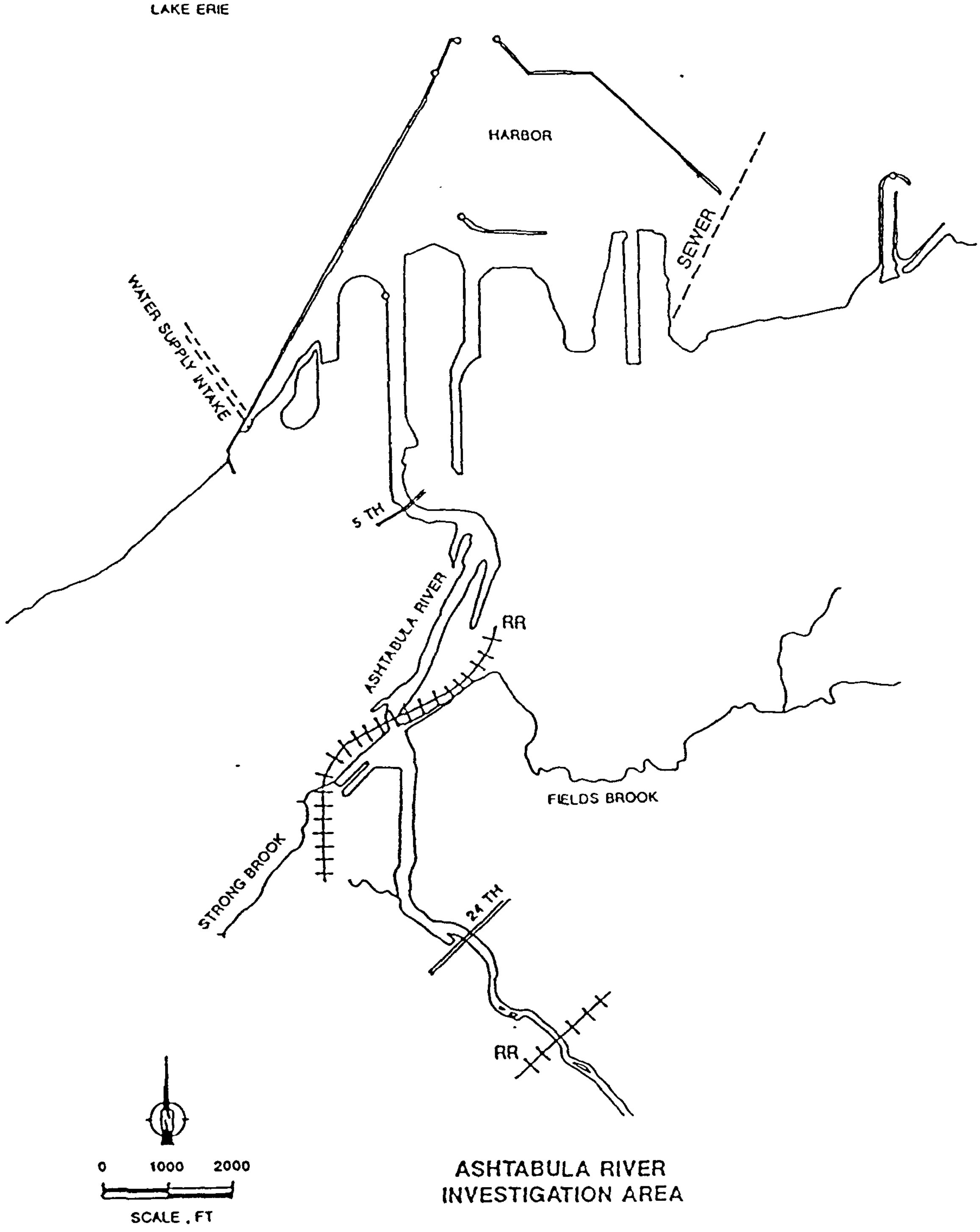


Saginaw Bay Master Station Locations



(ARCS Station 01=Michigan DNR Station 48)

Ashtabula River



ASHTABULA RIVER
INVESTIGATION AREA

Sheboygan River Superfund Sampling Locations