OPERATING PLAN

for the

Upper Mississippi River System Long Term Resource Monitoring Program

by

U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

in cooperation with

U.S. Army Corps of Engineers
North Central Division, Planning Division
Chicago, Illinois 60605

and

the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin

August 1992

Revised 09/93

This report reflects the long-term goals, objectives, and strategies of the Upper Mississippi River System Long Term Resource Monitoring Program. Accomplishment of this work continues to be derived from the efforts of the Ecological Research and Evaluation Division and the Information Systems Support Division of the Environmental Management Technical Center and six state-operated data collection field stations. At the time of publication of this report, Robert L. Delaney was Center Director, Barry W. Drazkowski was Deputy Center Director, Dr. John W. Barko was Science Technical Director, Norman W. Hildrum was Technical Director, and Terry D'Erchia was Report Editor.

The Operating Plan was developed with funding provided by the Long Term Resource Monitoring Program.

This Operating Plan is dedicated to the memory of U.S. Fish and Wildlife Service employee Mary Lubinski. Mary's skillful efforts contributed greatly to its production. The long, painstaking hours of work she spent preparing this document for publication are recognized and appreciated. Her valiant, unfailing spirit and devotion are embodied in it.

Preface

This revised Operating Plan, completed in 1992, was prepared to implement the Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System (UMRS). The original 1988 Operating Plan guided the LTRMP early in the Program. This revision has been necessitated by (1) major discrepancies over the last 4 years between appropriated and authorized funding, (2) a 5-year Program extension, (3) information and experience gained over the last 4 years, (4) recent Program reviews, (5) moving the Program into a fully operational phase, and (6) coordinating the Program with the U.S. Army Corps of Engineers' (COE) Navigation Plan of Study.

The LTRMP was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the COE's Environmental Management Program. The original authorization for the LTRMP was for 10 years, starting in 1987. Authorization has since been extended for an additional 5 years (to 2002) by Section 405 of the Water Resources Act of 1990 (Public Law 101-640).

The LTRMP is being implemented by the Environmental Management Technical Center, an office of the U.S. Fish and Wildlife Service, in cooperation with the five Upper Mississippi River Basin states, Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The COE provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information to maintain the UMRS as a viable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products. Specific products are described at the task level.

Recognizing that the LTRMP transcends regional and state boundaries, Program participants representing the Federal Government and the Upper Mississippi River Basin states have pledged their best efforts toward achieving the goals and objectives depicted in this Operating Plan and are committed to managing the UMRS as an integrated ecosystem.

This Operating Plan was endorsed by the LTRMP Analysis Team on January 27, 1993, and by the Environmental Management Program Coordinating Committee on February 23, 1993.

Changes to this Operating Plan will be coordinated with and endorsed by the LTRMP Analysis Team. Dated changes will be incorporated into revised textual/tabular pages for future updates of the document.

This report should be cited as:

U.S. Fish and Wildlife Service. 1992. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002. 179 pp.

Executive Summary

The Upper Mississippi River System (UMRS) has long been recognized as a unique national resource. Within the past 60 years, Congress has authorized a Federal navigation project and several fish and wildlife refuges for major portions of this river system. Presently, over 420,000 acres of UMRS land and water are under Federal management. Large financial investments are made each year to maintain and improve the commercial navigability of the UMRS; however, relatively few investments have been made to maintain or enhance the natural resources of the same area.

The Mississippi River and its tributaries are being rapidly, and, in certain cases, irreversibly altered by increased urban, industrial, and agricultural development. Exploitation of the UMRS has shown that its resources are not limitless. Activities such as increased navigation, dredging, barge fleeting, construction, wetlands development, intensive agricultural practices and associated sediment and chemical impacts, industrial waste discharges, and recreational pressures have stressed many areas of the system and threaten the fish, wildlife, recreational, and economic resources of the entire region. The problems associated with these activities are becoming increasingly complex and a lack of information has made it difficult for Federal and State agencies to manage the river system for competing uses. River managers and administrators must be provided with scientifically sound information on which to base decisions ultimately determining the fate of the system.

Scientific information on a system as large and diverse as the UMRS can be provided only through a comprehensive and properly designed and implemented data collection and interpretation program. Past attempts to implement such a program on the UMRS have been unsuccessful because of the (1) lack of an integrated plan, (2) lack of adequate funding and personnel, (3) lack of a designated lead agency, and (4) low priority consideration of the UMRS as a multiple-use resource.

This Operating Plan establishes a framework and schedule for the completion of a comprehensive Long Term Resource Monitoring and Computerized Inventory and Analysis Program for the UMRS. This Program has been designed to collect scientifically valid and statistically sound data over time to detect site-specific and/or system-wide changes. The data base will be helpful in evaluating various impacts on the system and will serve as a reliable information source for management agencies. It also will support and be integrated with specific navigation impact assessments being conducted by the U.S. Army Corps of Engineers (COE).

While data regarding various aspects of the UMRS are now available, inconsistent and incompatible resource assessment techniques, instruments, and methodologies hinder comprehensive resource monitoring efforts and make system-wide comparisons virtually impossible. Furthermore, dissemination of research information and uniform adoption of state-of-the-art advances in assessment technology and methodology have been slow.

Federal and State resource management agencies need baseline information to ensure that the UMRS is available for multiple uses in the future. In addition, a computerized inventory and analysis system is needed to assimilate and store historical data as well as to manage data generated through the Long Term Resource Monitoring Program (LTRMP). A computerized information transfer system will provide resource managers with site-specific and system-wide data, using standardized and state-of-the-art methodologies.

Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP, therefore, is to provide decision makers with information to maintain the UMRS as a viable multiple-use large river ecosystem. The long-term goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products. Specific products are described at the task level.

The LTRMP for the UMRS was initiated in 1987, as identified in the January 1, 1982, Comprehensive Master Plan for managing the UMRS. The UMRS encompasses the commercially navigable portions of the Mississippi River north of Cairo, Illinois, plus the entire Illinois River and Waterway, and four other Midwestern rivers (Fig. 1). The LTRMP was originally authorized for 10 years under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the COE's Environmental Management Program (EMP). A 5-year Program extension was authorized by Section 405 of the Water Resources Act of 1990 (Public Law 101-640).

The LTRMP is being implemented by the Environmental Management Technical Center (EMTC), an office of the U.S. Fish and Wildlife Service, in cooperation with field stations managed by the five Upper Mississippi River Basin states, Illinois, Iowa, Minnesota, Missouri, and Wisconsin. Guidance is being provided by the COE, which has overall responsibility for the Program. Respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

Several organizations or groups provide input and guidance to the LTRMP. The Upper Mississippi River Basin Association (UMRBA) is composed of the five Basin states and representatives from the participating Federal agencies. The UMRBA serves as a clearinghouse for all components of the EMP, directs Program policy, and facilitates coordination and cooperation among Program participants.

A Science Review Committee has been selected by EMTC staff to review the scientific and technical aspects of the Program. This committee consists of seven members of the scientific community from North America and Europe.

An LTRMP Analysis Team, made up of members from the five Basin states and participating Federal agencies, assists in developing Program goals and objectives, setting priorities, defining products, and reviewing progress.

The original Operating Plan for the LTRMP, prepared in 1988, guided the early Program. The 1988 Operating Plan (Rasmussen and Wlosinski) addressed the significant environmental variables, methodologies, data management systems, and administrative requirements necessary to initiate the Program. Program progress so far has been depicted in the First and Second Annual Reports (USFWS 1989, 1990). Detailed work plans are developed each year to describe research priorities and objectives, strategies, and tasks to accomplish Program goals.

This revised Operating Plan was prepared in 1992 to continue Program operation and was necessitated by (1) major discrepancies over the last 4 years between appropriated and authorized funding, (2) a 5-year Program extension, (3) information and experience gained over the last 4 years, (4) recent Program reviews, (5) evolution of the Program into a fully operational status, and (6) a need to coordinate the Program with the U.S. Army Corps of Engineers' Navigation Plan of Study.

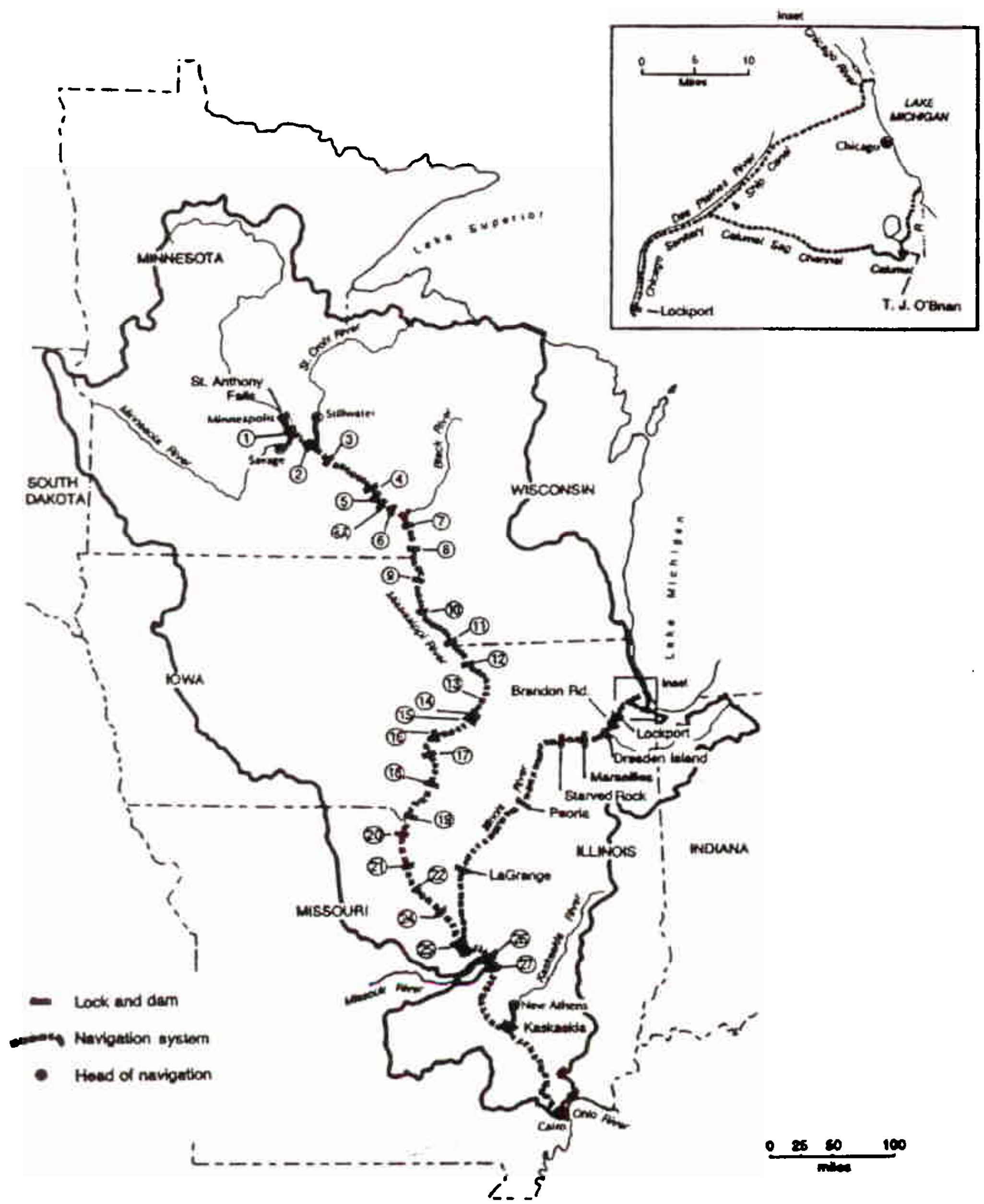


Figure 1. Upper Mississippi River System (Adopted from the Master Plan)

The body of the Operating Plan begins with the Program's mission statement, followed by goals, objectives, strategies, and tasks. Schematic diagrams are included to demonstrate linkages between products, objectives, and strategies. Individual tasks within the Program are described with details related to specific input requirements, accomplishments to date, initiation and completion dates, and expected products. The main text of the Operating Plan is followed by a series of appendixes, including (1) a conceptual model of the Upper Mississippi River Basin, (2) a summary of the Program planning history, (3) a Program schedule with expected products and a listing of completed reports, and (4) a record of expenditures to date and projected future budgetary requirements.

Table of Contents

List of Tables

List of Figures

Introduction

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System (UMRS), which encompasses the commercially navigable reaches of six Midwestern rivers, was initiated in 1987. The overall mission of the Program is to provide decision makers with information to maintain the UMRS as a viable large river ecosystem, given its multiple-use character. A general conceptual model providing a whole-system understanding of the structure and function of the Upper Mississippi River Basin is developed in Appendix A. The model provides basin-wide background information, directs experimental designs, prioritizes efforts, and identifies cause-and-effect mechanisms for strategic and trend models. The river basins of the UMRS are subject to many natural and human-induced disturbances, some of which have caused or are expected to result in large-scale resource problems.

Studies currently being conducted in the Program are (1) long-term changes in the UMRS, (2) significant resource problems, and (3) responses to disturbance. Long-term trends in selected resource components are being monitored using six field stations and remote sensing/geographic information system (GIS) technologies. Significant resource problems also are being evaluated through relatively short-term problem analyses that address responses to disturbances at various spatial and temporal scales. Results of both monitoring and problem analyses efforts, besides providing a better understanding of the UMRS, will help design and interpret habitat rehabilitation/improvement projects and develop management alternatives for optimum environmentally sustainable development.

The LTRMP currently is being implemented by the Environmental Management Technical Center (EMTC), an office of the U.S. Fish and Wildlife Service (Service), in cooperation with the five Upper Mississippi River Basin states, Illinois, Iowa, Minnesota, Missouri, and Wisconsin, with guidance and overall Program responsibility provided by the U.S. Army Corps of Engineers (COE). Respective agency roles are outlined in a 1988 Memorandum of Agreement between the Service and the COE.

The Operating Plan for the LTRMP was originally adopted by the EMTC in 1988 (Rasmussen and Wlosinski) and has been used to the present time. This updated and expanded version of the Operating Plan is intended to supersede the original 1988 version. Revisions have been necessitated by (1) major discrepancies over the last 4 years between appropriated and authorized funding, (2) a 5-year Program extension, (3) information and experience gained over the last 4 years, (4) recent Program review, (5) moving the Program into a fully operational phase, and (6) coordinating the Program with the COE's Navigation Plan of Study.

The revised Operating Plan is intended to provide general rationale for Program goals and objectives and more specific rationale for strategies and tasks. Individual tasks within the Program are detailed according to specific input requirements, estimated time frames for initiation and completion, who will do the work, and products to be delivered. The time frames for Program elements and products are illustrated in Appendix C. Preliminary estimates of costs at the strategy level and expenditures to date are illustrated in Appendix D. While this revision of the Operating Plan makes no major changes in the resource problems or components selected in the original documents, such changes may occur in the future; therefore, this revision provides an explicit mechanism for modifying Program elements as new information becomes available.

The revised Operating Plan is organized to show how the expected informational products are linked to the mission, goals, objectives, and strategies of the Program. The body of the Plan begins with the Program mission statement, followed by goals, objectives, strategies, and tasks. Expected products are listed for each task and schematic diagrams demonstrate the links of informational

Expected products are listed for each task and schematic diagrams demonstrate the links of informational products between Program objectives. Appendix A explains the current Upper Mississippi River Basin conceptual model. Appendix B is a summary of Program planning history. Appendix C is a Program schedule showing anticipated product time frames and interrelationships. Appendix D includes annual and Program budget projections.

No attempt has been made within this document to estimate costs at the task level. More accurate task cost estimates are provided in the Annual Work Plans, only after Scopes of Work have been prepared, with attention to experimental methods/design, logistical considerations, and in-house versus contractual requirements. The organization of goals, objectives, strategies, and tasks within this revised Operating Plan do not reflect Program priorities, since all the elements of the Plan are equally important to the Program mission. Program priorities will be routinely reevaluated, with necessary changes and yearly priorities indicated in the Annual Work Plans.

To date, LTRMP reports have constituted the primary written products of the Program; however, the volume of technical articles prepared for publication in scientific journals may also increase. Although not specifically identified herein, journal publications are highly encouraged as a form of technology transfer in the Program. Progress and products to date within the Program are summarized in Annual Addendums to the Environmental Management Program and in Appendix C.

Background Information

The LTRMP has an extensive planning and development history (Appendix B). Jackson et al. (1981) developed a two-volume Long Term Resource Monitoring Plan for the Upper Mississippi River System. The Environmental Work Team (1981) then adopted the Plan and recommended implementing it. The Team further stated "It is anticipated that a period of 5 years will be required to fully implement the LTRM program" (based on full funding levels). The Team also found ". . . it has been documented that there is insufficient data to enable the Environmental Work Team to make quantifiable conclusions regarding the systemic environmental impacts of increasing commercial navigation levels." Based on these findings, they recommended that "Congress should authorize $34 million over the next 10 years to implement a program to fill these data gaps. This information is essential to interpret information developed in the Long Term Resource Monitoring Plan and to make the Computerized Inventory and Analysis System operable by obtaining information on water depth, substrates, velocities, and aquatic vegetation."

The Upper Mississippi River Basin Commission (UMRBC) prepared a Comprehensive Master Plan in 1982 for managing the UMRS. The UMRBC adopted the Long Term Resource Monitoring Plan and the Computerized Inventory and Analysis System recommendations of Jackson et al. (1981) and the Environmental Work Team (1981). The Master Plan did not, however, incorporate the recommendation for $34 million in funding over a 10-year period for navigation impact studies and geographic information system (GIS) data acquisition.

Section 1103 of the Water Resources Development Act of 1986 required the "implementation of a Long-Term Resource Monitoring Program," and that "implementation of a Computerized Inventory and Analysis System" be undertaken "as identified in the Master Plan. . . ." Because of the Congressional requirement to conduct the Programs "as identified in the Master Plan," the Master Plan recommendations are here reproduced (UMRBC 1982):

CONGRESS IMMEDIATELY AUTHORIZE IMPLEMENTATION OF A LONG-TERM RESOURCE MONITORING PROGRAM.

In addition to immediate implementation of projects to rehabilitate and enhance habitat areas, the evaluation phase of those projects and the ability to understand complex and dynamic system relationships depends on continued monitoring. A long-term resource monitoring program (LTRM) is needed to enable decision-makers to measure ecological impacts attributable to a combination of natural and man-induced forces. Included in that program are specific actions to further our understanding of the physical, chemical, and biological relationships in the system. The program would improve the understanding of future multi-purpose management needs and help determine equitable management actions.

Data have been collected over the years on many aspects of the environment of the UMRS. Differences in sampling methods, assessment instruments and analysis have made systemwide comparisons difficult. The implementation of this recommendation would provide a consistent, standardized resource monitoring program.

The Master Plan studies have identified the environmental variables to be monitored with respect to fish and wildlife, water quality, wilderness, and public recreational opportunities of the UMRS. Such variables include but are not limited to:

- Land use changes with respect to agriculture, commercial, industrial, urban, forest, transportation, and flood control.
- Habitat changes for aquatic and terrestrial organisms due to natural forces and man's actions.
- Species composition and relationships with habitat types.
- Rates, sources, and cause of sedimentation, sediment deposition, and resuspension.
- Recreational uses including temporal and spatial variations.

It is anticipated that a period of five years will be required to fully implement the LTRM program. Once fully in operation the LTRM could be an integral part of the management of the UMRS. The success of the Long-Term Resource Monitoring Program depends on the development of a computerized analytical inventory and analysis system for data storage, retrieval, and comparison.

CONGRESS IMMEDIATELY AUTHORIZE IMPLEMENTATION OF A COMPUTERIZED INVENTORY AND ANALYSIS SYSTEM FOR DATA STORAGE AND RETRIEVAL, AND FOR USE IN THE LONG-TERM RESOURCE MONITORING PROGRAM.

Alternative levels of computerized information systems were evaluated in the context of UMRS systemic management needs as identified by all components of the Master Plan. The need for centralized, consistent, comprehensive, and current data identified in the navigation, natural resource, and recreation recommendations is recognized as critical for future multi-purpose resource management decisions in the UMRS.

The Commission recognized that a fully operational centralized data repository and processing center requires a sequential development of the major components of the system. The Computerized Inventory and Analysis System should be developed according to the following steps, and be operational by 1987:

1. Continue utilization of the Minnesota Land Management Information Center or similar system to maintain and update information gathered during the Master Plan process.

2. Develop an information transfer service to provide for identification and transfer of information and technology while evaluating and improving the system. This phase should provide full service in the storage and distribution of data being developed and analyzed in the programs outlined in both the environmental and transportation recommendations.

3. Develop a management briefing system to provide support information to resource management entities of the UMRS.

4. Establish a geographic information center to serve as a centralized processing and repository center for system-wide information. All data from the distribution process network would be centralized for utilization by all participating entities.

A Geobased Information System (GIS) would provide an effective mechanism for the evaluation and analysis of the impacts associated with alternative multi-purpose river resource management proposals. Such a system is an essential component of a Long-Term Resource Monitoring Program. It would enhance the effectiveness of such a monitoring program because it would provide the capability of entry and retrieval of data, statistical analysis, modeling, spatial data manipulation, and interface with other systems.

In anticipation of the Water Resources Development Act passing in 1986, an interagency committee was formed to identify and describe the various components of the LTRMP. That committee identified four major program components: (1) evaluation of Habitat Rehabilitation and Enhancement Projects (HREP), (2) assessment of long-term changes in selected resource trend analysis (RTA), (3) assessment of specific resource problems, including a problem identification and analysis process (PIA), and (4) establishment of an integrated data base management system (IDMS) with a geographic information system capability. During 1987, interagency work groups and committees were formed to develop HREP, PIA, RTA, and IDMS reports summarizing each of these LTRMP components. These documents were developed independently by the work groups and were used extensively in the preparation of this revised Operating Plan.

A Plan of Study (POS) for determining the navigation effects of the second lock at Melvin Price Locks and Dam was prepared by an interagency formulation team in February 1991. The POS identified 16 study units, 14 of which were recommended for funding at a cost of approximately $25 million over an 8-year period. The studies would quantify the navigation traffic impacts on significant UMRS natural resources. The LTRMP recognizes this POS as the framework for an overall effort to predict navigation effects on the UMRS. The POS will form the basis for any following LTRMP navigation studies which are a part of the overall LTRMP. The LTRMP is designed to respond to a much broader range of data and study needs than those exclusively required to identity and quantify navigation effects.

Implementation Status

Most of the major startup costs of the Long Term Resource Monitoring Program (LTRMP) have already occurred. Facility, vehicle, and equipment acquisitions have been made. A centralized Environmental Management Technical Center (EMTC) is operational in Onalaska, Wisconsin, and initial computer hardware and software acquisitions and installations are complete. An initial Operating Plan, completed in 1988, formed the basis for Program implementation. Completed Program reports are listed as an attachment to Appendix C.

The EMTC's computer section has acquired geographic information systems (GIS) data on land cover/land use, soils, geology, transportation, hydrography, land ownership, and digital elevation models. Initial low-level aerial photography coverage also has been collected. Automation of high-resolution GIS data on land cover and aquatic zones is now nearing completion for LTRMP pools, and a GIS interface for field station use has been initiated. A data set inventory and query program has been completed, and a data base management program for water quality, fish, and vegetation monitoring data is operational. An ORACLE data base management system from the centralized Prime computer has been loaded, and applications are being developed. Implementation of a statistical analysis system which gives analytical capabilities at all field stations has occurred.

Six remote cooperative field stations (see map in Appendix E) have been established and are operational, with water/sediment, fish, and vegetation samples being collected at over 150 sites in six river pools or reaches. Initial data collection procedures manuals have been written. Procedures are being developing for collection of invertebrate and public use data. Standardized gear and sampling equipment have been purchased and field station staff have been trained. An extensive Quality Assurance/Quality Control program is operational for field data collection and data management. Appendix E depicts the locations of the six field stations and their proximity to Habitat Rehabilitation and Enhancement Project (HREP) sites. Appendix F is a current listing of field station addresses and personnel. Limited HREP monitoring also has started in cooperation with the U.S. Army Corps of Engineers, State field stations, and the EMTC.

A fully operational hydrographic survey system is in place at the EMTC, with large portions of Pools 8 and 13 mapped. Additional mapping of Lake Pepin and selected HREP sites has been done. A classification system for aquatic areas has been developed, and sedimentation transects have been established. Continuous water quality monitoring pilot studies, ichthyoplankton surveys, and field studies of the physical effects of navigation have been initiated. A pilot project of the effects of light reduction on aquatic plants is complete. Field measurements of physical impacts of commercial traffic have been completed at four Upper Mississippi River System sites and modeling of these impacts has begun.

A Science Review Committee of seven members was formed in 1990 to serve in a science oversight capability (Appendix G). An initial meeting was held and incorporation of the Committee's recommendations into the Program is under way. These recommendations have been incorporated in this revised Operating Plan.

Two policy/technical committees composed of participating state and agency members were formed in 1987. The two committees were recently merged into one Analysis Team to help develop LTRMP goals and objectives, set priorities, define products, and review progress. Specific Analysis Team duties include assisting in the development and periodic review of the LTRMP Operating Plan, reviewing the Annual Work Plans and Annual Reports to attain established goals and objectives, communicating the needs and desires of states and agencies, providing a focal point for state and agency coordination, coordinating related state and agency activities with the LTRMP, assisting in reviewing Scopes of Work, and reviewing products and reports. A listing of the Analysis Team members is included in Appendix H.

Fund expenditures to date (through Fiscal Year 1991) are itemized in Appendix D. The expenditures are distributed across appropriate goals, objectives, and strategies.

Detailed Program progress and organizational structure can be found in the first and second annual program reports. Development of the initial monitoring recommendations, including pool and river reach selection, is discussed in Appendix B.

Program Mission Statement, Goals, Objectives, and Strategies Summary

Mission Statement: Provide decision makers with information to maintain the Upper Mississippi River System as a viable large river ecosystem, given its multiple-use character.

The following section is an overview of the goals, objectives, and strategies for the Long Term Resource Monitoring Program (Fig. 2). Schematic diagrams are included after each objective to demonstrate linkage of informational products between Program objectives.

Goal 1: Develop a Better Understanding of the Ecology of the Upper Mississippi River System and its Resource Problems

- Objective 1.1: Plan Ecological Research
  - Strategy 1.1.1: Describe Ecosystem
  - Strategy 1.1.2: Select Priority Problems for Research
- Objective 1.2 Implement Ecological Research
  - Strategy 1.2.1: Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem
  - Strategy 1.2.2: Determine Effects of Navigation on Selected Components and Processes of the Upper Mississippi River System Ecosystem
  - Strategy 1.2.3: Determine Effects of Water Levels and Discharges on the Upper Mississippi River System Ecosystem
- Objective 1.3: Identify and Investigate Additional Environmental Problems Affecting the Upper Mississippi River System Ecosystem
  - Strategy 1.3.1: Review Updates of Conceptual Model
  - Strategy 1.3.2: Select New Problems for Research

Goal 2: Monitor Resource Change

- Objective 2.1: Develop a Resource Monitoring Plan
  - Strategy 2.1.1: Select Components and Reaches
- Objective 2.2: Implement Monitoring Program
  - Strategy 2.2.1: Monitor and Evaluate Floodplain Elevation
  - Strategy 2.2.2: Obtain and Evaluate River Discharge and Water Surface Elevation Data
  - Strategy 2.2.3: Monitor and Evaluate Water Quality
  - Strategy 2.2.4: Monitor and Evaluate Aquatic and Terrestrial Vegetation
  - Strategy 2.2.5 Monitor and Evaluate Sediment Composition
  - Strategy 2.2.6: Monitor and Evaluate Aquatic and Floodplain Habitat
  - Strategy 2.2.7: Monitor and Evaluate Selected Macroinvertebrate Populations and Communities
  - Strategy 2.2.8: Monitor and Evaluate Fish Communities, Guilds, and Populations
  - Strategy 2.2.9: Monitor and Evaluate Wildlife
  - Strategy 2.2.10: Monitor and Evaluate Public Use
- Objective 2.3: Synthesize and Evaluate Monitoring Data
  - Strategy 2.3.1: Multi-Component Syntheses
  - Strategy 2.3.2: Evaluate and Refine Monitoring Design

Goal 3: Develop Alternatives to Better Manage the Upper Mississippi River System

- Objective 3.1: Develop Alternative Management Objectives
  - Strategy 3.1.1: Identify Expectations for Future Uses of the Upper Mississippi River System (Exclusive of Commercial Navigation)
  - Strategy 3.1.2: Predict Future Conditions Without Change in Management

Strategy 3.1.3: Identify Ecologically Realistic Levels for Future Consumptive Use
Strategy 3.1.4: Identify Alternative Management Objectives
Strategy 3.1.5: Identify Future Conditions Needed to Meet Alternative Objectives
Objective 3.2: Formulate Management Alternatives
Strategy 3.2.1: Prepare Management Alternatives
Objective 3.3 Evaluate Management Alternatives
Strategy 3.3.1: Identify Constraints on Implementation
Strategy 3.3.2: Test and Assess the Effectiveness of Prototype Management
Strategy 3.3.3: Evaluate and Compare Management Alternatives

Goal 4: Provide for the Proper Management of Long Term Resource Monitoring Program Information
Objective 4.1: Provide Direction for Automation Activities
Strategy 4.1.1: Develop and Update Information Management Guidance Documents
Objective 4.2: Provide Needed Automation Tools
Strategy 4.2.1: Acquire, Install, Operate, and Maintain Hardware and Software
Objective 4.3: Ensure Proper Management and Analysis of LTRMP Data
Strategy 4.3.1: Develop Data Management and Analysis Capabilities
Objective 4.4: Provide Access to LTRMP Data
Strategy 4.4.1: Develop an Information Sharing Process
Strategy 4.4.2: Develop a Technology Transfer Process

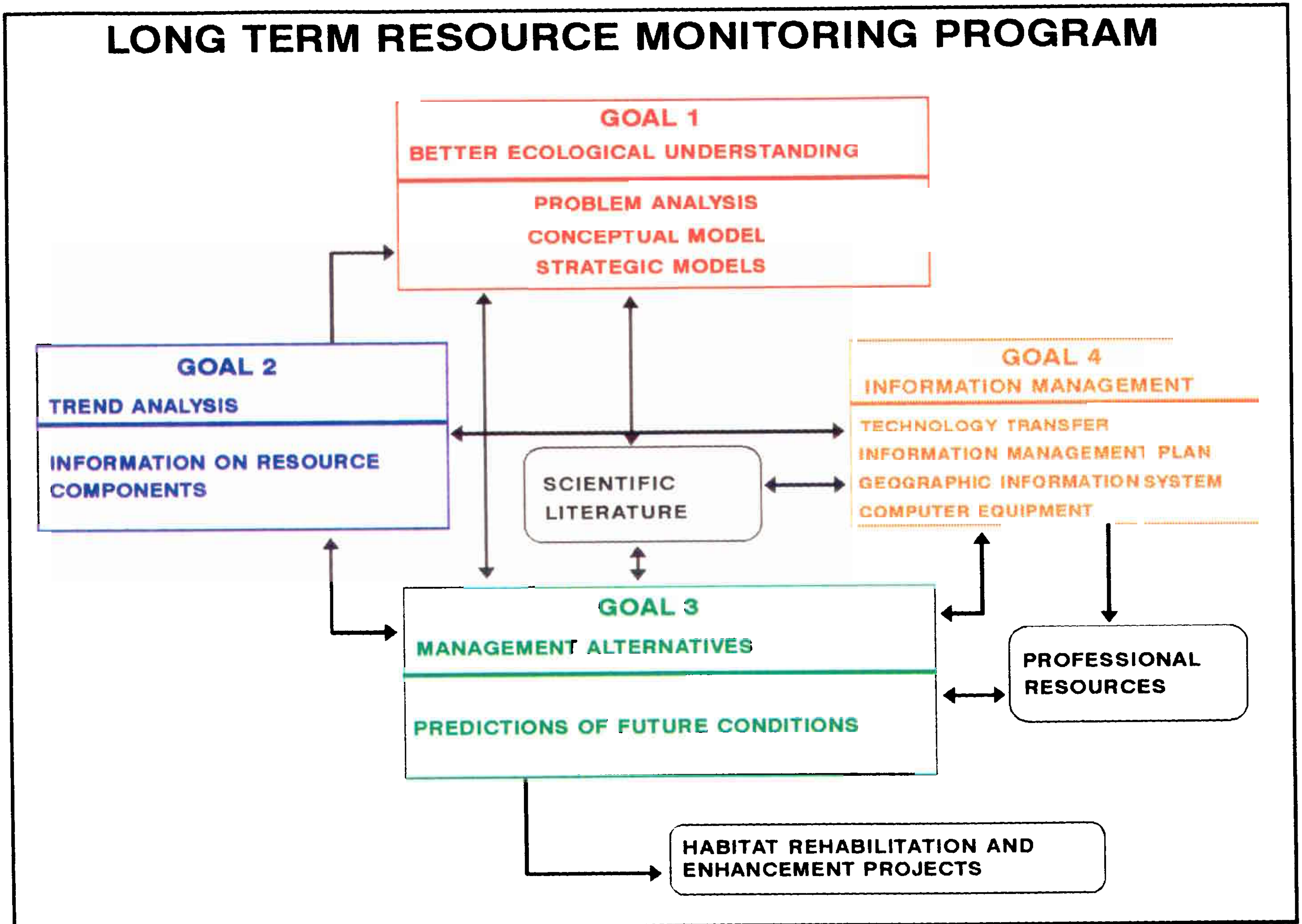


Figure 2. The Interrelationships Affecting Long Term Resource Monitoring Program Goals

References

Analytical Technologies, Inc. 1990. Automated Data Systems Manual - Long Term Resource Monitoring System Functional Description. Analytical Technologies, Inc., St. Paul, MN.

Environmental Work Team. 1981. Comprehensive Master Plan for the Management of the Upper Mississippi River System - Environmental Report. Prepared by the Environmental Studies Work Team for Upper Mississippi River Basin Commission, Bloomington, MN.

Jackson, G. A., C. E. Korschgen, P. A. Thiel, J. M. Besser, D. W. Steffeck, and M. H. Bockenhauer. 1981. A Long Term Resource Monitoring Plan for the Upper Mississippi River System. Contract Number 14-16-009-81-903. Upper Mississippi River Basin Commission, Bloomington, MN. 2 Vols.

Rasmussen, J. L., and J. H. Wlosinski. 1988. Operating Plan of the Long Term Resource Monitoring Program for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1988. EMTC 88-01. 55 pp. (NTIS # PB88 169669/AS)

Upper Mississippi River Basin Commission (UMRBC). 1982. Comprehensive Master Plan for the Management of the Upper Mississippi River System. Upper Mississippi River Basin Commission, Bloomington, MN. 193 pp.

U.S. Fish and Wildlife Service (USFWS). 1987. Action Plan Report - Integrated Data Management System. U.S. Fish and Wildlife Service, Twin Cities, MN. 31 pp.

USFWS. 1989. First Annual Report of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin, January 1989. EMTC 89-02. 130 pp. (NTIS # PB91 174102)

USFWS. 1990. Second Annual Report, 1989. Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-05. 267 pp. (NTIS # PB91-117317)

Glossary

Acronyms and Abbreviations

COE	U.S. Army Corps of Engineers
CPUE	catch-per-unit-effort
EMP	Environmental Management Program
EMP-CC	Environmental Management Program-Coordinating Committee
EMTC	Environmental Management Technical Center
EPA	U.S. Environmental Protection Agency
GIS	geographic information systems
GREAT	Great River Environmental Action Team
HREP	Habitat Rehabilitation and Enhancement Project
IDMS	Integrated Data Management System
IMP	Information Management Plan
ISSD	Information Systems Support Division
LAN	Local Area Network
LTRM	Long Term Resource Monitoring
LTRMP	Long Term Resource Monitoring Program
PIA	Problem Identification and Analysis
POS	Plan of Study
RTA	Resource Trend Analysis
Service	U.S. Fish and Wildlife Service
UMRBC	Upper Mississippi River Basin Commission
UMRCC	Upper Mississippi River Conservation Committee
UMRS	Upper Mississippi River System
USGS	U.S. Geological Survey

Terms

Annual Work Plan

a document prepared by the EMTC in cooperation with EMP participants for the U.S. Army Corps of Engineers' review and concurrence. This plan is designed to allow the Corps, Service, and Program participants to agree at the beginning of each fiscal year on the priority and cost of work to be accomplished. The format of the Annual Work Plan follows that of the revised Operating Plan.

Conceptual Model

general description of how the ecosystem processes of the Upper Mississippi River System work on five different spatial scales. The model is used to help select systemic problems and resource components and to identify representative monitoring reaches and sites.

Executive Briefing System

on-line system which provides resource managers and decision makers with rapid access to frequently requested LTRMP information. Information is generally in graphic form with little manipulation or recombination capabilities.

Information Sharing

the capability to provide LTRMP participants, in a timely and cost-effective manner, with access to a wide range of LTRMP data in a variety of forms and formats. Shared data often will be further manipulated or recombined by participants to meet their specific needs.

Master Plan

comprehensive plan for managing the Upper Mississippi River System.

Plan of Study

document produced by the St. Louis District Corps of Engineers to develop studies of the impacts of navigation traffic resulting from constructing the Melvin Price Locks and Dam, and studies of other navigation and recreation traffic impacts.

River Resource Forum

interagency committee of decision makers in the St. Paul District Corps of Engineers.

Scope of Work

will determine the direction and magnitude of research for specific tasks. Attention will be given to experimental design and methods.

Strategic Model

box-and-arrow model that identifies relationships between systemic problems (i.e., sedimentation, navigation, and water level fluctuations) and resource components. A strategic model is a planning tool to help establish strategies or priorities for research.

Study Sheet

precursor to the Scope of Work that will be included in the Annual Work Plan.

Trend Model

box-and-arrow model that describes anticipated changes in resource components of the Upper Mississippi River System ecosystem. A trend model is a planning tool for establishing sampling locations and frequencies and identifying supplementary data needs.

Goal 1: Develop a Better Understanding of the Ecology of the Upper Mississippi River System and its Resource Problems

Informed Upper Mississippi River System (UMRS) management requires an improved understanding of the ecosystem and its resource problems. Navigation, sediment-related problems, and water level regulation have been identified by interagency committees as three major problems for the Long Term Resource Monitoring Program (LTRMP) to address. Studies have been and will be designed to examine these specific problems, as well as additional environmental problems, and to suggest possible solutions. Problem analysis research will provide decision makers with information on the major human-induced disturbances affecting the UMRS.

Data collected in the trend analysis element of the Program (Goal 2) will be used to make correlative relationships with the resource problems. To the extent that problem analysis can determine cause-and-effect relationships, problem analysis also will play a role in the design and evaluation of some Habitat Rehabilitation and Enhancement Projects (HREPs), and in the development of management objectives (Goal 3). Resource problem analysis will rely on the Information Systems Support Division (Goal 4) at the Environmental Management Technical Center (EMTC) to manage and archive data as well as to manage problem analysis research.

Models

Models of the UMRS and of known resource problems will be used to help develop Program implementation strategies. Information generated during the Program will be used to refine the models and to quantify the relationships the models describe. Model updates, produced at regular intervals, will serve as milestones for evaluating progress along individual lines of inquiry. Conceptual, strategic, and trend models have been used in initial Program development.

The conceptual model (Appendix A) serves as an up-to-date ecological description of the major factors and disturbances currently affecting the Upper Mississippi River Basin. The conceptual model links the decision-making processes within the Program to prevailing scientific knowledge.

Strategic and trend models (Fig. 1-1) are intended to graphically illustrate the lines of inquiry being pursued within the Program. Strategic models are box-and-arrow diagrams of relationships believed to be important in linking resource components to resource problems. Strategic models are useful in visualizing the packages of information required and targeted for generation during the Program. Studies are designed and conducted to quantify the relationships (arrows) within strategic models. The clear presentation of the many relationships that may control a resource component also makes it possible to review and prioritize (by ranking the arrows) required studies.

Trend models (Fig. 1-1) are graphic depictions of anticipated changes in resource components, serving two purposes. The first is to clearly describe which variables (measurements) of a resource component are expected to change and the time period(s) over which the change will occur. This information is necessary for establishing trend analysis sampling designs that provide data to measure the change. The second purpose of a trend model is to describe, in general terms, the disturbance(s) that will likely control the change. This estimate is necessary to determine which data need to be collected to explain any observed changes. In the example of fish catch-per-unit-effort (CPUE) in Figure 1-1, the long-term decrease in sediment-sensitive fishes is postulated as

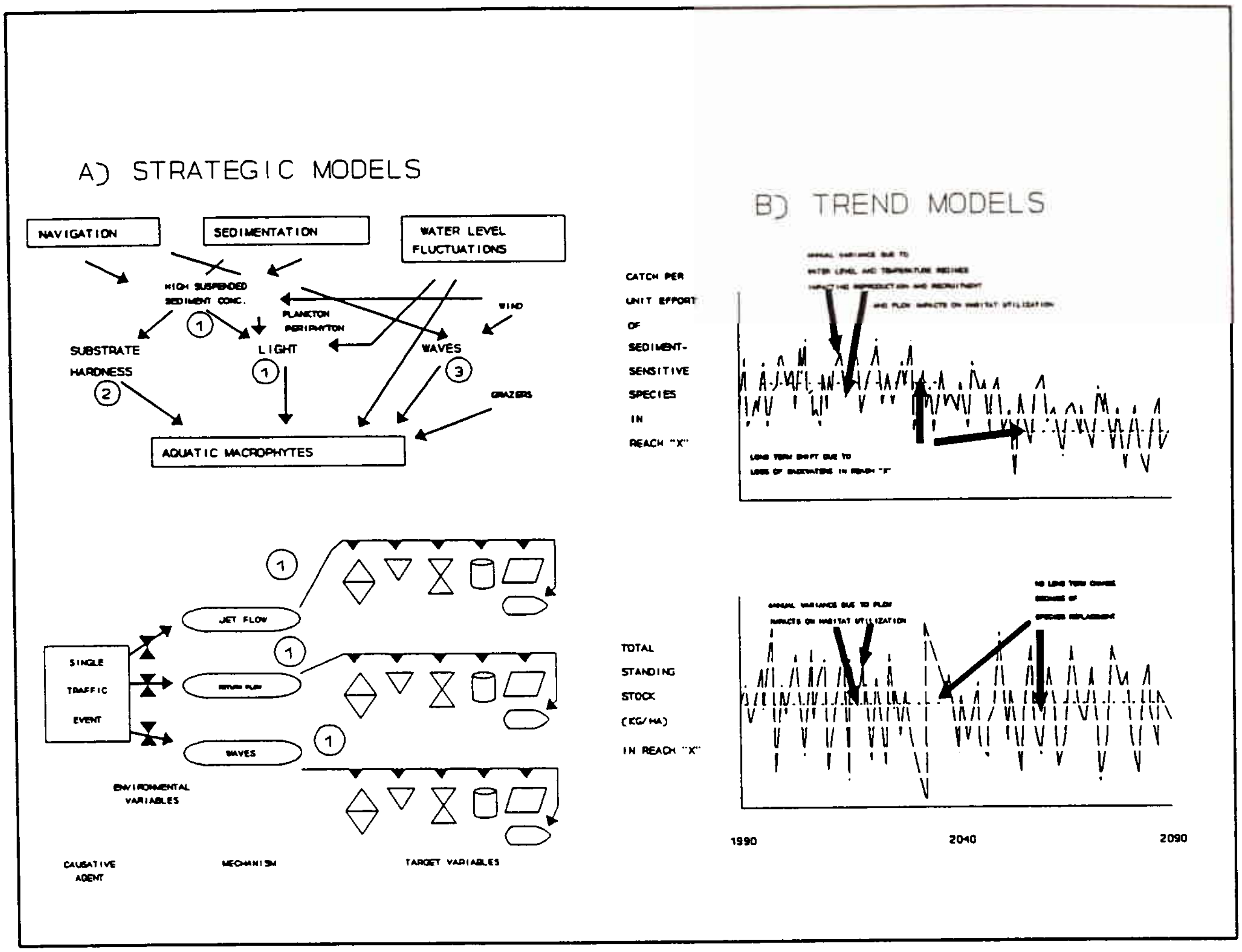


Figure 1-1. Examples of Strategic and Trend Models Used in Program Development

related to losses of backwater habitat. Identifying backwater losses as a controlling disturbance requires that the LTRMP monitor habitat change as well as the CPUE.

In addition to their roles in initial Program development, each strategic and trend model will be used to construct more elaborate quantitative or mathematical models as the Program matures.

Objective 1.1: Plan Ecological Research

The problem analysis component of the Program addresses important resource problems. Problem analysis usually consists of short-term studies, as compared to long-term resource monitoring for trend analysis. The initial planning steps for conducting ecological research include describing the ecosystem and selecting the problems for further study.

The current problem analysis component of the LTRMP was based on recommendations in the Long-Term Resource Monitoring Report of the Master Plan and from the Environmental Work Team.

Strategy 1.1.1: Describe Ecosystem

A general description of the UMRS ecosystem is necessary before ecological research can be implemented. An initial account has been developed, as well as a conceptual model describing how the processes of the UMRS interact.

Task 1.1.1.1 Initial Description

The UMRS ecosystem for the LTRMP initially was described in the 1981 Master Plan and the Long-Term Resource Monitoring Report (Volumes 1 and 2).

Inputs:

1. Interagency planning reports.
2. Information from UMRS resource professionals.

Product:

1. Description of the UMRS listed in reports.

Task 1.1.1.2 Conceptual Model with Updates

A conceptual model describing how UMRS processes interact on five different spatial scales (basin, stream network, floodplain reach, navigation pool, and habitat) was developed by EMTC staff in 1991. The conceptual model lists major abiotic and biotic factors and natural and human-induced disturbances affecting the UMRS structure or function. Although the conceptual model was not fully developed when the Program was initiated, many of the ideas contained in the model were well known and used during the pre-Program decision-making process. The conceptual model will be used to support Program decisions in several areas, including (1) identifying and prioritizing resource problems for investigations, (2) selecting resource components for monitoring, (3) developing strategic and trend models and identifying cause-and-effect relationships to be quantified, and (4) selecting appropriate experimental designs.

In a similar manner, strategic models identify relationships between systemic problems (sedimentation, navigation, and water level fluctuations) and resource components, and trend models describe anticipated changes to resource components (water quality, vegetation, and fish). Strategic models will be used as planning tools to help establish strategies or priorities for research. Trend models are also planning tools and will help establish sampling locations and frequencies and identify supplementary data needs.

The conceptual model will be revised as necessary in response to new information related to ecosystem structure, function, or disturbance. Model revisions will help determine if the magnitude of a resource problem has changed, or how the problem and its potential solutions vary across different spatial scales within the UMRS. The conceptual model will be updated in 1993 and every

3 years thereafter. The relationship of the conceptual model to other Program components is graphically depicted in Figure 1-2.

Inputs:

1. Literature on studies of the UMRS ecosystem, large floodplain rivers, relevant environmental impacts, and the recovery of damaged ecosystems.
2. Information from professional resources (UMRS managers and researchers and the Science Review Committee).
3. Evaluation and summaries of trend analysis monitoring (Strategies 2.2.1 to 2.2.10 and 2.3.1).
4. Results of problem analysis research (Strategies 1.2.1 to 1.2.3, 1.3.1, and 2.3.1).
5. Input to the development of management alternatives and HREPs (Goal 3).

Products:

1. A report describing the initial conceptual model, spatial scales, major factors, disturbances, and resource problems.
2. Input to strategic and trend models (Strategies 1.2.1 to 1.2.3, 1.3.1, 1.3.2, 2.2.1 to 2.2.10, and 2.3.1).
3. Input to selecting processes for research (Strategies 1.2.1 to 1.2.3).
4. Input to establishing experimental design (Strategies 1.2.1 to 1.2.3, 1.3.2, and 2.2.1 to 2.2.10).
5. Input to the development of management alternatives and HREPs (Goal 3).
6. Input to technology transfer (Objective 4.4).

Strategy 1.1.2: Select Priority Problems for Research

The selection of priority problems for research has been made by interagency committees. As time passes and priorities change, other problems may be identified and evaluated through conceptual model updates, upon the recommendations of the Analysis Team.

Task 1.1.2.1 Initial Selection of Priority Problems

A list of 10 critical resource problems, eight of which addressed the problem areas of navigation, sedimentation, and river regulation, were listed in an interagency team report in 1987. The original Operating Plan identified five major resource problems: (1) navigation, (2) sedimentation effects, (3) water level fluctuation, (4) lack of aquatic vegetation, and (5) reduced fisheries populations. Of these five, the first three are considered to be major problems. The last two are secondary; however, all five will be targeted by the LTRMP. Sub-problems within each area will be identified and evaluated upon the recommendations of the Analysis Team.

Inputs:

1. Interagency planning reports.
2. Original Operating Plan.
3. Information from UMRS resource professionals.

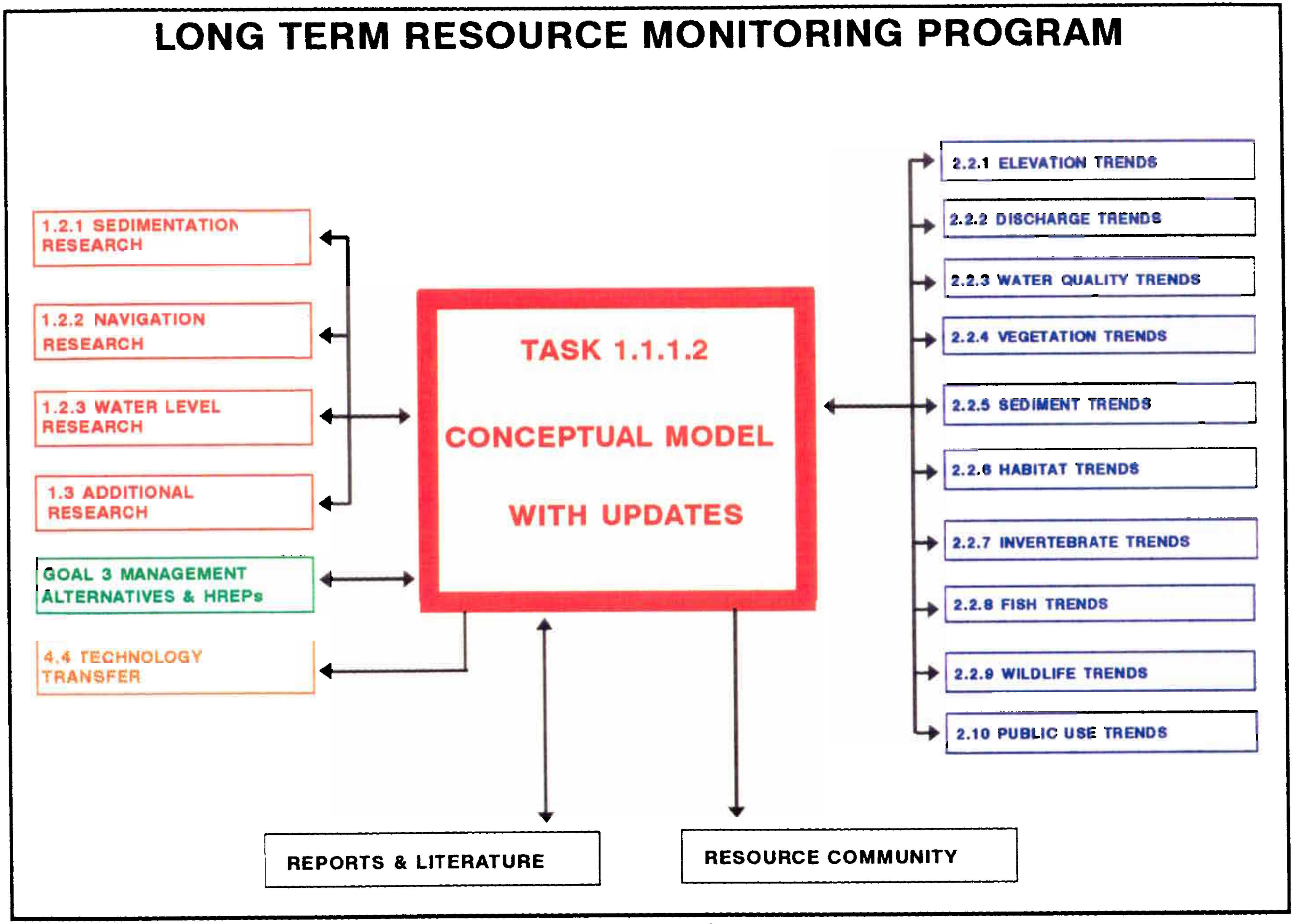


Figure 1-2. The Interrelationships Affecting the Conceptual Model, Task 1.1.1.2

Product:

1. List of initial priority resource problems.

Objective 1.2 Implement Ecological Research

Ecological research on the three major resource problems of navigation, sedimentation, and water level regulation will be implemented to provide information on the major human-induced disturbances affecting the UMRS. The planning format for accomplishing research in these three areas is as follows: developing a strategic model; selecting relationships for research; establishing experimental designs; and conducting the research, including data evaluation and synthesis.

Strategic models will be used as planning tools to help establish strategies or priorities for research. Strategic models identify relationships between systemic problems (i.e., navigation, sedimentation, and water level regulation) and resource components (i.e., water quality, vegetation, fish, and invertebrates). The strategic models, along with other information, will be used to select the priority processes for research. After the research processes have been determined, experimental designs will be formulated and Scopes of Work developed. Evaluations on a case-by-case basis will be made to choose the most appropriate scientific personnel for each research task. The pool of potential researchers includes staff at the EMTC and the LTRMP field stations, or other professionals through contracts or cooperative agreements. Research performed by LTRMP field station staff or other researchers will be monitored by EMTC project officers.

Strategy 1.2.1: Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem

Sedimentation is widely considered to be the most severe environmental problem on the UMRS. Modern agricultural practices, land clearing, and construction of the navigation system have led to excessive erosion and sedimentation in the UMRS floodplain. Hydraulic and hydrologic processes and human-induced disturbances, including commercial and recreational navigation and channel maintenance, are also important factors in sediment movement.

A strategic model of sedimentation that relates selected sediment processes, geomorphic changes in the UMRS floodplain, sediment-related geochemistry, and the biological effects of sediment transport and accumulation on aquatic plants and organisms will be developed from the LTRMP conceptual model and adapted from existing literature. This strategic model is a planning tool to help establish strategies or priorities for sedimentation research by identifying the major processes and relationships working on the ecosystem.

Additional field and laboratory investigations will be conducted to refine the strategic model and to answer important questions. Results of elevation surveys, direct measurements of sedimentation, sediment type surveys, remote sensing, and other information will be used to develop a geographic information system (GIS) inventory of areas in the UMRS floodplain with excessive suspended sediment levels and sediment accumulation. The relationship of sedimentation research to other Program components is graphically depicted in Figure 1-3.

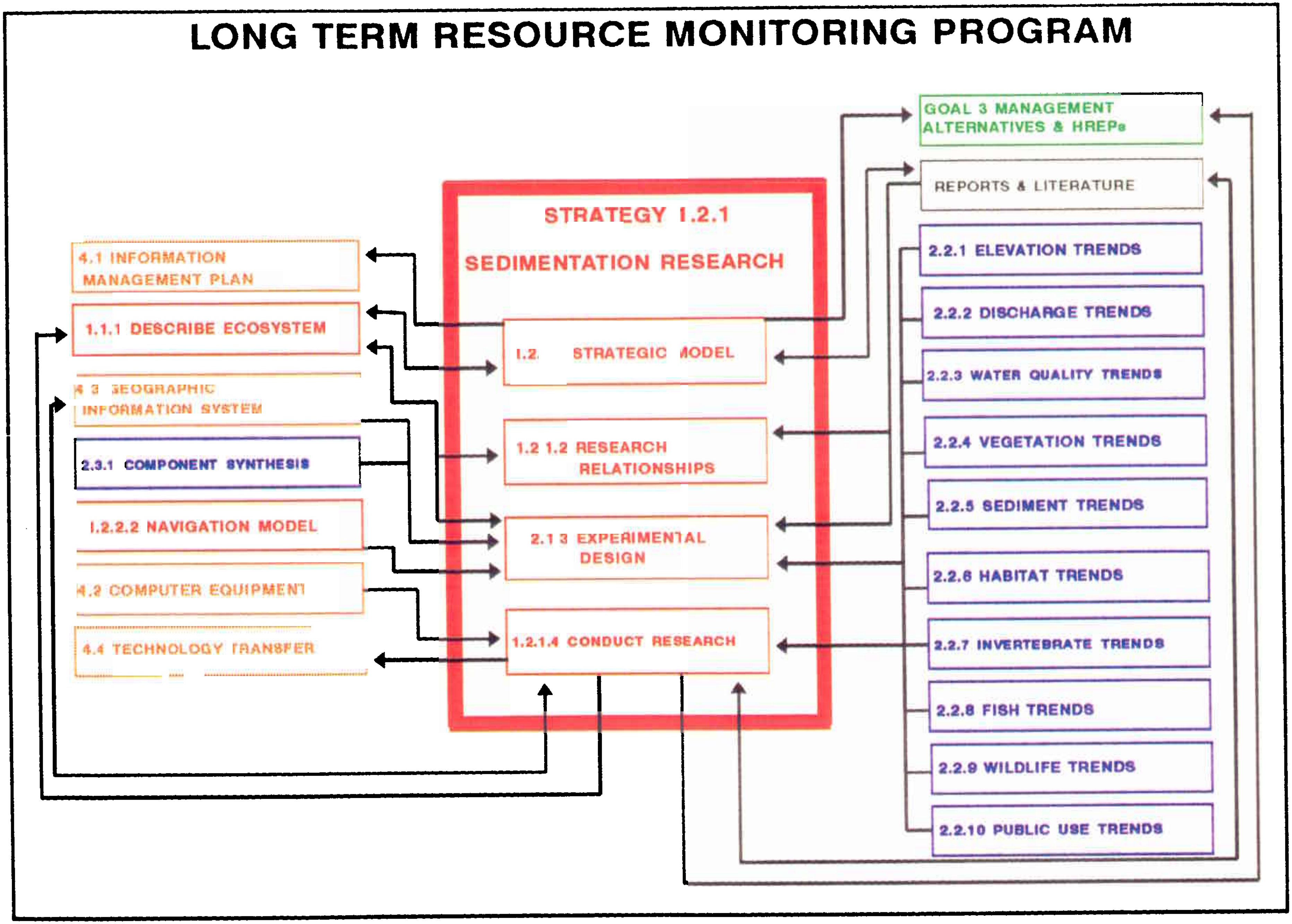


Figure 1-3. The Interrelationships Affecting Sedimentation Research, Strategy 1.2.1

Task 1.2.1.1 Develop Strategic Models

A box-and-arrow model that describes sediment transport processes in the UMRS will be developed in 1992. The model will be updated every 3 years, or sooner if new information becomes available, and reviewed by the interagency sponsors. Strategic models of sediment transport processes will allow the development of predictive techniques linking sediment processes to ecosystem conditions at appropriate spatial and temporal scales. EMTC staff members have the primary responsibility for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review on sediment processes, ecological effects, and related predictive effects.
2. Conceptual model (Task 1.1.1.2).
3. Sedimentation research (Task 1.2.1.4).

Products:

1. Report(s) describing the strategic model for sediment processes.
2. Input to selecting processes for research (Task 1.2.1.2).
3. Input to the development of management alternatives and HREPs (Goal 3).
4. Input to the Information Management Plan (Objective 4.1).
5. Input to the conceptual model (Task 1.1.1.2).

Task 1.2.1.2 Select Processes for Research

Sediment-related processes or relationships identified in the strategic model will be used along with other information to establish research priorities and strategies. Study sheets will be prepared for priority research projects for inclusion in the Annual Work Plan. The study sheet is a precursor to the Scope of Work. The primary responsibility for research selection and study sheet preparation lies with the EMTC staff, with input and review by the Analysis Team. Relationship selection for sedimentation began in 1987 and will continue throughout the life of the Program.

Inputs:

1. Sediment-related strategic model (Task 1.2.1.1).
2. Conceptual model (Task 1.1.1.2).
3. Literature on sediment processes.

Products:

1. Study sheets for the Annual Work Plan.
2. Input to experimental design (Task 1.2.1.3).
3. Priority list of research needs.

Task 1.2.1.3 Establish Experimental Design

In addition to posing hypotheses, selecting methods and sampling frequencies and identifying sites in the UMRS ecosystem where significant sediment-related and sediment transport problems occur is an important component of the experimental design. EMTC staff and research cooperators will prepare Scopes of Work to be reviewed by the Analysis Team.

Case-by-case evaluations will select the best person or group to do the research. The work could be done by EMTC or LTRMP field station staff or other appropriate scientific personnel. Research performed at LTRMP field stations or by contractors will be monitored by EMTC project officers. This task was initiated in 1988 and experimental designs for sediment-related initiatives will be developed as needed throughout the Program.

Inputs:

1. Literature on sediment processes.
2. Relationship selection for sediment-related research (Task 1.2.1.2).
3. Evaluation of trend analysis data, especially for sediment, floodplain elevation, water quality, and habitat (Strategies 2.2.1 to 2.2.10).
4. U.S. Geological Survey (USGS) estimates of sediment yields of UMRS tributaries.
5. GIS (Objective 4.3).
6. Conceptual model (Task 1.1.1.2).
7. Strategic model for navigation (Task 1.2.2.2).
8. Experimental design from trend analysis components (Strategies 2.2.1 to 2.2.10).
9. Synthesis of trend analysis data (Strategy 2.3.1).
10. COE dredging logs.

Products:

1. Scopes of Work for sedimentation research with interagency reviews.
2. Procurement.
3. Input to sediment-related research (Task 1.2.1.4).

Task 1.2.1.4 Conduct Research

Research will be conducted as prescribed in the experimental design. Scopes of Work for each research task and a report will be prepared. Sediment-related research began in 1988 and will be conducted throughout the Program.

Inputs:

1. Experimental design (Task 1.2.1.3).
2. Literature on sediment processes.
3. GIS (Objective 4.3).
4. Hydrologic information (Objective 2.2).
5. Results of sediment sampling obtained by other agencies.
6. Sediment type distribution survey results (Strategy 2.2.5).
7. Floodplain elevation results (Strategy 2.2.2).
8. Computer facilities (Objective 4.2).

Products:

1. Reports of sediment-related research.
2. Input to the sedimentation strategic model (Task 1.2.1.1).
3. Input to the conceptual model (Task 1.1.1.2).

4. GIS (Objective 4.3).
5. Input to management alternatives (Goal 3).
6. Input to technology transfer (Objective 4.4).
7. Input to the sediment trend analysis component (Strategy 2.2.5).
8. Journal articles (Objective 4.4).

Strategy 1.2.2: Determine Effects of Navigation on Selected Components and Processes of the Upper Mississippi River System Ecosystem

Commercial and recreational traffic is expected to increase on the UMRS in the future. Research is necessary to understand current impacts and to predict and avoid or minimize future problems associated with increased traffic levels. Informational needs related to navigation have been identified or summarized in a variety of documents (Appendix B), including the pre-Program planning documents for the LTRMP. These needs include analyses of physical (i.e., velocity changes, waves, drawdown, and sediment resuspension) and biological (i.e., fish, macroinvertebrates, and plants) impacts, spatial evaluations of how impacts vary among different river reaches, and investigations of commercial and recreational navigation impacts on other natural phenomena.

LTRMP research into the effects of commercial and recreational navigation will be closely coordinated with the COE's efforts to predict the effects of UMRS navigation system expansion. Since the initiation of the LTRMP, the St. Louis District COE (with the help of many resource agencies and the EMTC) produced a Plan of Study (POS) for navigation expansion related to the construction of the Melvin Price Locks and Dam. The initial objective of this POS was to develop studies of the impacts of navigation traffic increments, as facilitated by the second lock. This objective was broadened to include other navigation and recreation traffic impacts, in light of the lack of available information.

This POS serves as a framework for an overall effort to predict navigation effects on the UMRS and represents considerable interagency planning and agreement. The EMTC views the POS as the definitive document for identifying studies to quantify impacts of navigation traffic on significant UMRS resources. The POS will also form the basis for any new LTRMP studies. Future POS review, approval, funding, and implementation are uncertain at present. Specific tasks and scheduling of LTRMP navigation studies will therefore be partially contingent on COE decisions regarding the POS. Work units listed in the POS will likely be modified to take advantage of opportunities and products presented by ongoing LTRMP investigations and other emerging data.

Continued coordination of studies between the COE and the LTRMP is necessary. The Interagency Coordinating Team formed during the development of the POS (or a similar Interagency Team) should provide this function when the POS is implemented. Primary responsibilities of this Team should be to ensure interagency acceptance of study designs and products, to optimize data collection for the benefit of both programs, and to avoid duplicated efforts. The LTRMP will actively avoid duplication of POS efforts by participating on the Team and incorporating study approaches described in the POS work units, by revising work schedules to optimize product usefulness, and by exchanging information products. The EMTC believes that in addition to the coordinating function of an Interagency Coordinating Team, high-level scientific oversight and program design will be necessary to ensure that the best available technology and scientific investigations are carried forth.

The LTRMP has the technical and scientific capabilities to conduct or manage discrete POS work unit tasks, particularly those related to biological impacts, spatial classification of the UMRS, and biological data management. However, the EMTC will become involved in POS implementation only to the extent that the POS is compatible with the Program's primary goals and objectives. The following is an outline of the approach the EMTC will use in implementing navigation-related research. The relationship of navigation research to other Program components is graphically depicted in Figure 1-4.

Task 1.2.2.1 Review Plan of Study Work Units

EMTC staff will review the POS work units, including the flow charts and hypotheses, to determine which units are the most appropriate and have the highest priority for the Program.

Inputs:

1. POS work units.
2. Revised Operating Plan.

Products:

1. List of high priority work units.
2. Input to strategic navigation model (Task 1.2.2.2).

Task 1.2.2.2 Develop Strategic Model

EMTC staff will develop a box-and-arrow model that relates the known and expected impacts of navigation on the UMRS. This navigation strategic model will be developed from the LTRMP conceptual model, POS flow charts and hypotheses, the public use trend model, and existing literature.

This strategic model is a planning tool to help establish strategies or priorities for navigation research by identifying the major processes and relationships working on the UMRS ecosystem. The model will be developed in 1991 and updated every 3 years, or sooner if warranted by new data, and reviewed by the interagency sponsors. EMTC staff, in cooperation with POS researchers, have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Flow charts and hypotheses from the POS.
3. Public use trend model (Task 2.2.10.1).
4. Literature on navigation.
5. Input to selecting relationships for research (Task 1.2.2.3).

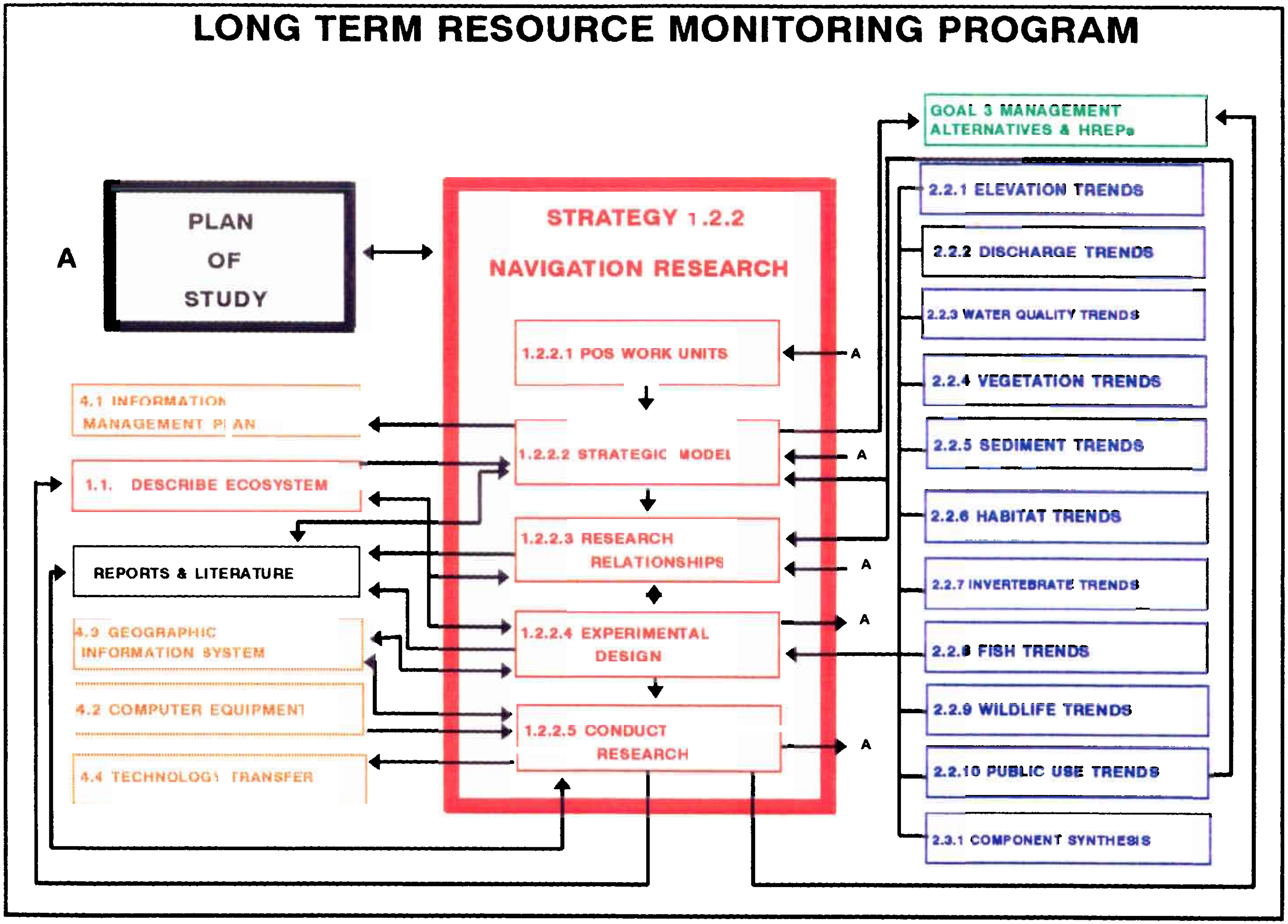


Figure 1-4. The Interrelationships Affecting Navigation Research, Strategy 1.2.2

09/93

Products:

1. Report(s) describing the navigation strategic model.
2. Input to selecting processes for research (Task 1.2.2.3).
3. Input to the development of management alternatives (Goal 3).
4. Input to the Information Management Plan (Objective 4.1).

Task 1.2.2.3 Select Processes for Research

Processes or relationships identified in the strategic navigation model will be used along with other information to establish priorities and strategies for navigation research. Study sheets will be prepared for priority research projects. The study sheet is a precursor to the Scope of Work. Primary responsibility for selecting research areas and preparing study sheets lies with the EMTC staff and research cooperators, with input and review by the Analysis Team. The selection of relationships for navigation began in 1987 and will continue throughout the life of the Program.

Inputs:

1. POS flow charts, hypotheses, and public use trend model (Task 2.2.10.1).
2. Navigation impact literature review.
3. POS.
4. Conceptual model (Task 1.1.1.2).
5. Navigation trend model (Task 2.2.10.1).

Products:

1. Study sheets for the Annual Work Plan.
2. Input to experimental design (Task 1.2.2.4).
3. Priority list of research needs.

Task 1.2.2.4 Establish Experimental Design

Important components of this task include posing hypotheses, selecting methods, determining sampling frequency, and identifying sampling locations. EMTC staff will develop Scopes of Work and will have them reviewed by the Analysis Team.

Case-by-case evaluations will select the best person or group to do the research. The work could be done by EMTC or LTRMP field station staff or other appropriate scientific personnel. Research performed at the LTRMP field stations or by contractors will be monitored by EMTC project officers. This task was initiated in 1987 and will continue throughout the life of the Program.

Inputs:

1. Literature on navigation.
2. Strategic model for navigation (Task 1.2.2.2).
3. Conceptual model for the UMRS (Task 1.1.1.2).
4. Experimental designs from trend analysis components (Strategies 2.2.1 to 2.2.10).
5. GIS (Objective 4.3).
6. POS.

7. Synthesis of trend analysis data (Strategy 2.3.1).
8. Evaluation of the trend analysis data (Strategies 2.2.1 to 2.2.10).
9. Selected POS work units (Task 1.2.2.1).

Products:

1. Scopes of Work for navigation research with interagency review.
2. Procurement.
3. Input to navigation research (Task 1.2.2.5).

Task 1.2.2.5 Conduct Research

The selected personnel using the sampling designed in the Scope of Work will conduct navigation research and prepare a report. Navigation research was initiated in 1987 and will continue for the life of the Program.

Inputs:

1. Experimental design (Task 1.2.2.4).
2. Literature review.
3. GIS (Objective 4.3).
4. Computer facilities (Objective 4.2).

Products:

1. Reports on navigation research.
2. Input to the navigation strategic model (Task 1.2.2.2).
3. Input to the conceptual model (Task 1.1.1.2).
4. Input to the POS.
5. GIS (Objective 4.3).
6. Input to technology transfer (Objective 4.4).
7. Input to the development of management alternatives and HREPs (Goal 3).

Strategy 1.2.3: Determine Effects of Water Levels and Discharges on the Upper Mississippi River System Ecosystem

River regulation is an extremely important tool in managing the Upper Mississippi River System ecosystem. Regulation takes place through the operation of numerous water control structures already in place on the Mississippi and Illinois Rivers. Regulation affects water depth, velocity, and physical factors, which then affect a wide range of biological processes.

Initial effects of river regulation on the UMRS ecosystem will be determined through a literature search and analyses of the historical record of water level elevations and discharges (Strategy 2.2.2) and of resource components (Strategy 2.2.1 and 2.2.3 to 2.2.10). Spatial analyses will quantify the effects of river regulation on various habitats. The results from the literature search and analyses should pinpoint possible research needs concerning the effects of river regulation and should supply information for developing management alternatives (Goal 3). Research on the influence of river regulation on ecological components initially will be conducted in selected pools and river reaches where GIS data sets of floodplain and water surface elevation, habitat, and vegetation are being developed.

Work within this strategy must be closely coordinated with the development of a historical data base for water level elevations and discharges (Strategy 2.2.2), other historical data bases of resource components (Strategy 2.2.1 and 2.2.3 to 2.2.10), and the development of management alternatives (Goal 3). Work to date in these areas includes the preparation of draft reports by the COE identifying river regulation constraints for Pools 9 and 18 on the Mississippi River and the initiation of a historical data base for water levels and discharges. The relationship of water level research to other Program components is graphically depicted in Figure 1-5.

Task 1.2.3.1 Develop a Strategic Model

A box-and-arrow model relating the effects of water levels and discharges on the UMRS ecosystem will be developed using the literature and analyses of historical data. This model will be developed in coordination with the water levels and discharge trend model (Task 2.2.2.1). An initial model will be developed in 1992 and will be updated every 3 years. The strategic model for the effects of river regulation will link processes to biological components at appropriate spatial and temporal scales. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on the effects of water levels and discharges.
2. Conceptual model (Task 1.1.1.2).
3. Historical data for water level elevations and discharges (Strategy 2.2.2).
4. Historical data for other resource components (Strategies 2.2.1 and 2.2.3 to 2.2.10).
5. GIS (Objective 4.3).
6. Computer equipment (Objective 4.2).
7. Research results from water level research (Task 1.2.3.4).

Products:

1. Report(s) describing the strategic model of the effects of river regulation.
2. Input to select relationships for research (Task 1.2.3.2).
3. Input to provide information for management alternatives and HREPs (Goal 3).
4. Input to the conceptual model (Task 1.1.1.2).
5. Input to the Information Management Plan (Objective 4.1).

Task 1.2.3.2 Select Processes for Research

Processes or relationships identified in the strategic model (Task 1.2.3.1) will be used along with other information to establish priorities and strategies for research on the effects of river regulation. Study sheets will be prepared for priority research projects included in the Annual Work Plan. The study sheets will identify hypotheses, show the importance and relationship of research to the entire water level strategy, and specify the length of the study, the products, and the cost estimates. The primary responsibility for selecting research and preparing study sheets lies with the EMTC staff, with input and review by the Analysis Team. The selection process for research projects began in 1990 and will be ongoing.

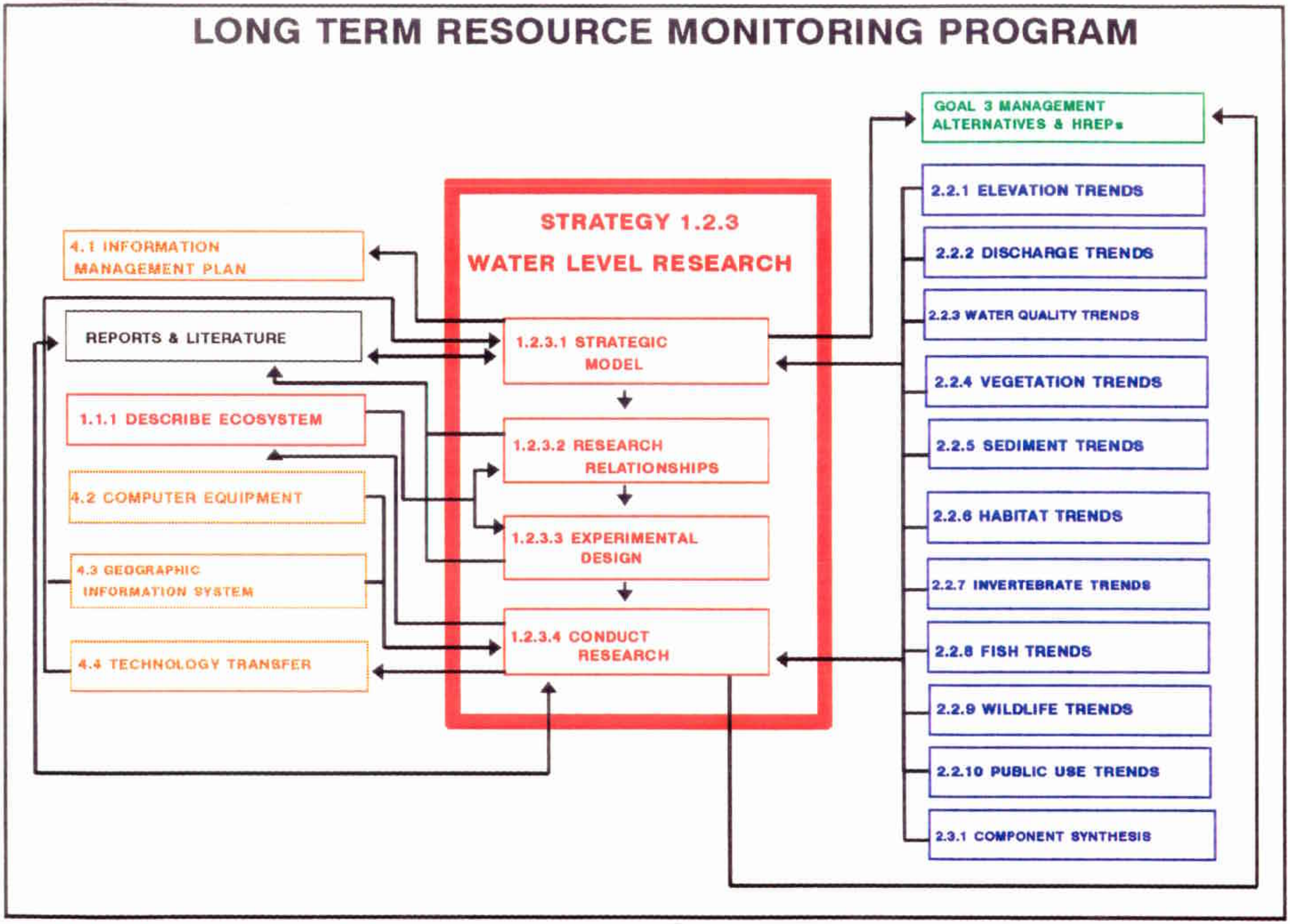


Figure 1-5. The Interrelationships Affecting Water Level Research, Strategy 1.2.3

Inputs:

1. Strategic model of water levels and discharges (Task 1.2.3.1).
2. Literature on river regulation.
3. Conceptual model (Task 1.1.1.2).

Products:

1. Priority list of research needs.
2. Input to experimental design (Task 1.2.3.3).
3. Study sheets for the Annual Work Plan.

Task 1.2.3.3 Establish Experimental Design

Scopes of Work will include hypotheses, experimental methods, personnel involved with the study, sampling areas and frequencies, importance and relationships to the entire water level strategy, equipment needs, length of the study, interim products and schedule, final products, and cost estimates. EMTC staff members are responsible for developing Scopes of Work that will be reviewed by the Analysis Team.

Individuals to perform research will be selected on a case-by-case basis. Research studies may be accomplished in-house, at field stations, or by other appropriate scientific personnel through contracts or cooperative agreements. Research performed at field stations or contracted will be monitored by a project officer at the EMTC. This task began in 1990 and will continue for the life of the Program.

Inputs:

1. Literature on river regulation.
2. Research priorities (Task 1.2.3.2).
3. Conceptual model (Task 1.1.1.2).
4. Strategic model for water levels and discharge (Task 1.2.3.1).
5. Research study acceptance through the Annual Work Plan process.

Products:

1. Scopes of Work for Analysis Team review.
2. Input to research on water levels and discharges (Task 1.2.3.4).
3. Procurement.

Task 1.2.3.4 Conduct Research

Research using the experimental design included in the Scope of Work (Task 1.2.3.3) will be performed for those studies receiving funding through the Annual Work Plan.

Inputs:

1. Experimental design (Task 1.2.3.3).
2. Literature on river regulation.
3. Historical water level and discharge data (Strategy 2.2.2).

4. GIS (Objective 4.3).
5. Computer facilities (Objective 4.2).
6. Trend analysis information (Objectives 2.2 and 2.3).

Products:

1. Research report(s) on the effects of water level and discharge.
2. Input to the water level and discharge strategic model (Task 1.2.3.1).
3. Input to the conceptual model (Task 1.1.1.2).
4. Input to development of management alternatives and HREPs (Goal 3).
5. Journal articles (Objective 4.4).
6. Input to technology transfer (Objective 4.4).

Objective 1.3: Identify and Investigate Additional Environmental Problems Affecting the Upper Mississippi River System Ecosystem

Monitoring activities will facilitate continuous updating and prioritization of river resource problems, including those currently highlighted (e.g., navigation, sedimentation) for investigation. Additional problems will likely include aquatic macrophyte declines, reduced availability of fish and wildlife habitat, resource exploitation, and introductions of exotic plant and animal species (i.e., purple loosestrife and zebra mussels).

Strategy 1.3.1: Review Updates of Conceptual Model

The conceptual model will be used as a basis for identifying additional environmental problems affecting the integrity of the UMRS ecosystem. As the conceptual model is elaborated, additional processes and mechanisms will be investigated, with attention to resource problem solving and river management (Goal 3).

Task 1.3.1.1 Review Conceptual Model

This task will begin in 1992 and will continue on an annual basis. Primary responsibility for the review lies with EMTC staff members, with input from LTRMP field station staff and river researchers and managers.

Input:

1. Conceptual model (Task 1.1.1.2).

Products:

1. List of new components, relationships, or processes that are making important changes in the UMRS ecosystem.
2. Input to the selection of new problems for research (Strategy 1.3.2).

Strategy 1.3.2: Select New Problems for Research

Additional environmental problems will be better defined in terms of scope and impact magnitude through communications with resource managers and researchers, plus long-term resource monitoring activities and literature review. After the problems have been identified and prioritized, the same basic format used for sedimentation, navigation, and river regulation research will be used. The research procedure includes developing a strategic model(s), selecting the processes or relationships for research, establishing an experimental design(s), and conducting research. Program priorities related to additional resource problems will be reflected in Annual Work Plans.

Task 1.3.2.1 Develop a Strategic Model

A box-and-arrow model relating the known and expected impacts of identified problems on the UMRS ecosystem will be developed. EMTC staff have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers. This activity will be initiated only if a high priority problem has been identified.

Inputs:

1. Literature on research topic.
2. Conceptual model (Task 1.1.1.2).

Products:

1. A report describing the strategic model.
2. Input to selecting the processes for research (Task 1.3.2.2).
3. Input to the development of management alternatives (Objectives 3.1 to 3.3).
4. Input to Information Management Plan (Objective 4.1).

Task 1.3.2.2 Select Relationships for Research

Processes or relationships identified in the strategic model (Task 1.2.3.1) will be used along with other information to establish research priorities and strategies. Study sheets will be prepared for priority research projects included in the Annual Work Plan. The primary responsibility for research selection and study sheet preparation lies with the EMTC staff, with input and review by the Analysis Team.

Inputs:

1. Strategic model for identified problems (Task 1.2.3.1).
2. Literature on research topics.
3. Conceptual model (Task 1.1.1.2).

Products:

1. Priority list of research needs.
2. Input to experimental design (Task 1.2.3.3).
3. Study sheets for the Annual Work Plan.

Task 1.3.2.3 Establish Experimental Design

Scopes of Work will include hypotheses, experimental methods, personnel involved with study, sampling areas and frequencies, equipment needs, length of study, interim products and schedules, final products, and cost estimates. EMTC staff members are responsible for developing the Scopes of Work, which then will be reviewed by the Analysis Team.

Individuals to perform research will be selected on a case-by-case basis. Research studies may be accomplished by EMTC or LTRMP field station staff or other appropriate scientific personnel through contracts or cooperative agreements. Research performed at field stations or contracted will be monitored by EMTC project officers. This activity will be initiated only if a high-priority problem has been identified.

Inputs:

1. Literature on research problem.
2. Research priorities (Task 1.2.3.2).
3. Conceptual model (Task 1.1.1.2).
4. Strategic model for the research component (Task 1.3.2.1).
5. Research study acceptance through the Annual Work Plan process.
6. GIS (Strategy 4.3.1).
7. Experimental design for the trend analysis components (Strategies 2.2.1 to 2.2.10).
8. Evaluation of the trend analysis data (Strategies 2.2.1 to 2.2.10).
9. Synthesis of trend analysis data (Strategy 2.3.1).
10. Relationship selection for research (Task 1.3.2.2).

Products:

1. Scopes of Work for Analysis Team review.
2. Input to conducting research (Task 1.3.2.4).
3. Procurement.

Task 1.3.2.4 Conduct Research

Selected personnel will perform research using the experimental design included in the Scope of Work (Task 1.3.2.3) for those studies receiving funding through the Annual Work Plan. A report synthesizing the results will be provided for each research effort.

Inputs:

1. Experimental design (Task 1.3.2.3).
2. Literature on research problem.
3. GIS (Strategy 4.3.1).
4. Computer facilities (Objective 4.2).
5. Trend analysis information (Strategies 2.2.1 to 2.2.10).

Products:

1. Report(s) on research.
2. Input to the strategic model (Task 1.2.3.1).

3. Input to the conceptual model (Task 1.1.1.2).
4. Input to development of management alternatives and HREPs (Goal 3).
5. Input to technology transfer (Objective 4.4).
6. GIS (Strategy 4.3.1).

Goal 2: Monitor Resource Change

Informed Upper Mississippi River System (UMRS) management requires an improved understanding of the ecosystem and of the long-term resource trends and conditions. A primary goal of the Long Term Resource Monitoring Program (LTRMP) is to monitor and evaluate long-term changes or trends in selected physical, chemical, and biological components of the UMRS. Most of the monitoring will focus on selected pools and river reaches. Historical data also will be obtained and evaluated to help detect changes in the system. The scope and design of monitoring activities will be reviewed periodically and modified as necessary.

Evaluating long-term UMRS ecosystem trends requires consistent and scientifically sound measurements to detect site-specific and/or system-wide changes. Geographic information systems (GIS) will be an important tool in the analysis of all components. Monitoring results will provide information to solve sediment, navigation, and river regulation problems and will also allow Habitat Rehabilitation and Enhancement Project (HREP) evaluations. Monitoring UMRS ecosystem data and evaluating trends also will help develop scientifically sound UMRS management alternatives.

The LTRMP monitoring design will be adapted to longitudinal differences in the UMRS ecosystem, and sampling designs and procedures will be applied consistently at monitoring sites.

The LTRMP will complement the resource monitoring efforts of other agencies and will not duplicate or replace any work currently being completed under other programs and funding sources. The Information Systems Support Division at the Environmental Management Technical Center (EMTC) will manage and archive historical monitoring as well as manage and analyze LTRMP-generated monitoring information.

Objective 2.1: Develop a Resource Monitoring Plan

Resource monitoring is necessary to support the mission of the Program and to define the long-term rate, direction, and extent of changes over time in the UMRS.

The current LTRMP trend analysis component was based on the Long-Term Resource Monitoring Report of the Master Plan for managing the UMRS and on the 1981 Environmental Work Team findings.

Strategy 2.1.1: Select Components and Reaches

With limited monetary resources, choices had to be made as to which resource components and areas of the UMRS would be monitored. The selection and priorities of components and areas were made by an interagency group.

Task 2.1.1.1 Select Resource Components

From the original list of 14 ecosystem components proposed for monitoring in the 1981 Master Plan document, 8 were included in the LTRMP in 1987. The current list of 10 monitoring compone :ts, developed in 1990, combined birds and mammals, separated water and sediment, and added floodplain elevation and hydrology components. The current monitoring components for the

LTRMP are (1) floodplain elevation, (2) river discharge and water surface elevation, (3) water quality, (4) aquatic and terrestrial vegetation, (5) sediment composition, (6) aquatic and floodplain habitat, (7) macroinvertebrates, (8) fish, (9) wildlife, and (10) public use. The number of monitored components and the amount of effort placed on each depends on the funding level and relative priority given to each component in the Annual Work Plan. For example, in the startup years of the Program, when funding was below authorized levels, only water quality, fish, and vegetation were monitored at LTRMP field stations. Selecting the monitoring components is a cooperative effort by EMTC staff and the Analysis Team.

Inputs:

1. Previous planning documents.
2. Budget values.

Products:

1. Report or list of monitoring components.
2. Input to Information Management Plan (Objective 4.1).

Task 2.1.1.2 Select Resource Trend Analysis Pools and Reaches

Site selection is a critical element in plan design, and the same sites should be sampled consistently over time. From the original list of 17 pools and reaches recommended as monitoring sites in the Master Plan document, six were chosen for inclusion in the LTRMP. The monitoring sites are Pools 4, 8, 13, and 26; an open river reach of the Mississippi River; and La Grange Pool on the Illinois River. Specific sampling locations are selected to meet the experimental designs of the various monitoring efforts. Initial funding levels limited data collection to Pools 8, 13, and 26, but by 1990, field stations at all six sites were operational. Selecting the initial monitoring pools and reaches was a cooperative effort by EMTC staff and the Analysis Team. Land cover data generated in 1992 will allow validation or modification of current sampling sites.

Inputs:

1. Previous planning documents.
2. Spatial data base (Objective 2.2).
3. GIS (Objective 4.3).

Products:

1. Report or list of monitoring sites.
2. Validation or modification of site selection.

Objective 2.2: Implement Monitoring Program

After the initial planning phase was completed (Objective 2.1), monitoring was implemented in six UMRS areas. The implementation phase has been coordinated with State and Federal agencies and will continue throughout the Program.

A standardized treatment of resource components has been prescribed in this revised Operating Plan. With some exceptions to fit individual components, the basic approach includes developing a trend model, establishing the experimental design, obtaining monitoring data, evaluating and summarizing the data, updating the trend model, and refining and evaluating the experimental design.

A trend model for all the trend analysis components will be developed from the LTRMP conceptual model or adapted from existing literature. This trend model then will be used as a planning tool to help establish sampling locations and frequencies and monitoring strategies or priorities, and to identify supplementary data needs. The trend model also will help develop the experimental design.

An analysis of water quality, vegetation, macroinvertebrates, and fish will be done annually, and a summary will be completed every 5 years. The other components will be analyzed either annually or on a cycle appropriate to their collection.

Strategy 2.2.1: Monitor and Evaluate Floodplain Elevation

Topographic and bathymetric floodplain elevations will be obtained using several methods with varying resolutions, depending on available technologies. Initial bathymetric data will be obtained by boat surveys. Initial topographic data will be acquired using 1:24,000 USGS quad maps or finer resolution data provided by other agencies. High-resolution point data will be used to determine specific elevation changes during the life of the Program. Lower resolution elevation coverages will be created and compared with historical data sets to determine changes over time. The GIS data base will monitor floodplain elevation changes due to sediment transport processes and will better define floodplain habitats. Spatial and temporal resolution for elevation data will be dictated by the conceptual model. The relationship of floodplain elevation to other Program components is graphically depicted in Figure 2-1.

Task 2.2.1.1 Develop a Trend Model

A box-and-arrow trend model describing known and expected changes in floodplain elevations and their relationships to the UMRS will be completed by 1992 and will be updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation and summary of results (Task 2.2.1.5).

Products:

1. A report describing the trend model.
2. Input to the experimental design (Task 2.2.1.2).
3. Input to evaluate experimental design (Task 2.2.1.6).
4. Input to develop management alternatives (Objectives 3.1 to 3.3).

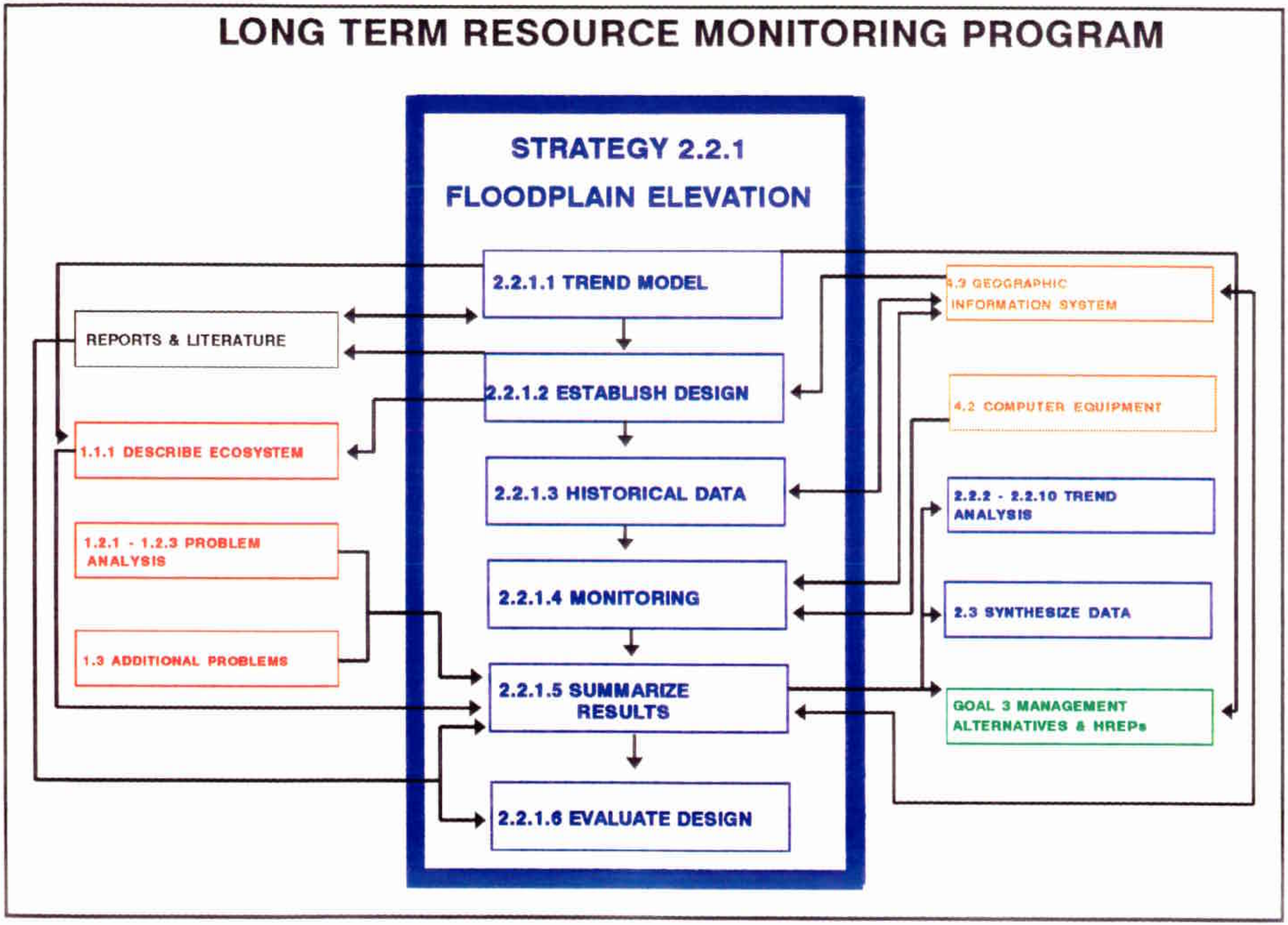


Figure 2-1. The Interrelationships Affecting Floodplain Elevation, Strategy 2.2.1

Task 2.2.1.2 Establish Experimental Design and Necessary Updates

The initial sampling procedures and experimental-design for floodplain elevations were developed in 1988. Sampling protocol, including the selection of spatial and temporal scales, will be outlined in the 1992 Procedures Manual and will be updated as necessary. The primary responsibility for this task lies with EMTC staff, with input from river managers and researchers, and agency sponsor review.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Trend model (Task 2.2.1.1).
3. Literature on floodplain elevation sampling.
4. GIS (Objective 4.3).
5. Evaluation and refinement of the experimental design (Task 2.2.1.6).

Products:

1. Documented experimental design.
2. Procedures manual with updates.
3. Input to obtaining historical and present-day monitoring data (Tasks 2.2.1.3 and 2.2.1.4).

Task 2.2.1.3 Obtain Historical Monitoring Data

A historical spatial data base of floodplain elevations for selected pools and reaches was initiated in 1990 and should be completed in 1992, depending on funding. EMTC staff members are primarily responsible for this effort, with input from river managers and researchers and other experts.

Inputs:

1. Brown flowage easement and Mississippi River Commission survey maps.
2. Other historical maps.
3. Procedures manual and experimental design (Task 2.2.1.2).

Products:

1. Historical GIS coverage data base of elevations from Brown flowage easement and Mississippi River Commission survey maps (Objective 4.3).
2. Historical GIS coverages and point data bases from other historical sources (Objective 4.3).
3. Input to the evaluation and summary of floodplain elevation data (Task 2.2.1.5).
4. Input to the evaluation of the experimental design (Task 2.2.1.6).

Task 2.2.1.4 Conduct Monitoring

Surveys of floodplain elevation for selected pools, reaches, and areas were initiated in 1989 and will be continued throughout the life of the Program. As time and funds permit, additional pools and reaches will be surveyed. High-resolution transects will be monitored annually to more accurately determine sedimentation rates. All areas initially surveyed will be resurveyed between 1998 and 2001. EMTC staff members are primarily responsible for this effort. Survey data from the COE hydrographic surveys on main channels also will be obtained to augment EMTC surveys.

Inputs:

1. USGS 1:24,000 quad maps.
2. GIS (Objective 4.3).
3. Computer hardware systems (Objective 4.2).
4. Procedures manual and experimental design (Task 2.2.1.2).
5. COE hydrographic survey data.

Products:

1. GIS data bases and floodplain elevation maps for specific points in time (Objective 4.3).
2. Input to the evaluation and summary of floodplain elevation data (Task 2.2.1.5).
3. Input to the evaluation of the experimental design (Task 2.2.1.6).

Task 2.2.1.5 Evaluate and Summarize Results

Reports will document the rate of floodplain elevation change in surveyed areas. Reports on available elevation data collection techniques will be compiled in 1991. Depth distribution reports will be compiled in 1993 and again every 5 years. The report on sedimentation and scouring depends on the creation of the historical data base and is scheduled to be completed in 1994. A report on the changes between the initial surveys of 1988-1992 and the later surveys of 1998-2001 will be completed in 2002. EMTC staff members are primarily responsible for this task.

Inputs:

1. GIS historical and present-day data bases of floodplain elevation (Tasks 2.2.1.3, 2.2.1.4, and Objective 4.3).
2. Computer hardware systems (Objective 4.2).

Products:

1. Reports on floodplain elevation changes and evaluation of the influence of sediment.
2. Input to the evaluation and refinement of the experimental design (Task 2.2.1.6).
3. Input to the conceptual model and floodplain elevation trend models (Tasks 1.1.1.2 and 2.2.1.1).
4. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
5. Input to identify and investigate additional resource problems (Objective 1.3).
6. Input to all other monitoring components, especially sediment, and aquatic and floodplain habitats (Strategies 2.2.2 to 2.2.10).
7. Input to the synthesis and evaluation of all monitoring data (Objective 2.3).
8. Input to the development of management alternatives and HREPs (Goal 3).
9. Map products.

Task 2.2.1.6 Evaluate and Refine Experimental Design

The experimental design, survey(s), and data processing methods will be evaluated and appropriate revisions will be made in the experimental design and procedures manual in 1996. EMTC staff members are primarily responsible for this task, with input from LTRMP field stations and river managers and researchers.

Inputs:

1. Floodplain elevation data sets (Tasks 2.2.1.3 and 2.2.1.4).
2. Data evaluations and summaries (Task 2.2.1.5).
3. Trend model for floodplain elevation (Task 2.2.1.1).

Products:

1. Report on the effectiveness of sampling design.
2. Review with incorporation of appropriate changes to the sampling procedures (Task 2.2.1.2).

Strategy 2.2.2: Obtain and Evaluate River Discharge and Water Surface Elevation Data

River discharge and water surface elevation data bases will be created for the UMRS ecosystem, including major tributaries, from data collected by the COE, USGS, and other organizations. These data, along with predicted pool elevations provided by the National Weather Service, will be made available through the EMTC computer facility. GIS coverages relating pool elevations to discharge will be developed using water surface and discharge tables and backwater curves from the COE. Data obtained will be used to develop a functional understanding of the relationships between river discharge, water surface elevations, and other ecosystem components in selected pools and river reaches. The relationships of discharge and water level elevation to other Program components are graphically depicted in Figure 2-2.

Task 2.2.2.1 Develop a Trend Model

A box-and-arrow model will be developed to describe the known relationships of river discharge and water surface elevation in the UMRS ecosystem. The trend model will be developed in coordination with the strategic model for water level research (Task 1.2.3.1). This model will be completed in 1992 and updated every 3 years or more frequently if warranted by new information. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on large river hydrology.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation and summary of annual results (Task 2.2.2.4).
4. Results from water level research (Strategy 1.2.3).

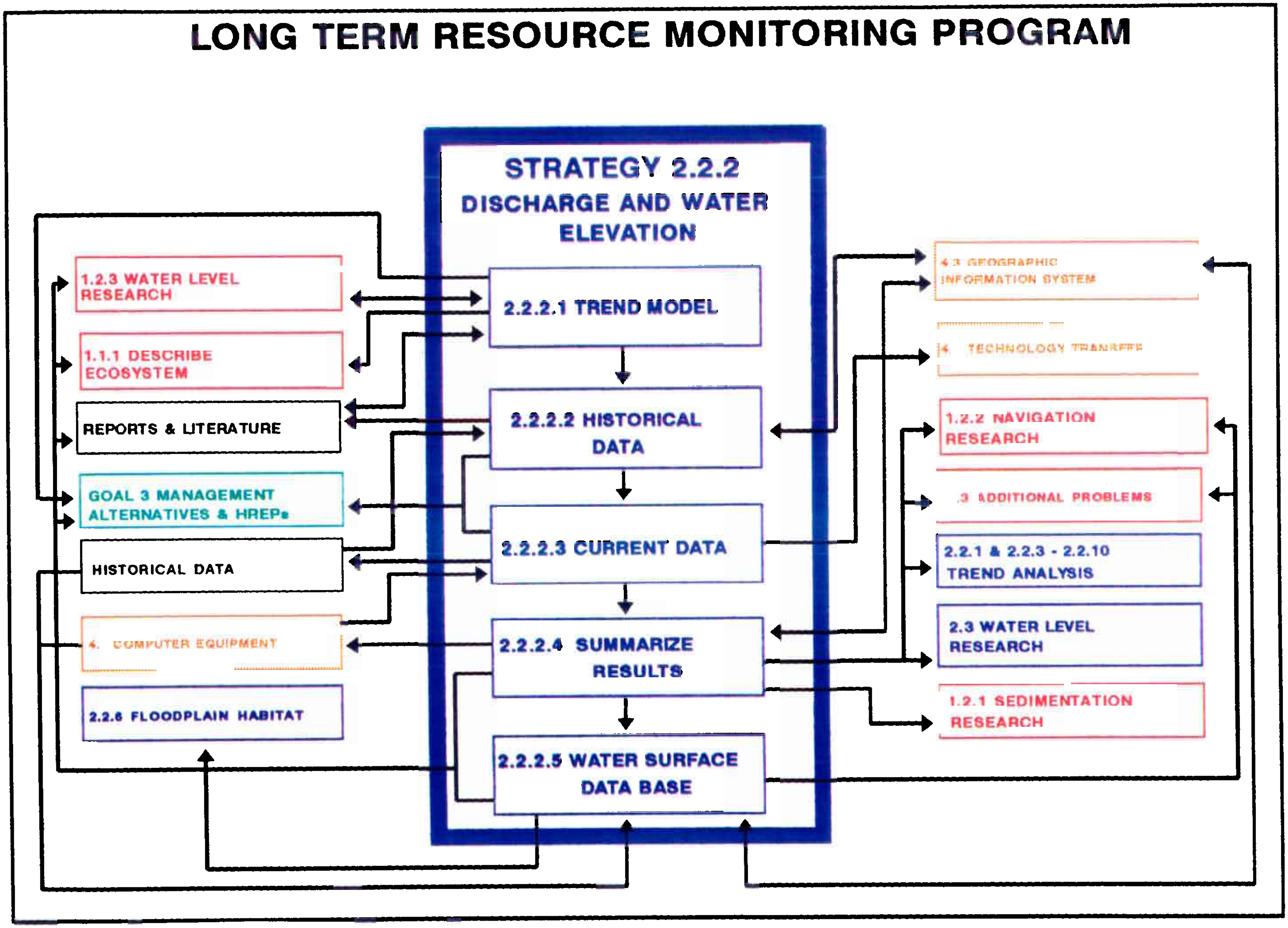


Figure 2-2. The Interrelationships Affecting Discharge and Water Elevation, Strategy 2.2.2

Products:

1. A report describing the river discharge trend model.
2. Input to the effects of river regulation (Strategy 1.2.3).
3. Input to developing management alternatives and HREPs (Goal 3).

Task 2.2.2.2 Obtain Historical Data

Historical (pre-1991) river discharge and water surface elevation data bases will be obtained from the COE, USGS, and other organizations in 1991. Historical data will be updated as new data become available from cooperating organizations. A report on the evaluation of pre-1991 historical discharge and water surface elevation data will be completed in 1992. EMTC staff members are responsible for this task, with cooperation from the COE, USGS, and other organizations.

Inputs:

1. Historical hydrographical data.
2. GIS (Objective 4.3).
3. Current monitoring data (Task 2.2.2.3).

Products:

1. Historical GIS data bases of discharge and surface elevations (Objective 4.3).
2. Report on historical (pre-1991) discharge and elevation data.
3. Input to GIS coverage of water surface elevation and river discharge (Task 2.2.2.5).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.2.3 Obtain Current Data

The EMTC will arrange for the transfer of current discharge and water surface elevation data from cooperating agencies, as well as predicted pool elevations from the National Weather Service. This method of data transfer will be in place in 1992 and will continue throughout the life of the Program using existing communication capabilities. EMTC staff members are responsible for this task, with cooperation from other agencies.

Inputs:

1. Data from cooperating agencies.
2. Computer equipment (Objective 4.2).
3. Communication capabilities (Objective 4.2).

Products:

1. Up-to-date discharge and water surface elevation data.
2. Input to technology transfer (Objective 4.4).
3. Input to the historical data base (Task 2.2.2.2).
4. Input to GIS coverage of water surface elevation per river discharge (Task 2.2.2.5).
5. Input to the development of management alternatives and HREPs (Goal 3).
6. Input to the evaluation and summary of annual data (Task 2.2.2.4).

Task 2.2.2.4 Evaluate and Summarize Annual Results

Annual reports on river discharge and water surface elevation will be the responsibility of the EMTC staff beginning in 1992. Emphasis will be placed on special hydrologic conditions or events that occurred during the year.

Inputs:

1. Data bases of river discharge and surface elevations (Task 2.2.2.3).
2. GIS (Objective 4.3).
3. Computer hardware systems (Objective 4.2).

Products:

1. Reports describing spatial and temporal trends and functional relationships.
2. GIS data base (Objective 4.3).
3. Input to the conceptual model and the river discharge and water surface elevation trend model (Tasks 1.1.1.2 and 2.2.2.1).
4. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
5. Input to identify and investigate additional resource problems (Objective 1.3).
6. Input to all other monitoring components (Strategies 2.2.1 and 2.2.3 to 2.2.10).
7. Input to the synthesis and evaluation of all monitoring data (Objective 2.3).
8. Input to the development of management alternatives and HREPs (Goal 3).
9. Input to technology transfer (Objective 4.4).

Task 2.2.2.5 Develop Geographic Information System Coverage of Water Surface Elevation Data Base

A GIS coverage of water surface elevation by level of river discharge will be developed using water surface elevations, discharge tables, and backwater curves from the COE, as well as remote sensing technology. This task will generate spatial data from the point data and will allow determination of elevations at specific river miles. A pilot project for this task will begin in 1992 and will be completed in 1993. EMTC staff members are ultimately responsible for this task and may require input from appropriate scientific personnel through cooperative agreements or contracts, as well as from river researchers and managers.

Inputs:

1. Water surface and discharge tables and backwater curves from the COE.
2. Remote sensing data.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. Report on pilot project using data tables and remote sensing data.
2. GIS coverages of water level elevations (Objective 4.3).
3. Input to the conceptual model (Task 1.1.1.2)
4. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).

5. Input to identify and investigate additional resource problems (Objective 1.3).
6. Input to the development of management alternatives and HREPs (Goal 3).
7. Input to monitoring aquatic and floodplain habitat (Strategy 2.2.6).

Strategy 2.2.3: Monitor and Evaluate Water Quality

Material transport, including water quality constituents, is a major function of the riverine ecosystem. Sedimentation and sediment transport (Strategy 1.2.1) have major impacts on the water quality in the ecosystem. Navigation (Strategy 1.2.2) impacts water quality through sediment resuspension. Sediment composition (Strategy 2.2.5) both determines and results from conditions in the overlying water column. River regulation's influence on the ecosystem (Strategy 1.2.3) also will be reflected in water quality through changes in bathymetry.

The quantity and quality of fish habitat (Strategy 2.2.8) in the System is closely coupled with water quality (e.g., via dissolved oxygen, temperature, pH, ammonia, hardness, alkalinity, and light penetration). Water quality factors such as nutrient availability and light penetration are major determinants of aquatic macrophyte production (Strategy 2.2.4). Macroinvertebrate populations (Strategy 2.2.7) are influenced by water quality conditions and provide a direct link to fish and wildlife populations. In addition, water quality has both a direct and an indirect influence on wildlife populations (Strategy 2.2.9) that depend on the biotic and abiotic resources of the river ecosystem.

Development of management alternatives will depend heavily on understanding and improving water quality in the UMRS, since attempts to modify System conditions will ultimately involve water quality.

Parameters that have been monitored since initiation of the Program include water temperature and depth, dissolved oxygen, specific conductance, current velocity, turbidity, and Secchi disk transparency. From June to November 1991, the pH, light attenuation, suspended solids, dissolved chloride, and selected biological metal and nutrient parameters were monitored biweekly by LTRMP field station personnel. Analyzing these parameters will determine their feasibility and usefulness for future applications. The relationships of water quality to other Program components are graphically depicted in Figure 2-3.

Task 2.2.3.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of water quality to the UMRS ecosystem will be completed in 1992 and updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation and summary of annual and 5-year trends (Tasks 2.2.3.6 and 2.2.3.8).
4. Summary of historical data (Task 2.2.3.5).

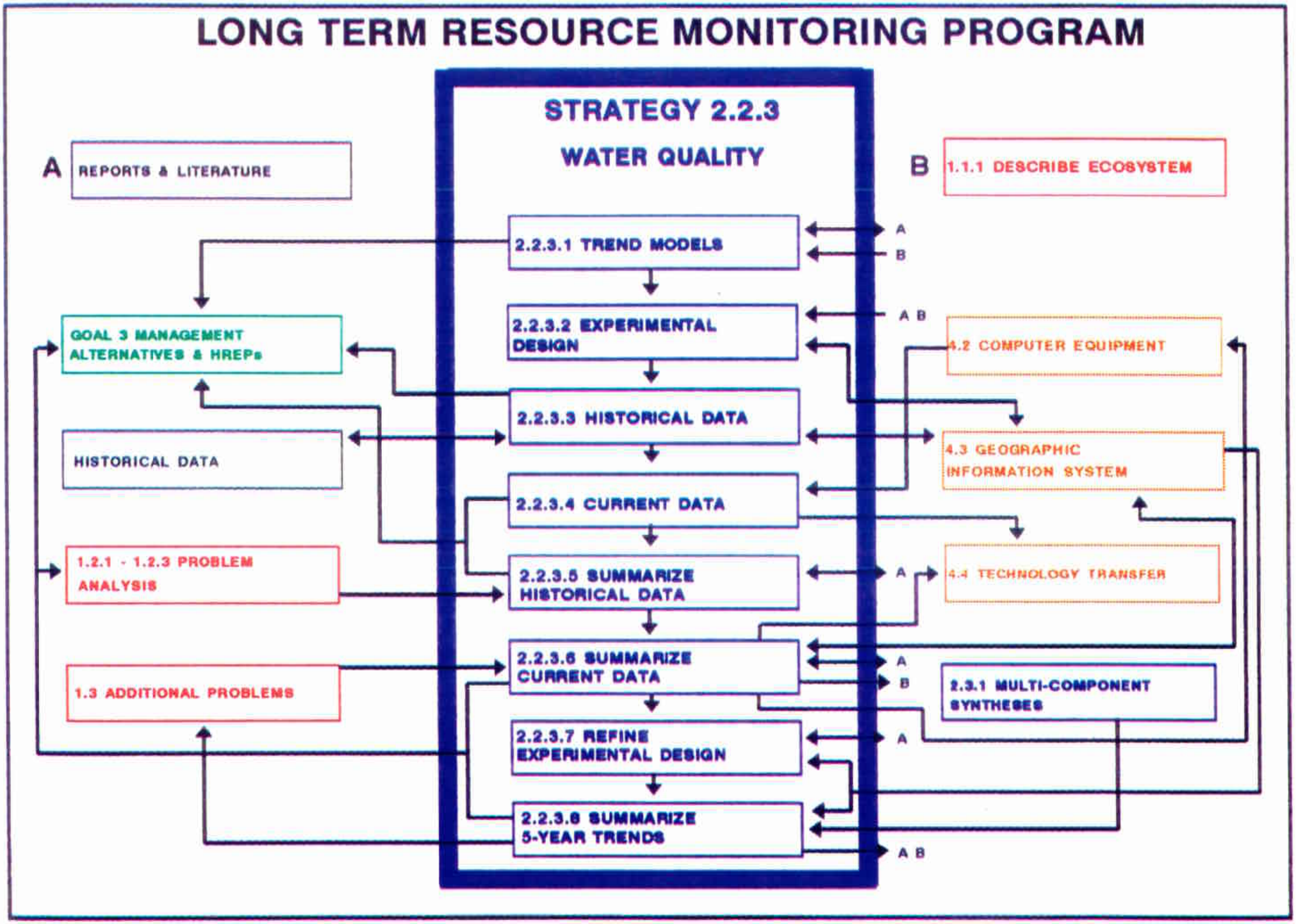


Figure 2-3. The Interrelationships Affecting Water Quality, Strategy 2.2.3

Products:

1. A report describing the water quality trend model.
2. Input to experimental design development (Task 2.2.3.2).
3. Input to the evaluation of the experimental design (Task 2.2.3.7).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.3.2 Establish Experimental Design

Steps included in this task are to (1) determine water quality characteristics and constituents to be monitored, (2) select monitoring sites in different aquatic habitats in selected pools and reaches, (3) determine appropriate sampling frequencies to obtain reliable data, (4) select standardized and analytical procedures, and (5) develop a cooperative water quality monitoring network that includes other agencies conducting UMRS water quality monitoring, and to ensure, to the extent possible, that compatible and comparable data are obtained by the various cooperating agencies.

The initial experimental design for monitoring water quality was developed in 1988. Water quality characteristics, sampling procedures, sampling frequency, and quality assurance procedures are outlined in a procedures manual approved by the interagency sponsors in 1989. This procedures manual will be updated in 1992 and will again be reviewed by the interagency sponsors. The primary responsibility for this task lies with EMTC staff members, with input from river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Trend models (Task 2.2.3.1).
3. Literature review of water quality monitoring in large rivers.
4. GIS (Objective 4.3).
5. Evaluation and refinement of the experimental design (Task 2.2.3.7).
6. Historical water quality data and evaluation (Tasks 2.2.3.3 and 2.2.3.5).
7. Current water quality data and evaluation (Tasks 2.2.3.4 and 2.2.3.6).

Products:

1. Documented experimental design.
2. Procedures manual with updates.
3. Input to annual monitoring data and historical monitoring data (Tasks 2.2.3.4 and 2.2.3.3).

Task 2.2.3.3 Obtain Historical Monitoring Data

A historical data base on water quality characteristics and constituents for selected pools and reaches will be initiated in 1992 and completed in 1994. Historical water quality data sources include UMRS state agencies, the USGS, the U.S. Environmental Protection Agency (EPA), the COE, the Service, universities, and industry. EMTC staff members are primarily responsible for completing this task, with input from the above-mentioned agencies and river managers and researchers.

Inputs:

1. Historical water quality data.
2. Procedures manual with updates (Task 2.2.3.2).
3. GIS (Objective 4.3).

Products:

1. Historical data set on water quality parameters (Objective 4.3).
2. Input to the historical evaluation and summary of data (Task 2.2.3.5).
3. Input to the experimental design (Task 2.2.3.2).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.3.4 Conduct Current Monitoring

Water quality monitoring data collection was initiated in 1988 and will continue throughout the life of the Program. Amendments to cooperative agreements with the states will be renewed annually. LTRMP field station staff members are responsible for the collection and quality assurance of these data, with guidance from the EMTC staff.

Inputs:

1. Procedures manual and the experimental design (Task 2.2.3.2).
2. Computer equipment (Objective 4.2).

Products:

1. Annual data sets on water quality.
2. Amendments to cooperative agreements.
3. Input to the annual evaluation and 5-year trend analysis (Tasks 2.2.3.6 and 2.2.3.8).
4. Input to the evaluation of the experimental design (Task 2.2.3.7).
5. Input to technology transfer (Objective 4.4).
6. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.3.5 Evaluate and Summarize Historical Data

Analyses of historical water quality data will be directed at (1) revealing long-term trends, (2) interpreting short-term variability, (3) interpreting or predicting changes as a result of management actions or extreme events, and (4) interpreting and predicting biotic resource changes in response to water quality changes. Historical data analysis will begin after the data have been obtained in 1994, and the task will be completed in 1996. EMTC staff members are primarily responsible for this task, with input from the agencies that have the historical data, and river managers and researchers.

Inputs:

1. Historical water quality data base (Task 2.2.3.3).
2. GIS (Objective 4.3).
3. Historical hydrologic data base (Strategy 2.2.2).
4. Historical weather and climate data base.

5. Existing water quality literature on Mississippi River water quality.

Products:

1. Report on the evaluation and summary of historical water quality data.
2. Input to updates of the conceptual model and the water quality trend model (Tasks 1.1.1.2 and 2.2.3.1).
3. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
4. Input to identify and investigate additional problems (Objective 1.3).
5. Input to the development of management alternatives and HREPs (Goal 3).
6. Input for the synthesis and evaluation of all monitoring components (Objective 2.3).

Task 2.2.3.6 Evaluate and Summarize Current Monitoring Results

An annual field station report on water quality was initiated in 1989. This annual report will be a publication or presentation that has been mutually agreed upon by the LTRMP field station staff and the EMTC staff. EMTC staff members will similarly compile reports, publications, or presentations on the composite data collected at all field stations. Staff members of both the EMTC and the LTRMP field stations are responsible for this task.

Inputs:

1. Water quality data sets from annual monitoring (Task 2.2.3.4).
2. Literature on water quality.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. Annual LTRMP field station reports, publications, or presentations on water quality.
2. Annual EMTC synthesis reports, publications, or presentations on water quality.
3. GIS (Objective 4.3).
4. Input to updates of the conceptual model and the water quality trend model (Tasks 1.1.1.2 and 2.2.3.1).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
6. Input to identify and investigate additional problems (Objective 1.3).
7. Input for the evaluation and refinement of the experimental design (Task 2.2.3.7).
8. Input to the development of management alternatives and HREPs (Goal 3).
9. Input for the synthesis and evaluation of all monitoring components (Objective 2.3).
10 Input to the experimental design (Task 2.2.3.2).
11. Input to the evaluation of 5-year trends (Task 2.2.3.8).
12. Input to technology transfer (Objective 4.4).

Task 2.2.3.7 Evaluate and Refine Experimental Design

The water quality monitoring design will be reviewed periodically to optimize the statistical validity and sampling effort, starting in 1992 and continuing every 3 years thereafter. Appropriate refinements will be made and documented in revisions to the experimental design and procedures manual. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Annual water quality data sets (Task 2.2.3.4).
2. Evaluations and summaries of the data (Task 2.2.3.6).
3. Trend model for water quality (Task 2.2.3.1).
4. GIS (Objective 4.3).
5. Literature on statistics and water quality monitoring.

Products:

1. Refine experimental design and procedures manual.
2. Input to the experimental design (Task 2.2.3.2).

Task 2.2.3.8 Evaluate and Summarize 5-Year Trends

This task will be to synthesize 5 years of water quality data for all trend analysis areas. Due to financial constraints, it may not be possible to analyze all habitat types in one year, so it may take 3 or more years for a 5-year analysis of all habitat types. This analysis is scheduled twice during the Program; once in 1993 and again in 1998. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Data sets from annual monitoring (Task 2.2.3.4).
2. Annual LTRMP and EMTC reports (Task 2.2.3.6).
3. GIS (Objective 4.3).

Products:

1. Report on 5-year UMRS water quality monitoring analysis.
2. Input to the conceptual model (Task 1.1.1.2).
3. Input to the water quality trend model (Task 2.2.3.1).
4. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
6. Input to identify and investigate additional resource problems (Objective 1.3).
7. Input to the development of management alternatives and HREPs (Goal 3).

Strategy 2.2.4: Monitor and Evaluate Aquatic and Terrestrial Vegetation

Aquatic and terrestrial vegetation occupying the UMRS floodplain represent a valuable ecological resource. Some functions and values provided include biomass production, food chain support, nutrient recycling, fish and wildlife habitat, erosion control, water quality protection, and aquifer recharge. Existing and potential impacts that may jeopardize the functional vitality and stability of vegetation include an increase in commercial and recreational navigation activities, elevated sedimentation and turbidity levels, bank erosion, degraded water quality, and conversion of bottomlands.

Understanding the cumulative impacts of anthropogenic activities and natural UMRS vegetation trends requires analysis at various spatial and temporal scales. Aquatic and terrestrial vegetation will be monitored and evaluated through a program combining multi-resolution land cover mapping and field sampling. Basic information on the systemic distribution of land cover and vegetation will be determined using low-resolution satellite data. High-resolution (1:15,000) aerial photography is being used to map land cover to the genus level in selected pools and reaches. Very high-resolution species data also are being collected at the LTRMP pools and reaches, and historical data bases will be generated for selected pools and reaches. A classification system based on mapping at the genus/association level has been adopted for selected pools and reaches.

Land cover data will be acquired at least every 5 years for selected pools and reaches. Historical and recent land cover data will be used to support field sampling strategies, in the analysis of high resolution data collected in the field, and in the analysis of long-term trends. The relationships of vegetation to other Program components are graphically depicted in Figure 2-4.

Task 2.2.4.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of aquatic and terrestrial vegetation to the UMRS ecosystem will be completed by 1991 and will be updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review.
2. Conceptual model formulation (Task 1.1.1.2).
3. Evaluation and summary of annual and 5-year trends (Tasks 2.2.4.6 and 2.2.4.8).
4. Spatial data bases (Task 2.2.4.4).

Products:

1. A report describing the vegetation trend model.
2. Input to the development of the experimental design (Task 2.2.4.2).
3. Input to the evaluation of sampling design (Task 2.2.4.7).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.4.2 Establish Experimental Design

Experimental designs for the System (low-resolution) and selected pools and reaches (high- and very high-resolution) have been or will be developed. The initial experimental design for the very high-resolution vegetation component was developed in 1989. A high-resolution classification scheme for mapping remote sensing data also was developed and high-resolution information on vegetation distribution was collected. Vegetation sampling protocols for field work in LTRMP pools were outlined in a procedures manual in 1989, were updated for 1991, and will again be reviewed by interagency sponsors. A low-resolution classification system will be

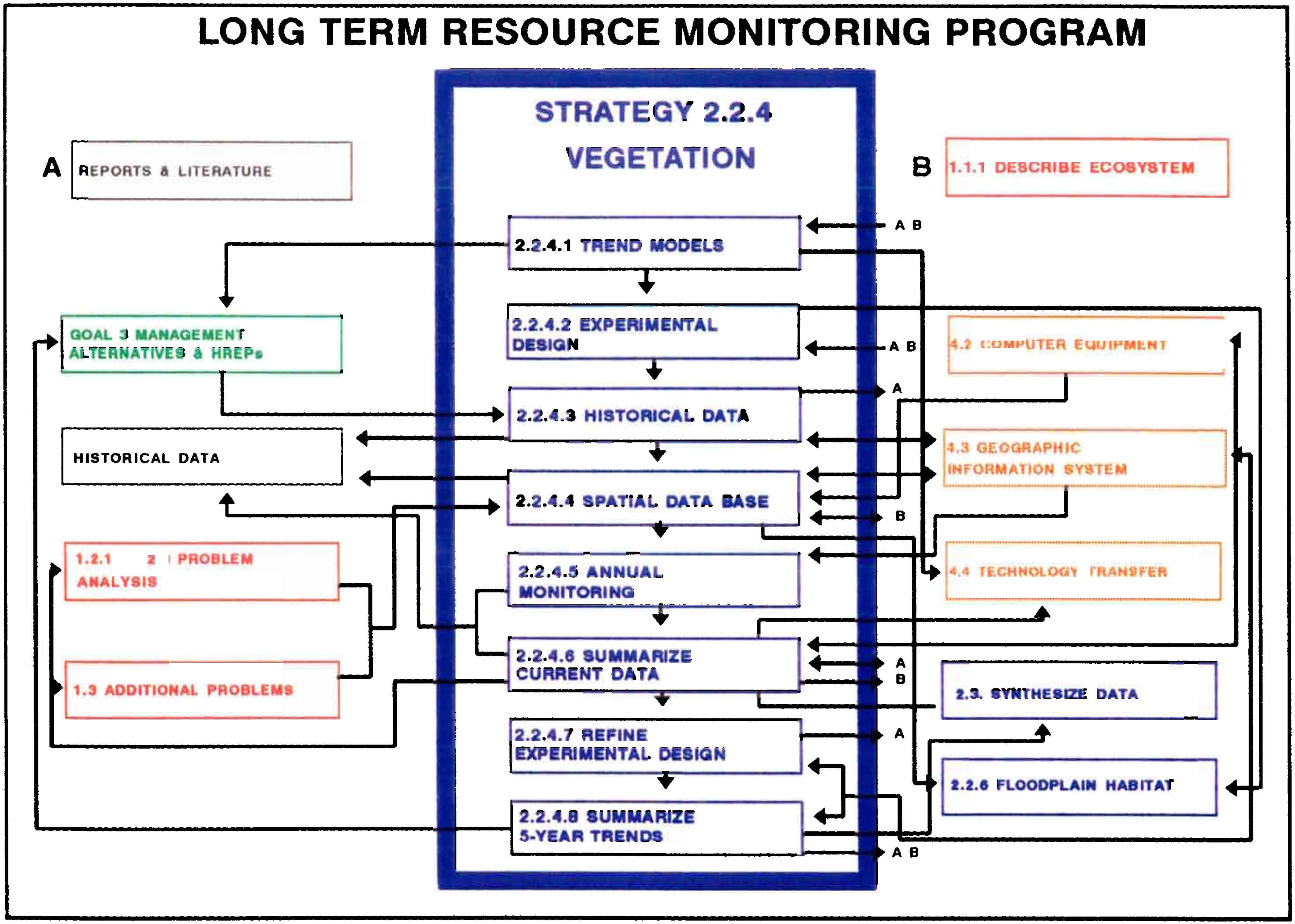


Figure 2-4. The Interrelationships Affecting Vegetation, Strategy 2.2.4

completed in 1992. The primary responsibility for this task lies with the EMTC staff, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Vegetation trend model (Task 2.2.4.1).
3. Literature review of historical UMRS land cover classification systems and sampling methods in large rivers.
4. Evaluation and refinement of the sampling design (Task 2.2.4.7).

Products:

1. Procedures manual with updates.
2. Documented experimental design.
3. Classification systems.
4. Input for obtaining annual monitoring data and historical data (Tasks 2.2.4.5 and 2.2.4.3).
5. Input to the classification of aquatic and floodplain habitats (Task 2.2.6.2).
6. Input to the spatial data base (Task 2.2.4.4).

Task 2.2.4.3 Obtain and Evaluate Historical Information

Historical data initially will be acquired and evaluated for a selected pool or reach to define procedures for analyzing the usefulness and application of older data. These procedures will then be used to generate historical GIS coverages for the remaining selected pools and reaches. This task will be initiated in 1992 and completed in 1994. Historical vegetation data sources include State and Federal agencies and universities. EMTC staff members are primarily responsible for completing this task, with input from the above-mentioned agencies and institutions and river managers and researchers.

Inputs:

1. Historical data.
2. GIS (Objective 4.3).
3. Experimental design for vegetation (Task 2.2.4.2).

Products:

1. Report on selection of spatial and temporal scales for evaluation of historical land cover.
2. Report on procedures used to define long-term vegetation trends for a selected reach.
3. Historical GIS coverages for the selected pools and reaches (Objective 4.3).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.4.4 Produce Spatial Data Bases

Spatial land cover data bases will be developed at a 1:15,000 scale for selected pools and reaches and for the UMRS ecosystem at a lower resolution. This task was initiated for pools and reaches in 1989 and will be repeated at least every 5 years. The high-resolution key pools and reaches data base will be completed in 1991 by a contracted agency. The low-resolution systemic UMRS data base will be developed by EMTC staff in 1991 and 1992.

Inputs:

1. High-resolution (1:15,000) aerial photography for selected pools and reaches.
2. Low-resolution satellite data for the UMRS.
3. Conceptual model (Task 1.1.1.2).
4. Vegetation experimental designs for each resolution (Task 2.2.4.2).
5. GIS (Objective 4.3).
6. Computer equipment (Objective 4.2).

Products:

1. Selected methodologies for collection of land cover data.
2. Map products.
3. GIS land cover data bases (Objective 4.3).
4. Input to the conceptual model (Task 1.1.1.2).
5. Input to the vegetation trend model (Task 2.2.4.1).
6. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
7. Input to identify and investigate additional problems (Objective 1.3).
8. Input to monitor and evaluate aquatic and floodplain habitat (Strategy 2.2.6).
9. Input for the synthesis and evaluation of all monitoring components (Objective 2.3.1).
10. Input to evaluate experimental design (Task 2.2.4.7).
11. Input to obtaining present-day data (Task 2.2.4.5).
12. Input to the evaluation of vegetation monitoring (Task 2.2.4.6).
13. Input to development of management alternatives and HREPs (Goal 3).

Task 2.2.4.5 Conduct Annual Monitoring

Very high-resolution species data were first collected in the field in 1990, and collection will continue throughout the life of the Program. Amendments to cooperative agreements with the states will be renewed annually. LTRMP field station staff members are responsible for data collection and quality assurance, with guidance from EMTC personnel.

Inputs:

1. Procedures manual and the experimental design (Task 2.2.4.2).
2. High-resolution (1:15,000) aerial photography.
3. Spatial data base (Task 2.2.4.4).
4. GIS (Objective 4.3).

Products:

1. Annual vegetation data sets (Task 2.2.4.5).
2. Amendments to cooperative agreements.
3. Input to the annual evaluations and 5-year trend analysis (Tasks 2.2.4.6 and 2.2.4.8).
4. Input to the evaluation of the sampling design (Task 2.2.3.7).

Task 2.2.4.6 Evaluate and Summarize Present-Day Annual Results

An annual field station report on vegetation was initiated in 1990. The annual report will be a publication or presentation that has been mutually agreed upon by the LTRMP field station staff and the EMTC staff. EMTC staff members will similarly compile reports, publications, or presentations on the composite data collected at all field stations. Staff members of both the EMTC and the LTRMP field stations are responsible for this task.

Inputs:

1. Literature review.
2. Very high-resolution vegetation data sets from annual monitoring (Task 2.2.4.5).
3. GIS (Objective 4.3).
4. Multi-temporal high- and low-resolution GIS land cover data for selected pools and reaches (Task 2.2.4.4).

Products:

1. Annual LTRMP field station reports, publications, or presentations.
2. Annual EMTC synthesis reports, publications, or presentations Objective 4.4).
3. Input to development of management alternatives and HREPs (Goal 3).
4. Input to updates of the conceptual model and the vegetation trend model (Tasks 1.1.1.2 and 2.2.4.1).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
6. Input to identify and investigate additional problems (Objective 1.3).
7. Input for the evaluation and refinement of the experimental design (Task 2.2.4.7).
8. Input for the synthesis and evaluation of all monitoring components (Objective 2.3).
9. GIS coverages and maps showing changes.

Task 2.2.4.7 Evaluate and Refine Sampling Design

This evaluation will be done at all scales to determine if the correct quality and quantity of data are being collected to test the hypothesis. Spatial and temporal data collected from field inventory work and remote sensing will be analyzed for trends and used to refine or support specific experimental designs and the procedures manual. The first evaluation of the vegetation sampling design was done in 1991. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Annual very high-resolution vegetation data sets (Task 2.2.4.5).
2. The evaluation and summary of annual data (Task 2.2.4.6).
3. Trend model for vegetation (Task 2.2.4.1).
4. GIS (Objective 4.3).
5. Spatial data bases (Task 2.2.4.4).

Products:

1. Report on the effectiveness of sampling design.

2. Review and incorporation of appropriate changes to the sampling procedures (Task 2.2.4.2).

Task 2.2.4.8 Evaluate and Summarize 5-Year Trends

This task will synthesize 5 years of very high-, high-, and low-resolution vegetation data. Due to financial constraints, it may not be possible to analyze all habitat types, key pools and reaches, and the system in one year; therefore, it may take 3 or more years for a 5-year analysis of all areas and all scales. This type of analysis is scheduled twice during the Program; once beginning in 1994 and again in 1999. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Data sets from annual monitoring (Task 2.2.4.5).
2. Annual LTRMP and EMTC reports (Task 2.2.4.6).
3. GIS (Objective 4.3).
4. Spatial data bases (Task 2.2.4.4).
5. Vegetation trend model (Task 2.2.4.1).

Products:

1. Report on 5-year UMRS vegetation and land cover synthesis.
2. Input to the conceptual model (Task 1.1.1.2).
3. Input to the vegetation trend model (Task 2.2.4.1).
4. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
5. Input to the development of management alternatives and HREPs (Goal 3).

Strategy 2.2.5 Monitor and Evaluate Sediment Composition

Surficial sediments will be characterized subjectively by visual inspection and tactile properties in selected UMRS pools and reaches. Characterization results will be verified by subjecting an appropriate number of subsamples to quantitative laboratory analyses. Analyses will include particle size gradation, bulk density, moisture content, and organic matter content. Attention will be given to lateral and longitudinal gradients within selected sediment type areas in the GIS data bases. Localized influences of tributary inflows, sediment sources, sediment transport mechanisms, vegetation, hydrology, and floodplain configuration on sediment type also will be evaluated using GIS approaches. Information on sediment type in relation to other features of each site will be used to define specific habitats for comparison with results of macrophyte, macroinvertebrate, fish, and waterfowl surveys. Sediment resampling seasonally and through time (at sites selected on the basis of initial survey work) will provide information on episodic and long-term changes in sediment physical composition and distribution. Ultimately, this information will be coupled with information on sedimentation and sediment transport for use in evaluating navigation and river regulation effects. The relationships of sedimentation to other Program components are graphically depicted in Figure 2-5.

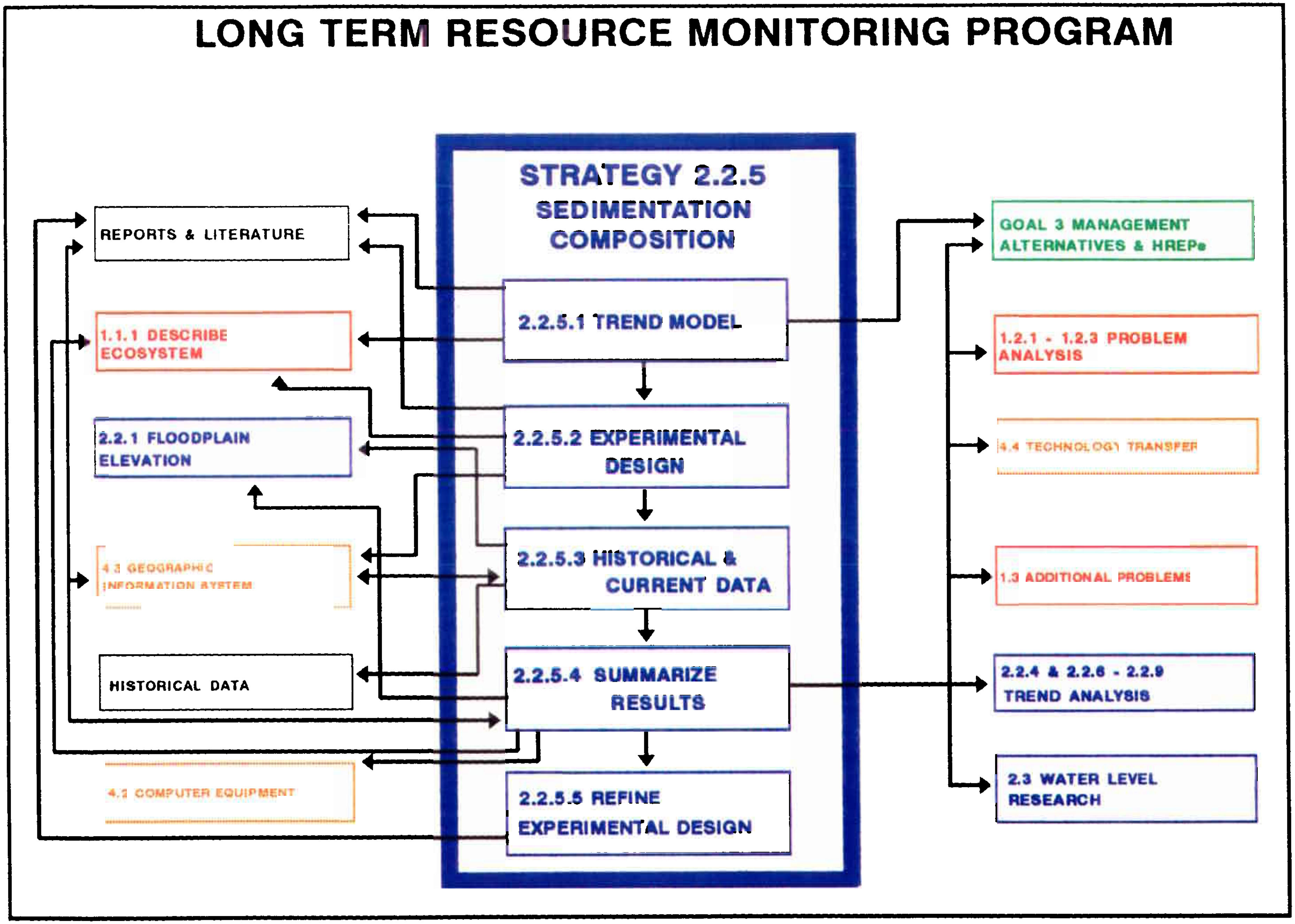


Figure 2-5. The Interrelationships Affecting Sedimentation Composition, Strategy 2.2.5

Task 2.2.5.1 Develop a Trend Model

A box-and-arrow model describing sediment type distribution in the UMRS floodplain and the known and expected relationships of sediment characteristics to the ecosystem will be completed in 1992 and updated every 3 years or as necessary. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on fluvial geomorphology.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation and summary of results (Task 2.2.5.4).

Products:

1. A report describing the sediment composition trend model.
2. Input to experimental design development (Task 2.2.5.2).
3. Input to evaluation of the experimental design (Task 2.2.5.5).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.5.2 Establish Experimental Design

The initial experimental design for the sediment component will be developed in 1991. The sediment sampling protocol will be outlined in a procedures manual and will be reviewed by interagency sponsors in 1992. The procedures manual will be updated again in 1994 if necessary and will be reviewed by the interagency sponsors. The primary responsibility for this task lies with the EMTC staff, with input from river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Trend model for sediment (Task 2.2.5.1).
3. Literature on sediment sampling in large rivers.
4. Historical data on sediment type distribution in the UMRS.
5. GIS (Objective 4.3).
6. The evaluation and refinement of the experimental design (Task 2.2.5.5).

Products:

1. Documented experimental design.
2. Procedures manual with updates.
3. Input for obtaining historical and present-day monitoring data (Task 2.2.5.3).

Task 2.2.5.3 Obtain Historical and Present-Day Monitoring Data

Historical sediment composition data will be retrieved from the COE, Service, USGS, EPA, State agencies, and universities in 1991 and 1992. Collection of present-day sediment composition data will begin in 1992 and will extend for the next 4 to 6 years. EMTC staff members are responsible for this task, with the cooperation of LTRMP field station staff and river managers and researchers.

Inputs:

1. Historical data.
2. Procedures manual and experimental design.
3. Results of bathymetric surveys (Strategy 2.2.1).
4. GIS (Objective 4.3).

Products:

1. Data sets of sediment composition.
2. Sediment composition maps of selected sites.
3. GIS data base for sediment types (Objective 4.3).
4. Input to the evaluation and summary of data (Task 2.2.5.4).
5. Input for the evaluation of the experimental design (Task 2.2.5.5).

Task 2.2.5.4 Evaluate and Summarize Results

Seasonal/episodic and long-term trends in sediment type and distribution in selected pools and reaches will be reported in 1993 and again in 1998. Evaluations and summaries of sediment composition will be conducted by EMTC staff, with assistance from LTRMP field station staff.

Inputs:

1. Sediment composition data sets (Task 2.2.5.3).
2. Literature on fluvial geomorphology.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. Reports on sediment type distribution and evaluation of changes (Objective 4.4).
2. Input to updates of the conceptual model and the sediment composition trend model (Tasks 1.1.1.2 and 2.2.5.1).
3. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
4. Input to identify and investigate additional problems (Objective 1.3).
5. Input to the evaluation and refinement of the sampling design (Task 2.2.5.5).
6. Input to the development of management alternatives and HREPs (Goal 3).
7. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
8. GIS data base (Objective 4.3).
9. Input to other resource monitoring components (Strategies 2.2.1 to 2.2.4 and 2.2.6 to 2.2.9).
10. Input to the selection of research projects (Task 1.2.1.2).

Task 2.2.5.5 Evaluate and Refine Experimental Design

The experimental design and procedures manual will be revised and evaluated in 1992. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Historical and present-day sediment composition data set (Task 2.2.5.3).
2. Evaluations and summaries of sediment composition data (Task 2.2.5.4).
3. Trend model for sediment composition (Task 2.2.5.1).

Products:

1. Report on effectiveness of sampling design.
2. Review and incorporation of appropriate changes to the sampling procedures (Task 2.2.5.2).

Strategy 2.2.6: Monitor and Evaluate Aquatic and Floodplain Habitat

Monitoring and mapping the dynamic mosaic of riverine habitat conditions are central to many LTRMP activities. An aquatic and floodplain habitat classification system is needed to facilitate monitoring, mapping at different spatial scales, habitat evaluation, and orientation to areas with similar habitat conditions. Aquatic and riverine floodplain zones cover large areas and are based on the natural and constructed geomorphic features of large rivers. Within these zones is a dynamic mosaic of habitat conditions, mediated by water depth and temperature, current velocity, turbulence, light, cover, substrate type, microtopography, etc. The areal extent and distribution of specific habitat types (microhabitats) varies greatly with river discharge rates and season. GIS coverages of habitat conditions will be developed and used to assess habitat availability and suitability for selected species and life stages of aquatic organisms.

Floodplain habitat initially will be classified according to vegetation forms. Maps of floodplain habitat conditions such as vegetation types, elevation, and hydrologic regime will be developed and used together to assess habitat suitability and availability in selected areas.

Mapping habitat conditions will require using GIS, remote surveying, and hydraulic modeling technologies. A standard set of definitions of habitat types and conditions will be used for consistent measurements and mapping.

Habitat mapping will be conducted at a low level of resolution (aquatic zones, physiognomic vegetation types) System-wide, at a high level of resolution (aquatic zones, geomorphic features, elevation, hydrologic regime, soils and sediment type, vegetation) in selected pools and river reaches for monitoring purposes, and at very high levels of resolution in smaller study areas for research purposes. Survey frequency for aquatic habitat monitoring will be dictated by the rate of change in floodplain morphology and vegetation. The relationships of floodplain habitat to other Program components are graphically depicted in Figure 2-6.

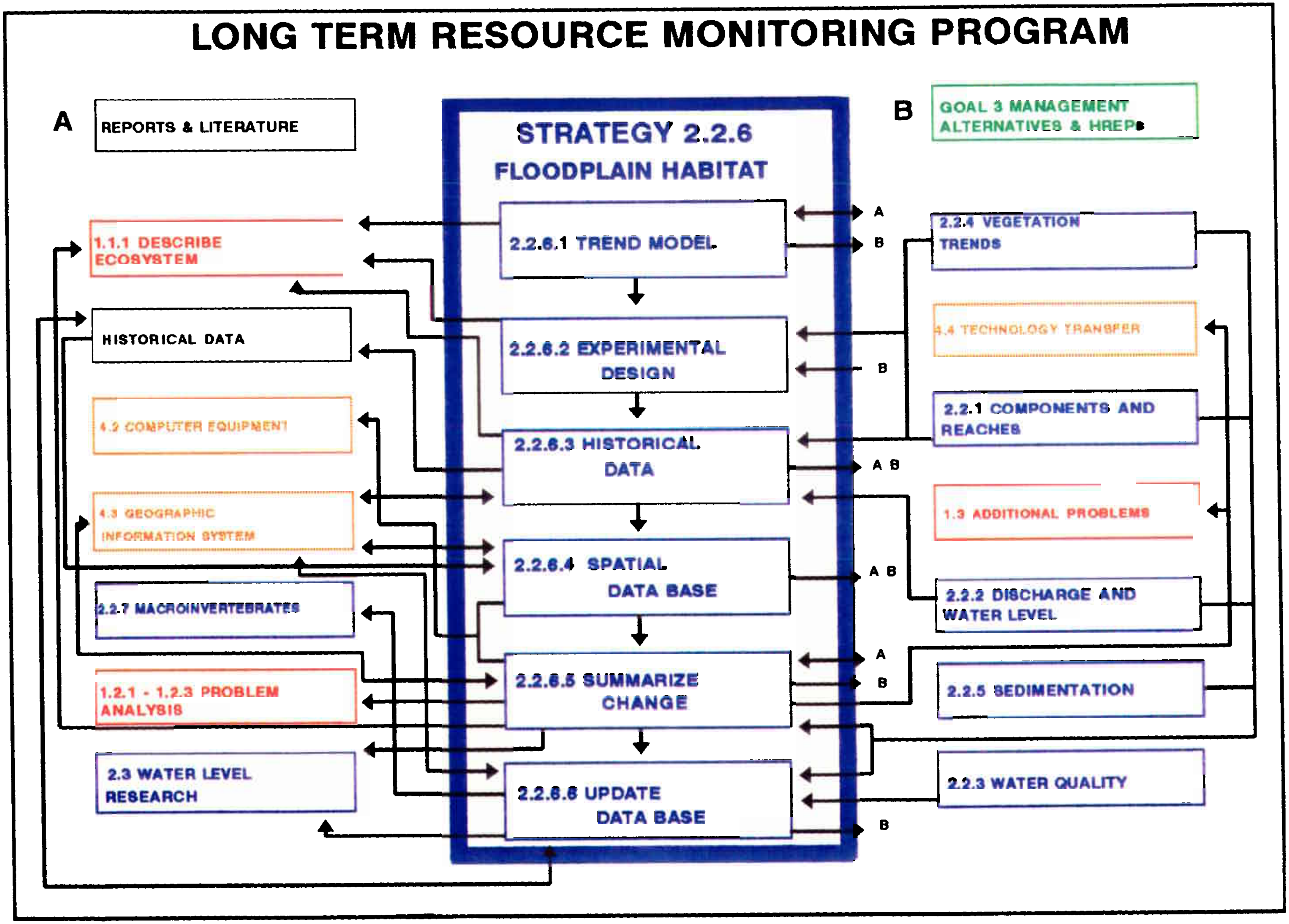


Figure 2-6. The Interrelationships Affecting Floodplain Habitat, Strategy 2.2.6

09/93

Task 2.2.6.1 Develop a Trend Model

A box-and-arrow model describing the known and expected processes of habitat change and relationships to the UMRS ecosystem will be completed in 1991 and updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation of habitat changes (Task 2.2.6.5).

Products:

1. A report describing the aquatic and floodplain habitat trend models.
2. Input to the development of the experimental design (Task 2.2.6.2).
3. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.6.2 Establish Experimental Designs

Developing a standardized habitat classification system that incorporates all trend analysis data sets is an integral part of the experimental design for monitoring aquatic and floodplain habitat components. The aquatic habitat classification was developed in 1991 and the floodplain system will be developed in 1992. The 1992 procedures manual will include a classification system which will be updated in 1995 and reviewed by the interagency sponsors. The primary responsibility for this task lies with the EMTC staff, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on habitat classification and fluvial geomorphology.
2. UMRS vegetation classification (Task 2.2.4.2).
3. Conceptual model for temporal and spatial data needs (Task 1.1.1.2).
4. Aquatic and floodplain habitat model (Task 2.2.6.1).

Products:

1. Classification system.
2. Procedures manual.
3. Documented experimental design.
4. Input for evaluating historical information and evaluating changes in habitat (Tasks 2.2.6.3 and 2.2.6.5).
5. Report describing development of and definitions for a UMRS aquatic and floodplain habitat classification system.
6. Report on the systematic approach to quantifying habitat in terms of relationships between physical, chemical, and biological parameters.
7. Input to producing a spatial data base of aquatic zones and floodplain vegetation (Task 2.2.6.4).
8. Input to refining and updating the aquatic and floodplain habitat data base (Task 2.2.6.6).

9. Determination of appropriate methodologies (correlations, regression, ordination).

Task 2.2.6.3 Obtain and Evaluate Historical Information

The acquisition of historical data on aquatic and floodplain habitats was initiated in 1990 and will continue on an ongoing basis. Each pool or river reach will take a year or two to complete. EMTC staff members have the primary responsibility for this task.

Inputs:

1. Historical aerial photography.
2. Historical elevation data (Strategy 2.2.1).
3. Historical hydrologic data (Strategy 2.2.2).
4. Historical vegetation data (Strategy 2.2.4).
5. Historical geomorphological survey maps.
6. GIS (Objective 4.3).
7. Procedures manual (Task 2.2.6.2).

Products:

1. Report on historical habitat conditions.
2. GIS coverages of historical habitat conditions (Strategy 4.3.1).
3. Input to development of management alternatives and HREPs (Goal 3).
4. Input to evaluate changes in habitat (Task 2.2.6.5).
5. Input to the conceptual model (Task 1.1.1.2).

Task 2.2.6.4 Produce a Systemic Spatial Data Base

Landsat imagery for the entire System has been acquired. A low-resolution spatial data base of aquatic zones and floodplain vegetation forms for the entire UMRS will be initiated in 1992, completed in 1994, and then repeated every 5 years. In 1997, new data will be acquired and analyzed for changes. The responsibility for this data base lies with the EMTC staff.

Inputs:

1. COE navigation charts.
2. Bathymetric maps of the main channel and borders.
3. Satellite imagery.
4. Classification system (Task 2.2.6.2).
5. GIS (Objective 4.3).
6. Computer equipment (Objective 4.2).

Products:

1. GIS coverages of aquatic zones and vegetation forms by pool and river reach for the entire UMRS (Objective 4.3).
2. Five-year systemic change detection.
3. Input to development of management alternatives and HREPs (Goal 3).

Task 2.2.6.5 Evaluate and Summarize Change in Habitat

The changes in key pools and reaches in habitat type composition, areal extent, and distribution will be documented in selected pools and reaches beginning in 1994. Apparent causal factors also will be identified. Changes will be evaluated every 5 years and after major flood events that produce significant changes in floodplain configurations and vegetation. EMTC staff members have the primary responsibility for this evaluation, with input from LTRMP field station staff and river researchers and managers.

Inputs:

1. Floodplain elevation surveys and GIS maps of selected pools and river reaches (Strategies 2.2.2 and 4.3.1).
2. Water surface elevation GIS models for selected pools and river reaches (Strategies 2.2.1 and 4.3.1).
3. Sediment type surveys and GIS maps of selected pools and river reaches (Strategies 2.2.5 and 4.3.1).
4. Vegetation surveys and GIS maps of selected pools and river reaches (Strategies 2.2.4 and 4.3.1).
5. Hydrologic records (Strategy 2.2.2).
6. Evaluation of historical information (Task 2.2.6.3).
7. Literature on floodplain ecology and fluvial geomorphology.
8. Experimental design (Task 2.2.6.2).
9. Computer equipment (Objective 4.2).
10. GIS (Objective 4.3).

Products:

1. Periodic reports on aquatic habitat conditions and changes and apparent causal factors of change.
2. GIS coverages of aquatic and floodplain habitats (Strategy 4.3.1).
3. Input to the development of management alternatives and HREPs (Goal 3).
4. Input to the conceptual model and the aquatic and floodplain habitat trend models (Tasks 1.1.1.2 and 2.2.6.1).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
6. Input to identify and investigate additional problems (Objective 1.3).
7. Input for the synthesis and evaluation of all monitoring components (Strategy 2.3.1).
8. Identification of quantitative relationships between parameters to define significant habitats.
9. Input to technology transfer (Objective 4.4).

Task 2.2.6.6 Refine and Update the Data Base

Refining and updating the high-resolution aquatic and floodplain habitat data base as bathymetric, water surface, sediment type, vegetation, water quality, geomorphology, and current velocity data become available will be an ongoing activity starting in 1992. The primary responsibility for this task lies with the EMTC staff.

Inputs:

1. Floodplain elevation surveys and GIS coverages of selected pools and river reaches (Strategies 2.2.1 and Objective 4.3).
2. Water surface elevation GIS coverages for selected pools and river reaches (Strategies 2.2.2 and Objective 4.3).
3. Sediment type surveys and GIS coverages of selected pools and river reaches (Strategies 2.2.5 and Objective 4.3).
4. Vegetation coverages and GIS coverages of selected pools and river reaches (Strategies 2.2.4 and Objective 4.3).
5. Additional surveys and GIS maps of aquatic and floodplain habitat conditions in selected areas (current velocity, turbulence, cover, water temperature, light conditions, suspended solids, vegetation, geomorphic features, hydrologic regimes) as required for research purposes.
6. Classification system (Task 2.2.6.2).
7. Water quality data and GIS (Strategies 2.2.3 and Objective 4.3).

Products:

1. Updated, refined GIS coverages of habitat type distribution (Objective 4.3).
2. Input to the development of management alternatives and HREPs (Goal 3).
3. Input to macroinvertebrate monitoring (Strategy 2.2.7).
4. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).

Strategy 2.2.7: Monitor and Evaluate Selected Macroinvertebrate Populations and Communities

Benthic macroinvertebrates are an important biotic component of the UMRS ecosystem. They provide a significant trophic link for fish, waterfowl, and furbearing mammals, and comprise a substantial portion of the total standing crop of consumer organisms in backwater habitats. Relative to fish and many other aquatic organisms, most benthic macroinvertebrates have very limited mobility, are less able to avoid unfavorable environmental conditions, are short-lived, and are very sensitive to environmental stressors. Consequently, they respond quickly to environmental changes.

Trend analyses of macroinvertebrates are needed to assess spatial and temporal patterns in benthic population abundances and to suggest potential mechanisms causing variance. Measuring key macroinvertebrate populations will assist in evaluating the condition of the riverine ecosystem. Standard qualitative and quantitative sampling techniques will be employed to obtain information on density, biomass, life stages, and production of the dominant taxa. Historical information on river discharge, stage height, and water quality will be used to interpret trend analysis data from monitoring efforts. Data from water quality monitoring (Strategy 2.2.3) and sediment type data (e.g., grain size, organic content, bulk density) from sediment composition monitoring (Strategy 2.2.5) will be used to evaluate the macroinvertebrate monitoring data. The relationships of macroinvertebrates to other Program components are graphically depicted in Figure 2-7.

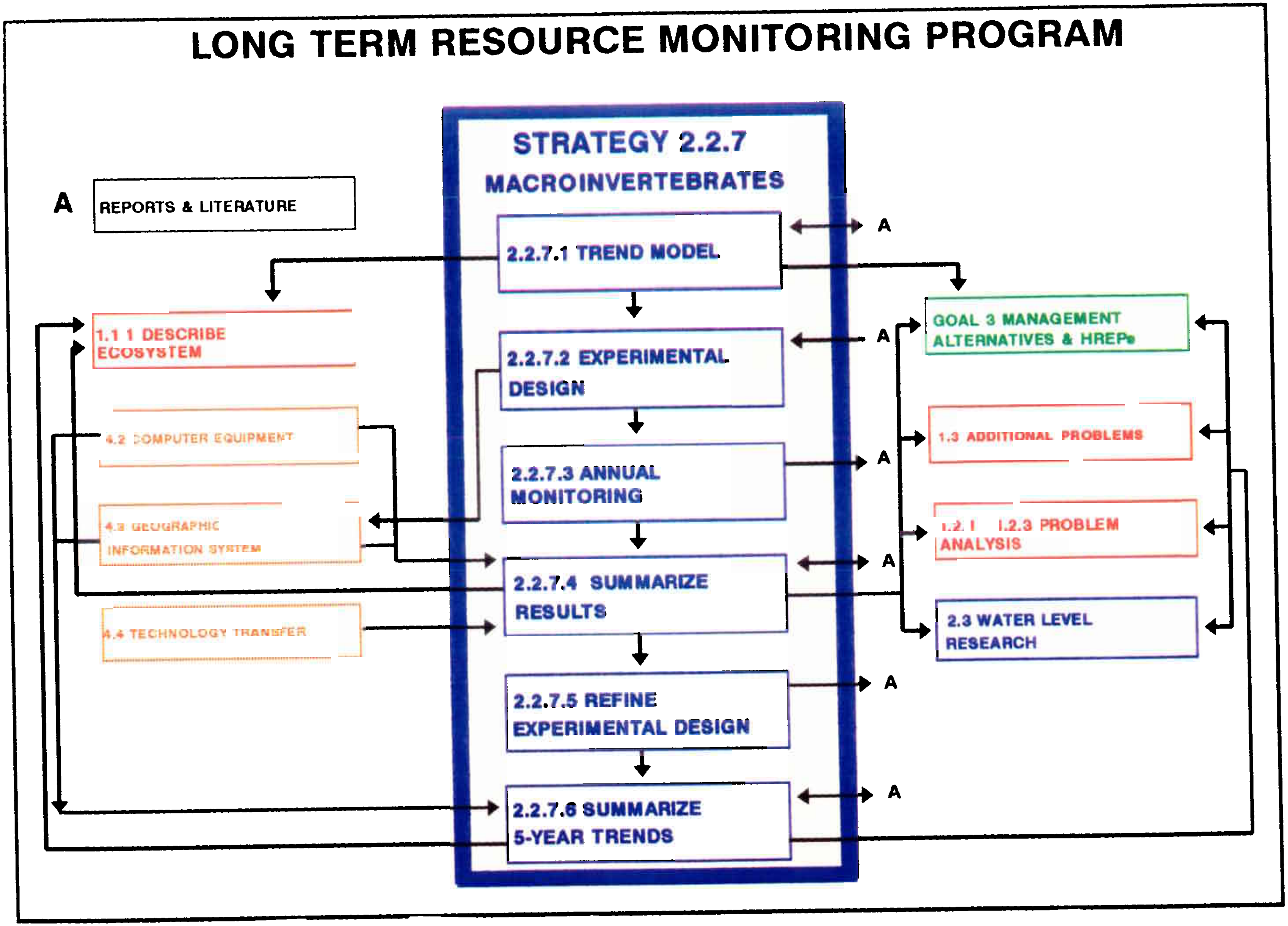


Figure 2-7. The Interrelationships Affecting Macroinvertebrates, Strategy 2.2.7

Task 2.2.7.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of invertebrates in the UMRS ecosystem will be completed by 1992 and updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature review.
2. Conceptual model (Task 1.1.1.2).
3. Evaluation and summary of annual and 5-year trends (Tasks 2.2.7.4 and 2.2.7.6).

Products:

1. A report describing the macroinvertebrate trend model.
2. Input to the development of the experimental design (Task 2.2.7.2).
3. Input to the evaluation of the experimental design (Task 2.2.7.5).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.7.2 Establish Experimental Design

The experimental design will develop and document hypotheses, monitoring objectives, sampling procedures, spatial and temporal allocation of sampling efforts, numbers of replicate samples, and levels of taxonomic identification needed to characterize macroinvertebrate populations and community types with an acceptable level of confidence. The procedures manual for macroinvertebrate sampling will be completed in 1992 and will be reviewed by the interagency sponsors. EMTC staff members have the primary responsibility for this task, with input from personnel at the National Fisheries Research Center and river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Invertebrate trend model (Task 2.2.7.1).
3. Literature on sampling techniques and historical data.
4. GIS (Objective 4.3).
5. The evaluation and refinement of the experimental design (Task 2.2.7.5).

Products:

1. Documented experimental design.
2. Procedures manual with updates.
3. Input to obtain annual monitoring data (Task 2.2.7.3).

Task 2.2.7.3 Conduct Annual Monitoring

Macroinvertebrate sampling to monitor population and community trends will begin in two trend analysis areas in 1991, expand into the remaining pools in 1992, and continue annually. Amendments to cooperative agreements with the states will be renewed annually. After initial implementation by the National Fisheries Research Center staff, the LTRMP field station staff members are responsible for sample collection and quality assurance, with guidance from the EMTC staff. Taxonomic identification will be completed by the most appropriate scientific personnel.

Input:

1. Procedures manual and experimental design (Task 2.2.7.2).

Products:

1. Annual data sets of invertebrate collections.
2. Amendments to cooperative agreements.
3. Input to the annual evaluation and 5-year trend analysis (Tasks 2.2.7.4 and 2.2.7.6).
4. Input for the evaluation of the experimental design (Task 2.2.7.5).

Task 2.2.7.4 Evaluate and Summarize Annual Results

Trends on the density and biomass of macroinvertebrate taxa as outlined in the procedures manual will be quantified. A field station report, a publication, or a presentation that has been mutually agreed upon by the LTRMP field station staff and EMTC staff will be produced annually. The EMTC staff will similarly compile reports, publications, or presentations on the data collected at all field stations.

Inputs:

1. Macroinvertebrate data sets from annual monitoring (Task 2.2.7.3).
2. Literature on invertebrates.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. Annual LTRMP field station reports, publications, or presentations on macroinvertebrates.
2. Annual EMTC staff synthesis reports, publications, or presentations on macroinvertebrates.
3. Input to the development of management alternatives and HREPs (Goal 3).
4. Input to updates of the conceptual model and the macroinvertebrate trend model (Tasks 1.1.1.2 and 2.2.7.1).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
6. Input to identify and investigate additional resource problems (Objective 1.3).
7. Input to technology transfer (Objective 4.4).
8. Input to the evaluation and refinement of the experimental design (Task 2.2.7.5).
9. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
10. Input to the 5-year trend evaluation (Task 2.2.7.6).

Task 2.2.7.5 Evaluate and Refine Experimental Design

The experimental design and procedures manual will be revised in 1993 and 1994, after the initial sampling design has been established in the manual. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Annual macroinvertebrate data sets (Task 2.2.7.3).
2. Evaluations and summaries of the data (Task 2.2.7.4).
3. Macroinvertebrate trend model (Task 2.2.7.1).

Products:

1. Report on the effectiveness of the sampling design.
2. Review and incorporation of appropriate changes to the sampling procedures (Task 2.2.7.2).

Task 2.2.7.6 Evaluate and Summarize 5-Year Trends

In addition to annual analyses of the macroinvertebrate data (Task 2.2.7.4), 5-year trends also will be synthesized in 1996. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Data sets from annual monitoring (Task 2.2.7.3).
2. Annual reports (2.2.7.4).
3. Literature review.
4. GIS (Objective 4.3).
5. Computer equipment (Objective 4.2).

Products:

1. Report on 5-year UMRS macroinvertebrate analysis.
2. Input to the conceptual model (Task 1.1.1.2).
3. Input to the macroinvertebrate trend model (Task 2.2.7.1).
4. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
5. Input to the development of management alternatives and HREPs (Goal 3).
6. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
7. Input to identify and investigate additional resource problems (Objective 1.3).

Strategy 2.2.8: Monitor and Evaluate Fish Communities, Guilds, and Populations

Trends in relative abundances of fish communities, guilds, and populations will be determined by analyzing annual monitoring data collected at representative river reaches (Pools 4, 8, 13, 26, La Grange Pool, and an open river reach) and habitats (tailwater, channel border-unstructured, channel border-wing dam, impounded, and backwater-contiguous). Initial information on the distribution and current trends of UMRS fishes, their habitats, and their responses to habitat problems will be gathered from the literature and from other existing data. This information will be used to formulate hypotheses and strategic models to determine the variables to be monitored and to identify sampling sites and procedures. Data from the initial years of sampling will be analyzed to detect sources of variance and determine ways to reduce variability and effort. Procedures will be developed to calculate annual relative abundance and recruitment indices. Sampling procedures will be calibrated in target habitat types to relate catch rates and standing stocks. Sauger, black crappie, and channel catfish will be the target species initially monitored for changes in population structure. The relationships of fish to other Program components are graphically depicted in Figure 2-8.

Task 2.2.8.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of fish to the UMRS ecosystem will be completed by 1992 and updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on fisheries in large rivers.
2. Conceptual model formulation (Task 1.1.1.2).
3. Evaluation and summary of annual and 5-year trends (Tasks 2.2.8.4 and 2.2.8.6).

Products:

1. A report describing the fish trend model.
2. Input to the development of the experimental design (Task 2.2.8.2).
3. Input to the evaluation of the experimental design (Task 2.2.8.5).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.8.2 Establish Experimental Design

The initial experimental design for the fish component was developed in 1989. A hypothesis was proposed and historical data have been and will continue to be identified. Fisheries sampling procedures, including site selection, target species, and sampling frequency have been outlined in a procedures manual that was approved by interagency sponsors in 1989. The procedures manual will be updated in 1992 and reviewed again by the interagency sponsors. The primary responsibility for this task lies with the EMTC staff, with input from river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Fish trend model (Task 2.2.8.1).
3. Literature review of fish sampling methods in large rivers and historical data.
4. GIS (Objective 4.3).
5. Evaluation and refinement of the experimental design (Task 2.2.8.5).
6. Sampling gear calibration (Task 2.2.8.7).

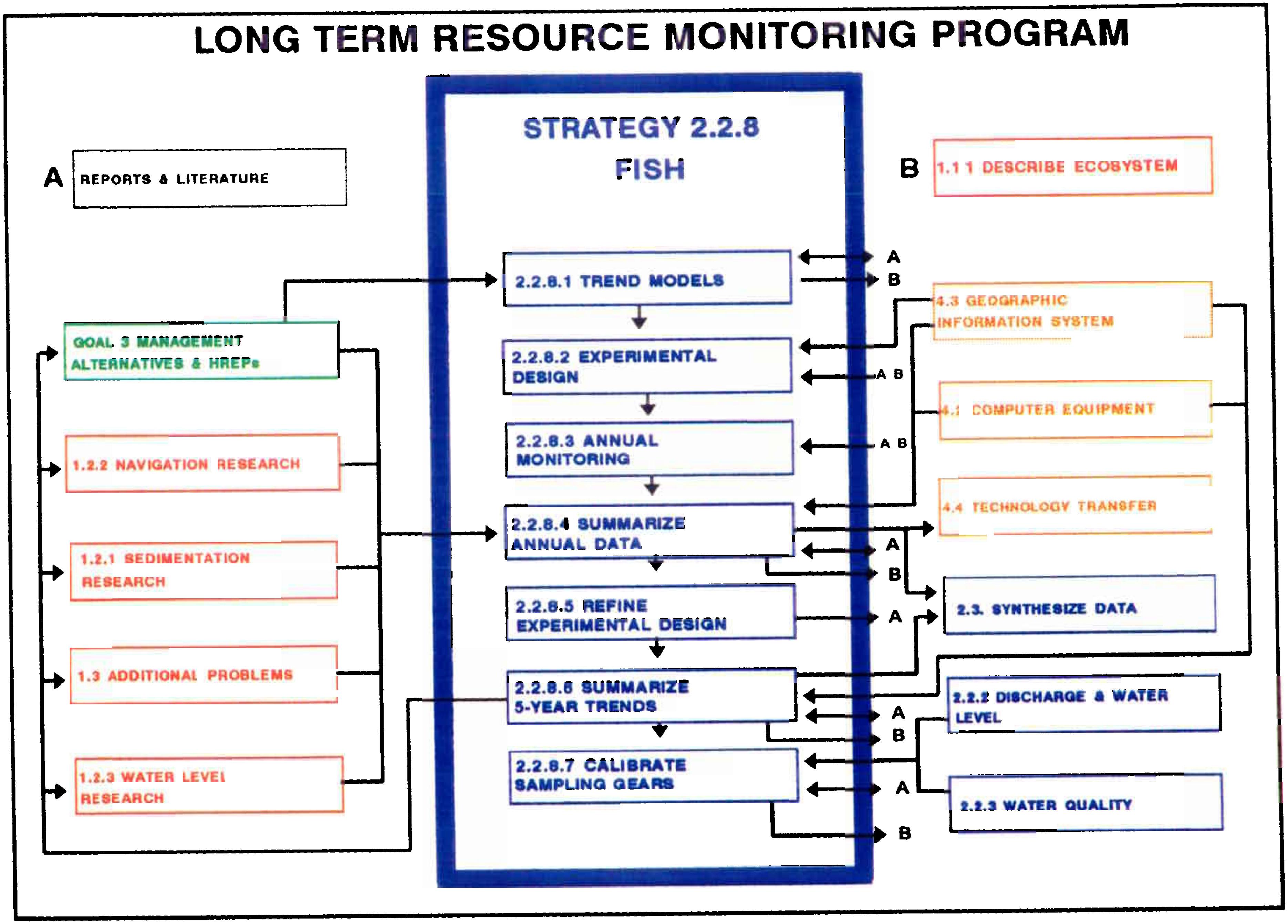


Figure 2-8. The Interrelationships Affecting Fish, Strategy 2.2.8

09/93

Products:

1. Procedures manual with updates.
2. Documented experimental design.
3. Input for obtaining annual monitoring data (Task 2.2.8.3).

Task 2.2.8.3 Conduct Annual Monitoring

Fisheries monitoring data collection was initiated in 1989 and will continue annually. Amendments to cooperative agreements with the states will be renewed annually. LTRMP field station staff members are responsible for the collection and quality assurance of these data, with guidance from EMTC staff.

Input:

1. Procedures manual and experimental design (Task 2.2.8.2).

Products:

1. Annual data sets of fish collections.
2. Amendments to cooperative agreements.
3. Input to the annual evaluation and 5-year trend analysis (Tasks 2.2.8.4 and 2.2.8.6).
4. Input to the evaluation of the experimental design (Task 2.2.8.5).

Task 2.2.8.4 Evaluate and Summarize Annual Results

Trends in fish populations and communities will be analyzed annually. Annual field station reports on fish were initiated in 1990. Annual station reports or another type of publication, presentation, or report that has been mutually agreed upon by LTRMP field station staff and EMTC staff will be produced annually. The EMTC staff will similarly compile reports, publications, or presentations on the composite data collected at all field stations. Analytical procedures to model annual changes in relative abundance and distribution will be developed by staff from both the EMTC and the LTRMP field stations.

Inputs:

1. Fish data sets from annual monitoring (Task 2.2.8.3).
2. Literature on fisheries.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. Annual LTRMP field station reports, publications, or presentations of fish monitoring.
2. Annual EMTC synthesis reports, publications, or presentations of fish monitoring.
3. Input to development of management alternatives and HREPs (Goal 3).
4. Input to updates of the conceptual model and the fish trend model (Tasks 1.1.1.2 and 2.2.8.1).
5. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).

6. Input to identify and investigate additional research problems (Objective 1.3).
7. Input to the evaluation and refinement of the experimental design (Task 2.2.8.5).
8. Input to technology transfer (Objective 4.4).
9. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).

Task 2.2.8.5 Evaluate and Refine the Experimental Design

The experimental design and procedures manual will be evaluated and revised in 1991 and 1992. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. The annual fisheries data sets (Task 2.2.8.3).
2. The evaluations and summaries of the data (Task 2.2.8.4).
3. Trend model for fish (Task 2.2.8.1).
4. Literature on fish stock assessment.

Products:

1. Report of effectiveness of the sampling design.
2. Review and incorporate appropriate changes to the sampling procedures (Task 2.2.8.2).

Task 2.2.8.6 Evaluate and Summarize 5-year Trends

Five-year trends will be summarized in the fisheries data for all trend analysis areas. Another source of data to include in this summary could be the Upper Mississippi River Coordinating Committee's (UMRCC's) commercial fishing statistics. Due to financial constraints, it may not be possible to analyze all habitat types in one year; therefore, it may take 3 or more years for a 5-year analysis of all habitat types. This type of analysis is scheduled twice during the Program; once beginning in 1993 and again in 1998. EMTC staff members are primarily responsible for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Data sets from annual monitoring (Task 2.2.8.3).
2. Annual LTRMP and EMTC reports (Task 2.2.8.4).
3. Literature review.
4. UMRCC's commercial fishing reports.
5. GIS (Objective 4.3).
6. Computer equipment (Objective 4.2).

Products:

1. Report on 5-year UMRS fisheries analysis.
2. Input to the conceptual model (Task 1.1.1.2).
3. Input to the fish trend model (Task 2.2.8.1).
4. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
5. Input to development of management alternatives and HREPs (Goal 3).

6. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
7. Input to identify and investigate additional resource problems (Objective 1.3).

Task 2.2.8.7 Calibrate Sampling Gear

Under selected conditions, sampling gear will be calibrated to relate relative abundance to standing stocks to determine the effectiveness of the experimental design and sampling procedures. This calibration will be done from 1993 to 1996. EMTC staff members are primarily responsible for this task, with assistance from LTRMP field station staff, river managers and researchers, or other appropriate scientific personnel.

Inputs:

1. Literature review of calibration methods.
2. Discharge, water level, water quality, and fish data (Strategies 2.2.2, 2.2.3, and 2.2.8).

Products:

1. Report on the effectiveness of the sampling design.
2. Review and incorporation of appropriate changes in the experimental design (Task 2.2.8.2).
3. Equations that relate catch rates to standing stocks under specific environmental conditions.
4. Input to the conceptual model (Task 1.1.1.2).

Strategy 2.2.9: Monitor and Evaluate Wildlife

Wildlife (for purposes of LTRMP monitoring) includes all vertebrates that occur in the UMRS floodplain, except fish, domestic animals, and humans. Target species will be selected to monitor changes in the UMRS ecosystem. Data on wildlife populations that are seasonally or annually dependent upon UMRS resources may reflect regional status as well as overall population status. The ecological impacts of changes in chemical and physical parameters, in vegetation, and in the composition/structure of the lower trophic levels are expressed in the wildlife community. However, impacts are not always realized until the wildlife population approaches a threshold. The proposed study approach should provide a systematic ecological perspective on wildlife use, distribution, and abundance. A balanced perspective is essential in the development of realistic and socially and ecologically responsive management objectives.

Target wildlife species will be selected based on (1) estimates of population size, distribution and dependence on river habitat; (2) trophic level; and (3) population status (endangered, threatened, increasing, or decreasing). The most appropriate methodologies for selecting wildlife populations will be evaluated by a literature review and by consultations with resource managers and researchers. Considerations include population size coupled with habitat complexity, the size of the area to be surveyed, and the level of accuracy required. Sampling protocols for determining population size will be based on the ease of population estimates. Similarly, sampling protocols will take into account the geographic area that each wildlife population uses. Population estimations will involve various types of stratification (habitat-based) and sampling techniques (direct observation, capture, photography, and video). Spatial scale is limited to the floodplains of the Mississippi and Illinois Rivers.

Experimental design considerations also will include life history, breeding and wintering areas, and the significance of the UMRS as a migration corridor. This information then will be used to model the influence of habitat components on the size and structure of the selected wildlife populations. The relationships of wildlife to other Program components is graphically depicted in Figure 2-9.

Task 2.2.9.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of wildlife to the UMRS ecosystem will be completed in 1992 and updated every 3 years if warranted by new data. The EMTC staff has the primary responsibility for this task, with input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Literature on large river wildlife and migratory waterfowl.
2. Conceptual model formulation (Task 1.1.1.2).
3. Evaluation of annual reports (Task 2.2.9.4).

Products:

1. A report describing the wildlife trend model.
2. Input to the development of the experimental design (Task 2.2.9.5).
3. Input to evaluation of the experimental design (Task 2.2.9.2).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.9.2 Establish Experimental Design

The initial experimental design and sampling procedures will be developed in 1992 by the U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, La Crosse, Wisconsin. The experimental design will include extensive use of wildlife data obtained by other agencies and other elements of the Service. Wildlife sampling protocols, including target species, site selection, and sampling frequency, will be outlined in a procedures manual. This wildlife procedures manual will be developed in 1992 and will be reviewed by the interagency sponsors. The primary responsibility for this task lies with the EMTC staff, with input from river managers and biologists.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Wildlife trend model (Task 2.2.9.1).
3. Literature review of wildlife sampling methods in large rivers.
4. Current monitoring, survey, and count data from applicable agencies.
5. GIS (Objective 4.3).
6. Evaluation of the experimental design (Task 2.2.9.5).

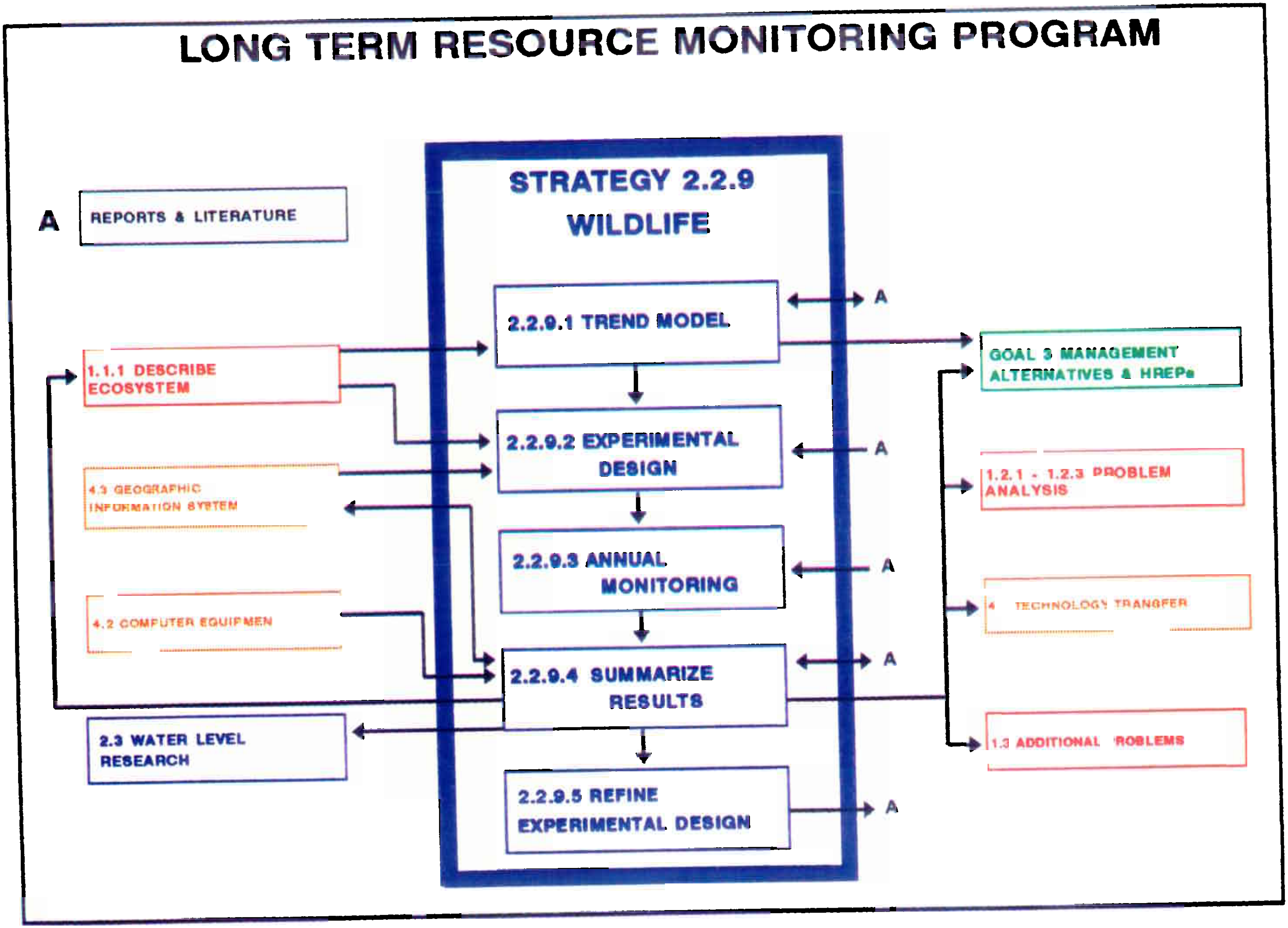


Figure 2-9. The Interrelationships Affecting Wildlife, Strategy 2.2.9

Products:

1. Procedures manual with updates.
2. Documented experimental design.
3. Input for obtaining annual monitoring data (Task 2.2.9.3).

Task 2.2.9.3 Conduct Annual Monitoring

The annual monitoring effort will include field sampling and collecting data obtained by other agencies. EMTC staff members are primarily responsible for this task and will acquire the data with the assistance of the LTRMP field station staff and river biologists, or through a contract or cooperative agreement with other appropriate scientific personnel.

Inputs:

1. Procedures manual and experimental design (Task 2.2.9.2).
2. Data from other agencies.

Products:

1. Annual wildlife data sets.
2. Input to the evaluation of data (Task 2.2.9.4).
3. Input to the evaluation of the experimental design (Task 2.2.9.5).

Task 2.2.9.4 Evaluate and Summarize Annual Results

Trends in important wildlife target species and communities will be documented.

Inputs:

1. Wildlife data sets from annual monitoring (Task 2.2.9.3).
2. Literature review.
3. External reports and data from UMRS state and federal agencies and universities.
4. GIS (Objective 4.3).
5. Computer equipment (Objective 4.2).

Products:

1. Annual reports.
2. Input to development of management alternatives and HREPs (Goal 3).
3. Input to updates of the conceptual model and the wildlife trend model (Tasks 1.1.1.2 and 2.2.9.1).
4. Input to sedimentation, navigation, and river regulation research (Strategies 1.2.1 to 1.2.3).
5. Input to identify and investigate additional resource problems (Objective 1.3).
6. Input to technology transfer (Objective 4.3).
7. Input to the evaluation and refinement of the experimental design (Task 2.2.9.5).
8. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
9. GIS habitat maps and data files of population data (Objective 4.3).

Task 2.2.9.5 Evaluate and Refine Experimental Design

The experimental design and procedures manual will be revised in 1995. EMTC staff members have the primary responsibility for this task, with assistance from LTRMP field station staff and river managers and researchers.

Inputs:

1. Annual wildlife data sets (Task 2.2.9.3).
2. Data evaluations and summaries (Task 2.2.9.4).
3. Wildlife trend model (Task 2.2.9.1).

Products:

1. Report on the effectiveness of the sampling design.
2. Review and incorporation of appropriate changes to the sampling procedures (Task 2.2.9.2).

Strategy 2.2.10: Monitor and Evaluate Public Use

Public use of the UMRS causes resource impacts at varying degrees throughout the System. The upper pools experience the greatest use, due in part to the spatial relationship of the UMRS to large metropolitan areas and in part to the System's high aesthetic quality. This public use is resulting in resource management conflicts. At this time, there is no mechanism to restrict or limit public use in response to a resource problem, nor is there information available on Mississippi River System resource use trends to support or negate that type of mechanism. More information is needed to assess the spatial and temporal impacts of public use on the System's ecological processes and to develop appropriate management strategies to ameliorate the adverse impacts of increasing public use.

The spatial and temporal distribution of the types of public use occurring on the UMRS will be researched. This information then will be compared to historical information to develop types of use trends for specific river reaches. Trend data also will be compared with ecological trend information to identify cause-and-effect relationships and to identify the development of ecological sensitivities to specific types of use. An integral part of this evaluation is the development of appropriate methodologies for determining spatial and temporal use patterns. Spatial scales are limited to the floodplains of the Mississippi, St. Croix, and Illinois Rivers. However, demographic information outside that area must be considered in the development of any trend model. The relationships of public use to other Program components are graphically depicted in Figure 2-10.

Task 2.2.10.1 Develop a Trend Model

A box-and-arrow model describing the known and expected relationships of public use to the UMRS ecosystem will be completed in 1991 and updated every 3 years or sooner if warranted by new data. EMTC staff members have the primary responsibility for this task and will solicit input from public use specialists.

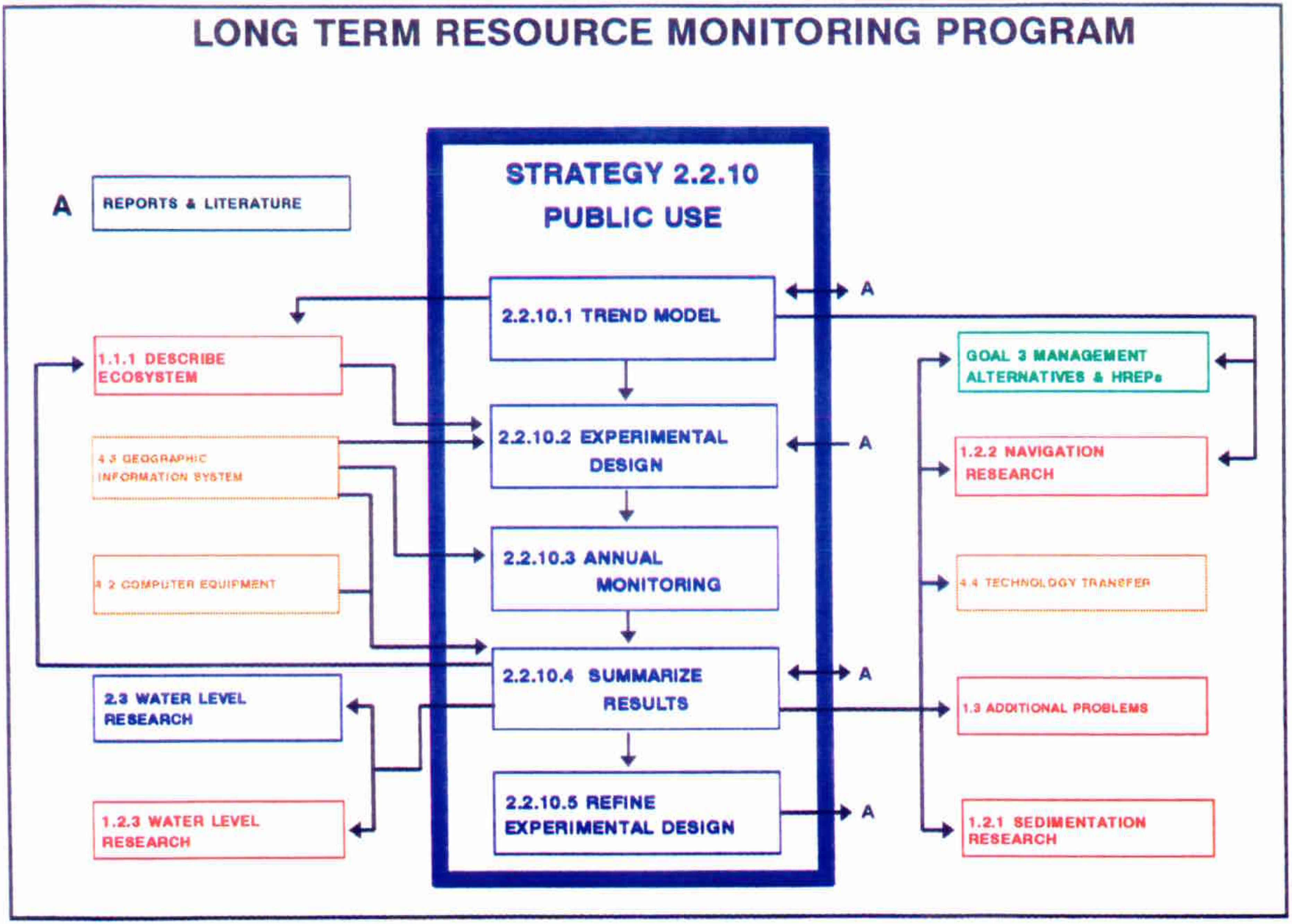


Figure 2-10. The Interrelationships Affecting Public Use, Strategy 2.2.10

Inputs:

1. Literature on public use of large rivers.
2. Conceptual model formulation (Task 1.1.1.2).
3. Evaluation and summary of results (Task 2.2.10.4).

Products:

1. A report describing the public use trend model.
2. Input to the experimental design (Task 2.2.10.2).
3. Input to review of navigation models (Task 1.2.2.2).
4. Input to evaluation of the experimental design (Task 2.2.10.5).
5. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.2.10.2 Establish Experimental Design

Survey and sampling methodologies will begin in 1991 and will be completed in 1992. The resulting procedures will be reviewed by the interagency sponsors and will be updated in 1995, if needed. The EMTC staff has the primary responsibility for implementation, although development of the initial surveys and methodologies will be done by the Recreation Subcommittee of the River Resources Forum, the Recreation Technical Committee of the UMRCC, and other interested river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Trend model (Task 2.2.10.1).
3. Literature review of public use sampling methodologies and historical data from state agencies.
4. GIS (Objective 4.3).
5. Evaluation and refinement of the experimental design (Task 2.2.10.5).

Products:

1. Procedures manual with updates.
2. Input for obtaining monitoring data (Task 2.2.10.3).

Task 2.2.10.3 Conduct Monitoring

Monitoring data will be collected as prescribed in the procedures manual. Pilot public use surveys on Pools 2 through 5 and Pool 13 began in 1991. An analysis of these results will dictate sampling frequency, but for planning purposes a 5-year cycle has been proposed. Data will be collected by a state contractor, using existing LTRMP cooperative agreements. EMTC staff members are responsible for coordinating and implementing this task.

Input:

1. Procedures manual and experimental methodology (Task 2.2.10.2).

Products:

1. Data sets of public use on the UMRS.
2. Amendments to cooperative agreements.
3. Input to the evaluation of data (Task 2.2.10.4).
4. Input to the evaluation of the experimental design (2.2.10.5).

Task 2.2.10.4 Evaluate and Summarize Results

EMTC staff will coordinate the evaluation and interpretation of all sampling data and will compile this information in reports, publications, or presentations. Analytical procedures to model changes in relative density, type, and distribution of public use will be developed. Reports will be completed in 1992 and again in 1997.

Inputs:

1. Public use monitoring data sets (Task 2.2.10.3).
2. Literature on public use of large rivers.
3. GIS (Objective 4.3).
4. Computer equipment (Objective 4.2).

Products:

1. LTRMP reports, publications, or presentations on the distribution, type, and density of public use, and changes since the last sampling cycle.
2. Input to the development of management alternatives and HREPs (Goal 3).
3. Input to updates of the conceptual model and the public use model (Tasks 1.1.1.2 and 2.2.10.1).
4. Input to identify and investigate additional research problems (Objective 1.3).
5. Input to sedimentation, navigation, and water level research (Strategies 1.2.1 to 1.2.3).
6. Input to technology transfer (Objective 4.4).
7. Input to the synthesis and evaluation of all monitoring components (Objective 2.3).
8. Input to the evaluation and refinement of the experimental design (Task 2.2.10.5).

Task 2.2.10.5 Evaluate and Refine Experimental Design

The experimental design and the procedures manual will be revised in 1992 after analysis of the 1991 public use surveys (Task 2.2.10.3). EMTC staff members are primarily responsible for this task, but will rely on input provided by the Recreation Subcommittee of the River Resources Forum, the Recreation Technical Committee of the UMRCC, and river managers and researchers.

Inputs:

1. Public use surveys (Task 2.2.10.3).
2. Evaluations and summaries of data (Task 2.2.10.4).
3. Public use trend model (Task 2.2.10.1).

Products:

1. Report on effectiveness of the sampling design.
2. Review and incorporation of appropriate changes to the sampling procedures (Task 2.2.10.2).

Objective 2.3: Synthesize and Evaluate Monitoring Data

The relationships of all resource monitoring components for all trend analysis areas will be determined in the LTRMP. The selected resource components being monitored in the LTRMP are interdependent, as described in the conceptual model (Task 1.1.1.2). Therefore, changes documented in one component may relate to changes in other components. Directions and rates of change need to be evaluated, correlations identified, and any ecological trends defined. This information will then assist in refining the conceptual model, developing resource management alternatives (Goal 3), and identifying potential new resource problems (Objective 1.3).

Strategy 2.3.1: Multi-Component Syntheses

Evaluating all the major ecosystem components will provide us with a better understanding of the UMRS's condition. The compilation and evaluation of all the trend analysis data is the essence of the LTRMP.

Task 2.3.1.1 Develop Multi-Component Trend Model(s)

Trend models describe anticipated changes in UMRS resource component relationships and can be used as planning tools to identify supplementary data needs. Multi-component trend models will be developed every 3 years starting in 1992 or more frequently if warranted by new information. EMTC staff members have the primary responsibility for this task and will solicit input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Conceptual model (Task 1.1.1.2).
2. Trend models for all of the components (Strategies 2.2.1 to 2.2.10).
3. Literature on all trend analysis components of large river systems.
4. Evaluation and summary of synthesis results (Task 2.3.1.2).
5. Evaluation and summary of trend analysis components (Strategies 2.2.1 to 2.2.10).

Products:

1. Report describing the multi-component trend model(s).
2. Input to modify components or design (Task 2.3.2.2).
3. Input to evaluate the value of component data (Task 2.3.2.1).
4. Input to the development of management alternatives and HREPs (Goal 3).

Task 2.3.1.2 Evaluate and Summarize Results

An annual report will summarize and evaluate monitoring data from all UMRS trend analysis areas and all monitoring components, starting in 1992. Measured changes, relationships, and ecological trends within spatial and temporal contexts described in the conceptual model also will be identified. EMTC staff members are responsible for this evaluation and will request input from LTRMP field station staff and river managers and researchers.

Inputs:

1. Data summaries for water quality, vegetation, macroinvertebrate, fish, wildlife, and recreation (Tasks 2.2.3 to 2.2.4 and 2.2.7 to 2.2.10).
2. Data as available for floodplain elevation, sediment, discharge, aquatic, and floodplain habitat (Tasks 2.2.1, 2.2.2, 2.2.5, and 2.2.6).
3. Spatial and temporal data needs of the conceptual model (Task 1.1.1.2).
4. Data as available from research on sedimentation, navigation, water level, and other resource problems (Strategies 1.2.1 to 1.2.3 and Objective 1.3).
5. GIS (Objective 4.3).

Products:

1. Annual synthesis reports.
2. Input to the conceptual model (Task 1.1.1.2).
3. The development of management alternatives and HREPs (Goal 3).
4. GIS (Objective 4.3).
5. Input to the refinement of the monitoring design (Strategy 2.3.2).
6. Input to technology transfer (Objective 4.4).
7. Input to navigation, sedimentation, and river regulation research (Strategies 1.2.1 to 1.2.3).
8. Input to component data evaluation (Task 2.3.2.1).

Strategy 2.3.2: Evaluate and Refine Monitoring Design

The LTRMP is a dynamic program designed to reflect the habitat alternatives of the UMRS. As the UMRS and technologies change, the monitoring program should also change to reflect the present situation. Evaluations of the monitoring design will be conducted to refine the methods, frequencies, and location of sampling as well as component selection.

Task 2.3.2.1 Evaluate Value of Component Data

EMTC staff will evaluate the component data every 3 years starting in 1992 to determine their relative value to the Program. EMTC staff will have assistance from LTRMP field station personnel and river managers and researchers.

Inputs:

1. Data sets and evaluation of the trend analysis components (Strategies 2.2.1 to 2.2.10).
2. Multi-component evaluation and summary (Task 2.3.1.2).

Products:

1. Report on the evaluation of component data.
2. Input to modify components or design (Task 2.3.2.2).

Task 2.3.2.2 Modify Components or Design

Changes in the scope of component work or in the experimental design will be made every 3 years starting in 1992. The EMTC staff has primary responsibility for this task, with input from LTRMP field station staff, the Analysis Team, and river managers and researchers.

Inputs:

1. Evaluation of the value of component data.
2. Trend analysis experimental designs and analysis reports (Strategies 2.2.1 to 2.2.10).

Product:

1. Modification of the trend analysis experimental design or scope of component development (Strategies 2.2.1 to 2.2.10).

Goal 3: Develop Alternatives to Better Manage the Upper Mississippi River System

Goal 3 outlines the mission of the Long Term Resource Monitoring Program (LTRMP), to provide decision makers with information to maintain the Upper Mississippi River System (UMRS) as a viable large river ecosystem given its multiple-use character. Goal 3 develops management alternatives for implementation by natural resource management agencies.

Improved management will be necessary to maintain the integrity of the UMRS ecosystem. Development and implementation of resource management plans are responsibilities of the State and Federal agencies charged with managing the UMRS. The LTRMP will contribute to an improved understanding of the river ecosystem and will assist these natural resource management agencies in facilitating improved management.

Work in Goal 3 will include formulation and evaluation of resource management alternatives. The planning process will be a collaborative interdisciplinary synthesis of ideas and information, conducted in close coordination with the resource management agencies. Resource managers from other agencies and elements of the Service will contribute to all stages of the planning process, particularly in identifying alternative management objectives and in formulating management alternatives. An increasing amount of effort and funding will be allocated to Goal 3 as the Program matures. The relationship of Goal 3 to other Program components is graphically depicted in Figure 3-1.

Objective 3.1: Develop Alternative Management Objectives

Existing resource management plans for the UMRS have few specific objectives. These objectives for the UMRS must be developed in forms that are both ecologically sound and socially realistic. The LTRMP cannot independently develop management plans for the UMRS. However, these plans can be developed in consultation with the State and Federal agencies charged with managing the UMRS.

Formulating resource management plans with attention to specific objectives will require sufficient quantity, quality, and distribution of river resources. Scenarios of future conditions of UMRS resources that may develop without change in present management or that may be required to meet alternative management objectives will be simulated.

Strategy 3.1.1: Identify Expectations for Future Uses of the Upper Mississippi River System (Exclusive of Commercial Navigation)

UMRS management objectives must be designed to meet, to the degree possible, socially realistic expectations for the use of river resources. Needs and expectations for recreation and commercial fisheries have changed considerably over time. Information on present and future user expectations of the UMRS will be obtained from existing management plans, consultations with resource management agencies, and any available surveys of users of the UMRS and other large rivers in the United States. This task will be accomplished through the cooperation of EMTC staff and river managers beginning in 1992 and taking one year to complete.

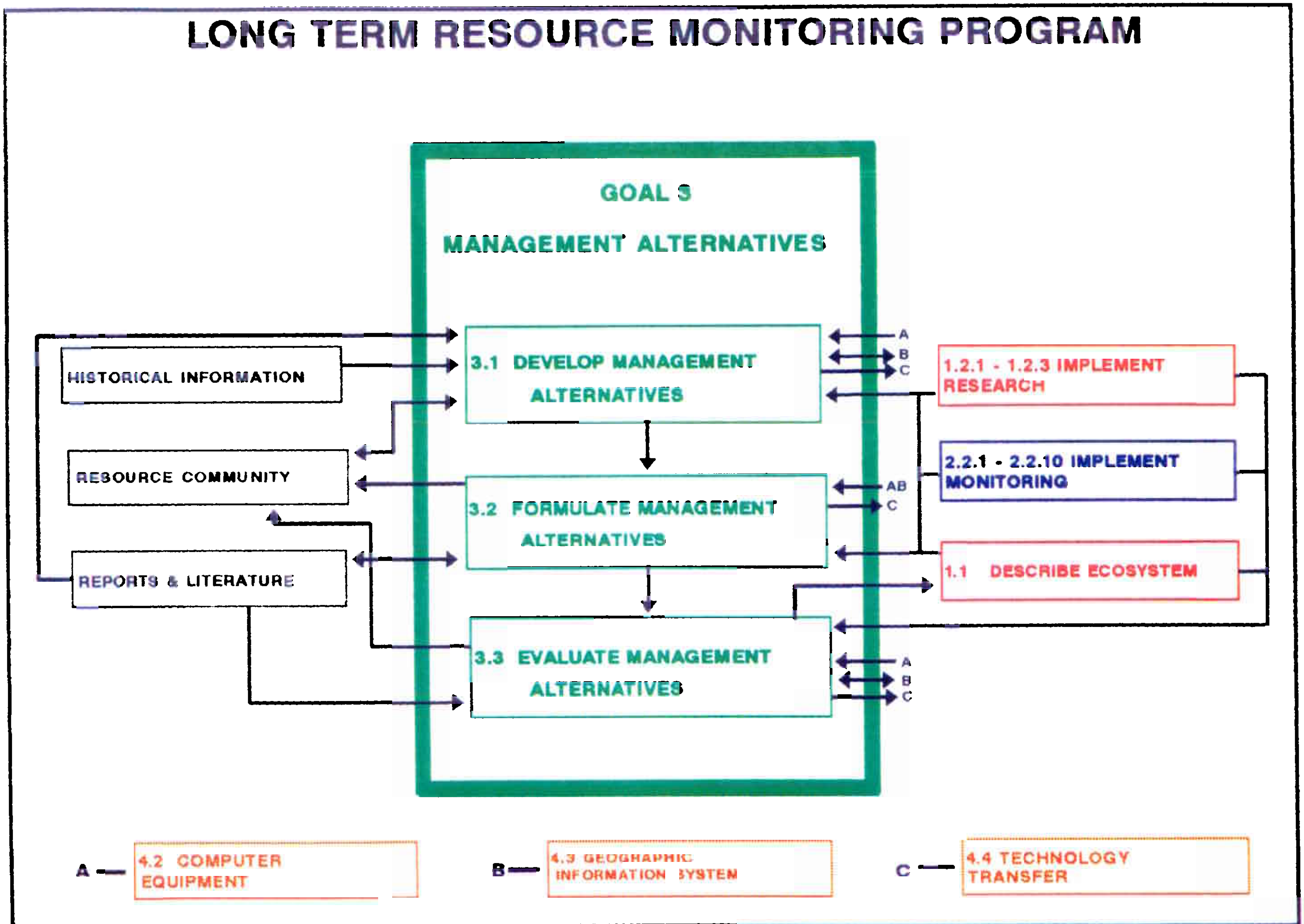


Figure 3-1. The Interrelationships Affecting Management Alternatives, Goal 3

Inputs:

1. Existing UMRS management plans.
2. Interviews with resource managers and agency administrators.
3. Existing literature on public use expectations on U.S. rivers.
4. Results of user surveys on the UMRS.
5. Evaluation of public use monitoring (Task 2.2.10.4).

Products:

1. Report identifying expectations for use of UMRS resources.
2. Input to identify management objectives (Strategy 3.1.4).
3. Formulate management alternatives (Objective 3.2).
4. Input to technology transfer (Objective 4.4).

Strategy 3.1.2: Predict Future Conditions Without Change in Management

A prediction of the future condition of the UMRS without changes in the present management regime will be made to serve as a "no action" condition for identifying and comparing alternative management objectives. This prediction will consider the present management regime and known and expected trends in the ecology of the UMRS. Future conditions will be projected along a timeline and at different spatial scales, relying heavily on GIS techniques for display and analysis. EMTC staff will predict the future condition of UMRS resources, with the assistance of subject matter experts from resource management agencies and the academic community. This task will be initiated in 1992 and will be an ongoing activity, with periodic refinements.

Inputs:

1. Existing UMRS management plans.
2. Problem analysis strategic models and research (Strategies 1.2.1 to 1.2.3).
3. Trend analysis models and research (Strategies 2.2.1 to 2.2.10).
4. Consultations with resource management agencies.
5. Literature on large river ecology, geomorphology, and ecological and resource management.
6. GIS (Strategy 4.3.1).
7. Computer equipment (Objective 4.2).
8. Conceptual model (Task 1.1.1.2).

Products:

1. Report on future UMRS conditions.
2. GIS simulations of future UMRS conditions (Strategy 4.3.1).
3. Input to identify realistic levels of future consumptive uses (Strategy 3.1.3).
4. Input to formulating management alternatives (Objective 3.2).
5. Input to technology transfer (Objective 4.4).

Strategy 3.1.3: Identify Ecologically Realistic Levels for Future Consumptive Use

In addition to being socially desirable, resource management objectives must be ecologically attainable. Objectives involving consumptive use of UMRS resources must be realistic with respect to the compensatory reserves of exploited populations. Conservative estimates of sustainable levels of consumptive use will be made using existing literature and UMRS monitoring information to help identify alternative management objectives. EMTC staff will conduct this task in 2 years, beginning in 1992, with the assistance of subject matter experts from resource management agencies, the academic community, and other appropriate scientific personnel through contracts or cooperative agreements.

Inputs:

1. Existing UMRS management plans.
2. Strategic and trend model development (Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
3. Results of monitoring and evaluation of river resources, especially public use, fish, and wildlife (Objectives 2.1 to 2.10).
4. GIS (Strategy 4.3.1).
5. Ecological and resource management literature.

Products:

1. Report on ecologically realistic future UMRS resource consumption levels.
2. Input to refined strategic and trend models (Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
3. Input to identify alternative management objectives (Strategy 3.1.4).

Strategy 3.1.4: Identify Alternative Management Objectives

A set of alternative resource management objectives will be identified, based on use expectations, projected future UMRS resource conditions, and estimates of realistic consumptive use levels. These alternative management objectives will be logically derived; specific with respect to animal population size, structure, spatial distribution, and temporal presence; and will reflect a range of reasonable options for satisfying use expectations. Alternative objectives for water quality and habitat type distribution also will be identified. EMTC staff will conduct this task with help from subject matter experts from resource management agencies and the academic community. The task will begin in 1995 and will take one year to complete.

Inputs:

1. Use expectations (Strategy 3.1.1).
2. Projection of future conditions without change in present management (Strategy 3.1.2).
3. Estimates of ecologically realistic levels of future consumptive uses (Strategy 3.1.3).

Products:

1. Report identifying alternative resource management objectives and supporting rationale.

2. Input to formulating management alternatives (Objective 3.2).

Strategy 3.1.5: Identify Future Conditions Needed to Meet Alternative Objectives

The future conditions of UMRS resources needed to meet alternative objectives will be predicted using a variety of techniques, with heavy reliance on LTRMP models, monitoring information, results of ecological research, and GIS. EMTC staff will perform this task, with the assistance of ecological literature, subject matter experts from resource management agencies, and the academic community. A report on this task will be produced in 1998.

Inputs:

1. Alternative resource management objectives (Strategy 3.1.4).
2. Conceptual, strategic, and trend model development (Task 1.1.1.2 and Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
3. Results of monitoring and evaluation of river resources (Strategies 2.2.1 to 2.2.10).
4. GIS (Strategy 4.3.1).
5. Literature on fisheries, wildlife management, limnology, and ecology.

Products:

1. Report on the future UMRS conditions needed to attain alternative objectives.
2. GIS simulations of future UMRS conditions (Strategy 4.3.1).
3. Input to formulating management alternatives (Objective 3.2).

Objective 3.2: Formulate Management Alternatives

Attaining management objectives requires different types and degrees of active resource management. River resource management alternatives (Strategy 3.1.4) that would attain alternative resource management objectives and the needed future ecological conditions (Strategy 3.1.5) will be formulated. Management alternatives will range from river regulation and structural alternatives acting over a large spatial scale to other combinations of more localized and organism-specific management measures, such as Habitat Rehabilitation and Enhancement Projects (HREPs). Management alternatives will include the full range of river resource management measures, including river regulation, physical habitat, water quality, fisheries, wildlife, public use, and navigation management.

Strategy 3.2.1: Prepare Management Alternatives

Management alternatives will be formulated to meet the previously developed objectives (Objective 3.1). A variety of alternatives will be formulated, including those based on single and multiple management measures and HREPs. EMTC staff will conduct this task in cooperation with Environmental Management Program sponsors and other appropriate scientific personnel through contracts or cooperative agreements. This task will be an ongoing activity, beginning in 1991 for HREP involvement and at a later date for other management alternatives. Alternative formulation will be revised as appropriate, pending results of testing and evaluations of prototype management measures (Task 3.3.2).

Inputs:

1. Alternative management objectives (Objective 3.1).
2. Conceptual, strategic, and trend model development (Task 1.1.1.2, Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
3. Findings of LTRMP problem and trend analysis research (Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
4. HREP planning and (definite) project reports.
5. Literature on river, lakes, and reservoir management.
6. Consultations with resource management agencies.
7. GIS (Objective 4.3).
8. Computer equipment (Objective 4.2).

Products:

1. Reports describing formulation of management alternatives, the theoretical basis for management and projected system responses, and spatial and temporal applications.
2. Input to the evaluation of management alternatives (Objective 3.3).
3. Input to the HREP planning process.
4. Input to technology transfer (Objective 4.4).

Objective 3.3 Evaluate Management Alternatives

River management alternatives will be evaluated by predicting the future condition of river resources under different alternatives. GIS displays will be used to illustrate spatial distribution and to quantify estimates of future resources under alternative management scenarios. Ecological, engineering, legal, and administrative constraints on implementing the management alternatives also will be identified. Management alternatives will be evaluated and compared according to the probability of attaining objectives, cost, and time required.

New or unproven management measures that are components of larger management alternatives will be evaluated by prototype tests. Prototype management measures will be tried in the field and/or laboratory, incorporated into HREPs when appropriate, and then will be carefully monitored and evaluated. Information on management alternatives and specific management measures will be synthesized and predictive techniques will be refined on an ongoing basis.

Strategy 3.3.1: Identify Constraints on Implementation

Each management alternative for the UMRS has constraints (hydrologic, engineering, economic, legal, ecological, and administrative) on implementation. This strategy will involve a series of tasks identifying implementation constraints for various management alternatives and, in some cases, for individual management measures. Implementation constraints for different management alternatives will be identified by the EMTC staff and/or resource management agencies or other appropriate scientific personnel through contracts or cooperative agreements. Work on this task began in 1990 and will continue through 2002. A study on the constraints of river regulation was completed in 1991 for Pools 9 and 18.

Inputs:

1. Hydrologic records and analysis (Strategy 2.2.2).
2. Existing resource management plans.
3. Information on real estate ownership in the UMRS floodplain.
4. COE reservoir regulation manuals for the UMRS.
5. Results of conceptual, strategic, and trend models (Task 1.1.1.2 and Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
6. Results of resource monitoring (Strategies 2.2.1 to 2.2.10).
7. Existing agency authorization documents.
8. Consultations with resource management agencies.
9. Computer equipment (Objective 4.2).

Products:

1. GIS maps of real estate ownership.
2. Report on implementation constraints for each management alternative, including identifying existing constraints that would have to be changed to allow implementation to proceed.
3. Input to identifying alternative management objectives (Strategy 3.1.5).

Strategy 3.3.2: Test and Assess the Effectiveness of Prototype Management

Management measures potentially suited for UMRS application will be evaluated by testing prototypes in the field, laboratory testing, and computer simulation. Field tests of prototypes will be incorporated into HREPs where possible. A series of tests and evaluations of different prototype management measures will be conducted by EMTC staff with field station assistance, by resource management agencies, and by subject matter experts under contract as appropriate.

Beginning in 1991, the LTRMP will become actively involved in monitoring selected HREPs with support provided by the Corps Districts for both routine performance evaluation and biological response studies. HREP monitoring work performed by EMTC and LTRMP field station staff will conform to LTRMP procedures where appropriate to ensure quality control. LTRMP research (Goal 1) and GIS applications will be incorporated into the biological response studies of HREPs. The LTRMP will assist the Corps' North Central Division in systemic evaluation of the ecological results of the HREP program. This task will be an ongoing activity beginning late in 1991.

Inputs:

1. Formulation of management alternatives (Objective 3.2).
2. GIS (Objective 4.3).
3. Computer equipment (Objective 4.2).

Products:

1. Reports on effectiveness of prototype river management measures.
2. Design criteria for HREP features.
3. Input to HREP evaluation reports.
4. Input to the conceptual model (Task 1.1.1.2).

Strategy 3.3.3: Evaluate and Compare Management Alternatives

Information on management alternatives and specific management measures will be synthesized. Management alternatives for the UMRS, including measures applied to HREPs, will then be systematically compared and evaluated based on probability estimates for attaining management objectives, cost, and time required for implementation and system response. EMTC staff will prepare reports displaying the management objectives, management alternatives, projected future conditions, and implementation constraints, with assistance from resource management agencies. This ongoing activity will begin in 1994.

Inputs:

1. Management alternatives and measures (Strategy 3.2.1).
2. Reports on implementation constraints (Strategy 3.3.1).
3. Results of prototype testing (Strategy 3.3.2).
4. GIS (Strategy 4.3.1).
5. Literature on ecological and resource management.
6. Conceptual, strategic, and trend models (Task 1.1.1.2, Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
7. Problem analysis and trend research (Strategies 1.2.1 to 1.2.3 and 2.2.1 to 2.2.10).
8. Projections of future conditions without management changes (Strategy 3.1.2).
9. Estimates of cost and time required for implementing management alternatives, based on experience with the HREP program, and consultations with UMRS resource management agencies and resource management agencies of other large river systems.
10. Data on HREP biological, chemical, and physical responses.
11. Computer equipment (Objective 4.3).

Products:

1. Synthesis reports on management alternatives, including HREPs.
2. Projections of the future conditions of river resources under different management alternatives.
3. Systematically planned management alternatives for use by State and Federal resource management agencies.
4. Basis for legislative initiatives for improved UMRS management.
5. Input to conceptual model (Task 1.1.1.2).
6. Input to technology transfer (Objective 4.4).

Goal 4: Provide for the Proper Management of Long Term Resource Monitoring Program Information

The Upper Mississippi River System (UMRS) is a major multi-purpose water resource, providing commercial transportation and water supplies for domestic and industrial use and for energy production. It also provides habitat for aquatic and terrestrial species and is an important regional recreation resource. Federal interest in this area is clear. The Upper Mississippi River is the only inland waterway in the United States designated under Federal law as both a National Wildlife Refuge and a commercial navigation project.

The use of computer technology to support UMRS management decisions has been examined several times during the past two decades. The most recent effort was initiated as the result of Federal legislation. Specifically, Section 1103 of the Upper Mississippi River Management Act of 1986 requires implementation of a computerized inventory and analysis system. Consequently, a high priority of the Environmental Management Program (EMP) is developing this system to support the proper management, distribution, analysis, and access of Long Term Resource Monitoring Program (LTRMP) data. EMP program managers are instituting methods and procedures which ensure that only needed data are collected, properly stored, and made readily accessible to all users. The ability to acquire, store, retrieve, manipulate, model, display, and disseminate data obtained through LTRMP activities is critical to the success of the LTRMP.

The need for a corporate spatial data base management system to help river resource decision makers manage the highly complex UMRS was originally identified by the Great River Environmental Action Team (GREAT) study effort. Those involved in the GREAT study recognized the problems inherent in managing the resources of the UMRS, as well as the need to store, retrieve, and analyze complex information. New technological tools were required which could aid in evaluating alternative management proposals. A pilot study was developed by GREAT I to test the feasibility of using a geographic information system (GIS) as a resource management tool. The pilot study was conducted on Pools 4 and 5 of the UMRS to determine whether this computerized data storage, analysis, and mapping tool was applicable to the management problems associated with the study area. This study was later expanded to include Pools 4-14 and was used by the U.S. Fish and Wildlife Service in their Master Plan studies. Recognizing the potential of GIS applications, the GREAT I Team recommended further study by the Upper Mississippi River Basin Commission (UMRBC) as part of its Master Plan. One of the UMRBC recommendations was that "Congress immediately authorize implementation of a computerized inventory and analysis system for data storage and retrieval, and for use in the Long-Term Resource Monitoring Program."

The Environmental Management Technical Center (EMTC) serves as the centralized processing and repository site for UMRS information so that data collected as part of the EMP and future related efforts can be made available to all participating entities. The EMTC engages in a variety of automation support efforts (Fig. 4-1). Accurate and up-to-date information is required for resource managers and decision makers to select appropriate courses of action. Automation technology continues to evolve at a rapid rate; LTRMP automation support activities must respond readily to information management needs and evolving technology. To do that, clearly defined automation guidance is required.

The objectives identified in this chapter are intended to direct the automation support activities; identify and evaluate the cost-effective automation tools necessary to make the Program an operational success; establish a workable process to manage the data collected; and, most importantly, provide LTRMP participants access to the collected data. The relationship of Goal 4 to other Program components is graphically depicted in Figure 4-2.

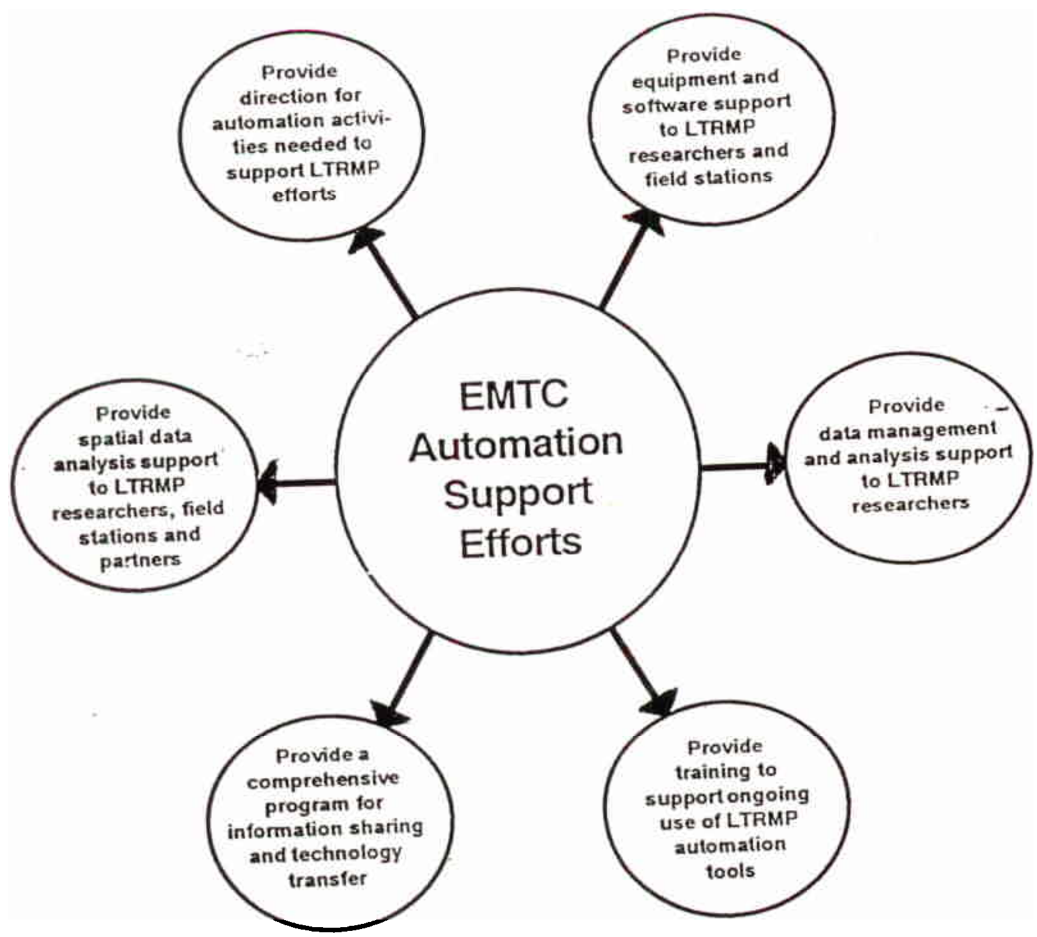


Figure 4-1. Environmental Management Technical Center's automation support effort

Objective 4.1: Provide Direction for Automation Activities

Information is a valuable resource that must be available in an appropriate format for decision makers. Concentrated efforts must be made to ensure that necessary automation support is provided to LTRMP researchers, decision makers, and resource managers.

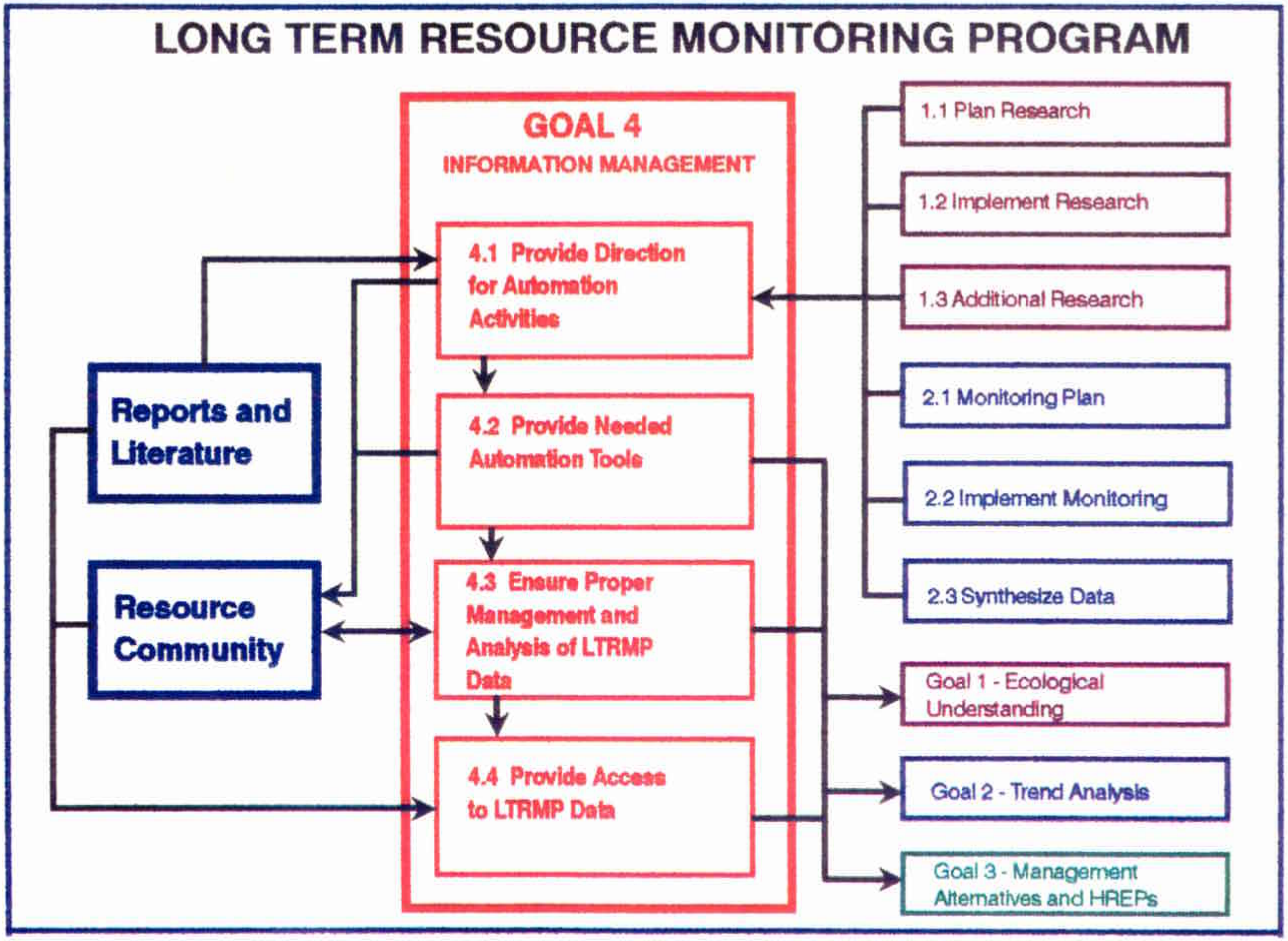


Figure 4-2. The Interrelationships Affecting Information Management, Goal 4

Initial LTRMP efforts concentrated on establishing the framework for this support, instituting needed administrative arrangements, and establishing a user network within the UMRS. Early technical tasks involved acquiring software and needed hardware, standardizing geographic nomenclature and data codes, and data formatting.

Strategy 4.1.1: Develop and Update Information Management Guidance Documents

A careful evaluation of LTRMP data processing needs is required to clearly determine the future direction of the LTRMP information management effort. Thus, the Integrated Data Management System (IDMS) Action Plan (USFWS 1987) and the Functional Description Report (Analytical Technologies, Inc. 1990) must be supplemented with a detailed Information Management Plan (IMP). Such a plan will become the basis for supportable management decisions concerning the most appropriate hardware, networking, and communications solutions available. The IMP will clearly define the data management system and is important to the success of the entire LTRMP. In addition, other guidance documents dealing with a wide range of topics (data collection, data processing, automation security, etc.) will be needed.

Task 4.1.1.1 Develop and Update Information Management Plan

EMTC staff will complete a detailed IMP outlining the hardware, software, networking, communications, and data distribution capabilities required to attain LTRMP objectives. A Functional Description Report was prepared in 1990 by Analytical Technologies, Inc.; elements of this report were incorporated in the IMP. The draft IMP was distributed for review in August 1991 and the final document was completed in January 1992. The IMP will be updated as necessary.

Inputs:

1. IDMS Action Plan (USFWS 1987).
2. UMRBC Master Plan (1982).
3. Functional Description Report (Analytical Technologies, Inc. 1990).
4. Types and amounts of data to be collected (Objective 2.1).
5. Data analysis and display requirements (Objectives 1.2 and 2.3).
6. Application needs of researchers and managers (Objectives 1.2 and 2.3).
7. Probable uses of LTRMP data by participants.

Products:

1. IMP (Task 4.1.1.1).
2. Input to the revision of the IMP (Task 4.1.1.2).
3. Input to the acquisition and replacement of equipment (Task 4.2.1.1).
4. Input to maintaining automation equipment (Task 4.2.1.3).
5. Input to GIS (Task 4.3.1.1).
6. Input to network and communication systems (Task 4.2.1.2).
7. Input to standards for data acquisition and storage (Task 4.3.1.2).

Task 4.1.1.2 Develop and Update Automation Guidance Documents

The information and data collection needs of LTRMP researchers, decision makers, and resource managers will change as researchers build upon previous efforts. Automation technology will also change, impacting data collection, storage, manipulation, display, and management capabilities. User demands for information sharing will become more sophisticated. The cumulative effect of these events will most likely result in the need to modify the spatial data base management system. To respond to this changing environment, the Information Systems Support Division (ISSD) staff at the EMTC will develop and update automation guidance documents as needed. A number of guidance documents were developed by ISSD staff during FY 1992 and 1993, including standard operating procedures (SOPs) and guidance documents for the Halon fire suppression system, photo interpretation, global positioning systems, data entry, processing satellite imagery, and computer center access control.

Inputs:

1. IMP (Task 4.1.1.1).
2. Modified types and amounts of data to be collected (Objectives 1.1, 1.3, and 2.2).
3. Modified data analysis and display requirements (Objectives 1.1, 1.3, and 2.2).
4. Modified application needs of researchers and managers (Objectives 1.1 and 1.3).
5. Modified uses of LTRMP data by participants.

Products:

1. Revised IMP (Task 4.1.1.1).
2. Input to the acquisition and replacement of hardware and software (Task 4.2.1.1).
3. Input to network and communication systems (Task 4.2.1.2).
4. Input to maintaining automation equipment (Task 4.2.1.3).
5. Input to GIS (Task 4.3.1.1).
6. Input to standards for data acquisition and storage (Task 4.3.1.2).

Objective 4.2: Provide Needed Automation Tools

The ISSD of the EMTC serves as the overall and day-to-day information manager for LTRMP efforts. ISSD staff members support the needs of researchers and resource managers by developing automation tools (hardware, software, communication) for use by Program researchers and staff.

Strategy 4.2.1: Acquire, Install, Operate, and Maintain Hardware and Software

Computer hardware and software have been and will continue to be acquired, installed, and maintained for LTRMP participants. The system allows GIS data base management, statistical analysis, and modeling capabilities. End users include EMTC staff, LTRMP field station staff, other EMP participants, and the UMRS resource agencies. Field stations are provided with computer capabilities that require minimal training and maintenance and that easily interact with data base management systems at the EMTC.

Task 4.2.1.1 Modify or Replace Substandard Hardware and Software and Acquire Additional Needed Capabilities

In response to Program activities, automation equipment will need to be replaced as it wears out, becomes technologically obsolete, and/or as Program requirements change. ISSD staff will accomplish this task on an ongoing basis. Initial automation equipment acquisitions began in 1987 and will continue throughout the life of the Program. Strategies were developed to support migration from Primos to a Unix computing environment and from DOS to Windows applications. Initiation of these migrations includes acquisition of several UNIX file servers (1991-1992) and an upgrade of SAS software to a Windows environment in FY 1993.

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Application needs of LTRMP staff.
3. Identified communications needs of LTRMP participants.
4. Size and scope of LTRMP GIS data base (Strategy 4.3.1).

Products:

1. A computer center and data storage facility.
2. Hardware and software available to researchers.
3. Facilities for developing GIS data (Strategy 4.3.1).

Task 4.2.1.2 Develop and Update Network and Communications Systems

To ensure maximum computing flexibility, most automation equipment will be linked through a Local Area Network (LAN). The LAN will allow peripheral sharing and information transfer, the use of multi-user software packages, and the direct transfer of information with field stations; it also will be accessible via easily learned interfaces. The LAN was installed in FY 1992. In FY 1993, a dedicated communications link which supports data transfer, remote access to EMTC computer hosts, and electronic mail was established with the Corps of Engineers.

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Identified communications needs of LTRMP participants.

Product:

1. Communication links among EMP partners.

Task 4.2.1.3 Maintain Hardware and Software

Automation resources will be managed to ensure timely and cost-efficient operations with minimal down time. ISSD staff began work on this task in 1987; this effort will continue throughout the life of the Program with the assistance of private sector vendors. Dependability and applicability of automation equipment are key ingredients in the successful support of LTRMP researchers, resource managers, and decision makers. ISSD supports over 200 pieces of hardware and software at the EMTC and field stations with ongoing acquisitions and appropriate maintenance contracts.

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Existing equipment and software.

Product:

1. Properly maintained equipment.

Objective 4.3: Ensure Proper Management and Analysis of LTRMP Data

The large amounts of data being collected and acquired by LTRMP participants must be available for decision makers, researchers, and resource managers to complete their assigned missions. If LTRMP automation support activities are to be successful over time, applications must be developed that support the day-to-day efforts of river managers.

Researchers should not be required to know specific computer development languages or data processing procedures to use the trend spatial data base management system. Systems will be developed using menu-driven options; graphical displays of river sections for query purposes; data entry screens with field edits; lookup help tables for all fields with standard inputs, allowing only specific entries in the fields; automated interfaces with communication packages; point-and-click technology using a mouse; and automated backup and restore procedures.

The work to be accomplished under this objective directly contributes to the successful completion of Goals 1, 2, and 3.

Strategy 4.3.1: Develop Data Management and Analysis Capabilities

Researchers and field stations will receive data management and analysis support related to data base development, data conversion, spatial analysis, and modeling capabilities, and support of remote sensing requirements. Program partners can manipulate collected data with various statistical and graphical software packages to better understand ecological processes, human-induced impacts, and potential management options.

GIS technology provides the power to handle large spatial data sets for extensive areas such as the UMRS. Once stored, mapped data are retrievable at both the centralized data center and remote field stations.

Task 4.3.1.1 Support Data Base Development and Management Activities Including Standards for Data Processing and Storage

Collected data must be managed as a critical resource essential to the success of the LTRMP and associated activities. During FY 1991, 1992, and 1993, EMTC and field station staff members accomplished a significant number of activities related to this task, including extensive QA/QC reviews of the component trend data, making data available to researchers for ongoing study efforts; and development of stand-alone applications to more effectively review, edit, extract, display, and verify LTRMP resource component trend data at the field stations. The effort begun in FY 1993 to collect water elevation data from the Corps of Engineers will continue.

In conjunction with Ecology staff, ISSD maintains data processing standards and data entry procedures, and continually strengthens the QA/QC process. In FY 1993, bar coding of data sheets was implemented as a data sheet and chemical sample tracking mechanism.

The ISSD capability allows management of numerous data sets of varying sizes and types and data access from several locations by users with various computer skills. It also allows a variety of applications and data uses and facilitates spatial data analysis, modeling, and statistical analysis. This system is compatible with data bases at LTRMP field stations, eliminating redundancies in data storage.

Users can display automated information in both tabular and graphic form; merge and relate data bases; and analyze relationships using multiple regression, multiple correlation, principal components analyses, and other statistical techniques.

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Computer hardware/software system (Task 4.2.1.1).
3. Data from trends and problem analyses (Goals 1 and 2).
4. Data from information on management alternatives (Goal 3).

Products:

1. GIS for EMP study area.
2. On-line data for all resource trend analysis components, problem analyses, and management alternatives (Goals 1, 2, and 3).
3. Input to modifying or acquiring new equipment (Task 4.2.1.1).
4. QA/QC data management error reports.

Task 4.3.1.2 Develop, Maintain, and Enhance Geographic Information Systems and Remote Sensing Analysis Capabilities

Data must be processed quickly and efficiently and be available for ready access, analysis, and manipulation. GIS data can be easily understood and related to other data and can be used to manage UMRS resources. ISSD staff, in cooperation with EMTC researchers and LTRMP field station staff, began this task in 1987 and will continue this effort throughout the life of the Program. Baseline land cover/land use GIS data for the key pools have been collected and installed in the data base, as well as Landsat Thematic Mapper data for the entire UMRS floodplain. Enhancements to the GIS and remote sensing capabilities include acquisition of a zoom transfer scope vertical measurement module which automates aerial photo data, and an ERDAS imaging graphical user interface. Accomplishments include development of a metadata catalog of GIS data (1993), development of standard operating procedures for photo interpretation and digitizing (1992), development of a data entry interface to standardize geographic data entry (1992), and development of a map composition graphical user interface (1992).

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Computer hardware/software system (Task 4.2.1.1)
3. Types and amounts of data to be collected (Strategy 4.1.1).
4. Data analysis and display requirements (Strategy 4.1.1).
5. Application needs and probable uses of LTRMP data by researchers and managers (Strategy 4.1.1).

Products:

1. Data entry, editing, manipulation, and output capabilities.
2. Automated quality assurance methods.
3. Data management standards and methods for all GIS data.
4. Data base management procedures for field sites.

Task 4.3.1.3 Support Analysis Efforts using Automated Tools

The issues facing UMRS researchers and managers are complex, necessitating careful application of automated data and use of sophisticated analysis tools. Types of data to be manipulated or analyzed include geographically based data, textual data, and tabular data. The spatial analysis formats of a GIS include point, line, cell, polygon, tabular, and textual data. Analysis capabilities include developing composite map overlays of information contained in grid cells and/or polygons. Data comparisons using Boolean logic, cellular weighing, or other methods are also possible. The system is able to reformat information from grid cell to polygon or polygon to grid cell. The GIS is also capable of using data sets created at different degrees of resolution and scales, and of interfacing with existing and proposed computer-based models and standard statistical packages (e.g., SAS).

ISSD staff, in cooperation with LTRMP ecological researchers and partners, have begun to develop automated tools to facilitate the analysis of complex resource issues. As data collection and management issues have been resolved, this effort will be further emphasized.

Currently available data analysis tools include customized graphical user interfaces which allow the user to concentrate on the data and the analysis rather than on the computer tools, and sophisticated raster analysis tools. Projects in progress include modeling of HREP management alternatives and analysis of submergent vegetation distribution in relation to bathymetry.

Inputs:

1. IMP (Tasks 4.1.1.1 and 4.1.1.2).
2. Computer hardware/software system (Task 4.2.1.1).
3. Data from trends and problem analyses (Goals 1 and 2).
4. Data from information on management alternatives (Goal 3).

Products:

1. Reports of studies published by the EMTC, as well as peer-reviewed articles and presentations at professional meetings.
2. Graphical user interfaces of spatial data for river researchers and managers.

Objective 4.4: Provide Access to LTRMP Data

The overall mission of the LTRMP is to provide decision makers with information to help determine alternative management strategies for the UMRS ecosystem.

Resource managers need to consider ecological, economic, and social interactions when making resource decisions. The complexity of these interactions requires better data collection, coordination, and analysis than has occurred in the past. For managers charged with the wise expenditure of public funds, information also must be accessed as cost effectively as possible. Typically, LTRMP participants will be able to use EMP data and GIS capabilities to:

1. Monitor habitat distribution and geographic extent.
2. Monitor and map vegetation type distribution and habitats.
3. Identify known and suspected problem areas.
4. Identify scarce habitat types and habitat deficiencies.
5. Map floodplain, wetland, and aquatic vegetation and enter data into GIS.
6. Develop floodplain, wetland, and aquatic plant bed habitat types based on site factors.
7. Map aquatic and riverine habitat using bathymetric capabilities and resource trend analysis data.

Strategy 4.4.1: Develop an Information Sharing Process

An information sharing process will be developed to provide river managers and researchers with access to information generated by the LTRMP to help maintain and improve river resources. A computerized system will provide resource managers with site-specific and System-wide data using standardized and state-of-the-art methodologies. The information sharing process will facilitate preparation and dissemination of reports, papers, bulletins, electronic media, maps, charts, etc. In addition, EMTC staff will participate in and host meetings, symposia, and workshops.

This system will be sensitive to the need for efficient, easy user access and direct field application use. A viable GIS for the EMP should go beyond project-specific applications and be as useful to field-level staff as to middle and upper managers.

Task 4.4.1.1 Develop, Edit, Publish, and Distribute Long Term Resource Monitoring Program Information

Reports facilitate regular communication among the LTRMP Analysis Team and field stations, the EMP Coordinating Committee, the UMRCC, the UMRBA, and other UMRS agencies. EMTC staff began distributing reports in 1988; 92 reports have been published to date.

A videotape depicting LTRMP activities was produced in 1992 and brochures and other Program documents have been developed and distributed. *River Almanac*, the official LTRMP newsletter, is a bimonthly information sharing bulletin published by the EMTC.

Inputs:

1. Data from LTRMP through the GIS (Task 4.3.1.1).
2. Research findings.

3. Field station reports.

Products:

1. Reports
2. Bimonthly newsletter
3. Videotape
4. Brochures

Task 4.4.1.2 Publish Articles in Peer-Reviewed Journals, Make Presentations, and Host Meetings

Publishing in peer-reviewed journals, making presentations, and assisting with hosting symposia and workshops is a high priority for EMTC and LTRMP field station staff. The first LTRMP-sponsored workshop was held in 1990. These activities will continue throughout the life of the Program.

Inputs:

1. Data from LTRMP through the GIS (Task 4.3.1.1).
2. Research findings.
3. Field station reports.

Products:

1. Peer-reviewed papers.
2. Symposia proceedings.
3. Reports distributed to EMP river researchers and managers.

Strategy 4.4.2: Develop a Technology Transfer Process

A process to efficiently transfer LTRMP technology will be developed. LTRMP participants and others will have access to tools and data to better understand and manage the resource. Training opportunities will be provided to make better use of the tools available for analysis of spatial and trend data.

Task 4.4.2.1 Conduct Hands-On Training in the Use of LTRMP Spatial Data

EMTC and field station staff will be offered training opportunities in the use of the automation tools that support LTRMP efforts. This training will help staff use the GIS and other analytical tools to apply LTRMP information. Training activities began in 1988 and will continue throughout the life of the Program. Training will be provided by EMTC staff, private vendors, and staff from other agencies. Training and user manuals have been developed for GIS software; GIS training classes developed by ISSD staff have been attended by over 100 LTRMP partners.

Input:

1. Training needs.

Products:

1 Training courses.
2. User manuals for automation tools.

Task 4.4.2.2 Develop Capabilities to Query and Retrieve Long Term Resource Monitoring Program Data

An automated archival system will be used to store LTRMP data and make them accessible to LTRMP staff and river resource managers. Automated interfaces will allow user access to the GIS and trend data at the EMTC computer center or over telephone lines. An EPPL7/GIS interface provides resource managers with applications that run on personal computers (FY 1991). A graphical user interface prototype and a spatial data library system were developed in FY 1993 to simplify review of LTRMP spatial and tabular data by Program participants. In a continuing effort to efficiently distribute large and small data sets from an archive, an anonymous File Transfer Protocol (FTP) server was established in FY 1993. This FTP server is a directory on the UNIX file server which is available to users retrieving large files. A standard communication protocol is utilized to download these files to the user's home system.

Program partners will be able to merge and relate data bases and analyze relationships using multiple regression, multiple correlation, principal components analyses, and other statistical techniques and to display information in both tabular and graphic form.

Inputs:

1. Data from LTRMP through the GIS (Task 4.3.1.1).
2. Research findings from trend analysis and problem analysis (Strategies 2.2.1 to 2.2.10 and 1.2.1 to 1.2.3).
3. Field station reports.

Products:

1. Interface tools to simplify GIS access.
2. On-line system designed to provide easy access to EMP data.
3. Data set inventory.
4. Input for problem analysis, trend analysis, and the development of management alternatives (Goals 1, 2, and 3).

Appendix A
A Conceptual Model of the Upper Mississippi River Ecosystem

The following model was developed by Dr. Kenneth Lubinski, U.S. Fish and Wildlife Service, Environmental Management Technical Center.

Introduction

The floodplain rivers of the Upper Mississippi River System (UMRS) are subject to many natural and human-induced disturbances (Fig. A-1). Combinations of disturbances frequently overlap in time and spatial scale. Multiple disturbances can result in complex ecological responses that resist explanation and limit the ability of resource managers to evaluate and solve resource problems.

A conceptual model is a description of what is presently known or believed about a system. The use of a conceptual model can improve resource managers' understanding of disturbances and ecological responses. This appendix describes the UMRS ecosystem using a conceptual model and discusses how this model can be used in developing Long Term Resource Monitoring Program (LTRMP) strategies. The model lists and describes major factors and disturbances occurring at five spatial scales: basin, stream network, floodplain reach, navigation pool, and habitat. During LTRMP implementation, the conceptual model is expected to provide an ecological foundation for setting Program priorities, directing investigations, and guiding experimental designs.

Definitions

<u>Major factors</u>, both biological (biotic) and non-biological (abiotic), act to maintain the ecosystem within certain limits over <u>reference time periods</u> (Fig. A-2). For instance, light availability during growth and reproductive periods is thought to be a major factor controlling the distribution and abundance of submerged aquatic plants in the UMRS. Abiotic factors tend to exert more control over ecosystem processes in streams and rivers than do biotic processes (Ryder and Pesendorfer 1989).

A <u>disturbance</u> is an event that disrupts biology at the ecosystem, community, or population level (Pickett and White 1985; Resh et al. 1988; Sparks et al. 1990; Fig. A-2). A disturbance can be natural or human-induced and may be temporary (e.g., a catastrophic flood) or permanent (e.g., the impoundment of a river reach). Frequently, a disturbance benefits one species or group of species while adversely impacting another.

A disturbance refers to an ecological response to an atypical occurrence, as opposed to a <u>resource problem</u>, which exists when an element of the ecosystem reaches a level of public concern. Increased sedimentation in the UMRS is a well known resource problem that is expected to cause the loss of many river backwaters over the next 50 to 200 years (Bellrose et al. 1979; McHenry et al. 1984). <u>Resource components</u> are ecosystem elements that are monitored as indices of ecosystem health or integrity.

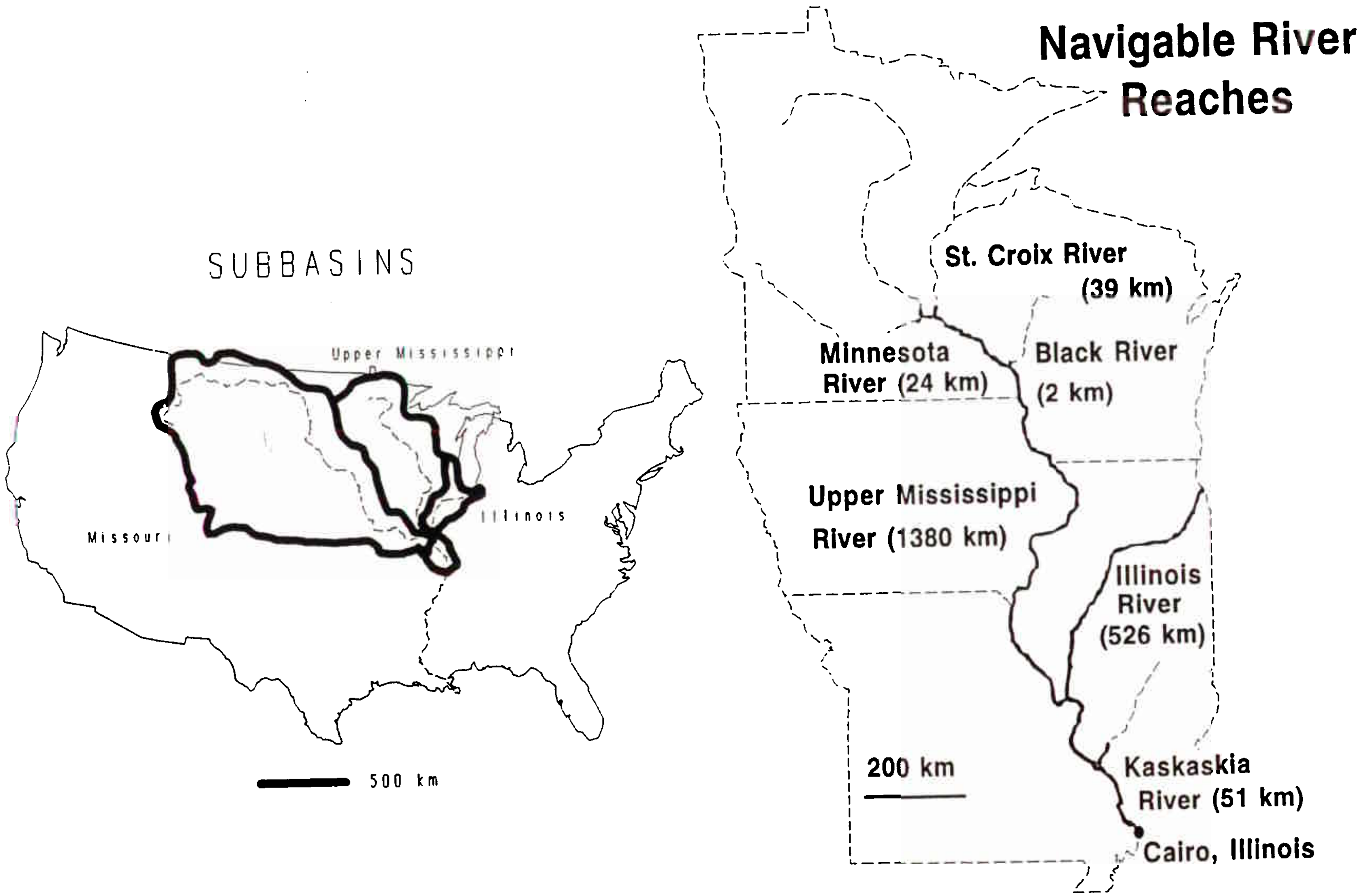


Figure A-1. The Navigable River Reaches of the Upper Mississippi River System and Subbasins Above Cairo, Illinois

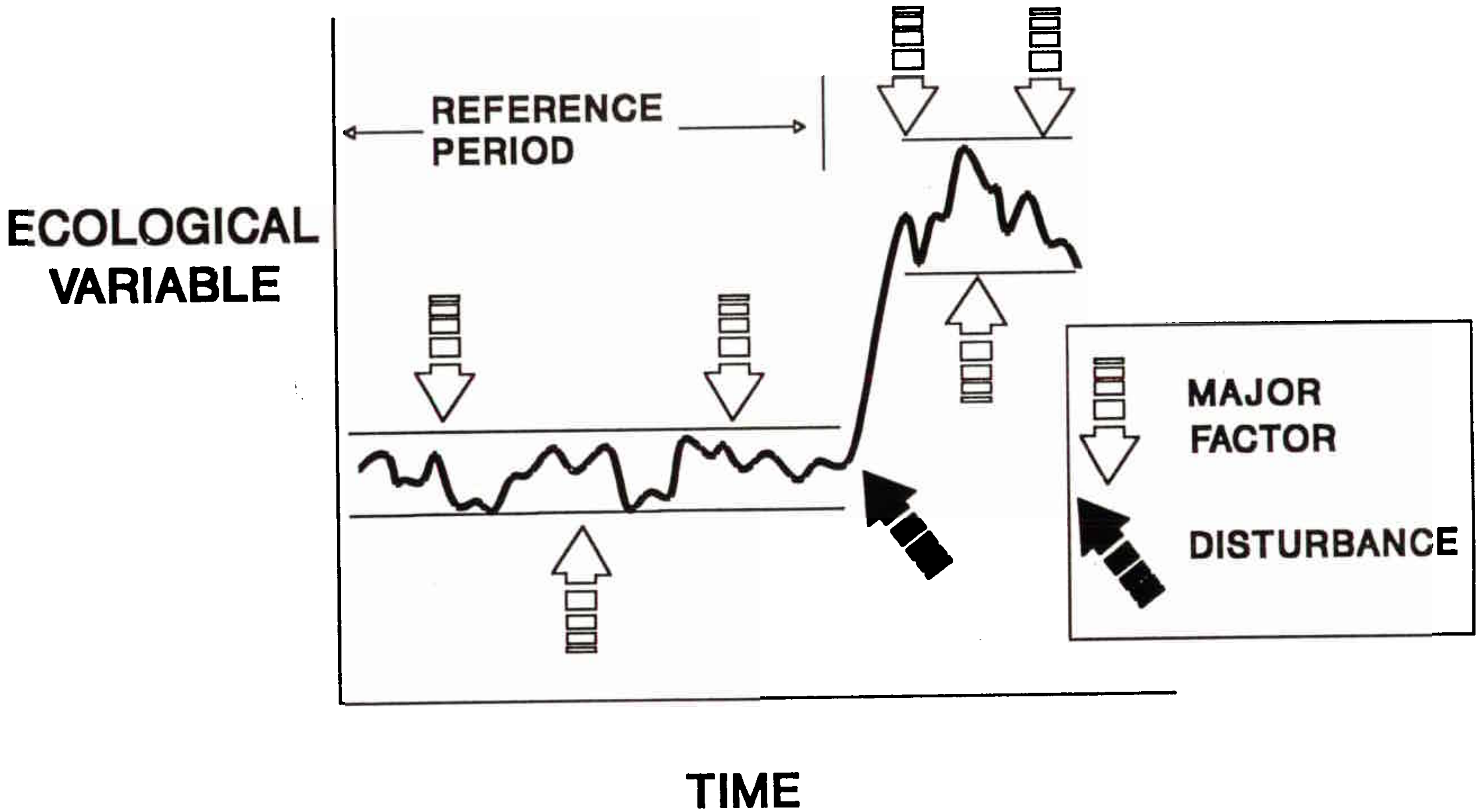


Figure A-2. Major factors keep ecological variables within specific limits. A disturbance causes the variable to exceed these limits.

Temporal and Spatial Scales

Studies of aquatic ecosystem responses to disturbances are increasingly using hierarchical systems of temporal and spatial scales (Petts 1989; Ward 1989a). Generally, disturbances at small spatial scales occur within relatively short temporal scales, and disturbances at large spatial scales occur at longer temporal scales (Ward 1989a). Our approach to understanding relevant past and future disturbances to the rivers in the UMRS includes evaluations at two temporal scales (reference periods) and five spatial scales.

Two reference time periods are useful for defining long term disturbances in the floodplain rivers of the UMRS. Presettlement ecosystem conditions were those that existed in the 500- to 1,000-year period prior to 1800 when Europeans began colonizing sites along the rivers (Fig. A-3). Theoretically, the UMRS ecosystem, having adapted to postglacial climate conditions, existed in a relatively stable equilibrium during the presettlement period. Post-dam ecosystem conditions were those during the 5- to 10-year period following construction of each of the navigation dams (in the 1930s for most of the dams; 1913 for the dam at Keokuk, Iowa). Studies of ecological changes associated with sedimentation during the last 50 years, for example, frequently compare present conditions to post-dam conditions.

Spatial Scales

The five spatial scales used to describe ecosystem structure and function in the UMRS are basin, stream network, floodplain reach, navigation pool, and habitat. Major factors and disturbances that operate at any one scale can also, through more specific mechanisms, control ecological structure or function at smaller scales. In addition, a small-scale disturbance, if repeated often enough or at many locations, can have cumulative impacts at larger scales.

Basin Scale

The basin is the accepted fundamental land unit for studies of river ecology (Petts 1989). The Mississippi River Basin above Cairo, Illinois, covers 1.86 million km^2. Major subbasins include those of the Upper Mississippi, Illinois, and Missouri Rivers (Figs. A-1, A-4).

Geology, climate, and vegetative cover are the major factors regulating ecosystem processes in the river basins (Bhowmik et al. 1984; Resh et al. 1988). Earthquakes act as geologic disturbances at this scale, particularly in the New Madrid area (Simons et al. 1981).

Glacial events prior to 12,000 BP (before present) were natural climatic disturbances that had dramatic impacts on the ecology of the Upper Mississippi River Basin (UMRB; Fremling and Claflin 1984; Nielsen et al. 1984). Their major effects were leveling the topography of the area and providing postglacial surficial materials (Nielsen et al. 1984). Loess blown by postglacial winds now forms a mantle over half of the Upper Mississippi and Illinois Subbasins and serves as a major source of silt in the UMRS ecosystem (Nielsen et al. 1984).

The UMRB has a temperate, humid climate (U.S. Army Engineer District, St. Louis et al. 1970; Slizeski et al. 1982). The latitudinal range of the Basin (37° to 48° north) covers approximately 1,300 km (800 mi). Air and water temperatures at any time of the year can vary greatly across the Basin's north-south axis, and seasonal events at the northern edge of the Basin can lag behind (in the spring) or

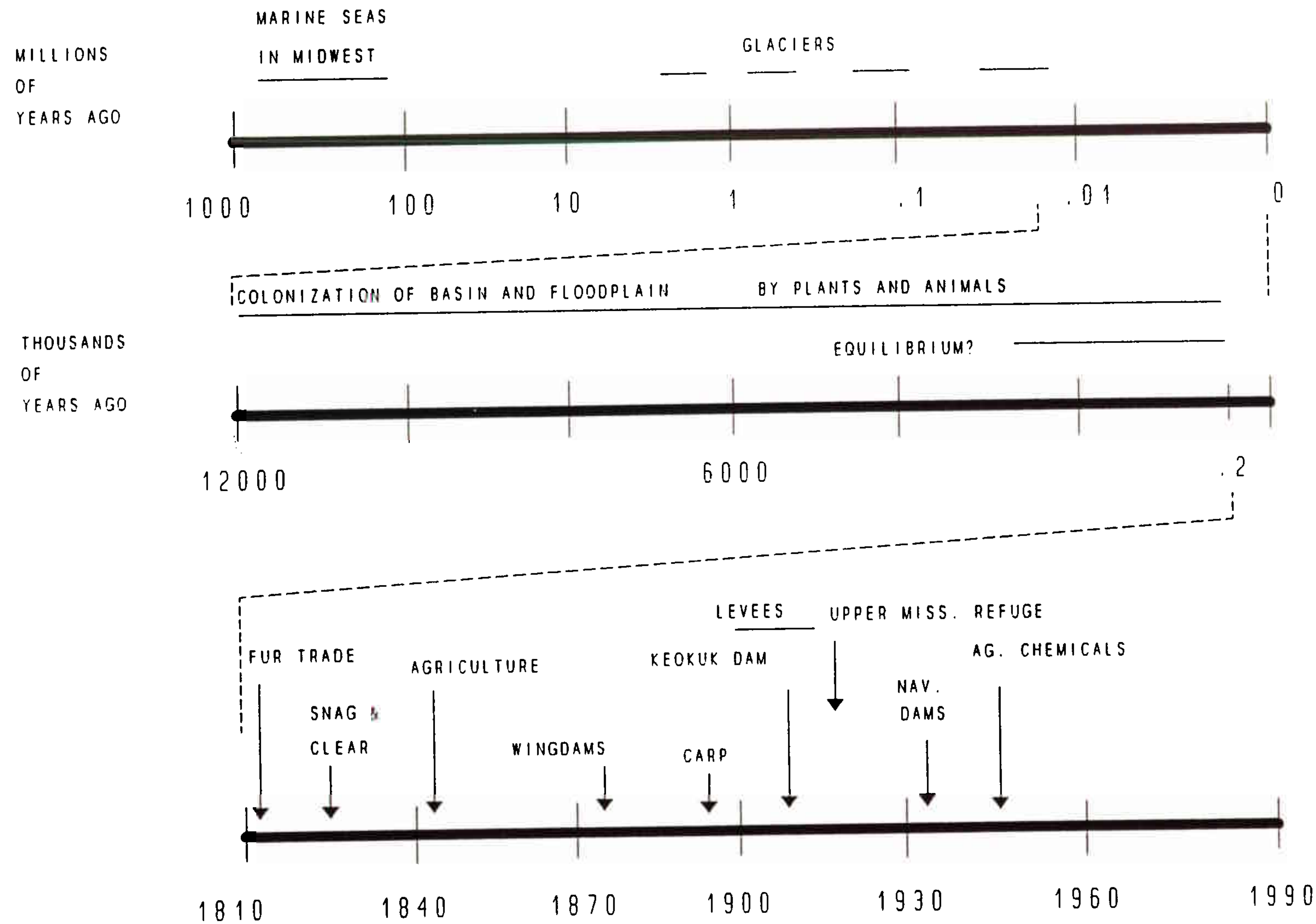


Figure A-3. Upper Mississippi River System Ecological Time Scales

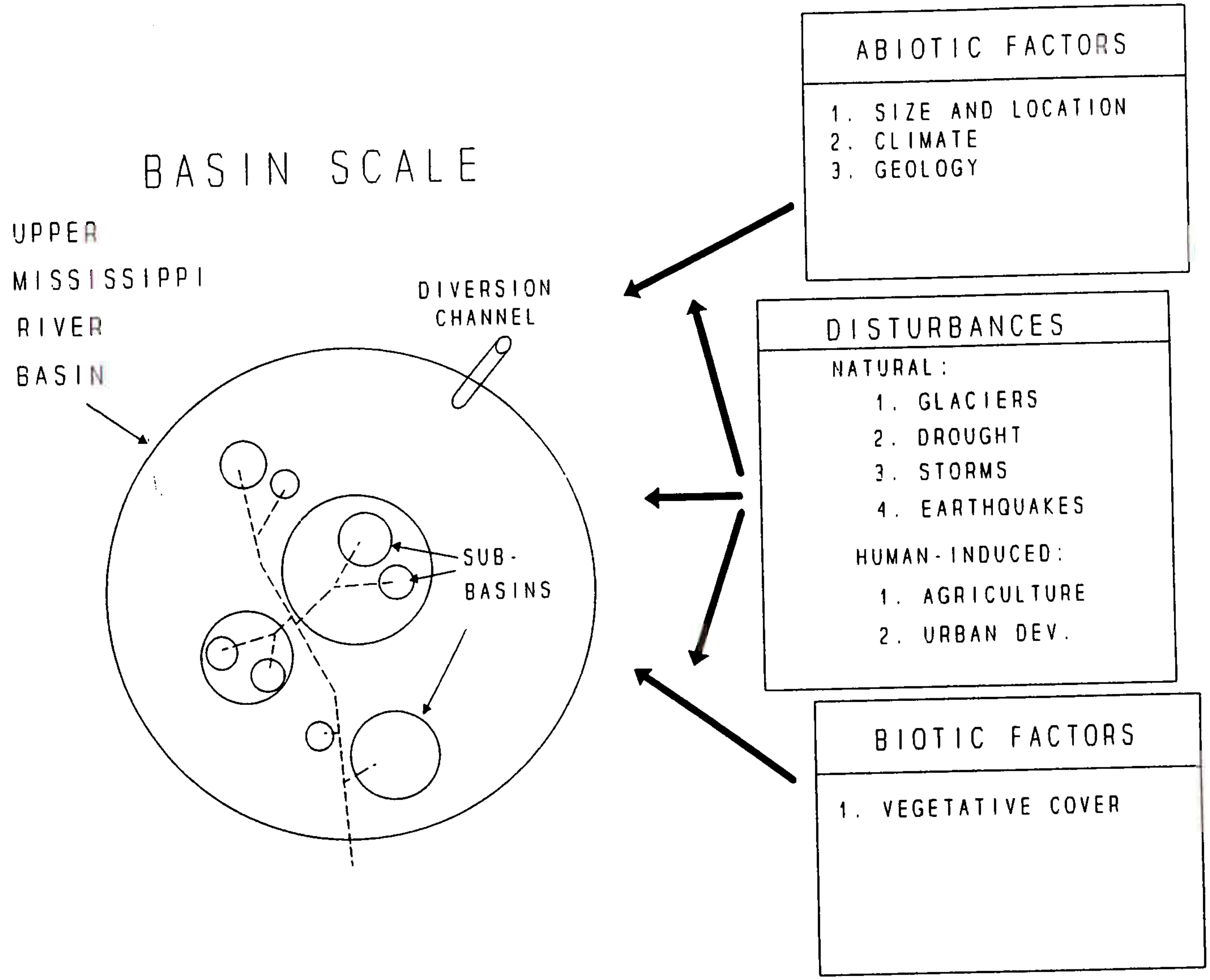


Figure A-4. The Basin Spatial Scale

precede (in the fall) those at the southern edge by 2 to 4 weeks. Annual freeze-free periods range from 90 d in the north (excepting the mountainous area of the Missouri Subbasin) to 180 d in the south.

Several associations between global and regional climate patterns and aquatic ecosystem structures are being explored (Blumberg and DiToro 1990; Magnuson et al. 1990; Regier and Meisner 1990). Efforts to explain how river flows are controlled by large-scale climate patterns are increasing (Knox et al. 1975; Molles and Dahm 1990) and will help forecast ecological changes in the UMRS associated with acid rain or global warming.

Storms and droughts act as natural climatic disturbances at the basin scale. The average annual number of thunderstorm days range from 30 d in the north to 60 d in the south (U.S. Army Engineer District, St. Louis et al. 1970).

The basin's vegetative cover, controlled by the climatic and geological factors noted above, plays a major role in controlling ecosystem structure and function. In the absence of human disturbance, the vegetation would be dominated by deciduous forest and prairie (Colman 1953; Coe et al. 1986). The soils within the watershed are among the most fertile in the world, and large-scale conversions of prairies and forests to agricultural and urban land (achieved by plowing, clearing, draining, and tiling) have occurred. In 1970, 61% of the combined Upper Mississippi and Illinois Subbasins was in cropland (USDA 1970). These conversions have had major impacts on water quality and sediment transport at the next spatial scale.

Stream Network Scale

A stream network includes the water-carrying channels that lie above a defined location in a basin. The river reaches of the UMRS are among the largest rivers in the stream network above Cairo, Illinois. These reaches are morphologically and functionally similar to many of their larger tributaries, but are distinguishable because they support commercial navigation (Figs. A-1, A-5).

At the stream network scale, longitudinal gradients are emphasized (Vannote et al. 1980; Minshall et al. 1985; Ward 1989a). Stream morphology gradually changes downstream in response to a combination of geologic and hydrologic variables (Leopold et al. 1964). Water quality gradients occur as water and materials processed during transport are mixed with flows from tributaries, stream banks, or beds.

Runoff, and, to a lesser extent, groundwater flow, point source discharges, and interbasin diversions of water, links the UMRS stream network to the basin. Major periods of water and material transport to the stream network are associated with snowmelt and spring and fall rains.

The vertical gradients of the major Upper Mississippi and Illinois Rivers' tributaries are greater than those of the main stems (Nielsen et al. 1984; Fig. A-6). As a result, UMRS floodplains were aggrading with alluvium even during the presettlement period. However, land use changes, stream channelizations designed to transport water rapidly off the basin, and dam constructions have greatly accelerated the aggradation rate. The Illinois River has been impacted more by sedimentation than the Mississippi River because of its shallower gradient.

Potential erosion and sediment loadings from tributaries tend to increase downstream on the Upper Mississippi and Illinois Rivers, resulting in increased suspended sediment concentrations. Suspended sediment concentrations in the open Mississippi River (below the mouth of the Missouri River) are relatively high in comparison to upstream reaches. This pattern exists even though the

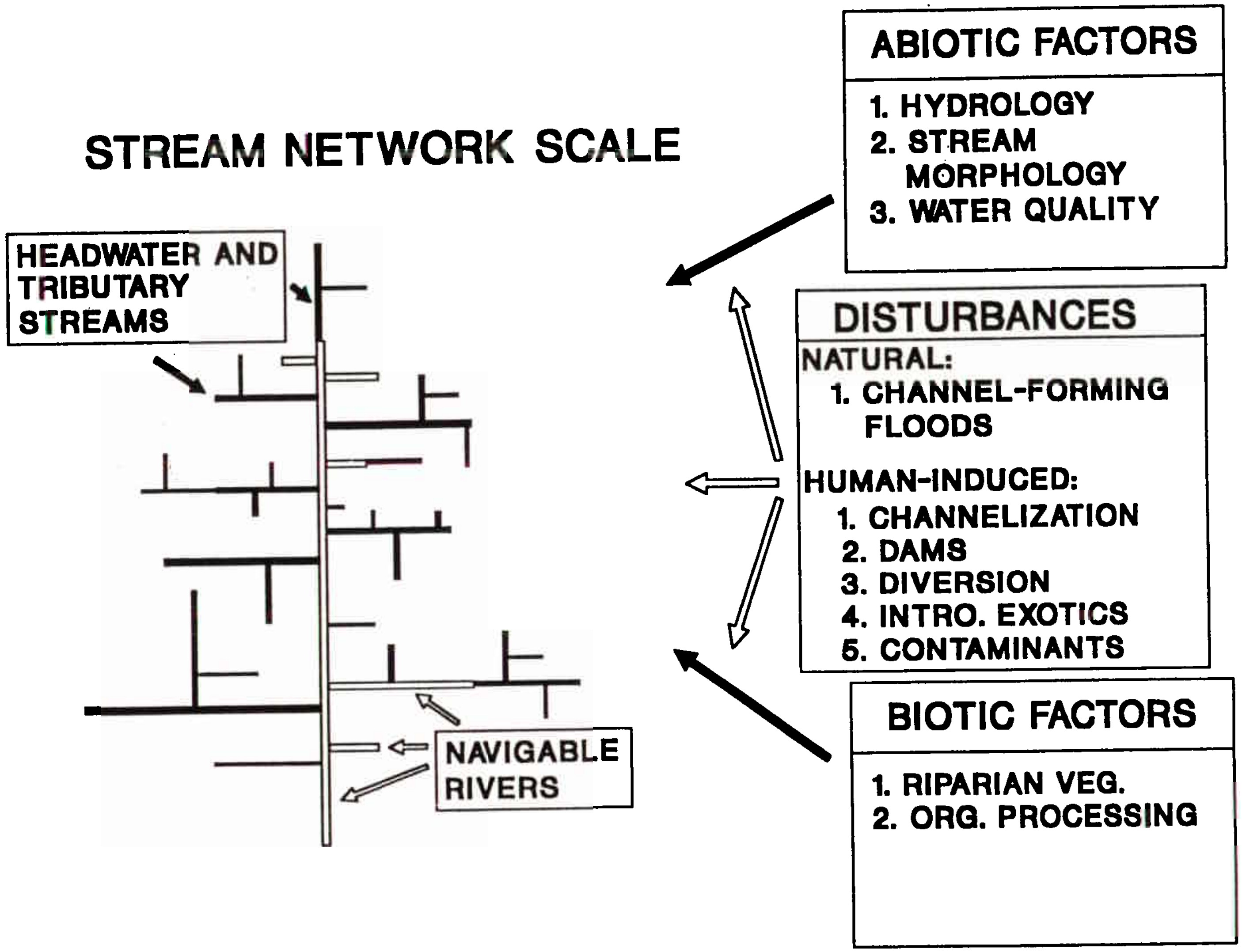


Figure A-5. The Stream Network Spatial Scale

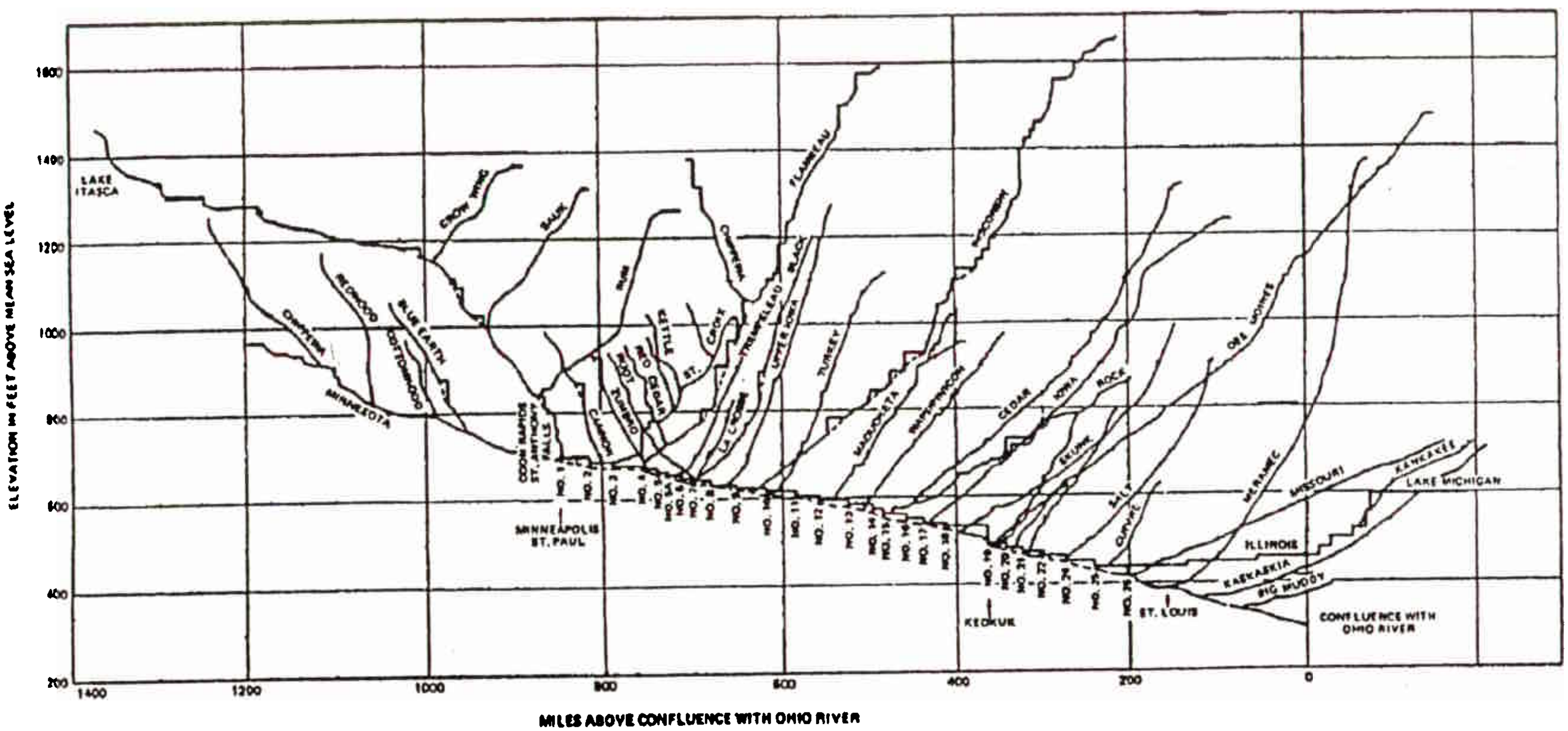


Figure A-6. Vertical Profiles of Major Upper Mississippi River System Tributaries

Missouri River, because of the trapping action of upstream reservoirs, presently delivers only one-third of the suspended sediment load it carried around 1700 (Meade, in press).

Floods capable of rerouting channels and reshaping floodplain contours are the most common natural disturbances at the stream network scale. These floods occur on UMRS rivers at frequencies of 100 to 500 yr (U.S. Army Engineer District, St. Paul 1970).

Human-induced disturbances include dams, water diversions, introductions of exotic species, and the release of contaminants. Dams act as human-induced disturbances at this spatial scale by resetting ecological continua backwards (Ward and Stanford 1983), creating tailwaters and increasing velocities immediately downstream, but decreasing velocities and increasing sedimentation rates upstream.

Lake Michigan water is diverted into the UMRS via the Illinois Waterway. The pollutional history of the Illinois River has been well documented (Mills et al. 1966; Starrett 1972). Recent water quality improvements in the Illinois River have been observed, but aquatic macrophytes and benthic invertebrates still have not returned to the middle river reaches since large-scale die-offs occurred in the 1950s. Sediment quality, including composition and toxicity, is a likely limiting factor (Sparks 1984).

Common carp, grass carp, the Asiatic clam, purple loosestrife, and the zebra mussel are among the most well known exotic species that have been introduced into the UMRS. Common carp rapidly became a major component of the fish community and commercial harvest after its introduction in the late 1800s. Asiatic clams were introduced into the UMRS in the 1970s and now are widespread. Purple loosestrife is spreading rapidly throughout the UMRS. The zebra mussel may become a dominant invertebrate in the UMRS in the near future. Differences of opinion exist as to whether these exotics outcompete native species or simply fill available niches in disturbed habitats.

Wiener et al. (1984) provided a recent review of contaminant studies related to the UMRS. Known problem areas include the Illinois River and reaches of the Mississippi River immediately below Minneapolis-St. Paul and St. Louis. Fish consumption advisories for specific river reaches are issued as necessary by each of the five UMRS states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). In the 1970s, advisories based on poly chlorinated biphenyl (PCB) concentrations in common carp resulted in sharp declines in the commercial fishery harvest below Minneapolis-St. Paul. One source of PCBs has since been identified and eliminated, and recent data suggest that sediment PCB concentrations in this river reach are now declining. Other contaminants that have been implicated as potential problems in localized UMRS areas are heavy metals, chlordane, and mercury.

Floodplain Reach Scale

The island-braided channels (Shumm 1972; Nielsen et al. 1984) of the UMRS travel through wide alluvial floodplains. The floodplain reach spatial scale recognizes a common theme of large river systems (Sedell et al. 1989), the existence of reaches that are structurally distinguishable and whose ecological characteristics are controlled by the degree of interaction or exchange of materials between the river and its floodplain. Reaches of this type, structured by both natural events and human-induced disturbances, can be identified on the Upper Mississippi and Illinois Rivers.

The Upper Mississippi River includes three floodplain reaches (Fig. A-7), based on vegetative cover and the presence of agricultural levees (Gilbertson and Kelly 1981; Peck and Smart 1986). The upper floodplain reach runs from Minneapolis, Minnesota, to Clinton, Iowa, and includes

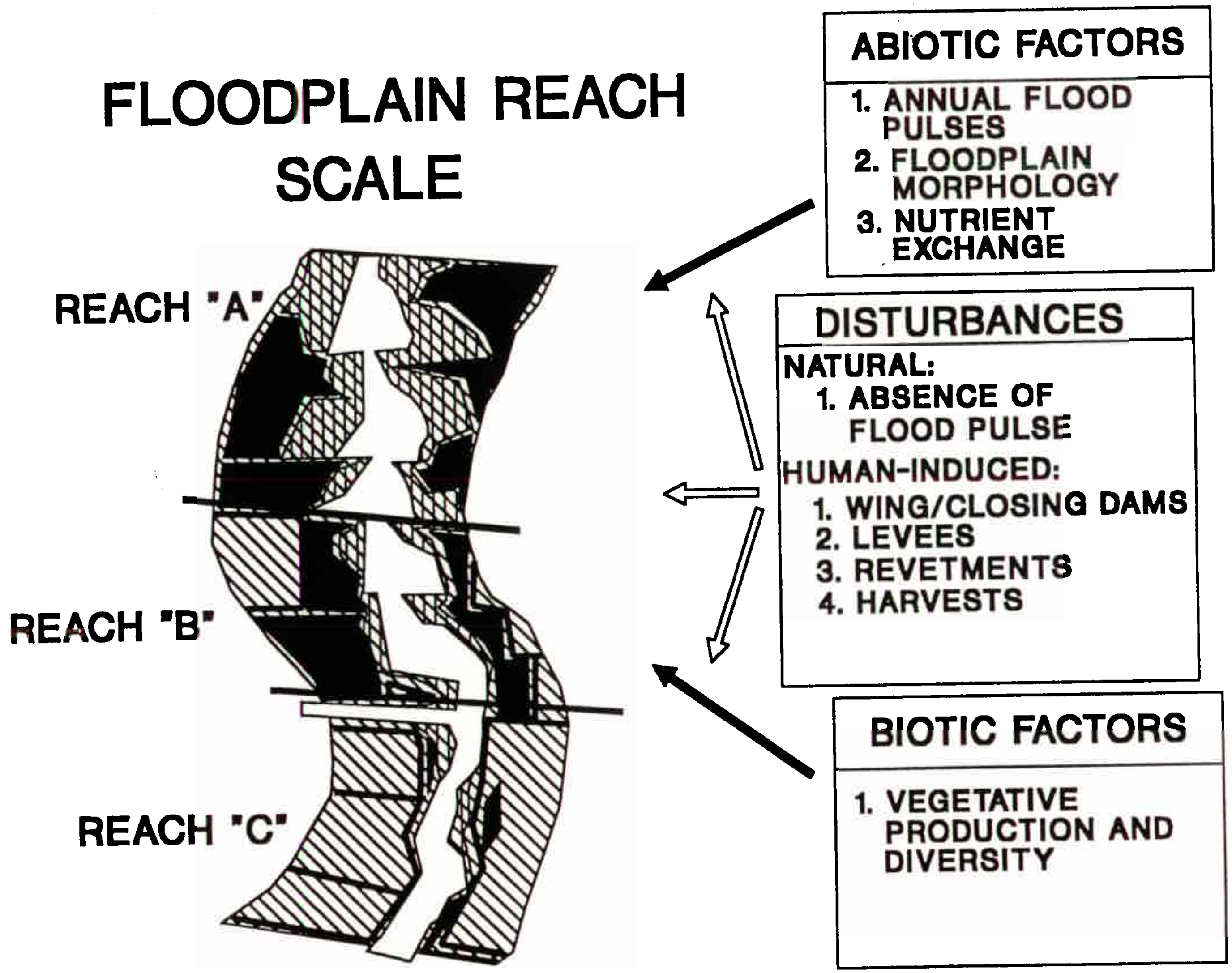


Figure A-7. The Floodplain Reach Spatial Scale

Navigation Pools 1 through 13. This reach contains large areas of off-channel water, large acreages of aquatic vegetation, and few agricultural levees. The middle floodplain reach runs from Clinton, Iowa, to the mouth of the Missouri River, and includes Navigation Pools 14 through 26. The floodplain in this reach contains limited aquatic vegetation, a higher proportion of water in channels, and a moderate amount of land in agricultural levees. The lower floodplain reach runs from the mouth of the Missouri River to Cairo, Illinois. This reach contains almost no aquatic vegetation, a high proportion of water in channels, extensive levees, and no dams. The main navigation channel in this reach has been constricted by numerous wing dams and subsequent sedimentation (Simons et al. 1981).

Two floodplain reaches occur along the Illinois River (Mulvihill and Cornish 1929; Starrett 1972). The upper reach runs between the confluence of the Kankakee and Des Plaines Rivers and Hennepin, Illinois. This reach passes through a young geological valley and has a relatively high gradient and narrow floodplain. Three navigation dams occur along this reach. The lower floodplain reach runs from Hennepin, Illinois, to the Mississippi River. The valley of this reach is geologically older and wider than the upper reach. It was used by the Mississippi River before recent glacial activity redirected the Mississippi channel westward. The lower reach has a very shallow gradient, has been extensively levied, and contains two navigation dams.

The natural floodplain lakes that occur on the UMRS represent exceptions to the typical channel/floodplain pattern in their respective reaches. Lake Pepin occurs in the upper floodplain reach of the Upper Mississippi River, is 21 mi in length, and was formed by an alluvial delta of the Chippewa River. Peoria Lake, 20 mi in length, occurs in the lower floodplain river reach of the Illinois River. It was formed by alluvial deltas of Tenmile Creek and Farm Creek. The lateral extent of these lakes covers much of the available floodplain.

Major abiotic factors at the floodplain reach spatial scale include the annual flood pulse (Junk et al. 1989) and floodplain morphology. These two factors control the amount of land that is flooded at moderate to high river discharges. The area that is intermittently flooded is called the Aquatic/Terrestrial Transition Zone (ATTZ; Junk et al. 1989).

The annual discharge regime of UMRS rivers is typically bimodal. The regime is characterized by a large spring flood pulse associated with snowmelt (March through April) and spring rains (March through June), and a smaller, less predictable, fall flood pulse associated with fall rains (late August to mid-October). As a result of flow integration as water passes through the stream network, the annual discharge regimes of UMRS rivers tend to be smoother and more predictable than those of progressively smaller tributaries.

The absence of a flood pulse, resulting from a lack of precipitation, is a natural disturbance at the floodplain reach spatial scale (Sparks et al. 1990). In the absence of floods, carbon and nutrient exchange between the UMRS rivers and floodplains is limited, plant life histories are interrupted, and certain fishes cannot use spawning and nursery areas on the floodplain (Ward 1989b).

Human-induced disturbances at the floodplain reach spatial scale include physical modifications to the floodplain and overharvests of floodplain plants and animals. Wing dams, closing dams, and revetments have been constructed on UMRS reaches to aid navigation by confining river flows to narrow channels. These structures can increase sedimentation rates, alter water level regimes, and prevent channel meandering and natural succession. Agricultural levees eliminate interactions between rivers and their floodplains at moderate to high discharges, and increase flood peaks.

Trees, mussels, and fishes in the UMRS have been harvested at levels resulting in species losses or changes in population structure. The lumber industry peaked in the mid- to late 1800s. Mussels were severely impacted by commercial harvests in the early 1900s and are again in jeopardy from exploitation by the cultured pearl industry. Each of the five UMRS states has an active program to detect and reduce overexploitation of UMRS fishery resources.

Navigation Pool Scale

The navigation pool scale is unique among the spatial scales because it is directly associated with a human-induced disturbance. This scale focuses on the ecological changes associated with the operation of the 35 navigation dams on the Upper Mississippi and Illinois Rivers. Major factors at this scale are the same as those at the floodplain reach scale.

A navigation pool, by definition, includes all of the water between one dam and the next dam upstream (Fig. A-8). Navigation dams on the UMRS raise upstream surface water elevations to varying degrees, depending on the lift required to create a 9-ft channel, the pool length, and the river gradient.

UMRS navigation dams are designed to pass flood flows without raising flood peaks, the one exception being the Keokuk Dam, which provides hydroelectricity as well as a navigational channel. At moderate to high river discharges, gates in the dams are lifted out of the water or are dropped to the bottom of the river to pass flood flows. Since floods of this magnitude occur almost annually, the navigation pools are considered intermittent, low flow impoundments.

The impacts of navigation dams on longitudinal river gradients (i.e., water quality, velocity, sedimentation rates) are evaluated at the stream network scale. At the navigation pool scale, impacts associated with changes in water levels are emphasized. Because water levels in navigation pools are no longer allowed to drop below certain elevations, some floodplain areas that used to become dry during summers are now permanently wet and will remain so until sedimentation results in the succession of these areas to terrestrial habitats. Organic and nutrient cycling between the soils of these pools and the river has decreased.

The conversion of terrestrial to aquatic habitats that accompanied the construction of the navigation dams has been well documented (Peck and Smart 1986).

At low to moderate discharges, navigation dams are operated to keep water levels at a specific location in the pool as constant as possible. This location is called the hinge point (HP in Fig. A-8) of the pool. In pools where the hinge point is at the downstream dam, water levels fluctuate most in the upper reaches of the pool (TW in Fig. A-8), and least in the lower reaches of the pool (PL in Fig. A-8). However, in some cases the hinge point is in the middle of the pool. Then, during rising discharge periods, the water level in the lower reach of one of these pools can actually fall while the water level in the upper reach is rising. Operating the navigation dams can disrupt the discharge/water level relationship at a site, disturbing near-shore biota.

Because the gates in navigation dams are pulled out of the water during flood periods, the dams do not completely prohibit fish migrations. However, high velocities created below dam gates during low to moderate river discharges do reduce fish movement from one navigation pool to another. Water flows over the gates or through the hydroelectric plant and at the Keokuk Dam, the greatest barrier to fish migration on the UMRS.

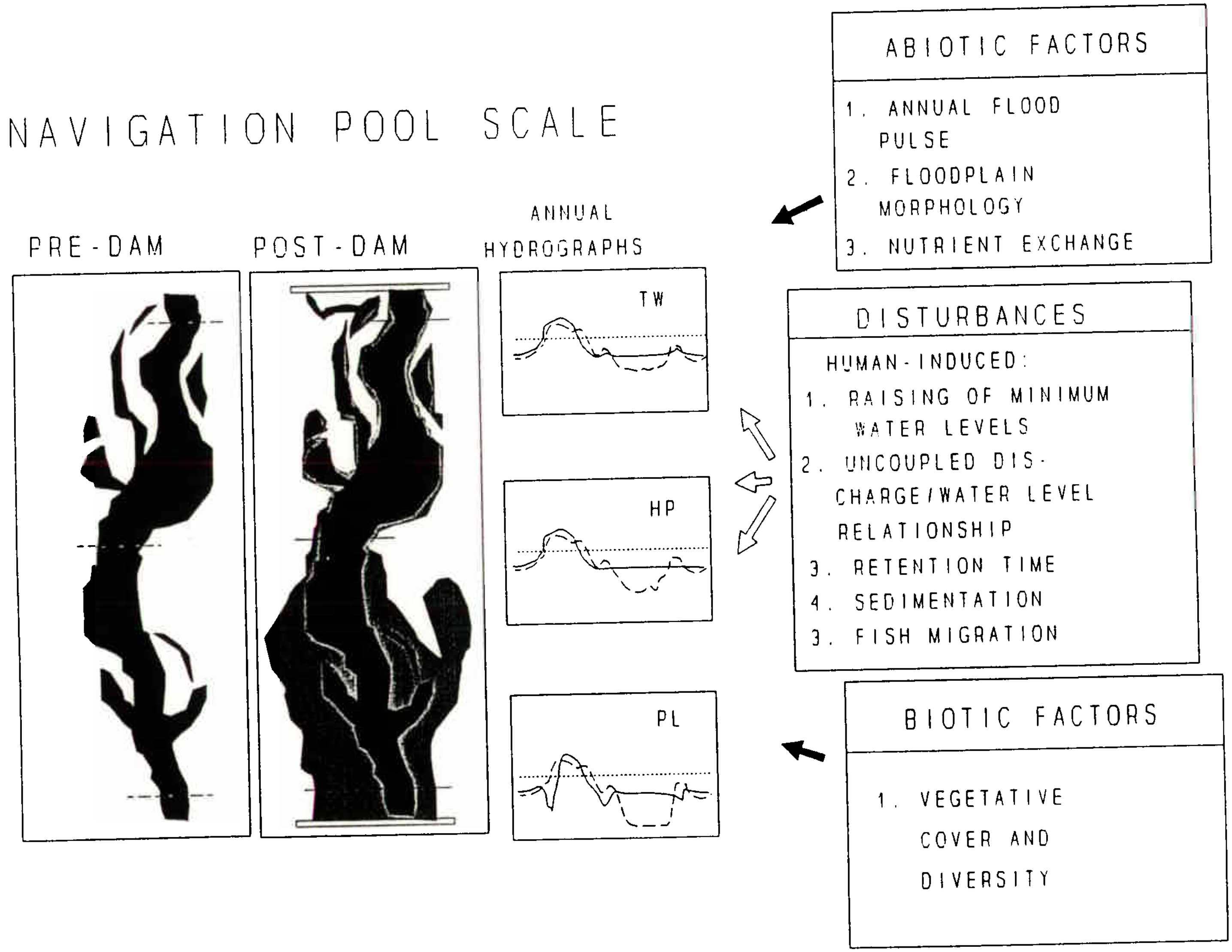


Figure A-8. The navigation pool scale. The hydrographs represent water level conditions at three locations where daily water levels are typically recorded (TW = tailwater; HP = hinge point; PL = pool).

Habitat Scale

The habitat spatial scale addresses fine structural heterogeneities in UMRS floodplains and aquatic areas. Figure A-9 illustrates four aquatic habitat categories.

Habitat categories are defined by a combination of geomorphological and physical variables. Major factors characterizing UMRS aquatic habitats include velocity, substrate type, dissolved oxygen, temperature, turbidity, cover, and depth. In addition to determining the value of habitat categories to aquatic populations, these factors influence the extent to which habitats are impacted by disturbances at this and larger spatial scales.

The importance of the habitat spatial scale is linked to the tendency of many plant and animal species to associate with certain habitat categories. These associations can be viewed as functional attributes of the habitat. The UMRS rivers provide a variety of habitats for resident and migratory animal species.

Habitat templates for lotic systems are not easily quantified (Poff and Ward 1990). Several classification systems for UMRS aquatic habitats have been proposed (Rasmussen 1979; Cobb and Clark 1981). However, the variable UMRS water levels and discharges prohibit applying habitat labels to specific locations.

Natural disturbances at the habitat scale are local events resulting in changes in one or more major factors. These disturbances include the formation or dislodging of debris or ice dams and wind. Human-induced disturbances that have the same effects include clearing and snagging operations to promote boat traffic, dredging and the disposal of dredged material, habitat rehabilitation, barge fleeting, and commercial and recreational traffic.

Boat traffic is an example of a disturbance that acts at a small spatial scale but that can have cumulative impacts. For example, bank erosion can result from the cumulative impacts of waves created by repetitive traffic at the same location. In addition, small-scale impacts among sites can accumulate to have a greater impact at a larger spatial scale.

Linking the Conceptual Model to the LTRMP

The LTRMP conceptual model is intended to be dynamic and is subject to elaboration or modification in response to new information. Model revisions may also require changes in LTRMP monitoring and research strategies. The model will be used to support Program decisions in several areas, including (1) identifying and prioritizing resource problems for investigation, (2) selecting resource components for monitoring, (3) developing strategic models and identifying cause-and-effect relationships to be quantified, and (4) selecting appropriate experimental designs. Although the conceptual model was not fully developed when the Program was initiated, many of the ideas contained in the model were well known and were used during the pre-Program decision-making process in each of these areas (Appendix B).

The LTRMP is problem oriented. Program decisions related to pertinent subject matter favor studies that document cause-and-effect relationships and spatial or temporal patterns, or that evaluate solutions to high priority resource problems. Sedimentation, increased navigation, and water level fluctuations are three high priority resource problems currently under investigation. Regular model revisions will provide a mechanism for redirecting Program priorities, as necessary,

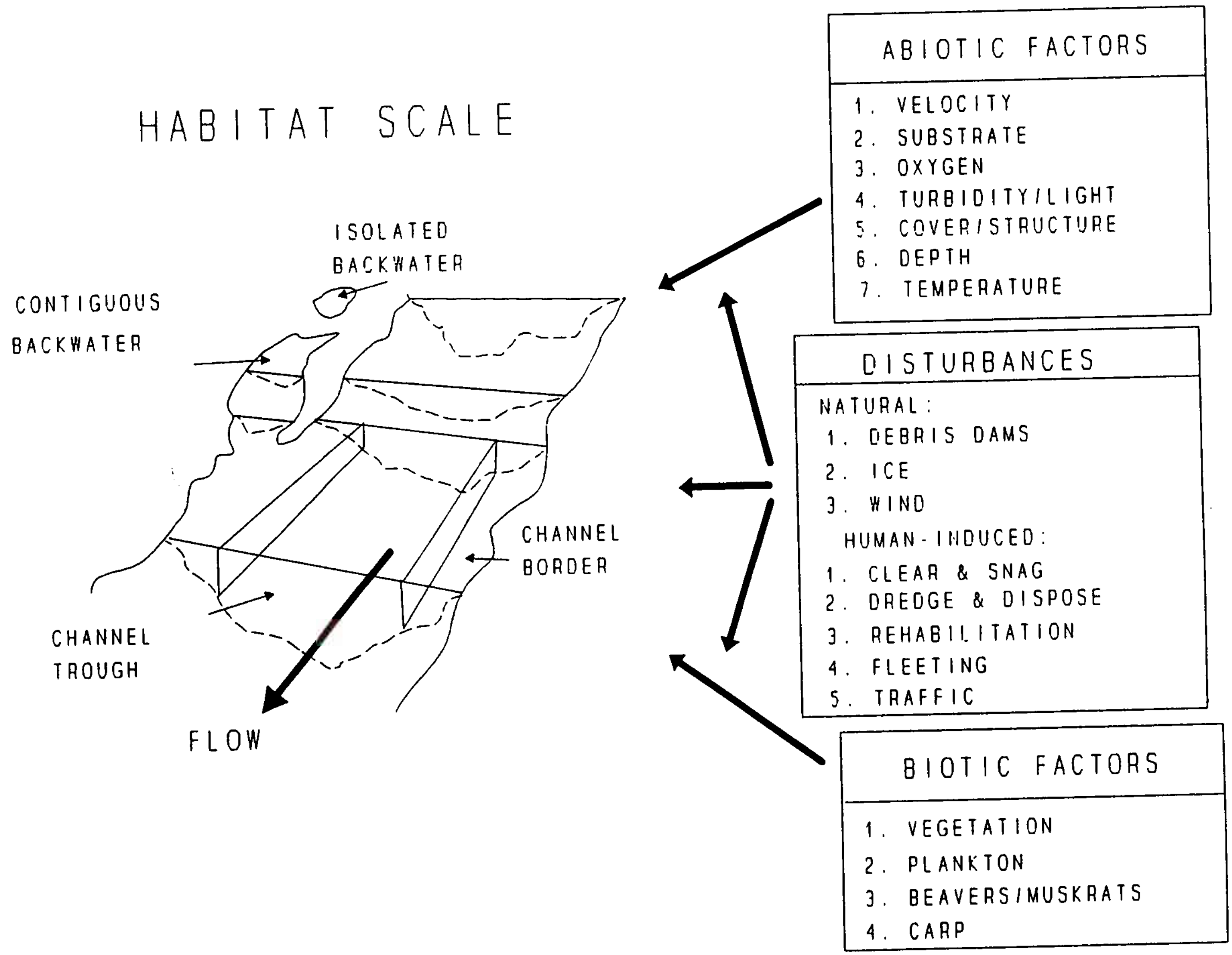


Figure A-9. The Habitat Scale

toward growing resource problems. Model revisions also will help identify whether the magnitude of a resource problem has changed or will show how the problem and its potential solution vary across different spatial scales within the UMRS. For example, the conceptual model helps to illustrate the point that while the impacts of sedimentation on abiotic and biotic factors (substrate, turbidity, depth, vegetation) occur at the habitat scale, many disturbances that produce increased sedimentation (impoundment, tributary channelization, agricultural development) and therefore its long term solution, need to be addressed at larger spatial scales.

Several criteria have been used to select resource components for long term monitoring. The model focuses on criteria that are based on ecological properties. For instance, water quality and vegetation are major factors in the model because they can control ecosystem structure and function at several scales. If new information reveals that important abiotic or biotic controlling factors are not being monitored, these can be added to the list of resource components.

The conceptual model provides a reference framework for constructing strategic models related to the resource problems under investigation. A strategic model is a box-and-arrow representation of the cause-and-effect relationships affecting a resource component across different spatial scales. Strategic models will be constructed for each resource problem component combination to identify and prioritize relationships that will be quantified through LTRMP experimentation. The conceptual model will be used as a guide to the construction of these strategic models and to ensure that they address cause-and-effect mechanisms that occur across different spatial scales.

Within the LTRMP, experimental design refers to selecting sampling sites and frequencies, either for monitoring resource components or for quantifying cause-and-effect relationships. Field stations to monitor resource components were sited in recognition of the floodplain reach spatial scale described in the conceptual model. The selection of sampling sites for the water quality and fish resource components has been based on hypotheses related to differences at the habitat spatial scale. Sampling frequencies have focused on anticipated changes related to disturbances, and as a result have been based on known or assumed variances over the reference periods described in the model. The model will continue to be used extensively in establishing future experimental designs for the LTRMP.

Summary

The conceptual model describes major ecological factors and disturbances that operate at several spatial scales in the river reaches of the UMRS. The model is intended to provide an ecological basis for setting priorities, selecting resource components to be monitored, establishing strategic models, and guiding experimental designs within the LTRMP. The model will be revised as necessary in response to new information related to ecosystem structure, function, or disturbances.

References

Bellrose, F. C., F. L. Paveglio, Jr., and D. W. Steffeck. 1979. Waterfowl populations and the changing environment of the Illinois River Valley. Illinois Natural History Survey Bulletin. Vol. 32. Article 1. Illinois Institute of Natural Resources. 54 pp.

Bhowmik, N. G., M. Demissie, D. T. Soong, A. Klock, N. R. Black, D. L. Gross, T. W. Swipe, and P. G. Risser. 1984. Conceptual models of erosion and sedimentation in Illinois. Vol 1. Project summary. Illinois Scientific Surveys Joint Report 1, Illinois Department of Energy and Natural Resources. 31 pp.

Blumberg, A. F., and D. M. Di Toro. 1990. Effects of climate warming on dissolved oxygen concentrations in Lake Erie. Transactions of the American Fisheries Society 119:210-223.

Cobb, S. P., and J. R. Clark. 1981. Aquatic habitat studies on the Lower Mississippi River, river mile 480-530. Report 2, aquatic habitat mapping. Miscellaneous Paper E-80-1. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. 23 pp.

Coe, M. D., D. Snow, and E. Benson. 1986. Atlas of ancient America. Facts on File, Inc., New York. 240 pp.

Colman, E. A. 1953. Vegetation and watershed management: An appraisal of vegetation management in relation to water supply, flood control, and soil erosion. Ronald Press Company, New York. 412 pp.

Fremling, C. R., and T. O. Claflin. 1984. Ecological history of the Upper Mississippi River. Pages 67-98 in J. G. Wiener, R. V. Anderson, and D. R. McConville, editors. Contaminants in the Mississippi River. Butterworth Publishing Company, Boston, MA.

Gilbertson, D. E., and T. J. Kelly. 1981. Summary resource description Upper Mississippi River System. Vol. 4. Biology. Water Resources Research Center, University of Minnesota, St. Paul, MN. 102 pp.

Junk, W. J., P. B. Bayley, and R. E. Sparks. 1989. The flood pulse concept in river-floodplain systems. Pages 110-127 in D. P. Dodge, editor. Proceedings of the International Large River Symposium, Canadian Journal of Fisheries and Aquatic Sciences Special Publication 106.

Knox, J. C., P. J. Bartlein, K. K. Hirschboeck, and R. J. Muckenhirn. 1975. Response of floods and sediment yields to climatic variation and land use in the Upper Mississippi Valley. Institute for Environmental Studies, Report 52. University of Wisconsin-Madison, WI. 76 pp.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial processes in geomorphology. W. H. Freeman Company, San Francisco, CA. 522 pp.

Magnuson, J. J., J. D. Meisner, and D. K. Hill. 1990. Potential changes in the thermal habitat of Great Lakes fish after global climate warming. Transactions of the American Fisheries Society 119:254-264.

McHenry, J. R., J. C. Ritchie, C. M. Cooper, and J. Verdon. 1984. Recent rates of sedimentation in the Mississippi River. Pages 99-117 in J. G. Wiener, R. V. Anderson, and D. R. McConville, editors. Contaminants in the Mississippi River. Butterworth Publishing Company, Boston, MA.

Meade, R. H. River-sediment inputs to major deltas. J. D. Milliman and S. Sabhasri, editors. Sea-level rise and coastal subsidence: Problems and strategies. John Wiley and Sons, New York. (In press)

Mills, H. B., W. C. Starrett, and F. C. Bellrose. 1966. Man's effect on the fish and wildlife of the Illinois River. Illinois Natural History Survey Biological Notes No. 57. Illinois Natural History Survey, Champaign, IL. 24 pp.

Minshall, G. W., K. W. Cummings, R. C. Peterson, C. E. Cushing, D. A. Bruns, J. R. Sedell, and R. L. Vannote. 1985. Developments in stream ecosystem theory. Canadian Journal of Fisheries and Aquatic Sciences 42:1045-1055.

Molles, M. C., Jr., and C. N. Dahm. 1990. A perspective on El Nino and La Nina: Global implications for stream ecology. Journal of the North American Benthological Society 9(1):68-76.

Mulvihill, W. F., and L. D. Cornish. 1929. Flood control report: An engineering study of the flood situation in the state of Illinois. Illinois Division of Waterways, Springfield, IL.

Nielsen, D. N., R. G. Rada, and M. M. Smart. 1984. Sediments of the Upper Mississippi River: Their character, distribution, and transport. Pages 99-117 in J. G. Wiener, R. V. Anderson, and D. R. McConville, editors. Contaminants in the Mississippi River. Butterworth Publishing Company, Boston, MA.

Peck, J. H., and M. M. Smart. 1986. An assessment of the aquatic and wetland vegetation of the Upper Mississippi River. Hydrobiologia 136:57-76.

Petts, G. E. 1989. Chapter 1. Perspectives for ecological management of regulated rivers. Pages 3-24 in J. A. Gore and G. E. Petts, editors. Alternatives in Regulated River Management. CRC Press, Inc., Boca Raton, Florida.

Pickett, S. T. A., and P. S. White, editors. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, Orlando, FL. 472 pp.

Poff, N. L., and J. V. Ward. 1990. Physical habitat template of lotic systems: Recovery in the context of historical pattern of spatiotemporal heterogeneity. Environmental Management 14(5):629-645.

Rasmussen, J. L. 1979. A compendium of fishery information on the Upper Mississippi River. 2nd ed. Upper Mississippi River Conservation Committee, Rock Island, IL. Special Publication. 259 pp.

Regier, H. A., and J. D. Meisner. 1990. Anticipated effects of climate change on freshwater fishes and their habitat. Fisheries (Bethesda) 15(6):10-15.

Resh, V. H., A. V. Brown, A. P. Covich, M. E. Gurtz, H. W. Li, G. W. Minshall, S. R. Reice, A. L. Sheldon, J. B. Wallace, and R. C. Wissmar. 1988. The role of disturbance in stream ecology. Journal of the North American Benthological Society 7(4):433-455.

Ryder, R. A., and J. Pesendorfer. 1989. Large rivers are more than flowing lakes: A comparative review. Pages 65-85 in D. P. Dodge, editor. Proceedings of the International Large River Symposium, Canadian Journal of Fisheries and Aquatic Sciences Special Publication 106.

Sedell, J. R., J. E. Richey, and F. J. Swanson. 1989. The river continuum concept: A basis for the expected ecosystem behavior of very large rivers. Pages 49-55 in D. P. Dodge, editor. Proceedings of the International Large River Symposium, Canadian Journal of Fisheries and Aquatic Sciences Special Publication 106.

Simons, D. B., R. M. Li, Y. H. Chen, S. S. Ellis, and T. P. Chang. 1981. Investigation of effects of navigation development and maintenance activities on hydrologic, hydraulic, and geomorphic characteristics in the Upper Mississippi System. Submitted to the Upper Mississippi River Basin Commission.

Slizeski, J. J., J. L. Anderson, and W. G. Dorough. 1982. Chapter 2. Hydrologic setting, system operation, present and future stresses. Pages 15-37 in L. W. Hesse et al., editors. The Middle Missouri River. The Missouri River Study Group, Norfolk, NE.

Shumm, S. A. 1972. Fluvial geomorphology: The historical perspective. H. W. Shen, editor. River Mechanics, Colorado State University Press, Fort Collins, CO.

Sparks, R. E. 1984. The role of contaminants in the decline of the Illinois River: Implications for the Upper Mississippi. Pages 25-66 in J. G. Wiener, R. V. Anderson, and D. R. McConville, editors. Contaminants in the Mississippi River. Butterworth Publishing Company, Boston, MA.

Sparks, R. E., P. B. Bayley, S. L. Kohler, and L. L. Osborne. 1990. Disturbance and recovery of large floodplain rivers. Environmental Management 14(5):699-709.

Starrett, W. C. 1972. Man and the Illinois River. Pages 131-169 in C. A. Carson and J. A. McCann, editors. International Symposium on River Ecology and the Impact of Man. Academic Press, New York.

U.S. Army Engineer District, St. Louis, North Central Engineer Division, and Environmental Science Services Administration. 1970. Upper Mississippi River Comprehensive Basin Study. Appendix C. Climatology and meteorology. Upper Mississippi River Comprehensive Basin Study Coordinating Committee, Minneapolis, MN.

U.S. Army Engineer District, St. Paul. 1970. Upper Mississippi River Comprehensive Basin Study. Appendix D. Surface water hydrology. Upper Mississippi River Comprehensive Basin Study Coordinating Committee, Minneapolis, MN.

U.S. Department of Agriculture. 1970. Upper Mississippi River Comprehensive Basin Study. Appendix N. Agriculture. Upper Mississippi River Comprehensive Basin Study Coordinating Committee, Minneapolis, MN.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Ward, J. V. 1989a. The four-dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8(1):2-8.

Ward, J. V. 1989b. Riverine-wetland interactions. Pages 385-400 in R. R. Sharitz and J. W. Gibbons, editors. Freshwater Wetlands and Wildlife, Department of Energy Symposium Series No. 61. U.S. Department of Energy Office of Scientific and Technical Information, Oak Ridge, TN.

Ward, J. V., and J. A. Stanford. 1983. The intermediate-disturbance hypothesis: An explanation for biotic diversity patterns in lotic ecosystems. Pages 347-356 in T. D. Fontaine III and S. M. Bartell, editors. Dynamics of lotic ecosystems. Ann Arbor Science Publishers, Ann Arbor, MI. 494 pp.

Wiener, J. G., R. V. Anderson, and D. R. McConville, editors. 1984. Contaminants in the Upper Mississippi River. Proceedings of the 15th Annual Meeting of the Mississippi River Research Consortium. Butterworth Publishers, Boston, MA. 368 pp.

Appendix B
Planning History of the Long Term Resource Monitoring Program

Development of Initial Monitoring Recommendations

Public Law 95-502 authorized preparation of a Comprehensive Master Plan for management of the Upper Mississippi River System (UMRS) by the Upper Mississippi River Basin Commission (UMRBC) in 1978. The plan, completed in 1982 (UMRBC 1982), recommended implementing a long-term resource monitoring program for the UMRS. This recommendation was based on the findings of Jackson et al. (1981) and the Environmental Work Team (1981).

In addition to long-term monitoring, Jackson et al. (1981) also recommended a computerized data management and information transfer system, and a special studies and short-term impact monitoring program to document physical, chemical, and biological changes due to localized impacts.

Implementation of Monitoring Recommendations

A Long Term Resource Monitoring Program (LTRMP) Steering Committee was formed in the fall of 1986 after Congressional authorization and receipt of initial Program funding.

The Monitoring Needs Report (USFWS 1986), approved by the Steering Committee, recommended that the monitoring program be composed of three sections: (1) Integrated Data Management (IDM), (2) Resource Trend Analysis (RTA), and (3) Problem Identification and Analysis (PIA).

Interagency committees were formed to prepare IDM, RTA, and PIA implementation reports. The IDM (USFWS 1987a), RTA (USFWS 1987b), and PIA (USFWS 1987c) reports were conceptually approved by the Environmental Management Program-Coordinating Committee (EMP-CC). The EMP-CC replaced the previous LTRMP Steering Committee and assumed an oversight function for the LTRMP and Habitat Rehabilitation and Enhancement Projects.

Staff at the Environmental Management Technical Center (EMTC) initiated work on the LTRMP Operating Plan in April 1987 using the IDM, RTA, and PIA reports, the Environmental Management Program General Plan (USACE 1986), and EMP-CC guidance as inputs.

Trend analysis components recommended in the 1988 Operating Plan included (1) land use, (2) water and sediment, (3) vegetation, (4) invertebrates, (5) fish, (6) birds, (7) mammals, and (8) public use. These components were essentially the same as those recommended by the RTA work group, except that bathymetry was combined with the water and sediment element, and recreation was renamed public use.

Program funding did not allow the high level of monitoring (22 pools) recommended by the RTA work group. The EMTC coordinated with federal and state agency resource managers to narrow the geographic scope of monitoring to five pools and one reach.

The original 1988 Operating Plan recommended a minimum of three field stations with substations to adequately cover the geographic area encompassed by these six pools and reaches.

Recommended field station locations were in La Crosse, Wisconsin; Bellevue, Iowa; and Havana, Illinois. As more funds became available, additional field stations were added in Alton, Illinois; Lake City, Minnesota; and Cape Girardeau, Missouri.

The original 1988 Operating Plan grouped the PIA's 10 high priority problems into major problem areas: (1) sedimentation, (2) navigation effects, (3) water level fluctuation, (4) lack of aquatic vegetation, and (5) reduced fisheries populations. Of these five, the first three were given highest priority upon the recommendation of the Corps of Engineers (Whiting 1987).

References

Environmental Work Team. 1981. Comprehensive Master Plan for the Management of the Upper Mississippi River System - Environmental Report. Prepared by the Environmental Studies Work Team for Upper Mississippi River Basin Commission, Bloomington, MN.

Jackson, G. A., C. E. Korschgen, P. A. Thiel, J. M. Besser, D. W. Steffeck, and M. H. Bockenhauer. 1981. A Long Term Resource Monitoring Plan for the Upper Mississippi River System. Contract Number 14-16-009-81-903. Upper Mississippi River Basin Commission, Bloomington, MN. 2 vols.

Upper Mississippi River Basin Commission. 1982. Comprehensive Master Plan for the Management of the Upper Mississippi River System. Upper Mississippi River Basin Commission, Bloomington, MN. 193 pp.

U.S. Army Corps of Engineers. 1986. Upper Mississippi River System Environmental Management Program General Plan. U.S. Army Corps of Engineers, North Central Division, Chicago, IL. 31 pp. + appendixes.

U.S. Fish and Wildlife Service (USFWS). 1986. Long-Term Resource Monitoring Program Monitoring Needs Report. 15 pp.

USFWS. 1987a. Action Plan Report - Integrated Data Management System. U.S. Fish and Wildlife Service, Twin Cities, MN. 31 pp.

USFWS. 1987b. Action Plan Report - Environmental Management Program Resource Trend Analysis. U.S. Fish and Wildlife Service, Twin Cities, MN. 23 pp. + Appendixes A-H.

USFWS. 1987c. Action Plan Report - Problem Identification and Analysis. U.S. Fish and Wildlife Service, Twin Cities, MN. 22 pp. + Appendixes 1-2.

Whiting, R. J. 1987. U.S. Army Corps of Engineers letter to Joseph Scott, Long Term Resource Monitoring Program Manager. 2 pp. + 5 enclosures.

Appendix C
Reports and Schedule of Products

Introduction

The primary purpose of this appendix is to indicate when anticipated products will be generated under the Long Term Resource Monitoring Program (Table C-1). The products generated under Goals 1 (Problem Analysis) and 2 (Trend Analysis) follow learning, decision-making, and implementation steps that will be documented at regular intervals during the Program.

The typical decision-making process for problem analysis activities is slightly different than that used for trend analyses (Fig. C-1). Common cycles for problem analysis decisions repeat annually and every 3 years. Annual decisions for the funding of problem analysis studies will be based on up-to-date reviews of the conceptual and strategic models. Proposed studies will be described in Study Sheets or Draft Scopes of Work in the Draft Annual Work Plan. A one-page Study Sheet will contain the following items: study title, relationship of study to the Program, objectives, anticipated time schedule, product(s), and costs. The Draft Annual Work Plan will be distributed for interagency review. After modifications and the completion of the Final Annual Work Plan, Draft Scopes of Work will be distributed for technical review. Final Scopes of Work will be used to establish contracts for acquiring the needed informational products.

Whenever necessary or at 3-year intervals, study and trend results will be used to modify the conceptual and strategic models (Fig. C-1). These modifications will be summarized in model updates and may result in reevaluation of the problem relationships already being investigated or the selection of new resource problems for study.

The Environmental Management Technical Center (EMTC) anticipates that decisions related to trend analyses typically will occur during an initial period and later at annual and 5-year cycles (Fig. C-1). Trend models and hypotheses will be used to establish initial experimental designs. The experimental designs, including methods of selection and sampling locations and frequencies, will be reported in a procedures manual. During the initial 3 years of sampling for each resource component, data sets will be subjected to statistical analyses to evaluate sampling designs and make necessary modifications. After this initial 3-year period, changes to the sampling design for a specific component will be limited to ensure comparability of annual results over the rest of the Program period. Beyond the initial period, routine products will be generated annually and every 5 years.

Trend models will be modified, if necessary, every 3 years. Examples of events that could result in the modification of a trend model include an unexplained die-off of a population, a major environmental accident (e.g., oil spill) that requires evaluation, or a significant publication describing a factor that controls a resource component being monitored. Most trend models focus on long-term trends the EMTC believes will result from sedimentation and annual changes associated with year-to-year differences in river hydrology.

Multi-component trend analyses (i.e., correlations and other syntheses) will be completed on a 3-year schedule.

Reports Referenced in Table C-1

R(1) U.S. Fish and Wildlife Service. 1987. Action Plan Report - Environmental Management Program Resource Trend Analysis. U.S. Fish and Wildlife Service, Twin Cities, MN. 23 pp. + apps. A-H.

R(2) U.S. Fish and Wildlife Service. 1987. Action Plan Report - Problem Identification and Analysis. U.S. Fish and Wildlife Service, Twin Cities, MN. 22 pp. + apps. 1-2.

R(3) U.S. Fish and Wildlife Service. 1985. Action Plan Report - Computerized Inventory and Analysis/Geobased Information System for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Twin Cities, MN. 26 pp.

R(4) Rasmussen, J. L., and J. H. Wlosinski. 1988. Operating plan of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the Environmental Management Technical Center, Onalaska, Wisconsin, January 1988. EMTC 88-01. 55 pp. (NTIS # PB88 169669/AS)

R(5) Bogner, W. C., T. W. Soong, and N. G. Bhowmik. 1988. Physical impacts of navigation: Ohio River field data collection. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1988. EMTC 88-02. 32 pp. (NTIS # PB89 126510/AS)

R(6) Lubinski, K. S., and J. L. Rasmussen. 1988. Chapter 1. Background. Pages 1-7 *in* Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(7) Lubinski, K. S., and J. L. Rasmussen. 1988. Chapter 2. General experimental design. Pages 1-4 in Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(8) Lubinski, K. S., and R. Burkhardt. 1988. Chapter 5. Water quality. Pages 1-31 *in* Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(9) Ahearn, S. C., R. D. Martin, and J. H. Wlosinski. 1989. Recommendations for estimating suspended solids in the Upper Mississippi River System using remote sensing. Report by the University of Minnesota, St. Paul, and the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1989. EMTC 89-01. 23 pp. (NTIS # PB89 236715/AS)

R(10) U.S. Fish and Wildlife Service, Environmental Management Technical Center. 1989. First annual report of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1989. EMTC 89-02. 130 pp. (NTIS # PB91 174102)

R(11) Millar, J. D., and M. S. Mahaffy. 1989. Background study on the environmental impacts of barge fleeting. Report by the U.S. Fish and Wildlife Service, Rock Island Field Office, Rock Island, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1989. EMTC 89-04. 49 pp. (NTIS # PB90 133595/AS)

R(12) Bhowmik, N. G., T. W. Soong, and W. C. Bogner. 1989. Impacts of barge traffic on waves and suspended sediments: Ohio River at river mile 581. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS 14-16-0003-88-973, March 1989. EMTC 89-05 (October 1989). 99 pp. (NTIS # PB90 133513/AS)

R(13) Burkhardt, R., J. L. Rasmussen, and K. S. Lubinski. 1988. Chapter 3. Quality assurance/quality control. Pages 1-23 *in* Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(14) Burkhardt, R., J. L. Rasmussen, and K. S. Lubinski. 1988. Chapter 7. Fish. Pages 1-28 *in* Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(15) U.S. Fish and Wildlife Service, Environmental Management Technical Center. 1990. Long Term Resource Monitoring Program annual work plan for Fiscal Year 1991. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in cooperation with the U.S. Army Corps of Engineers, Chicago, Illinois, August 1990. 12 pp. + 4 attachments.

R(16) Schellhaass, S. M., and G. L. Benjamin. 1990. Summary of water quality characteristics at selected habitat sites, Navigation Pool 8 of the Mississippi River, July 17 through October 31, 1988. Report by the Wisconsin Department of Natural Resources, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-01. 19 pp. (NTIS # PB90-267394)

R(17) Gent, R. D., M. Griffin, and S. Gritters. 1990. Summary of water quality characteristics at selected habitat sites, Navigation Pool 13 of the Mississippi River, August 1 through October 31, 1988. Report by the Iowa Department of Natural Resources, Bellevue, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-02. 21 pp. (NTIS # PB91-105338)

R(18) Hawkins, Jr., A. S., and J. L. Stewart. 1990. Pilot project on the Middle Branch Whitewater Watershed 1990. Report by the U.S. Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-03. 34 pp. (NTIS # PB91-122655)

R(19) Belanger, K. D., D. J. Dieterman, and T. W. Deyo. 1990. Pre- and post-construction water quality monitoring for Habitat Rehabilitation and Evaluation Projects at Big Lake Bay, Finger Lakes, Lake Onalaska, and the Pool 8 islands area of the Upper Mississippi River. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-04. 17 pp. (NTIS # PB91-106385)

R(20) U.S. Fish and Wildlife Service, Environmental Management Technical Center. 1990. Second annual report 1989. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, through the U.S. Fish and Wildlife Service, Division of Enhancement, Region 3, Twin Cities, Minnesota, in cooperation with U.S. Army Corps of Engineers, Chicago, Illinois, and the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, September 1990. EMTC 90-05. 267 pp. (NTIS # PB91-117317)

R(21) Owens, J., and W. G. Crumpton. 1990. Pilot study to evaluate an inexpensive, portable device to continuously monitor dissolved oxygen, water temperature, and photosynthetically active radiation in Upper Mississippi River System backwaters. Report by the Iowa State University, Ames, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, October 1990. EMTC 90-06. 19 pp. (NTIS # PB91106070)

R(22) Korschgen, C. E. 1990. Feasibility study impacts of turbidity on growth and production of submersed plants. Report by the U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, November 1990. EMTC 90-07. 11 pp. (NTIS # PB91135475)

R(23) Davies, J. N. 1990. Chapter 6. Vegetation. Pages 1-24 *in* Procedures manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03.

R(24) Anderson, R. V., J. W. Grubaugh, and D. B. Markillie. 1991. Summary of water quality characteristics at selected habitat sites, Navigation Pool 26 of the Mississippi River, July 17 through October 31, 1988. Report by Western Illinois University, Macomb, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1991. EMTC 91-01. 48 pp. (NTIS # PB91 174128)

R(25) U.S. Fish and Wildlife Service. 1992. Operating Plan for the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin, August 1992. EMTC 91-P002. 175 pp.

R(26) Eckblad, J. W. 1991. LTRMP Observational Bulletin No. 1. Status of macroinvertebrate populations of the Upper Mississippi River. Report by Luther College, Decorah, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1991. EMTC 91-03. 8 pp. (NTIS # PB91-197863)

LTRMP Reports Published as of September 1993

1993

Adams, J. R. 1992. Bed material characteristics of the Mississippi River within Pool 19. Illinois State Water Survey, Champaign, Illinois. Contract Report 535, ISSN 0733-3927. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-R006. 113 pp.

Adams, J. R. 1992. Sediment concentration changes caused by barge tows. Pages 677-682 *in* Marshall Jennings and Nani G. Bhowmik, editors. Proceedings, American Society of Civil

Engineers' Hydraulic Engineering Sessions at Water Forum '92, Baltimore, Maryland, August 2-6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R023. 6 pp.

Adams, J. R., N. G. Bhowmik, and E. Delisio. 1989. Measuring resuspension of sediment by barge tows. Pages 765-770 *in* Sam S. Y. Wang, editor. Sediment Transport Modeling. Proceedings of the International Symposium of the Hydraulics Division of the American Society of Civil Engineers, New Orleans, Louisiana, August 14-18, 1989. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R002. 6 pp. (NTIS #PB94-108982)

Adams, J. R., and E. Delisio. 1990. Ambient suspended sediment concentration and turbidity levels. Pages 865-869 *in* Richard M. Shane, editor. Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R018. 5 pp.

Adams, J. R., and E. Delisio. 1990. Temporal and lateral distributions of resuspended sediment following barge tow passage on the Illinois River. *In* Howard H. Chang and Joseph C. Hill, editors. Volume 2, Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R011. 6 pp. (NTIS #PB94-108784)

Armson, R. 1992. Mississippi River boating survey: Results and technical report. Minnesota Center for Survey Research, University of Minnesota, Minneapolis. Technical Report #92-3. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-R026. 13 pp. + Appendixes. (NTIS #PB94-109071)

Barko, J. W., R. F. Gaugush, W. F. James, B. J. Johnson, T. J. Naimo, J. T. Rogala, S. J. Rogers, and D. M. Soballe. 1993. Hydrologic modification for habitat improvement in the Finger Lakes: Pre-Project Report Number 2, 1993. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin; U.S. Fish and Wildlife Service, National Fisheries Research Center, La Crosse, Wisconsin; and U.S. Army Corps of Engineers, Waterways Experiment Station, Eau Galle Limnological Laboratory, Spring Valley, Wisconsin, April 1993. EMTC 93-T002. 57 pp. (NTIS # PB93-181865)

Bhowmik, N. G. 1989. Physical impacts of human alterations within river basins: The case of the Kankakee, Mississippi, and Illinois Rivers. Pages B-139 to B-146 *in* Proceedings, XXIII Congress of the International Association for Hydraulic Research, Ottawa, Canada, August 21-25, 1989. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R004. 8 pp. (NTIS #PB94-108891)

Bhowmik, N. G. 1989. Sediment management problems of backwater lakes and alternative solutions. *In* Proceedings, Second Conference on the Management of the Illinois River System: The 1990s and Beyond, Peoria, Illinois, October 3-4, 1989. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R014. 7 pp.

Bhowmik, N. G. 1991. Commercial navigation in large rivers and the development of appropriate management alternatives. Pages 93-103 *in* F. H. M. van de Ven, D. Gutknecht, D. P. Loucks, and K. A. Salewicz, editors. Proceedings, Hydrology for the Water Management of Large River

Basins, Vienna, August 11-24, 1991. IAHS Publication No. 201. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R017. 11 pp.

Bhowmik, N. G. 1991. Physical changes due to navigation in the Upper Mississippi River System. *In* Proceedings, 1991 Governor's Conference on the Management of the Illinois River System, Third Biennial Conference, Peoria, Illinois, October 22-23, 1991. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R019. 9 pp. (NTIS #PB94-108917)

Bhowmik, N. G., and J. R. Adams. 1989. Successional changes in habitat caused by sedimentation in navigation pools. Hydrobiologia 176/177:17-27. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R025. 11 pp.

Bhowmik, N. G., and J. R. Adams. 1990. Sediment transport, hydraulic retention devices, and aquatic habitat in sand-bed channels. Pages 1110-1115 *in* Howard H. Chang and Joseph C. Hill, editors. Volume 2, Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R024. 6 pp. (NTIS #PB94-108792)

Bhowmik, N. G., J. R. Adams, and R. E. Sparks. 1986. Fate of navigation pool on Mississippi River. Journal of Hydraulic Engineering 112(10):967-970. ISSN 0733-9429/86/0010-0967. Paper No. 20939. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R001. 4 pp.

Bhowmik, N. G., and M. Demissie. 1989. Sedimentation in the Illinois River Valley and backwater lakes. Journal of Hydrology 105:187-195. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R013. 9 pp.

Bhowmik, N. G., and B. S. Mazumder. 1990. Physical forces generated by barge-tow traffic within a navigable waterway. Pages 604-609 *in* Howard H. Chang and Joseph C. Hill, editors. Volume 1, Hydraulic Engineering, Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R020. 6 pp.

Bhowmik, N. G., B. S. Mazumder, and T. W. Soong. 1992. Return flows in large rivers associated with navigation traffic. Pages 760-765 *in* Marshall Jennings and Nani G. Bhowmik, editors. Proceedings, Water Forum '92, Hydraulic Engineering Sessions of the American Society of Civil Engineers, Baltimore, Maryland, August 2-6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R022. 6 pp.

Bhowmik, N. G., A. C. Miller, and B. S. Payne. 1990. Techniques for studying the physical effects of commercial navigation traffic on aquatic habitats. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Technical Report EL-90-10. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-R007. 129 pp.

Bhowmik, N. G., W. C Bogner, J. A. Slowikowski, and J. Rodger Adams 1993. Source monitoring and evaluation of sediment inputs for Peoria Lake. Office of Hydraulics and River Mechanics, Illinois State Water Survey, Champaign, Illinois. Illinois Department of Energy and Natural Resources Report ILENR/RE-WR-93/01. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1993. EMTC 93-R016. 60 pp. (NTIS # PB 93-188472)

D'Erchia, F. 1991. PC ARC/INFO: An evaluation report. U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, Colorado. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-R030. 42 pp. (NTIS #PB93-236123)

D'Erchia, F., and M. Laustrup. 1993. Status report on the development of a systemic land cover/land use spatial data base for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-P001. 7 pp. (NTIS #PB94-108669)

Gaugush, R. F. 1992. Kriging and cokriging applied to water quality studies. Pages 236-253 *in* Proceedings, Third National U.S. Fish and Wildlife Service Geographic Information Systems Workshop, La Crosse, Wisconsin, May 3-6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R027. 18 pp. (NTIS #PB93-174365)

Holland -Bartels, L. E., M. R. Dewey, and S. J. Zigler. 1993. Pilot study of spatial patterns of ichthyoplankton among river reaches and habitats of the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, National Fisheries Research Center, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-S010. 47 pp. + Appendixes A-C. (NTIS #PB93-183515)

Johnson, B. L. 1993. Review of existing models for evaluating fish population changes relative to environmental impacts. Report by the U.S. Fish and Wildlife Service, National Fisheries Research Center, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1993. EMTC 93-S005. 25 pp. (NTIS # PB94-102514)

Kelly, T. 1993. An origin-destination model of recreational boating on the Twin Cities reaches of the Mississippi and St. Croix River. Minnesota Department of Natural Resources, St. Paul, Minnesota. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R028. 13 pp. + Appendixes. (NTIS #PB94-109139)

Lowenberg, C. D. 1993. Introduction to GIS - Using EPPL7 on a microcomputer. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-P002. 95 pp. + Appendixes.

Lowenberg, C. 1993. User's manual, Fish and Wildlife Application EPPL7 interface program. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1993. EMTC 93-P003. 49 pp.

Lubinski, K. 1993. A conceptual model of the Upper Mississippi River System ecosystem. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-T001. 23 pp. (NTIS #PB93-174357)

Lubinski, K. S., G. Carmody, D. Wilcox, and B. Drazkowski. 1991. Development of water level regulation strategies for fish and wildlife, Upper Mississippi River System. Regulated Rivers: Research and Management 6:117-124. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R005. 8 pp.

Mazumder, B. S., N. G. Bhowmik, and T. W. Soong. 1991. Turbulence and Reynolds stress distribution in a natural river. Pages 906-911 *in* Richard M. Shane, editor. Proceedings, 1991 National Conference of the Hydraulics Division of the American Society of Civil Engineers, Nashville, Tennessee, July 29-August 2, 1991. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R012. 6 pp.

Mazumder, B., N. G. Bhowmik, and T. W. Soong. 1993. Turbulence in rivers due to navigation traffic. Journal of Hydraulic Engineering 119(5):581-597. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1993. EMTC 93-R031. 17 pp. (NTIS # PB94-102092)

Milhous, R. T., R. C. MacArthur, F. D. Shields, Jr., and J. Rodger Adams. 1990. Sediment and aquatic habitat associations in river systems: Results from the ASCE Task Committee on Sediment Transport and Aquatic Habitats. Pages 1104-1109 *in* Howard H. Chang and Joseph C. Hill, editors. Hydraulic Engineering. Volume 2, Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R008. 6 pp.

Olsen, D. A. 1993. User's manual: Production ARCEDIT. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1993. EMTC 93-P005. 15 pp. + Appendix A + diskette.

Owens, T., and D. Olsen. 1993. Introduction to GIS: Using ARC/INFO on a UNIX platform. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, June 1993. EMTC 93-P004. 165 pp.

Richardson, L. A. H., and T. L. Clemment. 1993. A summary of water quality characteristics at selected habitat sites in Navigation Pool 8 of the Mississippi River from July 17, 1988, to December 31, 1990. Report by the Wisconsin Department of Natural Resources, Onalaska, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, June 1993. EMTC 93-S009. 21 pp. (NTIS #PB94-108255)

Scott, J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T. C. Edwards, Jr., J. Ulliman, and R. G. Wright. 1993. Gap analysis: A geographic approach to protection of biological diversity. Wildlife Monograph No. 123. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-R010. 41 pp.

Soong, T. W., and N. G. Bhowmik. 1991. Two-dimensional hydrodynamic modeling of a reach of the Mississippi River in Pool 19. Pages 900-905 *in* Richard M. Shane, editor. Hydraulic

Engineering. Proceedings of the 1991 National Conference of the Hydraulics Division of the American Society of Civil Engineers, Nashville, Tennessee, July 29-August 2, 1991. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R003. 6 pp. (NTIS #PB94-108990)

Soong, T. W., and N. G. Bhowmik. 1992. Characteristics of waves and drawdown generated by barge traffic on the Upper Mississippi River System. Pages 672-676 *in* Marshall Jennings and Nani G. Bhowmik, editors. Saving a Threatened Resource - In Search of Solutions. Proceedings, Water Forum '92, Hydraulic Engineering Sessions of the American Society of Civil Engineers, Baltimore, Maryland, August 2-6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R015. 5 pp. (NTIS #PB94-108966)

Soong, T. W., W. C. Bogner, and W. F. Reichelt. 1990. Data acquisition for determining the physical impacts of navigation. Pages 616-621 *in* Howard H. Chang and Joseph C. Hill, editors. Hydraulic Engineering. Volume 1, Proceedings, 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30-August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R009. 6 pp. (NTIS #PB94-108925)

U.S. Fish and Wildlife Service. 1992. Proceedings: Third National U.S. Fish and Wildlife Service Geographic Information Systems Workshop. Hosted by the Environmental Management Technical Center, Onalaska, Wisconsin, May 3-6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-R029. 279 pp.

U.S. Fish and Wildlife Service. 1993. Annual Work Plan, Fiscal Year 1994, for the Upper Mississippi River System Long Term Resource Monitoring Program. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1993. EMTC 93-P006. 95 pp.

Vohs, P. A., I. J. Moore, and J. S. Ramsey. 1993. A critical review of the effects of turbidity on aquatic organisms in large rivers. Report by Iowa State University, Ames, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-S002. 139 pp.

Waltermire, R. G. 1993. ARC/INFO to GRASS Conversion Manual. Report by TGS Technology, Inc., Fort Collins, Colorado, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-S001. 73 pp.

Waltermire, R. G. 1993. ARC/INFO to EPPL7: Converting ARC/INFO version 5 data on a Prime minicomputer to EPPL7 on a microcomputer. Report by TGS Technology, Inc., Fort Collins, Colorado, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-S011. 21 pp.

Wilcox, D. B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-T003. 9 pp. + Appendix A. (NTIS # PB93-208981)

Wilcox, D. B., and K. W. Willis. 1993. Identification of constraints on river regulation. Lock and Dam 9 near Lynxville, Wisconsin, Upper Mississippi River 9-Foot Channel Project. Report by the U.S. Army Corps of Engineers, St. Paul District-Minnesota, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1993. EMTC 93-S012. 91 pp. (NTIS # PB94-103603)

1992

Adams, J. R. 1992. Identification of study approaches to determine physical impacts of commercial navigation on the Upper Mississippi River System. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS 14-16-0003-80-973, November 1992. EMTC 92-S005. 11 pp. (NTIS #PB93-127694)

Bhowmik, N. G. 1992. Hydraulic changes in rivers due to navigation. Pages 10-22 to 10-40 *in* Proceedings, Fifth Federal Interagency Sedimentation Conference, March 18-21, 1991, Las Vegas, Nevada. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S020.

Bhowmik, N. G., and T. W. Soong. 1992. Waves generated by recreational traffic: Part I, Controlled Movement. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S013. 34 pp.

Bhowmik, N. G., and T. W. Soong. 1992. Waves generated by recreational traffic: Part II, Uncontrolled Movement. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S016. 24 pp.

Bhowmik, N. G., T. W. Soong, W. F. Reichelt, and N. M. L. Seddik. 1992. Waves generated by recreational traffic on the Upper Mississippi River System. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS14-16-0003-80-973, November 1992. EMTC 92-S003. 68 pp. (NTIS #PB92-161868)

Eckblad, J. 1992. Sampling the dominant benthic macroinvertebrates of Mississippi River backwater lakes. Report by Luther College, Decorah, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S014. 13 pp.

Gutreuter, S. 1992. Systemic features of fisheries of the Upper Mississippi River System, 1990 fisheries component annual report. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, October 1992. EMTC 92-T001. 42 pp. (NTIS #PB93126431)

Illinois State Water Survey. 1992. Bibliographical materials related to navigation project. Materials compiled by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S012. 5 pp. (NTIS #PB94-109113)

Langrehr, H. A. 1992. Summary of vegetation sampling for selected transects in Pool 8, Upper Mississippi River System, 1990. Annual report by the Wisconsin Department of Natural Resources, Onalaska, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental

Management Technical Center, Onalaska, Wisconsin, October 1992. EMTC 92-S001. 29 pp. (NTIS # PB94-103728)

Oberfoell, G. A. 1992. The use of geographic information systems to develop applications for the analysis of fisheries telemetry data. Report by St. Mary's College, Winona, Minnesota, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S037. 38 pp. (NTIS #PB94-109097)

Peitzmeier-Romano, S., K. D. Blodgett, and R. E. Sparks. 1992. Summary of vegetation sampling for selected transects of La Grange Pool, Illinois River, 1990. Report by the Illinois Natural History Survey, Havana, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, November 1992. EMTC 92-S007. 34 pp. (NTIS #PB94-109477)

Roseboom, D. P., R. M. Twait, and T. E. Hill. 1992. Physical characteristics of sediment and habitat affecting aquatic plant distribution in the Upper Mississippi River System: FY 90. Report by the Illinois State Water Survey, Peoria, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S011. 77 pp.

Schellhaass, S. M., and H. A. Langrehr. 1992. A summary of water quality characteristics at selected habitat sites in Navigation Pool 8 of the Mississippi River for 1 January-30 December 1989. Report by the Wisconsin Department of Natural Resources, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S022. 47 pp. (NTIS # PB94-103538)

Shay, T. A., and R. D. Gent. 1992. Summary of vegetation sampling for selected transects in Pool 13, 1990. Report by the Iowa Department of Natural Resources, Bellevue, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, November 1992. EMTC 92-S015. 26 pp. (NTIS #PB94-109261)

U.S. Fish and Wildlife Service. 1992. Abstracts, First Annual Field Station Meeting, Cape Girardeau, Missouri, April 14-15, 1992. Environmental Management Technical Center, Onalaska, Wisconsin. 16 pp.

U.S. Fish and Wildlife Service. 1992. Annual Work Plan for the Upper Mississippi River System Long Term Resource Monitoring Program, Fiscal Year 1993. Environmental Management Technical Center, Onalaska, Wisconsin, October 1992. EMTC 92-P001. 65 pp.

U.S. Fish and Wildlife Service. 1992. Information Management Plan. Environmental Management Technical Center, Onalaska, Wisconsin, January 1992. EMTC 91-08. 39 pp. (NTIS # PB92-162429/AS)

U.S. Fish and Wildlife Service. 1992. Journal articles published 1991 to date and presentations January-May 1992. Environmental Management Technical Center, Onalaska, Wisconsin. 54 pp.

U.S. Fish and Wildlife Service. 1992. 1992 Annual Field Station Meeting Summary, Cape Girardeau, Missouri, April 14-15, 1992. Environmental Management Technical Center, Onalaska, Wisconsin. 10 pp.

U.S. Fish and Wildlife Service. 1992. Operating Plan for the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin, August 1992. EMTC 91-P002. 183 pp.

1991

Anderson, R. V., J. W. Grubaugh, and D. B. Markillie. 1991. Summary of water quality characteristics at selected habitat sites - Navigation Pool 26 of the Mississippi River, July 17 through October 31, 1988. Report by Western Illinois University, Macomb, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1991. EMTC 91-01. 48 pp. (NTIS # PB91 174128)

Eckblad, J. W. 1991. LTRMP Observational Bulletin No. 1. Status of macroinvertebrate populations of the Upper Mississippi River. Report by Luther College, Decorah, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1991. EMTC 91-03. 8 pp. (NTIS # PB91-197863)

Laustrup, M. S., and J. H. Wlosinski. 1991. Guidelines for the collection of spatial data for the Upper Mississippi River. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1991. EMTC 91-06. 35 pp. (NTIS # PB91-235937)

U.S. Army Corps of Engineers. 1991. Identification of constraints on regulation of Upper Mississippi River System Lock and Dam 18. Report by the U.S. Army Corps of Engineers, Rock Island, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1991. EMTC 91-07. 54 pp. (NTIS # PB92 104728)

U.S. Fish and Wildlife Service. 1991. Draft Fiscal Year 1992 Annual Work Plan for the Long Term Resource Monitoring Program, Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1991. 50 pp.

White, B. M., and T. W. Owens. 1991. Geographic information system pilot project for the Upper Mississippi River System. Report by the U.S. Fish and Wildlife Service, National Ecology Research Center, and TGS Technology, Inc., Fort Collins, Colorado, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, June 1991. EMTC 91-05. 48 pp. (NTIS # PB91-218172)

1990

Belanger, K. D., D. J. Dieterman, and T. W. Deyo. 1990. Pre- and post-construction water quality monitoring for Habitat Rehabilitation and Evaluation Projects at Big Lake Bay, Finger Lakes, Lake Onalaska, and the Pool 8 islands area of the Upper Mississippi River. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-04. 17 pp. (NTIS # PB91-106385)

Gent, R. D., M. Griffin, and S. Gritters. 1990. Summary of water quality characteristics at selected habitat sites - Navigation Pool 13 of the Mississippi River, August 1 through October 31, 1988. Report by the Iowa Department of Natural Resources, Bellevue, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-02. 21 pp. (NTIS # PB91-105338)

Hawkins, Jr., A. S., and J. L. Stewart. 1990. Pilot project on the Middle Branch Whitewater Watershed 1990. Report by the U.S. Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota, for the U.S. Fish and Wildlife Service, Environmental

Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-03. 34 pp. (NTIS # PB91-122655)

Korschgen, C. E. 1990. Feasibility study: Impacts of turbidity on growth and production of submersed plants. Report by the U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, November 1990. EMTC 90-07. 11 pp. (NTIS # PB91135475)

Owens, T. 1990. Vegetation workshop - Aerial photography interpretation. Manual by TGS Technology, Inc., Fort Collins, Colorado, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, November 1990. 31 pp. (NTIS #PB94-108958)

Owens, J., and W. G. Crumpton. 1990. Pilot study to evaluate an inexpensive, portable device to continuously monitor dissolved oxygen, water temperature, and photosynthetically active radiation in Upper Mississippi River System backwaters. Report by the Iowa State University, Ames, Iowa, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, October 1990. EMTC 90-06. 19 pp. (NTIS # PB91106070)

Schellhaass, S. M., and G. L. Benjamin. 1990. Summary of water quality characteristics at selected habitat sites - Navigation Pool 8 of the Mississippi River, July 17 through October 31, 1988. Report by the Wisconsin Department of Natural Resources, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-01. 19 pp. (NTIS # PB90-267394)

U.S. Fish and Wildlife Service. 1990. Long Term Resource Monitoring Program Annual Work Plan for Fiscal Year 1991. Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. 12 pp. + 4 attachments.

U.S. Fish and Wildlife Service. 1990. Revised Procedures Manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03. 216 pp.

U.S. Fish and Wildlife Service. 1990. Second annual report 1989. Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-05. 267 pp. (NTIS # PB91-117317)

1989

Ahearn, S. C., R. D. Martin, and J. H. Wlosinski. 1989. Recommendations for estimating suspended solids in the Upper Mississippi River System using remote sensing. Report by the University of Minnesota, St. Paul, Minnesota, and the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1989. EMTC 89-01. 23 pp. (NTIS # PB89 236715/AS)

Bhowmik, N. G., T. W. Soong, and W. C. Bogner. 1989. Impacts of barge traffic on waves and suspended sediments: Ohio River at River Mile 581. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS 14-16-0003-88-973, March 1989. EMTC 89-05 (October 1989). 99 pp. (NTIS # PB90 133513/AS)

Millar, J. D., and M. S. Mahaffy. 1989. Background study on the environmental impacts of barge fleeting. Report by the U.S. Fish and Wildlife Service, Rock Island Field Office, Rock Island, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1989. EMTC 89-04. 49 pp. (NTIS # PB90 133595/AS)

U.S. Fish and Wildlife Service. 1989. First annual report of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin, January 1989. EMTC 89-02. 130 pp. (NTIS # PB91 174102)

U.S. Fish and Wildlife Service. 1989. Revised Procedures Manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03. 216 pp.

1988

Bogner, W. C., T. W. Soong, and N. G. Bhowmik. 1988. Physical impacts of navigation: Ohio River field data collection. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1988. EMTC 88-02. 32 pp. (NTIS # PB89 126510/AS)

Lubinski, K. S., and J. L. Rasmussen. 1988. Procedures Manual of the Long Term Resource Monitoring Program for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 88-03. 216 pp.

Rasmussen, J. L., and J. H. Wlosinski. 1988. Operating Plan of the Long Term Resource Monitoring Program for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1988. EMTC 88-01. 55 pp. (NTIS # PB88 169669/AS)

1987

PIA Work Group. 1987. Problem identification and analysis report. Report submitted to the Environmental Management Coordinating Committee, March 18, 1987. 58 pp.

U.S. Fish and Wildlife Service. 1987. Action Plan Report - Integrated Data Management System (IDMS). Report prepared by the U.S. Fish and Wildlife Service, March 10, 1987. 31 pp.

U.S. Fish and Wildlife Service. 1987. Environmental Management Program, Resource Trend Analysis Action Plan Report. Environmental Management Technical Center, La Crosse, Wisconsin, March 1987. 87 pp.

Table C-1. Schedule of Products

		EARLY ACTIONS FY86/87	FY88	FY89	FY90	FY91	OUT YEARS FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY2000	FY2001	FY2002
GOAL 1	**Develop Better Understanding**																
Obj. 1.1	Plan Ecological Research																
Strat. 1.1.1	Describe ecosystem																
Task 1.1.1.1	Initial description	R(1,2)		R(4)		R(25)											
Task 1.1.1.2	Conceptual model with updates					CM		CM(u)			CM(u)			CM(u)			CM(u)
Strat. 1.1.2	Selection of priority problems for research																
Task 1.1.2.1	Initial selection of priority problems	R(2)		R(4)		R(25)											
Obj. 1.2	Implement ecological research																
Strat. 1.2.1	Sedimentation research																
Task 1.2.1.1	Develop strategic model			X	X	SM		SM(u)			SM(u)			SM(u)			SM(u)
Task 1.2.1.2	Select relationships for research	IR	IR	IR	R(15)	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP
Task 1.2.1.3	Establish experimental design	S	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT
Task 1.2.1.4	Conduct research	X	X	R(9)	R(21,22)	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E
Strat. 1.2.2	Navigation research																
Task 1.2.2.1	Review POS Work Units				X	X	X	X	X	X	X	X	X	X	X	X	X
Task 1.2.2.2	Develop strategic model			X	X	SM		SM(u)			SM(u)			SM(u)			SM(u)
Task 1.2.2.3	Select relationships for research	IR	IR	IR	R(15)	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP
Task 1.2.2.4	Establish experimental design	S	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT
Task 1.2.2.5	Conduct research		R(5)	R(11,12)	X	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E	R,E
Strat. 1.2.3	Water level research																
Task 1.2.3.1	Develop strategic model			X	X	SM		SM(u)			SM(u)			SM(u)			SM(u)
Task 1.2.3.2	Select relationships for research				IR	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP	IR,WP
Task 1.2.3.3	Establish experimental design				S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT	S,CT
Task 1.2.3.4	Conduct research				X	R	R	R	R	R	R	R	R	R	R	R	R
Obj. 1.3	Identify and investigate additional problems																
Strat. 1.3.1	Review updates of conceptual model																
Task 1.3.1.1	Review conceptual model						R	R(u)	R(u)	R(u)	R(u)	R(u)	R(u)	R(u)	R(u)	R(u)	R(u)
Strat. 1.3.2	Select new problems for research																
Task 1.3.2.1	Develop strategic model(s)						SM?	SM?	SM?	SM?	SM?	SM?	SM?	SM?	SM?	SM?	SM?
Task 1.3.2.2	Select relationships for research						IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?	IR,WP?
Task 1.3.2.3	Establish experimental design						S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?	S,CT?
Task 1.3.2.4	Conduct research						R?	R?	R?	R?	R?	R?	R?	R?	R?	R?	R?

Legend: CA = Cooperative Agreement; CM = Conceptual Model; CT = Contract; DS = Data Set; E = Equation; IR = Interagency Review; M = Maps; PM = Procedures Manual; R = Report; S = Scope of Work; SM = Strategic Model; TM = Trend Model; (u) = Update; WP = Annual Work Plan; X = Execute; ? = If Necessary

Table C-1, Continued

		EARLY ACTIONS										OUT YEARS					
		FY86/87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY2000	FY2001	FY2002
GOAL 2	Monitor Resource Change																
Obj. 2.1	Develop resource monitoring plan																
Strat. 2.1.1	Select components and reaches																
Task 2.1.1.1	Select resource components	R(1)	R(4)														
Task 2.1.1.2	Select trend analysis reaches	R(1)	R(4)				R(u)										
Obj. 2.2	Implement monitoring program																
Strat. 2.2.1	Monitor and eval. floodplain elevation																
Task 2.2.1.1	Develop trend model						TM			TM(u)			TM(u)			TM(u)	
Task 2.2.1.2	Establish design		IR,PM(u)				IR,PM(u)										
Task 2.2.1.3	Obtain historical monitoring data				DS		X										
Task 2.2.1.4	Conduct monitoring			M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS
Task 2.2.1.5	Evaluate and summarize results			M,DS	M,DS,R	M,DS	M,DS,R	M,DS,R	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS	M,DS,R
Task 2.2.1.6	Eval. and refine exp. design																
Strat. 2.2.2	Obtain and eval. discharge and water elevation					X		R,IR			R,IR						
Task 2.2.2.1	Develop trend model						TM			TM(u)			TM(u)			TM(u)	
Task 2.2.2.2	Obtain historical data					DS	R										
Task 2.2.2.3	Obtain current data						DS,R	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
Task 2.2.2.4	Eval. and summarize annual results						R	R	R	R	R	R	R	R	R	R	R
Task 2.2.2.5	Develop GIS water surface data base							M,R									
Strat. 2.2.3	Monitor and eval. water quality																
Task 2.2.3.1	Develop trend model						TM			TM(u)			TM(u)			TM(u)	
Task 2.2.3.2	Establish experimental design			R(6,7,8),IR			IR,PM(u)										
Task 2.2.3.3	Obtain historical monitoring data						DS	DS	DS								
Task 2.2.3.4	Conduct current monitoring		CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS	CA(u)DS
Task 2.2.3.5	Eval. and summarize historical data								X	X	R						
Task 2.2.3.6	Eval. and summarize current results			R		R R(16,17,24)	R	R	R	R	R	R	R	R	R	R	R
Task 2.2.3.7	Eval. and refine exp. design					R	R										
Task 2.2.3.8	Eval. and summarize 5-year trends							R					R				
Strat. 2.2.4	Monitor and eval. aq. and terr. vegetation																
Task 2.2.4.1	Develop trend model					TM			TM(u)			TM(u)			TM(u)		
Task 2.2.4.2	Establish experimental design			R(6,7,13),IR		IR,PM(u)	R										
Task 2.2.4.3	Obtain and evaluate historical information						DS	DS	DS,R								
Task 2.2.4.4	Produce spatial data bases			M	R				M(u)					M(u)			
Task 2.2.4.5	Conduct annual monitoring			DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)	DS,CA(u)
Task 2.2.4.6	Eval. and summarize annual results				R	R,M	R,M	R,M	R,M	R,M	R,M	R,M	R,M	R,M	R,M	R,M	R,M
Task 2.2.4.7	Eval. and refine exp. design				R			R									
Task 2.2.4.8	Evaluate and summarize 5-year trends								R					R			
Strat. 2.2.5	Monitor and eval. sediment composition																
Task 2.2.5.1	Develop trend model						TM			TM(u)			TM(u)		TM(u)		
Task 2.2.5.2	Establish experimental design						IR,PM		IR,PM(u)								
Task 2.2.5.3	Obtain historical/present monitoring data					DS	DS,M	DS,M	DS,M	DS,M	DS,M	DS,M					
Task 2.2.5.4	Eval. and summarize results							DS,R					DS,R				
Task 2.2.5.5	Eval. and refine exp. design							R									

Legend: CA = Cooperative Agreement; CM = Conceptual Model; CT = Contract; DS = Data Set; E = Equation; IR = Interagency Review; M = Maps; PM = Procedures Manual; R = Report; S = Scope of Work; SM = Strategic Model; TM = Trend Model; (u) = Update; WP = Annual Work Plan; X = Execute; ? = If Necessary

Table C-1. Continued

		EARLY ACTIONS FY86/87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	OUT YEARS FY97	FY98	FY99	FY2000	FY2001	FY2002
GOAL 2	Monitor Resource Change (continued)																
Strat. 2.2.6	Monitor and eval. aq. and floodplain habitat																
Task 2.2.6.1	Develop trend model					TM			TM(u)			TM(u)			TM(u)		
Task 2.2.6.2	Establish experimental design				R		PM,R,IR			PM(u),IR							
Task 2.2.6.3	Obtain and evaluate historical information									M	R,M	M	M	M,R	M	M	M,R
Task 2.2.6.4	Produce a spatial data base						M		X			DS					
Task 2.2.6.5	Evaluate and summarize change in habitat				M	M	M	M	M	M,R	M,R	M,R	M,R	M,R	M,R	M,R	M,R
Task 2.2.6.6	Refine and update the data base						M	M(u)	M(u)	M(u)	M(u)	M(u)	M(u)	M(u)	M(u)	·M(u)	M(u)
Strat. 2.2.7	Monitor and eval. macroinvertebrates																
Task 2.2.7.1	Develop trend model						TM			TM(u)			TM(u)			TM(u)	
Task 2.2.7.2	Establish experimental design					R(26)	IR,PM			IR,PM(u)							
Task 2.2.7.3	Conduct annual monitoring					DS	DS	CA,DS	CA,(u),DS	CA(u).DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(U0,DS	CA(u),DS	CA(u),DS
Task 2.2.7.4	Evaluate and summarize annual results							R	R	R	R	R	R	R	R	R	R
Task 2.2.7.5	Evaluate and refine exp. design							R	R								
Task 2.2.7.6	Evaluate and summarize 5-year trends										R					R	
Strat. 2.2.8	Monitor and eval. fish																
Task 2.2.8.1	Develop trend model						TM			TM(u)			TM(u)			TM(u)	
Task 2.2.8.2	Establish experimental design			R(6,7,14),IR			IR,PM(u)										
Task 2.2.8.3	Conduct annual monitoring			CA,DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS	CA(u),DS
Task 2.2.8.4	Evaluate and summarize annual results				R	R	R	R	R	R	R	R	R	R	R	R	R
Task 2.2.8.5	Evaluate and refine exp. design					R											
Task 2.2.8.6	Evaluate and summarize 5-year trends							R					R				
Task 2.2.8.7	Calibrate sampling gears							R	R	R	R						
Strat. 2.2.9	Monitor and eval. wildlife																
Task 2.2.9.1	Develop trend model						TM	DS	DS	TM(u)	DS	DS	TM(u)	DS	DS	TM(u)	DS
Task 2.2.9.2	Establish experimental design						PM,IR			PM(u),IR							
Task 2.2.9.3	Conduct annual monitoring						DS	DS	DS	DS	DS	DS	DS	DS	DS	DS	DS
Task 2.2.9.4	Evaluate and summarize annual results						M,R	M,R	M,R	M,R	M,R	M,R	M,R	M,R	M,R	M,R	M,R
Task 2.2.9.5	Evaluate and refine exp. design								R								
Strat. 2.2.10	Monitor and eval. public use																
Task 2.2.10.1	Develop trend model						TM			TM(u)			TM((u)			TM(u)	
Task 2.2.10.2	Establish experimental design						PM,IR			PM(u),IR							
Task 2.2.10.3	Conduct monitoring					DS					DS					DS	
Task 2.2.10.4	Evaluate and summarize results						R					R					R
Task 2.2.10.5	Evaluate and refine experimental design							R									
Obj. 2.3	Synthesize and evaluate monitoring data																
Strat. 2.3.1	Multi-component syntheses																
Task 2.3.1.1	Develop multi-component trend model(s)						TM			TM(u)			TM(u)			TM(u)	
Task 2.3.1.2	Evaluate and summarize results						R	R	R	R	R	R	R	R	R	R	R
Strat. 2.3.2	Evaluate and refine monitoring design																
Task 2.3.2.1	Evaluate value of component						R			R			R				R
Task 2.3.2.2	Modify components or designs						R			R			R				R

Legend: CA = Cooperative Agreement; CM = Conceptual Model; CT = Contract; DS = Data Set; E = Equation; IR = Interagency Review; M = Maps; PM = Procedures Manual; R = Report; S = Scope of Work; SM = Strategic Model; TM = Trend Model; (u) = Update; WP = Annual Work Plan; X = Execute; ? = If Necessary

Table C-1. Continued

		EARLY ACTIONS FY86/87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	OUT YEARS FY96	FY97	FY98	FY99	FY2000	FY2001	FY2002
GOAL 3	Develop Alternatives to Better Manage. . .																
Obj. 3.1	Develop alternative management objectives																
Task 3.1.1	Identify constraints on implementation	R(3)				R	R,M	R	R	R,M	R	R	R,M	R	R	R,M	R
Task 3.1.2	Identify river user expectations							R									
Task 3.1.3	Predict future conditions without change							R	R	R	R	R	R	R	R	R	R
Task 3.1.4	Identify levels for future consumptive use								R								
Task 3.1.5	Identify alternative management objectives										R						
Task 3.1.6	Identify future conditions												R				
Obj. 3.2	Formulate management alternatives																
Task 3.2.1	Prepare management alternatives					X	X	X	X	X	X	X	X	X	X	X	X
Obj. 3.3	Evaluate management alternatives																
Task 3.3.1	Test and assess prototype management					X	X	R	R	R	R	R	R	R	R	R	R
Task 3.3.2	Evaluate and compare management alternatives								R	R	R	R	R	R	R	R	R
GOAL 4	Provide Proper Information Management																
Obj. 4.1	Provide direction for automation activities																
Strat. 4.1.1	Develop and update information systems plan																
Task 4.1.1.1	Prepare information systems plan				R												
Task 4.1.1.2	Refine and update plan					R	R	R	R	R	R	R	R	R	R	R	R
Obj. 4.2	Provide needed automation tools																
Strat. 4.2.1	Acquire and maintain equipment																
Task 4.2.1.1	Modify and replace equipment	X	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)
Task 4.2.1.2	Develop network and comm. systems				X	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)
Task 4.2.1.3	Maintain automation equipment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Obj. 4.3	Ensure proper data management																
Strat. 4.3.1	Dev. a geographic information system																
Task 4.3.1.1	Develop GIS	X	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)
Task 4.3.1.2	Adapt standards for data acq. and storage	R(13)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)
Obj. 4.4	Provide access to collected data																
Strat. 4.4.1	Dev. info. sharing and tech. transfer system																
Task 4.4.1.1	Publish and distribute LTRMP reports	X	X	R(10)	R(20)	R(25)	X	X	X	X	X	X	X	X	X	X	X
Task 4.4.1.2	Publish in journals and host meetings			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 4.4.1.3	Dev. programs to query and retrieve data	X	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)
Task 4.4.1.4	Training in use of automation tools	X	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)	X(u)

Legend: CA = Cooperative Agreement; CM = Conceptual Model; CT = Contract; DS = Data Set; E = Equation; IR = Interagency Review; M = Maps; PM = Procedures Manual; R = Report; S = Scope of Work; SM = Strategic Model; TM = Trend Model; (u) = Update; WP = Annual Work Plan; X = Execute; ? = If Necessary

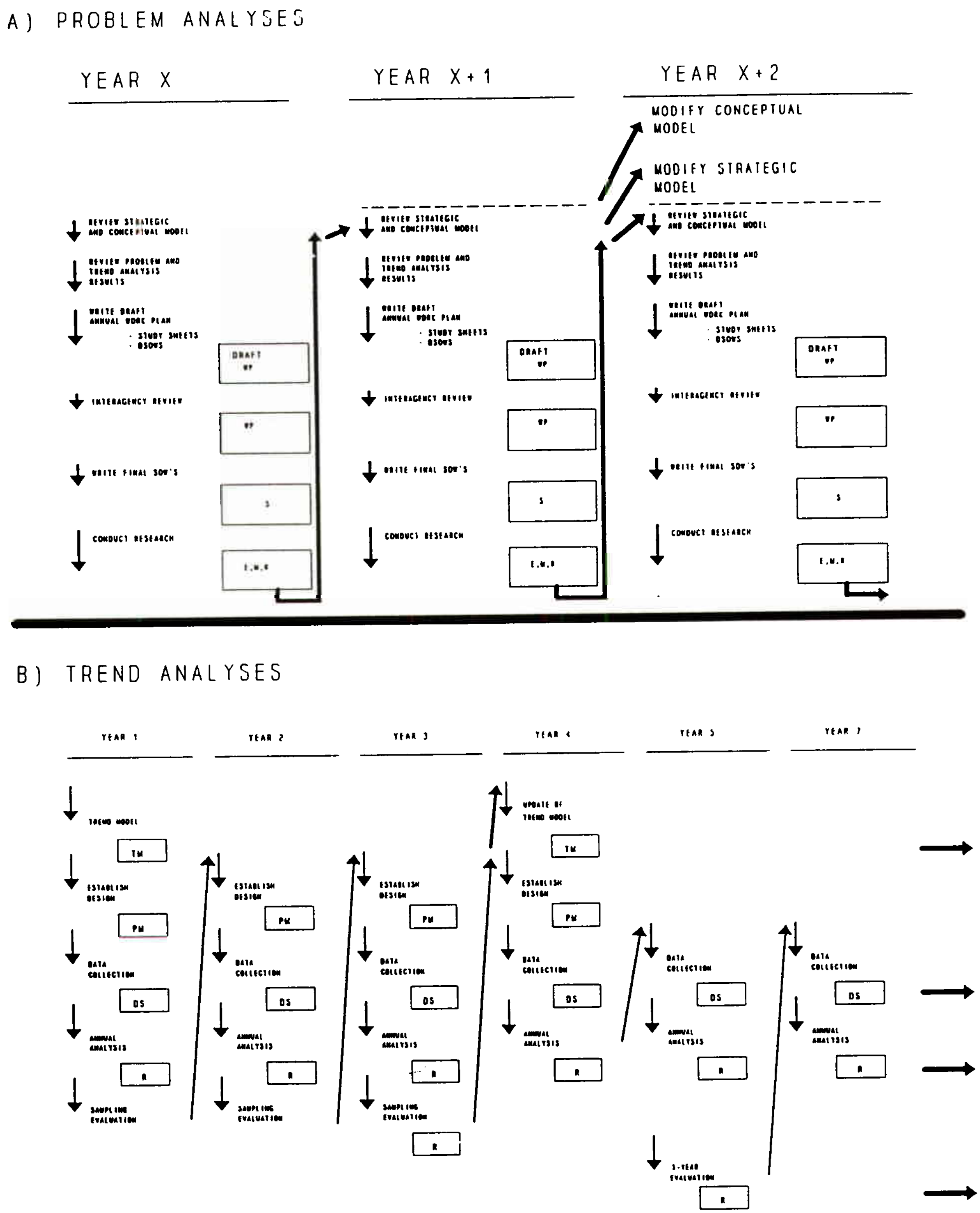


Figure C-1. Typical decision-making and product cycles associated with (A) problem analyses and (B) trend analyses. Products (in boxes) are coded as follows: DS = data set, E = equation, M = map, PM = procedures manual, R = reports, S = Scope of Work, TM = trend model, WP = Annual Work Plan

Appendix D
Annual and Program Period Budgets

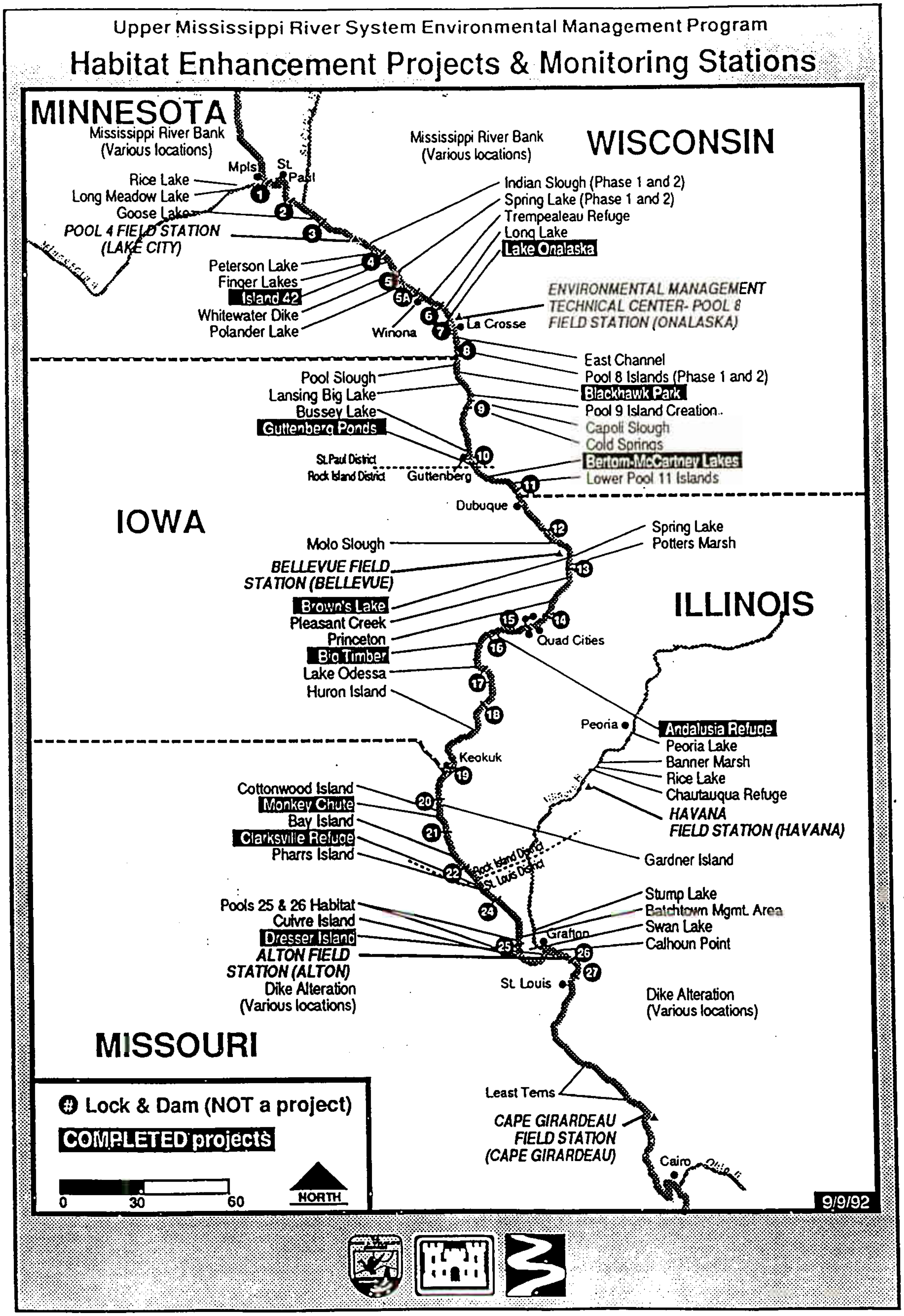
Table D-1 specifies the estimated budget projections by goal, objective, and strategy. Table D-1 will be annually updated after preparation of a yearly annual work plan.

Table D-1. Estimated budget projections by goal, objective, and strategy - this table will be updated yearly

		THROUGH FY92	FY93	THROUGH FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	TOTAL
GOAL 1	Develop Better Understanding													
Obj.1 .1	Plan Ecological Research													
Strat.1 .1 .1	Describe ecosystem	50.0		50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0
Strat.1 .1 .2	Selection of priority problems for research	30.0		30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
Obj.1 .2	Implement ecological research													
Strat.1 .2 .1	Sedimentation research	580.3	154.9	735.2	127.5	127.5	127.5	127.5	127.5	127.5	127.5	127.5	127.5	1882.7
Strat.1 .2 .2	Navigation research	2419.5	53.9	2473.4	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	2912.6
Strat.1 .2 .3	Water level research	159.7	60.6	220.3	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	77.4	916.9
Obj.1 .3	Identify and investigate additional problems													
Strat.1 .3 .1	Review updates of conceptual model	20.0		20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Strat.1 .3 .2	Select new problems for research	24.0	299.5	323.5	333.9	333.9	333.9	333.9	333.9	333.9	333.9	333.9	333.9	3328.6
SUBTOTALS		3283.5	568.9	3852.4	587.6	587.6	587.6	587.6	587.6	587.6	587.6	587.6	587.6	9140.8
GOAL 2	Monitor Resource Change													
Obj.2 .1	Develop resource monitoring plan													
Strat.2 .1 .1	Select components and reaches	30.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
Obj.2 .2	Implement monitoring program													
Strat.2 .2 .1	Monitor and eval. floodplain elevation	787.0	163.6	950.6	110.5	110.5	110.5	110.5	110.5	110.5	110.5	110.5	110.5	1945.1
Strat.2 .2 .2	Obtain and eval. discharge and water elevation	81.7	24.5	106.2	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	294.3
Strat.2 .2 .3	Monitor and eval. water quality	3289.4	1005.6	4295.0	1120.0	1120.0	1120.0	1120.0	1120.0	1120.0	1120.0	1120.0	1120.0	14375.0
Strat.2 .2 .4	Monitor and eval. aq. and terr. vegetation	2055.8	511.5	2567.3	709.9	709.9	709.9	709.9	709.9	709.9	709.9	709.9	709.9	8956.4
Strat.2 .2 .5	Monitor and eval. sediment composition	401.9	35.6	437.5	109.2	109.2	109.2	109.2	109.2	109.2	109.2	109.2	109.2	1420.3
Strat.2 .2 .6	Monitor and eval. aq. and floodplain habitat	277.3	97.6	374.9	131.3	131.3	131.3	131.3	131.3	131.3	131.3	131.3	131.3	1556.6
Strat.2 .2 .7	Monitor and eval. macroinvertebrates	515.1	202.0	717.1	163.9	163.9	163.9	163.9	163.9	163.9	163.9	163.9	163.9	2192.2
Strat.2 .2 .8	Monitor and eval. fish	2563.1	796.5	3359.6	959.1	959.1	959.1	959.1	959.1	959.1	959.1	959.1	959.1	11991.5
Strat.2 .2 .9	Monitor and eval. wildlife	5.0	9.4	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.4
Strat.2 .2 .10	Monitor and eval. public use	71.9	0.0	71.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.9
Obj.2 .3	Synthesize and evaluate monitoring data													
Strat.2 .3 .1	Multi-component syntheses	65.8	36.9	102.7	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	492.4
Strat.2 .3 .2	Evaluate and refine monitoring design	30.0		30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0
SUBTOTALS		10174.0	2883.2	13057.2	3368.1	3368.1	3368.1	3368.1	3368.1	3368.1	3368.1	3368.1	3368.1	43370.1
GOAL 3	Develop Alternatives to Better Manage...													
Obj. 3 .1	Develop alternative management objectives	10.0		10.0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	48.7
Obj. 3 .2	Formulate management alternatives	10.0		10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
Obj. 3 .3	Evaluate management alternatives	102.8	182.3	285.1	296.9	296.9	296.9	296.9	296.9	296.9	296.9	296.9	296.9	2957.2
SUBTOTALS		122.8	182.3	305.1	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	301.2	3015.9
GOAL 4	Provide Proper Information Management													
Obj. 4 .1	Provide direction for automation activities													
Strat. 4 .1 .1	Develop and update information systems plan	143.6	59.3	202.9	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	1025.5
Obj. 4 .2	Provide needed automation tools													
Strat. 4 .2 .1	Acquire and maintain equipment	3578.0	524.5	4102.5	136.8	136.8	136.8	136.8	136.8	136.8	136.8	136.8	136.8	5333.7
Obj. 4 .3	Ensure proper data management													
Strat. 4 .3 .1	Dev. a geographic info. system	1523.4	471.1	1994.5	463.0	463.0	463.0	463.0	463.0	463.0	463.0	463.0	463.0	6161.5
Obj. 4 .4	Provide access to collected data													
Strat. 4 .4 .1	Dev. info. sharing and tech. transfer system	297.6	214.1	511.7	303.4	303.4	303.4	303.4	303.4	303.4	303.4	303.4	303.4	3242.3
SUBTOTALS		5542.6	1269.0	6811.6	994.6	994.6	994.6	994.6	994.6	994.6	994.6	994.6	994.6	15763.0
GOAL 5	EMTC and Field Station Administration Expenses *	2603.1	954.7	3557.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3557.8
SUBTOTALS		2603.1	954.7	3557.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3557.8
TOTALS		21726.0	5858.1	27584.1	6261.5	6261.5	6261.5	6261.5	6261.5	6261.5	6261.5	6261.5	6261.5	74847.6

* Original Operating Plan Table D2 included field station administration expenses ($450,000) dispersed over Goal 2 Strategies. In Fiscal Year 1994 and beyond, Goal 5 costs have been distributed throughout Goals 1 through 4.

Appendix E
Location and Habitat Rehabilitation and Enhancement Projects Map



Appendix F
Long Term Resource Monitoring Program Field Station Directory

September 1993

U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650
(608) 783-7550
FAX (608) 783-8058

Lake City Field Station

Minnesota Department of Natural Resources
1801 S. Oak Street
Lake City, MN 55041
(612) 345-3331
FAX (612) 345-3975
Team Leader - Walter Popp
Fisheries Specialist - Mark Stopyro
Fisheries/Water Quality Specialist - Steve DeLain
Vegetation Specialist - Kristine Kruse
Water Quality Specialist - Robert Burdis

Bellevue Field Station

Iowa Department of Natural Resources
Mississippi River Monitoring Station
206 Rose Street
Bellevue, IA 52031
(319) 872-5495
FAX (319) 872-5456
Team Leader - Russ Gent
Fisheries Specialist - Michael Griffin
Fisheries Specialist - Scott Gritters
Vegetation Specialist - Theresa Blackburn
Water Quality Specialist - David Gould
Water Quality Specialist - Michael Steuck

Havana Field Station

Illinois Natural History Survey
LTRMP Havana Field Station
704 N. Schrader Avenue
Havana, IL 62644
(309) 543-6000
FAX (309) 543-2105
Team Leader - K. Douglas Blodgett
Water Quality Specialist - Steven Stenzel
Water Quality Technician - Rick Wright
Technical Assistant - Stephanie Edwards
Fisheries Specialist - Paul Raibley
Fisheries Technician - Matt O'Hara
Fisheries Technician - Kevin Irons
Vegetation Specialist - Andrew Spink

Onalaska Field Station

Wisconsin Department of Natural Resources
LTRMP Pool 8 Field Station
575 Lester Avenue
Onalaska, WI 54650
(608) 783-6169
Team Leader - Terry Dukerschein
Fisheries Specialist - Andy Bartels
Fisheries Technician - Steve Skemp
Vegetation Specialist - Heidi Langrehr
Water Quality Technician - Lisa Hodge Richardson
Water Quality Technician - Troy Clemment
Water Quality Specialist - Jim Fischer

Alton Field Station

Illinois Natural History Survey
LTRMP Pool 26 Field Station
1005 Edwardsville Road
Wood River, IL 62095
(618) 259-9027
FAX (618) 259-9456
Team Leader - Chuck Theiling
Data Entry Specialist - Brenda Plunk
Fisheries Specialist - Fred Cronin
Fisheries Technician - Dirk Soergel
HREP Fisheries Specialist - Rob Maher
HREP Fisheries Technician - Brad Kerans
HREP/Invertebrate Specialist - John Tucker
HREP Technician - J. B. Camerer
Technician - James Thatcher
Vegetation Specialist - John Nelson
Vegetation/GIS Technician - Anjela Redmond
Water Quality Specialist - Eric Ratcliff
Water Quality Technician - Mack Sitzes

Open River Field Station

Missouri Department of Conservation
2302 County Park Drive
Cape Girardeau, MO 63701-1842
(314) 290-5734 FAX (314) 290-5736
Team Leader - Robert Hrabik
Fisheries Biologist - Michael Petersen
Fisheries Specialist - David Herzog
Water Quality Biologist - Jennifer Frazier
Water Quality Specialist - Lesly Conaway

Appendix G
Science Review Committee

September 1993

Dr. P. Burrough
University of Utrecht
P.O. Box 80115
Utrecht 3508 TC, THE NETHERLANDS

Mr. James Callahan
National Science Foundation
Ecosystem Studies Program, Room 2115
1800 G Street, NW
Washington, DC 20550

Dr. Michael Church
University of British Columbia
Department of Geography
Vancouver, B.C., V6T 1W CANADA

Dr. Thomas Lillesand
Environmental Remote Sensing Center
1231 Meteorology and Space Science Bldg.
1225 W. Dayton Street, UW-Madison Campus
Madison, WI 53706

Dr. Geoffrey Petts
The University of Technology
Geography Department
Loughborough
Leicestershire, England LE3 IITU

Dr. Susan Stafford
Oregon State University
Department of Forest Science
Peavy Hall 154
Corvallis, OR 97331-5705

Dr. J. Ward
Colorado State University
Department of Biology
Fort Collins, CO 80523

Appendix H
Analysis Team

Members

September 1993

Mr. Bill Bertrand
Conservation Resource
Administrator
IL Department of Conservation
P.O. Box 149
Aledo, IL 61231

Mr. Tom Boland
IA Department of Natural
Resources
Bellevue Research Station
24143 Hwy 52
Bellevue, IA 52031

Mr. Gordon Farabee
MO Department of Conservation
Fisheries Division
P.O. Box 180
Jefferson City, MO 5102-0180

Mr. Tim Schlagenhaft
MN Department of Natural
Resources
Lake City Field Station
1801 S. Oak Street
Lake City, MN 55041

Ms. Pam Thiel
Project Leader
U.S. Fish and Wildlife Service
Fisheries Assistance Office
51 E. 4th Street, Room 101
Winona, MN 55987

Mr. John Wetzel
WI Department of Natural
Resources
State Office Building
3550 Mormon Coulee Road
La Crosse, WI 54601

Mr. Don Williams
Biologist
USACE-North Central Division
CENCD-PE-PD-PL
111 N. Canal Street
Chicago, IL 60606-7205

Mailing List

Mr. Al Ames
Great Lakes Region Director
U.S. Department of Transportation
Maritime Administration
2860 South River Road, Suite 185
Des Plaines, IL 60018-2413

Mr. Richard Astrack
GIS Coordinator
USACE-St. Louis District
1222 Spruce Street
St. Louis, MO 63103-2833

Mr. Ken Barr
Archaeologist
USACE-Rock Island District
Clock Tower Building
P.O. Box 2004
Rock Island, IL 61204-2004

Mr. Terry Birkenstock
GIS Coordinator
USACE-St. Paul District
190 Fifth Street East
St. Paul, MN 55101-1638

Mr. Steve Blanchard
U.S. Geological Survey
102 E. Main Street, 4th Floor
Urbana, IL 61801

Mr. K. Douglas Blodgett
Team Leader
IL Natural History Survey
LTRMP Havana Field Station
704 N. Schrader Avenue
Havana, IL 62644

Mr. Steve Cobb
USACE-LMVD
820 Crawford
Vicksburg, MS 39180-0080

Mr. William Donels
EMP Coordinator
IL Department of Conservation
Division of Planning
524 S. 2nd Street, Room 310
Springfield, IL 62701-1787

Ms. Terry Dukerschein
Team Leader
WI Department of Natural
Resources
Onalaska Field Station
575 Lester Avenue
Onalaska, WI 54650

Mr. Jon Duyvejonck
UMRCC Coordinator
U.S. Fish and Wildlife Service
Rock Island Field Office
4469 48th Avenue, Court
Rock Island, IL 61201

Mr. James Fisher
Complex Manager
U.S. Fish and Wildlife Service
Upper Mississippi River Complex
51 E. 4th Street, Room 101
Winona, MN 55987

Mr. Russ Gent
Team Leader
IA Department of Natural Resources
Mississippi River Monitoring Station
206 Rose Street
Bellevue, IA 52031

Mr. David Gross
IL State Geological Survey
615 E. Peabody Drive
Champaign, IL 61820-6970

Ms. Marlene Hanson
Congressman Steve Gunderson's Office
622 E. State Highway 54
P.O. Box 247
Black River Falls, WI 54615-0247

Mr. James Harrison
Public Affairs Director
MN/WI Boundary Area Commission
619 2nd Street
Hudson, WI 54016

Mr. Mark Heywood
MN Department of Natural Resources
P.O. Box 6247
Rochester, MN 55903

Mr. Robert Hrabik
Team Leader
MO Department of Conservation
Open River Field Station
2302 County Park Drive
Cape Girardeau, MO 63701-1842

Mr. Tom Keevin
USACE-St. Louis District
CELMS-PD-AE
1222 Spruce Street
St. Louis, MO 63103-2833

Mr. Rich Klukas
U.S. Park Service
Midwest Regional Office
1709 Jackson Street
Omaha, NE 68102

Mr. Michael Mac Mullen
Wetlands Coordinator
U.S. Environmental Protection Agency
77 W. Jackson Blvd.
Chicago, IL 60604

Mr. Rick Nelson
Field Supervisor
U.S. Fish and Wildlife Service
Rock Island Field Office
4469 48th Avenue, Court
Rock Island, IL 61201

Mr. Gary Nordstrom
State Conservationist
U.S. Department of Agriculture
Soil Conservation Service
600 FCS Building
375 Jackson Street
St. Paul, MN 55101-1854

Mr. Lance Perry
WI Department of Natural Resources
GEF 2 IM/8
P.O. Box 7921
Madison, WI 53707

Mr. Walt Popp
Team Leader
MN Department of Natural Resources
Lake City Field Station
1801 S. Oak Street
Lake City, MN 55041

Mr. Glenn Radde
MN Department of Natural Resources
500 Lafayette Street
Box 11, MIS Bureau
St. Paul, MN 55155-4011

Mr. Bernie Schonhoff
IA Department of Natural Resources
3390 Highway 22
Muscatine, IA 52761

Mr. Jerry Skalak
HREP/GIS Coordinator
USACE-Rock Island District
ATTN: CENCR-PD
Clock Tower Building
P.O. Box 2004
Rock Island, IL 61204-2004

Ms. Deb Southworth
U.S. Fish and Wildlife Service
Bishop Henry Whipple Federal Building
1 Federal Drive
Fort Snelling, MN 55111-4056

Dr. Richard Sparks
IL Natural History Survey
Forbes Biological Station
P.O. Box 590
Havana, IL 62644

Ms. Holly Stoerker
Executive Director
Upper Mississippi River Basin Association
415 Hamm Building
408 St. Peter Street
St. Paul, MN 55102

Mr. Robert Stratton
Complex Manager
U.S. Fish and Wildlife Service
Mark Twain National Wildlife Refuge
1704 N. 24th Street
Quincy, IL 62301

Mr. Norman Stucky
Environmental Coordinator
MO Department of Conservation
2901 N. Truman Boulevard
P.O. Box 180
Jefferson City, MO 65102

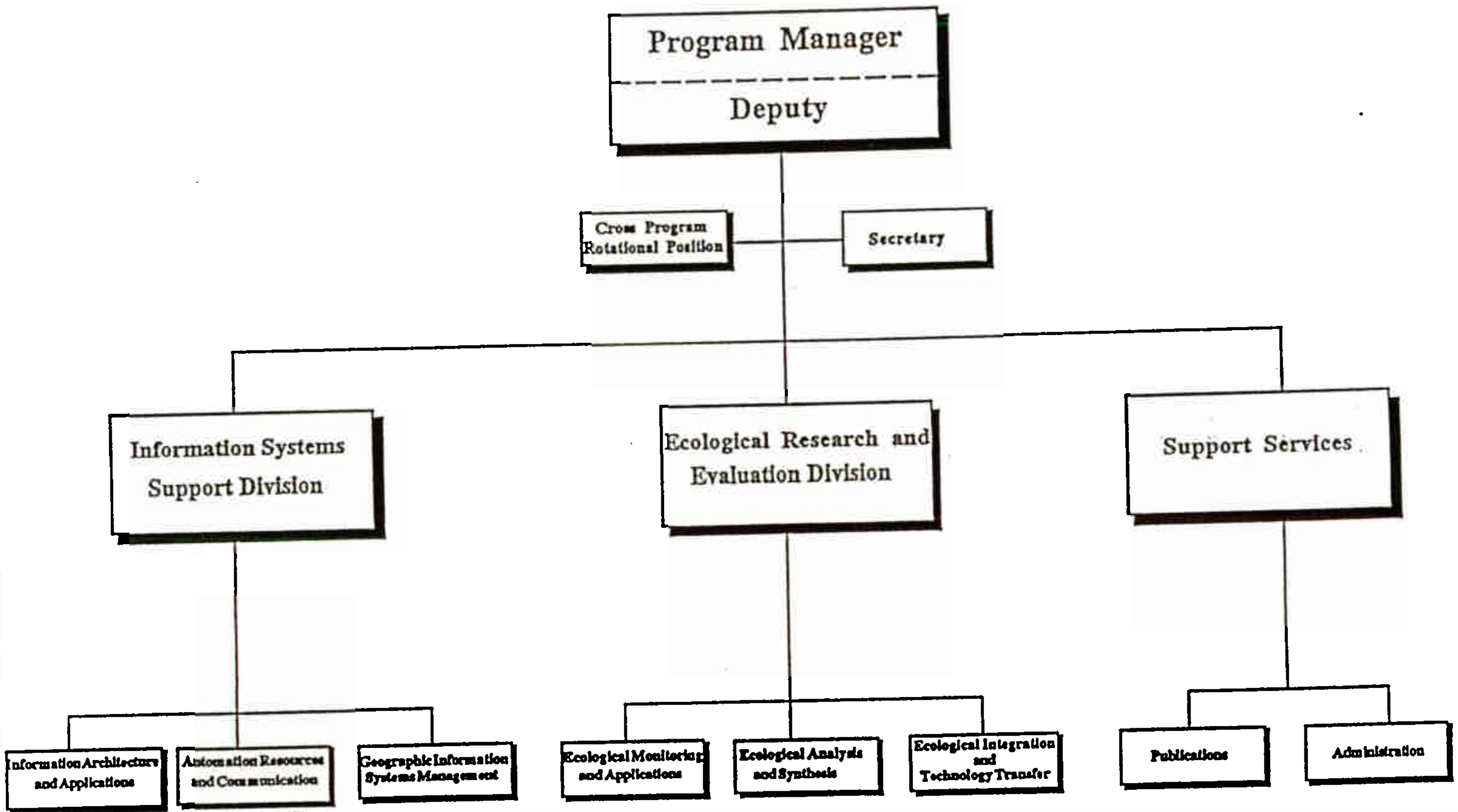
Mr. Ralph Swanson
U.S. Fish and Wildlife Service
Division of Ecological Services
4401 North Fairfax Drive
400 ARLSQ
Arlington, VA 2203

Mr. Charles Theiling
Team Leader
IL Natural History Survey
LTRMP Pool 26 Field Station
1005 Edwardsville Road
Wood River, IL 62095

Mr. Dan Wilcox
Fisheries Biologist
USACE-St. Paul District
Environmental Research
(CENCS-PD-ER)
190 Fifth Street East
St. Paul, MN 55101-1638

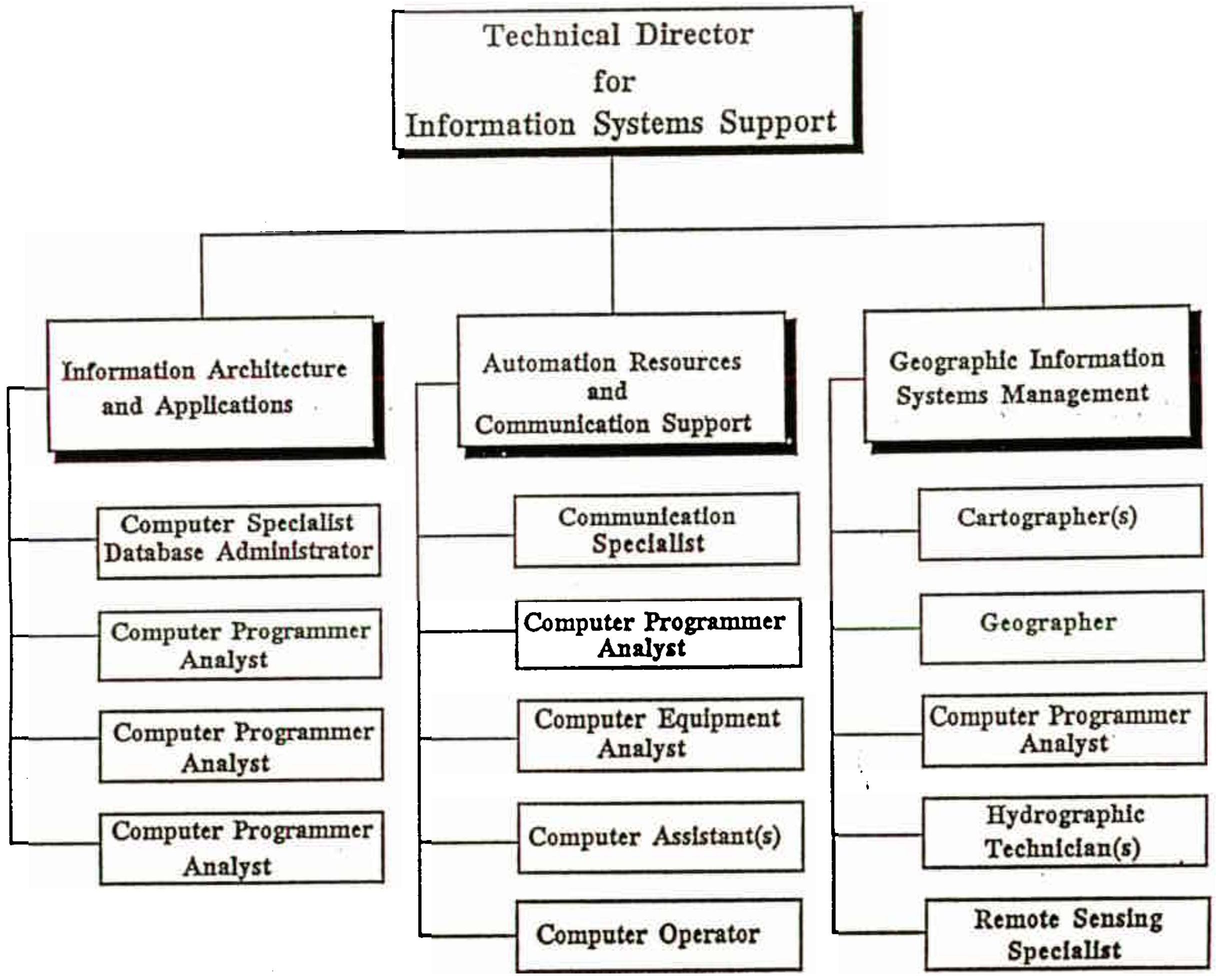
Appendix I
Organizational Charts
Environmental Management Technical Center

Organization Chart
Environmental Management Technical Center

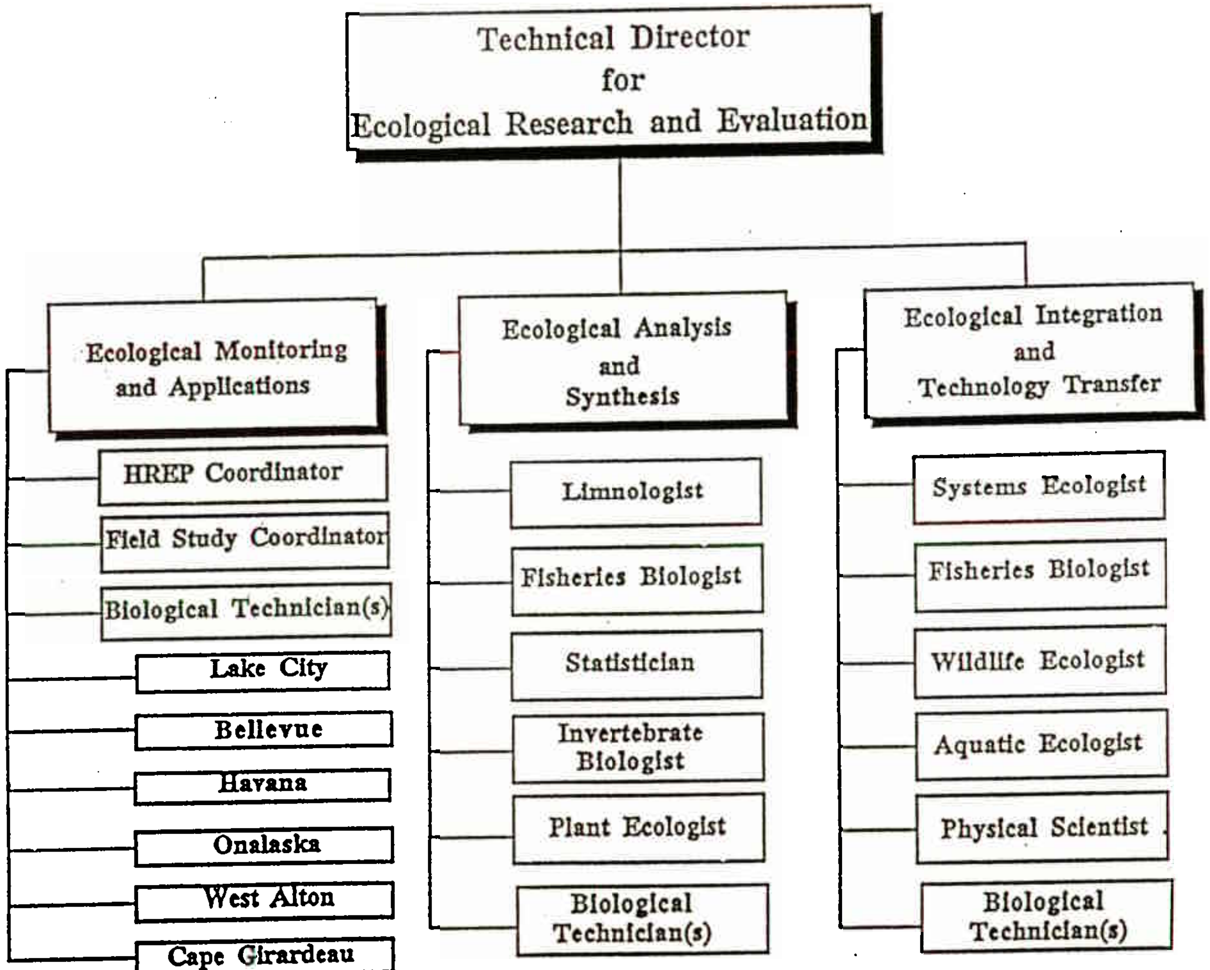


Program Manager	7/19/91 Date	Assistant Regional Director - Enhancement	7/29/91 Date	Regional Director	8/5/91 Date

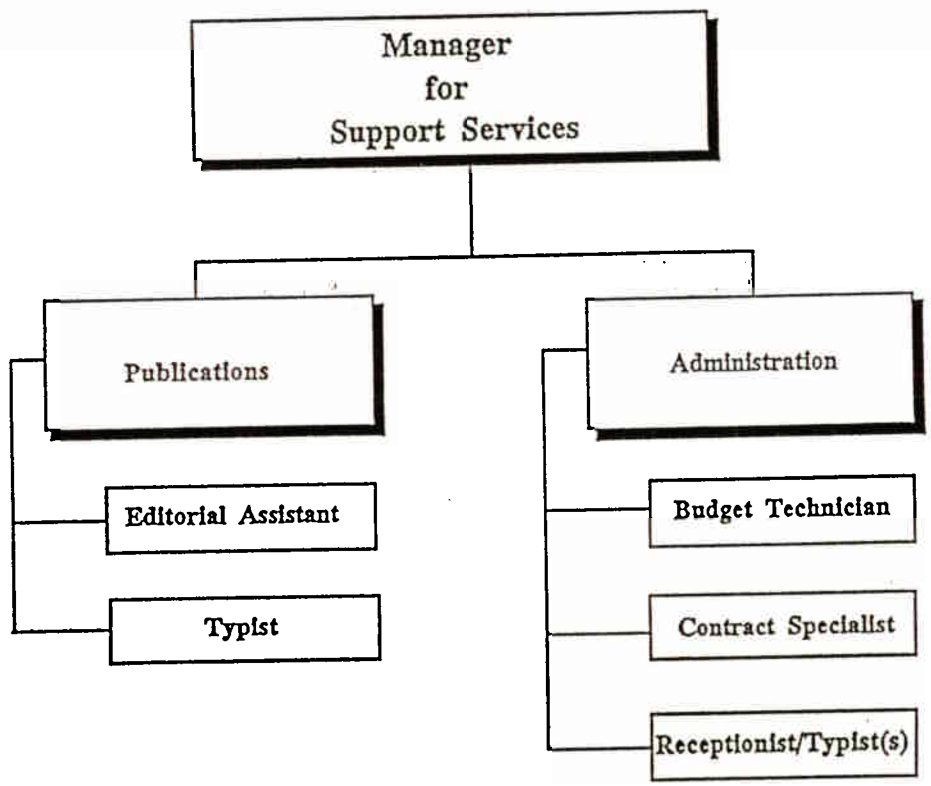
Organization Chart
Information Systems Support Division



Organization Chart
Ecological Research and Evaluation



Organization Chart
Support Services



REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0705-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE August 1992 (Rev. September 1993)	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program

5. FUNDING NUMBERS

6. AUTHOR(S)

U.S. Fish and Wildlife Service

7. PERFORMING ORGANIZATION NAME AND ADDRESS

U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Fish and Wildlife Service
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

91-P002

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Release unlimited. Available from National Technical Informaiton Service, 5285 Port Royal Road, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This Operating Plan establishes a framework and schedule for the completion of a comprehensive Long Term Resource Monitoring and Computerized Inventory and Analysis Program for the Upper Mississippi River System. This Program has been designed to collect scientifically valid and statistically sound data over time to detect site-specific and/or system-wide changes. The data base will be helpful in evaluating various impacts on the system and will serve as a reliable information source for management agencies. It also will support and be integrated with specific navigation impact assessments being conducted by the U.S. Army Corps of Engineers. In addition, a Computerized Inventory and Analysis System is needed to assimilate and store historical data as well as to manage data generated through the Long Term Resource Monitoring Program (LTRMP). A computerized information transfer system will provide resource managers with site-specific and system-wide data, using standardized and state-of-the-art methodologies. Several organizations or groups provide input and guidance to the LTRMP. The Upper Mississippi River Basin Association (UMRBA) is composed of the five basin states and representatives from the participating Federal agencies. The UMBRA serves as a clearinghouse for all components of the Environmental Management Program, directs Program policy, and facilitates coordination and cooperation among Program participants.

14. SUBJECT TERMS

Mississippi River, Illinois River, resource management, long-term data, river research, spatial data analysis, GIS

15. NUMBER OF PAGES

179 pp.

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	