Strategic and Operational Plan
for the Long Term Resource Monitoring Program
on the Upper Mississippi River System,
Fiscal Years 2010-2014

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Developed for the

Environmental Management Program
Coordinating Committee

by the
Strategic Planning Team

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Executive Summary

"*The mission of the Long Term Resource Monitoring Program is to support decision makers with the information and understanding needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem.*"

The Mississippi River System is the largest river system in the United States and fourth largest river system in the world. The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System (UMRS) was created in 1986 as part of the Environmental Management Program (EMP). The EMP pioneered scientific monitoring and ecosystem restoration for the UMRS and has gained worldwide recognition. The LTRMP consists of a comprehensive program of monitoring, research, and data management that provides critical information about the status and trends of key resources. LTRMP information is used extensively by resource managers, planners, administrators, scientists, academics, legislators, and the general public for improved understanding, problem solving, and informed decision-making about issues important to the UMRS.

A Strategic Plan for the LTRMP covering 2010-2014 was developed by the Strategic Planning Team. The EMP Coordinating Committee endorsed that Plan in August 2008. The Plan builds upon previous experience and knowledge to focus the LTRMP and maximize benefits of the public investment. For example, full implementation of this plan will result in systemic coverage of the 2.7 million acres of the UMRS floodplain with high resolution topographic, bathymetric, and land cover data. These data can be combined with other data sets to help develop more effective models that improve our scientific understanding of processes that drive habitat patterns and ecological responses. This knowledge will increase the effectiveness of large river restoration efforts and greatly reduce costs for project planning and design.

After the Strategic Plan was endorsed, the Operational Planning Team defined actions for implementing the Strategic Plan. The Strategic and Operational Plans are combined into this joint document. Text specific to the Operational Plan is contained within boxes throughout the document.

This Strategic and Operational Plan identifies a set of priorities for 2010-2014 selected from a broad universe of possibilities. It identifies the key elements required for LTRMP to accomplish its mission. In addition to the core elements of monitoring, research, and data management, this plan addresses important new information needs resulting from data gaps that have been identified as our understanding of the ecosystem improves. The actions presented in this plan are essential to understanding the river ecosystem and helping decision makers make informed choices. The annual costs for implementing this Plan exceed recent EMP appropriations, and fully accomplishing the Plan will require funding levels greater than those described in the authorizing legislation.

This plan also provides a link to the newly authorized Navigation and Ecosystem Sustainability Program (NESP), which integrates ecosystem restoration and navigation efficiency on the UMRS. Restoration goals have been established jointly under EMP and NESP and focus on ecosystem process, function, structure, and composition. The LTRMP is ideally suited to aid in the development and tracking of key indicators that will document progress towards those goals. This will ultimately lead to a better understanding of the ecosystem services provided by the UMRS. In addition, LTRMP data can aid in

planning and evaluating habitat restoration projects following an adaptive management framework proposed by NESP.

During 2010-2014, the LTRMP will maintain the commitment expressed in the 2005-2009 plan to a complete program, including monitoring, analysis, research, communication, and management and serving of data and products, to the extent possible under any budget scenario. However, meeting the mission of LTRMP will require full execution of this Plan. The Plan expresses priorities among the outcomes and outputs, and describes new actions necessary to fulfill LTRMP's mission. These actions build upon past accomplishments and ongoing work, and envision cooperative efforts both within and outside the partnership to enhance our collective capabilities. Refer to Table ES-1 for a list of outcomes and outputs identified in the Strategic Plan.

Highlights of the actions proposed include:

Monitoring (Outcome 1):
- Continue annual data collection as conducted during 2005-2009 and add first period fish sampling in all study reaches and additional fixed site sampling for water quality in Pools 4 and 8.
- Collect systemic land cover photography in 2010, as part of the typical 10 year cycle, and process in subsequent years.
- Finish collecting data on land elevation (LiDAR) and bathymetry and create a seamless GIS elevation layer for the system.
- Work with the partnership and the Analysis Team to develop indicators of ecosystem health at the system, reach, and project scale; and then determine the ability of current monitoring to assess those indicators and provide suggestions to enhance monitoring, if needed.
- Explore the potential for implementing new monitoring components for mussels, floodplain forests, and invertebrates.

Research (Outcome 2):
- Expand data analyses, including use of data outside of LTRMP.
- Develop and implement plans for focused research on aquatic vegetation, mussels, floodplain connectivity, and landscape patterns.
- Develop models to predict effects of management actions, concentrating initially on models of flow and sediment dynamics, and develop decision support tools to transfer data and knowledge to users.

Integration of HREP with LTRMP (Outcome 3):
- Review lessons learned, documented, and applied to past and current HREP's to identify opportunities to further evaluate ecological response.
- Create a HREP-LTRMP Science Liaison position/team within EMP to guide and coordinate integration between the programs.
- Increase collaboration between scientist and managers during design and evaluation of rehabilitation and enhancement projects, including more participation in project delivery teams and greater utilization of LTRMP infrastructure for project monitoring.

Outreach and Communication (Outcome 4):
- Create an Outreach Team, lead by a LTRMP Outreach Coordinator, to summarize LTRMP information, develop outreach messages, determine appropriate mechanisms for distribution, and gage customer satisfaction.

Data Management, Infrastructure, and Personnel (Management of LTRMP Resources):
- Support data management to increase capability to collect and store data, and to provide data in ways that meet the needs of scientists, managers, and decision makers.
- Develop a life-cycle schedule for major equipment and a long term plan for equipment refreshment.
- Develop a workforce plan, including descriptions of the roles of each partner agency and key staff, and provide for appropriate career support and training.

Among the Outputs, this plan reaffirms that during 2010-2014, continued collection of monitoring data is a top priority (Output 1.1). However, those data must be transformed into useful knowledge and communicated to managers and stakeholders. Thus, as a second priority, the Plan seeks to expand data analyses, focused research (Outputs 2.1 and 2.2), and communication of knowledge (Outputs 4.1 and 4.2). Third level priorities include developing indicators of ecosystem health at various scales (Output 1.2), exploration of additional monitoring components (Output 1.3), and better integration of monitoring and rehabilitation (Output 3.1). In addition, maintaining professional staff, facilities, and equipment (Strategies 1 & 2) is essential to continuing LTRMP's reputation for state of the art science and data delivery.

The Team also considered how to implement this Plan during FY 2010–2014. Many elements of the plan build upon other elements and should be sequenced (e.g., research is needed to define mussel sampling methods before a monitoring procedure can be established). Sequencing among outputs provides a transition from the 2005-09 plan to the 2010-14 plan and can change to reflect changes in funding levels. Also, for many of the Plan's elements, there is considerable flexibility in the amount of effort that can be applied annually.

Implementing the Plan will still require annual development of a Scope of Work for LTRMP. This annual process should focus on priorities of the partnership, but should also remain flexible to account for budget variability, staffing capabilities, and unanticipated opportunities.

The Planning Team envisions an expanded LTRMP operating under EMP, but with the understanding that a transition to NESP is possible. To achieve LTRMP's mission, all elements of the Plan can be accomplished under either program. Initial budget estimates indicate that full implementation will require more funding than is currently authorized under EMP. If a transition to NESP occurs, some aspects of this Plan may be accomplished through other funding sources within NESP.

Table ES-1. Outcomes and Outputs for the Long Term Resource Monitoring Program during 2010-2014.

Outcome 1: Enhanced knowledge about system status and trends

Output 1.1: Status and trends information based on long-term data sets for aquatic vegetation, water quality, fish, and land use/land cover.
Output 1.2: Indicators of success at system, floodplain reach, and geomorphic reach-scales based on system goals and objectives.
Output 1.3: Additional information for status and trends knowledge regarding mussels, bathymetry and floodplain elevation, floodplain forest, and invertebrates.
Output 1.4: Data collected at spatial scales that are appropriate to monitor progress toward meeting system and reach goals and objectives.

Outcome 2: Enhanced knowledge about system process, function, structure, and composition

Output 2.1: Insights about river process, function, structure, and composition based on long-term data sets.
Output 2.2: Information generated from focused research agenda on setting management objectives and defining indicators, aquatic vegetation, mussels, floodplain connectivity, and landscape patterns.
Output 2.3: Decision support tools (e.g., models of system structure and function) to facilitate improved scientific understanding and restoration management.
Output 2.4: Operational framework for adaptive management that clarifies relationships at multiple scales among past, present, and future adaptive management projects.

Outcome 3: Enhanced use of scientific knowledge for implementation of ecosystem restoration programs and projects

Output 3.1: Use LTRMP infrastructure, data sets, and expertise to help formulate, design, and evaluate ecological restoration projects.

Outcome 4: Enhanced ecological understanding to inform decisions

Output 4.1: Key decisions are informed by LTRMP data, research, and decision support tools.

Output 4.2: Key decision makers are satisfied with LTRMP information and decision support system.

Strategic Management of LTRMP Organizational Resources

Strategy 1: Effectively manage LTRMP data and information by maintaining information technology systems, enhancing water quality software, providing user-friendly interface for web based library and query tools, expanding data clearinghouse functions, and extending data catalogue functions.
Strategy 2: Effectively manage LTRMP personnel and facilities by creating a workforce plan that provides direction for staffing roles and responsibilities and professional development, maintains facilities, and utilizes the equipment refreshment plan to maintain equipment.

Strategic and Operational Plan for the Long Term Resource Monitoring Program on the Upper Mississippi River System, Fiscal Years 2010 – 2014

Introduction

"*The mission of the Long Term Resource Monitoring Program is to support decision makers with the information and understanding needed to maintain the Upper Mississippi River System as a viable multiple-use large river ecosystem.*"

The Long Term Resource Monitoring Program (LTRMP) was created over 20 years ago as part of the Environmental Management Program (EMP). The LTRMP consists of a comprehensive program of monitoring, research, and data management that provides critical information about the status and trends of key resources. LTRMP information is used extensively by resource managers, planners, administrators, scientists, academics, legislators, and the general public for improved understanding, problem solving, and informed decision-making about issues important to the Upper Mississippi River System (UMRS).

This strategic plan identifies a set of broad priorities for 2010-2014 selected from a broader universe of possibilities. It defines a larger program than the current LTRMP, but out of necessity does not identify all potential partnership information needs. In addition to the core elements of monitoring, research, and data management, this plan addresses important new information needs resulting from data gaps that have been identified as our understanding of the ecosystem improves. Implementation of this strategic plan will be accomplished through the development of a companion effort known as an operational plan, which will provide the implementation details.

The actions presented in this plan are essential to addressing those information needs, understanding the river ecosystem, and helping decision makers make informed choices. Many elements of the plan build upon other elements and should be sequenced (e.g., research is needed to define mussel sampling methods before a monitoring procedure can be established) to help inform future budget decisions. In addition, maintaining professional staff, facilities, and equipment is essential to continuing LTRMP's reputation for state of the art science and data delivery.

This plan also provides a link to the newly authorized Navigation and Ecosystem Sustainability Program (NESP), which integrates ecosystem restoration and navigation efficiency on the UMRS. Restoration goals have been established jointly under EMP and NESP and focus on ecosystem process, function, structure, and composition (Galat et al. 2007)[1]. The LTRMP is ideally suited to aid in the development and tracking of key indicators that will document progress towards those goals. This will ultimately lead to a better understanding of the ecosystem services provided by the UMRS. In addition, LTRMP data can aid in planning and evaluating habitat restoration projects following an adaptive management framework proposed by NESP.

> **OPERATIONAL PLAN FOR 2010-2014:**
> - The Environmental Management Program (EMP) Coordinating Committee endorsed the Strategic Plan for the Long Term Resource Monitoring Program (LTRMP) on August 6, 2008. The Strategic

[1]Galat, D. L., J. W. Barko, S. M. Bartell, M. Davis; B. L. Johnson, K. S. Lubinski, J. M. Nestler, and D. B. Wilcox. 2007. Environmental Science Panel Report: Establishing System-wide Goals and Objectives for the Upper Mississippi River System. Upper Mississippi River System Navigation and Ecosystem Sustainability Program Environmental Report 6. U.S. Army Corps of Engineers, Rock Island, St. Louis, and St. Paul Districts. 41 pp.

Plan is the template for the Operational Plan. Actions for implementing the strategies are identified throughout this document under the heading "**OPERATIONAL PLAN FOR 2010–2014**" and are contained within boxes.

- For 2010-2014, the LTRMP will maintain the commitment expressed in the 2005-2009 plan to a complete program, including monitoring, analysis, research, communication, and management and serving of data and products, to the extent possible under any budget scenario. However, fully meeting the mission of LTRMP will require full execution of this Operational Plan. Full execution will greatly improve the ability of LTRMP to gather critical data, to use data and research to provide critical information and management tools, and to communicate those products to managers and the public.
- In concert with Outcomes 1-4, Strategies 1 and 2 describe actions that must be taken to guide and maintain a vibrant, well-managed organization that can achieve the Program's goals.
- An annual review of progress in implementing this Strategic and Operational Plan will be presented to the EMP Coordinating Committee at their November meeting. Information will be gathered from partners, coordinated with the Analysis Team, and presented to the EMP Coordinating Committee by LTRMP managers from the Corps of Engineers (COE) and U.S. Geological Survey Upper Midwest Environmental Sciences Center (UMESC).
- The Operational Planning Team envisions a broad perspective within the partnership. The EMP Coordinating Committee will develop a document that describes the roles and functions of partners, including a potential expansion of the range of expertise within partner groups. In addition, they will provide a recommendation regarding developing and codifying a charter for the Analysis Team.

Outcome 1: Enhanced knowledge about system status and trends

Six study reaches are monitored annually by LTRMP (Figure 1). Standardized monitoring in these six reaches provides valuable information over the wide range of environmental and human-use gradients that exist in the UMRS. The multi-component and multi-habitat sampling design provides data on a broad range of environmental conditions and on biota at both community and species levels. Current monitoring protocols for water quality, aquatic vegetation, fish, and land cover continue to build upon a historic database that now spans more than 20 years. Program partners have identified monitoring resource status and trends as the highest priority of LTRMP because of our need to understand recent and long-term trends in indicators of management success (see Output 1.2), cyclical changes in important ecological components, and the status of indicators used for analyzing relationships among components. Maintaining the continuity and integrity of the data set for the active components is crucial to these analyses.
For large rivers that are highly variable over space and time, long-term data are essential to understanding system dynamics. The LTRMP will continue to build upon over 20 years of data and experience in delivering high quality scientific information to decision makers. The knowledge derived from consistent monitoring will continue to be directly incorporated into management actions and question-driven scientific investigations, thereby enhancing existing knowledge about ecosystem process, function, structure, and composition (Output 2.1) and building upon our ability to evaluate management actions (Output 3.1).

Output 1.1: Status and trends information based on long-term data sets for aquatic vegetation, water quality, fish, and land use/land cover.

By maintaining sampling designs and procedures, the relevance of a monitoring program increases over time. Longer data strings mean that changes in status and trends can be more reliably detected against

the background of long-term cycles and wide variation. Desired levels of statistical confidence for assessing trends in indicators of success will be determined under Output 1.2. The generalized sampling design used by LTRMP allows a wide variety of questions to be addressed through data analyses. Some questions require different statistical designs and can be best answered through focused study (see Outcome 2). The long-term data will, however, continue to be an important source for investigating system process, function, structure, composition, and status and trends. The sampling effort required to produce data sets that are useful for analyses of both trends and status and other elements of this Strategic Plan will be addressed in the next phase of planning with development of an Operational Plan for FY 2010-2014. LTRMP will continue to evaluate the effectiveness of the data and the efficiency with which it is collected.

OPERATIONAL PLAN FOR 2010-2014:
The Operational Planning Team developed definitions of continuity and integrity, as applied to the LTRMP data sets, to help in making decisions regarding monitoring efforts. These definitions consider current and future uses of LTRMP data and our ability to conduct useful analyses of data through time.
- "Continuity of LTRMP data sets" refers to the ability to maintain a data string through time and space such that analyses of repeated events, different time periods, or longer term dynamics are possible as the data string is extended. Typically this requires consistent methods of data collection over time, or if methods change, conducting analyses that define comparability between data sets collected by different methods. Data may be collected over different time intervals (e.g., daily, seasonal, annual, multi-year intervals), but for any interval the consistency of data collection through time should be sufficient to allow use of standard statistical analyses without large data gaps.
- "Integrity of LTRMP data sets" refers to the ability to maintain a consistent line of specific knowledge, evidence, or indicators from a data string. Such knowledge is generated by a specific analysis with specific data requirements. Those requirements should be maintained within the data set, both temporally and spatially, such that results of the analysis are directly comparable with the same analysis performed for different times or locations.

Activities

    1.1a)   Activities associated with current standardized data collection are shown in Table 1.

OPERATIONAL PLAN FOR 2010-2014:
During 2010-2014, sampling will include:
- Data collection as shown in Table 1.
- Expand fish sampling to include period 1 in all six study areas. This will restore both spatial and temporal continuity to the fish data and restore data integrity for calculating indicators across seasons and years, and among all study area.
- Expand water quality data collection at fixed sites in Pools 4 and 8 at bi-weekly intervals during July and August, and at four historic fixed sites in Pools 8 and 9 (three tributaries and Reno spillway) during April through August. The purpose is to allow better description of water quality dynamics during spring and summer and to maintain specific data strings that have provided information critical to state needs for river management programs.
- Collect aerial photography for land cover information in 2010, with processing in subsequent years.
- Finish collection and processing of LiDAR and bathymetry data (See output 1.3).

Output 1.2: Indicators of success at system, floodplain reach, and geomorphic reach-scales based on system goals and objectives.

The UMRS Partnership recently developed ecosystem restoration goals for the UMRS. Development of geomorphic reach objectives has been initiated and is expected to be completed by 2010. The development of indicators based upon these goals and objectives will be an important activity under EMP and the newly authorized Navigation and Ecosystem Sustainability Program. LTRMP will continue to use its rich historical database to refine the list of indicators in the 2008 Status and Trends Report and to develop new key system and reach scale indicators. The monitoring program will be used to track the status and trends of those indicators over time to measure progress towards meeting system and reach goals and objectives.

Activities

 1.2a)   Aid in the development of key indicators by providing LTRMP data and information

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OPERATIONAL PLAN FOR 2010-2014:
- In December 2008, the Analysis Team formed a working group to develop a list of potential ecological indicators of use to managers that can be derived from LTRMP data (work will begin in FY09). Initial efforts will focus on indicators contained in the 2008 Status and Trends Report, but will consider other possibilities. Examples may include metrics that we already have procedures to calculate (e.g., species-specific parameters, acres of cover types or habitats) and other new metrics (e.g., related to guilds or communities of fish or vegetation, occurrence of metaphyton, landscape metrics). The LTRMP will provide information (e.g., Status & Trends Report, LTRMP data sets) as needed to the Analysis Team working group and other groups to help with development of objectives and indicators.
- As work on objectives progresses, the Analysis Team working group will provide recommendations for indicators appropriate to assess success in achieving each objective and the audience for those indicators (e.g., managers, scientists, administrators, public, congress).
- In addition, the LTRMP will work to develop indicators of ecosystem health. We will explore indicators that can provide useful references for current and, when possible, past conditions, and can help the partnership make judgments regarding desired future conditions and benchmarks for the UMRS.
- LTRMP work on indicators will be coordinated with other partner groups working on objectives and indicators (NESP, Water Quality Task Force, etc.). These groups may develop objectives for different purposes and different locations that require different indicators. We will strive to develop a core set of indicators that apply broadly across the system, but can be complimented by more specific indicators, as needed.

 1.2b)   Track the status and trends of key indicators using LTRMP data and information

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OPERATIONAL PLAN FOR 2010-2014:
- As the list of indicators is developed (in Activity 1.2.a above), we will conduct analyses to determine the utility of LTRMP to calculate potential new indicators, then explore the dynamics of those indicators as they relate to management objectives. For potential indicators of system health, we will assess those indicators at appropriate spatial and temporal scales and compare indicators within the UMRS and, if possible, to other river systems.

Output 1.3: Additional information for status and trends knowledge regarding mussels, bathymetry and floodplain elevation, floodplain forest, and invertebrates.

The current monitoring effort provides critical data for the active components (e.g., water quality, aquatic vegetation, fish, and land cover). However, data from additional components are needed to broaden our understanding of the relationships among ecosystem components and processes and to track the status and trends of important species or guilds. Of the additional components considered, partners have identified mussels, bathymetry and floodplain elevation, floodplain forest, and macroinvertebrates as priority additional components over the next 5 years.

<u>Activities</u>

- 1.3a) Mussels — Freshwater mussels (Unionidae) are possibly the most threatened faunal group in the UMRS, yet we have very limited knowledge about the community ecology, distribution, and status of mussels within the system. The lack of information at the species, community, and population level complicates mussel resource management, impact assessment, and planning and construction of both habitat and navigation projects. Protocols for conducting mussel surveys and fundamental investigations of species distribution and ecology are needed to help design a long-term monitoring plan for mussels.
- 1.3b) Bathymetry & Floodplain Elevation — Floodplain topographic and bathymetric information is needed to create a seamless elevation data layer system wide. Such information is essential to habitat restoration planning, landscape modeling, and research about the ecology of floodplain communities.
- 1.3c) Floodplain Forest — Floodplain forest is one of the most important land cover types on the UMRS. Healthy and diverse forests are critical to the survival of many species, especially neo-tropical migrant birds. Since river impoundment in the 1930s, forests have undergone significant changes in species composition (e.g., declines in oak and hickory species and increases in silver maple) and distribution. Monitoring protocols should be developed to track changes in forest communities in addition to conducting focused research concerning the factors that affect forest composition and regeneration. This information is urgently needed to increase our understanding of restoration and management techniques and the ecological value of diverse floodplain forests.
- 1.3d) Macroinvertebrates — A healthy invertebrate community is essential to a productive and diverse river system. Aquatic insects, fingernail clams, and crustaceans provide essential food resources for migratory birds, fish, mammals, and other biota. They are also excellent indicators of water and sediment quality and may be indicators of system productivity. Current information about the status and trends of important macroinvertebrate communities is sparse. More broadly based, statistically valid monitoring protocols need to be evaluated to track changes in key macroinvertebrate communities. Focused research should be conducted to investigate factors that may limit macroinvertebrate distribution and abundance.

OPERATIONAL PLAN FOR 2010-2014:
- Plans for finishing bathymetry and LiDAR data collection and analyses will be developed in FY09. Those plans will be implemented as funds and opportunities are available. The goal will be to develop a seamless elevation data layer for the entire UMRS.
- For each potential new component, the Analysis Team will define the purposes for data collection. They will then recommend members for a working group to develop a plan for devising and evaluating different methods for data collection to meet that purpose.
- After sampling designs for a new component are proposed, additional funding will be required to test the design and data collection methods in the field. Testing will be implemented as funds and opportunities are available.
- We would consider adding components to standard LTRMP sampling only after potential sampling designs and methods are fully evaluated and vetted. New designs could incorporate sampling at different spatial and temporal scales than those used for the current components (e.g., sampling outside current trend pools and at multi-year time intervals).

Output 1.4: Data collected at spatial scales that are appropriate to monitor progress toward meeting system and reach goals and objectives.

After river goals, objectives, and indicators are established at various geographic scales, additional status and trends information at corresponding spatial scales may be needed to enhance our ability to track success in meeting those goals within UMRS geomorphic and floodplain reaches, and the system. A variety of new or expanded monitoring designs may need to be developed depending on information needs. These could include additional sampling outside trend reaches at specific locations (e.g., tributaries) or a statistically based random sampling design at geomorphic and floodplain reaches, or systemic scales. This information will provide decision makers with enhanced understanding of the dynamics of large floodplain rivers and facilitate successful multi-purpose resource management. Changes to the sampling designs and procedures will be considered only after careful evaluation of the existing protocols relative to the newly identified systemic, floodplain, and geomorphic reach objectives.

Activities

    1.4a) After system and reach objectives and indicators are established (see Output 1.2), evaluate current sampling design for effectiveness at tracking indicators of success and, if needed, explore new, or reinstatement of original, sampling designs.

OPERATIONAL PLAN FOR 2010-2014:
- Work on this output will be considered after system and reach objectives and indicators are established (see Output 1.2, as lead by NESP and the Analysis Team), and in conjunction with work under Output 1.2.b, which will determine the ability of current LTRMP sampling to provide data needed for calculating indicators.
- If these efforts suggest that additional or restructured sampling designs would be useful, the Analysis Team will recommend members of a team to develop potential sampling designs that meet those data needs.
- Any new sampling designs would need to be evaluated. Evaluation could involve analyses of existing data or external data sources, modeling, or collection of new data, and would consider the effect of design changes on the continuity and integrity of existing data.
- Only after potential methods are fully evaluated and vetted would we consider changing the LTRMP sampling design.

Outcome 2: Enhanced knowledge about system process, function, structure, and composition

Effective management requires knowledge about factors controlling the dynamics and interactions of important system components. To gain this knowledge, the program should continue on a logical growth path by expanding from a primary focus on data collection to additional emphasis on analyses, research, and model building that stress work on Goals 1 (Understand the system) and 3 (Develop alternate management actions) in the 1993 Operating Plan. This will require development of a science-management process that provides for integration and coordination of research and monitoring activities. In addition, this will require using information and research capabilities to build on past efforts, particularly in producing models and decision support tools for managers.

Work under this outcome can be focused most effectively once management objectives and indicators of management success are developed by the partnership. System goals for ecosystem restoration efforts based on river process, function, structure, and composition have been developed by the broad river partnership. Geomorphic reach objectives are now being developed through similar regional efforts. The LTRMP should participate in and support those efforts where possible. The LTRMP data, combined with focused research, will continue to improve our understanding of how process, function, structure, and composition influence the physical, chemical, and biological components of the system, and ultimately the ecosystem services they provide.

The current Additional Program Element process for LTRMP focuses research on important management questions. These focused questions were developed and prioritized by the partnership and form the strategic research agenda of LTRMP. Current focal questions were developed for a two-year time frame and will be modified to direct focused research over the next five years. Implementation of this effort will be guided through the development of the focused research plan identified in Output 2.2. Many of the focal questions are related to process, function, structure, and composition. Addressing these questions will require a LTRMP staff committed to both research and monitoring.

In addition to focused research, adaptive management has been identified as one approach to enhance learning from management actions. A framework for adaptive management will likely be developed by the partnership, within the FY 2010–2014 timeframe. Staff within the LTRMP can contribute to certain components of an adaptive management framework such as model development, restoration design intended to enhance learning, and development of monitoring plans to measure indicators of success at appropriate spatial and temporal scales.

OPERATIONAL PLAN FOR 2010-2014:
- The LTRMP Science Director will lead development of an overall plan to guide and coordinate outputs under Outcome 2, including as they relate to Outcomes 1 and 3. This plan will consider ways to prioritize and sequence analyses and focused research, create opportunities for designing and implementing field experiments, generate data and information needed for modeling efforts, and make effective use of LTRMP and HREP capabilities,

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Output 2.1: Insights about river process, function, structure, and composition based on long-term data sets.

The LTRMP has created an unprecedented, multidisciplinary data set that provides a tremendous opportunity for developing new knowledge through data analyses. Analyses will concentrate on improving our knowledge of system structure and function as related to management needs. Such analyses will explore patterns in the data (among pools, strata, years, or seasons), relationships among variables (within and among components), evaluation of various metrics as potential indicators, or generating new variables from existing data (e.g., length frequencies, growth, year class strength, production). When appropriate, we will build on past analyses, contributing to the focused research agenda (Output 2.2), engaging others outside the partnership in conducting analyses and using data sets outside of LTRMP as needed.

Activities

2.1a)   Conduct analyses of LTRMP and other data sets.

OPERATIONAL PLAN FOR 2010-2014:
- Along with LTRMP data, additional data sets might include historical surveys, U.S. Environmental Protection Agency Environmental Monitoring and Assessment Program (both Great Rivers and Regional data), Illinois River Long Term Fish Monitoring data, U.S. Fish and Wildlife Service data sets, hydrology data from COE and U.S. Geological Survey, etc.
- Analyses will be coordinated with work conducted under other elements of the Operational Plan (e.g., under 1.2, 2.2, 2.3). Specific analyses to be conducted will be determined annually in developing the Scope of Work.
- The LTRMP has staff in place, primarily at UMESC and the field stations, who can access, synthesize, and analyze these data or supervise analyses. This effort may be increased by pursuing additional funding from outside sources.   We will also explore opportunities to engage academics through leveraging LTRMP or NESP funds, external grant proposals, or graduate student support. Analyses funded by external sources will require some LTRMP support for administration and oversight of those efforts.

Output 2.2: Information generated from focused research agenda on setting management objectives and defining indicators, aquatic vegetation, mussels, floodplain connectivity, and landscape patterns.

The activities listed below are in priority order, but we expect to address questions associated with all five research areas. The current annual time frame for Additional Program Element projects will be replaced with a 5-year focused research plan for each major question that can be implemented as funding and opportunities allow. The annual scope of work will follow the 5-year focused research plan with minor annual adjustments as we learn and get feedback from within and outside the program. Along with research efforts within the program, we will look for opportunities to leverage with other programs and funding sources, and to engage others outside the partnership (e.g., academics) in pursuing this agenda. In addition, we will look for opportunities for efforts under Output 2.1 to contribute to Output 2.2. New emerging issues may increase the importance of other questions and we should be flexible enough to be able to address those questions, if needed. However, our goal is to concentrate our science efforts and make substantial progress in addressing the priority areas as listed.

<u>Activities</u>

Develop and implement a 5-year focused research plan that will address the following five priority research areas. Additional areas may be added over time.

2.2a)   Provide data and analysis to aid the partnership in setting (science and restoration) management objectives and defining indicators
2.2b)   Aquatic vegetation
2.2c)   Mussels
2.2d)   Connectivity of the river to its floodplain
2.2e)   Landscape patterns in the river corridor

OPERATIONAL PLAN FOR 2010-2014:
- Activity "a" will be pursued mainly under Output 1.2.
- For Activities b-e, a team will be formed for each theme area to develop a research agenda for that topic.
- After research agendas are developed, they will be implemented through the LTRMP Scope of Work and through proposals for external funding such as, U.S. Department of Interior cyclical funding sources, joint efforts with academic institutions (external grant proposals, graduate student support, etc.), and NESP and other Corps of Engineers authorities. These efforts may involve analyses of existing data, modeling, or new data collection efforts. The research agendas may be modified as needed to accommodate new findings or new directions as work progresses.
- Any data collection efforts conducted under this Output will include a plan for managing and providing access to all data collected.
- Multiple projects and products conducted under this output will be coordinated by the LTRMP Science Director.
- There will be a transition period within FY2010-2014 when the focused research plans are being developed, but not yet implemented. During this time we will consider support for active APE studies that can provide critical information and come to conclusion with additional funding.
- These themes will represent the primary areas for focused studies within LTRMP, but we will maintain the option to address other questions when unanticipated, but important, information needs arise.

Output 2.3: Decision support tools (e.g., models of system structure and function) to facilitate improved scientific understanding and restoration management.

Efforts under this output will be driven by the need to provide data and tools that help managers understand the system better and make more effective management decisions. These may include tools that organize existing data sources into portable data sets (e.g., the Spatial Query Tool) that managers can apply in their daily jobs and use to organize their own data. In addition, models are needed that combine existing data and concepts into tools that document our current understanding of the system and can be used to explore outcomes of management alternatives. Modeling will be critical for developing effective adaptive management plans and for directing efforts in data analyses and focused research. A primary need is to develop a model that moves water and its associated constituents (chemicals, suspended materials, and biota) within channels and across the floodplain under varying discharge regimes. Once this modeling framework is built, a data layer depicting floodplain elevation (derived from combined bathymetry and LIDAR data; see Output 1.3) can provide a template for modeling management actions that modify flow distributions, water stage, or land elevation. Historical information on floodplain elevation and distribution of landforms can provide useful comparisons over time.

<u>Activities</u>

2.3a) Develop or improve models of sediment and flow dynamics

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OPERATIONAL PLAN FOR 2010-2014:
- We will expand on existing work with the goal of producing a generalized model of movements of water and of suspended and dissolved constituents that can be applied at different locations and spatial scales with the UMRS.
- The model should provide the ability to dynamically model flow within channels and across the floodplain throughout a complete annual discharge regime. The model should be able to determine probability of inundation at different points within the floodplain, and water retention times and rates of exchange of water and solutes among different spatially defined units.

2.3b) Provide assistance to decision makers who ask for decision support tools

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OPERATIONAL PLAN FOR 2010-2014:
- Some of the efforts of the outreach position (Outcome 4.1) will be applied to this Output. The outreach coordinator will work with partners and determine information needs, then provide input to LTRMP regarding the types of decision support tools needed.
- The goal of this Output is to link data, modeling, and research to provide information relevant to manager's needs and available in the most useful format. In addition, we will identify when needed data or information are not available and determine options for filling that need. This effort will result in a "tool box" of decision support products that can be applied to different issues in different locations, as needed.
- Based on knowledge of relations among components of the UMRS and about how the system functions, we will develop decision support systems to help managers evaluate different management options. These decision support systems should allow managers to consider various "what if" scenarios to compare the predicted effects of alternative management actions.
- Develop a computerized "data map" that uses a GIS-based approach to catalog and display data available on the UMRS at different, user-defined spatial scales (e.g., project, reach, system). The map would include data from LTRMP and other sources. These data and the mapping tool would be developed as an Internet-based application using enterprise GIS technologies (ESRI's ArcGIS Server).
- Provide support for development of the NESP Decision Support System for managing data and information derived from NESP projects.

Output 2.4: Operational framework for adaptive management that clarifies relationships at multiple scales among past, present, and future adaptive management projects.

Ultimately, rehabilitation of the UMRS will be achieved by an accumulation of management actions that build on, and learn from, each other. Project implementation has been measured for past habitat rehabilitation and enhancement projects (HREP) and lessons learned have been incorporated into new projects and documented in the HREP manual. The learning opportunities provided by HREPs for both project implementation and ecological effects can be further enhanced through a more formalized and intentional process of adaptive management. Examples of additional learning opportunities include further

evaluation of existing HREPs, and participation in design and evaluation of new HREPs (single and multiple projects) to increase their learning potential. These efforts will support development of a more formalized adaptive management framework as required under NESP. The LTRMP should participate when appropriate in ongoing activities to develop an adaptive management framework. That framework should build upon data, information, and planning available from LTRMP and other sources, and incorporate critical elements and issues embodied in the LTRMP strategic plan.

Activities

    2.4a)   Clarify relationships at multiple scales among past, present, and future restoration projects that provide significant learning opportunities

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OPERATIONAL PLAN FOR 2010-2014:
- Form a team to review past and current restoration activities and determine if opportunities exist for new data collection or analyses that can help us learn about the ecological effects of these activities, either individually or as multiple projects (e.g., island building, dredging, drawdowns).
- In looking for learning opportunities, the team should consider:
  - coordination with other elements of the Operational Plan and ability to help pursue the focal area research agendas (Outcome 2.2),
  - opportunities to reduce uncertainty in management actions, and
  - whether past or current projects are candidates for additional monitoring of long term effects on specific biota or processes.

After suggestions for new analyses or monitoring are completed, they will be considered for implementation under other elements of the LTRMP Operational Plan (e.g., 3.1, 2.1, 2.2), under HREP funding, or through NESP.

    2.4b)   Participate in and provide expertise as needed to refine ongoing adaptive management activities

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OPERATIONAL PLAN FOR 2010-2014:
- The LTRMP Science Director (UMESC) and the EMP Manager (COE) will provide information to LTRMP/EMP regarding NESP activities associated with adaptive management. LTRMP staff (all agencies) will provide input and participate to assist with NESP when LTRMP input is useful and warranted.
- We will work with the partnership to increase LTRMP's role in leading adaptive management efforts.

    2.4c)   Participate in restoration planning efforts

OPERATIONAL PLAN FOR 2010-2014:
- Most effort for this activity will occur under Outcome 3.1 in conjunction with HREP planning and with design of projects and monitoring plans. Efforts will be concentrated on projects that provide critical learning opportunities (i.e., adaptive management projects) to increase understanding about how different actions can be best applied to meet management objectives, both locally and systemically.
- In addition, LTRMP staff will be encouraged to participate in NESP planning activities conducted by reach level planning teams (Fish and Wildlife Work Group, Fish and Wildlife Interagency Committee, River Resource Action Team Tech Group, and Illinois River Work Group) and by Project Development Teams (PDT's).

2.4d)   Develop an approach to documenting and delivering lessons learned

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OPERATIONAL PLAN FOR 2010-2014:
- Work with the COE staff to help develop a decision support system for restoration activities including providing data and advice, and possibly help with programming, web access, or development of interactive tools.

Outcome 3: Enhanced use of scientific knowledge for implementation of ecosystem restoration programs and projects

Effective ecosystem restoration involves using the best available information and decision support tools to formulate, design, and evaluate management actions that address system, reach and site-specific goals and objectives. This outcome envisions a greater linkage between river managers who design restoration projects and LTRMP staff who conduct monitoring and research so that restoration projects are developed with the best available scientific information.

The LTRMP capabilities should be used to inform the development of restoration goals and objectives, develop indicators, help design project evaluation studies, and track progress towards meeting those goals and objectives. In addition, there are opportunities to use LTRMP data, focused research, and modeling to aid in project evaluations and to better link site-specific projects to system and reach objectives.

The LTRMP staff and program managers should be proactive in recognizing opportunities to use multiple projects as replicates, alternate treatments, or large scale manipulations that provide improved learning potential. Establishing a communications and data link between LTRMP staff, Project Delivery Teams (PDTs), and the NESP Science Panel is an important component of this outcome.

Output 3.1: Use LTRMP infrastructure, data sets, and expertise to help formulate, design, and evaluate ecological restoration projects.

The purpose of this output is to ensure that the LTRMP information and staff are integrated into ecosystem restoration efforts at system, reach, and site-specific levels, and that lessons learned are shared. Priority will be placed on ensuring existing knowledge and expertise are used to inform ecosystem project design and evaluation studies. LTRMP personnel and infrastructure will also continue to support completion of site-specific project evaluations.

OPERATIONAL PLAN FOR 2010-2014:
- Continue to build a closer working relationship between the HREP and LTRMP components of the EMP to enhance the ecological benefits of habitat restoration projects.
  - Hold joint meetings/workshops between LTRMP staff; project, resource, and refuge managers; and other program partners in a formalized, regular basis in an effort to analyze projects at a broad, systemic, multiple-project basis.
  - Integrate LTRMP scientists in project delivery team meetings (especially during project formulation, the collection of baseline data, pre-project monitoring plans, and the development of post construction monitoring plans).
  - Collaborate in the preparation and implementation of a plan to prioritize project monitoring based on type of restoration activity and the amount of risk and uncertainty in the outcome.

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    - o Work to facilitate monitoring of representative projects within each type of restoration activity.
    - o Collaborate in the development of adaptive management plans that link science and management in the areas of greatest risk and uncertainty.
    - o Leverage the existing LTRMP infrastructure to evaluate HREP's efficiently
- Create a HREP/LTRMP Science Liaison position/team for EMP to (1) help define opportunities for useful interactions between PDT's, LTRMP scientists, and all program partners in HREP design and evaluation, and (2) act as an operational link for adaptive management efforts between EMP and NESP. The role(s) of this position/team will be developed with the participation and involvement of the EMP partnership, including evaluation of the current HREP/LTRMP Integration Project (from FY07-09).
- Enhance project evaluation and ecological monitoring to include both physical and biological effects. Determine how project features perform relative to ecological processes, functions, structure, and composition.

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Outcome 4: Enhanced ecological understanding to inform decisions

Critical to the success of EMP is providing decision makers with targeted, easily accessible, and usable information regarding the UMRS ecosystem. This will require both the development and delivery of important information that is responsive to identified needs.

Output 4.1: Key decisions are informed by LTRMP data, research, and decision support tools.

Activities

Identify decision makers, the information they need, and their preferred format for that information – including:
  4.1a) Elected officials and the public – condensed information from various LTRMP sources
  4.1b) Program managers – condensed technical information from program reports
  4.1c) Project managers – technical reports from both cited and non-cited sources
  4.1d) Scientists/technical professionals – scientific/technical information from peer reviewed journals

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OPERATIONAL PLAN FOR 2010-2014:
- Create a position description and hire an Outreach Coordinator to serve as a central point of communications for the development and execution of an outreach plan for transferring knowledge to the target audiences above. This will include summarizing information generated by LTRMP, development of outreach messages, and determining the appropriate mechanisms for distribution.
- Each field station and partner agency will be asked to provide a contact person to work with the Outreach Coordinator to form an Outreach Team.

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Output 4.2: Key decision makers are satisfied with LTRMP information and decision support system.

Activities

    4.2a) Effectively and efficiently deliver LTRMP information and expertise to the key decision makers. This is a role for all EMP partners

    4.2b) Create a communications and outreach team/group with at least one new professional communicator at its core

    4.2c) Improve the delivery of LTRMP information based on decision maker feedback

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OPERATIONAL PLAN FOR 2010-2014:
- Outreach Coordinator evaluates satisfaction of decision makers with LTRMP information delivery and recommends changes/enhancements.
- Develop targeted reports to communicate key scientific findings to all decision makers identified in Output 4.1.

Strategic Management of LTRMP Organizational Resources

Strategy 1. Effectively manage LTRMP data and information

Information generated under the LTRMP is only as useful as the quality of data management and delivery. Collecting, organizing, analyzing, storing, and reporting these data are fundamental program elements that cannot be compromised without jeopardizing the value of information and the historic database used by decision-makers and the scientific community.

Technology for data collection has advanced significantly and LTRMP has kept up with these advances, making the program a leader in the ability to manage and deliver data. Electronic data capture used by LTRMP has improved the efficiency, accuracy, and economy of data collection and entry. Geospatial data (land cover, bathymetry, aerial photography) are processed using advanced hardware and software and are used frequently by field managers and biologists to design and evaluate projects and investigate ecological relationships.

The relational database management system has been consistent over the life of the program and currently houses over 1.3 million records. Data from this system, as well as geospatial information and research results, are available in a variety of formats, including scientific manuscripts, program technical reports, completion reports, fact sheets, maps, and raw data. A comprehensive peer review process ensures scientific rigor and integrity. In addition, a web-based access system allows users to search and download information for specific uses.

Maintenance of existing data management tools, and investing in new technologies when appropriate, will improve efficiency and is critical to the continued integrity of this program. For example, new GIS technology allows for the creation of web enabled analytical tools that could previously function only on desktop computers. This allows users to view and access historical data over a much broader spatial scale than previously, which aids in measuring and tracking ecosystem indicators.

With adaptive management an important component of NESP, it is more important than ever to improve access to all forms of data and information pertinent to the Upper Mississippi River ecosystem. Some

information collected by partners external to LTRMP can be accessed through the existing LTRMP database; however, expanding the data clearinghouse to provide "one-stop" access to non-LTRMP data would be a valuable step in implementing adaptive management.

Actions

S-1a) Maintain data management systems through an information technology refresher planning process

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OPERATIONAL PLAN FOR 2010-2014:
- UMESC will develop a plan for maintaining effective and efficient capabilities for electronic data capture in the field and for data storage and management at UMESC.

S-1b) Enhance the information management software used for data capture and management within the water quality component

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OPERATIONAL PLAN FOR 2010-2014:
- UMESC will develop a plan to update the data capture software for the water quality lab to ensure the functionality of the software into the future.

S-1c) Develop a user-friendly interface with component data for web-based library and query tools
S-1d) Expand data clearinghouse functions
S-1e) Extend data catalogue functions

OPERATIONAL PLAN FOR 2010-2014:
- Implement the ESRI Enterprise GIS tools, such as Arc Spatial Database and ArcGIS Server. These tools will allow data to be viewed with an internet browser or through ArcGIS on desktop computers, where they can be combined with other data sets.
- UMESC will develop procedures for ensuring that data collected under focused research efforts are archived and made publicly available (also see Output 2.2.). We will begin with current projects and apply the procedures to past projects as interest, time, and funding permit.

Strategy 2. Effectively manage LTRMP personnel and facilities

Meeting the outcomes in this strategic plan depends upon having appropriate staff and expertise within LTRMP. Staffing levels and expertise should be continuously evaluated to identify program needs, and training or additional staffing should be considered when necessary.

As with all effective organizations, maintaining productive and motivated staff is essential to program success. Within LTRMP there is a wide range of expertise from field station biologists and managers to USGS scientists and administrative personnel. It is important to provide the working environment and opportunities they need to develop professionally and ensure continuity in the program. For example, professional advancement for some positions within USGS is based on publication of peer-reviewed manuscripts. This process can take significant time; consequently some data useful to managers cannot be released prior to publication. Program administrators will develop effective ways to provide professional advancement opportunities for all LTRMP staff while meeting partners' data needs in a timely manner.

LTRMP facilities and equipment (boats, motors, sampling equipment, etc) need to be well maintained and replaced when necessary to maintain a safe and functional work environment.

<u>Actions</u>

S-2a) Create a workforce plan that provides direction for professional development and advancement for LTRMP staff, and includes or addresses:
- o Professional scientists and the support they need
- o Other professional and technical staff
- o Clarity about roles and responsibilities
- o Staffing necessary for the implementation of the strategic plan
- o Enhanced communication among staff in various LTRMP organizations

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OPERATIONAL PLAN FOR 2010-2014:
- UMESC and the COE will work with the partnership to develop a workforce plan to describe staffing needed to fully implement the Operational Plan.
- The LTRMP will include support for research and publishing to assist principal investigators, and for training to maintain and improve the technical expertise of staff.
- UMESC and the COE will update descriptions of the roles of each partner agency and key staff for review by the partnership.
- The LTRMP will enhance communication among staff, for example, by supporting a biennial meeting of LTRMP staff and partners.

S-2b) Maintain the facilities

OPERATIONAL PLAN FOR 2010-2014:
- It will be the responsibility of each partner to maintain a safe, secure, and effective facility and working environment for their staff.

S-2c) Replace equipment as needed through the equipment refreshment plan

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OPERATIONAL PLAN FOR 2010-2014:
- UMESC and the field stations will develop a list of standard equipment required to execute the program and develop a life cycle schedule for major equipment.
- UMESC will maintain a prioritized list for equipment refreshment and develop guidelines for what items will, and will not, be included on the list.
- The LTRMP budget will include at least 1% of annual funding for equipment refreshment.

OPERATIONAL PLAN FOR 2010-2014:

Implementation of actions to achieve the Plan during 2010–2014:
The Strategic Planning Team developed ranks for the Plan's outputs and assigned priorities for activities within each output (Table 2). The Team used this information to develop considerations for how to implement the Plan during the 5-year period covered.

Although achieving the LTRMP mission requires full implementation of this Plan, many elements of the plan build upon other elements and can be sequenced (e.g., research is needed to define mussel sampling methods before a monitoring procedure can be established). Sequencing of activities can help create a smooth transition from the 2005–2009 plan to the 2010–2014 plan and can provide more effective use of effort under variable funding levels. There is also considerable flexibility in the amount of effort that can be applied annually to many of the Plan's elements. Thus, these elements can be expanded or contracted as required.

Implementing the Plan will still require developing an annual Scope of Work for LTRMP. In developing the Scope, Program managers should reflect the priorities of the partnership and strive to maintain continuity of work between years whenever possible. But, they should also retain flexibility to account for annual budget variations, staffing capabilities, and unanticipated opportunities, including opportunities for cooperative efforts both within and outside the partnership that can enhance our collective capabilities.

The Strategic and Operational Plan can be accomplished under either EMP or NESP. Initial budget estimates indicate that full implementation will require more funding than is currently authorized under EMP. If a transition to NESP occurs, funds within NESP that are designated for LTRMP will be applied to carry out this Plan. However, some aspects of the Plan may be accomplished through other funding sources within NESP (e.g., funds designated for adaptive management or for project monitoring) in ways that leverage needs and capabilities between programs. Thus, some priorities expressed in the Strategic and Operational Plan may change once NESP is adequately funded.

Figure 1. Map of the Upper Mississippi River System showing locations of the study reaches for the Long Term Resource Monitoring Program (Navigation Pools 4, 8, 13, and 26; an Open River Reach on the Mississippi River; and La Grange Pool on the Illinois River).

Table 1. Sampling effort within the Long Term Resource Monitoring Program during fiscal years 2005–2009, with additional sampling to be added for 2010–2014, and data collected by each component.

Component	Study Area						Summary of data collected[1]
	4	**8**	**13**	**26**	**La Grange**	**Open River**	
Aquatic Vegetation	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	450 stratified random sample sites over growing season.	__[2]	[2]	[2]	Species, abundance, frequency, distribution, depth, substrate, detritus
Fisheries	~160 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~180 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~200 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~180 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~270 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	~165 samples; 2 periods: Aug. 1–Oct. 30, 6 sampling gears. Mix of stratified random and fixed sites.	Species; catch-per-effort; length; subsample for weight, age, & diet; secchi; water depth, temperature, velocity, conductivity; vegetation density; substrate; dissolved oxygen
Added fish monitoring for 2010–2014	1st period, June 15–July 31, 82 samples	1st period, June 15–July 31, 82 samples	1st period, June 15–July 31, 100 samples	1st period, June 15–July 31, 92 samples	1st period, June 15–July 31, 120 samples	1st period, June 15–July 31, 82 samples	
Water Quality	135 stratified random sites done in each episode (winter, spring, summer, and fall); 14 fixed sites[3]	150 stratified random sites done in each episode (winter, spring, summer, and fall); 13 fixed sites[3]	150 stratified random sites done in each episode (winter, spring, summer, and fall); 12 fixed sites[3]	121 stratified random sites done in each episode (winter, spring, summer, and fall); 9 fixed sites[3]	135 stratified random sites done in each episode (winter, spring, summer, and fall); 11 fixed sites[3]	150 stratified random sites done in each episode (winter, spring, summer, and fall); 9 fixed sites[3]	Suspended solids, major plant nutrients, chlorophyll a, silica, pH, secchi, temperature, dissolved oxygen, turbidity, conductivity, vegetation type & density, wave height, depth, current velocity, depth of snow/ice, substrate, phaeophytin, phytoplankton (archived),
Added water quality monitoring for 2010–2014	14 fixed sites in Pools 4 biweekly during July and August.	4 historic + 2 new fixed sites, biweekly from April through August.	none	none	none	none	
Land Cover/Land Use	Land Cover/Land Use digital aerial photography will be acquired in 2010 and processed in subsequent years. Systemic land cover data for the Upper Mississippi River System is collected approximately every 10 years. To date, systemic land cover has been mapped twice through the Long Term Resource Monitoring Program, in 1989 and 2000.						

[1]A full list and explanation of data collected by each component is available through the LTRMP data web site at http://www.umesc.usgs.gov/data_library/other/ltrmp_monitoring.html.
[2]Aquatic vegetation is not sampled in Pool 26 and La Grange because previous sampling revealed very low abundance, or in Open River due to a lack of suitable habitat.
[3]Frequency of fixed site sampling is bi-weekly in April, May, and June, and monthly in all other months, with no sampling in December and February (i.e., winter sampling in January only).

Table 2. Outcomes, Outputs, and Activities identified in the Long Term Resource Monitoring Program Strategic and Operational Plan, with ranks as assigned to Outputs and priorities as assigned to Activities within each Output. See the text of the Plan for a more complete description of each table element. Activities under "Regional Program Support & Management" are support elements provided by the Corps of Engineers and are not listed within the text of the Plan.

Rank for Outputs	Priorities for Activities	Outputs	Activities
Outcome 1		
1		**1.1**	**Status and Trends**
	1 1 1 1 1 1	Existing	Aquatic Vegetation Fisheries Water Quality LU/LC (Staff Support) Bathymetry (Staff Support) 2010 LU/LC (Data Interpretation)
	4 4 3 3 3 5	New	Bathymetry (acquisition) Bathymetry processing & serving LiDAR (acquisition) LiDAR processing & serving LiDAR (staff support) Status and Trends Report
4		**1.2**	**Indicators**
	1 2		Development Track status and trends
5		**1.3**	**Added Info for Status & Trends**
	1 1 1 1 2 2 3 3		Bathymetry Plan (Pending) LiDAR Plan (Adopted) Mussel Monitoring Plan + testing Mussel Monitoring Forests Plan + testing Forest Monitoring Macroinvertebrate Plan + testing Macroinvertebrate Monitoring
8	1	**1.4**	**Sampling at Various Spatial Scales**
Outcome 2		
2.5	1	**2.0**	Overarching Science Coordination Plan
2.5		**2.1**	**Data Insights/Analysis**
	 1 1 1 2		Conduct analyses of LTRMP and other data sets Statistical Evaluation Data management Science management Analysis of existing data
2.5		**2.2**	**Focused Research**
	 1 2 3 4 5 1		Provide data analysis (see output 2.1) Aquatic Vegetation Mussels Connectivity Landscape Special APE/science Mgmt.
7		**2.3**	**Decision Support Tools**
	2 1		Develop or improve model of sediment and flow dynamics Decision Support Systems

9		**2.4**	**Adaptive Management**
	2		Clarify relationships
	4		Participate and provide…
	1		Participate in restoration and planning efforts
	3		Develop an approach to documenting and delivering lessons learned
		Outcome 3	
6		**3.1**	**LTRMP-HREP**
	1		Restoration team and LTRMP meetings
	3		PDT involvement
	2		Science liaison
			Project evaluation/ecological monitoring
		Outcome 4	
3	1	**4.1**	**Outreach coordinator:** communication strategy
			Informed Decisions (Who) Outreach Plan
	2		Public/officials
	1		Program Managers
	1		Project Managers
	3		Scientific/technical
3		**4.2**	**LTRMP Info Satisfaction**
	1		Deliver information
	1		Outreach team
	2		Improve delivery
		Strategies	
1a		**S1**	**Data serving**
	1		Data Visualization
	2		Data management
1a		**S2**	**Infrastructure**
	1		Workforce plan
	4		Staff support & training
	3		Field Station Meetings
	1		Facilities
	2		Field Equipment
1a			**Regional Program Support & Management**
	4		2015-2019 planning
	2		Strategic/Operational Plan Updates
	3		UMESC (Report to Congress)
	1		USACE management
	1		USACE Technical Support