FINAL

INTEGRATED FEASIBILITY REPORT AND PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

for the

UMR-IWW System Navigation Feasibility Study

24 September 2004

"To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System"

US Army Corps of Engineers®

EXECUTIVE SUMMARY

PURPOSE

The purpose of this document is to provide a comprehensive documentation of the Upper Mississippi River-Illinois Waterway (UMR-IWW) System Feasibility Study process and recommended plan of action. Traditionally, the Feasibility Report and Programmatic Environmental Impact Statement (PEIS) are produced as two separately bound documents. However, a single integrated document meets the requirements of the National Environmental Policy Act (NEPA) and the Corps of Engineers decision-making process without duplication. The main table of contents includes asterisks for those traditional NEPA required chapters and sections to allow ready access for those specifically interested in the NEPA compliance review.

The report organization and contents are intended to allow the reader to become familiar with the background and history of this magnificent river system leading to the current study including a full disclosure of decision process and compliance with Corps policy and guidance in addition to applicable Federal and State laws. The information provided in Chapters 1 through 3 establishes a review of the study purpose, history, organizational structure, and decision process. Chapters 4, 6, 7, and 12 provide a comprehensive description and explanation of the UMR-IWW System Navigation Study decision process leading to the identification of a Recommended Plan for Ecosystem Restoration and Navigation Efficiency (Chapter 14). Chapters 5, 8, 9, 10, and 11 provide legally required disclosure and documentation concerning the direct, indirect, and cumulative environmental effects attributable to the proposed actions as well as appropriate avoid, minimize, and mitigation measures. Chapter 13 outlines the process followed by this study during the public review period (May 14 – July 30, 2004) and a summary of the comments received from Federal and State agencies, non-governmental organizations and the public. Chapter 15 provides a listing of the Corps team that assisted in the preparation of this document. Chapter 16 provides a comprehensive listing of the 140+ technical reports (with abstracts) that were generated over the course of this decade-long study. Chapter 17 lists the references cited in the document. Chapter 18 includes a listing of the individuals and organizations that received a hardcopy of this Final document. The appendices included on the enclosed Compact Disc contain electronic copies of several thousand pages of detailed information documenting the methodology, results, and conclusions for each of the primary study components: Engineering, Economics, Environmental Impacts, Ecosystem Sustainability, Public Involvement, Real Estate, and Quality Management. Two additional appendices are also provided that: (1) convey the responses to comments received during the review period for the draft version of this document (May 14 – July 30, 2004); and (2) document the guidance memorandums that have shaped and guided the study since August 2001.

BACKGROUND AND NEED FOR ACTION

The study was initiated in April 1993 to address the potential economic losses to the Nation for significant traffic delays at locks on the commercial navigation system between 2000 and 2050. In 2001, the study was restructured to address the ongoing cumulative effects of navigation, and the ecosystem restoration needs, with a goal of attaining an environmentally sustainable navigation system, in addition to insuring an efficient transportation system for the future. The study area extends from Minneapolis-St. Paul downstream to the confluence of the Ohio River and the Illinois Waterway from Grafton, Illinois, upstream through the Thomas J. O'Brien Lock in Chicago. It includes 37 locks (29 on the UMR and 8 on the IWW) and approximately 1,200 miles of navigable waterway within portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The principal navigation problem addressed by this study is the potential for significant traffic delays on the UMR-IWW Navigation

System within the 50-year planning horizon. The principal environmental problems addressed by this study are changes to ecosystem structure and function that have occurred since initiation of the operation and maintenance of the existing 9-Foot Channel Navigation Project. The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions while restoring, protecting, and enhancing the environment. The goal of the feasibility study is to outline an integrated plan to ensure the economic and environmental sustainability of the UMR-IWW Navigation System to ensure it continues to be a nationally treasured ecological resource as well as an efficient national transportation system as designated by Congress in the 1986 Water Resources Development Act (Public Law 99-662).

STUDY PROCESS

The study generally followed the Corps of Engineers 6-step planning process including identification of problems and opportunities, inventory of forecast resource conditions, formulation of alternatives, evaluation of alternatives, comparison of alternative plans, and selection of a recommended plan. The PEIS is intended to provide a detailed accounting of potential environmental consequences resulting from the proposed Federal action and includes a description of affected environment, environmental effects, cumulative effects, and statutory and other applicable requirements. The study included a high degree of collaboration with Federal and State agencies, non-governmental organizations, and the public.

INVENTORY AND FORECAST RESOURCE CONDITIONS

Importance of the System

Traffic usage and tonnage increased rapidly through the 1970s, but growth rates have flattened considerably since the 1980s. Traffic increased by a factor of 8 between 1950 and 1980. Between 1965 and 2002, commercial traffic increased by an annual average growth rate of 2.2 percent for the UMR reach, 1.2 percent for the IWW reach, and 3.0 percent for the Middle Mississippi River (MMR) reach. Traffic is greatest at the downstream end of the navigation system as different regions add or consume commodities in the downstream or upstream direction, respectively. For the 10-year period 1990-1999, delays per tow averaged 3.4 hours at Locks 20-25; 2.2 hours at Locks 14-18; 0.9 hour at Locks 8-13; and 0.4 hour for Upper St. Anthony Lock to Lock 7. The system carried approximately 50 percent of the Nation's corn and 40 percent of the Nation's soybean exports in 2002. The existing system generates an estimated $1 billion of transportation cost savings to the Nation. These benefits compare with the annual operation and maintenance costs of approximately $115 million.

The Upper Mississippi River System is also considered a tremendous natural resource. The ecosystem consists of hundreds of thousands of acres of bottomland forest, islands, backwaters, side channels, and wetlands—all of which support more than 300 species of birds, 57 species of mammals, 45 species of amphibians and reptiles, 150 species of fish, and nearly 50 species of mussels. More than 40 percent of North America's migratory waterfowl and shorebirds depend on the food resources and other life requisites (e.g., shelter, nesting habitats, etc.) that the system provides. The system's ancient fish and freshwater mussels are a unique and significant fauna. The Upper Mississippi River System (UMRS) and associated environments have a rich record of human history spanning over 12,000 years. It also provides boating, camping, hunting, trapping, and other recreational opportunities to more than 11 million visitors each year. Needs for the ecosystem are presented as objectives for the desired future condition of river habitats and ecological processes.

Future Without-Project Condition

The future without-project condition defines what the likely and foreseeable conditions will be for the system in the absence of any Federal action. The without-project condition serves as a baseline against which alternative plans are evaluated. The future demand for waterway transportation is a key factor in defining the without-project condition and determining the need for future navigation improvements. A scenario-based approach to traffic forecasting was used to address the inherent uncertainty in forecasting economic conditions over the 50-year planning horizon. Such an approach follows recommendations provided by the Federal Principals Task Force, which includes members from the Departments of Transportation, Interior, and Agriculture, and the Environmental Protection Agency. The scenarios developed represent a range of alternative views of the future demand for navigation on the UMR-IWW System. A consequence of applying a scenario-based approach to traffic forecasting is multiple representations of the without-project condition. Specifically, this approach is intended to define a range of plausible alternative future scenarios that ultimately describe the demand for inland waterway transportation. It was assumed that some Federal and non-Federal actions would take place to a limited degree as traffic increases to insure best utilization of the system in the overall public interest, including economic efficiency, safety, and environmental impact.

The impacts of human activities on the ecosystem have resulted and continue to result in a decline in the environmental quality of the UMRS. The resource impacts include backwater and secondary channel sedimentation, altered hydrology, loss of connectivity of the floodplain to the river, impeded fish migration, loss of island habitat, endangered plant and animal species, and loss of native plant community diversity and abundance. Large increments of ecosystem decline can be attributed to the construction and operation of the navigation system, but there are many ecological stressors contributing to ecosystem degradation including land use changes, floodplain development, exotic species, sedimentation resulting from land use practices, construction of the levee system, and non-point source pollution. The primary authority available to the Army Corps of Engineers to address this decline is the Environmental Management Program (EMP), established by the Water Resources Development Act (WRDA) of 1986. The feasibility study has concluded that the current level of authority and authorized appropriations in the EMP and national programmatic authorities and the limited environmental management activities available under a single-purpose navigation project have been insufficient to meet the environmental needs on the UMRS. Degradation of the system will continue in the future in the absence of any additional Federal action.

FORMULATION OF ALTERNATIVES

Navigation Efficiency Alternatives

The formulation of navigation efficiency alternatives began by identifying measures that meet the planning objective of providing a safe, reliable, efficient, and sustainable UMR-IWW Navigation System over the planning horizon. Navigation efficiency improvement measures can be categorized into either small-scale or large-scale improvements. “Small-scale” measures of reducing traffic congestion can generally be defined as any navigation improvement less costly than constructing a new lock. More than 92 small-scale measures were considered and divided into the categories of “structural” measures (requiring some amount of construction to implement) and “nonstructural” measures (those not requiring construction, but rather procedural or policy changes). The overall performance (total lock transit time reduction) of small-scale measures is generally less effective and less efficient than demonstrated with the large-scale measures. “Large-scale” measures involve constructing a new 1,200 foot lock or extending the existing lock to 1,200 feet. Passage through a 1,200 foot lock can be accomplished in a single lockage as opposed to the current double lockage process. Qualitative and quantitative screening processes were applied to reduce the number of measures for further evaluation and combination into alternatives. The measures that survived the screening processes include mooring facilities, switchboats, congestion fees, deck winches and excess lockage time charges, lock extensions, and new locks. These measures were combined into the following alternatives.

Alternative 1: No Action. The no action, or without-project condition, describes the future in the absence of additional Federal action.

Alternative 2: Congestion Fees Implemented through a Lockage Fee (imposed on commercial traffic). The objective of this form of congestion fees is to improve overall system efficiency by charging all users a lock usage fee, subsequently inducing marginal users (those that benefit the least from system use) to leave the system.

Alternative 3: Deck Winches and Excess Lockage Time Charges. Installation of deck winches was evaluated as a means of generating additional operating efficiency. It was assumed that installation of winches would be motivated by the prospect of having to pay a fee if lockage time exceeded a specified threshold. A training program for barge operators and installation of deck winches are the two components of the measure.

Alternative 4: Moorings (12, 14, 18, 20, 22, 24, and La Grange); Switchboats at Locks 20-25. Moorings are tie-off facilities that allow the next tow to be served to wait closer to the lock chamber; switchboats would assist in handling the cuts of a double lockage, resulting in a shorter lockage time.

Alternative 5: Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20-25; Switchboats at Locks 14-18, La Grange, and Peoria. This alternative extends UMR Locks 20-25 to 1,200 feet by adding on to the original lock structure.

Alternative 6: Mooring (12, 14, 18, and 24); New Locks at 20-25, La Grange, and Peoria; Lock Extensions at 14-18; and Switchboats at Locks 11-13. This alternative includes new 1,200 foot locks at UMR 20-25, and also at Peoria and La Grange on the Illinois Waterway.

Ecosystem Restoration Alternative

The formulation of Ecosystem Restoration Alternatives began by identifying broad ecosystem goals that meet the planning objective of addressing cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System. This umbrella objective was further defined into systemic goals and site-specific objectives. These objectives were used to identify suitable types and numbers of ecosystem management and restoration measures. Improvements to the UMRS ecosystem can be accomplished by influencing the function and structure of the system with these actions.

Approximately 400 individual regulatory, operational, and structural actions were identified and reviewed for their potential to address UMRS environmental objectives. Twelve overarching categories of restoration measures (Table EX-1) were selected after considering input from UMRS stakeholders, coordinating committees, and the Navigation Study Science Panel.

Table EX-1. UMRS ecosystem restoration measures.

• Island Building	• Water Level Management – Backwater
• Island Protection	• Backwater Restoration (Dredging)
• Shoreline Protection	• Side Channel Restoration
• Fish Passage	• Wing Dam/Dike Alteration
• Floodplain Restoration	• Improve Topographic Diversity
• Water Level Management – Pool	• Dam Point Control

These measures were combined to form the following ecosystem restoration alternatives.

Alternative A: **No action/Without project.** Current environmental management activities and rehabilitation efforts continue at historic levels.

Alternative B: **No net loss.** Protect and maintain existing environmental diversity (current mosaic of habitat types and ecological diversity maintained into the future: no net loss).

Alternative C: **Restore the first increment of habitats** most directly affected by the navigation project.

Alternative D: **Restoration to an intermediate level,** which includes management practices and cost effective actions affecting a broad array of habitat types.

Alternative E: **Restoration to a high level,** which includes most environmental objectives that could be accomplished in the context of the navigation project.

Adaptive Management

Implementation of any alternative needs to be done in the context of a comprehensive and integrated plan for river management because many system components are intrinsically linked. Making decisions to address and resolve the complex assortment of ecological needs and objectives within the UMRS should be conducted in the context of a long-term commitment to a policy of adaptive management. Adaptive management is a process that seeks to aggressively use management intervention as a tool to strategically probe the functioning of an ecosystem. Management measures are designed to test key hypotheses about the structure and functioning of the ecosystem. Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management actions as tools to not only change the system, but as tools to learn about the system.

EVALUATION OF ALTERNATIVE PLANS

Navigation Efficiency Alternatives

The navigation efficiency alternatives were evaluated using the system of four primary accounts established in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). These accounts have been devised to encompass all significant effects of a plan as required by the National Environmental Policy Act of 1969 (NEPA). The accounts established by the P&G include national economic development (NED), regional economic development (RED), environmental quality (EQ), and other social effects (OSE). Three additional accounts were established for comparative considerations and include Contribution to Planning Objectives (safety, reliability, efficiency, and sustainability), Acceptability, and Adaptability.

National Economic Development. The NED provides a measurement of the monetary impacts to the national economy. These impacts include both positive effects (primarily transportation efficiencies) and negative effects (costs required to implement and operate each alternative, including site-specific and system mitigation costs). The NED is measured as annual net benefits, which are defined as the difference between annual benefits and annual costs. Positive net benefit numbers represent benefits to the Nation, and negative net benefit numbers represent a loss to the Nation. This evaluation recognizes the uncertainty associated with the future demand for waterway transportation and the lack of definitive data on demand elasticity for commodities shipped on the river, particularly grain. Five different scenarios represent the uncertainty in future demand for waterway transportation. The uncertainty in demand elasticity is being represented by the use of three different economic modeling conditions. The question of demand elasticity centers on the issue of how the demand for waterway shipment of commodities responds to rising transportation costs. The condition reflecting an inelastic state is represented by the Tow Cost Model (TCM), while the ESSENCE Model represents the upper (E_{UB}) and lower (E_{LB}) bounds of an elastic condition. Net benefits were computed for each scenario and each assumption of elasticity, which results in 15 different economic conditions (given five traffic scenarios and three economic model specifications). Figure EX-1 displays the net benefits computed for each alternative and economic condition.

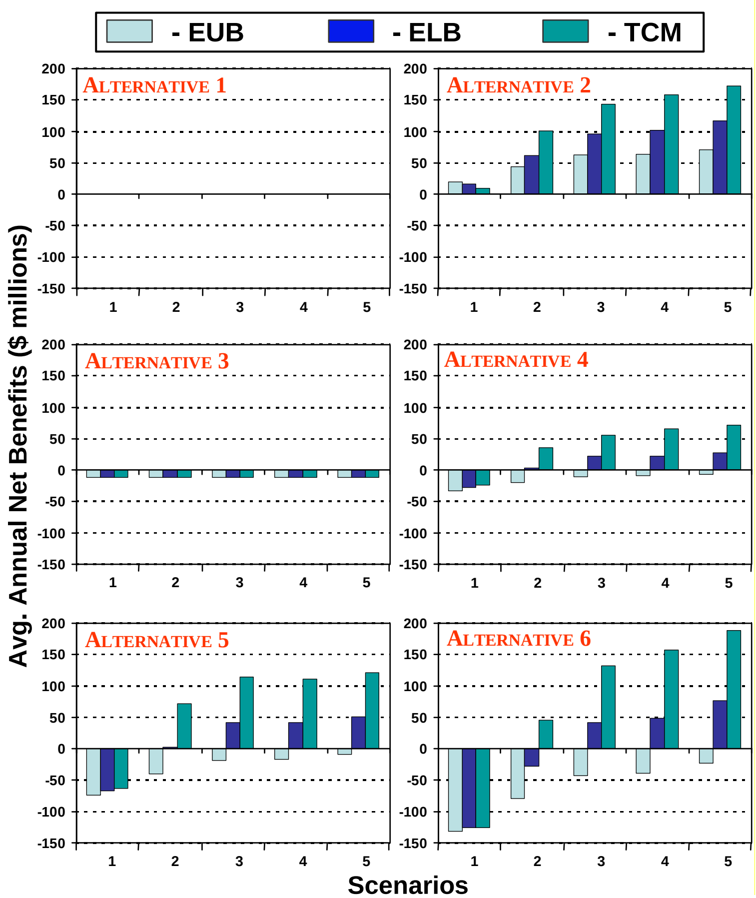

Figure EX-1. Average annual net benefits ($ millions) for navigation efficiency alternatives across the range of 15 possible economic conditions created by the use of five scenarios and three economic models.

Environmental Quality. The environmental consequences of navigation improvements were determined, and avoid, minimize, and mitigation measures were considered for each alternative. Both construction site impacts and system impacts resulting from traffic increases were considered. This was used in an ecological risk assessment framework to determine the incremental traffic effects on fisheries, submersed aquatic vegetation, bank erosion, backwater and side channel sedimentation, and historic properties. The site-specific and the systemic environmental consequences were assessed and monetized for each of the navigation efficiency alternatives and are displayed in Table EX-2.

Table EX-2. Description of avoid, minimize, and mitigation measures recommended to offset the incremental effects of additional commercial traffic resulting from the navigation efficiency alternatives.

Alternative 4	Environmental Impacts	Mitigation Cost
Bank Erosion	Increase erosion on 10.8 miles of shoreline	$ 17,563,523
Backwater and Secondary Channel	Increase sedimentation at 31 sites	$ 29,390,769
Plants	Degrade 5.5 miles of plant beds	$ 3,306,020
Fish	8,360,000 fewer fish in the river	$ 13,167,619
Monitoring	43 studies and 40 years of bioresponse monitoring	$ 7,171,441
Historic Properties	Potential destruction of 100 historic sites	$ 9,500,000
Site Specific	Construction site impacts of 1 mooring cell	$ 4,764,413
Administration	50 years	$ 8,486,379
Total		$ 93,350,164

Alternative 5	Environmental Impacts	Mitigation Cost
Bank Erosion	Increase erosion on 10.8 miles of shoreline	$ 17,563,523
Backwater and Secondary Channel	Increase sedimentation at 31 sites	$ 29,390,769
Plants	Degrade 19 miles of plant beds	$ 12,021,890
Fish	22,800,000 fewer fish in the river	$ 36,196,040
Monitoring	Studies and 40 years of bioresponse monitoring	$ 9,400,000
Historic Properties	Potential destruction of 105 historic sites	$ 10,200,000
Site Specific	Construction site impacts of 1 mooring cell, 5 locks	$ 15,127,011
Administration	50 years	$ 12,989,923
Total		$ 142,889,156

Alternative 6	Environmental Impacts	Mitigation Cost
Bank Erosion	Increase erosion on 10.8 miles of shoreline	$ 17,563,523
Backwater and Secondary Channel	Increase sedimentation at 31 sites	$ 29,390,769
Plants	Degrade 27.5 miles of plant beds	$ 16,530,098
Fish	28,360,000 fewer fish in the river	$ 59,156,934
Monitoring	67 studies and 40 years of bioresponse monitoring	$ 14,292,780
Historic Properties	Potential destruction of 112 historic sites	$ 10,590,000
Site Specific	Construction site impacts of 1 mooring cell, 12 locks	$ 37,297,628
Administration	50 years	$ 18,482,173
Total		$ 203,303,905

Note: Alternatives 1, 2, and 3 have no mitigation costs associated with them.

Regional Economic Development. The income and employment benefits for each alternative were computed for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri, along with the Lower Mississippi River region and the rest of the United States. These income and employment effects are derived from direct construction expenditures required to implement an alternative and from the transportation efficiencies generated by the alternative.

Other Social Effects. The positive or negative impacts of waterway traffic versus rail for the categories of emissions, accidents, noise and other community impacts are provided for each alternative. A positive number indicates a project benefit, while a negative number indicates a project cost or disbenefit.

Planning Objectives. Each alternative was evaluated for its contribution to meeting the objective of providing a safe, reliable, efficient, and sustainable UMR-IWW Navigation System.

Acceptability. Institutional and social acceptability of the alternatives with respect to acceptance by Federal, State, and local entities and the general public can be viewed in Chapter 13, Stakeholders Perspective.

Adaptability. Each alternative was evaluated for its ability to adjust, based on changes in future conditions or the degree to which the commitment is reversible. Small-scale measures are generally more adaptable than large-scale measures.

Ecosystem Restoration Alternatives

Ecosystem restoration alternatives were evaluated under seven accounts of National Ecosystem Restoration (NER) Benefits, Environmental Quality, Regional Economic Development, Other Social Effects, Contribution to Planning Objectives, Acceptability, and Adaptability. National Ecosystem Restoration (NER) benefits is pursuant to Engineer Regulation 1105-2-100 and the next three are pursuant to the Principles and Guidelines (P&G) primary accounts to facilitate an evaluation process. Within these accounts, the four P&G evaluation criteria of completeness, efficiency, effectiveness, and acceptability are included to provide the primary basis of comparing and evaluating the ecosystem alternative plans.

Environmental Benefits - National Ecosystem Restoration (NER). The environmental equivalent to the NED is the National Ecosystem Restoration (NER) benefits, which is the plan that reasonably maximizes ecosystem restoration benefits compared to costs. The benefits are expressed in terms of acres of influence, which is the area positively affected by the restoration measure. The summary of these results is shown on Figure EX-2.

Environmental Quality (EQ). Environmental quality effects were evaluated primarily by assessing the ability of the alternative to fully address the needs of the UMRS ecosystem. By examining the number, type, and potential results of restoration measures, the completeness and diversity of ecosystem alternatives were quantitatively and qualitatively assessed. This process included identifying the extent to which the alternative plan maintains or exceeds the existing condition, accounts for ecosystem needs identified in the virtual reference, accounts for nine essential UMRS ecosystem objectives identified in *A River that Works and a Working River* report, and affects ecosystem diversity. Figure EX-2 contains a summary of the evaluation results for NER and EQ.

Regional Economic Development (RED). The income and employment benefits for each alternative were computed for the states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri along with the Lower Mississippi River region and the rest of the United States. RED benefits are presented as average annual income and average annual jobs created from 2005 to 2035. The RED assessment considered only income and employment directly related to alternative construction, which made up approximately 75 percent of the total alternative cost.

Other Social Effects (OSE). Other social effects were considered primarily in the form of ecosystem goods and services maintained or enhanced by the alternative plans (e.g., water quality, nutrient processing, recreation, commercial fishing, etc.).

Contribution to Planning Objectives. Each alternative was evaluated for its contribution to meeting the objective of addressing the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.

Acceptability. Institutional and social acceptability of the alternatives with respect to acceptance by Federal, State and local entities and the general public can be viewed in Chapter 13, Comments and Views.

Adaptability. Each alternative was evaluated for its ability to adjust, based on changes in future conditions or the degree to which the commitment is reversible.

ECOSYSTEM RESTORATION ALTERNATIVES

Alternative Evaluation Results

ACCOUNTS	ALTERNATIVE PLANS					
	A	B	C	D	E	Other
A. Environmental Benefits (NER)	**Rank**					
A1. Project Cost						
A1a. Total Cost	$0.0	$1,691,700,000	$2,816,600,000	$5,182,800,000	$8,416,700,000	
A1b. Cost (w/out Fish Passage or WLM)	$0.0	$1,561,900,000	$2,686,800,000	$4,262,700,000	$6,272,800,000	
A1c. Total Average Annual Cost (Base Year 2005)	$0.0	$35,080,000	$58,400,000	$106,290,000	$174,520,000	
A2. Env. Benefits (Acres of Influence) (w/out FP or WLM)	0	119,800	223,700	388,300	604,100	
A3. Cost Effectiveness						
A3a. Alternative Cost Effectiveness (A1b ÷ A2)	$0	$13,000	$12,000	$11,000	$10,400	
A3b. Water Level Management Cost Effectiveness	-	High	High	High	Moderate	
A3c. Fish Passage Cost Effectiveness	-	-	-	High	Moderate	
B. Environmental Quality	**Rank/Considerations**					
B1. Completeness						
B1a. Relation to Existing Condition	Lose	Maintain	Restore	Restore	Restore	
B1b. Proportion of the Ecosystem Measures	0%	43%	56%	70%	83%	
B1c. UMRCC Env. Objectives (River that Works R.)	0/9	6/9	7/9	8/9	8/9	
B2. Ecosystem Diversity						
B2a. Maintain viable populations of native species in situ.	-	Low	Moderate	High	High	
B2b. Represent all native ecosystem types across their natural range of variation.	-	Low	Moderate	High	High	
B2c. Restore and maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.).	-	Low	Low	Moderate	High	
B2d. Integrate human use and occupancy within these constraints.	-	-	-	-	-	

Figure EX-2. Partial copy of the Ecosystem Restoration Alternative Evaluation Scoresheet.

CUMULATIVE EFFECTS

The cumulative effects of the navigation project and other human activity in the UMRS basin create a without-project future for the UMRS ecosystem that would include fewer backwater acres, less water depth in non-channel habitats, degraded forest structure and land cover diversity, and uncoordinated floodplain management. Deep backwaters, grasslands, hardwood forests, and marsh are the most threatened habitats. The game and non-game animals that depend on the diverse river ecosystem would decline commensurate with the decline of river habitats. River regulation, sedimentation, and floodplain development are considered primary stressors. The direct effects of the navigation efficiency alternatives were considered in light of these ongoing cumulative effects. The adaptive implementation of the proposed mitigation plan will offset these direct effects. The recommended ecosystem restoration plan was designed to compensate for other cumulative effects including the ongoing effects of operation and maintenance activities. The ecosystem restoration alternatives developed for this study were structured to address aspects of a sustainable ecosystem associated with the Navigation project. It is important to note that the Navigation Study recommendation for ecosystem restoration alone cannot achieve full system sustainability because many issues are beyond the reach of the navigation project. True sustainability can only be met through the integration of upland and main stem resource objectives and management actions.

COMPARISON OF ALTERNATIVE PLANS

Navigation Efficiency Alternatives

The comparison of alternative plans is an iterative process that involves comparison of the NED benefits initially, and then across the additional criteria of environmental quality, RED, and other social effects, contributions to planning objectives, acceptability and adaptability. Alternative 3 Deck winches is screened from further consideration since it produces negative benefits across all economic conditions. Alternative 2 Congestion fees is screened from further consideration since it fails to fully meet the planning objectives of economic sustainability by limiting growth on the system. In addition, current law prohibits congestion fees, and current national policy makes institutional acceptability of this alternative doubtful. The NED and other criteria comparison of Alternatives 4, 5, 5B and 6 do not result in a clear best alternative as indicated in the premise set comparison in Table EX-3.

Table EX-3. Alternative that maximizes net benefits for each economic condition based on premise set comparison.

Demand Elasticity Assumption	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TCM	Alternative 1	Alternative 5	Alternative 6	Alternative 6	Alternative 6
ELB	Alternative 1	Alternative 4	Alternative 5B	Alternative 6	Alternative 6
EUB	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1

*Scenario 3 ELB average annual net benefits are essentially equal for Alternative 5 ($41 million); Alternative 5B, a variation of alternative 5 ($44 million); and Alternative 6 ($42 million).

The need for navigation efficiency improvements is very much dependent on the assumptions of demand elasticity and traffic forecasts. The no growth scenario 1 results in no action being needed and the high growth scenarios 3, 4, and 5 result in the need for Alternative 6 implementation. Implementation of any plan needs to be done in an adaptive framework.

Ecosystem Restoration

The comparison of ecosystem restoration plans is also an iterative process that involves comparison of the NER benefits initially, and then across the additional criteria of environmental quality, RED, and other social effects, contributions to planning objectives, acceptability and adaptability. Based on assessment of these key evaluation criteria, it was determined that Alternative D outperforms Alternative E because it contains measures that are more effective and have a greater likelihood of success. Though D and E were very close in their overall ranking, Alternative D was identified as the recommended alternative primarily because it is likely to achieve a high degree of completeness and diversity in the most efficient manner. Based on stakeholder input and discussion, the existing Alternative D measures have been further refined to include embankment lowering at lock and dam sites to promote floodplain connectivity and include the addition of measures that reduce water level fluctuation on the Illinois River in an effort to improve aquatic habitat. The revised alternative is designated D*.

MAJOR AREAS OF CONTROVERSY

The following items represent the major areas of concern as expressed by some agencies and organizations, followed by the approach used to address the concerns in the study.

The proposed 15 year Ecosystem Restoration Authority is insufficient to begin serious restoration efforts. The recommended plan is to seek approval of a $5.3 billion 50-year framework for ecosystem restoration, including authorization for the first 15-year increment at $1.462 billion. This alternative contains the measures that were found to be the most cost effective and have a greater likelihood of success. Authorization for additional increments would be contingent upon a future report submitted to Congress. This adaptive implementation approach will provide sufficient time to plan, design, construct, and monitor the performance of a diverse group of measures. It also includes application of research to be conducted to better understand the ecological response of measures and guide future investments.

Funding of ecosystem restoration needs to be predominately Federal funding. The proposed regional cost sharing arrangement as supported by the Mississippi Valley Division, States, U.S. Fish and Wildlife Service is for a combination of 100 percent Federal and cost-shared 65 percent Federal and 35 percent non-Federal funding for implementation of the ecosystem restoration portion of the plan. The recommended ecosystem restoration framework plan consists of an estimated 1,010 projects with a combined first cost of about $5.3 billion, of which $4.25 billion is proposed to be 100 percent Federal.

The Scenarios developed to represent the future traffic forecasts do not represent a valid picture for the future. The recommended plan recognizes the uncertainty in demand for waterway transportation especially grain, and has accounted for the uncertainty by the development of an adaptive implementation strategy. The Department of Transportation and Agriculture concur that the scenarios represent a plausible range of future demand for grain exports. The traffic scenarios calling for traffic increases have been recently characterized by the U.S. Department of Agriculture as consistent with their Baseline Projections for grain exports. In a letter of February 24, 2004 the Administrator of the Agricultural Marketing Service indicates that the USDA’s latest Baseline Projections show corn exports increasing by 53 percent for the next decade and that the Baseline increase in export growth is consistent with the positive growth scenarios used in the Corps’ feasibility study. The USDA’s Chief Economist, estimated that corn exports through the Gulf of Mexico would increase 29 to 36 percent by 2014.

Use of the Tow Cost and ESSENCE economic models are not sufficient to make an investment decision. The feasibility study recognizes that the current economic models available to the Corps of Engineers have strengths and weaknesses. Rather than using a single model, the study utilizes two economic models and five potential future traffic scenarios to display a range of potential benefits for the navigation improvements being evaluated. The result is that the uncertainties surrounding the justification of the navigation efficiency improvements are fully displayed for decision makers in the Administration and the Congress. The Corps is actively engaged in a research program to improve its economic modeling capability but the results of this research are years away from potential application to navigation studies. The adaptive implementation strategy includes reevaluation with new economic models when they become available in the future. The Corps has initiated a research effort, outside this study, to develop new economic forecasting models that incorporate spatial equilibrium concepts. Upon the completion, testing, peer review, and acceptance of such models, an evaluation report would be prepared utilizing these new tools to re-evaluate UMR-IWW commercial traffic forecasts. This report would convey this new information to Congress along with the Corps' recommendation whether or not to stop or delay construction based upon changes in traffic forecasts.

The study needs to fully evaluate non-structural measures. The recommended alternative calls for immediate implementation of small-scale measures such as mooring cells and switchboats at the most heavily utilized locks while larger scale measures are planned and designed. The Feasibility Study concluded that master scheduling and congestion fees, were impractical to implement due to operational and market characteristics of the system. The Corps is committed to the development and testing of an appointment scheduling system during the adaptive implementation process.

Public REVIEW AND COMMENT

The Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement public review period extended from May 14 to July 30, 2004. Nearly 40,000 comments on the draft report were received from over 4,300 persons during the public comment period. The global importance of this issue is reflected in the fact that email responses were received from each of the 50 States, in addition to Washington, D.C., and Canada. The comments ranged from complete support of the recommended plan to support for returning the river to its natural state. These views are not necessarily those of the general public, since they do not constitute a valid random or representative sample of the general public. Thus, although this information can provide insight into the perspectives and values of the respondents, it does not necessarily reveal the desires of society as a whole.

The State and Federal agencies generally agreed with the adaptive implementation strategy central to the recommended plan. They felt this approach would provide the opportunity to re-evaluate investment decisions as more information is obtained. The navigation and agriculture non-governmental organizations generally endorsed the recommended plan with a heavy emphasis on supporting infrastructure improvements. The environmental non-governmental organizations generally support more ecosystem restoration than contained in the recommended plan and support the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks.

Chapter 13 contains a summary of report comments and stakeholder views received during the May 14 – July 30 review period. A complete record of comments, responses, and letters can be found in the Response to Comments Appendix.

RECOMMENDED PLAN: DUAL PURPOSE INTEGRATED PLAN

The UMRS is a multi-purpose river system that provides economic and environmental benefits to the Nation. The stakeholders of the UMRS have expressed their desire to seek a balance between the economic, ecological, and social conditions to ensure the waterway system continues to be a nationally treasured ecological resource as well as an efficient national transportation system. It is proposed that an integrated plan be approved as a framework for modifications and operational changes to the Upper Mississippi River and Illinois Waterway System to provide for navigation efficiency and environmental sustainability, and to add ecosystem restoration as an authorized project purpose. The integrated plan will provide better focus and flexibility to adaptively manage the operation and maintenance of the system for both navigation and the environment. The plan will include a long-term framework (Alternatives 4 and 6) for navigation efficiency improvements to include small-scale structural and nonstructural measures, new 1,200-foot locks and lock extensions, and appropriate measures to avoid, minimize, and mitigate for environmental impacts at a first cost of $2.4 billion plus annual switchboat operation costs of $18 million. It also includes a $5.3 billion long-term framework

(Alternative D*) ecosystem restoration plan to be accomplished in cooperation with the U.S. Fish and Wildlife Service, the five States, and private non-profit groups to improve the natural resources of the river through projects for habitat creation, water level management, fish passage, and floodplain restoration.

Recommended Cost Sharing Plan

The proposed cost sharing arrangement is for a combination of 100 percent Federal and cost-shared 65 percent Federal and 35 percent non-Federal funding for implementation of the ecosystem restoration portion of the plan. The 100 percent Federal funding is proposed for those ecosystem restoration measures that primarily address the ongoing impacts of the existing 9-foot navigation project. There are three primary reasons for recommending a large proportion of 100 percent Federal funding: (1) there are extensive Federal resources within the waterway including almost 285,000 acres of National Wildlife and Fish Refuges; (2) there is a large role that the operation of the existing 9-foot navigation project has played in the environmental degradation addressed by the ecosystem restoration plan; and (3) there is the interstate nature of the navigation system and the fact that is passes through five different states significantly complicating any cost sharing arrangements. The operation, maintenance, replacement, repair and rehabilitation costs are proposed to be assumed by the agency with management responsibility for the land on which the project is located or the operation and maintenance responsibility for the structure being modified. The plan also includes seeking authority to allow for Federal participation (100 percent Federal or cost shared as applicable) in major rehabilitation of projects damaged in major flood events.

The recommended ecosystem restoration framework plan consists of an estimated 1,010 projects with a combined first cost of about $5.3 billion. The total estimated operation and maintenance costs for these projects over a 50-year project life in 2003 dollars are estimated at $257 million. The first cost of the 100 percent Federal projects is estimated at about $4.25 billion. The total first cost of the cost shared floodplain restoration projects is estimated at about $1.05 billion with a Federal share of about $680 million and a non-Federal share of about $370 million. Since the majority of the land and water areas of the UMRS are managed by either the U.S. Fish and Wildlife Service or the 5 states, the Corps operation and maintenance responsibility will be largely limited to fish passage facilities, operational costs of water level management, and operation and maintenance of dike and wing dam alterations. These costs are estimated at a total of $30 million over a 50-year period. The remaining 50-year total operation and maintenance cost of $227 million will be borne by the U.S. Fish and Wildlife Service, the states and other cost share partners.

The primary partners in the implementation of the ecosystem restoration projects will be the U.S. Fish and Wildlife Service and the states in assuming the operation and maintenance responsibility for completed habitat projects and the states and non-profit entities for cost sharing and operation and maintenance of floodplain restoration projects. The partners have expressed interest in participating in this cost sharing arrangement.

Adaptive Implementation

The integrated plan will be implemented through an adaptive approach that will include checkpoints requiring future reporting to the Administration and Congress. The plan will be administered by the Corps of Engineers in full collaboration with the other Federal and State agencies involved in management of the UMRS. The integrated plan will seek authorization for the following:

1. **Authorization and immediate implementation of Alternative 4 small-scale structural and nonstructural measures at a total cost of $218 million to include:**
    - Mooring facilities at Lock and Dams 12, 14, 18, 20, 22, 24 and LaGrange ($11 million).
    - Switchboats at Lock and Dams 20-25 phased approach ($207 million for 15 years).

- o Appropriate mitigation.
- o Cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

2. Authorization and immediate implementation of the first increment of Alternative 6 at a total cost of $1.66 billion to include:

- o New 1,200 foot Locks at Lock and Dams 20-25, La Grange, and Peoria ($1.46 billion).
- o Appropriate mitigation ($200 million for site-specific system effects).
- o Adaptive implementation to include the following decision points and Congressional oversight:
  - ▪ A notification report at the end of design and before construction contract award that presents (1) all new information resulting from monitoring river traffic and markets, and (2) the results of any improved models and analysis.
  - ▪ An evaluation report will be submitted in approximately 5-7 years to the Administration and Congress upon the reevaluation of regional, national and world market conditions and development and application of new peer-reviewed models, concluding with a recommendation on whether or not to stop or delay lock construction. These new models will be subjected to review by scientific peers and the model's acceptability will be based on validated theory, computational correctness, and model appropriateness for the study tasks.
  - ▪ An updated feasibility report requiring additional authorization before proceeding with the five lock extensions at Locks 14-18.
- o The cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

3. Authorization of continued study and monitoring of the system to include:

- o Development of an appointment scheduling system.
- o Development of a new spatial model.
- o Collection of demand elasticity data.
- o Monitoring of traffic delays and patterns.
- o Monitoring of domestic and global grain market conditions, land use, crop yield technology, and developments in China regarding import trends.
- o Cost of the study and monitoring plan shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

4. Authorization of the first 15 year increment of the Alternative D* framework at a total cost of $1.462 billion to include:

a. The following measures shall be specifically authorized for implementation at a total Federal cost of $250 million and require project implementation reports to be approved by the Secretary of the Army prior to appropriation of funds.
   - o Fish passage at Dams 4, 8, 22, and 26, and initial Engineering and Design at Dam 19 ($209 million total).
   - o Dam point control at Dams 25 and 16 ($41 million total).

b. A programmatic authority to implement measures that will provide substantial restoration benefits and will include funds for adaptive management and monitoring at a total cost of $935 million. These measures will include:
   - o water level management (i.e., drawdowns) in 12 pools,
   - o 23 island building projects,
   - o backwater restoration at 33 sites,

- o 29 side channel restoration efforts,
- o wing dam/dike alteration at 19 locations,
- o island/shoreline protection at 73 sites,
- o improving topographic diversity at 9 locations,
- o 13 dam embankment lowering projects, and
- o reduction of water level fluctuation on the Illinois River.

The programmatic authority will include the following:

- o Project implementation reports for these measures will be reviewed and approved by the Secretary of the Army (the Secretary)..
- o Total cost of each feature will not exceed $25 million and will be appropriated from the general fund of the U.S. Treasury.
- o The cost of operation, maintenance, repair, replacement, and rehabilitation for these features shall be the responsibility of the Federal or State agency administering and managing the public land on which the project is located.
- o The costs for major rehabilitation of projects constructed and damaged in major flood events shall be 100 percent Federal within the project and aggregate limits specified above.
- o The cost of a new report at the end of 15 years to be provided to the full Congress for potential authorization of additional increments of the plan.

c. Authorization for acquisition of 35,000 acres of land for the purposes of floodplain connectivity, wetland and riparian habitat protection and restoration at a total cost of $277 million. The acquisition shall be from willing sellers. The total Federal cost is estimated at $180 million and the non-Federal cost is estimated at $97 million. The cost sharing requirements for this acquisition are as follows:

- o The Federal share of the cost of land acquisition and restoration shall be 65%.
- o The non-Federal sponsor shall be responsible for all lands, easements, rights-of-way and relocations necessary to implement the land acquisition and restoration projects.
- o Non-Federal sponsors may include nonprofit entities.
- o Regardless of the date of acquisition, the value of lands or interest in lands and incidental costs for land acquired by a non-federal sponsor in accordance with a project implementation report for any land acquisition and restoration project shall be included in the total cost of the project and credited towards the non-Federal share (35%) of the cost of the project. The value of the lands or interest in the lands and incidental costs for lands acquired by a non-Federal sponsor that exceed the non-Federal share of the land acquisition and restoration project costs shall be reimbursed to the non-Federal sponsor.
- o The non-Federal sponsor shall be responsible for the cost of operation, maintenance, repair replacement, and rehabilitation of projects under this section.
- o The costs for major rehabilitation of projects in this section that are damaged by flood events shall be cost shared.
- o The Secretary may provide credit, including in-kind credit, toward the non-Federal share of land acquisition and restoration projects under this section for the reasonable costs of any work performed in connection with a study, preconstruction engineering and design, or construction that is necessary for project implementation. The credit for the work shall be limited to the non-Federal share and shall not result in any reimbursement.
- o Project implementation reports for these features will be reviewed and approved by the Secretary.

UMR-IWW System Navigation Feasibility Study
Participating Agencies and Organizations

American Rivers
American Waterway Operators
Audubon Society
Illinois Department of Natural Resources
Illinois Department of Transportation
Illinois State Water Survey
Illinois Stewardship Alliance
Iowa Department of Agriculture
Iowa Department of Natural Resources
Iowa Department of Transportation
Iowa Institute of Hydraulic Research
Midwest Area River Coalition 2000
Minnesota Department of Agriculture
Minnesota Department of Natural Resources
Minnesota Department of Transportation
Mississippi River Basin Alliance
Missouri Department of Conservation
Missouri Department of Natural Resources
Missouri Department of Transportation
National Corn Growers Association
The Izaak Walton League of America
The Nature Conservancy
U.S. Army Corps of Engineers
U.S. Department of Agriculture
U.S. Department of Transportation, Maritime Administration
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency
Upper Mississippi, Illinois and Missouri River Association
Upper Mississippi River Conservation Committee
Upper Mississippi River Basin Association
Wisconsin Department of Natural Resources
Wisconsin Department of Transportation

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1.0 PURPOSE OF AND NEED FOR ACTION

1.1 Purpose of this Feasibility Report and Programmatic Environmental Impact Statement (PEIS)

The purpose of this document is to provide a comprehensive documentation of the Upper Mississippi River-Illinois Waterway (UMR-IWW) System Feasibility Study process and final recommendations for action. Traditionally, the Feasibility Report and PEIS are produced as two separately bound documents. However, a single integrated document meets the requirements of the National Environmental Policy Act (NEPA) and the Corps decision-making process without duplication. The main table of contents includes asterisks for those traditional NEPA required chapters and sections to allow ready access for those specifically interested in the NEPA compliance review.

The report organization and contents are intended to allow the reader to become familiar with the background and history of this magnificent river system leading to the current study including a full disclosure of decision process and compliance with Corps policy and guidance in addition to applicable Federal and State laws. The information provided in Chapters 1 through 3 establishes a review of the study purpose, history, organizational structure, and decision process. Chapters 4, 6, 7, and 12 provide a comprehensive description and explanation of the UMR-IWW System Navigation Study decision process leading to the identification of a Recommended Plan for Ecosystem Restoration and Navigation Efficiency (Chapter 14). Chapters 5, 8, 9, 10, and 11 provide legally required disclosure and documentation concerning the direct, indirect, and cumulative environmental effects attributable to the proposed actions as well as appropriate avoid, minimize, and mitigation measures. Chapter 13 outlines the process followed by this study during the public review period (May 14 – July 30, 2004). Chapter 15 provides a listing of the Corps team that assisted in the preparation of this document. Chapter 16 provides a comprehensive listing of the 140+ technical reports (with abstracts) that were generated over the course of this decade-long study. Chapter 17 lists the references cited in the document. Chapter 18 includes a listing of the individuals and organizations that received a hardcopy of this Final document. The Appendices included on the enclosed Compact Disc contain electronic copies of several thousand pages of detailed information documenting the methodology, results, and conclusions for each of the primary study components: Engineering, Economics, Environmental Impacts, Ecosystem Sustainability, Public Involvement, Real Estate, and Quality Management. Two additional appendices are also provided that (1) convey the responses to comments received during the review period for the draft version of this document (May 14 – July 30, 2004) and (2) document the guidance memorandums that have shaped and guided the study since August 2001.

1.2 Study Authority

Authority for the Upper Mississippi River-Illinois Waterway System Navigation Study (the Navigation Study) is contained in Section 216 of the Flood Control Act of 1970 (Public Law 91-611) which states:

> "*The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.*"

1.3 Study Purpose and Scope

The Upper Mississippi River-Illinois Waterway System Navigation Study is a feasibility study addressing navigation improvement planning and ecological restoration needs for the Upper Mississippi River and

Illinois Waterway system for the years 2000-2050. This study was originally narrowly focused on the need for navigation improvements at 29 lock and dam facilities (35 locks) on the Upper Mississippi River (UMR) and 8 locks on the Illinois Waterway (IWW) and the impacts of providing these improvements. Specifically, the principal problem addressed was the potential for significant traffic delays on the system within the 50-year planning horizon, resulting in economic losses to the Nation. The study was restructured in 2001 to additionally provide for a balanced consideration of fish and wildlife resources along with navigation improvement planning. The creation of this new study purpose was intended to provide consideration for the changes to ecosystem structure and function imposed by the operation and maintenance of the existing 9-Foot Channel Navigation Project in addition to the potential navigation system efficiency improvements. A major emphasis of the study was to identify a method to modify the way the Corps operates and maintains the system to strive for economic, environmental, and social sustainability. The feasibility study is intended to provide a long-range plan of action that will ensure the UMR-IWW System can maintain its recognition as a nationally treasured ecological resource as well as an efficient national transportation system.

The primary opportunities are to reduce or eliminate commercial traffic delays and improve the national and regional economic conditions while restoring, protecting, and enhancing the environment. **The primary goal of the feasibility study is to outline an integrated dual-purpose plan to ensure the economic and environmental sustainability of the UMR-IWW Navigation System.** To fully address this goal, the following three planning objectives were established:

OBJECTIVE 1. Recommend measures to provide for a safe, reliable, efficient, and sustainable UMR-IWW Navigation System over the planning horizon.

OBJECTIVE 2. Recommend measures to address the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.

OBJECTIVE 3. Assure that any recommended measures are consistent with protecting the Nation's environment and avoiding, minimizing, or mitigating significant environmental, cultural, or social impacts.

The following four major constraints or assumptions have limited the range of options and investigations undertaken as part of this study:

a) No systemic modifications to deepen or widen the channel were considered.
b) This report represents a system level feasibility study that assesses the navigation efficiency and ecosystem restoration needs for the 50-year planning horizon. As such, it differs from a traditional feasibility study in scope and level of detail of site-specific planning and engineering. Recommendations for navigation efficiency and ecosystem restoration improvements will generally require additional site-specific planning and engineering documentation prior to initiation of construction activities.
c) This study will only address ecosystem and floodplain management needs related to the navigation system. While this study is systemic in nature, it does not represent a comprehensive river basin study.
d) Because of authority, resource, and time constraints, this study does not represent a full multi-modal study. The study did not attempt to fully assess all possible future alternative transportation modes that could be developed or to present a full comprehensive analysis of the potential environmental impacts associated with increased use of alternative modes if waterway improvements are not made. However, some evaluations of existing primary alternatives (e.g.,

railroads) were conducted, including an evaluation of transportation cost comparisons and limited evaluation of environmental impacts.

1.4 Study Vision Statement

A key foundation of the restructured study has been the emphasis on collaboration with the stakeholders of the system (See Section 2.2.3). As part of the study restructuring, the stakeholders were asked to help develop a new vision statement that acknowledged the restructured study purpose and primary objectives. The collaboratively developed vision statement reads as follows:

"To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System."

The following definition of sustainability was collaboratively developed and agreed to by the group as well:

"The balance of economic, ecological, and social conditions so as to meet the current, projected, and future needs of the Upper Mississippi River System without compromising the ability of future generations to meet their needs."

The vision statement and definition of sustainability form the basis for the restructured feasibility study. The sustainability concept will reflect that economic activity will be evaluated for environmental impact and that environmental actions will be evaluated for economic impact. The goal of economic and ecosystem sustainability will be achieved through an integrated and adaptive river management process.

1.5 Description of the Study Area

The study area comprises the Upper Mississippi River System (UMRS), as defined by Congress in the Water Resources Development Act of 1986 (WRDA 1986), which includes the Upper Mississippi River from Minneapolis, Minnesota, to Cairo, Illinois (854 river miles); the Illinois Waterway from Chicago to Grafton Illinois (327 river miles); and navigable portions of the Minnesota (15 river miles), St. Croix (24 river miles), Black (1 river mile) and Kaskaskia Rivers (36 river miles). The study area includes portions of five Midwestern States: Minnesota, Wisconsin, Iowa, Illinois, and Missouri (Figure 1-1). Fifty-eight counties and 23 major river communities lie on the banks of the UMR, including the cities of Minneapolis, St. Paul, Red Wing, and Winona, Minnesota; La Crosse and Prairie du Chien, Wisconsin; Dubuque, Davenport, Muscatine, and Keokuk, Iowa; Moline, Rock Island, Quincy, Alton, and Cairo, Illinois; and Hannibal, St. Louis, and Cape Girardeau, Missouri. Twenty counties and 15 major communities border the Illinois Waterway. River cities include Chicago, Joliet, Ottawa, LaSalle-Peru, Peoria, Pekin, Beardstown, and Grafton.

Because of the dual-purpose nature of this study, it is important for the reader to understand the differentiation between the UMRS ecosystem, which refers to the entire floodplain area and associated physical, chemical, and biological components, and the UMR-IWW Navigation System, which refers to the narrow (300-500 m) 1,200 miles of 9-foot navigation channel, 37 lock and dam sites (43 locks), and thousands of channel training structures (Figure 1-2). Differentiation was necessitated for plan formulation purposes, especially in the formulation/evaluation of alternative improvement plans. The following provides a more detailed description of these study area components.

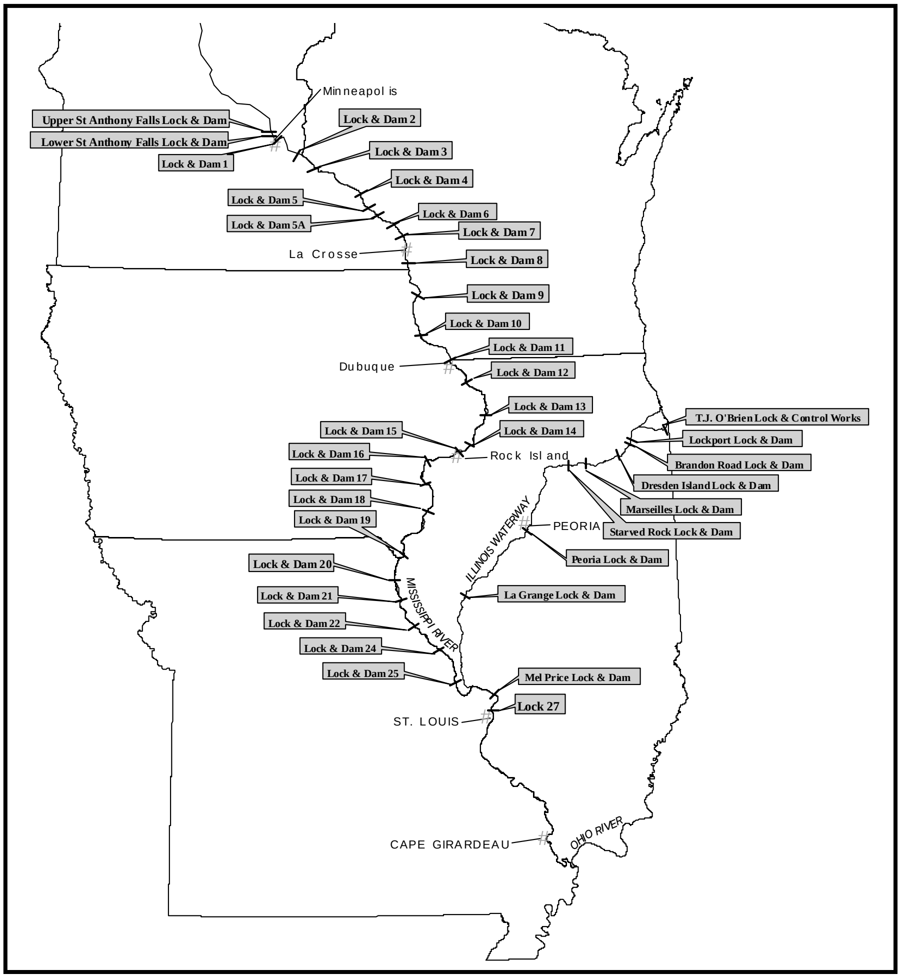


Figure 1-1. Upper Mississippi River-Illinois Waterway Navigation System.

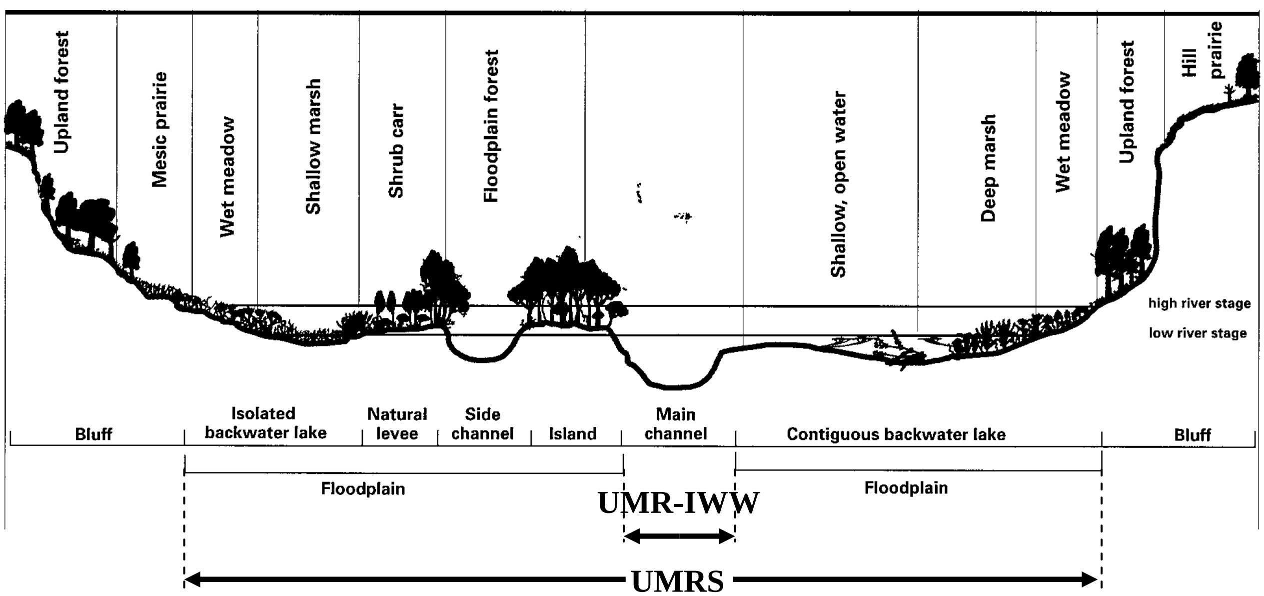


Figure 1-2. Illustrative cross section of the river valley showing the primary ecosystem habitat types and spatial differentiation between the UMR-IWW Navigation System and UMRS Ecosystem.

1.5.1 UMRS Ecosystem

The UMRS ecosystem includes the UMR-IWW System, as well as the aquatic and terrestrial habitats and species that are critically important to large river floodplain ecosystems. The total acreage of the UMRS river-floodplain ecosystem exceeds 2.6 million acres. The UMRS ecosystem is typically described using four distinct river reaches based on ecological criteria, including river flow and hydrology, geomorphology, and land use. The following provides a brief description of these four UMRS reaches.

- **Reach 1:** The **Upper Impounded Reach** includes UMR Pools 1 through 13. It is characterized by an island-braided morphology, the locks and dams which had a pronounced effect on the distribution of river water, urban development in some floodplain areas, and a relative lack of levees throughout the reach. The reach has a high proportion of public land that supports forest, wetland, and other desirable habitat.

- **Reach 2:** The **Lower Impounded Reach** includes UMR Pools 14 through 27. It exhibits significant change through the reach. It emerges from a narrow gorge through Pools 14 and 16 and spreads out to a 5- to 7-mile broad fertile floodplain that has been highly developed for agriculture and about 50 percent leveed. The lock and dam system maintains stable navigable water depths, but did not greatly expand surface waters in most of the reach. Floodplain terrestrial prairie and forest were developed for agriculture long ago, but riparian forests and forested islands persist riverward of the levees.

- **Reach 3:** The **Middle Mississippi River Reach** beginning just south of the Missouri River (below Lock 27) is a free-flowing reach (i.e., no dams) with a highly developed channel and floodplain. The navigation channel is maintained with channel training structures (e.g., stone dikes, closing structures, etc.) and dredging. It is largely a single main channel with degraded side channels and very few backwaters. The main stem levees are very large and isolate more than 80 percent of the floodplain except during the most extreme floods. The floodplain is predominantly crops except for a narrow riparian corridor between the levees and river channel and habitat patches within agricultural levee districts.

- **Reach 4:** The **Illinois Waterway** has an upper reach with relatively steep gradient, with an average fall of 18 inches per mile, five high head dams (>20-foot lift), an impounded river valley and a river bottom comprised primarily of sand, rock cobble, and bedrock. The upper reach is heavily developed with industry and large cities such as Chicago, La Salle, and Peru. The lower river reach occupies the pre-glacial bed of the Mississippi River and has a low gradient, with an average fall of 1.8 inches per mile, two low head dams (<10-foot lift), a broad floodplain, and a river bottom comprised primarily of silt and sand. The Lower Illinois Reach includes Peoria Lake, a large main stem lake; the La Grange Pool, which is a mix of agriculturally developed floodplain, and channels, backwaters, and managed wetlands; and the Alton Pool, which is highly developed for agriculture except near the confluence with the Mississippi River.

The Upper Mississippi River System Flyway is used by more than 40 percent of the migratory waterfowl traversing the United States. The river system also supports migratory fish that move from the ocean to the headwaters and riverine species that have been documented to move great distances through the Mississippi River Drainage. The freshwater mussel assemblage, one of the most diverse and abundant when compared to other regions of the world, is highly threatened by human activity of all types. These migratory species and the threatened and endangered species in the region are the focus of considerable Federal and State wildlife management activities. In the middle and southern portions of the basin, the habitat provided by the main stem rivers represents the most important and abundant habitat in the region for many species.

1.5.2 UMR-IWW Navigation System

The Upper Mississippi River extends from the confluence with the Ohio River, River Mile 0.0, to Upper St. Anthony Falls Lock in Minneapolis-St. Paul, Minnesota, River Mile 854.0. The Illinois Waterway extends from its confluence with the Mississippi River at Grafton, Illinois, River Mile 0.0, to T. J. O'Brien Lock in Chicago, Illinois, River Mile 327.0. The UMR-IWW Navigation System contains 1,200 miles of 9-foot deep channels, 37 lock and dam sites, and thousands of channel training structures. The width of the 9-foot channel is generally maintained at 300 feet, but may extend to 500 feet on river bends. The 9-foot channel borders are delineated with red and green buoys maintained by the U.S. Coast Guard. Detailed navigation charts are available for both the UMR and IWW, and can be procured from Corps of Engineers District Offices.

1.6 Background and History

1.6.1 Upper Mississippi River Navigational Overview

The Federal Government began constructing navigation improvements on the Upper Mississippi River as early as the 1820s (Table 1-1). These initial efforts consisted primarily of removing snags, shoals, and sandbars; excavating rock ledges; and closing off meanders, sloughs, and backwaters to confine flow to the main channel. In 1878, Congress authorized the first comprehensive project on the Upper Mississippi River—the 4½-foot channel—and in 1907, the 6-foot channel. In the next two decades, Locks and Dams 1 and 2 and what is now Lock and Dam 19 were authorized. Since 1930, when Congress authorized the 9-Foot Channel Navigation Project, the remaining 26 locks and dams were constructed between Minneapolis, Minnesota, and St. Louis, Missouri. Below St. Louis, "open channel" techniques, such as stone dikes, bank revetment, and dredging, are used to maintain the channel. The 9-foot channel has been in operation since approximately 1940.

In the 1960s, due to increasing congestion at Lock and Dam 26, a study was conducted to evaluate replacing the facility with a new lock and dam near Alton, Illinois. In 1978, Congress authorized the construction of a new dam with a single 110-foot by 1,200-foot lock chamber. Construction was initiated in 1979. This facility, eventually named the Melvin Price Locks and Dam, was completed in 1990. The authorization (Public Law 95-502) required to build that lock and dam also directed that a study be completed to assess further navigation capacity needs. That study, the *Comprehensive Master Plan for the Management of the Upper Mississippi River System*, recommended construction of a second 110-foot by 600-foot lock at the new facility. This "Second Lock" was authorized by the Supplemental Appropriation Act of 1985 (Public Law 99-88) and WRDA 1986, and construction was completed in 1994.

1.6.2 Illinois Waterway Navigational Overview

The Illinois Waterway is a major tributary of the Upper Mississippi River. It provides navigation from Lake Michigan and Chicago to the Upper Mississippi River, linking the Great Lakes with the inland waterway system. The term "Illinois Waterway" is used in place of the Illinois River, since navigation between the UMR and Great Lakes includes all or portions of the Illinois River, Des Plaines River, Chicago Sanitary and Ship Canal, Cal-Sag Channel, Little Calumet River, and Calumet River. The Illinois Waterway has been continuously developed for navigational purposes since 1822 (Table 1-1). In 1927, Congress approved legislation authorizing a 9-foot by 200-foot-wide channel on the Illinois River from Utica, Illinois, to Grafton, Illinois. This project was to complement a similar project then under construction by the State of Illinois extending from Utica to Lockport, Illinois. In 1930, Congress enacted legislation enabling the Federal Government to assume responsibility of the Utica-to-Lockport segment, already about 75 percent completed. Three years later, the Corps of Engineers completed the project, and combining it with the earlier authorized Federal project between Utica and Grafton, opened the Illinois Waterway to navigation in 1933. Navigation on the waterway was further improved with the construction of locks and dams at Peoria and La Grange from 1936 to 1938, and the addition of the Thomas J. O'Brien Lock and Controlling Works on the Calumet River in Chicago in 1960.

Table 1-1. Timetable of Navigation Development Activities on the Upper Mississippi River and Illinois Waterway.

Activity	Year
Upper Mississippi River:	
Congress authorizes removal of snags and local obstructions	1824
Congress authorizes 4½-foot channel from mouth of Missouri River to St. Paul	1878
Congress authorizes 6-foot channel	1907
Construction of Meeker Island Dam (first Lock and Dam 1)	1913
Construction of Lock and Dam 19	1914
Construction of Lock and Dam 1	1917
Congress authorizes 9-foot-deep, 300-foot-wide channel from St. Louis to Cairo, Illinois	1927
Congress authorizes extension of 9-foot channel to St. Paul, Minnesota, through construction of locks and dams	1930
Construction of 29 locks and dams	1930-1940
Construction of Lock and Dam 27	1953
Construction of 1,200-foot chamber at Lock and Dam 19	1957
Upper and Lower St. Anthony Falls authorized	1937
Lower St. Anthony Falls constructed	1956
Upper St. Anthony Falls constructed	1963
Congress authorizes new dam and single 1,200-foot chamber at Lock and Dam 26	1978
Congress authorizes construction of second chamber (600-foot) at Lock and Dam 26 (R)	1985
Construction of 1,200-foot chamber at Melvin Price Locks and Dam (formerly L&D 26 (R))	1990
Construction of 600-foot chamber (2nd Lock) at Melvin Price Locks	1994
Major Rehabilitation/Maintenance	1986-present
Illinois Waterway:	
Congress authorizes construction of the Illinois and Michigan Canal	1822
Construction of Chicago Sanitary and Ship Canal and 5 low navigation locks and dams	1900
Construction of present-day system of 7 locks and dams	1933-1939
Construction of Thomas J. O'Brien Lock and Controlling Works	1960
Major rehabilitation/maintenance	1975-present

1.6.3 UMRS Ecosystem Overview

Prior to widespread European settlement of the region, the Upper Mississippi River System was a diverse landscape of tallgrass prairie, wetlands, savannas, and forests. Logging, agriculture, and urban development over the past 150 years have resulted in the present floodplain landscape that is more than 80 percent developed. Millions of acres of wetland drainage, thousands of miles of field tiles, road ditches, channelized streams, and urban storm water sewers accelerated runoff to the main stem rivers. The modern hydrologic regime is highly modified, with increased frequency and amplitude of changes in river discharge. Dams and river regulation throughout the basin also modify river flows. The modern basin landscape delivers large amounts of sediment, nutrients, and contaminants to the river. Since impoundment, sediment accumulation and littoral (i.e., wind and wave) processes in the navigation pools have greatly altered aquatic habitats.

At the historic system-wide scale, there were natural gradients in habitat among river reaches. Northern river reaches were more forested and were composed of mixed silver maple forests, river channels, seasonally flooded backwaters, floodplain lakes, marsh, and prairie. Beginning around the northern Iowa border and along the lower Illinois River, grasslands and oak savanna dominated floodplain plant communities. Historic surveys reveal a higher proportion of oaks and other mast trees in the forest community than at present. Below the Kaskaskia River, the floodplain was heavily forested with species characteristic of southern bottomland hardwood communities including bald cypress, nuttal and cherry bark oak. Impacts of river floodplain development include forest loss and water gain in northern reaches, and grassland and forest losses in the rest of the UMR-IWW.

European settlement in the Upper Midwest region brought many changes to the landscape and waterways. The rivers provided efficient transportation and were the focal point of commerce and colonization. The spread of the population upstream along the Illinois River is well documented. As the Midwest economy and population grew, so did the demand for water transport. The U.S. Government became involved in Mississippi River navigation in 1824 when the Army Corps of Engineers was tasked with removing logs and other obstructions from the river channels to ease constraints on steamboat travel which was very hazardous. Additional information about the UMRS affected environment is available in Chapter 4 of this document.

1.6.4 Related Historical Studies and Reports

Numerous studies and documents have been completed for the Upper Mississippi River and Illinois Waterway. It would be a major task to include a summary of each Federal, State, and private study about the rivers or their navigation system. However, an attempt has been made to include relevant historical studies undertaken prior to the initiation of this study. These studies served as valuable sources of preliminary data and reference material for the current study.

1972 - The *Mississippi River-Illinois Waterway 12-Foot Channel Study* was a joint effort between the North Central Division, Corps of Engineers, in Chicago, Illinois, and the Lower Mississippi Valley Division in Vicksburg, Mississippi. The St. Paul, Rock Island, St. Louis, and Chicago Districts accomplished the work tasks. The study findings were published in a September 1972 report (revised May 1973) which concluded that the costs and impacts associated with maintaining a 12-foot channel on the Mississippi River upstream of Grafton, Illinois, would exceed the benefits based on the traffic projections at that time.

1974 - An Environmental Impact Statement was prepared for *Operation and Maintenance of the 9-Foot Channel, Upper Mississippi River, Head of Navigation to Guttenberg, Iowa,* by the St. Paul District, Corps of Engineers. It was filed with the Council on Environmental Quality in August 1974.

1975 - The Environmental Impact Statement for *Operation and Maintenance of the 9-Foot Channel, Upper Mississippi River, Pools 11 through 22* was prepared by the Rock Island District, Corps of Engineers. The document was filed with the Council on Environmental Quality in January 1975.

1975 - The Environmental Impact Statement for *Operation and Maintenance of the 9-Foot Channel, Illinois Waterway* was prepared by the Chicago District, Corps of Engineers. The document was filed with the Council on Environmental Quality in February 1975.

1975 - In April 1975, the Missouri Botanical Garden published a report entitled, *Environmental Inventory and Assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers, a Vegetational Study.*

1975 **-** A Plan of Study for a Feasibility Study for the Upper Mississippi River, *Small Craft Lock Study,* was prepared in June 1975.

1975 **-** An *Environmental Inventory and Assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers: A Geomorphic Study* was published in July 1975.

1975 **-** The *Evaluation of Operational Improvements at Locks and Dam No. 26, Mississippi River* was prepared by Peat, Marwick, and Mitchell & Co. and published in July 1975. The report assesses the potential to improve lock efficiency through various operational and small-scale improvements.

1975 **-** The Environmental Impact Statement for *Operation and Maintenance of the 9-Foot Channel, Upper Mississippi River, Pools 24, 25 and Alton* was prepared by the St. Louis District, Corps of Engineers. The document was filed with the Council on Environmental Quality in September 1975.

1976 **-** The Environmental Impact Statement for *Operation and Maintenance of the 9-Foot Channel, Upper Mississippi River, Middle Mississippi River* was prepared by the St. Louis District, Corps of Engineers. The document was filed with the Council on Environmental Quality in April 1976.

1976 **-** The Environmental Impact Statement for *Construction of the New Lock and Dam 26 (renamed Mel Price L&D) on the Mississippi River* was prepared by the St. Louis District, Corps of Engineers. The document was filed with the Council on Environmental Quality in July 1976.

1977 **-** In September 1977, a *Recreational Craft Locks Study, Stage II Report - Upper Mississippi River (Draft)* was published. The study determined where an independent means of moving pleasure craft from pool to pool is desired, needed, and economically justified.

1978 **-** The consulting firm of Howard, Needles, Tammen, and Bergendoff, Minneapolis, Minnesota, conducted a study for the St. Paul District entitled, *Recreational Craft Locks Study, Selected Alternatives - Upper Mississippi River, Minneapolis to Guttenberg,* completed in October 1978. The purpose of this effort was to conduct a more detailed engineering analysis of selected alternatives and to identify several lock waiting area sites worthy of further study since the September 1977 effort.

1980 **-** Howard, Needles, Tammen, and Bergendoff provided technical assistance to the St. Paul District in accomplishing the *Recreational Craft Locks Study, Design of Lockage Waiting Areas at Lower St. Anthony Falls Lock, Lock 2, and Lock 3 - Upper Mississippi River*. The January 1980 report, following the study effort, included detailed designs and costs for the construction of five proposed lock waiting area beaches and appurtenances.

1980 **-** In November 1980, a report was published entitled, *Mississippi River Year-Round Navigation Study, Stage 2, Final Feasibility Study*. The study was a joint effort by the Corps of Engineers North Central and Lower Mississippi Valley Divisions. The purpose of the study was to explore the possibility of extending the navigation season on the Mississippi River and to include economic justification and environmental impacts for each means. The study findings detailed different types of engineering solutions such as gate modifications, gate replacements, lock and approach modifications, and channel modifications. The conclusions determined that year-round navigation on the river was technically feasible, but navigation interests did not express support for extending the navigation season.

1980 **-** The Upper Mississippi River Basin Commission (UMRBC) published a final report in November 1980 entitled, *The Upper Mississippi River Main Stem Level B Study*. The study participants included diverse representation from Federal, State, and local governmental entities, regional planning agencies, county representatives, universities, and private firms. The major recommendations regarded flood damage reduction, recreational boating safety, the relationship between navigation and the environment, water quality management planning, sedimentation analysis and control, and land-use management planning needs.

1981 **-** Under the auspices of the National Waterways Study, the Corps of Engineers Institute for Water Resources prepared, with the contracted assistance of A. T. Kearney, Inc., an *Evaluation of Present Waterways System*, dated March 1981. The report discusses commodity flow projections through 2003, lock capacity shortfalls, transportation capability of the present system, and potential actions to maintain or improve its capability. After evaluating the 8 regions and 31 separate facility locations in the present waterways system, the Institute for Water Resources identified Lock and Dam 26 as the most constraining structure on the Upper Mississippi River. Locks 15, 16, 17, 18, 19, 20, 21, 22, 24, and 25 also were identified as having increased delay times and possible sites needing additional capacity based on detailed project-level analysis of the relative benefits and costs using one or more scenarios or sensitivity analyses.

1981 **-** In April 1981, Louis Berger and Associates, Inc., under contract with the Upper Mississippi River Basin Commission Navigation and Transportation Work Team, prepared the *Final Report, Inventory of Potential Structural and Non-Structural Alternatives for Increasing Navigation Capacity - Upper Mississippi River System Master Plan*. This report assesses structural and nonstructural methods to increase capacity of existing locks on the Upper Mississippi River System.

1982 **-** Between 1977 and 1982, the *Great River Resource Management Study*, conducted by the St. Paul, Rock Island, and St. Louis Districts of the Corps of Engineers, with assistance from the U.S. Fish and Wildlife Service and the UMRBC, investigated several areas of river management. The studies focused on how to conduct channel maintenance practices, most importantly, dredged material placement, in an environmentally acceptable manner. The recommendations and techniques offered in the Great River Environmental Action Teams (GREAT I, II, and III) reports were approved by the Board of Engineers for Rivers and Harbors in 1982. Most suggestions were subsequently incorporated into the Corps of Engineers' channel maintenance program.

1982 **-** The UMRBC, responding to a congressional directive contained in Public Law 95-502, published its January 1982 *Comprehensive Master Plan for the Management of the Upper Mississippi River System*. The 3-year effort, undertaken by Federal, State, and local officials, produced several studies and recommendations. The comprehensive plan contains a management framework for resolving differences among competing interests and implementing the recommendations. The study provided the basis for Section 1103 of the 1986 Water Resources Development Act, which included authorization for a second lock at Melvin Price Locks and Dam and the Upper Mississippi River System Environmental Management Program. Section 1103 refers to the Master Plan as the guide for future water policy on the Upper Mississippi River System.

1982 **-** A St. Louis District report entitled, *Mississippi River Navigation System, Adequate Mooring Facilities for Watercraft - 81181*, was published in September 1982.

1983 **-** A July 1983 document entitled, *Recreation in the Upper Mississippi River System: An Overview of Facility Needs,* was published by the Upper Mississippi River Basin Association. It contains a list of projects within individual States eligible for public funding. The Upper Mississippi River potential projects included park improvements, parkland acquisition or development, boat access, lock waiting or holding areas, small-boat harbors and marinas, fishing areas, hiking trails and bikeways, scenic overlooks and wayside rests, interpretive centers, historical site restoration, and beach creation or enhancement.

1983 **-** In September 1983, Jon Gjerde prepared a report entitled, *Historical Resources Evaluation, St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony Falls.* This report is discussed in more detail in the historical properties section.

1985 **-** The St. Louis District published a *Reconnaissance Report - Lock and Dam 24, Station Service Hydropower* in April 1985.

1985 **-** The Rock Island District locks and dams were studied, evaluated, and described by Rathbun Associates in the report entitled, *Historical-Architectural and Engineering Study, Locks and Dams 11-22, Nine-Foot Navigation Project, Mississippi River*, dated December 1985.

1986 **-** The Rock Island District, in cooperation with the St. Paul District, prepared the *Final Report for the Mississippi River, Coon Rapids Dam to the Ohio River*, in July 1986. The report summarized the efforts to improve the flood control systems and cited hydroelectric power potential for 24 Mississippi River navigation projects within the study area.

1986 **-** The *Upper Mississippi River System - Environmental Management Program (UMRS-EMP)* was authorized in the Water Resources Development Act of 1986 (Public Law 99-662). This program, which includes the Mississippi River and the Illinois Waterway, seeks to rehabilitate and enhance environmental resources of both rivers. A more detailed description of this program is provided in Section 4.2.2.1.1 of this document.

1987 **-** The Environmental Impact Statement for *Major Rehabilitation Locks and Dams 2 through 10 Upper Mississippi River* was prepared by the St. Paul District, Corps of Engineers. The document was filed with the Council on Environmental Quality in June 1987.

1988 **-** A contracted effort between the St. Louis District, Corps of Engineers, and Simons and Associates, Inc., led to a report entitled, *Physical Impact of Navigation of the Upper Mississippi River System,* May 1988.

1988 **-** A *Final Environmental Impact Statement (FEIS), Second Lock at Locks and Dam No. 26 (Replacement), Mississippi River, Alton, Illinois and Missouri,* was published in July 1988. It was the St. Louis District's opinion that overall system-wide impacts of the second lock were minor. However, the District could not unequivocally state whether or not the system-wide incremental navigational impacts were negligible, minor, or significant. Consequently, an interagency Plan of Study was prepared to identify studies needed to better quantify navigation impacts on the Upper Mississippi River System due to the operation of the second lock.

1988 **-** The *1988 Inland Waterway Review* (November 1988) was prepared by the Institute for Water Resources for the Chief of Engineers. While this document does not constitute a system plan, it provides a 10-year outlook as to the priority needs for planning, design, construction, and operation of the entire inland waterway system. The review addresses the physical system, traffic levels, system/lock performance, and financial resource availability for waterways investment.

1988 **-** The Rock Island District Navigation System Support Center, established in 1988, prepared a *Report on the Upper Mississippi River and Illinois Waterway Navigation System* in 1989. The report is a historical and statistical overview of both navigation systems. It also forecasts growth and performance capability at each navigation structure.

1989 **-** A Final Programmatic Environmental Impact Statement, *Major Rehabilitation Effort, Mississippi River Locks and Dams 2-22; and the Illinois Waterway from La Grange to Lockport Locks and Dams; Iowa, Illinois, Missouri, Minnesota, and Wisconsin*, was completed in March 1989. Typical rehabilitative work included replacement and maintenance of machinery, removal and replacement of deteriorated concrete, reconstruction of dam piers and gate sills, and replacement of electro-mechanical systems.

1989 **-** The States of Illinois, Iowa, Wisconsin, Missouri, and Minnesota, with the U.S. Department of Agriculture and the U.S. Maritime Administration, investigated low-cost measures to maximize efficiency and productivity of the Upper Mississippi River Navigation System. A five-volume report entitled, *Upper Mississippi River Transportation Economics Study*, was published in April 1989. The primary product of the study was a computer evaluation model called Waterway Efficiency Evaluation Model (WEEM), which encompasses all aspects of barge operation and could be adapted for future use on other waterway systems. Study findings and recommendations included uniform application of fixed barge/tow rigging, fuel monitoring systems, stacking of empty backhaul barges, hull treatments, new barge and boat hull designs, reduced crew size, sequencing waiting tows, improving lock approaches, lock automation, and others.

1989 **-** A *Plan of Study (POS) for Upper Mississippi River and Illinois Waterway Navigation Studies* was distributed to the public on August 7, 1989. The POS provided the framework for U.S. Army Corps of Engineers' reconnaissance-phase planning studies for both waterways. It detailed the study authority, purpose, and how the engineering, economic, and environmental components would be addressed.

1989 **-** In December 1989, the U.S. Army Corps of Engineers published an *Analysis of Recreational Boating Impact on Navigation Lock Performance.*

1991 **-** A *Plan of Study for Navigation Effects of the Second Lock, Melvin Price Locks and Dam* was completed in February 1991. The report, developed by the Corps' Lower Mississippi Valley Division, with input from an interagency study team, identifies studies that would quantify navigation traffic impacts to significant Upper Mississippi River System natural resources. This report provided the basis for traffic effects research conducted for the UMR-IWW System Navigation Feasibility Study.

1992 – The *Avoid and Minimize Program* initiated in 1992 by the St. Louis District was developed as a commitment made in the 1988 Record of Decision attached to the Melvin Price Locks and Dam Environmental Impacts Statement for the Second Lock. The St. Louis District has implemented eight elements, including monitoring, modifications to existing structures, new structures, woody debris structures, etc., recommended by an interagency coordinating team.

1.7 Need for Action

The Upper Mississippi River System is considered a tremendous economic, social, and ecological resource, leading to its Congressional recognition (WRDA 1986) as a nationally significant ecosystem and a nationally significant transportation system. This study will determine whether navigation or ecosystem improvements are justified and, if so, the appropriate level of improvements, sites, and implementation schedule for the 50-year planning horizon. The topics presented in this section are intended to illustrate the economic, social and ecological importance of the UMRS leading to the call for action and intent of this study. A more comprehensive listing and description of the "*Need for Action*" can be found in Chapter 4 describing the future without-project conditions for the UMR-IWW Navigation System and the UMRS ecosystem.

1.7.1 Economic Importance of the Navigation System

The system is a vital part of our national economy. The navigable portions of these rivers and the locks and dams that allow waterway traffic to move from one pool to another are integral parts of a regional, national, and international transportation network. The system is significant for certain key exports and the Nation's balance of trade. For example, in 2000, the Upper Mississippi River System carried approximately 60 percent of the Nation's corn and 45 percent of the Nation's soybean exports. Corn and soybeans are shipped via the waterway at roughly 60 to 70 percent of the cost of shipping over the same distance by rail. Other commodities shipped on the system include coal, chemicals, petroleum, crude materials (sand, gravel, iron ore, steel, and scrap), and manufactured goods.

The importance of the Upper Mississippi River-Illinois Waterway as a shipping artery is underscored by the increases in tonnage shipped on the system. Waterborne commerce on the Upper Mississippi River has more than tripled over the past 35 years—growing from about 27 million tons in 1960 to 84 million tons in 1995. On the Illinois Waterway, the nearly 23 million tons shipped in 1960 doubled over that same timeframe, growing to 47 million tons in 1995. The UMR segment represents the Mississippi River from Minneapolis, MN to the mouth of the Missouri River. Because the confluence of the Mississippi River and the Illinois Waterway is above the confluence of the Mississippi River and the Missouri River, the majority of Illinois Waterway traffic is reflected in the traffic total for the UMR. The average annual unconstrained growth rates forecast as part of the study from 2000 to 2050 ranged from 0.6 to 1.2 percent for the Upper Mississippi River and between 0.7 and 1.2 percent for the Illinois Waterway. On the basis of these forecasts, total demand would grow on the Upper Mississippi River to approximately 155 million tons by 2050, with the Illinois Waterway increasing to 81 million tons. However, the portion of this total future demand that can be accommodated on the system depends in part on what, if any, improvements are made.

In addition to the navigation system, the Mississippi River basin's abundant and diverse resources have attracted and sustained human populations for thousands of years. The region is now home to more than 30 million people. Nearly 80 percent of the population lives in urban areas such as Minneapolis-St. Paul, Dubuque, Davenport-Bettendorf-Rock Island-Moline (Quad Cities), Muscatine, La Crosse, Quincy, Hannibal, Cape Girardeau, and St. Louis. Economic activities revolve around machinery, manufacturing, food and beverage processing, and crop, dairy and livestock production. Regional industries produce canned, frozen, and dairy foods and manufacture broadcast equipment, construction equipment, agricultural machinery, ammunitions, chemicals, and aluminum sheet. Many of those industries depend on the network's commerce route, which provides over 1,200 river miles of navigable channel with a minimum depth of 9 feet.

1.7.2 Existing System Capacity

Currently, the capacity of the system is limited by the existing lock facilities. All of the locks, except for UMR Locks 9 and 26, as well as the IWW T.J. O'Brien Lock, were constructed in the 1930s, and designed to accommodate smaller tows and only a fraction of the traffic that currently transits the system. The 1930s locks on the system are 600 feet long, while the prevailing 15-barge tow size has a length approaching 1,200 feet long. As a result, tows must lock through using a two-step process, which takes approximately 1.5 to 2 hours. In contrast, a tow can lock through a 1,200-foot lock (e.g., Lock 19 and 26, and T.J. O'Brien Lock) in approximately 0.5 to 1 hour.

During the 1988 initial appraisal for this study, a newly released report, *Inland Waterways Review*, listed eight of the 29 locks on the Upper Mississippi River and 3 of the 8 Illinois Waterway locks among the top 20 locks in the country with the highest average delays (USACE 1988b). Another report, the *Inland Navigation Needs Assessment,* identified 11 Upper Mississippi River locks as the highest priority locks for improvement on the Inland Waterway System (USACE 1990). This remains the case as demonstrated by delays at locks around the country in 1997 (USACE 1997e). The UMR-IWW System had over half (19 of 36) of the most delayed lock sites in the country. In addition, a number of the other sites are currently being addressed through ongoing capital improvement construction, including Kentucky Lock, Tennessee River; Inner Harbor Lock, Gulf Intercoastal Waterway; Olmsted Lock, Ohio River; and Marmet Lock, Kanawha River.

The capacity of a 110-foot by 600-foot-long lock chamber is approximately 45 to 55 million tons per year. In contrast, a 110-foot by 1200-foot-long chamber can process roughly 100 million tons per year. Currently, usage at UMR Locks 20 through 25 is 30 to 35 million tons, approaching 70 to 80 percent of their capacity. As locks approach their capacity, delays can increase exponentially. In 1995, for example, delays averaged 6.6 hours per tow at UMR Lock 22. Additional detail concerning current lockage delays is provided in Section 4.2.1.6.

1.7.3 Ecological Importance of the Ecosystem

The UMRS ecosystem consists of hundreds of thousands of acres of bottomland forest, islands, backwaters, side channels and wetlands—all of which support more than 300 species of birds, 57 species of mammals, 45 species of amphibians and reptiles, 150 species of fish, and nearly 50 species of mussels. More than 40 percent of North America's migratory waterfowl and shorebirds depend on the food resources and other life requisites (shelter, nesting habitats, etc.) that the system provides. It also provides boating, camping, hunting, trapping and other recreational opportunities. The following is a sample of the species and habitats that are of particular importance in the UMRS or are rarely found in other areas.

- The Mississippi River is the largest riverine ecosystem in North America and third largest in the world.
- Combined with the floodplains of the navigable sections of the Illinois, Minnesota, St. Croix, Black and Kaskaskia Rivers cover 2.6 million acres of land and water area.
- It is a 2.6-million-acre large river floodplain laboratory. It is a "system of systems" for us to use, understand and appreciate. It is a place for this and future generations to learn how to restore and maintain a "living river" in the face of a global human population that will grow by 1 billion people in the next 12 years.
- Today, some 297,000 acres of the floodplain are within the National Wildlife Refuge System.
- It is a migratory flyway for 40 percent of all North American waterfowl.
- It is a globally important flyway for 60 percent of all bird species in North America.
- At least 25 percent of all fish species in North America are found in the UMRS.
- It is important habitat for 286 State-listed or candidate species and 36 Federal-listed or candidate species of rare, threatened, or endangered plants and animals endemic to the UMR Basin.

1.7.4 Importance of the UMR-IWW System in National Defense

As a mode of transportation, the UMR-IWW System safely and securely transports and delivers a wide range of goods throughout the country and the world. In times of conflict and crisis, this system has been used to move troops and support materials safely and efficiently. Support of the Nation's defense from navigation projects ranges from carrying surge movements of industrial and energy commodities that rely on domestic water transportation to moving the Federal Emergency Management Agency's stockpiles of strategic commodities which rely on shipments through the ports and the inland waterways. Inland waterways support military preparedness and mobilization installations, fuel deliveries, support to ordnance works, arsenals, ammunition plants, and depots.

Waterways are critical assets in effective defense industry mobilization and to the U.S. defense. The success of a nation in military conflict depends on material production, transportation of materials for that production, as well as final delivery. A major defense mobilization requirement would induce sharp increases in waterborne traffic of strategic materials such as primary metal products, ores, energy commodities, and chemicals. The major sources of supply and production of these materials are accessible by the national waterways, which ensure secure and efficient support of all types of military operations.

The waterways in general, and in particular the UMR-IWW Navigation System, serve as primary routes for the movement of products, war material and supplies, oversized machinery, and equipment of strategic national importance.

It is important to emphasize the criticality of national security in port and waterway improvements that augment the capability to deploy and sustain military forces, when required. Preserving and enhancing our transportation resources not only makes that infrastructure safer, it also secures our Nation, facilitates growth in business and industry, creates jobs, and improves the quality of life of our citizens.

1.7.5 Cultural and Social Importance of the UMR-IWW System

The Upper Mississippi River System and associated environments have a rich record of human history spanning over 12,000 years that is increasingly being documented as one of the most archeologically and historically significant regions in the country. The abundant and diverse ecological resources found along the UMR-IWW have attracted and sustained human populations for thousands of years, providing food, water, shelter, and transportation. In modern times, the UMR-IWW System has assumed a significant role in the development and prosperity of the Midwestern economy and way or life. The presence of the rivers provides many benefits to the States and counties along the river corridor. Benefits are derived from the employment and income generated from transportation of goods, recreation, hydropower production, and water supply for municipalities, commercial, industrial and domestic use. Some of these benefits are:

- Commercial and recreational fishery.
- About half of the 30 million residents of the watershed rely on the water from the UMR and its tributaries for municipal and industrial water supplies.
- It provides for over $6.6 billion dollars in revenue annually from some 12,000,000 visitor-days of use by people that hunt, fish, boat, sightsee or otherwise visit the river, its magnificent bluffs and communities (Black et al. 1999).
- Recreation and tourism employ 143,000 people in the corridor.
- It provides the important benefit of over 1,200 river miles of diverse natural, rural and urban open space for human exploration, experiential education, spiritual renewal and aesthetic enjoyment.

The primary impact area of improvements lies within the 78 counties bordering the Upper Mississippi River and Illinois Waterway. Together, these counties contain nearly 5 percent of the nation’s population, with total population in 2000 of nearly 13.4 million. The 2000 population for the UMR counties was 5,933,130, and 7,441,055 for the IWW counties. Fifty-four percent of the study-area counties have over half of their population living in rural areas. Little fluctuation in the population of the study-area communities is indicated, with only a 5 percent increase from 2000-2020. Population declines are forecast mostly in rural counties.

Upper Mississippi River counties are economically diverse, receiving earnings from machinery manufacturing, food and beverage processing, and crop, dairy and livestock production. Regional industries produce canned, frozen, and dairy foods, and manufacture broadcast equipment, construction equipment, agricultural machinery, ammunitions, chemicals, and aluminum sheet. Similarly, agricultural and industrial production is also the center of economic activity along the Illinois Waterway. Regional industries produce chemicals, fertilizers, petroleum products, earthmoving equipment and off-highway trucks, communication towers, plastics, plate and sheet metal, and diesel engines. Agricultural activities focus on crop production including corn, soybeans, feed grains, vegetables, and pumpkins. Other important activities along the waterway include meat processing and manufacturing of patio furniture, paper products, musical instruments, and appliances.

Throughout the study area, the Upper Mississippi River and Illinois Waterway are essential to the economies of the counties and States that they border. The UMR segment represents the Mississippi River from Minneapolis, MN to the mouth of the Missouri River. Because the confluence of the Mississippi River and the Illinois Waterway is above the confluence of the Mississippi River and the Missouri River, the majority of Illinois Waterway traffic is reflected in the traffic total for the UMR. Nearly 80 million tons of commodities traverse the UMR and nearly 40 million tons travel on the IWW each year, making their way to and from other States, waterways, and international ports. The people living and working in those places rely on the river system for their livelihood.

An examination of recreational activity and associated economic impact on the UMRS was conducted by Carlson et al. (1995). This report was based on survey data collected in 1990 and 1991. Not surprisingly, water-based activities dominate recreation use, with boating, boat fishing and sightseeing being the most popular activities. Sixty-six to 75 percent of the recreational participants were from counties bordering the rivers, and most visits (75 percent) were day trips. The study estimated that over 12 million daily visits occurred throughout the Upper Mississippi River System during the study year. The overall economic impact analysis related visitor spending to regional income and employment; the analysis considered direct, indirect, and induced effects of this spending. In addition to the regional context (the "regions" being those 76 counties bordering the Illinois and Mississippi Rivers, and the entire 5-State area), the analysis also examined economic benefits to the Nation. It was estimated that, in the study year (1990), recreation activity generated $400 to $550 million in total output and 7,000 to 10,000 jobs regionally, and similarly $1.2 billion and over 18,000 jobs nationally.

Water transportation supports thousands of jobs throughout the river corridor, and the Nation, in a variety of industries. Agricultural, mining and manufacturing industries, public utilities, waterside commercial development, and water-based recreational activities depend on the inland waterway for their livelihood. The Regional Economic Development study traced expenditures and transportation cost savings throughout the economy in terms of additional full-time employment, wage and salary income, and output of the value of the good produced. The analysis reported that within the study-area States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, 21,891 man-years of employment are generated by water-based industries. This benefit also has an impact on other regions as well as the entire United States. In the States bordering the UMR-IWW study area, income generated by these business activities is estimated to be over $509 million, and for the entire United States it is estimated to be over $1.2 billion. Inland waterway transportation generates thousands of jobs and millions of dollars in taxes for the State and Federal governments.

2.0 STUDY BACKGROUND

2.1 Study History

Aspects of the Upper Mississippi and Illinois Waterway System Navigation Feasibility Study have been underway for more than a decade. The size and complexity of the system, uncertainty regarding economic forecasts and environmental impacts, and ultimately, the temporary halt of the study have contributed to this lengthy process. The study history can be categorized into a three-part assessment process: initial appraisal, reconnaissance study, and finally the feasibility study described in this report. These investigations involve progressively greater amounts of information gathering and assessment. The following section briefly highlights the study history of starting with an initial appraisal, conducting separate reconnaissance studies for the Upper Mississippi River and Illinois Waterways, and the decision to combine the two studies and conduct a single system feasibility study. The section concludes with a brief summary of some of the significant guidance and modifications that have been made to the scope of the study.

2.1.1 Initial Appraisal

Initial appraisals regarding potential capacity increases on the Upper Mississippi River and the Illinois Waterway were developed in May 1988. The initial appraisal recommended developing a plan of study to investigate a long-term solution to meeting increased navigation demand and reducing delays for commercial traffic on the system.

2.1.2 Reconnaissance Studies

In August 1989, a Plan of Study for the Upper Mississippi River and Illinois Waterway navigation feasibility investigation was completed. This document recommended undertaking two separate navigation reconnaissance studies for investigating potential navigation improvements—one for the Illinois Waterway and the other for the Upper Mississippi River. Specific investigations were recommended to define the base condition, analyze congestion problems, determine system benefits, and examine environmental impacts. The reconnaissance-level investigation was to begin the process of establishing prioritized, waterway-specific, capital investment recommendations, including efficiency measures, required to meet future traffic demand.

The Illinois Waterway Navigation Reconnaissance Study concluded that there may be economic feasibility for major capital improvements at the La Grange and Peoria Lock sites and the canal upstream of Marseilles Lock. The study findings are contained in a 3-volume reconnaissance report completed in October 1990 (http://www2.mvr.usace.army.mil/umr-iwwsns/documents/Final%20Reconnaissance%20Rpt.pdf). Following a 15-month investigation, the 2-volume Upper Mississippi River reconnaissance report was completed in June 1991 (http://www2.mvr.usace.army.mil/umr-iwwsns/documents/Final%20Reconnaissance%20Rpt.pdf). The Upper Mississippi River Reconnaissance Study concluded, based on preliminary economic analysis, that navigation improvements may be justified for Locks and Dams 25 through 11 between the years 2000 and 2050. Both documents recommended performing more detailed systemic feasibility level environmental, engineering, and economic studies.

2.1.3 Guidance and Decisions Prior to Start of Feasibility Study

In October 1991, the two studies were combined to provide a system approach in solving navigation problems common to both rivers. This systems approach was to include, as appropriate, environmental studies proposed by the Lock and Dam 26 (Melvin Price), Second Lock, Alton, Illinois *Plan of Study* that were needed to address navigation traffic impacts.

On December 9-10, 1992, a Reconnaissance Review Conference was held in Chicago, Illinois. Representatives of the five UMR-IWW states, the U.S. Fish and Wildlife Service, the U.S. Environmental

Protection Agency, and various groups representing a spectrum of interests met with Corps of Engineers staff to discuss conclusions and recommendations from the Upper Mississippi River Reconnaissance Study. In addition, discussions also covered material described in the Initial Project Management Plan (later renamed the Project Study Plan or PSP) outlining the scope, cost, and schedule for executing the feasibility study.

The general conclusion of the Reconnaissance Review Conference was to approve and institute portions of the recommended study plan that were not the subject of diverging views, and that the resolution of other issues would likely be resolved over a period of several months. In addition, the Corps of Engineers determined that the focus of 100% Federal funded environmental studies would be to assess the effects of incremental increases in traffic associated with any navigation improvements. A broader multi-purpose environmental study proposed by a number of agencies and organizations would require 50/50 cost sharing by the states or other sponsors because they would address issues beyond the scope of the Federal navigation project improvements. It also was determined that the study would not be multi-modal (e.g., not consider possible theoretical approaches that would potentially reduce river traffic such as grain pipelines, magnetic levitation trains, etc.), but that the evaluation would consider the use of other existing alternatives such as traditional rail. Further, as with other Corps transportation feasibility studies, an assumption was made that rail and highway systems have or would have the capacity to move goods not accommodated by the navigation system at the current rate structure.

On March 1, 1993, the Reconnaissance Study Report and the Initial Project Management Plan (IPMP) were approved, subject to modifications in response to various concerns raised at the Reconnaissance Review Conference. The study boundary was expanded to the mouth of the Ohio River in the IPMP. It also included flume construction and analysis work by the Corps' Waterways Experiment Station (WES) to determine physical effects of navigation and additional environmental studies to evaluate impacts to mussels, impacts to fish spawning habitat, effects of sediment resuspension on plants, and environmental impacts of recreational craft. The IPMP also included $7.5 million to provide for increased engineering detail to accomplish the site-specific feasibility study and report, assuming that the study would demonstrate justification for improvements. These efforts were to be initiated when the system feasibility study was sufficiently complete to support the timing, size, and justification for the first large-scale improvements. In regard to this item, the guidance acknowledged that several projects may have to be designed concurrently and that this need would be considered later in the study process.

Based on the approval of the Reconnaissance Study Report and Project Study Plan, the feasibility study was initiated in April 1993.

2.1.4 Guidance and Decisions Subsequent to Start of Feasibility Study

The study was initially developed as a 6-year effort, but due to the complexity of the study and comments from the public and coordinating agencies, modifications to the scope and timeframes were necessary.

As a result of strong interest and concerns expressed by state agencies, interest groups, and the public after the initial series of public informational meetings in 1993, public involvement efforts were enhanced to substantially increase the opportunities for the public to be informed about and react to the study throughout the study process. Updates included allowing increased public interaction with the study team through a wider variety of meetings, workshops, and conferences. A toll-free telephone number information line was developed, and the newsletter mailing list was expanded to include nearly 10,000 individuals and groups.

In August 1994, the study was modified to include a constrained budget scenario, consider risk and uncertainty using a probabilistic risk-based analytical framework, and evaluate the relationship between the condition and capacity of locks and potential reduced capacity related to the aging of existing structures. While efforts were undertaken to consider risk and uncertainty, the need for a constrained budget scenario was ultimately not required, and the ability to evaluate condition versus capacity, while attempted, was determined to be beyond the state of the art at that time.

In 1995, funding was increased for environmental studies associated with commercial traffic physical effects and ecological modeling and more comprehensive assessments of fish, plants, and mussel impacts. The additional efforts required by the work added 9 months to the schedule, moving the expected completion date from March 1999 to December 1999. As a result of feedback given at the fall 1994 public meetings, a Regional Economic Development (RED) analysis and assessment of the cumulative effects of the navigation system on the environment were added, along with increased efforts on innovative lock design.

In the spring of 1998, study efforts were delayed due to the fact that some economic, environmental, and engineering efforts were taking longer to complete and review than initially anticipated. During the summer of 1998, the Corps focused efforts on conducting technical reviews of the innovative, yet untested, economic model when it was realized how sensitive the model output was to certain inputs. An effort was then undertaken from November 1998 to February 1999 to gather data on the transportation demand characteristics of the commodities shipped on the rivers. In total, these efforts delayed the study an additional year, moving the projected completion date to December 2000.

The completion was further delayed in early 2000 during a Corps policy review of data and methodologies used on the study. In February 2000, the Department of Defense requested that the National Research Council (NRC) review the original Navigation Study activities in its role to advise the Federal Government on science issues for the National Academy of Science. The National Research Council launched this review in April 2000 and appointed an expert committee under the joint auspices of the National Academy of Science's Water Science and Technology Board (WSTB) and Transportation Research Board (TRB). This review was conducted in accordance with the following statement of task and was to be completed in one year:

> "*This study will focus on the U. S. Army Corps of Engineers' economic analysis regarding proposed improvements, including economic assumptions, methods and forecasts regarding barge transportation demand on the Upper Mississippi River-Illinois Waterway. The Corps must also consider larger water resources project planning issues such as formal U.S. federal water resource planning guidelines, possible environmental impacts, and the costs of navigation improvements. Thus while the committee will focus on the Corps' economic analysis, they will also comment upon the extent to which these larger issues are being appropriately considered in the navigation system feasibility study.*"

The NRC was hampered in its initial review of the study by the fact that a draft report had not been completed for the original study. However, the Corps study team provided a preliminary draft and partially completed reports in July 2000 to aid the NRC in their review. The NRC review report was provided to the Corps in February 2001 (National Research Council, 2001). This report included many recommendations; however, there were four that would influence the future of the study. They were:

1. The study should include equal consideration of fish and wildlife resources,
2. The study should assess ongoing effects of the existing Nine-Foot Channel Project,
3. Defensible 50-year forecasts are unlikely to be achieved,
4. The Spatial Equilibrium Model used was incomplete and should be further developed. It also lacked sufficient data to support assumptions. The NRC recommended that the model in its current form "should not be used in the feasibility study."

The complete NRC report can be viewed at: http://books.nap.edu/books/0309074053/html/index.html

After release of the NRC review, the Chief of Engineers announced a pause in the study to allow time to evaluate the comments and determine a new course of action. The Corps solicited help in this endeavor by forming a Federal Principals Task Force made up of senior members of the Department of Interior, Department of Agriculture, Department of Transportation, and Environmental Protection Agency. This task force provided a national level balance and guidance on important economic and environmental issues related to the NRC recommendations. The Federal Principals Task Force is a collaborative and collegial forum for advising the Corps on how to address the NRC recommendations and other key issues in an appropriate and effective manner. A counterpart-working group defined as the Regional Interagency Work Group was also established to help guide the future of this study at the local level. This group worked with members of the Project Delivery Team (PDT) on the details of the various broad actions needed to address the NRC recommendations and advise the Task Force on the preferred actions. The Federal Principals Task Force and Regional Interagency Work Group met several times during the spring and summer of 2001, in order to develop a plan of action on how to address the NRC recommendations. They considered several topics that needed to be addressed in the plan and presented them in the form of Issue Papers (see Interim Report for the Restructured UMR-IWW Navigation Feasibility Study, Appendix 3, July 2002). The topics covered the following environmental and economic issues:

ENVIRONMENTAL THEMES & ISSUES:

Theme 1a: Equal consideration for fish and wildlife resources.

Theme 1b: Environmental effects of the existing Nine-Foot Channel Project.

Issue 2: Incorporate a cause and effects cumulative effects analysis in the System Study.

Issue 3: Should the scope of the tow traffic effects analysis be expanded to include quantification of the impacts of existing traffic (including Second Lock traffic) and traffic increases expected to occur without navigation expansion, or should existing traffic impacts remain identified as the baseline condition?

Issue 4: Include an assessment of ongoing project operation and maintenance (O&M) impacts as an element of the System Navigation Study.

Issue 5: Include a comprehensive mitigation plan that addresses the total array of navigation effects (O&M impacts, baseline traffic, Second Lock traffic, avoid and minimize, and incremental traffic) as part of the Navigation Study.

Issue 6: Assessment of traffic effects due to the Second Lock, Melvin Price Lock and Dam.

Issue 7: Upper Mississippi River cooperating Federal and state agencies should develop and implement a comprehensive ecosystem management plan for the Upper Mississippi River System.

Issue 8: How will site-specific impacts be addressed and incorporated into the overall environmental impact assessment?

Issue 9: Inadequacy of incremental effects studies due to insufficient data.

ECONOMIC ISSUES:

Issue 1a: Calculation of Traffic Forecast: Relates to Issue 1, "Spatial Equilibrium Model and Data" of the National Research Council (NRC) review report.

Issue 1b: Demand Elasticities. Relates to Issue 1, "Spatial Equilibrium Model and Data" of the National Research Council (NRC) review report.

Issue 1c: Use of ESSENCE Model (Benefit Model). Relates to Issue 1, "Spatial Equilibrium Model and Data" of the National Research Council (NRC) review report.

Issue 2: Consider nonstructural options for improving traffic management as a baseline condition for the study. This relates to issue 2 of the National Academy of Sciences Review Report.

The Issue Papers were presented to the Federal Principals Task Force in May 2001. The task force summarized the Issue Papers and provided recommendations for restructuring the Upper Mississippi River and Illinois Waterway Navigation Feasibility Study to address the NRC review in the form of a concept paper. The recommendations are presented in total in Appendix 3 of the Interim Report for the Restructured UMR-IWW Navigation Feasibility Study.

2.1.5 Study Restructuring

The Concept Paper produced by the Federal Principals Task Force was used as the basis for new guidance developed by the Corps. The new guidance was released on August 2, 2001, and signaled the restart of the Navigation Study in a restructured format. The restructured feasibility study focused on the authorized Federal navigation projects on the Upper Mississippi River System (including the Illinois Waterway) and the ecological and floodplain resources that are affected by these navigation projects. The objectives of this restructured feasibility study were to relieve lock congestion, achieve an environmentally sustainable navigation system, and address ecosystem and floodplain management needs related to navigation in a holistic manner. The restructured navigation study would ensure that the rivers and waterway system could continue to be an effective transportation system and a nationally treasured ecological resource. The restructured study was designed to: (1) further identify the long-term economic and ecological needs, and potential measures to meet those needs, through collaboration with interested agencies, stakeholders, and the public; (2) evaluate various alternative plans to address those needs; (3) present a plan consisting of a set of measures for implementation that will achieve the study objectives; and (4) identify and address issues related to the implementation of the recommended plan.

A key foundation of the restructured study was it's new emphasis on collaboration among Federal and state agencies, non-governmental organizations, and the general public. Collaboration is an important mechanism for increasing cooperation and communication, fostering trust and understanding among participants, and allowing a greater set of interests to be met. Since the restart of the restructured navigation study, all interaction with the stakeholders has been accomplished in a collaborative atmosphere. Information has been expeditiously shared through meetings, phone calls, and email distribution. The coordinating committees that were used previously have been redesigned to allow more participation from the stakeholders of the system. Collaboration has occurred between the economic and environmental interests by having combined sessions of the Economic Coordinating Committee and the Navigation Environmental Coordinating Committee. Collaboration was also evident in the March 2002 and October 2003 series of public meetings where stakeholders participated in the meetings.

The following provides a quick reference to specific guidance memorandums or documents that have shaped and guided the restructured study since August 2001. Copies of these documents can be found on the CD accompanying this document or accessed on the study website: (http://www2.mvr.usace.army.mil/umr-iwwsns/):

a. **August 2001:** Guidance Memorandum, CECW-PM, dtd 2 Aug 2001, Subject: Upper Mississippi River and Illinois Waterway (UMR-IWW) System Navigation Study Project Guidance Memorandum.

   This memorandum provides the Mississippi Valley Division (CEMVD) guidance on the resumption of the subject navigation study. The Chief of Engineers has approved restart of the subject study, generally in accordance with the agreement contained in the enclosed Principals Group's Concept Paper and in accordance with guidance contained in this memorandum. The Principals Group consists of Washington-level representatives from the Department of Agriculture (USDA), Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), Maritime Administration (MARAD), and HQUSACE, formed to consider the NRC recommendations and advise the Chief of Engineers on potential study changes.

b. **October 2001:** Guidance Memorandum for Commander, Mississippi Valley Division (CEMVD-MD), CECW-P, dtd 29 Oct 2001, Subject: Review of Upper Mississippi River Comprehensive Management Plan, Final Plan of Action.

   The purpose of this memorandum is to provide comments on the subject plan of action. Most importantly, we must proceed in a manner consistent with commitments made by the Chief of Engineers to the Secretary of the Army and the Congress. These include the commitment that he will be personally responsible for producing a sound report on this project and making a recommendation; that under the study restructuring he has directed that the U.S. Army Corps of Engineers develop a comprehensive plan in phases; that he expects to make an interim report to the Secretary of the Amy in July 2002; that the interim report will present a conceptual plan for addressing navigation and ecosystem needs; and that he anticipated the release of a draft interim report for public review in spring 2002. Further, in response to findings of the National Academy of Science, he directed that scenarios and assumptions about world grain markets and competitive forces as well as macroeconomic considerations such as world competitiveness, transportation policy and national security issues will also be considered.

c. **July 2002:** Interim Report for the Restructured Upper Mississippi River-Illinois Waterway (UMR-IWW) System Navigation Feasibility Study. July 2002.

   This document provides a history of past study activities, the purpose of the restructuring, initial plan formulation activities including establishment of goals and objectives, and identification of implementation issues. It also presents a blueprint for moving forward with the feasibility study to ensure the Waterway System continues to be a nationally treasured ecological resource as well as an efficient national transportation system.

d. **February 2003:** Memorandum For Record (MFR), CEMVR-PM, dtd 6 Feb 03, Subject: UMR-IWW Scenario Probabilities.

   In accordance with comments received on the Draft Interim Report, the study team has explored opportunities for identifying scenario probabilities as part of a sensitivity analysis during the formulation process. This memorandum contains the background, evaluation of options, and initial recommendation on this issue. The scenario analysis was pursued based on a recommendation from the Federal Principals Task Force, in an attempt to address the difficulties and uncertainties associated with making 50-year traffic forecasts. The product of this effort was the development of five scenarios that ultimately described alternative levels of unconstrained waterway traffic forecasts for the Upper Mississippi River-Illinois Waterway System. Construction of the scenarios flowed from the effects of thirteen influential variables, which were classified into four "scenario drivers". While constructed to represent a range of outcomes, the scenarios were not intended to describe extreme or highly unlikely outcomes. Each scenario was intended to reflect reasonable representations of the values assumed for the individual variables combined in such a manner as to also represent reasonable plausible descriptions of UMR-IWW System unconstrained traffic. However, the likelihood of scenario occurrence, either numerical or ordinal, was not specified. The initial decision to not determine scenario probabilities was supported by the Federal Principals Task Force.

e. **August 2003:** Memorandum for HQUSACE (CEDC), CEMVD-MD-PM, 11 August 2003, Subject: Upper Mississippi River-Illinois Waterway (UMR-IWW) System Navigation Study Benefit Model Sensitivity Analysis.

This memorandum documents our use of the original Essence model in the ongoing Upper Mississippi River-Illinois Waterway System Navigation study. Reference 1.b. contains the recommendations of the project delivery team (PDT). The PDT recommended using the original version of the ESSENCE model to conduct a sensitivity analysis of spatial equilibrium effects on commodity movements along the river. They identified the original ESSENCE model as the most effective tool currently available to evaluate commodity elasticity and provide meaningful sensitivity feedback even though the National Research Council reviewers found it not ready for use as a primary evaluation tool. The MFR was developed in collaboration with stakeholders and contained input from the Federal Principals Task Force, Regional Interagency Work Group, and other stakeholders.

f. **January 2004:** Memorandum for Record: Upper Mississippi River-Illinois Waterway (UMR-IWW) System, Ecosystem Restoration – Discussion of Authorities and Cost Sharing Options, dtd. 9 January 2004.

Section 3.32 of the Interim Report dated July 2002 contains preliminary discussion of authority and cost sharing considerations pertaining to the implementation of ecosystem restoration measures to meet established restoration goals and objectives and assure the ecological integrity of the UMRS. The Interim Report indicated that the ecosystem restoration measures would be implemented through a combination of 100 percent Federal and cost shared measures and that the criteria for cost sharing would be addressed in the feasibility study. This memorandum further explores authority and cost-sharing options, evaluates the options and makes initial recommendations for inclusion in the feasibility report scheduled for completion in 2004.

The study is primarily being accomplished in accordance with the August 2001(ref a.) and October 2001(ref b.) Guidance Memorandums with the exception of the following:

a. **Sensitivity Analysis -** The Aug 2001 guidance letter stated that the ESSENCE model should not be used in the feasibility study and that a previously used and accepted model should be used in this study. Subsequent discussions highlighted the need for the use of the ESSENCE model to demonstrate the importance of the demand elasticity assumptions. The details on this topic are located in reference (e).

b. **Probabilities -** The Aug 2001 guidance letter includes the requirement to include an assessment of the likelihood of each of the scenarios developed. The advisability of assigning probabilities to the scenarios was evaluated in reference (d) above and found not to be recommended.

c. International Competitiveness - The August 2001 guidance letter also recommends addressing International Competitiveness in the analysis. International competitiveness will not be a primary evaluative criterion in the final decision process. However, it is inferred that a more efficient Navigation System will maintain the lowest possible water based transportation rates, equating to a more competitive commodity price on the international marketplace. The economic models will produce outputs that can easily be converted to export quantities for the various commodities under each of the various alternatives and scenarios.

d. Alternative Modes Analysis - The August 2001 guidance letter recommends a thorough evaluation of capacity, environmental and social impacts on alternative modes resulting from a model shift due to a Federal action on the waterway. Alternative modes evaluations will only be evaluated to a limited extent for environmental and social considerations. A thorough capacity analysis will not be conducted for any of the alternatives. The measurement of NED transportation savings will follow the guidance of Engineering Regulation (ER) 1105-2-100 with respect to alternative mode capacity. Paragraph 6-60.a.(4) states, "*In projecting traffic movements on other modes (railroad, highway, pipeline, or other), the without project condition normally assumes that the alternative modes have sufficient capacity to move traffic at current rates unless there is specific evidence to the contrary*."

2.2 Study Organization

The study boundaries cross three Corps of Engineers Districts (Rock Island, St. Paul, and St. Louis), five states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), 77 counties, and 38 major river communities. In addition, a large number of agencies, interest groups, and the general public have an interest and stake in the study outcome.

2.2.1 Study Team

The study is a multi-disciplinary and multi-district effort. Numerous team members are involved from the following Mississippi Valley Division (MVD) Corps of Engineers district offices: Rock Island (MVR), St. Paul (MVP), St. Louis (MVS) and New Orleans (MVN). Additional study team support and guidance has been provided by representatives from the Corps of Engineers Headquarters (HQ), Mississippi Valley Division (MVD), Engineering Research and Development Center (ERDC) and Institute for Water Resources (IWR). The study efforts were conducted by organizing efforts within five primary Corps work groups (Project Management/Plan Formulation, Economics, Engineering, Environmental/Historic Properties, and Public Involvement). Work group activities included the support and involvement of research facilities, universities, other agencies, and independent contractors.

The following paragraphs provide a brief description of the purpose and responsibilities for these five work groups.

2.2.1.1 Project Management/Plan Formulation

This group assured that work group elements and activities were completed on time and within funds allocated. It was charged with facilitating information sharing between work groups, ensuring efficient study progress, and leading and coordinating plan formulation efforts. The following provides a brief description of the tasks accomplished by this workgroup:

- Provided overall management to the multi-District study team.
- Managed study funds and schedules.
- Led plan formulation efforts in the evaluation of measures and alternatives.
- Served as spokesman for the Corps on all study related activities.

2.2.1.2 Economics

This group conducted economic evaluations to assure that system-wide effects of alternative plans were estimated and prepared the economic and social analysis section of the feasibility report. The following provides a brief description of the tasks accomplished by this workgroup:

- Developed description of historic traffic in terms of tonnages, average delay times at each lock, and a breakdown of the various commodity groups that are transported on the system.
- Developed waterway traffic forecasts to the year 2050 including the eight major commodity groups: grain and soybeans, agricultural chemicals, prepared animal feeds, coal, industrial chemicals, petroleum products, construction materials, and steel/steel sector raw materials.
- Developed a new economic benefit model.
- Helped establish the without-project condition.
- Performed sensitivity analysis for key parameters.
- Performed transportation rate analysis.

2.2.1.3 Engineering

This work group evaluated the current navigation system and anticipated without-project operations and maintenance, rehabilitation, and replacement needs. It also conducted engineering and cost estimating efforts to develop and evaluate potential measures and assure that estimates and recommended solutions were identified within reasonable limits. The following provides a brief description of the tasks accomplished by this workgroup:

- Determined the future physical condition and investments needed to maintain the current system at an acceptable level of performance.
- Evaluated efficiency improvements that could be considered in the without-project condition.
- Evaluated the feasibility of a universe of 92 small-scale structural and nonstructural measures to reduce lock congestion.
- Evaluated the feasibility of large-scale navigation improvements at 16 sites to include lock extensions and new locks. Developed several innovative techniques for construction of lock extensions or new locks.

2.2.1.4 Environmental/Historic Properties

This workgroup collected, analyzed, and interpreted environmental data and developed adequate tools to assess the impacts of the various Navigation Efficiency alternative plans over the without-project condition. It also developed the mitigation requirements and costs associated with various alternatives. It coordinated and prepared the environmental and historic properties portions of the feasibility report, assured project compliance with environmental statutes, executive orders, and memoranda, and started to prepare an Environmental Impact Statement (EIS) in compliance with the National Environmental Policy Act (NEPA) requirements. The following provides a brief description of the tasks accomplished by this workgroup:

Environmental Impact Assessment

- Through an extensive scoping and coordination process, identified biological, special concern, cultural/historic, socioeconomic, and recreational resources of concern for the UMR-IWW.
- As part of the initial screening process for large-scale improvement measures, completed preliminary assessments of site-specific construction impacts.
- Oversaw the completion of over 60 technical studies/reports conducted in support of the overall environmental impact analysis.

- Developed state-of-the-art models to simulate the hydraulic disturbances of towboats and barge traffic, and to assess the biological responses to these disturbances.
- Facilitated or participated in supporting studies on alternative modes impacts and cumulative effects.
- Developed a landform sediment assemblage database, performed archaeological and structural studies, and completed final programmatic agreement documentation as part of the cultural resources/historic properties analysis and compliance.
- Developed an initial strategy for implementation of mitigation requirements.

Ecosystem Restoration Alternatives

- Developed a comprehensive database of specific, quantitative, local to regional scale UMRS environmental objectives building on previous work from the Environmental Management Program Habitat Needs Assessment, Mississippi River Environmental Pool Plans, USFWS Comprehensive Conservation Plans, and related Study Efforts.
- Structured and conducted four regional two-day workshops to collaboratively review, refine, and add to the UMRS environmental objective database.
- Identified ecosystem management and restoration measures that would contribute to attaining the ecosystem objectives.
- Used multiple sources of input (e.g., UMRS Corps Districts, stakeholders, historical project costs and results, etc.) to estimate potential costs and outcomes of the management and restoration measures.
- Formed a panel of scientists and engineers (Navigation Study Environmental Science Panel). The Science Panel reviewed requirements for a sustainable river ecosystem and made recommendations for integrated and adaptive river system management.
- Combined varying types and numbers of management and restoration measures into alternative plans to address local, river reach, and system-wide needs of the UMRS ecosystem. Through collaborative work with UMRS stakeholders, coordinating committees, and the Navigation Study Science Panel, these tentative alternative plans were developed to provide a range of ecosystem protection and restoration opportunities.

2.2.1.5 Public Involvement

This group's role was to identify and include all potentially affected public interests in the study process, and provide opportunities to inform, educate, and solicit feedback. The public's comments and concerns were collected and identified from newsletter comment sheets, incoming correspondence, input at meetings, and messages left on the toll-free number. In addition, an internet web site was developed which facilitated the sharing of interim reports and other study information with the public. The following provides a brief description of the tasks accomplished by this workgroup:

- Distributed 24 newsletters from 1993 to September 2003 to a distribution of nearly 10,000 subscribers.
- Conducted Public Meetings
    - October-November 1993 – Public Informational Meetings (14 locations)
    - November 1994 – Public meetings and NEPA Scoping Meetings (8 locations)
    - November-December 1995 – Public Open Houses (5 locations)
    - July-August 1999 – Public Workshops (7 locations)
    - November 2000 – Public Open Forum Hearings (7 locations)
    - March 2002 – Public Meetings to present and get the public's reaction to the study's new direction (5 locations)

- October 2003 – Public Meetings to present Tentative Alternative Plans (7 locations)
- June 2004 – Public Hearings to present the Preferred Alternative Plan

- Developed and maintained a toll free information phone and message service.
- Developed and maintained a study website.

2.2.2 Study Cost

The majority of work completed between 1993 and December 2003 was for the determination of future navigation improvement needs and environmental impacts. Through December 2003, the expenditures for the study approached $70.6 million. The breakdown of these expenditures among project management, plan formulation, economic analyses, engineering assessments, environmental/historic property studies, public involvement, and real estate components of the study are illustrated below (Figure 2-1). A description of each of these work group's activities is provided in the previous Study Team Section.

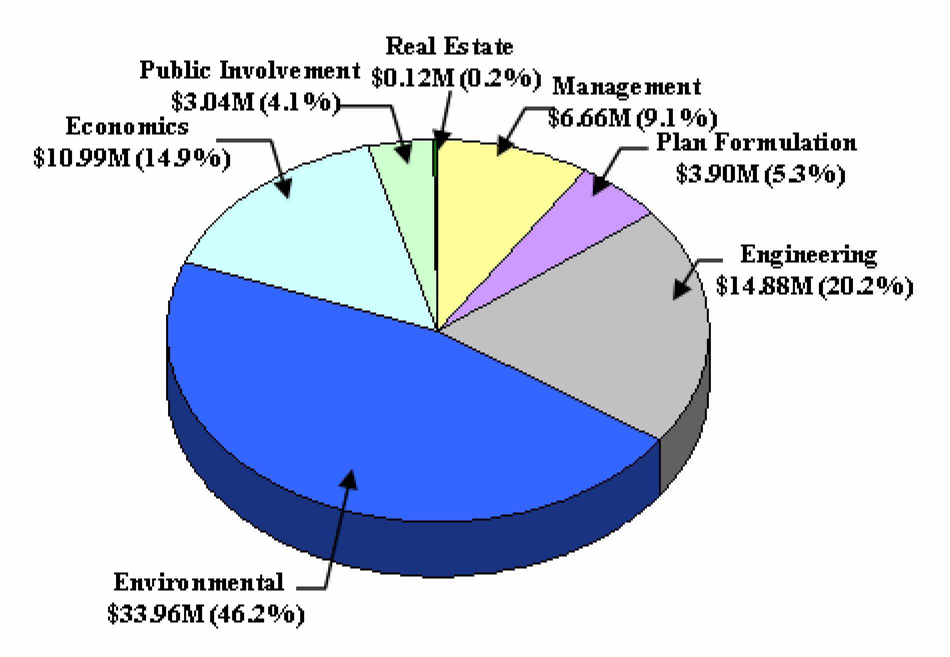


Figure 2-1. Expenditure distribution for UMR-IWW System Navigation Study (Recon + Feasibility) through September 2004 (Total = $73.54 million) for the seven main study workgroups ($ in millions and percent of total).

2.2.3 Collaboration

A National study of 105 ecosystem management projects found that *collaboration* was cited more than any other variable (61%) as critical to project success (Yaffee, Phillips et al. 1996). A key foundation of the restructured study is the emphasis on collaboration among Federal and State agencies, non-governmental organizations, and the general public. Collaboration is an important mechanism for increasing cooperation and communication, fostering trust and understanding among participants, and allowing a greater set of interests to be met.

The study team re-defined and re-structured their organizational structure in August 2001 to support an increased level of regional and national collaboration with stakeholders, federal partners, the five UMR-IWW states, and senior management. Upon approval of the study framework laid our in the Interim Report (July 2002), the study team developed a revised Project Management Plan (PMP) and re-defined the manner in which information would be shared amongst the technical components, stakeholders, federal partners and senior management (Figure 2-2). The study team has been working very closely with the stakeholders of the system in providing real time information at coordination meetings and through monthly status reports posted to the study website. The following provides a brief description of the primary interagency coordination committees that have been involved with the UMR-IWW Navigation Feasibility Study since it began in 1993:

2.2.3.1 Governors' Liaison Committee (GLC)

The GLC consists of designated representatives of the governors of the five study states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin). The goal of establishing the GLC was to assure that study recommendations would merit the support of the people of each state. The purpose of this key committee is to build consensus among the study area states and to provide the Corps with the position of the governor of each state on Navigation Study matters. A total of 36 GLC meetings have been held to date.

2.2.3.2 Navigation Environmental Coordination Committee (NECC)

The NECC consists of members from state natural resource agencies, the U.S. Fish and Wildlife Service, and the U.S. Environmental Protection Agency. This committee was established to facilitate coordination for study compliance with the National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, Endangered Species Act, and other environmental statutes requiring interagency coordination. Many Non-governmental Organizations (NGOs) have regularly participated in the NECC. The NECC has met more than 47 times to help refine environmental modeling procedures and to provide comments on environmental studies conducted as part of the overall study.

2.2.3.3 Economics Coordinating Committee (ECC)

The ECC consists of representatives from each of the five states, and one representative each from the Maritime Administration, the U.S. Department of Agriculture, Midwest Area Rivers Coalition (MARC) 2000, and the Corps of Engineers, who chaired the group. The purpose of the ECC is to allow partners and stakeholders with an opportunity to share their views on economic matters pertaining to the study, to facilitate efforts to arrive at a consensus on those matters among the members, and to engender a shared set of goals and expectations for the economic position of the study among all committee members and the public. The ECC has met 30 times to review key economic assumptions, and provide their input to the study.

2.2.3.4 Engineering Coordinating Committee (EnCC)

The EnCC consists of representatives from each of the five states in the study area and the Corps. They met three times during the study to discuss key engineering assumptions and findings. The EnCC met with navigation industry technical experts and representatives on several occasions to review the practical and logistical application of both small-scale and large-scale engineering alternatives. The Engineering Work Group also conducted several expert elicitation forums by inviting experts from construction and engineering firms to recommend and review conceptual designs and delay figures associated with construction and operation activities.

2.2.3.5 Public Involvement Coordinating Committee (PICC)

The PICC consists of representatives from each of the five states in the study area and the Corps. The PICC was established in 1993 to assist in the revision of the public involvement plan. Since then, the PICC has worked to create a shared set of goals and expectations regarding public involvement matters among all committee participants, the navigation industry, and the public.

Regular and open communication with our diverse group of stakeholders, state/federal agencies, and general public is a cornerstone of the re-structured study that has proven very beneficial. The distribution of preliminary data, analyses and documents has created a more open and trustful environment in which to discuss and collaboratively resolve many important technical or political issues. Previously the stakeholders would be engaged only after a final product had been delivered or final decision rendered. In the current organizational structure they are part of the process from initial development through final resolution. This approach has avoided many obstacles or deficiencies that may have only been identified after the fact. Detailed responses to frequently asked questions are provided on the study website and updated periodically. In addition, newsletters are published semi-annually and distributed to a mailing list of over 9,500 stakeholders and members of the interested public, and the study website is updated regularly with the latest meeting minutes, upcoming events/activities, reports, and information bulletins.

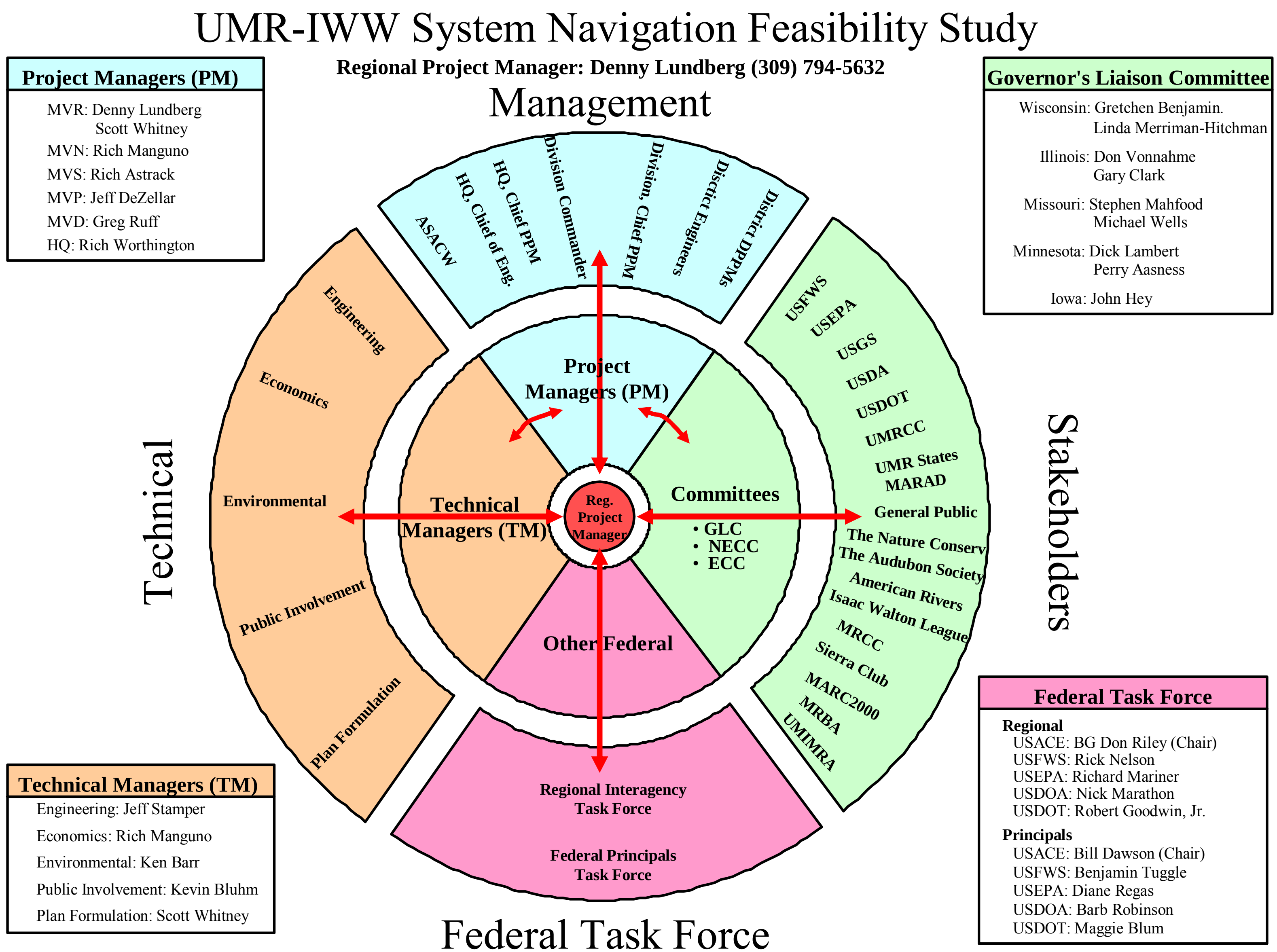


Figure 2-2. UMR-IWW System Navigation Feasibility Study Organizational Structure Schematic.

2.3 Corps/Agency Scoping Meetings and Concerns

This section will provide a synopsis of the major agency meetings whose outcomes significantly influenced the study scope and direction.

2.3.1 Lock and Dam 26 Second Lock Plan Of Study (POS; Feb 1991)

Development of the POS (USACE 1991b) is considered the starting point for the development of the Navigation Study environmental impact studies. When a second (600-foot) lock was added to the existing 1200' lock at Lock and Dam 26 (Alton, Illinois), it was acknowledged during preparation of the EIS that the physical effects and biological impacts of increased navigation traffic, induced by the addition of this lock, were not adequately understood. The second lock EIS recommended the development of a POS to investigate these potential impacts. In turn, an interagency memorandum of understanding was agreed to in 1988, and a task force was established to develop the POS.

Initial development of the POS was undertaken by the Corps' St. Louis District, for eventual review by state and federal agency staff. One of the outcomes of this review was the decision to formulate the POS using two interagency work groups, a hydraulic work group and a biological work group. The groups considered several impact assessment methodologies, and decided to use site-specific studies due to their flexibility and scientific basis for evaluating incremental impacts.

With this study design chosen, the groups used a two-phased approach that first outlined individual work units and attempted to establish a cause/effect relationship between current traffic levels and biological impacts, and to quantify those impacts. If significant traffic-induced impacts were determined, then a second phase would quantify the impacts due to the traffic increment that was attributable to the construction of the second lock. A list of 13 potential studies, prioritized into four categories from low to very high, was then developed by the work groups. The POS was completed in February 1991.

The POS was never formally implemented, but at the outset of the feasibility phase of the Navigation Study, it was determined that the environmental impact assessment would include the POS studies as appropriate.

2.3.2 Reconnaissance Review Conference (RRC)

Held on 9-10 December, 1992, this meeting was attended by Corps North Central Division (NCD) (in a reorganization, NCD was subsumed by the current Mississippi Valley Division) and Rock Island District personnel, various state and federal agency representatives and other interest groups. The overall purpose of this meeting was to review the 2-year reconnaissance phase of the Navigation Study, which was completed in 1992. The major issues which arose from the meeting were: 1) the public involvement effort was inadequate, and should be strengthened during the Feasibility Phase; 2) the environmental studies included in the Initial Project Management Plan (IPMP), which was released in November 1992, focused too narrowly on incremental traffic effects at the expense of broader environmental issues; and, 3) greater emphasis should be placed on environmental restoration opportunities and development of avoid and minimize measures for navigation system operation and maintenance actions.

2.3.3 Coordinating Committee Meetings

2.3.3.1 Technical Working Groups

During the early years of the feasibility study, technical working groups were assembled for each of the major resource categories. The objective of these groups, comprised of recognized subject area experts from government agencies, academia, and the private sector, was to prepare study plans for conduct of navigation impact assessments. These study plans, after review and comment by the work group members and the NECC (see next paragraph), formed the basis for detailed scopes of work for conducting individual study components. Technical work groups convened for fish, plants, mussels, recreational boating, bank erosion, fish passage, water level management, and ecosystem sustainability.

2.3.3.2 Work Group Coordination Committees

External coordination among the economic, engineering, public involvement, and environmental work groups was conducted on a regular basis throughout the feasibility phase. Committees were established and comprised of appropriate technical staff from the Corps of Engineers, other Federal agencies, appropriate agencies of the five UMR states (Illinois, Iowa, Minnesota, Missouri, Wisconsin), and the public. The public was represented by industry, academia, and other interests as deemed appropriate. The general purpose of the work group coordination committees was to garner external input and to review the technical aspects of the feasibility phase to help ensure development of a satisfactory product. The established committees included: the Economics Coordinating Committee, the Engineering Coordinating Committee, the Public Involvement Coordinating Committee, and the Navigation Environmental Coordination Committee.

The NECC was composed of Corps staff from the St. Paul, Rock Island, and St. Louis Districts and the Mississippi Valley Division (formerly North Central and Lower Mississippi Valley Divisions); U.S. Fish and Wildlife Service; the U.S. Environmental Protection Agency; Missouri Department of Conservation; and the Illinois, Iowa, Minnesota, and Wisconsin Departments of Natural Resources. Upon request of the Corps, other agency representatives were appointed by their respective agency heads. The NECC had a review and comment function with respect to environmental studies similar to the other committees, but in addition it also contributed to satisfying the statutory requirements for interagency coordination. The committee met on a regular basis during the study, and as of September 2004 had convened 47 meetings.

Issues and concerns focused on the technical merit, data inputs and comprehensiveness of the environmental studies. The NECC also provided a significant review function, and was afforded the opportunity to review and comment on all environmental work group products. These comments were considered and incorporated during the feasibility phase, and greatly influenced the scope and direction of the environmental efforts.

Three events involving the NECC are particularly noteworthy. In November, 1993, the NECC submitted to the Corps what was termed the 'Multi-Party Memorandum', a joint statement of their continued concerns and recommendations for additional efforts to lead toward a more adequate EIS. The recommendations were generally as follows: 1) Better define future without-project conditions, 2) develop a long-term plan for 9-foot channel operations and maintenance and unmitigated impacts 3) complete mitigation planning for the Lock and Dam 26 second lock (past and future water level regulation impacts) 4) examine restoration and enhancement opportunities 5) reconsider studies omitted from the Lock and Dam 26 POS, and 6) include a long-range plan for protection and restoration of significant UMR fish and wildlife resources.

The Corps, in February 1994, responded to each of the points raised in the Multi-Party Memorandum. The responses were given with the view that the system environmental studies were designed to identify and quantify impacts associated with incremental traffic increases. The response also emphasized that the Corps considered that any ecosystem management strategy would require 50% cost sharing with a non-federal sponsor, in view of Section 105(a) of WRDA 1986.

Concerns remained following the Multi-Party Memorandum and the Corps response, and in September 1994 a facilitated meeting was held with the NECC to better define unresolved environmental issues, and develop conceptual study plans to address these issues. Four main categories were identified from which plans would be developed: 1) cumulative impacts of channel maintenance dredging and material placement; 2) cumulative impacts of channel training structures; 3) effects of impoundment and river regulation; and, 4) fish passage through dams. Plans and budgets developed by Corps staff were reviewed by the NECC, and compiled in a January 1995 report, *UMR-IWWS Navigation Study – Conceptual Study Plans for Corps of Engineers Consideration* (USACE 1995a). The report used three major categories, with 12 separate studies identified. Coordinating agency comments on the plan package indicated that it was a positive step, but refinement and further definition were required.

As described in Chapters 8-10 and Appendix ENV-A, impact significance and mitigation planning have been topics of considerable discussion and debate with the NECC. To this end, a 'significance workshop' was held in conjunction with the December 1997 NECC meeting. The purpose of this workshop was to solicit, in a systematic manner, the state and federal agency's definitions of ecological significance relative to the resources being considered under the Navigation Study ecological risk assessment. Though it was agreed that significance may not be able to be determined for some resources, the workshop was considered a necessary first step toward future mitigation planning activities.

Though each agency representative provided their own perspective, some common points emerged. Cumulative/additive impacts should be considered; trust resources (including threatened/endangered species) are of special concern; narrow limits of loss would be acceptable for certain rare or declining species; impact avoidance should be emphasized; economic valuation of resource loss is problematic; essentially all losses are considered significant, particularly of non-game species. In addition, the workshop identified the need and availability of additional agency data, much of which was collected during subsequent field surveys, literature reviews or agency submissions.

3.0 DESCRIPTION OF FEASIBILITY STUDY PROCESS

Following the August 2001 guidance, the study shifted from a single purpose (Navigation Efficiency) study to a dual-purpose (Navigation Efficiency and Ecosystem Restoration) study approach employing the Corps traditional six-step planning process (Figure 3-1) specified in Engineer Regulation (ER) 1105-2-100, Planning Guidance Notebook. The process identifies and responds to problems and opportunities associated with the Federal objective and specified State and local concerns. The process provides a flexible, systematic, and rational framework to make determinations and decisions at each step so that the interested public and decision-makers can be fully aware of the basic assumptions employed, the data and information analyzed, the areas of risk and uncertainty, and the significant implications of each alternative plan.

The procedure used in formulating and evaluating the economic and environmental plans also complied with the general principles identified in Engineer Circular (EC) 1105-2-404, Planning Civil Works Project Under the Environmental Operating Principles, including broad formulation of alternatives to meet opportunities; identification of cost-effective plans with multiple benefits; and the recommended combined plan must be justified. It should be noted that trade-off analysis (as explained in the EC) was not conducted because no significant conflicts were found between the economic and environmental measures.

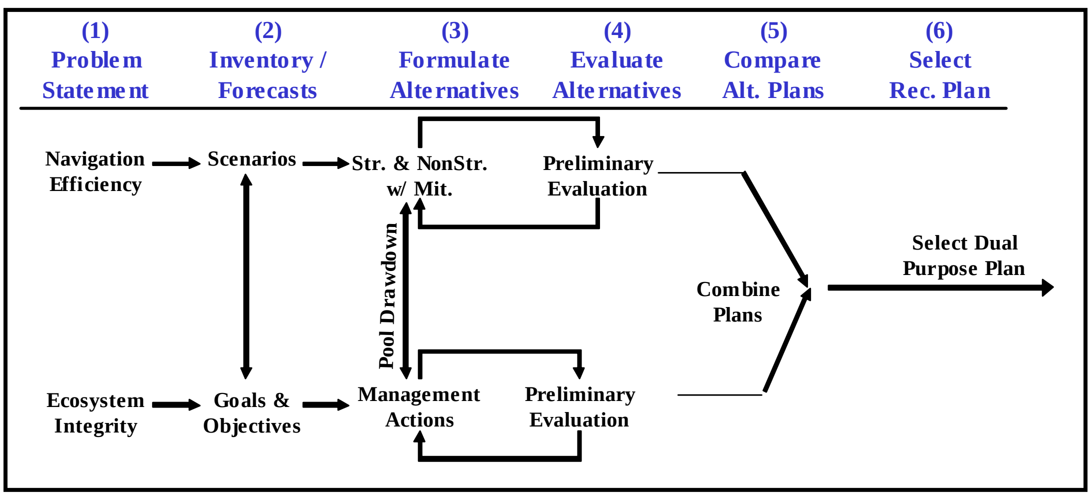


Figure 3-1. Decision Model for UMR-IWW System Navigation Feasibility Study.

The six steps of the Corps' Planning Process used in this Feasibility Study are briefly discussed in subsequent paragraphs:

1. **Identify Problems, Opportunities, and Constraints (Chapter 1):** The specific problems and opportunities are identified, and the causes of the problems discussed and documented. Planning goals are set, objectives established, and constraints identified.

2. **Inventory and Forecast Resource Conditions (Chapter 4):** This step characterizes and assesses conditions of the navigation system and the ecosystem as they currently exist and forecasts the without-project condition (or "no action" alternative) over the 50-year period of analysis. This assessment provides the basis by which to compare various alternative plans and their impacts.

3. **Formulate Alternative Plans (Chapter 6):** Alternative plans are developed in a systematic manner to insure that reasonable alternatives are evaluated. Navigation Efficiency Alternatives were developed by considering separately and in combination small- and large-scale measures. Varying types and quantities of management and restoration measures were combined into Ecosystem Restoration Alternatives to address local, river reach, and system-wide environmental needs and modifications to the existing operation and maintenance activities for the 9-foot channel project.

4. **Evaluate Alternative Plans (Chapter 7):** The evaluation of each individual alternative consists of measuring or estimating the economic, environmental, and social effects of each plan, and determining the difference between the without- and with-project conditions. Feasible plans are carried forward for comparison against one another.

5. **Compare Alternative Plans (Chapter 12):** Alternative plans are compared, focusing on the differences among the plans identified in the evaluation phase including public comment. Differences in the National Economic Development (NED) and National Ecosystem Restoration (NER) benefits produced by the alternatives are assessed. The regional economic development (RED) account impacts were quantified for the alternative plans but not used in the plan comparison/screening.

6. **Select Recommended Integrated Plan (Chapter 14):** A recommended plan was first identified for each of the study's two purposes, Navigation Efficiency and Ecosystem Restoration. The plans were subsequently combined to create the recommended integrated dual-purpose plan.

In the past, navigation efficiency was analyzed as a single purpose and generally studied for a single lock and dam location. The Upper Mississippi River-Illinois Waterway System Navigation Study was the first Corps planning study to consider and analyze an entire inland navigation system. Thus for the first time, the interrelationships, consequences and impacts of proposed actions could be considered for the entire Upper Mississippi inland navigation system.

While a dual-purpose approach is not a completely foreign concept, the geographical scale, systemic approach, 50-year planning horizon, and seemingly conflicting nature of economic, social, and environmental interests posed a unique challenge. Meeting such a challenge required innovation, nontraditional approaches, and a considerable amount of multidisciplinary collaboration. Traditional methodologies didn't always function well in all instances for this systemic, dual-purpose effort over such a large geographic area with all the uncertainties and varying interests involved. For instance, for navigation efficiency, five varying future without project scenarios were developed to cover a wide range of possible future navigation traffic rather than establishing one most likely future condition as is typical for most studies. As Figure 3-1 indicates, the Navigation and Ecosystem components proceeded on similar yet parallel tracks through the first five steps in the planning process. However, several management actions were identified that required consideration under both components (e.g., pool drawdown).

All steps within the study process are iterative, requiring the meticulous acquisition, analysis, and interpretation of a diverse array of new data and historic information. Approximately 140 individual technical reports were generated during the first three steps in the study process (see Chapter 16). These technical reports were an important part of the study documentation and form the basis for much of this document. Documentation is an important aspect of the Corps' study process and it is important that the reader understand that this document represents the culmination of a process that spanned more than a decade and attempts to summarize tens of thousands of pages from very detailed analytical reports covering a wide ranging array of study related topics.

4.0 INVENTORY AND FORECAST RESOURCE CONDITIONS

A comprehensive inventory of resource conditions is critical to understand the physical, economic, social, and ecological consequences of past, current and proposed actions. The forecast is necessary to understand the probable future condition of those resources (i.e., the without-project condition). The inventory and forecast, coupled with an understanding of historic change, are helpful to further define and characterize the problems and opportunities. The existing conditions are those at the time the study is conducted. The forecast of future conditions reflects changes expected to occur during the period of analysis (i.e., 50-years). The predicted future condition provides the basis from which alternative plans are formulated and impacts are assessed .

This chapter discusses navigation infrastructure and ecosystem conditions separately for the convenience of describing the distinct needs for each. It must be understood, however, that the two are distinctly inseparable in their function and impacts. Ecosystems evolved upon the physical and hydrologic template provided by the natural river over millennia, the navigation system was built upon and modified that physical and hydrologic template to benefit the evolution of the region's economic and social development. The impacts of the navigation system on the ecosystem have traditionally not been emphasized because there was little regard for those impacts as the system was built and operated in the early years. After environmental conditions were emphasized as a National priority in the 1970s, consideration for ecosystem impacts became more common in navigation system operation and maintenance activities. Environmental restoration was authorized and navigation system operations were altered to benefit the environment by allowing shallow drawdowns to promote emergent aquatic plants, for example. This study proposes that this evolution of management philosophy be continued and formalized through the establishment of a fully integrated river management plan that coordinates navigation and ecosystem needs.

4.1 Historical Conditions

4.1.1 UMR-IWW Navigation System

The 1930 Rivers and Harbors Act, passed on July 3, 1930, authorized the U.S. Army Corps of Engineers (USACE) to provide for an Upper Mississippi River (UMR) channel depth of 9 feet at low water, "*with widths suitable for long-haul, common carrier service*" (Merritt 1981). In the years between 1930 and 1940, the USACE transformed the once free-flowing Upper Mississippi and Illinois Rivers into a slack-water navigation system. As now completed, the Upper Mississippi River-Illinois Waterway System (UMR-IWW) 9-foot Channel Project consists of a total of 37 lock and dam complexes (UMR = 29 and Illinois Waterway (IWW) = 8) and provides for a reliable commercial transportation route between Minneapolis, Minnesota, Chicago, Illinois, and St. Louis Missouri. Ultimately, it provides a worldwide connection between Midwestern producers and markets and between Midwestern consumers and products.

4.1.1.1 Impoundment and River Regulation

The UMR-IWW System navigation dams transformed the rivers from free flowing, hydrologically variable, and complex channels to a series of navigation pools that create a stairstep from St. Louis to Minneapolis (Figure 4-1) and Chicago (Figure 4-2). The dams impound water to increase the depth of the main channel to 9 feet or greater and can cause substantial changes in the distribution of surface waters. To varying extents, the dams impose a hydrologic zonation in each pool with an impounded region close to the downstream dam that blends into shallow aquatic, marshy habitats at mid-pool, and riverine characteristics in upper pool reaches. A broad, open water impounded area and increased backwater area are most evident in Pools 5 to 13; the other pools do not show substantial increases in water area as a result of impoundment. They all, however, currently lack the low river stages characteristic of the undeveloped river during low flow periods. The UMR-IWW reach south of St. Louis to the Ohio River confluence is regulated only with training structures and therefore does not impound water as noted above.

4.1.1.2 Locks and Dams

Water levels upstream of the dams are regulated to maintain a continuous 9-foot navigation channel. All of the dams on the UMR and IWW are run-of-the-river dams. That is, they are operated to simply pass incoming flows and do not store water for flood control or other purposes. Discharges are controlled by systematically adjusting gates. Peoria and La Grange and Lock 27 are exceptions in that Peoria and La Grange have wicket gate dams and Lock 27 really has no controlling dam since it is in a canal. Each dam is operated to maintain a target water surface elevation at one or more control points within the pool. The procedures for the regulation of the UMR dams are contained in the *Upper Mississippi River - Nine Foot Channel Project, Master Water Control Manual* (USACE 1996c). The procedures for the regulation of the IWW dams are contained in the *Illinois Waterway - Nine Foot Channel, Master Water Control Manual* (USACE 1996b). An analysis of water level management on the Upper Mississippi River System was completed by the Long Term Resource Monitoring Program and is available in Wlosinski and Hill (1995).

Maintenance at locks and dams is performed on a daily basis or at longer intervals for major work. Personnel perform day-to-day maintenance of operating machinery and minor repair work on the facilities. During major maintenance and rehabilitation, lock gates and valves are removed, sandblasted, and repaired, as are dam gates when necessary. Major rehabilitation at Locks and Dams 2 to 22 and the Illinois Waterway was evaluated in a Programmatic Environmental Impact Statement (USACE 1989b).

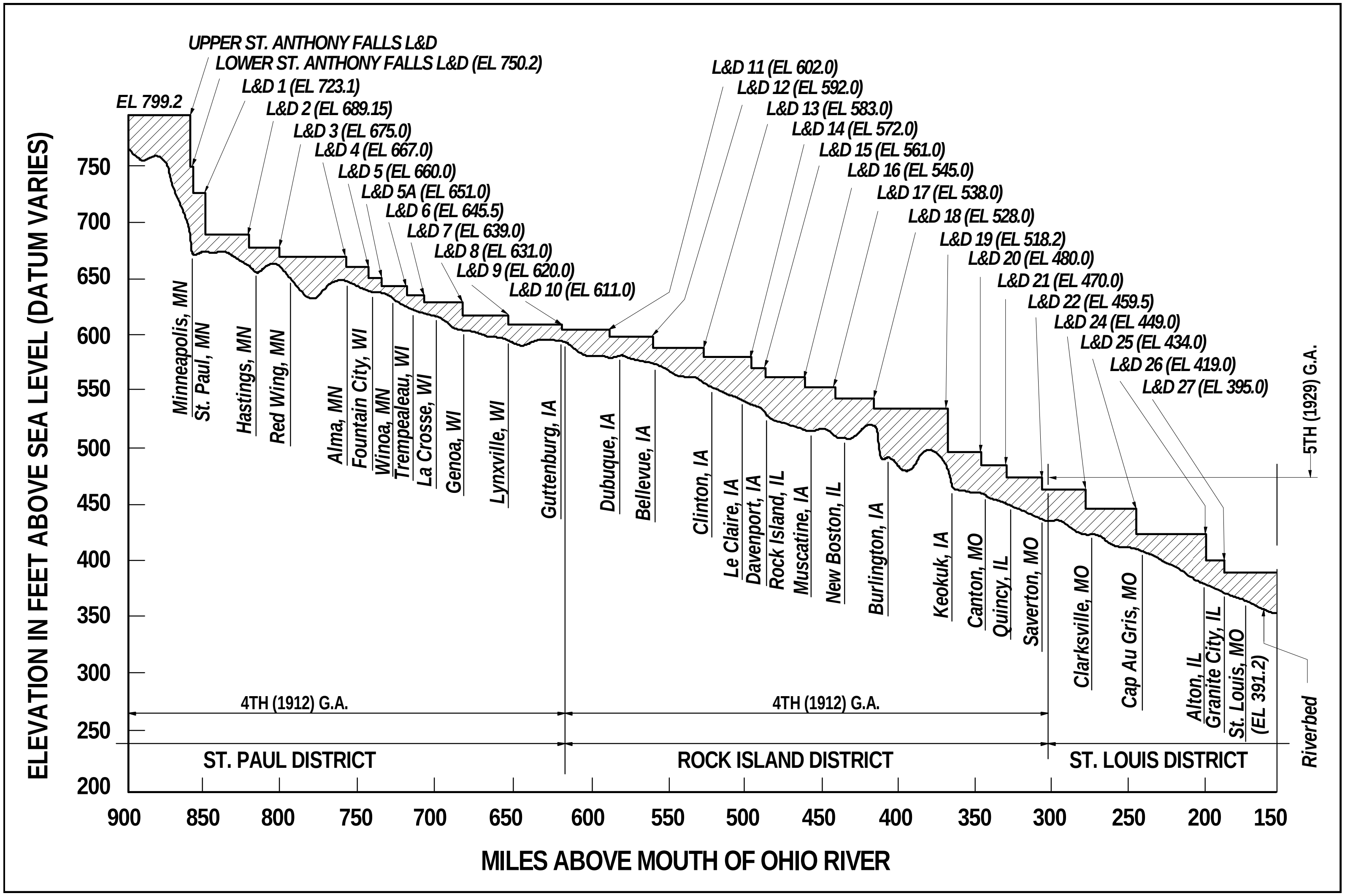


Figure 4-1. A longitudinal profile of the Upper Mississippi River lock and dam system (Courtesy of Dr. Tasuaki Nakato, University of Iowa, Iowa Institute of Hydraulic Research, Muscatine, Iowa).

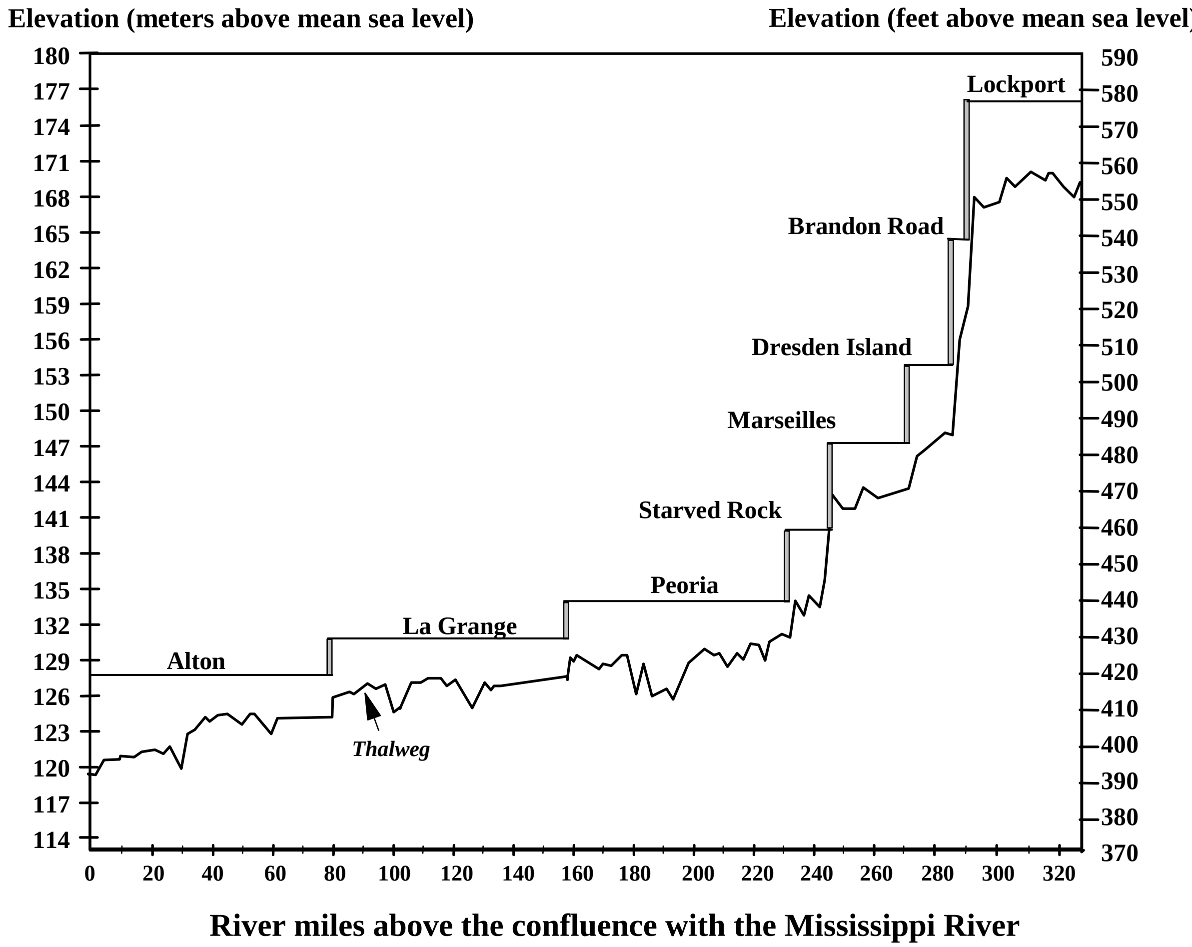


Figure 4-2. A longitudinal profile of the Illinois Waterway lock and dam system.

4.1.1.3 9-foot Channel Maintenance

Periodic dredging is required in order to maintain a 9-foot channel. In required locations, dredging occurs with a hydraulic cutterhead, mechanical, or dustpan dredge. In accordance with the Federal standard, dredged material placement sites are identified that represent the least costly alternative with sound engineering practices and meet environmental standards pursuant to the Clean Water Act. Placement of dredged material has occurred within the thalweg, shoreline, bottomland forests, agricultural fields, and beneficial use sites and for environmental restoration. Where recurrent dredge cuts occur, long-term site plans have been and are being developed. Placement sites are chosen in conjunction with On-Site Inspection Teams (OSITs), public coordination, and various other committees of river managers and biologists.

Dredging practices and policies are variable within the three UMR-IWW Corps Districts. St. Paul District's process and program can be found in its *Channel Maintenance Management Plan* (CMMP) (USACE 1996a) and associated Environmental Impact Statement dated March 20, 1997. Rock Island District's program is found in the *Long Term Management Strategy for Dredged Material Placement, Main Report, Mississippi River* (USACE 1990c) and *Illinois River* (USACE 1995) and associated Dredged Material Management Plans. A detailed description of channel maintenance dredging in the St. Louis District is found in the Environmental Impact Statement (EIS) on operation and maintenance of Pools 24, 25, and 26, Mississippi and Illinois Rivers (USACE 1975b).

Dredged material is generally placed adjacent to the main channel where beneficial uses may occur, such as recreational beach creation and island creation. Approximately 150 sites have been dredged in the past, with between 30 and 50 locations in the District dredged regularly for a total of approximately 8 million cubic yards annually.

4.1.1.4 Historic Commercial Traffic Patterns

Traffic usage and tonnage increased rapidly through the 1970s, but growth rates have flattened since the 1980s (Figure 4-3). Table 4-1 displays the annual system tonnage for the UMR, the IWW, and the Middle Mississippi River (MMR) sections of the UMR-IWW Navigation System. For the 37-year period from 1965 to 2002, traffic has increased by an average annual growth rate of 2.2 percent for the Upper Mississippi River System, an annual rate of growth of 1.2 percent for the Illinois Waterway System, and an annual rate of growth of 3.0 percent for the Middle Mississippi River System. The UMR segment represents the Mississippi River from Minneapolis, MN to the mouth of the Missouri River. Because the confluence of the Mississippi River and the Illinois Waterway is above the confluence of the Mississippi River and the Missouri River, the majority of Illinois Waterway traffic is reflected in the traffic total for the UMR. Table 4-2 displays the total tonnages through each of the locks and dams on the rivers. Traffic is greatest at the downstream end of the navigation system as different regions add or consume commodities in the downstream or upstream direction, respectively. Table 4-3 displays the number of commercial lockages at each lock and dam site. Further data and information concerning historic traffic patterns can be found in Section 2 of the Economic Appendix.

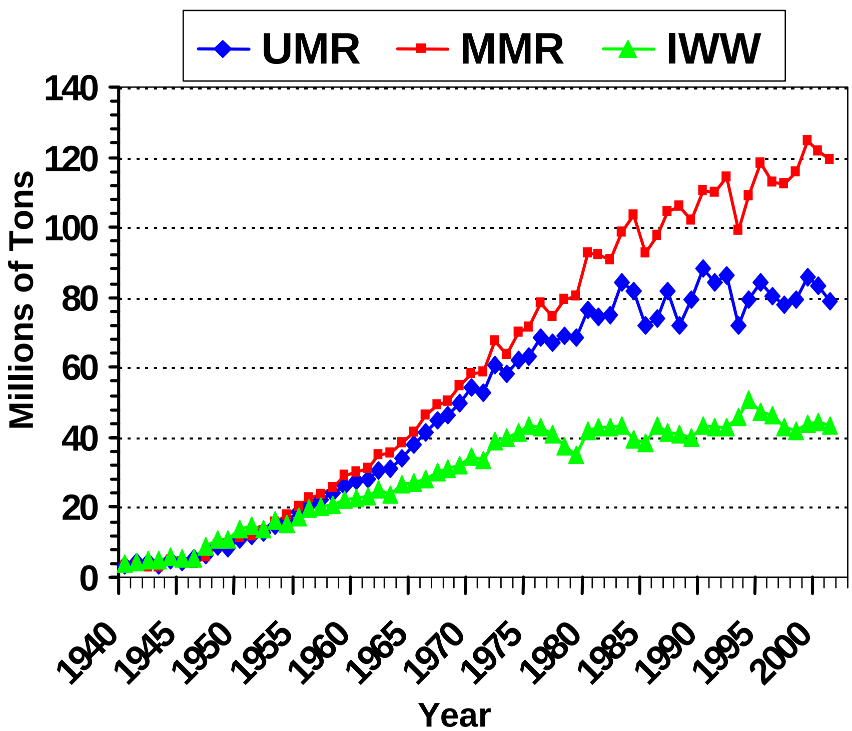


Figure 4-3. Historic commercial barge traffic levels (1965-2002) on the UMR, IWW, and MMR sections of the UMR-IWW Navigation System (Source: Waterborne Commerce Statistics Center).

Table 4-1. Historic commercial barge traffic levels (1965-2002) on the UMR, IWW, and MMR sections of the UMR-IWW Navigation System (Source: Waterborne Commerce Statistics Center).

Annual System Commodity Tonnages
(Millions)

Year	UMR	IWW	MMR
1965	37.8	27.2	41.5
1970	54.0	34.3	58.3
1975	63.1	43.6	71.6
1981	74.5	43.1	92.2
1982	74.7	42.7	90.5
1983	84.4	43.5	98.7
1984	81.8	39.6	103.6
1985	72.0	38.5	92.7
1986	73.7	43.4	97.7
1987	81.6	41.4	104.5
1988	72.0	41.0	106.0
1989	79.4	39.7	101.8
1990	88.4	43.3	110.3
1991	84.1	43.1	110.1
1992	86.2	42.7	114.5
1993	72.2	45.6	99.1
1994	79.4	50.9	108.9
1995	84.4	47.4	118.3
1996	80.4	46.2	113.0
1997	77.8	43.0	112.5
1998	79.6	41.8	115.8
1999	85.7	43.7	124.7
2000	83.3	44.2	121.6
2001	78.8	43.5	119.1
2002	84.1	43.0	--

Table 4-2. Historic commercial barge traffic levels (1990-2001) by lock for the UMR-IWW Navigation System (Source: Waterborne Commerce Statistics Center).

Traffic by Lock (millions of tons)

Upper Mississippi River (UMR												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
USA	1.21	1.53	1.90	1.42	1.64	1.72	1.76	1.91	2.01	2.06	2.24	1.83
LSA	1.54	1.51	1.94	1.39	1.67	1.75	1.76	1.91	2.00	2.07	2.24	1.81
1	1.52	1.59	1.94	1.42	1.65	1.72	1.77	1.91	1.98	2.07	2.25	1.83
2	14.23	11.85	12.72	7.68	9.54	9.42	10.61	9.84	10.89	11.54	10.84	8.58
3	14.10	12.09	12.92	7.71	9.60	9.54	10.58	9.80	10.88	11.55	10.87	8.58
4	14.72	12.53	13.49	8.11	10.20	10.51	11.42	10.57	11.73	12.34	11.80	9.36
5	14.73	12.76	13.71	8.30	10.58	10.69	11.80	10.98	12.05	12.77	12.05	9.49
5a	14.87	12.59	13.53	8.36	10.60	10.68	11.60	10.85	12.03	12.76	12.13	9.50
6	16.99	14.84	15.58	9.50	11.99	13.19	14.30	13.38	14.59	15.79	14.88	11.96
7	16.98	14.91	14.73	9.26	12.02	13.17	14.36	13.50	14.58	15.86	14.81	12.00
8	17.52	15.19	16.79	9.98	12.46	13.79	15.19	14.29	15.41	16.83	15.88	12.79
9	18.27	16.23	17.68	11.12	13.74	15.45	16.61	15.69	17.39	18.82	17.74	14.57
10	20.92	19.14	20.17	12.67	15.34	18.54	19.26	18.10	19.74	22.01	19.91	16.53
11	20.44	18.77	20.64	13.20	16.15	19.30	19.71	18.61	20.32	22.50	20.76	17.34
12	24.70	22.05	24.30	14.34	17.12	21.21	22.20	20.23	21.60	24.43	22.28	19.10
13	25.35	22.67	24.72	14.70	17.47	21.65	22.52	20.49	21.87	24.80	22.75	19.28
14	31.63	27.84	30.00	18.37	21.98	27.30	27.94	25.30	27.28	30.84	28.35	24.27
15	31.94	28.47	30.41	18.72	22.29	27.86	28.27	25.56	27.44	31.21	28.75	24.71
16	34.05	29.81	31.62	19.55	23.46	29.62	29.98	27.20	28.89	33.14	30.58	26.45
17	37.30	31.91	33.28	20.55	24.51	30.54	31.01	27.92	30.02	34.17	31.38	27.45
18	37.73	32.70	33.94	21.24	25.17	31.53	31.84	28.79	31.23	35.71	32.86	28.57
19	39.15	34.41	35.98	22.79	26.71	33.22	32.35	29.62	31.08	35.80	34.10	30.13
20	39.79	35.06	36.61	23.35	27.44	34.31	33.15	30.35	31.75	36.51	35.02	31.11
21	40.85	36.13	37.84	24.76	28.78	35.35	34.49	31.91	33.31	37.86	36.45	32.87
22	41.35	36.55	38.29	25.21	29.41	36.05	34.83	32.30	33.65	38.07	36.81	33.34
24	42.35	37.34	39.42	26.58	30.74	37.54	36.18	33.61	34.75	39.30	38.70	34.79
25	42.34	37.50	39.38	26.56	30.76	37.43	36.09	33.64	34.82	39.54	39.15	34.86
Mel Price (26)	80.45	73.90	74.67	62.34	71.19	78.42	73.88	70.85	73.69	77.58	77.11	75.94
27	85.37	80.64	81.46	67.80	77.32	84.43	79.49	77.17	80.75	83.38	82.63	81.09
Illinois Waterway (IWW)												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
LaGrange	36.03	33.89	33.15	33.34	38.35	38.95	35.42	34.85	36.10	35.60	35.17	36.75
Peoria	32.87	30.98	30.99	31.78	35.45	33.91	31.23	30.75	32.58	31.13	31.75	33.67
Starved Rock	23.71	22.41	22.80	23.26	26.33	22.13	20.74	21.11	23.00	21.38	22.34	23.30
Marseilles	21.50	20.62	20.70	21.18	23.97	19.12	18.37	18.88	21.00	19.16	20.22	20.89
Dresden Island	19.65	19.05	19.13	19.37	22.14	16.88	16.65	16.78	19.04	17.75	18.84	18.88
Brandon Road	17.50	16.89	16.75	17.08	20.04	15.11	15.09	15.54	17.26	16.07	16.93	16.42
Lockport	17.37	16.68	16.67	17.04	19.70	14.99	14.87	15.41	17.10	16.04	16.79	15.99
T.J. O'Brien	7.74	7.90	7.76	8.69	13.29	12.00	12.85	10.47	8.86	7.37	8.44	6.78

Table 4-3. Number of Commercial Lockages (1990-2001) at each lock and dam site in the UMR-IWW Navigation System.

Number of Commercial Vessels Locked (1990-2001)

Upper Mississippi River (UMR)												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
USA	2,083	2,021	2,206	1,863	1,951	1,936	1,967	2,025	2,127	2,044	2,350	2,035
LSA	1,381	1,265	1,453	1,084	1,327	1,308	1,348	1,450	1,526	1,522	1,730	1,483
1	1,263	1,152	1,351	968	1,133	1,102	1,149	1,163	1,214	1,280	1,377	1,172
2	1,619	1,358	1,291	814	972	1,096	1,166	1,090	1,222	1,228	1,172	813
3	1,647	1,355	1,291	800	946	1,269	1,282	1,126	1,212	1,283	1,281	863
4	1,610	1,360	1,281	799	955	1,091	1,176	1,103	1,239	1,253	1,200	846
5	1,590	1,351	1,266	814	993	1,120	1,195	1,139	1,263	1,266	1,206	855
5A	1,649	1,362	1,265	817	997	1,349	1,306	1,169	1,266	1,268	1,208	858
6	1,672	1,468	1,484	903	1,074	1,305	1,385	1,311	1,427	1,532	1,416	1,056
7	1,732	1,495	1,431	883	1,090	1,319	1,407	1,361	1,467	1,585	1,448	1,172
8	1,694	1,473	1,551	933	1,085	1,388	1,420	1,336	1,452	1,548	1,440	1,065
9	1,630	1,448	1,550	1,001	1,134	1,515	1,493	1,435	1,576	1,646	1,517	1,155
10	2,089	1,882	1,865	1,196	1,346	1,799	1,778	1,658	1,807	1,994	1,818	1,331
11	2,148	1,945	1,966	1,397	1,585	1,986	2,011	1,869	2,025	2,194	2,019	1,535
12	2,828	2,562	2,487	1,509	1,578	2,132	2,153	1,939	2,082	2,292	2,119	1,708
13	2,910	2,739	2,556	1,590	1,667	2,203	2,207	2,009	2,147	2,337	2,137	1,712
14 (Main)	3,448	3,103	3,113	2,043	2,271	2,922	2,970	2,720	2,859	3,197	2,949	2,323
14 (Auxiliary	0	11	0	0	4	3	2	4	0	0	1	0
15 (Main)	3,128	3,059	2,868	2,154	2,531	2,810	2,819	2,535	2,632	2,918	2,849	2,414
15 (Auxiliary)	632	811	630	289	220	759	835	797	838	891	774	568
16	3,403	3,360	3,171	2,222	2,381	3,088	3,092	2,826	2,893	3,177	2,930	2,469
17	3,277	3,004	2,985	1,849	2,021	2,762	2,774	2,495	2,607	2,975	2,752	2,307
18	3,327	3,038	3,038	1,917	2,051	2,827	2,820	2,552	2,647	3,033	2,812	2,397
19	3,377	3,266	3,240	2,030	2,118	2,875	2,861	2,556	2,579	2,990	2,753	2,374
20	3,424	3,225	3,338	2,150	2,353	3,208	3,006	2,675	2,658	3,056	2,824	2,481
21	3,624	3,335	3,378	2,297	2,471	3,130	3,109	2,792	2,798	3,176	2,918	2,639
22	3,646	3,300	3,340	2,283	2,457	3,146	3,071	2,683	2,685	3,079	2,875	2,621
24	3,790	3,446	3,486	2,454	2,592	3,235	3,115	2,727	2,706	3,088	2,999	2,711
25	3,809	3,452	3,482	2,451	2,616	3,230	3,114	2,727	2,703	3,100	3,063	2,807
Mel Price (26) Main	7,905	7,435	7,498	6,065	6,412	5,005	5,832	5,314	5,755	5,263	5,021	4,507
Mel Price (26) (Aux)	152				169	2,002	1,015	1,020	487	1,387	1,450	2,173
27 (Main)	7,101	7,516	7,119	7,450	6,950	7,531	6,118	6,108	6,452	6,778	6,440	6,718
27 (Aux)	3,004	1,911	2,064	156	1,102	834	1,875	1,277	1,062	1,041	1,232	1,032
Illinois Waterway (IWW)												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
LaGrange	3,526	3,301	3,335	3,181	3,518	3,473	3,284	3,132	3,064	3,123	3,157	3,496
Peoria	3,805	3,603	3,660	3,799	4,175	3,874	3,508	3,281	3,291	3,317	3,367	3,783
Starved Rock	3,104	2,809	2,924	3,083	3,255	2,928	2,729	2,715	2,679	2,684	2,636	2,844
Marseilles	2,918	2,706	2,780	2,826	2,979	2,380	2,459	2,417	2,462	2,547	2,503	2,612
Dresden Road	3,013	2,772	2,754	2,815	3,060	2,327	2,462	2,469	2,576	2,777	2,687	2,723
Brandon Road	3,419	3,145	3,152	3,056	3,295	2,365	2,776	2,765	2,773	2,932	2,898	2,794
Lockport	3,453	3,104	3,129	3,057	3,200	2,359	2,713	2,767	2,780	2,954	2,872	2,782
T.J. O'Brien	2,623	2,750	2,801	2,804	3,787	3,351	3,759	3,168	2,540	2,547	2,292	2,044

4.1.2 UMRS Ecosystem

Prior to widespread European settlement of the region, the UMRS ecosystem once supported a diverse landscape of tallgrass prairie, wetlands, savannas, and forests. Logging, agriculture, and urban development over the past 150 years have resulted in the present landscape that is more than 80 percent developed. Millions of acres of wetland drainage, thousands of miles of field tiles, road ditches, channelized streams, and urban storm water sewers accelerated runoff to the main stem rivers. The modern hydrologic regime is highly modified, with increased frequency and amplitude of changes in river discharge. Dams, reservoirs, and river regulation throughout the basin also modify river flows. The modern basin landscape delivers large amounts of sediment, nutrients, and contaminants to the river. Since impoundment, sediment accumulation and littoral (i.e., wind and wave) processes in the navigation pools have greatly altered aquatic habitats.

The historic UMRS ecosystem exhibited natural gradients in habitat among river reaches. Northern river reaches were more forested and were composed of mixed silver maple forests, river channels, seasonally flooded backwaters, floodplain lakes, marsh, and prairie. Beginning around the northern Iowa border and along the lower Illinois River, grasslands and oak savanna dominated floodplain plant communities. Historic surveys reveal a higher proportion of oaks and other mast trees in the forest community than at present. Below the Kaskaskia River, the floodplain was heavily forested with species characteristic of southern bottomland hardwood communities including bald cypress, nuttal, and cherry bark oak. Impacts of river floodplain development include forest loss and water gain in northern reaches, and grassland and forest losses in the rest of the UMRS.

European settlement in the Upper Midwest region brought many changes to the landscape and waterways. The rivers provided efficient transportation and were the focal point of commerce and colonization. The spread of the population upstream along the Illinois River is well documented. As the Midwest economy and population grew, so did the demand for water transport. The U.S. Government became involved in Mississippi River navigation in 1824 when the Army Corps of Engineers was tasked with removing logs and other obstructions from the river channels to ease constraints on steamboat travel which was very hazardous. The following provides a brief description of direct, indirect, and cumulative effects that have influenced the historic transition of the UMRS ecosystem:

4.1.2.1 Impoundment and River Regulation

The effects of the impoundment to support commercial navigation were perceived as ecologically beneficial for many years after the dams were completed. In many areas north of Clinton, Iowa, aquatic habitat was expanded across low elevation floodplain areas, resulting in large increases in the amount of open water area. The effect of water diversions from Lake Michigan down the Illinois River in the late 1800s was very similar, and the dams at Peoria and La Grange did little to increase the stage; rather, they fixed the high stage, preventing low flow drying and sediment compaction. In areas south of Clinton, there was relatively little change in the amount of open water area, but the low flow river stage was raised and fixed to support commercial navigation. New aquatic habitats were quickly colonized by fish and aquatic plants, resulting in a dramatic boon of river productivity. These high quality habitats remain intact in many of the northern pools, but they have been severely degraded in southern pools where sediment accumulates. Upstream reaches of most pools experience relatively natural water level variation, and the middle and lower pool portions of dams using “hinge point” operation (especially Pools 24 through 26) are periodically exposed, allowing consolidation of exposed soils during drawdown.

The term “pool aging” is a generic term for the numerous changes that occurred in the pooled UMR-IWW reaches over the last 60 years. Sediments from upland sources and eroding islands and riverbanks have filled many deepwater areas. Wind generated waves in the large open water habitats created by the dams have eroded plant beds and limited submersed aquatic plant production because they resuspend sediment and reduce light penetration through the water. Sediment quality is also degraded because the dams have essentially eliminated the low flow river stage and thus do not allow backwater sediments to be exposed as they would be in an unregulated river. Sediments retain a high moisture content and are unconsolidated because they are never exposed, which increases sediment resuspension and reduces water quality.

The navigation dams affect fish movement by blocking fish movements through the dam, since most species can pass only during high flow periods when the dam gates are out of the river. Some dams present more complete barriers than others (see connectivity discussion, Section 4.2.2.5).

4.1.2.2 Commercial Navigation Effects

Commercial navigation has had significant impacts on the river's ecosystem prior to impoundment by the dams. Notable changes occurred with the advent of the steamboats. Beyond their impact on the channel environment, steamboats created a huge demand for fuel wood. Large forest tracts were cleared to feed the demand for fuel. High-grading, where select hardwoods were sought, was common initially, but eventually entire forests were cleared. Where large tracts were cleared, agriculture typically followed in the clearings and prevented forest regeneration. Where regeneration did occur, it was typically from light seeded species such as elm, maple, and cottonwood. The hard mast communities never really recovered. The abundance of timber was reduced by 20 to 60 percent of the floodplain area during the steamboat era (1820-1920s).

Modern studies have provided increased insight into the direct and indirect effects of navigation traffic on the UMRS ecosystem. The physical effects of towboat drawdown, entrainment, and sediment resuspension have direct and significant impacts on fish, plants, and side channel/backwater habitats (see Chapter 8). Shoreline areas that are subject to towboat drawdowns and wake waves cannot support vegetation and inshore invertebrates. Fish populations can potentially be affected by propeller entrainment of larval fish. A larval fish entrainment model (Bartell and Campbell 2000, ENV 16) estimated that approximately 150,000 equivalent adult fish were lost per year from impacts on early fish life stages over the project area (of the 25 species of most interest on the UMR-IWW). Waves created by towboats can break aquatic plant stems and reduce plant growth by resuspending sediment, limiting light penetration, and inhibiting photosynthesis. Sediments resuspended by recreational and commercial boat traffic can be carried into sensitive backwaters and side channels, causing additional sedimentation. These areas are critical elements of large river ecosystems. Impacts of towboats operating in the main channel on freshwater mussels were investigated, but the effects were minimal. However, as explained below, towboat operation in channel border areas may affect mussels. The incremental impacts of increased traffic resulting from increased lockage capacity on fish, vegetation, side channels, and backwaters are addressed as part of the mitigation plan.

4.1.2.3 Fleeting

The environmental effects of fleeting have not been comprehensively assessed, but there are some well known impacts that raise concern. Tying barges off to trees can cause many forms of damage, from directly knocking the trees down to stripping bark and making them more susceptible to pests or disease. There is also the factor of barges scraping the bottom of the river in shallow channel border areas. This is where freshwater mussels and other benthic fauna may be affected by direct contact or prop wash. There are hydraulic and propeller strike impacts in fleeting areas from the frequent movement of towboats dropping off and picking up barges. Finally, there are aesthetic impacts where large numbers of rusting barges degrade the view from riverfront towns or natural areas.

4.1.2.4 Water Quality

Development in the UMRS and associated uplands had tremendous effects on water quality for several reasons. First, large human populations needed to dispose of their sewage, and the easiest disposal was to pipe sewage to the rivers. This was especially problematic downstream from large cities. Large fish kills and mussel die-offs were documented below Minneapolis, Minnesota, the Quad Cities, Illinois and Iowa, and St. Louis, Missouri. The most extreme example is the case of the Illinois River where the flow of the Chicago River was reversed through a series of canals and rivers to shunt pollution away from the city's water supply, Lake Michigan. The migration of the pollution downstream was slow, but steady, and the decline of aquatic communities was documented. At one point, the river was so degraded that most native plants and animals were eradicated for more than 100 miles downstream of Chicago. The Diversion, as it is known, also increased water levels throughout the river, causing significant changes to the distribution and character of floodplain lakes and channels.

Development throughout the UMR basin also caused significant changes to water quality. Deforestation, plowing the prairies, and urban development all disturbed native land cover and soil, which in turn released huge quantities of sediment and nutrients through the stream network. Sedimentation and excessive nutrient and pesticide runoff continue today as some of the most critical ecological impacts in the main stem rivers and Delta. Much of the sediment transported to the main stem rivers is mobilized from stream beds and banks where it is either latent deposits from earlier land use practices or deposits from active erosion. There are estimates that latent sediments may take 100 or more years to flush through the system once erosion rates are controlled. Storm waters carry an array of pesticides, fertilizers, oils, solvents, detergents, debris, and other contaminants emanating from rural and urban landscapes.

4.1.2.5 Agricultural Industrialization

Following World War II, there were significant changes in farming practices basin-wide. Not many entirely new farming practices were introduced; rather, the equipment, farms, and use of chemicals, and emphasis on monocultures all became bigger. Many of the problems with erosion and mass wasting in hilly landscapes were solved with the incorporation of terraces, grassed buffer strips, more densely planted crops, no till crop management, etc., under the guidance of the Soil Conservation Service (currently the Natural Resources Conservation Service). Many more problems were introduced or intensified, though. Waterway ditching and field tiling increased the magnitude and timing of storm runoff and drained prairie wetlands. Storm water is now transported to the main stem rivers at a rapid rate that is noticeably more erratic or flashy. In the river floodplain, agriculture accounts for about 50 percent of the entire floodplain area.

4.1.2.6 Exotic Species

Several prominent species introduced during the last decade have been exerting great pressure on environmental and economic components of the UMRS. Zebra mussels introduced to the Great Lakes spread rapidly through the UMRS. They have affected industrial water users whose pipes needed to be cleaned and monitored for encrustation. They also affected freshwater mussels where they colonized the shells in thick mats by competing for food and polluting the native mussels in their waste. Zebra mussel transport upstream in the UMR from the IWW was aided by the transport of adult zebra mussels on barges. Common carp introduced in the 1800s are currently among the most abundant fish species in the river. Asian carp introduced in the 1990s are dispersing rapidly upstream. Their potential competition with native species could be great based on food requirements, but the impacts have not been quantified. Some notable plant introductions are purple loosestrife in wetlands and a European variant of common reed. A fungus known as Dutch elm disease has also had a tremendous impact on the American Elm tree.

4.1.2.7 Environmental Improvements

Recognition of health and safety risks of pollution and habitat impacts of poor land use prompted significant environmental regulations and conservation incentive programs since the 1970s. Improvements in water quality and upland habitat have been significant, with most surface waters now in compliance with established standards. The degraded zones below cities discussed earlier have all demonstrated improvements in water quality and the recurrence of sensitive species like freshwater mussel and mayflies. Mass emergences of mayflies are once again blanketing riverbanks and riparian areas; snowplows are sometimes needed to clear bridges.

There is a long and complicated history of land use in the Midwest, but some examples of erosion in the early 1900s are quite extreme. There were massive efforts of the Works Progress Administration and the Civilian Conservation Corps in the 1930s to curb the extensive erosion problem throughout the Upper Midwest. Thousands of dry dams and ponds were constructed. Improved land use through the century has substantially controlled erosion and sedimentation in streams, but there still are problems and needs to restore degraded areas. Marginal lands that were set aside and planted to wildlife cover have been beneficial for terrestrial species.

Effective habitat protection, management, and restoration have been critical elements in maintaining high quality river-floodplain habitats in the UMRS. Habitat quality and quantity are directly related to the abundance of public land, so the Upper Impounded Reach (Pools 1 to 13) has greater potential under existing conditions. Natural resource managers in the reach have considerable experience with harvest and land management; they have more recently incorporated small- and large-scale habitat restoration. Large-scale water level management is an emerging tool for cost effective land management. Other UMRS reaches have more limited opportunities because of geomorphic and hydrologic conditions, as well as a lack of public land. Restoration on existing parcels has demonstrated the effectiveness of habitat management measures. Restoration on new land acquisitions is demonstrating that natural regeneration of wetlands is possible if naturalistic hydrologic patterns can be recreated.

Recent experience clearly demonstrates the restorative capabilities of rivers like the Mississippi and Illinois and the positive return on investments in environmental restoration. This experience is used later to help predict the benefits and outcomes of restoration measures proposed in the environmental alternative plans.

4.2 Existing Conditions

4.2.1 UMR-IWW Navigation System

The existing UMR-IWW Navigation System provides considerable transportation cost savings to the Nation. Measured as the transportation rate differential between an all-land routing versus water, the existing system generates an estimated $0.8 billion to $1.2 billion (2001 prices) of annual transportation cost savings (using Year 2000 traffic levels). These benefits compare with the average annual operation and maintenance costs of approximately $115 million per year. The Upper Mississippi River currently has 29 lock sites (consisting of 35 locks since some have two locks) while the Illinois Waterway has 8 lock sites (all with a single lock chamber). Much of the UMR-IWW lock and dam system was in place by the 1940s (Table 4-4). Only three of the existing 43 lock chambers are 1,200 feet in length, (e.g. Locks at 19, 26, and 27). The vast majority of the existing locks are 600 feet or less. This is problematic since modern tow configurations commonly (roughly 75 percent at Locks 20 through 25) include 15 barges and approach 1,100 feet in total length. As a result, the longer tows must lock through using a time-consuming two-step process in which the first three rows of barges (9 total) are locked through separately, and then the last two rows of barges (6 total) and the towboat are locked through second. The entire average processing time takes over 1.5 hours. The duration of this “double-lockage” process is highly variable since many steps are required and each is subject to mishaps, weather conditions, crew inefficiencies, etc. Also, the approaches to and exits from the locks are sometimes difficult due to high flow conditions, which lengthen the lock processing time. Small craft that require only a single lockage process through 600-foot and 1,200-foot locks in about 30 minutes. In contrast, Lock 19 has a 1,200-foot lock, and Melvin Price Locks and Dam (Lock 26 replacement) and Locks 27 both have a 1,200-foot and a 600-foot chamber at each site. The combined average lock process time for the longer tows and smaller tows is about 1.0 hour at Lock 19 and about 0.6 hour at Locks 26 and 27. Physical data on the locks including the location, year opened, and other physical characteristics are listed in Table 4-4. This table also provides a listing of lock utilization data from 2002. Utilization reflects the total time a lock chamber is in use divided by the total time the chamber is available for use during the navigation season.

4.2.1.1 Lock Capacity

In 2001, locked tonnage ranged from 24 to 35 million tons at UMR Locks 14 to 25, with tonnage increasing at downstream locks (Figure 4-4). Upstream from Lock 14, locked tonnage continues to taper off to a volume of 8 million tons at Lock 2. Above Lock 2, locked tonnage is 2 million tons or less. On the IWW, La Grange and Peoria processed (not all tonnage is locked due to intermittent open-pass conditions) tonnage in 2001 was 37 million and 34 million tons, respectively. Upstream of Peoria, locked tonnage on the IWW tapered off to 7 million tons at Thomas J. O'Brien Lock. Estimates of lock capacity are roughly 45 to 55 million tons at facilities with a single 110-foot by 600-foot chamber. The capacity at Peoria and La Grange is estimated to be larger due to year-round navigation at these sites and open-pass conditions during roughly 40 percent of the navigation season. There is generally no winter closure period on the IWW; therefore, traffic levels are more consistent throughout the year, with peak periods actually occurring during the December-February period when the UMR is largely closed due to ice formation.

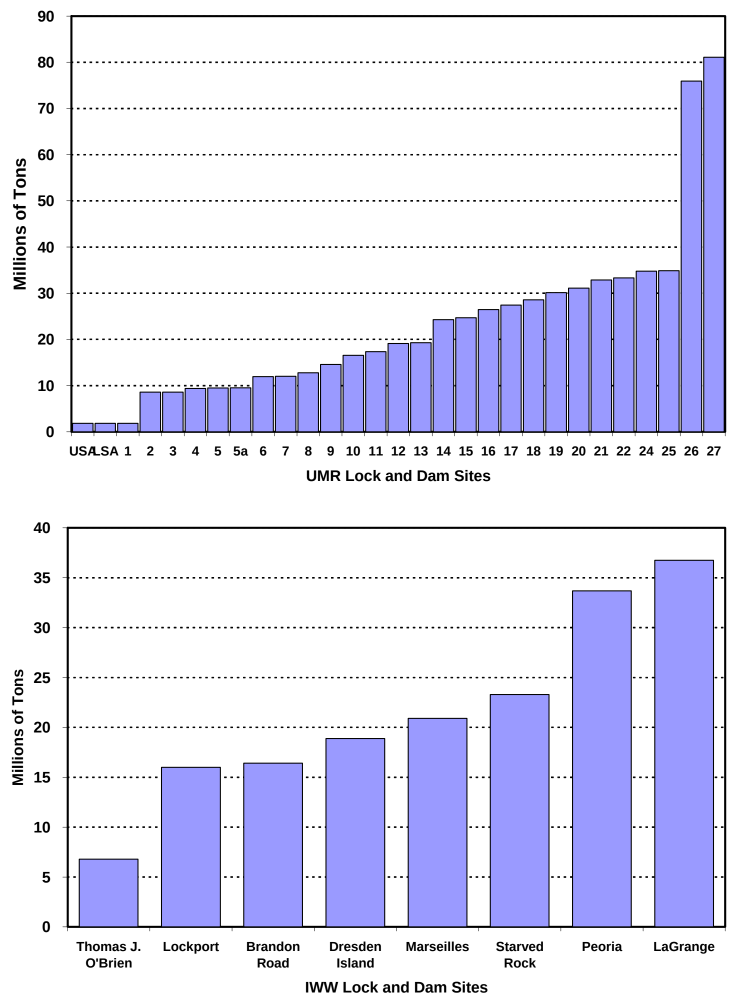


Figure 4-4. Tonnage of commodities passing through locks on the UMR and IWW during 2001 (Source: USACE Lock Performance Monitoring System).

4.2.1.2 Major Rehabilitation Program

Major rehabilitations have been conducted over approximately the last 20 years (Table 4-4) at most all the projects to repair/replace degraded electrical systems, unreliable machinery, deteriorated lock walls, lock gates, etc. The purpose of the rehabilitation projects was to restore performance or to ensure reliable performance and avoid the consequences of lengthy closures or slowed lock performance. The base performance of a lock, as reflected in the Lock Performance Monitoring System (LPMS) data, includes the occurrence of the rehabilitations. The LPMS data for the system was used to model the performance of the system for the existing conditions as well as being extrapolated into the future for the without-project condition. The historical occurrences of Major Rehabilitations and their effect on performance [in the LPMS database] necessarily make them part of the existing condition. The last several Major Rehabilitation projects underwent rigorous risk analysis and economic analysis to prove their justification. It is reasonable to extrapolate the need for major rehabilitations into the without-project future since they are a vital part of restoring/maintaining the projects' functions and performances.

Table 4-4. Physical characteristics of locks on the UMR and IWW.

Lock	River Mile	Year Opened	Length (Feet)	Width (Feet)	Lift (Feet)	2002 Utilization (%)	Major Rehab. Complete[1]
Upper Mississippi River							
USA	853.9	1963	400	56	49	15	2002
LSA	853.3	1959	400	56	25	16	1983
1 (Main)	847.6	1930	400	56	38	17	2003
1 (Auxiliary)	847.6	1932	400	56	38	0	
2 (Main)	815.0	1930	500	110	12	36	2003
2 (Auxiliary)	815.0	1948	600	110	12	n.a.	
3	796.9	1938	600	110	8	39	2003
4	752.8	1935	600	110	7	35	2003
5	738.1	1935	600	110	9	32	2002
5a	728.5	1936	600	110	5	33	2002
6	714.0	1936	600	110	6	38	2002
7	702.0	1937	600	110	8	40	2005
8	679.0	1937	600	110	11	40	2002
9	647.0	1938	600	110	9	41	2004
10	615.0	1936	600	110	8	44	2005
11	583.0	1937	600	110	11	51	2005
12	556.0	1938	600	110	9	52	2004
13	523.0	1938	600	110	11	50	1997
14 (Main)	493.0	1939	600	110	11	69	2000
14 (Auxiliary)	493.0	1922	320	80	11	7	
15 (Main)	482.9	1934	600	110	16	71	1996
15 (Auxiliary)	482.9	1934	360	110	16	14	
16	457.2	1937	600	110	9	68	1994
17	437.1	1939	600	110	8	74	1993
18	410.5	1937	600	110	10	71	1993
19	364.2	1957	1200	110	38	56	2008
20	343.2	1936	600	110	10	73	1994
21	324.9	1938	600	110	10	76	1990
22	301.2	1938	600	110	10	82	1990
24	273.4	1940	600	110	15	85	2007
25	241.4	1939	600	110	15	80	2001
Mel Price (26) (Main)	200.8	1990	1200	110	24	61	New lock
Mel Price (26) (Aux.)	200.8	1994	600	110	24	16	New lock
27 (Main)	185.5	1953	1200	110	21	68	2008
27 (Auxiliary)	185.5	1953	600	110	21	14	
Illinois Waterway							
LaGrange	80.2	1939	600	110	10	41	1991
Peoria	157.7	1938	600	110	11	40	1991
Starved Rock	231.0	1933	600	110	19	56	1984
Marseilles	244.6	1933	600	110	24	60	1996
Dresden Island	271.5	1933	600	110	22	51	1996
Brandon Road	286.0	1933	600	110	34	57	1996
Lockport	291.1	1933	600	110	40	58	1996
T.J. O'Brien	326.5	1960	1000	110	4	34	2008

[1] The dates indicate that almost every project has had some form of major repair. Such efforts have been required to restore reliability or reduce the risk of significant economic consequences associated with failure of repaired items. The dates listed are the end of the last Major Rehabilitation/Major Maintenance Activity at the Project. There generally were several contracts spanning many years. Future completion dates are estimated based on completed funding authorization documents, such as for Lock 27. Some projects have had two cycles of rehabilitation or are approaching the need for their second cycle, such as for La Grange presently in the planning stages for a stand-alone Major Rehabilitation report.

NOTE: The computation of the percent utilization for La Grange and Peoria is influenced by the amount of time the navigable pass is open, which is approximately 43 percent and 35 percent, respectively, on an average-annual basis.

4.2.1.3 Recreational Craft Lockages

In addition to the large volumes of commercial traffic that move over the UMR-IWW Navigation System, recreational vessel traffic is also a significant component of total system traffic. Table 4-5 describes the number of recreational vessels that passed through the locks on the UMR-IWW Navigation System for the period 1990-2001. Table 4-6 displays the number of recreation vessel lockages. Very few lock sites have auxiliary lock chambers that can be used for locking recreational craft, which minimizes the disruption to commercial traffic. The existing regulations for recreational craft lockage state that recreational craft will not be required to wait for lock turn for more than three commercial lockages. In many cases, recreational craft are locked between every commercial lockage. While recreational craft lockages typically take a relatively short time (approximately 15 minutes at UMR sites and 20 minutes at IWW sites) and recreational craft can use the chamber when it is being turned back, they have impacts when there is only one lock at a project. Several recreation craft can occupy the chamber during a lockage. Most recreation craft lockages occur during the months of better weather, such as May through October. Lockages peak on weekends and major holidays.

Table 4-5. Number of recreational craft locked (1990-2001).

Upper Mississippi River (UMR												
Lock	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
USA	4,671	3,407	3,355	1,455	2,874	2,595	2,503	2,402	2,607	2,351	2,514	1,434
LSA	4,615	3,362	3,165	1,392	2,786	2,547	2,396	2,288	2,452	2,355	2,408	1,387
1	6,733	6,423	5,795	2,662	5,706	5,056	4,656	5,447	6,988	6,465	6,656	4,265
2	12,211	10,332	10,665	6,460	11,988	11,784	11,476	10,396	12,541	11,766	11,442	8,793
3	17,798	17,913	17,857	10,397	20,211	19,924	19,392	17,282	20,171	19,561	18,496	15,245
4	12,127	13,630	13,352	7,115	14,576	15,168	13,253	13,231	12,894	12,942	12,616	10,754
5	8,651	9,654	9,584	5,315	9,914	10,108	9,817	9,624	9,128	9,118	8,869	7,611
5a	10,679	10,102	9,704	4,953	10,000	10,005	8,867	11,474	11,197	11,300	10,133	8,800
6	10,236	12,334	12,604	6,649	11,859	12,101	13,230	11,206	11,538	10,201	8,037	7,059
7	12,577	12,551	11,310	6,685	12,381	13,441	11,107	12,686	12,530	12,049	9,612	10,616
8	7,616	7,015	8,437	4,159	9,281	8,680	7,724	9,281	9,582	9,625	8,424	6,486
9	7,023	6,509	6,658	2,429	6,285	6,123	5,564	6,649	7,213	6,839	5,776	5,021
10	6,047	5,489	6,688	2,131	5,656	4,811	4,444	6,333	7,770	6,951	6,031	4,951
11	7,194	6,720	6,727	3,001	6,859	6,639	5,624	6,519	7,020	6,762	5,815	4,521
12	4,487	4,742	4,796	1,910	5,330	4,960	4,839	5,495	5,711	4,923	3,951	3,493
13	4,836	4,670	4,158	1,780	3,982	4,271	3,616	3,902	4,784	4,009	3,216	2,937
14 (Main)	1,290	1,411	1,309	874	1,790	1,403	1,155	1,761	2,007	1,569	1,696	1,038
14 (Auxiliary)	5,561	7,579	7,720	3,460	8,831	8,958	6,772	6,225	6,754	6,752	5,029	4,542
15 (Main)	142	140	53	434	1,032	218	185	144	173	86	138	691
15 (Auxiliary)	5,826	6,606	6,074	2,474	6,275	7,712	6,263	7,527	9,689	8,894	6,420	3,904
16	1,398	1,484	1,414	516	1,263	1,710	1,400	1,673	1,982	2,565	1,842	961
17	811	1,063	968	216	1,418	1,349	1,029	1,176	1,128	1,130	641	532
18	1,592	1,561	1,942	335	2,970	2,144	1,688	2,328	2,483	2,147	1,456	1,071
19	1,385	1,571	1,349	230	1,059	953	1,010	1,300	1,131	1,088	858	801
20	831	1,110	1,065	303	1,411	1,107	985	1,188	1,339	1,121	931	861
21	1,248	1,378	1,310	221	1,900	1,638	1,511	1,319	1,113	1,098	880	702
22	1,234	1,449	1,422	214	1,556	1,400	1,303	1,712	1,453	1,433	1,016	1,043
24	1,507	1,673	1,633	227	1,681	1,432	1,233	1,577	1,333	1,537	1,319	1,159
25	2,634	3,372	2,746	394	3,186	2,178	2,043	2,594	2,271	2,273	1,935	1,355
Mel Price (26) (Main)	2,855	3,839	3,650	1,141	4,280	1,560	324	160	1,144	129	154	642
Mel Price (26) (Aux.)	12	N/A	N/A	N/A	49	4,497	4,278	3,656	1,179	2,351	1,819	1,591
27 (Main)	374	275	343	553	601	897	316	538	299	395	354	318
27 (Auxiliary)	1,180	1,621	1,309	2	1,151	559	1,258	947	1,245	1,297	980	976
Illinois Waterway (IWW)												
Lock	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
LaGrange	428	1,480	1,679	14	1,168	680	261	827	473	808	461	475
Peoria	1,179	4,550	3,540	3,268	3,881	2,865	1,473	4,222	2,054	1,667	1,398	2,039
Starved Rock	3,361	3,607	3,266	2,147	3,198	3,207	3,053	4,991	4,460	4,113	3,204	2,905
Marseilles	3,436	3,933	3,743	2,836	3,961	1,676	2,938	3,469	3,522	3,390	2,961	2,852
Dresden Road	3,717	4,648	3,817	2,870	3,938	1,574	3,758	4,710	4,983	3,845	2,884	2,876
Brandon Road	1,556	1,652	1,481	1,203	1,617	924	1,464	1,757	1,693	1,560	1,556	1,480
Lockport	1,324	1,427	1,296	943	1,546	656	1,103	1,674	1,318	1,258	1,172	1,212
T.J. O'Brien	15,697	17,275	14,701	15,337	17,165	19,490	17,517	19,352	23,921	25,564	26,472	23,547

Table 4-6. Number of recreation vessel lockages (1990-2001).

Upper Mississippi River (UMR)												
Lock	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
USA	1,836	1,443	1,542	848	1,468	1,264	1,238	1,121	1,222	1,133	1,246	750
LSA	2,010	1,620	1,714	914	1,583	1,381	1,352	1,172	1,316	1,232	1,328	811
1	2,351	2,175	2,212	1,354	2,323	2,073	2,138	1,898	2,420	2,199	2,376	1,594
2	2,822	2,807	2,627	2,152	3,172	3,031	2,878	2,538	3,104	2,872	2,881	2,278
3	3,670	3,825	3,561	2,805	4,092	4,031	3,718	3,601	4,014	3,763	3,963	3,412
4	2,783	2,921	2,814	2,122	3,233	3,261	2,868	2,986	3,006	2,848	3,094	2,527
5	2,440	2,500	2,385	1,769	2,828	2,643	2,334	2,362	2,276	2,169	2,347	2,014
5A	3,240	3,324	3,051	2,245	3,654	3,350	2,901	2,829	2,883	2,739	2,927	2,424
6	3,074	3,162	2,983	2,251	3,323	3,106	2,975	2,554	2,718	2,477	2,538	2,246
7	3,342	3,406	2,888	2,480	3,410	3,274	2,917	2,780	2,767	2,820	2,760	2,360
8	2,367	2,290	2,199	1,451	2,543	2,278	1,889	2,093	2,258	2,180	2,071	1,667
9	2,201	2,230	2,190	1,206	2,291	2,086	1,903	2,052	2,120	2,098	1,997	1,740
10	2,312	2,169	2,072	1,051	2,340	2,072	1,770	1,676	2,018	1,894	1,758	1,389
11	2,091	1,922	1,798	1,074	2,086	1,792	1,519	1,650	1,727	1,609	1,613	1,342
12	1,601	1,803	1,524	709	1,738	1,486	1,439	1,461	1,627	1,410	1,318	1,025
13	1,217	1,224	1,137	617	1,219	1,168	1,063	1,105	1,316	1,159	1,116	911
14 (Main)	642	637	513	366	689	573	513	580	662	600	737	505
14 (Auxiliary	1,605	1,857	1,725	961	1,881	1,931	1,502	1,448	1,393	1,454	1,383	1,263
15 (Main)	79	80	31	207	466	102	63	58	70	36	73	219
15 (Auxiliary)	2,399	2,593	2,453	915	1,967	2,388	2,107	2,411	2,857	2,514	2,176	1,357
16	710	736	676	295	727	777	655	718	845	773	806	438
17	474	508	498	141	669	536	448	425	392	304	291	225
18	790	716	792	185	1,195	883	749	900	900	765	711	534
19	577	617	620	163	576	546	543	607	611	509	513	428
20	392	504	492	184	645	432	456	469	511	441	427	355
21	635	627	596	149	679	595	547	552	510	458	504	376
22	575	632	518	117	554	465	421	558	491	481	446	364
24	607	730	709	169	731	547	544	664	571	603	620	514
25	919	1,108	871	189	1,011	651	687	851	778	734	713	543
Mel Price (26) Main	823	1,124	1,165	443	1,402	546	133	60	508	59	83	268
Mel Price (26) (Aux)	6				23	1,623	1,589	1,345	544	1,135	1,068	988
27 (Main)	117	99	124	181	232	277	123	193	135	150	189	160
27 (Aux)	508	562	500	1	469	223	471	302	511	471	542	515
Illinois Waterway (IWW)												
Lock	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
LaGrange	181	546	630	7	434	223	92	264	176	285	256	260
Peoria	288	836	911	199	992	666	487	757	519	564	567	724
Starved Rock	1,199	1,120	1,057	879	899	988	882	1,061	984	915	889	856
Marseilles	1,046	1,131	1,109	844	948	542	927	1,080	994	879	1,012	984
Dresden Road	1,190	1,238	1,164	1,034	1,047	505	1,031	1,244	1,095	915	941	926
Brandon Road	661	671	609	583	564	336	598	717	622	572	622	671
Lockport	561	607	538	451	433	255	447	587	461	496	481	536
T.J. O'Brien	4,545	4,802	4,152	4,293	4,243	4,610	4,177	4,220	5,092	5,640	6,514	6,247

4.2.1.4 Fleet Characteristics, Port Facilities, and Fleeting

Roughly 50 towing or barge companies operate on the UMR-IWW Navigation System. These operators have approximately 12,500 hopper barges, 1,300 tank barges, and 550 towboats. There are 778 commercial docks in the UMR-IWW study area, with 453 (58 percent) providing services for shipping or receiving commodities. Facilities tend to be concentrated in medium and large urban centers such as Minneapolis/St. Paul, Chicago, St. Louis, Peoria, or the Illinois/Iowa Quad Cities area. About 160 fleeting areas are along the Upper Mississippi River and 42 are along the Illinois Waterway.

4.2.1.5 Commodities Shipped

Farm products, including corn, soybeans, and animal feeds, are the largest single commodity transported on the system (Figure 4-5). Other major commodities shipped on the system include coal, chemicals, petroleum, crude materials (sand, gravel, iron ore, steel, and scrap), and manufactured goods. Historic traffic patterns, by the commodity groups used in this study, are shown for both the UMR (Table 4-7) and IWW (Table 4-8) Navigation Systems. Additional facts and figures on commodities shipped on the UMR-IWW Navigation System can be found in Section 2.0 of the Economic Appendix.

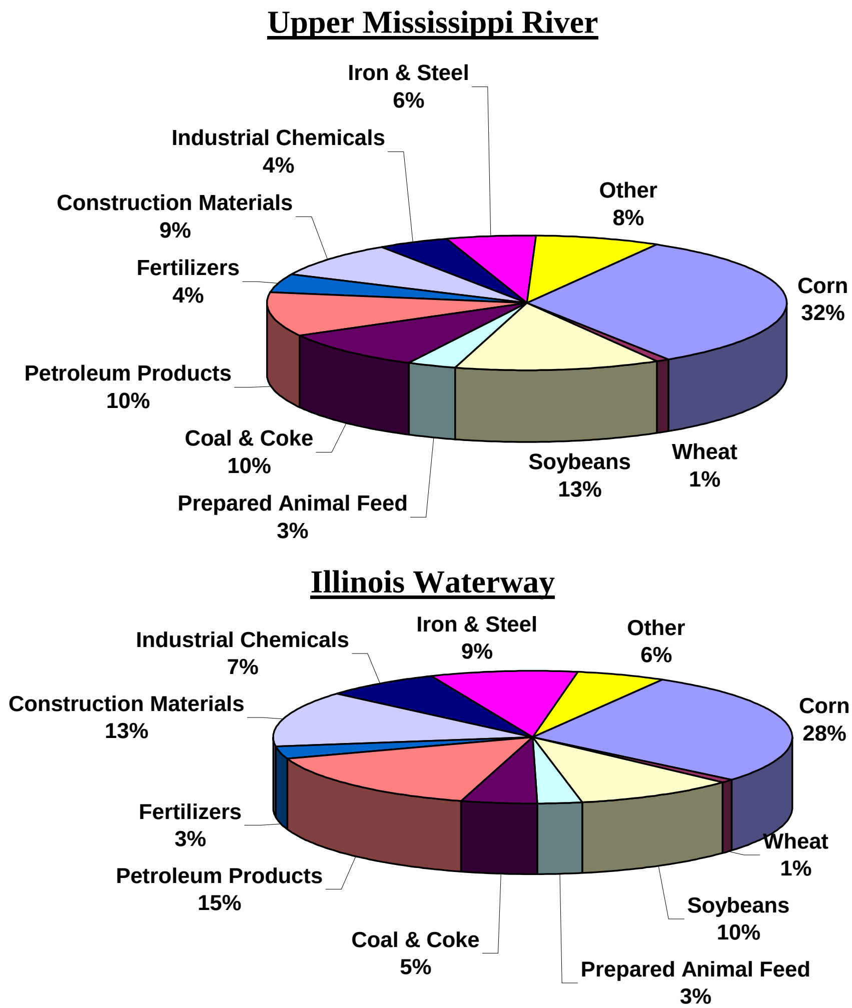


Figure 4-5. Commodity percentages by river for year 2000. (Source: Waterborne Commerce Statistics Center 2000).

Table 4-7. Upper Mississippi River (UMR) Traffic by Commodity Group (1972-2002). (Source: Waterborne Commerce Statistics Center)

UMR River Traffic by Commidity Group (Thousands of Tons)

YEAR	Corn	Wheat	Soybeans	Prepared Animal Feed	Coal & Coke	Petroleum Products	Fertilizers	Const. Materials	Industrial Chemicals	Iron & Steel	Other	TOTAL
1972	14,921	1,708	4,745	100	8,324	11,707	1,492	5,429	3,385	2,149	6,458	**60,417**
1973	17,524	1,285	4,436	24	6,483	8,752	2,517	5,294	2,994	2,017	6,493	**57,818**
1974	15,981	2,307	4,924	60	7,599	11,835	1,487	5,173	3,586	3,297	5,498	**61,747**
1975	17,611	2,887	4,168	89	8,806	12,009	1,805	4,630	3,323	2,651	5,100	**63,080**
1976	20,901	2,965	4,851	135	7,680	12,347	2,352	4,398	3,308	2,449	6,892	**68,277**
1977	18,778	2,714	4,767	129	9,057	11,945	2,496	4,843	3,228	2,786	6,277	**67,021**
1978	21,123	2,246	6,656	171	6,495	11,418	2,432	5,110	3,112	2,795	7,258	**68,816**
1979	22,661	2,452	5,237	1,333	7,189	9,979	2,195	5,721	2,961	2,047	6,732	**68,506**
1980	27,363	2,578	7,494	1,770	7,002	10,454	2,191	5,190	3,218	2,487	6,562	**76,308**
1981	27,883	3,118	7,265	1,932	6,144	10,276	2,444	4,455	3,002	2,949	5,037	**74,505**
1982	26,722	3,315	9,329	1,996	7,804	10,000	2,073	3,449	2,756	2,066	5,146	**74,656**
1984	26,618	4,542	8,329	2,663	9,889	9,867	4,602	4,414	3,034	2,672	5,142	**81,771**
1985	19,726	3,253	6,136	2,357	9,687	11,247	4,004	4,723	3,094	3,136	4,677	**72,039**
1986	15,140	2,045	9,561	3,068	10,997	10,614	4,486	5,100	3,765	3,448	5,497	**73,721**
1988	25,474	2,000	9,008	4,333	9,591	11,526	3,754	4,458	3,495	3,427	4,950	**82,016**
1989	27,175	2,908	5,818	3,901	9,605	10,450	3,222	4,969	3,492	3,110	4,701	**79,351**
1990	30,765	2,266	7,442	3,686	10,651	9,564	3,222	5,554	4,079	3,834	4,392	**85,455**
1991	29,069	2,080	8,347	3,937	9,630	9,586	3,296	4,909	4,058	3,634	5,523	**84,069**
1992	30,005	1,739	9,205	4,211	9,626	9,419	3,855	5,536	3,859	3,455	5,267	**86,177**
1993	23,758	883	8,360	3,922	8,371	6,389	3,834	4,836	3,600	3,343	4,858	**72,154**
1994	22,861	1,493	8,117	3,403	10,284	7,437	4,465	5,849	4,249	6,059	5,206	**79,423**
1995	31,018	981	9,408	3,427	9,009	6,957	3,744	5,603	4,001	5,260	4,998	**84,406**
1996	29,385	1,332	10,576	2,519	8,579	6,801	3,320	5,425	3,795	3,913	4,728	**80,373**
1997	24,622	1,142	10,458	2,690	7,500	7,718	3,023	6,095	4,063	4,653	5,871	**77,835**
1998	25,575	820	9,143	2,817	8,817	8,045	3,363	6,080	4,175	5,538	5,254	**79,627**
1999	30,692	989	11,439	2,653	8,554	7,266	3,184	7,225	3,938	5,142	4,570	**85,652**
2000	26,414	1,010	11,249	2,529	7,927	7,545	3,395	7,751	3,930	6,364	5,167	**83,281**
2001	25,537	825	9,925	2,355	7,611	8,268	3,493	6,799	3,417	4,534	6,023	**78,787**
2002	29,796	949	11,672	2,502	7,378	7,261	3,504	7,357	3,536	5,404	4,733	**84,092**
Average	**24,314**	**2,029**	**7,864**	**2,231**	**8,493**	**9,541**	**3,078**	**5,392**	**3,533**	**3,608**	**5,483**	75,565
Std. Dev.	**4,999**	**946**	**2,304**	**1,422**	**1,283**	**1,839**	**868**	**962**	**423**	**1,255**	**781**	**8,242**
Min	**14,921**	**820**	**4,168**	**24**	**6,144**	**6,389**	**1,487**	**3,449**	**2,756**	**2,017**	**4,392**	**57,818**
Max	**31,018**	**4,542**	**11,672**	**4,333**	**10,997**	**12,347**	**4,602**	**7,751**	**4,249**	**6,364**	**7,258**	**86,177**

Table 4-8. Illinois Waterway (IWW) Traffic by Commodity Group (1972-2002). (Source: Waterborne Commerce Statistics Center)

IWW River Traffic by Commidity Group (Thousands of Tons)

YEAR	Corn	Wheat	Soybeans	Prepared Animal Feed	Coal & Coke	Petroleum Products	Fertilizers	Const. Materials	Industrial Chemicals	Iron & Steel	Other	TOTAL
1972	9,265	260	2,300	28	6,793	7,170	704	5,121	2,544	2,019	5,682	**41,885**
1973	8,941	176	2,425	10	7,144	7,806	580	5,527	2,338	2,433	2,509	**39,890**
1974	7,817	395	2,044	40	6,998	8,314	702	4,940	2,806	3,247	6,350	**43,653**
1975	10,514	669	2,191	20	7,670	7,507	821	5,050	2,589	2,601	6,202	**45,832**
1976	12,759	564	2,140	23	6,590	6,940	1,219	4,730	2,485	2,699	5,125	**45,274**
1977	11,987	451	2,472	12	6,521	6,984	1,177	4,611	2,493	2,662	3,417	**42,787**
1978	11,599	174	2,845	67	3,852	5,751	1,268	4,004	2,549	2,645	5,059	**39,812**
1979	10,267	216	2,035	627	4,469	6,810	1,006	4,555	2,480	2,732	2,562	**37,760**
1980	12,396	351	2,769	926	5,805	6,601	1,066	4,655	2,579	2,852	4,119	**44,119**
1981	12,205	541	3,193	857	5,595	5,938	947	3,492	2,281	2,661	3,741	**41,451**
1982	14,318	542	3,755	950	4,434	6,011	742	3,717	2,062	1,784	3,235	**41,550**
1984	11,068	846	3,398	1,259	5,046	6,116	1,636	3,306	2,431	2,168	1,883	**39,156**
1985	11,518	406	3,003	917	4,997	5,556	1,357	3,113	2,623	2,668	1,966	**38,124**
1986	8,680	252	4,770	1,390	7,545	6,237	1,827	3,197	3,172	2,948	2,279	**42,298**
1987	11,254	270	3,612	1,847	5,847	6,002	1,540	3,936	2,911	2,386	1,519	**41,125**
1988	9,640	506	3,359	2,215	5,935	6,536	1,304	3,655	2,850	2,776	1,720	**40,496**
1989	10,505	948	2,486	1,533	4,527	6,024	1,256	4,327	2,835	2,651	2,030	**39,122**
1990	11,720	687	3,205	1,615	6,345	5,401	1,302	4,377	3,746	3,067	1,831	**43,296**
1991	11,199	387	3,703	1,910	6,563	6,007	1,213	3,226	3,721	3,077	2,125	**43,131**
1992	11,517	358	3,735	2,012	6,661	5,772	1,213	3,057	3,594	2,930	1,815	**42,664**
1993	13,188	284	4,234	2,316	7,749	5,176	1,334	3,248	3,265	2,939	1,901	**45,634**
1994	12,374	476	4,042	1,579	8,529	6,321	1,392	4,497	3,798	5,438	2,432	**50,878**
1995	13,543	457	4,282	1,466	8,238	4,735	1,395	2,820	3,543	4,672	2,285	**47,436**
1996	12,822	428	4,459	1,144	8,204	5,608	1,053	3,441	3,420	3,380	2,285	**46,244**
1997	11,052	402	4,527	1,172	4,942	6,175	1,051	3,508	3,662	4,049	2,451	**42,991**
1998	11,593	171	3,658	1,381	3,029	6,217	1,178	4,044	3,789	4,606	2,105	**41,771**
1999	13,266	294	4,591	1,221	1,447	5,690	1,108	5,243	3,526	4,366	2,972	**43,724**
2000	11,853	324	4,744	1,200	2,496	5,793	1,093	5,261	3,684	5,551	2,221	**44,220**
2001	12,120	287	4,425	1,157	2,112	6,590	1,371	5,844	3,151	4,036	2,397	**43,490**
2002	12,873	372	4,706	1,299	1,436	5,176	1,177	5,792	3,323	4,882	1,996	**43,032**
Average	**11,462**	**416**	**3,437**	**1,073**	**5,584**	**6,232**	**1,168**	**4,210**	**3,008**	**3,231**	**2,940**	**42,762**
Std. Dev.	**1,516**	**189**	**911**	**701**	**2,003**	**795**	**279**	**881**	**542**	**997**	**1,397**	**2,836**
Min	**7,817**	**171**	**2,035**	**10**	**1,436**	**4,735**	**580**	**2,820**	**2,062**	**1,784**	**1,519**	**37,760**
Max	**14,318**	**948**	**4,770**	**2,316**	**8,529**	**8,314**	**1,827**	**5,844**	**3,798**	**5,551**	**6,350**	**50,878**

4.2.1.6 Existing Lockage Delays

Eight locks on the UMR and three locks on the IWW were among 20 locks with the highest average delays in 1987 at the beginning of this study. This remains the case as illustrated on Figure 4-6, which shows the distribution of peak monthly delays at locks around the country in 1998. The UMR-IWW Navigation System had over half (19 of 36) of the most delayed lock sites in the country.

Under current conditions, delays to tows are common at a number of locks on the UMR system. Existing delays vary mostly on the basis of location in the system. In general, delays are greatest at the most downstream 600-foot locks. For the 10-year period 1992-2001, delays per tow averaged 3.4 hours at Locks 20-25; 2.1 hours at Locks 14-18; 0.8 hour at Locks 8-13; and 0.3 hour for Upper St. Anthony Falls Lock to Lock 7 (Table 4-9). On the IWW over the same period, delays per tow averaged 2.2 hours at Peoria and La Grange and 1.2 hours for each of the other six lock sites. Percent of tows delayed, average delay for tows, and the total ton-hours of delay by chamber during 2001 are presented in Table 4-10. Total ton-hours is the product of tons and average delay.

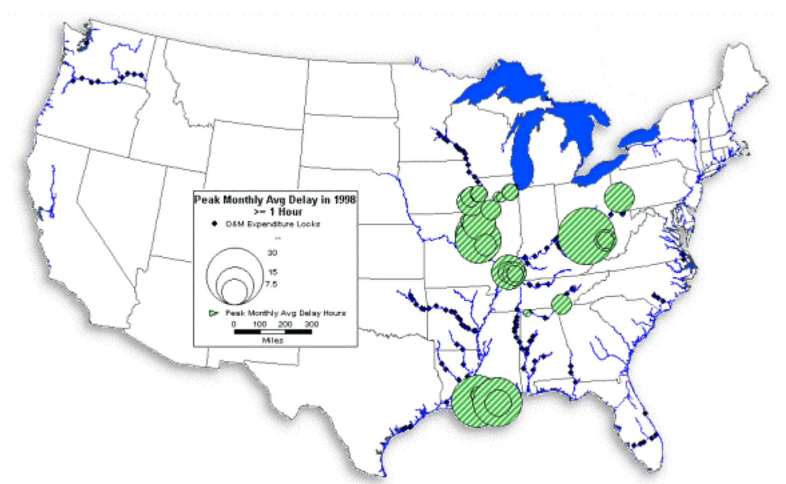


Figure 4-6. Peak monthly average lock delay in 1998 (Source: Navigation Data Center 1999).

4.2.1.7 Transportation Costs

An evaluation of transportation costs for the UMR system indicated that rate savings to waterway users in the year 2000 averaged about $8.08 per ton (1994 prices) over the best possible all-land routing alternative (TVA, Transportation Rate Analysis: Upper Mississippi River Navigation Feasibility Study, 1996). Savings for each of the 11 commodity groupings identified for this analysis are summarized in Table 4-11. Lists of individual commodities that comprise each of the 11 commodity groupings are shown in Table 2-10 in the Economics Appendix.

4.2.1.8 Benefits of the Existing System

The presence of the rivers provides many benefits to the regions, States, and counties along the river corridor and to the Nation as a whole. Benefits are derived from the employment and income generated from transportation of goods, recreation, hydropower production, and water supply for municipalities and commercial, industrial, and domestic use. The UMR-IWW Navigation System contributes significantly to regional and national economic development by offering a means of shipping bulk commodities at low cost, allowing for considerable transportation cost savings to the regional and national economy. The existing system generates an estimated $0.8 billion to $1.2 billion (2001 prices) of annual transportation cost savings (using Year 2000 traffic levels). These benefits compare with the average annual operation and maintenance costs ranging from $115 million to $126 million per year (the higher figure accounting for potentials such as stricter regulations, invasive species, increased security needs, etc.) and annual rehabilitation costs of approximately $56 million.

Table 4-9. Historic commercial barge traffic delays (1990-2001) by lock for the UMR-IWW Navigation System (Source: Waterborne Commerce Statistics Center).

Annual Average (hrs) Traffic Delays by Lock

Average Delay = average time from arrival to start of lockage.

Upper Mississippi River (UMR												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
USA	0.03	0.03	0.03	0.02	0.01	0.03	0.03	0.02	0.01	0.03	0.03	0.03
LSA	0.03	0.06	0.06	0.03	0.03	0.02	0.04	0.03	0.02	0.03	0.04	0.02
1	0.05	0.07	0.16	0.15	0.19	0.18	0.17	0.03	0.02	0.04	0.03	0.05
2	0.73	0.58	0.60	0.49	0.39	0.53	0.55	0.56	0.56	0.55	0.48	0.62
3	0.70	0.57	0.59	0.52	0.45	0.51	0.52	0.47	0.42	0.47	0.42	0.53
4	0.51	0.45	0.39	0.39	0.29	0.39	0.40	0.42	0.40	0.52	0.41	0.38
5	0.44	0.46	0.50	0.44	0.42	0.41	0.56	0.45	0.39	0.45	0.40	0.42
5a	0.42	0.42	0.41	0.46	0.33	0.44	0.43	0.49	0.42	0.50	0.45	0.41
6	0.67	0.71	0.64	0.70	0.46	0.63	0.73	0.68	0.60	0.66	0.61	1.05
7	0.83	0.70	0.68	0.64	0.55	0.60	0.67	0.70	0.75	0.65	0.69	0.86
8	0.89	0.81	0.89	0.60	0.62	0.89	0.96	0.88	0.75	0.83	0.77	0.89
9	0.54	0.47	0.57	0.39	0.46	0.60	0.60	0.65	0.70	0.70	0.76	0.65
10	0.71	0.51	0.69	0.51	0.39	0.81	0.89	0.95	0.67	0.76	0.73	0.82
11	1.79	1.39	1.19	0.74	0.72	1.25	0.97	0.96	0.84	0.95	0.94	0.95
12	1.31	1.32	1.24	0.70	0.57	0.98	1.13	1.01	0.82	1.06	0.87	1.30
13	1.16	1.52	1.25	0.95	0.71	1.32	1.26	0.82	0.70	1.00	0.99	0.97
14	3.97	1.43	1.19	0.89	0.93	1.66	2.40	2.75	2.53	3.91	2.57	2.48
15	3.11	2.53	2.78	2.09	1.10	2.56	3.23	1.68	1.89	2.75	1.48	2.83
16	1.91	1.83	2.20	2.71	0.92	1.60	1.67	1.24	1.55	1.78	1.27	2.04
17	3.91	1.85	2.26	5.14	0.88	2.25	1.81	1.57	2.16	2.15	1.55	1.75
18	3.07	2.89	2.62	2.88	0.97	3.17	2.53	1.47	1.25	1.80	1.60	2.11
19	1.01	0.88	1.11	1.07	0.70	0.82	0.85	0.77	0.70	0.74	0.81	0.79
20	5.31	1.97	2.65	5.16	0.99	2.24	3.43	1.76	1.71	2.17	2.72	2.38
21	2.35	2.07	2.33	1.90	1.05	3.15	3.02	1.73	1.68	1.94	2.21	2.65
22	5.06	3.06	4.21	3.43	1.76	6.62	8.32	3.53	2.90	3.83	3.64	5.20
24	6.00	2.94	4.16	3.06	1.48	5.05	4.79	3.03	4.60	2.92	2.71	4.10
25	3.76	2.86	6.51	2.93	2.68	5.78	3.94	3.07	4.82	3.81	3.23	5.71
Mel Price (26)	7.28	1.47	1.73	1.04	2.35	5.25	0.80	0.61	0.66	8.37	2.03	3.97
27	5.17	4.30	8.32	1.26	6.31	4.49	14.42	39.09	2.33	6.51	0.96	0.79
Illinois Waterway (IWW)												
Lock and Dam	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
LaGrange	1.47	0.52	1.17	0.22	1.51	3.54	6.32	3.67	2.11	2.79	4.61	2.47
Peoria	0.84	0.50	1.10	0.13	1.40	2.23	2.48	2.19	1.04	1.30	1.62	1.21
Starved Rock	0.85	0.91	0.84	1.12	1.54	1.70	0.95	1.38	1.16	1.29	1.35	1.53
Marseilles	1.35	1.14	1.24	1.35	1.60	2.18	1.02	1.61	1.52	1.68	1.72	2.02
Dresden Island	0.77	0.77	0.74	0.68	1.08	2.47	0.79	0.87	1.11	1.01	1.04	1.36
Brandon Road	0.93	0.89	0.94	1.24	1.67	2.38	0.95	1.19	1.34	1.28	1.45	1.73
Lockport	1.08	1.02	1.09	1.30	1.91	2.69	1.10	1.35	1.81	1.38	1.99	1.73
T.J. O'Brien	0.04	0.05	0.07	0.06	0.08	0.07	0.08	0.07	0.08	0.05	0.06	0.05

Table 4-10. Average delay and ton-hours of delay (2001).

Lock	Average Delay of Tows (Hours)	Total Tonnage (Millions)	Ton Hours of Delay (Millions)
Upper Mississippi River (UMR)			
USA	0.03	1.83	0.05
LSA	0.02	1.81	0.04
1 (Main)	0.05	1.83	0.09
2 (Main)	0.62	8.58	5.32
3	0.53	8.58	4.55
4	0.38	9.36	3.56
5	0.42	9.49	3.99
5a	0.41	9.50	3.90
6	1.05	11.96	12.56
7	0.86	12.00	10.32
8	0.89	12.79	11.38
9	0.65	14.57	9.47
10	0.82	16.53	13.55
11	0.95	17.34	16.47
12	1.30	19.10	24.83
13	0.97	19.28	18.70
14 (Main)	2.48	24.27	60.24
15 (Main)	2.83	24.71	69.89
16	2.04	26.45	53.96
17	1.75	27.45	48.04
18	2.11	28.57	60.28
19	0.79	30.13	23.80
20	2.38	31.11	74.04
21	2.65	32.87	87.11
22	5.20	33.34	173.37
24	4.10	34.79	142.64
25	5.71	34.86	199.05
26 (Main)	3.97	75.94	301.83
27 (Main)	0.79	81.09	64.04
Illinois Waterway (IWW)			
LaGrange	2.47	36.75	90.77
Peoria	1.21	33.67	40.74
Starved Rock	1.53	23.30	35.65
Marseilles	2.02	20.89	42.20
Dresden Road	1.36	18.88	25.68
Brandon Road	1.73	16.42	28.41
Lockport	1.73	15.99	27.66
T.J. O'Brien	0.05	6.78	0.34

Table 4-11. All land vs. water differential by commodity group (total system; 1994 prices).

Commodity Group	Weighted Differential ($)
Corn	7.08
Soybeans	12.85
Wheat	7.56
Farm NEC (Not Elsewhere Classified)	3.18
Coal	4.68
Petroleum	13.18
Ind. Chemicals	13.49
Ag. Chemicals	6.77
Iron & Steel	13.85
Aggregates	5.35
Miscellaneous	10.28
Average	**8.08**

4.2.1.9 Operations and Maintenance Costs for Navigation System

Operations and Maintenance (O&M) costs include funding for lock and dam personnel, maintenance crews, dredging, utilities, minor repairs, and the maintenance of training structures south of St. Louis. These routine costs are incurred annually, but historically they have not been sufficient to maintain an acceptable level of performance, leaving a need for additional monies to maintain a system that otherwise will deteriorate over time. Appropriations for the O&M budget have been nearly "flat-lined" in recent years when compared with the necessary repairs and other demands. This has resulted in the deferring of many maintenance-type items. There is a present system-wide backlog of unfunded critical maintenance items that exceeds $75 million. The entire backlog of maintenance items through 2002, which includes necessary repairs as well as critical items, totals $406 million for the UMR-IWW Navigation System. This will result in an increase in the unscheduled closures in the future.

Lock closure data were used to estimate lock closures based on the fact that the consequences of deferred maintenance should be represented in the data in the form of lock closures. Also, since not all repairs/needs can be addressed due to budget shortcomings, this had to be represented in the forecasting of this effect. It was represented by accounting for additional lock closures in that after a Major Rehabilitation project, only 80% of the lock closure days related to unreliable operation would be restored. This was based on the cost of items that require major rehabilitation in recent reports and the level of funding that was able to be obtained within the constraints of the Major Rehabilitation program and the O&M budget. In general, there are constraints that do not permit full restoration of a lock's equipment and features and was represented in each locks availability.

O&M costs based on historical cost data from 1981 to 2002 are estimated at $115 million per year (in 2000 price levels). Lock and dam operations account for $45 million, dredging $32 million, maintenance $23.5 million, contract expenses $13 million, and engineering costs $1.5 million. The percentage breakdown of baseline O&M costs is depicted on Figure 4-7.

Rehabilitation of the lock and dam system has been ongoing since 1975. The program involves project feature restoration work intended to improve the reliability of the existing structures for an additional

25 years. Widely varying levels of rehabilitation have been accomplished at the majority of lock sites on the Upper Mississippi River and Illinois Waterway. Over $900 million has been expended on this program since 1975. The funds received through this program are in addition to the O&M funds presented above. Although $900 million has been spent, additional rehabilitations are under way, some are awaiting funding approval, and others are being considered for timely preparation of engineering study for consideration of rehabilitation. In other words, rehabilitation of the system will be a continuous process conducted on a project-by-project basis under the present funding method and policies.

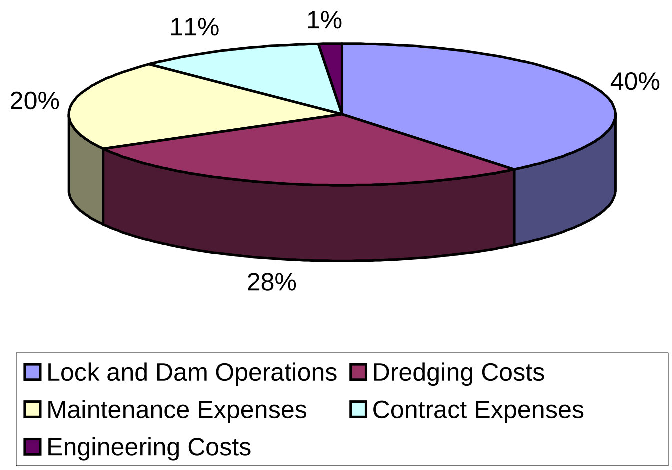


Figure 4-7. Existing Rehabilitation Program.

4.2.1.10 Condition Assessment of the Existing Navigation System

The existing navigation system was assessed for its capability to be sustained throughout the planning period. The condition of the existing locks and dams and the possible need for reconstruction was a particular focus. Inspections were conducted, reports were reviewed, and experience was used to determine that all lock and dam assets on the UMR and IWW could be sustained through the planning period. The T. J. O'Brien lock was initially considered to be the only exception, but a comprehensive Major Rehabilitation of the lock could avoid its reconstruction. It was concluded that with consistent O&M, periodic Major Rehabilitation, and the present types of use/exposure that the navigation system assets (locks and dams) can be sustained through the planning period. These assumptions and investment types were used in the analysis.

4.2.2 UMRS Ecosystem

The existing UMRS ecosystem is the product of many past and ongoing natural and human processes or disturbances. There are many Federal, State, and private entities that have responsibility for natural resource stewardship. Their management ranges from intensive land management activities to more passive conservation, preservation, and regulatory actions such as protecting land from development. Current management combined with past actions are responsible for the condition of the ecosystem components discussed in detail below. Land cover, floodplain and aquatic areas, and terrestrial habitat are all important determinants of habitat condition. Connectivity and fragmentation are measures of the connectedness of habitats, which is important for organisms to disperse their populations or to make seasonal movements or migrations. Diversity is a measure of the variety of physical habitats and organisms that an ecosystem supports.

4.2.2.1 Ecosystem Management Programs

The Upper Mississippi and Illinois Rivers have been carefully managed for over 100 years to conserve commercial and sport hunting and fishing resources and to conserve the resources they depend on. The impacts of increasing population through the late 1800s created great demand for the resources. Commercial hunting, fishing, and clamming had devastating impacts on local populations in some cases. The large charismatic individuals of species like the sturgeon, paddlefish, and catfish were fished out. Great flocks of passenger pigeons and waterfowl were hunted to extinction or the brink thereof. Entire mussel stocks were fished out for the button industry before clammers would move to the next river reach or mussel bed. The U.S. Bureaus of Fisheries and Wildlife were established to understand the populations and regulate harvests. Modern State natural resource management agencies continue the same tasks today in light of changing social priorities and non-native species introductions. State agencies in the region have a long history of interstate and interagency coordination through the Upper Mississippi River Conservation Committee (UMRCC), a forum established in 1943 through grass roots efforts. The unifying goal of the UMRCC is to "*Promote the preservation and wise utilization of the natural and recreational resources of the Upper Mississippi River (UMR) and to formulate policies, plans and programs for conducting cooperative studies*".

Growing populations in the region were driving the resource harvest. The increasingly dense concentration of people in cities also began to tax water supply and waste disposal capacity. The problem had significant human and river health consequences. Large reaches of river downstream from Chicago, Peoria, Minneapolis-St. Paul, the Quad Cities, and St. Louis were “dead zones” on a par with the nutrients impact of concern in the Gulf of Mexico. There were incremental improvements in waste treatment capabilities, but passage of the Clean Water Act in 1972 was the action that compelled municipalities and industry to improve waste treatment. Water quality regulation and monitoring continue today at Federal and State levels, with increased consideration for non-point urban and agricultural pollution.

There has never been an authorized Federal interest in unified fish and wildlife management, but the U.S. Fish and Wildlife Service has broad authority for refuge and ecosystem management, threatened and endangered species protection, and coordination activities, and the Corps of Engineers, has responsibility for the waterways and project lands. These authorities have been intrinsically linked since the planning for the 9-Foot Channel Project. Much of the upper waterway, in fact, flows through the Upper Mississippi River Fish and Wildlife Refuge, which was established in 1924. The establishment of the Upper Mississippi River National Fish and Wildlife Refuge and, later, others refuges in the region has been one of the most important habitat protection measures yet undertaken on the UMRS.

Current environmental management arrangements can be traced back to the establishment of the Great River Environmental Actions Teams (GREAT Studies) created in the 1970s to address channel maintenance and other Navigation System operation and maintenance issues. The District teams reviewed O&M procedures and needs and now closely coordinate with natural resource managers to minimize impacts. Important natural resource management programs are described below.

4.2.2.1.1 USACE Programs

4.2.2.1.1.1 Environmental Management Program (EMP)

Congress authorized the Upper Mississippi River System Environmental Management Program (EMP) in Section 1103 of the 1986 Water Resources Development Act. Over the course of its first 13 years, the EMP proved to be one of this country’s premier ecosystem restoration programs, leading Congress to reauthorize the EMP in the 1999 Water Resources Development Act. Section 509 of the 1999 Act made several adjustments to the program and established the following two elements as continuing authorities:

- Long-term resource monitoring, computerized data inventory and analysis, and applied research (known collectively as the LTRMP)

- Planning, construction, and evaluation of fish and wildlife habitat rehabilitation and enhancement projects (known as HREPs)

The Long Term Resource Monitoring Program (LTRMP) operates in six river reaches where State employees from Wisconsin, Illinois, Minnesota, Illinois, and Iowa use standardized monitoring protocols to track long-term trends in water quality, aquatic plants, terrestrial land cover, selected aquatic invertebrates, and fish. The program conducted a review of historic status and trends in 1999 and a Habitat Needs Assessment in 2000; it is currently preparing a report of baseline conditions and ecological changes over 10 years of study. The LTRMP provides a base of field science capability that is critical to the adaptive management and restoration response monitoring.

The Habitat Rehabilitation and Enhancement Project (HREP) component of the EMP aims to change the river's structure and hydrology to counteract the effects of an aging impounded river system. For example, HREPs may alter sediment transport and deposition, water levels, or connections between the river and its floodplain. These types of physical changes subsequently affect water quality parameters such as temperature, dissolved oxygen, and distribution of suspended sediments, thereby ultimately improving fish and wildlife habitat. To accomplish habitat management and restoration objectives, HREPs employ a variety of techniques: backwater dredging, water level management, island creation, shoreline stabilization, secondary channel modification, flow control, and aeration. Many projects combine these measures to address more than one problem. In addition, some projects also include innovative features or features that provide secondary benefits or complement the primary techniques. Examples include hillside sediment control, land acquisition, and notched wing dams. HREPs may be done in conjunction with other programs, including the Corps' channel maintenance work, to take advantage of synergies. Table 4-12 shows the range of project techniques that have been used, or are being considered for possible future use, as part of HREPs.

Table 4-12. Upper Mississippi River System Environmental Management Program Habitat Rehabilitation and Enhancement Project features.

Technique	Objectives
Dredge backwaters	Alter flow patterns and velocity Improve floodplain structural diversity Increase deepwater fish habitat for overwintering Provide access for fish movement Provide dredged material to support revegetation and island building
Manage water levels using dikes and water control systems	Restore natural hydrologic cycles Promote growth of aquatic plants as food for waterfowl Reduce backwater sediment loads Consolidate bottom sediments Control rough fish
Build islands	Decrease wind and wave action Alter flow patterns and sediment transport Improve aquatic plant growth Improve floodplain structural diversity Provide nesting and loafing habitat for waterfowl and turtles Restore woody vegetation
Stabilize shorelines	Prevent shoreline erosion Maintain floodplain structural diversity Create fish habitat Reduce sediment loads to backwaters Create barriers to waves and currents
Modify secondary channels	Improve fish habitat and water quality by altering inflows Stabilize eroding channel Reduce sediment load to backwaters by reducing flow velocities Maintain water temperature and provide rock substrate
Aerate	Improve fish habitat and water quality by introducing oxygenated water
Miscellaneous Experimental and Complementary Techniques:	
Large-scale water level management	Seed islands
Upland sediment control	Isolated wetlands
Land acquisition	Weirs
Riffle pools	Rock sills
Potholes	Sediment traps
Notched wing dams	Mussel substrates
Anchor tree clumps	Bottomland forest restoration
Vegetative plantings	Fish passage structures

The EMP has completed 40 HREPs affecting 67,000 acres of aquatic and floodplain habitat since 1986. As of October 2003, there were 8 projects under construction that will improve 38,000 acres and 16 projects still in various stages of design that will affect another 36,000 acres of river-floodplain habitat. When all these projects are completed, the total area of restored habitat will exceed 140,000 acres among the 64 projects. While these projects will improve habitat conditions on about 5 percent of the total Upper Mississippi River System floodplain area, they represent only a small fraction of the restoration needs stated in the Habitat Needs Assessment and other planning efforts.

EMP funding authority was raised to $33 million in 1999, but average funding for the program has been approximately $16.5 million. The highest funding exceeded $23 million (FY01) and the recent low of $12 million (FY02) made it difficult to maintain functional levels of restoration and monitoring.

4.2.2.1.1.2 Threatened and Endangered Species Coordination

In April 1998, the U.S. Fish and Wildlife Service (USFWS) Region 3 and the U.S. Army Corps of Engineers Mississippi Valley Division (MVD) voluntarily entered into formal Section 7 consultation under the Endangered Species Act of 1973, as amended (Public Law 93-205). The consultation covered the continued operation and maintenance of the UMR-IWW 9-Foot Channel Navigation Project. Specifically addressed within the consultation were operation and maintenance direct effects, navigation traffic indirect effects, recreation indirect effects, and cumulative effects. The direct effects of operation and maintenance included navigation channel dredging, dike and revetment maintenance, water level management, and management of Corps lands. A 1998 baseline was established for the effects, and a 50-year evaluation period (to 2048) was used.

Formal consultation was concluded in August 2000, when the MVD Commander sent a letter to the Director of USFWS Region 3 setting forth an implementation plan for the 9-Foot Channel Navigation Project that would accommodate the findings of the USFWS's Biological Opinion (BO) (USFWS 2000). The species of concern covered in the BO include:

- Decurrent False Aster – Incidental take with no significant Reasonable and Prudent Measures (RPM)
- Bald Eagle – Incidental take with no significant RPM
- Indiana Bat – Incidental take with no significant RPM
- Interior Least Tern – Incidental take with RPM
- Pallid Sturgeon – Jeopardy and incidental take with Reasonable and Prudent Alternative (RPA) and RPM
- Higgins Eye Mussel – Jeopardy and incidental take with RPA and RPM
- Winged Mapleleaf Mussel – Incidental take with RPM

The River Resources Action Team (RRAT) is an interagency committee that responds to multiple natural resource issues in the St. Louis District. The RRAT was the coordinating entity charged with resolving issues related to the Biological Opinion. The RRAT provides an effective forum for implementation of the reasonable and prudent alternatives and prudent measures contained in the BO for pallid sturgeon and least tern.

A subcommittee of the RRAT, the Pallid Restoration and Conservation Planning Team/Workgroup (Pallid Team), was formed to address studies and restoration directed toward pallid sturgeon aspects of the BO. The Pallid Team has reviewed and supplied input to the scope of work for the Pallid Habitat and Population Demographics Study and is working on an overall plan for the conservation and restoration of pallid sturgeon in the Middle Mississippi River. The plan will be reviewed by the full RRAT and forwarded to the USFWS Pallid Recovery Team for comment and inclusion.

The RRAT also provides a forum for coordination of the regulation works and channel maintenance programs that affect habitat in the lower pools and Middle Mississippi River. The team has supplied input and review for several ongoing planning efforts such as the side channel vision document, the alteration of existing stone dike structures planning effort, and pilot type projects for the Middle Mississippi River as well as the pooled portions within the St. Louis District. These efforts include incorporation of wood within existing dikes, constructing and placing wood structures within the Middle Mississippi River, designing and locating innovative structures such as off-bank line revetment, chevron dike structures, multiple round point structures, and notching of existing dikes.

A Decurrent False Aster (*Boltonia decurrens*) Inventory and Assessment was conducted on the Illinois River during 2000. *B. decurrens* occurs primarily in the Illinois River. Disturbed sites likely to support the plant are inspected, and where necessary, dredging or other activities are modified to avoid sites supporting the plant.

The interagency Mussel Coordination Team was formed to respond to the endangered mussel species issues raised by the BO. Their work efforts are concentrated in the pooled reaches of the UMR and tributaries. A long-term mussel monitoring program was initiated in 2000 to evaluate the health and status of Higgins' eye and other native mussels. Pilot Higgins' eye propagation and relocation projects were completed in 2000, 2001, and 2002. A Relocation Plan and Environmental Assessment was prepared in April 2002; the plan would be enacted over 10 years. Effort has also been devoted to monitoring zebra mussel infestations, monitoring larval zebra mussel distribution and concentrations, and a reconnaissance study for zebra mussel management on the UMRS. Host identification research for winged mapleleafs was completed in fall 2002. Winged mapleleaf propagation and relocation planning efforts were initiated in 2003 and the development of a long-term Relocation Plan and Environmental Assessment is scheduled to be completed in 2004. Pilot projects to test the efficacy of manually removing zebra mussels from native mussels on an annual basis were initiated in Pools 10, 11, and 14 during 2001 and 2002.

The Districts are also implementing nesting and wintering management guidelines in all operations to minimize disturbance of bald eagles (*Haliaeetus leucocephalus*). Staff at locks and dams report eagle counts during winter. Efforts to protect and enhance bald eagle habitat on Corps land are being incorporated into District forest management plans.

4.2.2.1.1.3 Forestry Program

The U.S. Army Corps of Engineers owns fee title to about 270,000 acres of General Plan lands purchased during the 1930s to implement the 9-Foot Channel Navigation Project. The Corps' forest management program was developed to utilize Federal timber – originally to support the War Effort for World War II. The program continued after the war to provide timber to industry. Essentially large blocks of area – up to several thousands of acres – were opened to bid. The successful high bidder cut trees over an 18-inch-diameter, which was purchased on scale. From 1942 to 1975, perhaps more than 70 percent of Corps fee title land had been bid. The Cooperative Agreements between the Department of the Army and the Department of the Interior identified timber management as a responsibility retained by the Corps on General Plan land. The most recent update to the Cooperative Agreement – 2001 continues that responsibility with a clearer message that forest management goals will be coordinated with the USFWS (and State Departments of Natural Resources). A significant milestone in the development of common goals and objectives for floodplain forest management on the UMR was accomplished with publication of the 2002 Upper Mississippi River Conservation Committee (UMRCC) Report, *Upper Mississippi and Illinois River Floodplain Forests: Desired Future and Recommended Actions* (UMRCC 2003). Corps and USFWS field staff led the interagency development of this report, which presents a vision for the floodplain forest that is shared by river managers, foresters, and biologists active in the UMRCC.

4.2.2.1.1.4 Other Corps Environmental Management Opportunities

Several more Corps programs and authorities improve river habitats, but the funding allocation has not been separated from traditional river management activities. Programs, projects, or activities that also enhance environmental resources or provide restoration opportunities in the main stem rivers include the following:

- Dredged Material Management Program, Rock Island District
- Avoid and Minimize Program, St. Louis District
- Channel Maintenance Management Plan, St. Paul District

- Committee to Assess Regulating Structures, Rock Island District
- Master Planning
- Threatened and Endangered Species Conservation Plan
- Section 204 Beneficial Uses for Dredged Material
- Section 1135 Aquatic Ecosystem Restoration
- Section 206 Aquatic Ecosystem Restoration
- Mississippi River Environmental Pool Plans
- Collaborative Planning through District Resource Forums

4.2.2.1.2 U.S. Fish and Wildlife Service

Federal interest in habitat protection increased in the early 1900s when commercial mussel, fish, and wildlife harvests were taking large quantities of the river system's resources, and sewage and industrial pollution from urban centers were degrading water quality and killing aquatic organisms. The Upper Mississippi River Wildlife and Fish Refuge was authorized in 1924, and eventually all Mississippi River USFWS National Wildlife Refuges combined acquired almost 270,000 acres. There are five National Wildlife Refuges on the Illinois River with a total of 16,000 acres (Table 4-13; USFWS 2002).

Table 4-13. Summary of UMRS National Wildlife Refuge lands (USFWS 2002).

Management Unit	Acres	Location
Upper Mississippi River National Wildlife and Fish Refuge		
Winona District	43,389	Pools 4-6
La Crosse District	46,469	Pools 7-8
McGregor District	90,678	Pools 9-11
Savanna District	52,973	Pools 12-14
Trempealeau NWR	5,733	Pool 6
Mark Twain National Wildlife Refuge Complex		
Port Louisa NWR	8,375	Pools 17-18
Great River NWR	10,037	Pools 20-24
Clarence Cannon NWR	3,751	Pool 25
Two Rivers NWR	2,660	Pools 25-26
Middle Mississippi NWR	4,400	Open River
Total Mississippi Acres	**268,465**	
Illinois River National Wildlife and Fish Refuges		
Cameron-Billsbach Unit	1,709	Peoria Pool
Chautauqua NWR	4,488	La Grange Pool
Emiquon NWR	1,303	La Grange Pool
Meredosia NWR	2,883	Alton Pool
Mark Twain National Wildlife Refuge Complex		
Two Rivers NWR	5,840	Alton Pool
Total Illinois Acres	**16,223**	

The refuge purposes are primarily for migratory birds, threatened and endangered species, and other Trust species, but their land conservation and management activities support the wide diversity of species present in the UMRS. Flood-prone lands sometimes become available after extreme floods, and Federal agencies including the Federal Emergency Management Agency, the Corps, and the Fish and Wildlife Service work together to acquire and manage these lands. Comprehensive Conservation Planning for USFWS refuges that is under way or recently completed has identified additional lands for acquisition to incorporate important resources. Total annual spending on environmental management is about $9 million for Fish and Wildlife Service refuges.

4.2.2.1.3 U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency has the responsibility to review and comment on all major Federal actions that may have a significant impact on the environment pursuant to Section 309 of the Clean Air Act. In the Clean Water Act, the U.S. Environmental Protection Agency was also given authority to regulate activities in wetlands and riparian areas, point source discharges, dredged material disposal, storm water discharge, and nonpoint source pollution.

4.2.2.1.4 U.S. Department of Agriculture

The U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) provides national leadership in a partnership effort to help people conserve, maintain, and improve America's natural resources and the environment. NRCS provides leadership for conservation activities on the Nation's 1.6 billion acres of private and other non-Federal land. This agency provides technical assistance and information to individuals; communities; tribal governments; Federal, state and local agencies; and others. The NRCS staff partners with staff of the local conservation district and state agencies and with volunteers. NRCS also offers financial assistance, surveys the Nation's soils, inventories natural resources conditions and use, provides water supply forecasts for western states, and develops technical guidance for conservation planning. NRCS also administers a small watershed program; plant materials program that provides effective solutions to conservation problems using plant materials; Resource Conservation and Development program (RC&D), a program which combines private and federal enterprises to address social, economic and environmental concerns; and emergency watershed protection program, which was established by Congress to respond to emergencies created by natural disasters. NRCS also provides technical assistance to the Commodity Credit Corporation programs such as the wetland reserve program (WRP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentives Program (WHIP), Farmland Protection Program (FPP) Conservation Reserve Program (CRP), and others. The benefits of these activities include sustaining and improving agricultural productivity; cleaner, safer, and more dependable water supplies; reduced damage caused by floods and other natural disasters; and an enhanced resource base to support continued economic development, recreation, and other purposes.

4.2.2.1.5 State Management Programs

The States of Minnesota, Wisconsin, Illinois, Iowa, and Missouri actively manage about 140,000 acres (State owned or General Plan lands). State Departments of Natural Resources spending for environmental management on the main stem rivers is less than $3 million (UMRCC 2000). States are also responsible for water quality management, drinking water, floodplain management, water use, transportation coordination, emergency response, historic property, and many other activities either individually or in coordination with Federal or local agencies and individuals.

4.2.2.1.6 Non-Governmental Organizations

Non-Governmental Organizations have long been involved in on-the-ground habitat protection work, river education, and advocacy work on behalf of the River's natural resources. For example, the Izaak Walton League took a lead role in advocating for the Upper Mississippi National Wildlife and Fish Refuge in the 1920's. The National Audubon Society, established in 1905, has long supported bird conservation work through its offices and chapters along the river. In the 1970's through the present, several environmental NGOs, with strong foundation and private support, established full time UMR project offices and have been actively engaged in the work of the Great River Environmental Action Teams in the 1970's, the Upper Mississippi Master Plan in the 1980's, and the current Navigation Study. Organizations with project offices on the river have included American Rivers, Audubon, the Mississippi River Basin Alliance, the Mississippi River Revival, the Nature Conservancy, the Sierra Club, and several statewide and local land trusts and watershed groups. Today conservation organizations including Ducks Unlimited and Pheasants Forever are increasing their participation in habitat protection and restoration efforts on public and private land. Land trust organizations including The Nature Conservancy, American

Land Conservancy, and Wetlands Initiative are sponsoring restoration opportunities on significant land acquisitions on the lower Illinois River and southern Illinois floodplain. Immediate opportunities for cost shared restoration on former cropland are about 15,000 acres.

Private duck hunting clubs have been active on the lower Illinois River for much of the 20th century; they currently manage about 60,000 acres (Havera 1995). Other private clubs manage land on the Mississippi River in northeast Missouri and near Burlington, Iowa. Remnant oxbow lakes and floodplain crop fields support migrating geese in the highly developed areas south of St. Louis.

Levee and drainage districts provide ongoing services to conserve and enhance ecosystem values. Thousands of acres of Federal and State wildlife refuges and parks are protected through flood control. Structures provide stability for water table variations and other natural cues to be managed for desired outcomes of targeted species. Acres of privately owned habitat areas are used for recreational purposes such as waterfowl hunting, bird watching, and fishing. For example, it is common for many levee and drainage districts to have thousands of acres of habitat that ranges from open water to wooded wetlands scattered throughout the district.

4.2.2.2 Land Cover

The Upper Mississippi River System floodplain area encompasses 2.6 million acres. Agriculture is the dominant land cover class, occupying about 50 percent of the floodplain. Open water is the second dominant land cover class, covering 17 percent of the floodplain. Floodplain forests follow closely, occupying 14 percent of the floodplain. No other class of vegetation exceeds 10 percent of the floodplain area, and only developed land areas exceed 5 percent.

Land cover classes are unevenly distributed throughout the river system, and the absolute floodplain area of river reaches and pools may also differ greatly. The largest differences occur in the amount and distribution of agriculture (Figure 4-8) and the proportion of open water in the floodplain.

Agriculture dominates the floodplain south of Rock Island, Illinois (Pool 14), and open water occupies a greater proportion of the floodplain between Minneapolis (Pool 1) and Clinton, Iowa (Pool 13). Wetland classes are generally more abundant between Minneapolis and Clinton. Grasslands are fairly evenly distributed but are rare throughout the river system. Woody classes are important throughout the river system and generally occupy between 10 and 20 percent of the floodplain.

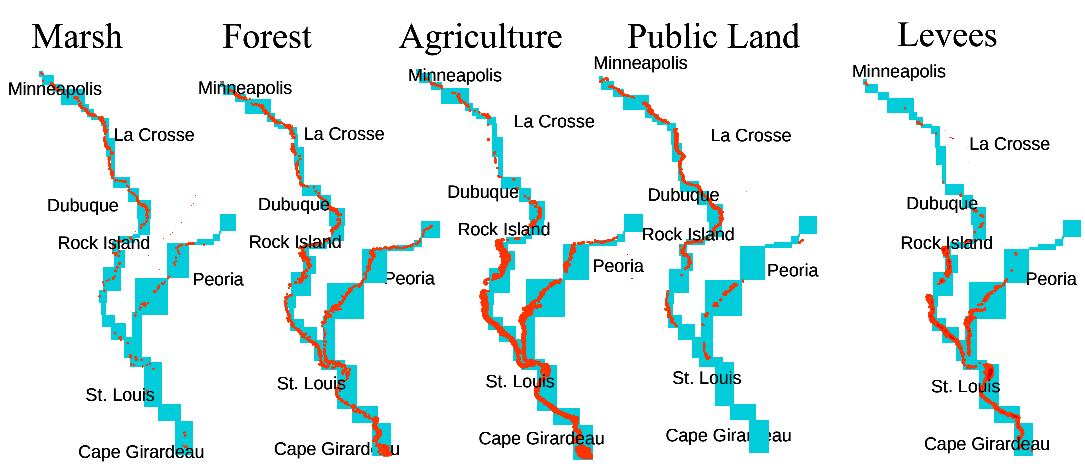


Figure 4-8. Marsh, forest, agriculture, public land, and levee distribution in the Upper Mississippi River System (USACE 2000).

4.2.2.3 Floodplain and Aquatic Areas

Geomorphic areas, or aquatic and terrestrial features within river reaches, are parts of the river system that have similar geologic origins, formed by similar river processes or man-made structures. They include channel, backwater, and floodplain areas. Aquatic areas are either contiguous (connected with the river) or isolated (normally not connected with the river). Similarly, floodplain areas are either contiguous or isolated from the river by levees that were put in place to protect people, infrastructure, and agricultural lands. The geomorphic area data is limited to Upper Mississippi River Pools 4 through 26, a reach of the Middle Mississippi River (River Miles 31-75), and the Illinois River La Grange Pool. The summary of the reach from Lake Pepin to St. Louis, Missouri, shows that about 40 percent of the total floodplain area (including both aquatic and floodplain areas) is leveed, but levees are concentrated south of Rock Island, Illinois (Figure 4-8). This figure closely approximates the amount of agriculture in the floodplain. The distribution of leveed floodplain as proportion of total floodplain area is about:

- 3 percent north of Pool 13;
- 50 percent from Pool 14 through Pool 26;
- 80 percent in the open river; and
- 60 percent of the lower 160 miles of the Illinois River.

Contiguous floodplain susceptible to seasonal flooding constitutes about 23 percent of the floodplain area system-wide. Islands are about 8 percent of the floodplain area, bringing the total terrestrial area to about 70 percent of the floodplain from Minneapolis to St. Louis.

The range of the proportional contribution of aquatic area types was 10 to 70 percent of the total river floodplain and aquatic area, which is indicative of the geomorphic variability among river reaches and the differing effects resulting from impoundment. Backwater aquatic area classes are more prominent in the northern pooled reaches, and channel habitats are more prominent in the southern pooled reaches. Overall:

- channel border is 6.6 percent of the total area,
- impounded area is 4.6 percent,
- contiguous backwaters are 3.9 percent,
- secondary channels are 3.7 percent,
- navigation channel is 3.2 percent,
- shallow aquatic area is 2.8 percent, and
- isolated backwaters are 2.0 percent.

Tailwaters, tertiary channels, tributary channels, and excavated channels are 0.2 percent or less of the total floodplain area, respectively.

4.2.2.4 Terrestrial Habitat Distribution

It is useful to examine the patterns of landscapes when assessing their ability to support desirable animal communities. An analysis of long-term change in several broad habitat classes helps assess general change over time. When examining existing conditions, or managing for discrete habitat or species, attention to fine details of habitat may be more appropriate.

<u>Grassland</u>

The Mississippi River floodplain from Iowa to southern Illinois has experienced a marked loss of grassland land cover. The extent of grassland fragmentation and conversion is the most extreme change in many parts of the UMRS. Grassland patch connectivity has been highly reduced, and connectivity to other natural habitats has been reduced where agriculture or development are adjacent to grassland patches.

Forest

Forest was and remains an important component of the floodplain landscape for many reptile, amphibian, bird, and mammal species. Contemporary forests are distributed differently and have different species composition than presettlement forests. They are even aged and have low tree species diversity. Changes in response to river and floodplain development differ among geomorphic reaches. Floodplain forests in upper pooled reaches mainly were replaced by water impounded by dams or development. Forests remaining in the upper pooled reaches have species composition similar to that in the past. In the southern pooled reaches, the lower Illinois River, and the Open River south to the Kaskaskia River, open forests and grassland-oak savannas joining dense riparian forests and grasslands were eliminated; but riparian forests remain largely intact (Figure 4-8). In the open river south of the Kaskaskia River, the floodplain was almost completely forested, but it was largely cleared and levees were constructed to provide various levels of protection.

Marsh

Marsh fragmentation is difficult to assess because river marshes were not well mapped in early periods, and they are inherently fragmented along backwater margins, wet meadows, and riverbanks. Generally, contemporary marsh communities are more abundant in northern river reaches than in southern reaches (Figure 4-8), where there are few backwaters, river water is turbid, and sediment quality is poor.

Agriculture

Croplands currently occupy about one-half of the total UMRS floodplain area, and agriculture is the dominant land cover class. Cropland distribution is skewed toward southern river reaches where levees protect the wide fertile floodplains. Agriculture is the largest continuous land cover class in the lower 500 miles of the Upper Mississippi River and the lower 200 miles of the Illinois River. Grasslands once occupied most of the current agricultural land, and forested areas were also converted to crops. Natural habitat along fencerows, riparian areas along streams and ditches, wetland patches, and set aside areas provide habitat within these agricultural landscapes. In 2000, these remnant patches made up 15 percent of the leveed areas and included native habitats characteristic of the region: forest, grassland, marsh, and open water.

4.2.2.5 Connectivity

Seasonal flooding is an ecologically important process in large river floodplain ecosystems because it connects the river with its floodplain. In the UMRS, many low elevation floodplain areas are no longer subject to seasonal flooding because they are permanently flooded from impoundment by navigation dams. Comparing pre-dam and post-dam, total open water area has decreased or remained stable in Pools 4 and 14 to 25, the Open River, and the Illinois River, but it increased in Pools 5 to 13 and 26. Stability implies that dams had little effect on the planform outline and amount of open water area. Decreases in water area are attributable to several geomorphic processes including loss of contiguous backwaters, filling of isolated backwaters, loss of secondary channels, filling between wing dams, and delta formation. Increases in water area are apparent where dam impacts inundated significant amounts of low elevation floodplain in lower pool areas.

The leveed areas enumerated above (see Figure 4-8 also) reduce aquatic habitat connectivity with floodplain habitats. Aquatic-terrestrial connectivity is important for many physical, chemical, and biological functions. Floodwater flow moves sediment and nutrients over the floodplain to shape it and to enrich the soils and rejuvenate marshes, prairies, and forests. Chemical transformations in floodplain habitats consume and transform nutrients to balance input and outputs and nutrient discharge to coastal areas (e.g., the Gulf of Mexico). Biological responses to flooding can be diverse and prolific; microbial and invertebrate production thrives on inundated floodplain vegetation, fish feed on the invertebrates and spawn in flooded land, stranded fish feed a variety of predators and scavengers, and shorebirds are drawn to exposed mud flats surrounding backwater lakes. Reduced connectivity to floodplain habitats has an impact on the functions described above, and also affects connected habitats and receiving waters by concentrating sediments and nutrients in smaller areas or shunting them downstream.

Connectivity of UMRS aquatic habitats has also been modified by dams that block fish migration on the main stem rivers and up into tributaries. Flood control and hydroelectric dams block access to over one-half of the length of tributary streams and rivers. Fish use tributaries for spawning and to seek refuge from harsh flow or water quality conditions on the main river. Upper Mississippi River System navigation dams are used to maintain low flow navigation, so the dams were constructed to allow high flows to pass freely through the dams with all gates open. Locks and Dams 1 and 19 present nearly complete barriers to upriver fish migration because they are also hydroelectric dams with high fixed crests. The other dams are open from 1 to 30 percent of the time, which provides some opportunity for upriver fish passage (Figure 4-9).

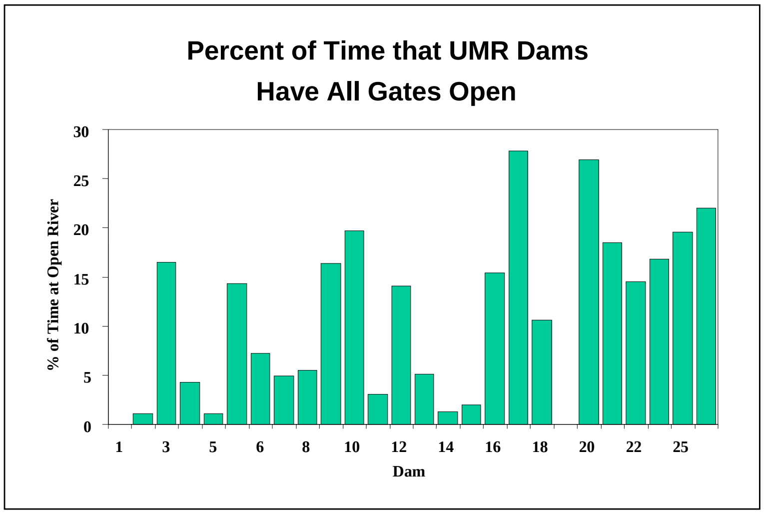


Figure 4-9. Percent of time that Upper Mississippi River navigation dam gates are raised out of the water, enabling upriver passage by some fish species.

4.2.2.6 Fragmentation

Natural habitats are highly connected south of Minneapolis to Clinton, Iowa, though river impoundments have disrupted the continuity of terrestrial floodplain communities. However, discontinuity in the distribution of public lands and levees (see Figure 4-8) has resulted in significant habitat fragmentation south of Rock Island and along the lower Illinois River. The riparian forest remains fairly contiguous in a narrow band along the longitudinal gradient of the rivers, but large tracts of other native floodplain terrestrial communities only remain as remnants in the national wildlife and fish refuges and State conservation areas.

4.2.2.7 Diversity

Habitat diversity is a measure of the different types of habitats, their size, and their relative abundance in a defined area. Habitat diversity can be calculated for both land cover and geomorphic areas. Land cover diversity is highest along Minnesota, Wisconsin, and northern parts of Illinois and Iowa in the Upper Impounded Reach (Pools 1 through 13). The other river reaches (i.e., Lower Impounded, Open River, and Lower Illinois River) have the lowest diversity scores. These lower reaches are highly developed for agriculture. Geomorphic area diversity follows a pattern very similar to land cover diversity.

4.3 Future Without-Project Conditions

The depiction of the future without-project condition represents a critical foundational element of the study background. The *without-project* condition describes the most likely condition expected to exist in the future in the absence of any change in law or public policy. The without-project condition includes any practice likely to be adopted in the private sector under existing law and policy, as well as actions that are part of broader private and public planning to alleviate transportation problems or concerns with the natural resources of the system. This is to insure that all Federal and non-Federal actions are appropriately considered. From a Federal perspective, this would include all structural and nonstructural actions that are currently authorized and are likely and foreseeable to be implemented for both navigation efficiency and ecosystem restoration. From a non-Federal perspective, it would include any potential navigation industry actions that may be taken in response to increasing congestion, or actions taken by State and non-governmental organizations to stop ecological degradation. The objective is to define the best use of existing facilities and programs to insure best utilization of the system for overall public interest concerns, including economic efficiency, safety, and environmental impact. The basic premise that applies to both the navigation system and ecosystem without-project conditions is that ongoing management activities, programs, and practices would continue throughout the 50-year planning horizon at contemporary levels of funding unless specific information suggested otherwise.

Identification of the most likely and foreseeable future conditions in the absence of any improvements to the existing UMR-IWW Navigation System or environmental resources is a fundamental first step in the evaluation of potential improvements. The without-project condition serves as a baseline against which alternative plans of improvement are evaluated. The increment of change between an alternative plan and the without-project condition provides the basis for evaluating the beneficial or adverse economic, environmental, and social effects of the considered plan.

4.3.1 UMR-IWW Navigation System

The without-project condition for the navigation system includes constructing a baseline condition that includes ongoing programs and practices likely to continue into the future. This includes continued operation and maintenance of the system at current flat-lined funding policies. The baseline also includes development of future demands for waterway transportation that are likely to occur. The future for waterway transportation for this study is being represented by five different scenarios that will ultimately result in five different without-project conditions. The without-project condition is then defined by including potential features and programs to the baseline that could potentially make better use of the existing system in the overall public interest. This includes continuation of the major rehabilitation program into the future, and potential Federal and non-Federal actions that could increase system efficiency.

A major concern of natural resource agencies since the study's beginning has been the ongoing and cumulative effects of the 9-foot channel project, including any effect from potential improvements by a Federal or non-Federal action that would increase traffic on the system. This concern helped to define the with project condition as any Federal action that would measurably increase system traffic. This results in most navigation efficiency measures being considered as part of the with-project condition.

The remainder of this section presents the baseline and most likely future without-project condition for the Upper Mississippi River and Illinois Waterway and the entire system of lock and dam structures, pools, and channels that provide the existing 9-foot-deep commercial navigation channel.

4.3.1.1 Operation and Maintenance of the Navigation System - Baseline

Operation and maintenance of the existing navigation infrastructure is expected to continue into the future. It is projected that the O&M budget will continue to be nearly flat (increasing only for inflation) at $115 million per year for the foreseeable future. Operating and maintaining the system to an acceptable level of performance will become increasingly more challenging in the future. The backlog of maintenance items will continue to grow, and the system will degrade and service interruptions will become more frequent. The reader is referred to the backlog of maintenance in Section 2.3 of the Engineering Appendix to get an appreciation for the shortcomings and uncertainties of the O&M funding. Several factors were identified that are likely to influence future operations and maintenance costs, even though they have not been significant in the past. Those factors could add as much as 10 percent to the baseline estimate, or about $11 million a year, but they were not included in the baseline estimate because of the uncertainty that they will actually occur. They include:

- New environmental constraints on channel maintenance dredging and material placement,
- Zebra mussels accelerating corrosion of unprotected steel and clogging pipes,
- Stricter painting regulations that increase costs,
- Increased lockages that increase wear and tear on lock components, and
- New security improvements and precautions at lock sites.

4.3.1.2 Traffic Forecasting – Scenario-based Approach - Baseline

In an effort to address the difficulty and inherent uncertainty of forecasting for a 50-year planning horizon, a scenario-based approach to traffic forecasting has been employed. Such an approach follows the guidance provided by the Federal Principals Task Force. The scenarios developed represent a range of alternative views of the future demand for navigation on the UMR-IWW Navigation System. A consequence of applying a scenario-based approach to traffic forecasting is multiple representations of the baseline and without-project condition. As currently constructed, individual scenarios will not be evaluated with respect to numerical probability or likelihood of occurrence. A single most probable baseline and without-project condition therefore will not be identified. The scenario-based approach is consistent with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) and Engineer Regulation (ER) 1105-2-100, the procedural and analytical framework for Corps feasibility studies. Specifically, this approach is intended to define a range of reasonable alternative future scenarios that ultimately describe the demand for inland waterway transportation of farm products for the waterway system.

4.3.1.2.1 Scenario Construct

A range of possible futures with respect to trends, policies, conditions, and events that could have an impact on the U.S. agricultural sector and export markets is considered in the scenarios. It is not presumed that the scenarios encompass the absolute extremes, but rather are limited to the more plausible.

The impacts of each scenario are translated into demand for barge transportation for farm products for the waterway system broken down by the UMR and the IWW. The demand forecast horizon was to 2050, and the resulting demand forecasts were unconstrained with respect to increases in future lock delays or waterway capacity. The farm products barge demand forecasts included breakdowns for corn, soybeans, wheat, and prepared animal feeds (or meal).

In producing unconstrained estimates of waterway demand, the scenarios contribute to the definition of the without-project condition by establishing the basis for specifying the without-project condition levels of waterway traffic. However, the unconstrained traffic estimates generated by the scenarios do not define the without-project condition levels of waterway traffic directly. The unconstrained demand must be processed through the waterway system economic model in order to identify the level of traffic "constrained" by the processing capability of the waterway system. This estimate of "constrained" traffic over the 50-year planning horizon defines the without-project condition with respect to waterway volume. As indicated above, with a scenario-based approach to traffic forecasting, multiple without-project conditions will be generated with respect to traffic.

In order to reflect a complete forecast of waterway demand, all commodity groups must be addressed. To such an end, single 50-year forecasts of waterway demand forecasts for each non-farm commodity group have been evaluated. These non-farm commodity groups are coal, agricultural chemicals, industrial chemicals, petroleum products, construction materials, iron and steel, and other products. These non-farm forecasts were based on a review and update of previously developed forecasts prepared in the mid-1990s, and by assessing those forecasts with relevant changes in market conditions and with respect to the scenarios developed for farm products. The single forecast for each non-farm group was combined with each of the scenarios for farm commodities to produce a set of scenarios that incorporated forecast waterway demand for all traffic.

The approach followed in scenario construction was built on five basic fundamentals:

1. Over the long run (5-year or longer periods), world production and world usage are by definition nearly identical.
2. Factors that affect world production indirectly affect world consumption, and factors that affect world consumption indirectly affect world production.
3. Trade between countries resolves imbalances between production and usage within countries.
4. As a surplus producer, world trade directly impacts U.S. agriculture. World needs represent export opportunities for the United States, and conversely their absence represents a lack of opportunities.
5. Barge movement volume was assumed to be unconstrained with respect to increases in the cost of water transportation.

The process of building the family of scenarios started with the construction of a central reference, the Central Scenario. The Central Scenario is intended to represent a "middle-of-the-road" U.S. export prospect. The Central Scenario essentially is a reference point with respect to the other scenarios. Around the Central Scenario, scenarios were developed that were more favorable and less favorable to U.S. agricultural trade. Each scenario has several key factors, or "drivers," that make it different and influence its relative output.

4.3.1.2.2 Scenario Drivers

To define the scenarios, four key drivers were identified that affect exports favorably or unfavorably. The key drivers are world trade, crop area, crop yield, and consumption drivers. Each key driver contains several variables that best reflect the prospects for change and scenario variation. The key drivers and the corresponding variables are displayed on Figure 4-10.

The key world trade drivers include the following:

- General world attitude toward using trade barriers to encourage or discourage trade (expansion or contraction of World Trade Organization (WTO) influence).
- Acceptance of Genetically Modified Organism (GMO) technology throughout the world and related trade limitations, if any.
- China's posture toward self-sufficiency as compared to being import dependent for food supplies.
- India's posture toward self-sufficiency as compared to being import dependent for food supplies.
- Possible shifts in relative competitiveness among major surplus producing countries.

The key crop area drivers include the following:

- Supply control policies in the United States, expressed in terms of land removed from cultivation (i.e., set-aside type policies).
- Conservation-oriented public policies removing land from cultivation.

- Cropping practices adopted to manage the problem of Hypoxia in the Gulf of Mexico.

The key crop yield drivers include the following:

- Rate and uniformity of increase.
- Climate change, including a consideration of the disparate views of the scientific community regarding global warming.

Scenario Drivers	Key Variables	Trade Scenarios: Least Favorable	Less Favorable	Central Scenario	Favorable	Most Favorable
World Trade	International trade policy (WTO)	The general movement toward less encumbered world trade relations is assumed to persist throughout the time period considered, though there will unquestionably be periods of more rapid advancement and even periods of retrenchment along with ever-present bilateral disputes.				
	GMO developments and acceptance	Identical to Central Scenario	Global non-acceptance is assumed.	Common acceptance is assumed. The use of GMO technology in grain and oilseed production is widely accepted through out the major producing regions of the world. Most importing countries accept GMO grains and oilseeds with no reservations while others require labeling of selected products derived from theri being processed. GMO technology is assumed to continue to expand into the foreseeable future.		
	China's willingness to participate in trade	Negligible grain trade is permitted with oilseed/meal trade unconstrained.	Identical to Central Scenario	Grain trade volume similar to that pledged by China as part of their WTO accension is assumed along with unconstrained oilseed/meal trade.	Identical to Most Favorable Scenario	Wheat imports more than three times and coarse grain imports nearly twice as large as those contained in the Central Scenario are permitted with unconstrained oilseed/meal trade.
	India's willingness to participate in trade	Negligible grain trade is permitted with oilseed/meal trade unconstrained.	Identical to Central Scenario	Consistent with ongoing policies, grain trade is assumed to be negligible and oilseed complex trade is unconstrained.	Identical to Central Scenario	Wheat and coarse grain imports are permitted to supply a notable portion of domestic needs with unconstrained oilseed/meal trade allowed.
	General competitiveness of U.S. agriculture	A decline in U.S. relative competitiveness is reflected by a moderation in supply availability (yield growth moderated).	Identical to Central Scenario	Assumed to be consistent with currently prevailing relationships.	Identical to Central Scenario	Identical to Central Scenario
Crop Area	U.S. supply control policy (set-a-side)	A U.S. acreage reduction policy of 5 percent is assumed to begin in 2005 and continue thereafter.	Identical to Central Scenario	Total absence of acreage limiting policies is assumed over the time period considered.	Identical to Central Scenario	Identical to Central Scenario
	Conservation issues	Identical to Central Scenario	CRP to grow by 3.2 million acres and WRP to grow by 1.25 million acres (by year 2007)	No allowance is made for policies that measurably impact cultivated area beyond that of existing programs. The development of desirable conservation practices that reduce soil, water, and air pollution will continue to evolve as they have in the past.		
	Hypoxia	Identical to Central Scenario	Specific crop area and yield impacts estimated in the Topic 6 Report on the Integrated Assessment on Hypoxia in the Gulf of Mexico were incorporated.	No specific policy addressing this issue is taken into consideration.	Identical to Central Scenario	Identical to Central Scenario
Crop Yield	Rate and uniformity of increase	A catch-up in technology used within producing areas outside the U.S. is incorporated through boosting non-U.S. yield growth rates relative to those assumed in the Central Scenario.	Global yield growth for corn and soybeans reduced by 10 % due to non-acceptance of GMO.	Yield changes consistent with that of the past 20-25 years are assumed to continue.	Identical to Central Scenario	Identical to Central Scenario
	Climatic variability	No specific adjusments are made to any scenario as sufficiently quantified impacts do not exist that deal with worldwide production.				
Consumption	Ethanol and Bio-diesel	Grain used for ethanol in the U.S. is assumed to grow nearly 30 percent faster than the more historic rate included in the Central Scenario.	Identical to Central Scenario	Growth consistent with that of the past 20-25 years is assumed to continue.	Identical to Central Scenario	Identical to Central Scenario
	Population	Central Sceanrio population estimates for the countries/regions considered are increased in line with the population implied by the U.N.'s low variant estimates.	Identical to Central Scenario	U.S. Bureau of Census population estimates used.	Identical to Central Scenario	Central Sceanrio population estimates for the countries/regions considered are increased in line with the population implied by the U.N.'s high variant estimates.
	Per capita consumption	Identical to Central Scenario	Identical to Central Scenario	Growth consistent with that of the past 20-25 years is assumed to continue.	Identical to Central Scenario	Grain and protein meal consumption growth outside the U.S. was boosted some 5 percent as compared to that of the Central Scenario.

Figure 4-10. Scenario development matrix.

The key consumption drivers include the following:

- Bulk agriculture commodity use as an alternative to petroleum-based energy (ethanol and bio-diesel).
- Alternative population growth assumptions.
- Alternative per capita consumption rates.

In order to quantify the prospects for U.S. grain and oilseed exports over an extended time frame under several defined scenarios, an analytical framework was created in which production and use were independently estimated for five geographical regions of the world (Table 4-14). The surplus or deficits implied by production/use imbalances quantify that geographic area's need for trade with a surplus implying export activity and a deficit implying an import activity.

Table 4-14. Global geographic regions.

Countries/Regions

USA Canada Mexico Brazil Argentina Other Latin America	West Europe	Central Europe FSU-15	Japan Taiwan South Korea China India Indonesia Malaysia Other Asia	Australia South Africa North Africa & Middle East Other Africa

The U.S. Department of Agriculture's World Production, Supply, and Demand database (USDA 2001) was the source of all historical area, yield, production, trade, and use data. That database begins in 1970 for most series, but is not complete across all countries of the world in the early years. The data set used in this study's analysis started with 1974 data.

4.3.1.2.3 Commodity Forecasts

Commodities included were wheat, rice, and coarse grains (corn, sorghum, barley, oats, and millet). The oilseeds included were soybeans, rapeseed, sunseed, peanuts, and cottonseed. Wheat, rice, and corn were considered individually, and the remaining grains were lumped together as other coarse grains. For oilseeds, soybeans were considered individually and the others were lumped together as other oilseeds.

The analytical horizon spanned the period 2001 through 2050. Within the analysis, annual estimates were made through 2010 and at 5-year increments through the remainder of the horizon.

In establishing production estimates, area and yield components were independently addressed (Figure 4-11). Area estimates were made with consideration given to trends that had occurred over the past 20 to 25 years, respect for cultivated area constraints suggested by historical cropping activity, and awareness of that region's agricultural characteristics. Individual and commodity group yield change rates were established with implied future yields then multiplied times area estimates to arrive at the production component.

Usage levels for each commodity group were established as the product of population estimates and per capita usage estimates. Population levels used in all scenarios quantified were directly derived from estimates made by the U.S. Department of Commerce, Bureau of the Census, and the United Nations. Per capita usage rates for grain fed to livestock, grains used in food and other uses, and for protein meal were derived for the 1975 to 2000 time frame and rates of change were estimated for the analytical horizon. Historical rates of change, along with consideration with respect to reasonableness across the usage category, were the major factors affecting change rates established for the forecast horizon. In a manner identical to production, usage estimates were then derived as the product of two components.

Within the Central Scenario, world supply and usage estimates were balanced over the forecast horizon. The balancing activity was an iterative process over the time span of the 50-year forecast horizon. The objective was to successively equate world production and world usage estimates through time in order to depict real world developments that could plausibly be expected to occur. Adjustments to area under cultivation in Argentina and Brazil were the focal point of the iterative balancing activity. Implied exports and imports are equal with the sum of either reflective of world trade volume. U.S. exports represent the portion of world trade that is estimated to be produced in the United States but not used within the United States, and for which there is an estimated deficit elsewhere.

For scenarios other than the Central Scenario, no attempt was made to balance world supply and use sums over the forecast horizon. Supply and use estimates implied by specified adjustments characterizing that alternative scenario were calculated independently. Implied country/regional imbalances quantify a need for trade under that scenario with the difference between total world supply and estimated world usage left unresolved. This inequality between estimated world supply and estimated world usage is, however, taken into consideration within the U.S. export estimates associated with each scenario. U.S. net exports implied by the scenario's U.S. production minus use calculation are adjusted up or down in proportion to the U.S. share of each commodity's Central Scenario world trade. The U.S. share of world trade within the Central Scenario is applied to the world's scenario imbalance. If the world imbalance is characterized by supply being greater than usage, the U.S. export estimate is adjusted proportionally downward; and if the world imbalance is characterized by usage greater than supply, the U.S. export estimate is adjusted proportionally upward. This approach allows the evaluation of adjustment combinations that could not practically be considered otherwise. At the same time, however, it also yields U.S. export levels that are biased upward in strong export scenarios and biased downward in weak export scenarios.

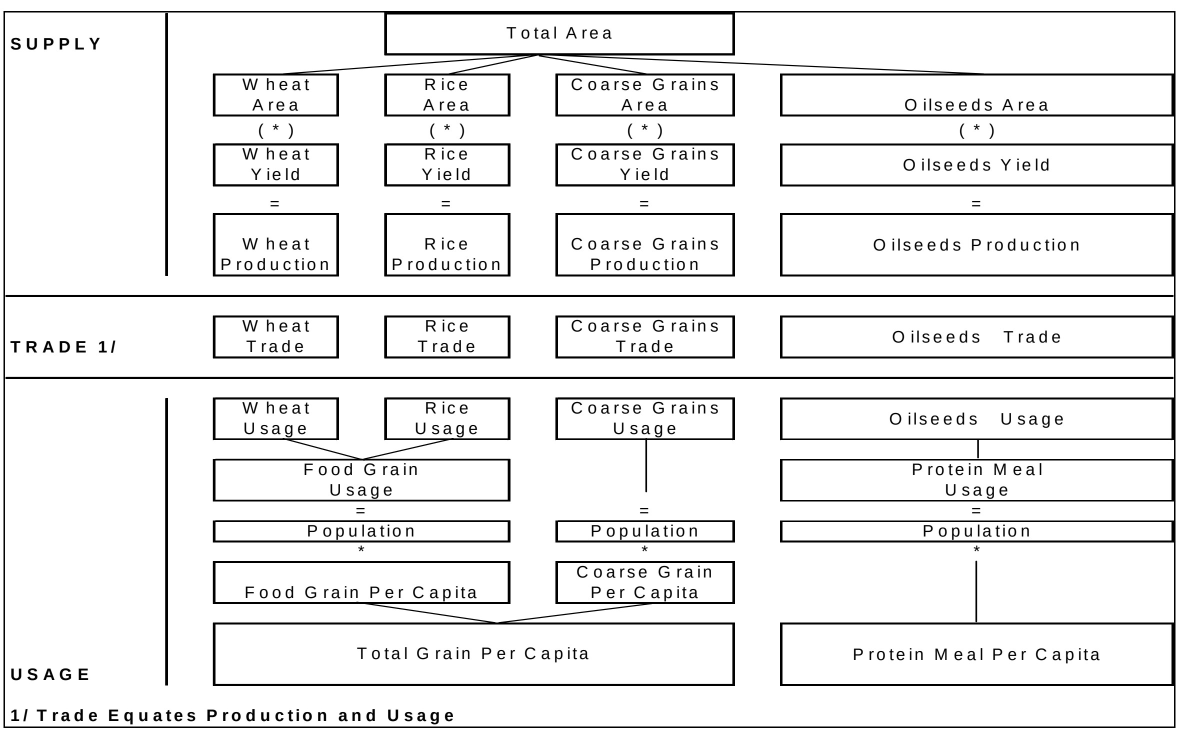


Figure 4-11. Country/region analytic framework.

The volume of grain moved on the UMR and IWW was determined by first allocating total U.S. exports of grain (corn, wheat, soybeans, and animal feed) by port range (Lakes, Atlantic, Center Gulf, Texas Gulf, Pacific, and Interior). The allocation of exports by port range was determined by applying the base year data (1995-2000), obtained from the U.S. Department of Agriculture's Federal Grain Inspection Service port share of grain to the export forecast for each grain. Barges of grain from the UMR and IWW are transported to ports located in the Center Gulf port range. The Center Gulf port range is located at the mouth of the Mississippi River where its confluence drains into the Gulf of Mexico. The Center Gulf port range includes ports where export grain elevators are located. Barges of grain that originated on the UMR-IWW are moved to these export elevators where either the grain is unloaded into temporary storage for loading onto a bulk ocean vessel or the grain is unloaded directly from the barge into the ocean vessel. The volume of grain moved on each river segment was determined by applying the river segment share of the base year data (1995-2000) to that of Center Gulf exports.

The results for barge demand in this study are reported as barge movements for each river segment, the UMR or the IWW, and were unconstrained by infrastructure. The forecasted volume of traffic on the UMR accounts for movements that either originated or terminated on the UMR, but does not include traffic that originated or terminated on the IWW.

A summary of the values and assumptions for key drivers for all scenarios, expressed relative to the Central Scenario is shown in Table 4-15. Total farm product movement projections for the various scenarios are presented in Tables 4-14 through 4-18. Projections for individual crops are presented in the paragraphs below.

4.3.1.2.4 Demand for Waterway Transportation

Exports of corn, wheat, soybeans, and protein meal were historically high in 1981 at 130.4 million metric tons. Over a 3-year period, 1979-1981, exports averaged 129.2 million metric tons. In 2000, exports of those same grains totaled 108.2 million metric tons, 17 percent below the historical high, but 50 percent greater than the level of exports in 1974. Between 1995 and 2000, total exports averaged 104.8 million metric tons per year. Based on the Central Scenario, exports are forecast to total 130.2 million metric tons in 2025 and 145.9 million metric tons in 2050. Somewhere between 2020 and 2025, total grain exports are forecast to equal the historical high, nearly 4 decades later. The range of exports across all scenarios by 2050 is projected to be as high as 161.4 million metric tons under the Most Favorable Trade Scenario, to as low as 36.8 million metric tons under the Least Favorable Trade Scenario. The range of exports could be as much as 15.5 million metric tons higher than the Central Scenario's projected export level or 109.1 million metric tons below the Central Scenario.

Exports of corn are expected to increase initially before retracting in about 2040 under all scenarios except the Least Favorable Trade Scenario. Under the Least Favorable Trade Scenario, corn exports are expected to be lower than exports in 2000 and to fall below 5 million metric tons by 2050. Corn exports are expected to be at their highest level at 123.0 million metric tons in 2040 under the Most Favorable Trade Scenario. The next highest level for corn exports is under the Favorable Trade Scenario, but its high in 2040 would be about 5 million metric tons more than the Central Scenario high. The historical high for corn exports was 61 million metric tons in 1979, and depending on the scenario, corn exports could reach that level as early as 2007 under the Most Favorable Trade Scenario, to as late as sometime between 2015 and 2020.

Regardless of the scenario, exports of wheat are expected to decrease throughout the forecast period. Under the Least Favorable Trade and Less Favorable Trade scenarios, wheat exports are expected to fall below 5 million metric tons by 2050 and to be close to 10 million metric tons in all the other scenarios.

Soybean exports are expected to be higher under all scenarios. The Central, Favorable Trade, and Less Favorable Trade Scenarios all increase in a similar fashion. Under the Most Favorable Trade Scenario, soybean exports initially rise to 37 million metric tons in 2035 before declining to 32.5 million metric tons in 2050. The reduction in soybean exports under the Most Favorable Trade Scenario after 2035 occurs as U.S. consumption increases and draws down soybean exports.

As with the case of wheat exports, protein or prepared animal feed exports are expected to be lower in all scenarios through 2050. However, while exports under the Most Favorable Trade Scenario are mostly less than the Central and Favorable Trade Scenarios, exports of protein meal are expected to rebound after 2020 under the Most Favorable Trade Scenario.

The other commodity forecasts in this evaluation are adjustments made to a report prepared for the Corps during the mid-1990s by Jack Faucett and Associates (JFA). Industry experts for each of the other commodities prepared detailed forecasts for the JFA report. Since the original forecast had a greater level of detail, the original forecasts were replaced, modified, or re-specified only if a major assumption had changed. The forecasts from the JFA report were updated using barge movement data through the year 2000. The JFA report developed forecasts of the demand for barge transportation of coal and coke, fertilizer, industrial chemicals, petroleum products, construction materials, iron and steel, and other miscellaneous products for the UMR-IWW Navigation System.

For this effort, independent forecasts were specified as necessary, or modifications made to the original forecasts were adopted if a major assumption from the previous report required changing, or if the Central Scenario in the farm products section of this analysis warranted substantial changes to the forecast for other commodities from the mid-1990s report. In addition, all other commodities were examined by making forecasts using macro economic variables, and then comparing the results to the original forecast.

In general, the assumptions and forecasts for coal and coke, petroleum products, fertilizer, construction materials, and other products from the JFA report are still valid. For all other commodities, the absolute levels of barge movements for 2000 are adjusted to reflect the most recent data. The forecasted change in barge movement volumes over the next 50 years is consistent with the original forecasts for coal and coke, petroleum products, fertilizer, construction material, and other products. Major modifications were made to the original forecasts for iron and steel and industrial chemicals due to assumptions that have since changed. The non-farm commodity barge movements are summarized in Table 4-20. UMR-IWW unconstrained tonnage forecasts for total farm products are summarized on Figure 4-12 below. Similarly, unconstrained forecasts for all commodities are summarized on Figure 4-13.

4.3.1.2.5 Scenario Traffic Forecast Comparison with USDA 10-year Grain Projections

A comparison was made between the Sparks scenarios described above and the U.S. Department of Agriculture's 10-year projection for soybeans (Figure 4-14) and corn (Figure 4-15). The USDA offers the following note to users of its baseline projections: "*USDA long-term agricultural baseline projections presented in this report are a Departmental consensus on a long-run scenario for the agricultural sector. These projections provide a starting point for discussion of alternative outcomes for the sector*." The note goes on the say, "*The scenario presented in this report is not a USDA forecast about the future. Instead, it is a conditional, long-run scenario about what would be expected to happen under a continuation of the 2002 Farm Act and specific assumptions about external conditions*."

In a recent letter to the Mississippi Valley Division Commander dated 24 February 2004, USDA writes: "*The UMR-IWW is a critical component of the U.S. agricultural transportation system. About one-half of the U.S. corn exports and about a third of the U.S. soybean exports are shipped on the UMR-IWW. USDA's latest Baseline Projections show corn production increasing 14 percent by 2013. Projections for corn exports show a 53 percent increase for the next decade. The Baseline's increase in export growth is* *consistent with the positive growth scenarios used in the Corps' feasibility study*." A follow-up letter (dated July 30, 2004) re-affirmed these major points. A summary of the USDA position can be found in Chapter 13. Their July 30 letter can be found in the Response to Comments Appendix.

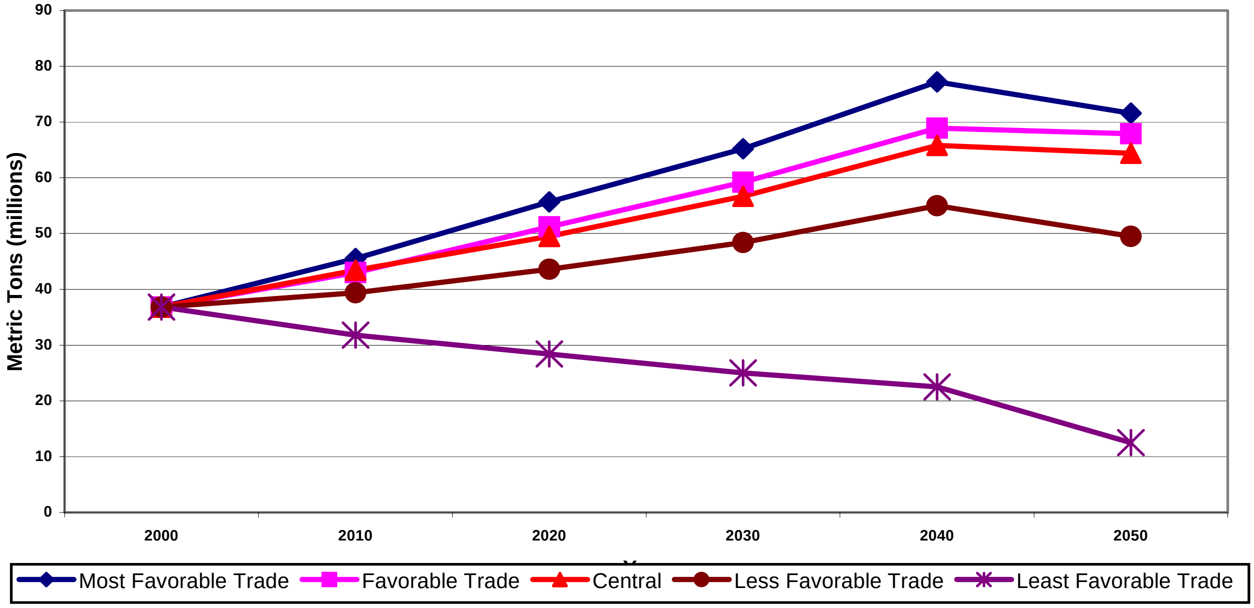


Figure 4-12. Upper Mississippi River System unconstrained traffic forecasts of total farm product movements by scenario.

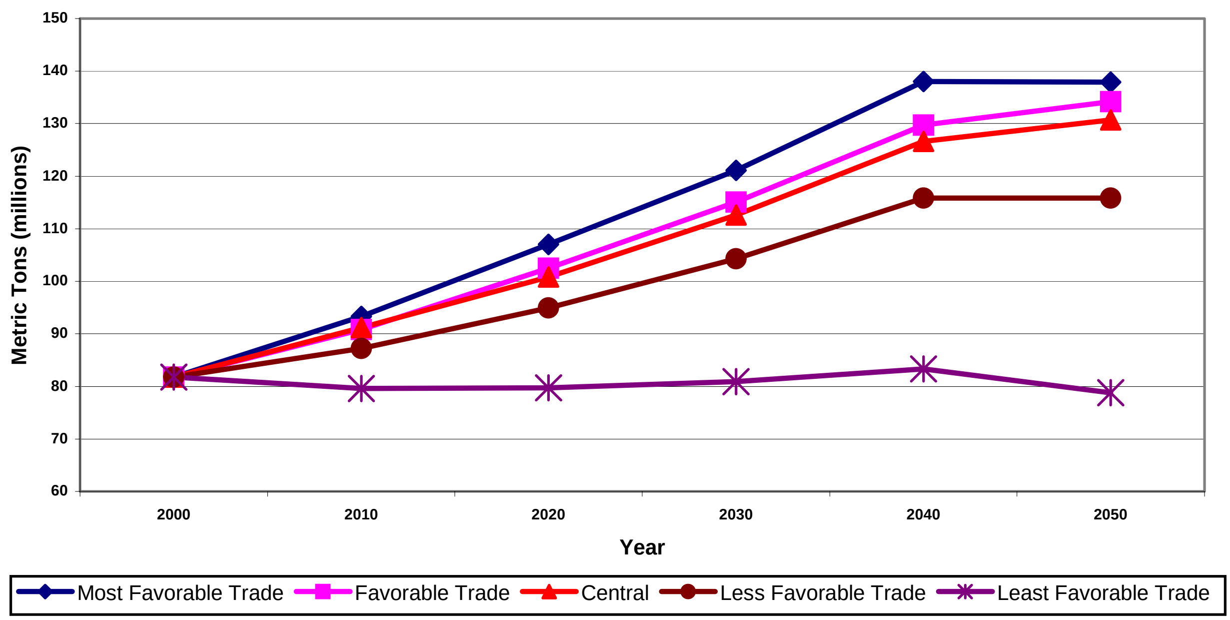


Figure 4-13. Upper Mississippi River System unconstrained traffic forecasts of all commodities by scenario.

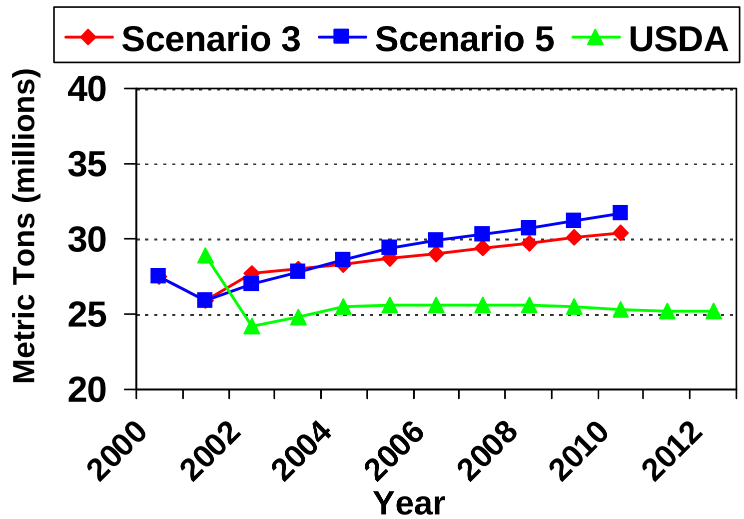


Figure 4-14. Comparison of the Sparks scenarios and the USDA 10-year projection for soybeans.

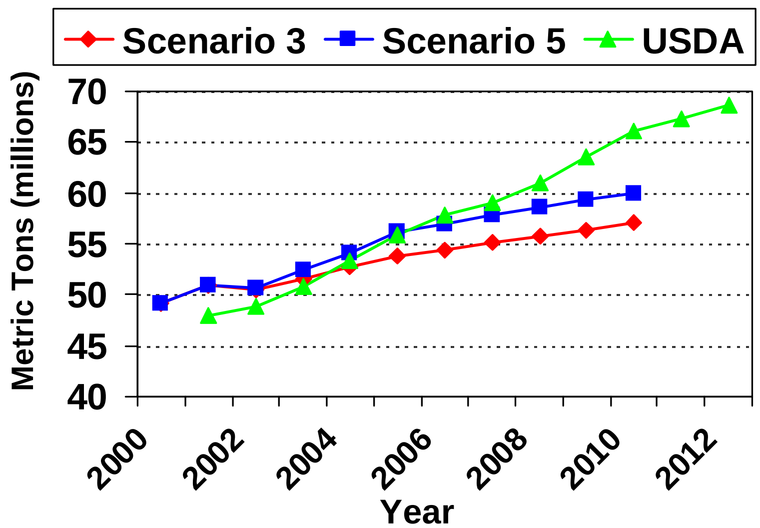


Figure 4-15. Comparison of the Sparks scenarios and the USDA 10-year projection for corn.

Table 4-15. Upper Mississippi River System total farm product movements – Central Scenario (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Corn	24.0	38.1	46.9	14.1	8.8
Soybeans	10.2	13.5	16.5	3.3	2.9
Wheat	0.9	0.6	0.4	-0.3	-0.3
Meal	1.7	0.7	0.6	-1.0	-0.1
Total	36.8	52.9	64.3	16.1	11.4

Table 4-16. Upper Mississippi River System total farm product movements – Most Favorable Trade Scenario (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Corn	24.0	45.1	58.4	21.1	13.4
Soybeans	10.2	14.0	12.3	3.8	-1.7
Wheat	0.9	0.7	0.3	-0.2	-0.4
Meal	1.7	0.6	0.6	-1.1	0.0
Total	36.8	60.4	71.7	23.6	11.3

Table 4-17. Upper Mississippi River System total farm product movements – Favorable Trade Scenario (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Corn	24.0	40.0	50.0	16.1	10.0
Soybeans	10.2	13.5	17.0	3.3	3.4
Wheat	0.9	0.6	0.4	-0.3	-0.3
Meal	1.7	0.7	0.5	-1.0	-0.2
Total	36.8	54.9	67.9	18.1	13.0

Table 4-18. Upper Mississippi River System total farm product movements – Less Favorable Trade Scenario (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Corn	24.0	32.7	35.1	8.7	2.4
Soybeans	10.2	12.9	14.4	2.7	1.5
Wheat	0.9	0.3	0.0	-0.6	-0.3
Meal	1.7	0.1	0.0	-1.6	-0.1
Total	36.8	46.0	49.4	9.2	3.4

Table 4-19. Upper Mississippi River System total farm product movements – Least Favorable Trade Scenario (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Corn	24.0	15.3	0.7	-8.7	-14.6
Soybeans	10.2	10.2	11.3	0.0	1.1
Wheat	0.9	0.3	0.1	-0.6	-0.2
Meal	1.7	0.5	0.4	-1.3	0.0
Total	36.8	26.3	12.5	-10.5	-13.7

Table 4-20. Summary of non-farm commodity barge movements, Upper Mississippi River System (million metric tons).

	2000	2025	2050	Change 00-25	Change 25-50
Coal and Coke	8.2	9.0	10.9	0.8	1.9
Pet. Prods.	8.5	9.4	9.1	0.9	-0.4
Agri. Chem.	3.1	2.9	2.6	-0.2	-0.2
Const. Mat.	10.0	11.4	13.6	1.4	2.3
Indus. Chem	4.1	6.8	12.0	2.6	5.3
Iron and Steel	6.4	7.4	9.0	1.0	1.6
Miscellaneous	4.7	6.8	9.1	2.1	2.3
Total Non-Farm	45.0	53.7	66.3	8.6	12.6

4.3.1.3 Major Rehabilitation Program for Locks and Dams: Without-Project Condition

In order to provide continued service, it will be necessary to make recurring expenditures over and above those associated with operations and maintenance. These recurring expenditures, referred to as major rehabilitation, will be required at every lock site in the system during the next 50 years. The need for future rehabilitation of locks and dams was based on a qualitative assessment using historical data, lock cycle analysis, and engineering judgment to estimate which components were likely to require restoration and when they would be required over the 50-year planning horizon. It was determined that periodic rehabilitation would be needed at most lock and dam sites approximately every 25 years, with variations based on equipment needs, degree of barge impact to gates and concrete, weather-related deterioration, and modernization. Major rehabilitation projects have the effect of increasing reliability by reducing lock closures, a significant consequence of unreliable performance. Anticipated future rehabilitation needs were determined to be $25 to $30 million per lock site, and $15 million per dam for each 25-year cycle of rehabilitation (1997 price levels). Therefore, two rehabilitation undertakings were planned over the 50-year period for each of the 37 lock and dam sites.

The timing of major rehabilitations was estimated based on historical occurrences of rehabilitations. A cost sensitivity analysis was performed for the future with-project condition (although this section pertains to without-project discussion, the results are pertinent) to determine the impacts if the interval between rehabilitations was shortened by five years. The result was that the additional cost of more frequent rehabilitations was minimal compared to the cost for whole system. Conversely, if major rehabilitations were not performed or significantly delayed, there would be increasing unreliability and lock closures on the system. Such a future with extreme funding constraints was not considered since the B/C ratio for the base system is greater than 5:1 making it an economical investment.

The study concluded that the life of existing locks and dams and their components can be extended for another 50 years with normal periodic rehabilitation and match the design life of any new construction being considered as part of the “with-project” condition.

When projected over the 50-year planning horizon, the total cost of the navigation system is projected to be an average annual amount of approximately $181 million a year for the entire UMR-IWW Navigation System (annual operation and maintenance costs of $115 to $126 million and annual rehabilitation costs of approximately $65 million).

It is assumed that since the current system is economically justified, major rehabilitation of the locks and dams in the without-project condition will continue to occur in the future to keep the system operating to an acceptable level of performance. Major rehabilitation projects have been demonstrated to be economically justified in the past, which reinforces the determination for their continuance in the future. This feasibility study is not seeking approval for appropriations of future major rehabilitations. The assumption is that individual Rehabilitation Evaluation Reports will be completed in the future that will seek appropriation on a site-by-site basis.

4.3.1.4 Lockage Efficiency Improvement Measures: Without-Project Condition

The existing system was evaluated to determine if additional efficiencies could be gained under existing authorizations and be included as part of the without-project condition. Table 4-21 summarizes these without-project measures that could occur to some level and contribute to system efficiencies. More details of these measures are contained in Section 3 of the Engineering Appendix and in Engineering Reports #6 *Detailed Assessment of Small-Scale Measures* and #7 *Summary of Small-Scale Measures Screening.*

Table 4-21. Without-project small-scale measures to improve lockage efficiency.

Helper Boats
Lock Operating Procedures
Industry Self Help
N-up / N-down Servicing
Recreational Vessel Lockages
Deck Winches
OMNI System
Switchboats

4.3.1.4.1 Helper Boats

Helper boats (800 to 1,200 horsepower) are an industry initiative to provide a safer and faster approach to the locks that experience severe outdraft. Currently, an average of 80 percent of downbound double-cut tows receive assistance at Locks 20 through 25. The other 20 percent of downbound double-cut tow lockages occur during non-outdraft conditions or do not request assistance. This profile of use is expected to continue into the future, and the timesaving is incorporated into the without-project condition based on its existing level of use.

4.3.1.4.2 Lock Operating Procedures

The current operating policy for the navigation system is first come, first served for commercial tows. However, the lockmasters can, and often do, depart from this procedure when warranted to obtain greater efficiency. It has been assumed that all system locks will use the most efficient locking policies that are deemed to be acceptable from both safety and operational perspectives. This includes the use of industry self-help and N-up/N-down servicing.

4.3.1.4.2.1 Industry Self-Help

Industry self-help is a practice employed during double lockages to reduce total lockage time and improve overall lock performance. With industry self-help, the first cut of the double lockage can be moved to the guidewall or hauled to a remote site where the tow will be reassembled. This is accomplished by means of a towboat in the queue disengaging from its own barges and assisting with the extraction of the first cut of the double lockage. The efficiency gain results from the double-locking tow being able to reassemble without occupying the chamber. A variety of factors and conditions, which can be site specific, limit the times when self-help can actually be implemented. With these restrictions factored in, industry self-help currently results in approximately 5 to 15 minutes in savings, on average, for a double lockage.

Currently, industry self-help is used on a limited basis. Table 4-22 displays contemporary (1992-1998) use of vessel-assisted exits for double lockages at selected sites on the Mississippi River. The data in the table are taken from the Lock Performance Monitoring System (LPMS). Inspection of the data reveals that vessel assists on exit for double lockages were generally in the 1 to 2 percent range.

It would be reasonable to expect that the future use of industry self-help would increase with an expected increase in congestion. However, because of a number of considerations, including potential liability (for both waterway operators and the Federal Government), safety, and the potential for adverse environmental effects, the use of self-help in the future was assumed to be restricted to contemporary usage, which is about 1.8 percent of all tow lockages for the average of Locks 20 through 25.

Table 4-22. Contemporary (1992-98) percentage of double lockage tows using industry self-help

Percentage of Double Lockage Tows using Industry Self Help								
Lock	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**Average**
UM11	0.1%	1.0%	1.0%	1.6%	1.6%	0.8%	2.8%	1.1%
UM12	0.0%	1.0%	0.0%	0.0%	0.2%	0.1%	0.0%	0.2%
UM13	0.0%	0.3%	0.0%	0.1%	0.6%	0.1%	0.0%	0.2%
UM14	0.0%	0.5%	0.0%	0.0%	1.2%	3.1%	8.8%	1.2%
UM15	0.0%	1.0%	0.2%	0.8%	0.3%	0.5%	2.9%	0.6%
UM16	0.0%	0.5%	0.0%	0.0%	0.9%	0.9%	2.9%	0.5%
UM17	0.0%	1.3%	0.1%	0.0%	0.3%	0.1%	0.0%	0.2%
UM18	0.1%	1.6%	0.1%	1.3%	1.1%	0.3%	0.0%	0.7%
UM20	0.3%	6.8%	0.5%	1.8%	6.9%	0.1%	3.1%	2.7%
UM21	0.1%	1.9%	1.0%	0.5%	0.8%	1.1%	13.9%	1.5%
UM22	0.6%	2.0%	0.2%	0.2%	0.2%	0.6%	0.1%	0.5%
UM24	0.6%	3.3%	0.4%	3.4%	2.0%	0.8%	1.7%	1.8%
UM25	4.5%	2.1%	2.8%	2.2%	2.3%	1.0%	1.0%	2.5%
Average	**0.5%**	**1.8%**	**0.5%**	**0.9%**	**1.4%**	**0.7%**	**2.9%**	**1.1%**

Source: Lock Performance Monitoring System

Note: Some of the higher uses such as Locks 14 and 21 in 1998 account for assist on downbound exits primarily for safety reasons related to construction, not specifically for efficiency.

4.3.1.4.2.2 N-up/N-down Servicing

The practice of N-up/ N-down servicing is another means by which additional operational efficiency can be derived. The primary benefit of N-up/N-down arises from minimizing approach times. N-up/ N-down servicing, multiple upstream lockages followed by multiple downstream lockages, results in a higher percentage of turnback lockages (next tow traveling in the same direction) that generally take significantly less time than exchange lockages (next tow traveling in the opposite direction). The time savings of replacing an exchange lockage with a turnback lockage is on average approximately 10 minutes on single lockages and 17 minutes on double lockages. However, the additional time associated with turning back the chamber (averaging 11 minutes) reduces the time savings. As a result, the net savings of N-up/N-down servicing is roughly 6 minutes to double lockage tows. The use of N-up/N-down is expected to continue into the future whenever queue lengths exceed six tows upstream and downstream.

4.3.1.4.3 Recreational Vessel Lockages

Current operating policies state that recreational vessels will not be required to wait for more than three commercial lockages before being locked. In many cases, recreational vessels are locked between every commercial lockage. While recreational vessel lockages typically take a relatively short time (approximately 15 minutes at Mississippi River sites and 20 minutes at Illinois Waterway sites) and can use the chamber when it is being turned back for the next tow, they do affect the overall scheduling of lockages. It is assumed that the existing policies for recreational lockages will continue through the period of analysis. Any growth in the number of recreational craft on the river can be accommodated by placing more recreational craft in the lock chamber during a recreational craft lockage.

4.3.1.4.4 Deck Winches

Mounting deck winches on all barges could reduce the time to tighten the primary fore/aft couplings. Permanent deck winches have had limited use primarily on petroleum/chemical barges, and one company has outfitted all its barges with deck winches. However, widespread implementation is not anticipated because of the relatively high costs and lower potential for the company making the expenditure to gain the full benefits. The concern over the benefits relates to the fact that the hopper barges in the system's fleet are essentially interchangeable and a barge owned by one company may frequently be found in the tow of another company. As a result, the assumed benefit of purchasing winches would not necessarily be accrued by the company that made the investment. The without-project condition assumes no increase in the use of winches above the current usage.

4.3.1.4.5 OMNI System

A recording system called OMNI (Operations and Maintenance Navigation Information) collects and stores daily hydraulic data, weather conditions, and equipment conditions at each lock site. Vessel name and number, number of barges and commodities being hauled, and pool and tail water levels are included in the stored data. This information is available online and is currently being used by the navigation industry as a transportation management tool. Further information on this system can be accessed from the OMNI website http://www.mvr.usace.army.mil/mvrimi/omni/webrpts/default.asp.

4.3.1.4.6 Switchboats Provided by Federal Action

Implementation of switchboats is within the Corps' current O&M authorization, although the authority cannot require industry to use switchboats except under emergency conditions. The only available funding source for placement of switchboats is the O&M Appropriation, which is not sufficient to fund the yearly costs. In addition, there are environmental considerations as stated above that will control its use. Implementation of switchboats as a Federal without-project action is not likely and foreseeable.

4.3.1.4.7 Switchboats Provided by Non-Federal Action

Switchboats in the form of industry self-help are expected to continue at current levels into the future. Additional switchboat use will also be limited by the environmental considerations outlined above.

4.3.1.5 Additional Considerations

4.3.1.5.1 Open River Conditions

At times on the Illinois Waterway at the Peoria and La Grange sites, flow conditions permit navigation transit over the dams. During these periods, referred to as open river, use of the locks is not necessary. Periods of open river are significant in that transit time is considerably shorter compared to times when transit through the locks is required. Open river periods have varied significantly from year to year (3 percent to 98 percent) and month to month. For the period 1939 to 1998, open river was observed approximately 38 percent and 42 percent of the time for Peoria and La Grange, respectively.

The historical pattern of open pass at Peoria and La Grange has been incorporated into the specification of transit curves, which describe the relationship between traffic volume and expected annual delay. This is described in Chapter 4 of the Economic Appendix. Figure 4-16 graphically displays the historical open river percentages at Peoria and La Grange and shows that the year-to-year annual percentages at the two sites have tracked closely over the years.

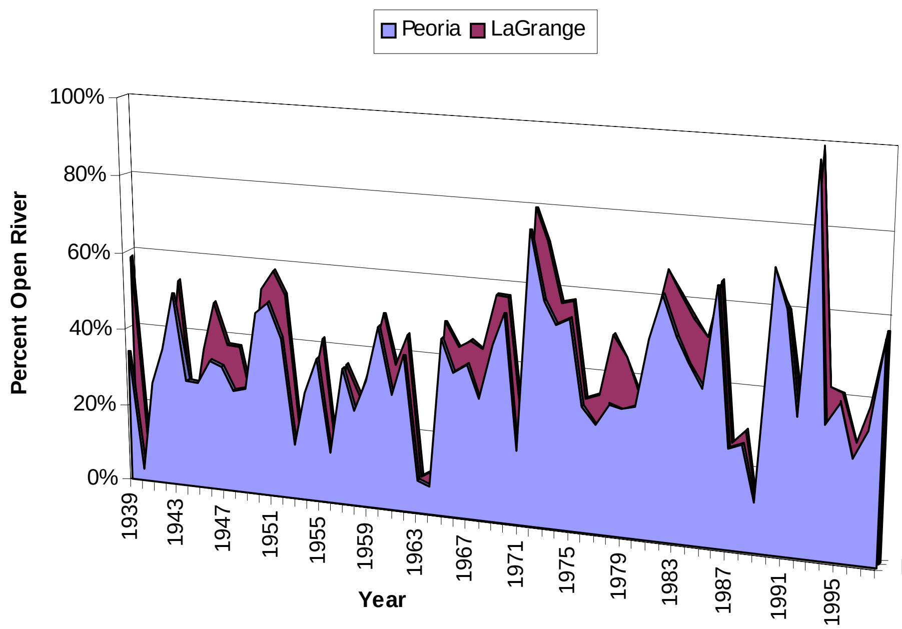


Figure 4-16. Historical (1939-98) percentage of the navigation season that wicket gates at Peoria and La Grange dams were down, allowing open river passage by commercial tows.

4.3.1.5.2 Alternative Mode Capacity

Alternative non-water transportation modes are assumed to have sufficient capability to move all traffic that would not be accommodated by water. All traffic moving by non-water modes in the future was assumed to do so at current real (constant dollar) prices.

The above assumption follows directly from the planning guidance provided in Engineer Regulation (ER) 1105-02-100. The relevant section of this guidance indicates that, "*the without-project condition normally assumes that the alternative modes have sufficient capacity to move traffic at current rates unless there is specific evidence to the contrary.*" This feasibility study investigated the issue of railroad capacity and addressed the question of future railroad rates in the face of significant volumes of potential waterway demand going unmet due to an increase in the cost of water transportation. The investigation is documented in a separate volume, "*The Incremental Cost of Transportation Capacity in Freight Railroading*." That work concluded, "*In most cases, the line-haul segments that, together, form the routes over which expanded traffic flows must be accommodated can be modified to do so without-placing undesirable pressure on competitively developed railroad rates.*"

Comments generated during the review of the work did not constitute a basis for an alternative conclusion. Therefore, in the absence of specific evidence to the contrary, the guidance provided by ER 1105-02-100 of a perfectly elastic supply of alternative mode service was incorporated into this feasibility analysis.

4.3.1.5.3 Unmodeled Waterway System

Delay and congestion costs at other potential system constraint points not explicitly modeled will not change significantly over the period of analysis. Also, all existing waterway projects across the national waterway system will be operated and maintained through the period of analysis.

4.3.1.5.4 User Taxes

Waterway user taxes will continue in the form of the towboat fuel tax prescribed by the Water Resources Development Act of 1986, Public Law 99-662. In a letter dated July 30, 2004 the Midwest Area River Coalition (MARC) 2000 states: "*Since 1980, an estimated 40 percent of the funds collected by a $.20 per gallon tax on diesel fuel have come from traffic originating or terminating in the Upper Mississippi River study area. Trust Fund documents demonstrate that only 15 percent have returned to the region.*" This letter is provided in its entirety in the Response to Comments Appendix. In accordance with the cost share specifications described in Section 102 of the Water and Resource Development Act of 1986, one-half of the cost of navigation improvement construction shall be paid from amounts appropriated from the general fund of the U.S. Treasury and one-half of the cost of construction shall be paid from the amounts appropriated from the Inland Waterways Trust Fund.

4.3.1.6 Environmental Consequences

The five without-project traffic projections and continued without-project operation and maintenance of the UMR–IWW Navigation System would have foreseeable environmental consequences. Such consequences are generally viewed as potentially negative for traffic scenarios 2 through 5 (increased traffic) and potentially positive for scenario 1 (decreased traffic). The assessment of environmental consequences for the future without-project conditions were developed based on decadal increments of commercial traffic projections (years 2000, 2010, 2020, 2030, 2040, and 2050). The system-wide effects of without-project increases in commercial traffic were generally driven by hydraulic disturbances that would primarily affect the aquatic environment and aquatic resources. Because the hydraulic disturbances produced by commercial traffic do not extend to floodplain areas (except where increased bank erosion may occur), floodplain terrestrial habitats and organisms would be largely unaffected. The following provides a listing of significant environmental resources and processes that would potentially be affected by the without-project traffic and continued O&M practices:

Significant aquatic resources:

- Fish
- Aquatic plant community (emergent/rooted floating leaf/submersed aquatic vegetation)
- Freshwater mussels

Significant ecological processes:

- Bank erosion
- Sediment transport into and deposition in backwaters and side channels

Significant floodplain resources:

- Cultural resource sites along main channel banklines
- Site-specific endangered resources along main channel banklines

A full disclosure of the methodology and findings from these evaluations can be found in the EIS Supplemental Documentation Appendix. The following paragraphs provide a summation of the without-project environmental consequences.

4.3.1.6.1 Fisheries

It is important to consider impacts to fisheries because there are many sport, commercial, forage, and predatory species, as well as the Federal- and State-listed protected species, living in affected habitats. Fish are variously affected in their larval, fry, juvenile, and adult stages. Several riverine fish species (freshwater drum, walleye, etc.) have a pelagic larval stage where they drift in the main channel as they absorb their yolk and develop into swimming fry. After they become swimming fry, they may move to more sheltered habitat out of the main channel and away from barge traffic. There, they feed and grow to a juvenile stage, where they may or may not shift habitats again. Most often, juveniles and most adults are found together, but a few adults may achieve a size where predation pressures are minimal and they can exploit a wide variety of habitats. Impacts from navigation traffic are in the form of shear stress and wake wave stranding of larval fish, direct impacts of propeller strikes on adult fish, and habitat degradation in terms of hydraulic disturbance, sediment resuspension, plant bed erosion, and other indirect effects.

Results: The NavLEM model (see Chapter 8) was used to estimate the effect of commercial navigation on fish population. Without-project estimates of fish mortality varied between fish species. The large numbers of larvae estimated to be entrained and killed translate into orders of magnitude fewer adults lost as represented in Table 4-23.

Table 4-23. Estimated number of equivalent adult fish lost annually due to commercial navigation Year 2000.

	Mississippi River					Illinois Waterway		
Species	Pools USA-3	Pools 4-8	Pools 9-15	Pools 16-27	Open River	Lower	Middle	Upper
Bigmouth Buffalo	1	10	41	114	112	22	10	6
Crappie	132	807	4,226	1,889	371	1,656	796	491
Blue Catfish	0	0	326	837	52	0	0	0
Bluegill	4	150	2,312	5,221	24	157	75	47
Blue Sucker	0	0	7	3	3	0	0	0
Channel Catfish	188	25	1,813	9,274	639	2,758	1,420	807
Freshwater Drum	149	557	6,137	13,027	670	3,116	1,482	947
Flathead Catfish	31	10	274	1,070	152	584	283	162
Goldeye	8	49	640	1,328	616	205	98	0
Sturgeon	13	183	580	1,425	2,962	688	329	0
Largemouth Bass	1	1	28	145	143	92	45	27
Mooneye	14	103	1,410	2,193	1,261	544	0	0
Paddlefish	19	150	483	1,035	1,135	561	0	0
Northern Pike	47	259	791	1,161	1,290	551	272	150
River Carpsucker	11	148	574	1,350	497	757	363	217
Sauger	371	152	1,235	3,252	530	1,022	474	289
Smallmouth Bass	1	1	17	92	99	56	27	15
Smallmouth Buffalo	2	31	127	347	348	155	33	21
Spotted Sucker	446	703	29,098	12,804	5,977	12,135	5,684	0
Shorthead Redhorse	14	34	1,137	637	335	732	349	218
Walleye	64	26	214	564	92	177	82	50
White Bass	135	4,061	6,137	5,148	286	3,940	1,878	659
Bowfin	2,989	18,420	59,337	127,833	167,391	71,759	33,438	1,039
Common Carp	458	841	24,262	80,906	3,139	36,960	17,763	10,538
Emerald Shiner	151	5,758	53,880	35,906	812	116,571	58,414	32,792
Gizzard Shad	2,228	2,031	7,918	40,321	71,440	108,197	54,400	31,495
Shortnose Gar	978	5,712	16,955	19,798	2,477	2,028	1,023	0
TOTALS	8,455	40,222	219,959	367,680	262,853	365,423	178,738	79,970

The fisheries are generally expected to maintain their existing community structure and distribution in the without-project condition. Invasive species such as the silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*) are expected to expand their range within the UMRS. Reasonable and prudent measures will continue to be implemented to protect the pallid sturgeon (*Scaphirhynchus albus*).

4.3.1.6.2 Submersed aquatic plants

Several studies were performed to identify the physical forces created by commercial navigation on the environments around them. It was found that the greatest ecological stressors created by passing commercial craft included physical breakage from waves and resuspension of sediments, which inhibited plant photosynthesis. These ecological stressors had the greatest potential to effect submersed aquatic vegetation with lesser effects on floating leaf and emergent aquatic plants. Submersed aquatic plants are keystone components of the aquatic system because they provide habitat, structure, and food to a variety of invertebrates and fish that feed on them. They are a critical primary producer that converts nutrient energy and sunlight into forms that can be exploited by primary consumers (i.e., invertebrates), which fuel they secondary consumers in the system. In the UMRS, American wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*) were identified as two species subject to barge disturbance in channel borders. These species were selected as representative species for plant growth modeling because they are common and important species in the UMR, information in the literature on their growth is useful for model calibration, and they exhibit different growth forms. Sediment resuspended by passing vessels reduces underwater light and can reduce photosynthesis, growth, and reproduction by plants.

Results: In the without-project condition, submersed aquatic plant beds are expected to maintain their existing community structure and distribution. Future invasive species introductions may alter the species composition of plant beds as they have in the past.

4.3.1.6.3 Freshwater Mussels

Freshwater mussel resources in the UMRS are part of the richest mussel community in the world. The UMRS once supported an abundant and diverse assemblage of approximately 50 freshwater mussel species. Freshwater mussels are currently the most threatened aquatic resource in the Nation and in the UMRS. The number of species found in the UMRS has declined to about 30 species, several of which are State- or Federal-listed threatened or endangered species. Mussels are sessile creatures that develop and persist in suitable habitat patches defined by substrate, current, water quality, and food supply. Those patches have been variously affected by channel maintenance structures, dredging, and impoundment. Site-specific impacts of commercial navigation are not well documented, and it would be difficult to elucidate the relative impact of many other stressors on this unique fauna. Direct impacts are known where barges nose into the bank to wait for locking or traffic.

Results: Freshwater mussels are expected to maintain their existing community structure and distribution in the without-project condition. The zebra mussel will remain a threat to native mussel populations. The black carp (*Mylopharyngodon piceus*), an Asian carp that feeds on mussels and is commonly used in aquaculture, may invade the system, further stressing native mussels. Reasonable and prudent measures will continue to be implemented to protect the federally endangered Higgins' eye pearly mussel (*Lampsilis higginsii*).

4.3.1.6.4 Bank Erosion

Bank erosion and sediment transport are natural processes responsible for creating the diverse geomorphology and habitat found in the UMRS. Bank erosion is a hazard to navigation though because of the ability of the channel to shift and change on a large scale, which leaves trees, shoals and bars where the channel had been. The earliest navigation improvements mitigated these hazards by digging them out, building current deflectors to concentrate flow, dredging, and armoring banklines. The modern navigation system still contends with the erosive forces of channel flow, but also considers erosion from towboat wake waves and propeller wash and wind generated waves in impounded areas. A bank erosion survey identified 43 sites on the Mississippi River and 29 sites on the Illinois River where towboats were contributing to bank erosion. Natural resource managers desire a certain level of natural processes, but there is also a need to protect high value resources such as heron rookery trees, eagle roosting trees, sheltered backwaters, etc., in the altered ecosystem.

Results: Bank erosion will continue at the 72 sites identified on the UMRS if these are left unprotected. Natural resource areas with high value may be protected through normal operation and maintenance of the system.

4.3.1.6.5 Backwater and Secondary Channel Sedimentation

Backwater and secondary channel sedimentation have long been the primary natural resource issue in the Upper Mississippi and Illinois Rivers. The problem of sedimentation stems from disturbances at the source of the sediment and at the endpoint in the stream network and main stem rivers. Upland development and agriculture mobilized sediment through clearing, plowing, and building. These changes coupled with ditching, tiling, channelization, and other hydrologic disturbances resulted in great stream bank erosion also. The end result in many places was mass wasting, gullying, and streambed entrenchment. Bedload sediments commonly form deltas as they enter the floodplain, and sometimes create chronic channel maintenance dredging. In other places, the deltas form diverse floodplain mosaics that are frequently identified as critically important habitat. Fine sediments are transported farther throughout the river floodplain. Fine sediments flow with river currents to backwaters and slackwater areas where they drop out of suspension. If they are not exposed to dry during low flow periods, the sediment remains semi-fluid and unstable. Waves from boats and wind can disturb the bottom and resuspend the sediment, which clouds the water and can ultimately inhibit plant growth. Over the years, sediment has tended to fill low areas in the backwaters and floodplain, creating a more topographically uniform, less diverse habitat. Impacts from increased navigation traffic consist of the direct impacts of increased scour and sediment transport to backwaters. Indirect effects of navigation include the induced sedimentation in impoundment-created backwaters and reduced sediment quality from maintaining high water levels.

Results: A summary of the specific backwaters and secondary channels determined to have either a medium or high potential for impacts from towboats is presented in Section 8.4.5.5.

UMR: For without-project conditions in the UMR, 12 backwaters and 5 secondary channels were determined to have medium potential for impacts from towboats.

IWW: For without-project conditions in the IWW, 7 backwaters and 15 secondary channels were determined to have medium or high impact potential from towboats. The backwaters and secondary channels in the IWW pools have a greater potential for impacts than those in the UMR pools.

Open River: All backwaters and side channels were determined to have negligible potential for impacts from towboats for the without-project conditions.

4.3.1.6.6 Historic Properties

The Historic Properties Management Plans (HPMP) developed by the three Districts for the UMR and IWW project areas have identified a suite of ongoing and potential impacts to over 2,000 archeological sites as a result of the operations and maintenance of these projects. Summary tables identifying numbers of archeological sites by observed and potential impacts on the UMR and IWW are presented in Appendix ENV-C. The three Districts have identified a total of 72 archeological sites as a stewardship priority based on a number of factors including National Register of Historic Places (NRHP) status, research potential, sensitivity, and observed threats. A sample of these sites (n=16) was revisited in order to assess the extent of one observed impact, shoreline erosion.

Results: The HPMP research evaluated over 2,000 archeological sites and documented that, on average, archeological sites have incurred impacts from three separate sources of actions, with some sites having incurred impacts from as many as seven distinct sources. The erosion research concluded that from 5 to 50 meters of shoreline erosion had occurred on, or adjacent to, the sample of stewardship priority archeological sites over the last 60 years. It is assumed that both the observed operations and maintenance impacts and the documented erosion rate will continue throughout the project areas over the 50-year planning horizon under current management practice.

The UMR and IWW project areas include NRHP eligible multiple property nominations for the Upper Mississippi River 9-Foot Navigation Project, 1931-1948 and the Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945. The Upper Mississippi River 9-Foot Navigation Project 1931-1948 nomination recognizes 25 multiple property historic districts, delineates the district boundaries, categorizes the 158 contributing and 409 noncontributing resources within those districts, and defines architectural and engineering significance. The Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945, nomination identifies 8 historic districts and 72 contributing resources within those districts.

Results: The ongoing operation and maintenance of the UMR and IWW projects will result in period actions designed to repair or replace elements of the infrastructure that may have an adverse effect on contributing elements of the multiple property nominations. It is assumed that such periodic maintenance will continue throughout the project areas over the 50-year planning horizon under current management practice.

Archival documentation has identified a total of 964 potential submerged cultural resources in the UMR and IWW project areas. The total includes shipwrecks, navigation markers, and channel construction structures. Also, an untold number of archeological sites were submerged as a result of lock and dam construction. Current management practice that potentially threatens these resources includes water level management, leases or permits that approve near-shore construction, and dredging to maintain access to marinas, boat docks, and other shoreline development.

Results: Water level management periodically exposes submerged cultural resources and, as a result, can indirectly subject these resources to vandalism and looting. Near-shore construction requiring Corps approval, such as boat dock construction, has the potential to affect submerged cultural resources including submerged archeological sites and shipwrecks. Dredging outside the active navigation channel and near the current shoreline also has the potential to affect submerged archeological sites and shipwrecks. It is assumed that these threats will continue throughout the project areas over the 50-year planning horizon under current management practice.

4.3.1.7 Summary of Future Without-Project Navigation System Conditions

Given sufficient maintenance, periodic inspections, sustained existing policies and practices, and continuing rehabilitation, the navigation structures on the system could be kept functional for the next 50 years (Table 4-24). At the current time there is no UMR-IWW lock and dam site in such a state of degradation that will cause its near-term failure or replacement. The existing navigation system already uses industry self-help, helper boats, and N-up/N-down policy to increase operating efficiency as needed. There is very little remaining for the government to do regarding these measures to increase efficiency. Increased industry-wide use of deck winches and powered ratchets is unlikely and, therefore, not accounted for in the system economic analysis. Future use of these measures due to a Federal or non-Federal action will be controlled because of public interest concerns including potential liability, safety and environmental consequences.

The without-project condition will continue to affect fish, submersed aquatic plants, banklines, backwaters and secondary channels, and historic properties. Invasive species will continue to threaten native species as new exotics are introduced into the system. Commercial navigation traffic effects will continue and O&M activities will affect floodplain natural resources through dredged material placement and construction activities. As projects are developed, individual sites will continue to be evaluated; significant resources will be avoided and impacts minimized or mitigated. The Corps O&M

environmental stewardship program, which includes, recreation site and forest management, will continue. Endangered species will be dealt with through the Endangered Species Act process, and reasonable and prudent measures will be implemented when appropriate to ensure their survival.

Table 4-24. Summary of annual costs associated with the future without-project navigation system conditions. System Investment for 37 lock sites, 32 dams, and 1,200 miles of Waterway.

Feature	Annual Cost (millions)[a]
Operations and Maintenance	$115.0 to $126.0[b]
Lock Rehabilitations	$42.7
Dams Rehabilitations	$21.4
Environmental Stewardship	$1.0
Total	**$180 to $191**

[a]2000 Price levels and 6-3/8% interest.
[b]See rationale for range in Section 4.3.1.1

4.3.2 UMRS Ecosystem

Although differences among reaches are significant, resource managers have generally concluded that the UMRS ecosystem has been significantly altered, is currently degraded, and is expected to get worse under the without-project condition. The factors most commonly identified as the major contributors of this alteration and degradation (e.g., sedimentation, impoundment, channelization, levees, etc.) also suggest the most promising avenues for ecological restoration.

While the ongoing efforts to protect, maintain, and restore habitat have proven beneficial, there remains a convincing body of evidence that the future without-project ecosystem condition will continue to degrade and the habitat loss projected in the Cumulative Effects Study (WEST 2000, ENV40) and Habitat Needs Assessment (USACE 2000) will be realized in the next 50 years. The without-project ecosystem condition assumes the Corps and other Federal/State agencies would continue their respective environmental management activities and rehabilitation efforts at historic levels and the current floodplain land use, cover, and management practices would remain largely unchanged. The following paragraphs establish and describe the assumptions and ecological consequences of the without-project ecosystem condition.

4.3.2.1 Assumptions

In order to develop future forecasts, one must first establish assumptions concerning present conditions, trends, uses, and management practices in an attempt to limit the possible change variables. Subsequent paragraphs in this section describe the assumptions that were adopted and the resulting predictions for the future without-project UMRS ecosystem condition.

4.3.2.2 Land Use, Cover, and Management Practices

The current mix of land use, cover, and management practices is assumed to continue at present levels. Specifically, the following assumptions were established:

1) Land presently in agricultural use will remain in agricultural use.
2) Developed land will remain developed.3) Existing plans for floodplain vegetation management will be implemented.
4) The climate and hydrologic regime will not change.
5) The present set of floodplain vegetation natural disturbances (e.g., wind, fire, flood, ice, diseases, etc.) will continue.

The UMRS floodplain area encompasses 2.6 million acres. Agriculture is the dominant land cover class, occupying about 50 percent of the floodplain. Open water is the second dominant land cover class, covering 17 percent of the floodplain. Floodplain forests follow closely, occupying 14 percent of the floodplain. None of the other classes exceeds 10 percent of the floodplain area, and only developed land areas exceed 5 percent.

4.3.2.3 Ecosystem Management Programs

The array of natural resource management programs described in Section 4.2.2.1 is anticipated to continue at similar levels, but these efforts have not been sufficient to stave off the indirect impacts of the multiple environmental stresses in the region. Management of the existing public lands, approximately 600,000 acres or 22 percent of the total floodplain area, will continue. The distribution of these lands, however, is highly skewed to the Upper Floodplain Reach north of Pool 14. Environmental management opportunities decline in downstream reaches where public lands are a relatively small component of the floodplain:

- Upper Impounded Reach 57% Public Land
- Lower Impounded Reach 11% Public Land
- Unimpounded Reach 8% Public Land
- Illinois River 12% Public Land

Given the average funding level, the UMRS-EMP would receive approximately $540 million for HREPs over 50 years. That would complete approximately 2 projects per year, or about 100 projects over the next 50 years, and maintain some monitoring activities. The environmental objectives database created for this study includes more than 1,400 objectives for similar restoration actions. Because HREPs have been larger-type projects, they would be expected to achieve about 7 percent of the environmental objectives over 50 years.

The contribution of private organizations in meeting ecosystem objectives has increased considerably in recent years with a few prominent land purchases and increased conservation on private land. Land conservancy agencies fulfill the function of real estate broker with their relative flexibility in acquisition compared to agencies. The opportunity to work on smaller scales on private lands must be encouraged. It is difficult to speculate on the scale of future land acquisition opportunities, but there are enough opportunities to test methods and outcomes.

Habitat quality and diversity are not likely to increase unless natural disturbances are restored, sediments are managed, exotic species are controlled, and other management measures are enacted. The present array of species and communities (many degraded) will likely be present within the project time frame. Depending on changes in agricultural product demand, agricultural conservation programs, and urban expansion, the presently degraded basin hydrology will likely persist. Current water quality standards would remain and water quality would likely be improved further with the enactment of regulations for Total Maximum Daily Loads (TMDLs) for non-point sources.

4.3.2.4 Historic Properties

4.3.2.4.1 Archeological Resources

Consolidation of extant geomorphological and historic properties data for the UMRS has been accomplished in support of the Navigation Study. Landform sediment assemblage (LSA) maps have been developed for the UMRS in the St. Paul and Rock Island Districts. These maps characterize the UMRS as consisting of a series of discontinuous geologic units that were formed by alluvial fills from the Late Wisconsinan and Holocene periods. Each LSA has an ordered structure of development with predictable ages that provide the primary context of archeological deposits.

Archeological resources have been mapped for the entire UMRS by the three Corps Districts: St. Louis, Rock Island, and St. Paul. Archeological site and survey data are consolidated across District boundaries according to navigation zone. The navigation zone includes areas within the UMR and IWW main channel, island, and backwater corridor and extends landward one-quarter mile past the railroad grade or principal meander belt levee as shown on the U.S. Geological Survey 7.5-minute quadrangle maps, regardless of ownership.

There are 1,257 recorded archeological resources within the navigation zone on the UMR and 785 recorded archeological resources within the navigation zone on the IWW. On the UMR, 104 sites (8.3 percent) have been determined eligible for inclusion in the National Register of Historic Places (NRHP), 1,011 sites (80.4 percent) have yet to have their NRHP eligibility determined, and 142 sites (11.3 percent) have been determined ineligible for inclusion in the NRHP. On the IWW, 21 sites (2.7 percent) have been listed on the NRHP, 80 sites (10.2 percent) have been determined eligible for inclusion in the NRHP, 379 sites (48.2 percent) have yet to have their NRHP eligibility determined, and 305 sites (38.8 percent) have been determined ineligible for inclusion in the NRHP.

The record for prehistoric cultural components is consistent across the UMR and the IWW. The earliest components, Paleo-Indian and Early Archaic, are the rarest, representing just 0.2 percent (n=7) and 0.3 percent (n=10), respectively. This is likely due to the limited representation of Late Woodfordian and Early Holocene landforms within the navigation zone. Middle Archaic and Late Archaic period sites are somewhat more common, 1.1 percent (n=30) and 2.5 percent (n=72), respectively, while Woodland period sites are by far the most common component at 44 percent (n=1,224). The dramatic increase is thought to represent both a general population increase during the Woodland period as well as alluvial burial of earlier Archaic period sites. There is a rather significant decrease in Mississippian and Oneota components (5.7 percent, n=163 and 2.5 percent, n=74) following the Woodland period and may reflect a preference for settlement on landforms outside the navigation zone boundaries. Finally, non-diagnostic prehistoric components, that is, archeological sites that lack diagnostic lithic, shell, or ceramic artifacts, represent 20.3 percent (n=584) of the components identified within the navigation zone.

Historic period components identified in the navigation zone represent Native American and Euro-American traditions and differ somewhat between Districts on the UMR and between the UMR and the IWW. Historic Native American components represent 1.8 percent (n=52) of the total components identified within the navigation zone. These components have been documented most frequently in the St. Paul District (n=34, 4.8 percent) compared to Rock Island District (n=6, 0.9 percent), St. Louis District (n=2, 0.6 percent), and the IWW (n=10, 0.9 percent). It has been suggested that the generally low numbers of historic Native American sites may be due to inadequate recognition of this site type and not a settlement pattern or preference. Historic Euro-American components represent 16.9 percent (n=480) of the total components identified within the navigation zone. These components are further subdivided on the IWW into historic, colonial, pioneer, frontier, early industrial, urban industrial, and post-war study units.

The area of potential effect for the navigation study includes the site-specific locations where various improvement measures are proposed and potential bank erosion areas as a result of the cumulative effect of increased commercial navigation traffic. Potential erosion areas have been identified for the IWW and UMR as part of two reports entitled *Bank Erosion Field Survey Report of the Upper Mississippi River and Illinois Waterway* (Bhowmik et al. 1999, ENV 8) and *Identification of Potential Commercial Navigation Related Bank Erosion Sites* (Landwehr and Nakato 1999, ENV 9). The erosion areas include those with high potential for bank erosion where navigation is a contributing mechanism, those with medium potential for bank erosion where navigation is a contributing mechanism, barge facilities, primary waiting points, secondary waiting points, and alternate waiting points.

A preliminary assessment identified 37 previously recorded archeological resources on the UMR and 86 previously recorded archeological resources on the IWW within 50 meters of the potential erosion areas. Studies conducted for the Corps by Bear Creek Archeology (BCA) of Cresco, Iowa, and the Illinois State Museum (ISM) of Springfield, Illinois, prioritized each of the erosion areas according to the potential to affect historic properties. Results of these studies are presented in the cumulative effects section of this document.

4.3.2.4.2 Architectural and Engineering Resources

At UMR Lock 19 in October 1978, the Keokuk Lock, Dam, and Powerhouse Historic District was listed on the National Register of Historic Places (NRHP). This District was listed as a result of major modifications to the Corps dry dock, determined to be a significant resource. A Federal property is listed on the NRHP with support from the National Park Service, which formerly lists the property or a number of similar properties, designated as a District. The National Park Service is assigned the task of maintaining the NRHP list.

In 1984, the St. Paul District and the Minnesota State Historic Preservation Officer determined that Lock and Dam 1 eligible to the NRHP. The National Park Service formally determined the UMR Locks and Dams 3 through 10 eligible to the NRHP on February 25, 1986. Two years later, the Rock Island and St. Louis Districts recognized the significance of Locks and dams 11 through 25 eligible for NRHP listing. As a result of the major rehabilitation program on the UMR and IWW, the Corps contracted with the National Park Service to complete the Historic American Engineering Record (HAER) for the UMR system. This documentation records the most significant engineering and architectural history for posterity. The Library of Congress accepted the UMR HAER in November 1988. In 1992, the National Park Service and the Corps published the results of the HAER documentation as Gateways to Commerce, which includes history, setting, and the significance of the Corps' 9-Foot Channel Project on the UMR.

Adjacent to the IWW, the Illinois and Michigan Canal was designated as a National Historic Landmark in January 1964 and listed on the NRHP in October 1966. The Hennepin Canal (Illinois and Mississippi Canal) was listed on the NRHP on May 22, 1978. The Illinois and Michigan Canal was designated the Illinois and Michigan Heritage Canal Corridor in 1984. T. J. O'Brien Lock; the Chicago Sanitary and Ship Canal; Lockport Lock; Brandon Road Lock and Dam; Dresden Island Lock and Dam; Marseilles Lock, Dam, and Canal; and Starved Rock Lock and Dam are within the canal corridor boundaries. In July 1993, portions of the IWW were determined eligible for listing as the Multiple Property Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945.

In 1998, in support of the UMR-IWW System Navigation Study, the St. Louis and Rock Island Districts completed the NRHP forms for the UMR and IWW. The Upper Mississippi River 9-Foot Navigation Project 1931-1948 was completed in 2000. The nomination recognizes 25 multiple property historic districts and defines architectural and engineering significance. The NRHP form for the Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945 has been drafted and identifies 8 historic districts.

In 1998, the Corps' St. Louis and Rock Island Districts contracted a study to complete the NRHP Multiple Property Nomination Registration Forms for the UMR and IWW Federal Navigation Projects, in support of the UMR-IWW System Navigation Study. These NRHP nomination forms detail the history, property types, evaluation methods, and significance of 14 NRHP Historic Districts within the UMR 9-Foot Navigation System. The NRHP form for the 14 Districts delineates district boundaries, categorizes the 158 contributing and 409 noncontributing resources, and evaluates each District's contribution to patterns of transportation, maritime history, engineering, commerce, conservation, military, politics, economics, labor, and social history during the period from 1931 to 1948. In 2001, the St. Paul District and the State of Minnesota determined that the UMR channel construction structures (including wing dams, closing dams, and shore protection, other ancillary and associated features dating between 1873 and 1936 located in Navigation Pools

1 through 10) within the boundary waters of the State of Minnesota were determined NRHP eligible. In 2003 the Upper Mississippi River Navigation Project, 1931-1948, NRHP nomination forms were signed by the Illinois, Iowa, Missouri, and Wisconsin State Historic Preservation Officers. Also, in 2003, Meeker Island Dam (above Lock and Dam 1), the Upper and Lower St. Anthony locks and dams were determined NRHP eligible.

In 1998, the Corps' St. Louis and Rock Island Districts contracted a study to complete the NRHP Multiple Property Nomination Registration Forms for the UMR and IWW Federal Navigation Projects, in support of the UMR-IWW System Navigation Study. These NRHP nomination forms detail the history, property types, evaluation methods, and significance of 14 NRHP Historic Districts within the UMR 9-Foot Navigation System. The NRHP form for the 14 Districts delineates district boundaries, categorizes the 158 contributing and 409 noncontributing resources, and evaluates each District's contribution to patterns of transportation, maritime history, engineering, commerce, conservation, military, politics, economics, labor, and social history during the period from 1931 to 1948. The Upper Mississippi River Navigation Project, 1931-1948, contains 14 multiple property historic districts, and was signed by the Illinois, Iowa, Missouri, and Wisconsin State Historic Preservation Officers in 2003. Also, in 2003, Meeker Island Dam (above Lock and Dam 1), the Upper and Lower St. Anthony locks and dams were determined NRHP eligible.

The historic resources of the Illinois Waterway Navigation Facilities consists if 7 multiple property historic districts, and was signed by the Illinois State Historic Preservation Officer on December 10, 2002. The NRHP form delineates the 7 district boundaries, categorizes the 35 contributing and 18 noncontributing resources, and evaluates each District's contribution to patterns of transportation, maritime history, engineering, commerce, conservation, military, politics, economics, labor, and social history during the period from 1905 to 1952.

To fulfill the requirements of the certification procedure, the Corps' Rock Island and St. Louis Districts forwarded both NRHP nomination forms for the Illinois Waterway Navigation Facilities and the Upper Mississippi River Navigation Project, 1931-1948 to the Corps Headquarters in Washington, DC, which were certificated by the Deputy Historic Preservation Officer (DHPO). The NRHP nomination forms were formerly submitted to the National Park Service Keeper of the National Register of Historic Places in January 2004 for evaluation and potential certification for listing. If the UMR and IWW are listed on the NRHP, they will achieve much-deserved international attention. The Corps' contribution to the Nation's engineering history will be ensured for our significant waterways.

4.3.2.4.3 Native American Indian Trust Responsibilities

The Corps remains unaware of any lands held in Federal trust or of any Federal trust responsibilities for Native Americans within the Navigation Study area. This area is 854 miles of the Upper Mississippi River (UMR, between the Falls of St. Anthony in Minnesota and the mouth of the Ohio River) and 348 miles of the Illinois Waterway (IWW, between Chicago and the confluence of the Mississippi River). The National Historic Preservation Act recognizes those properties of traditional religious and cultural importance to a tribe or native organization may be determined eligible for inclusion on the National Register of Historic Places.

4.3.2.5 Predictive Studies

4.3.2.5.1 Cumulative Effects Study

The Navigation Study Cumulative Effects Study (WEST 2000, ENV40) provided for a comprehensive examination of significant ecological processes and resources to provide estimates of systemic change over time and predicted future without-project condition. The primary objective of this study was to assess the direct and indirect impacts of past, present, and reasonably foreseeable future actions associated with the continued operation of the 9-foot channel navigation project on the UMR and IWW. The study used a mix of qualitative and quantitative methods to conduct the analysis, beginning with a thorough review and compilation of pertinent existing data, including all practically available historic and contemporary mapping and photogrammetric data. Historic photographs from approximately 1930, 1940, 1975, and 1989 were used to construct patterns of change for aquatic habitats (e.g., backwaters, side channels, etc.) since construction of the lock and dam system, and to help forecast future geomorphic and ecological conditions through 2050.

The Cumulative Effects Study (WEST 2000, ENV40) concluded that the UMRS planform features are quite stable and are not projected to change much in absolute area over the next 50 years. The projected changes for all the pools along the UMRS include a prediction that total water area will decrease by only 1.4 percent by the year 2050. The system-wide area of aquatic area classes is predicted to change as follows:

- Contiguous backwaters decrease by 2.1 percent.
- Isolated backwaters decrease by 3.6 percent.
- Main channel decreases by 0.7 percent.
- Secondary channels decrease by 2.6 percent.
- Island area decreases by 2.0 percent.

These acreage change predictions should not be considered to be precise estimates of change, but should rather be considered as indicators of the types and general amounts of changes likely to occur in the future. Also, it must be emphasized that the predictions include changes in surface area only, and do not account for many factors that affect habitat quality.

Island loss is largely due to island erosion predicted to occur in Pools 5, 8, 9, and 10. For many other reaches, the area of islands increases. The total perimeter of islands, a measure of shoreline complexity, is predicted to decrease by 3.7 percent. The area change predictions should not be considered as precise estimates of change, but should rather be considered as indicators of the location, types, and general amounts of changes likely to occur in the future. Also, it must be emphasized that the predictions include changes in surface area only, and do not account for many factors (depth, structure, vegetation, etc.) that affect habitat quality.

The Cumulative Effects Study geomorphic change assessment of Mississippi River reaches concluded that Pools 8 and 9 have been, and are predicted to continue to be, dominated by island erosion. The Pools 5 through 9 reach is the only reach where water area is expected to increase, including both isolated and contiguous backwater. This is because of the predicted continued erosion of islands in the reach. In all other reaches, total water area is expected to decrease, including both isolated and contiguous backwater areas.

Pools 10 through 20 have experienced loss or little change in the amount of contiguous backwater area. Generally, aquatic area losses and gains in this Mississippi River reach are expected to continue in the future at slower than historical rates. The Illinois River was estimated to lose 25 percent of its present aquatic area in the next 50 years. Continued secondary channel loss was projected for the open river reach.

The planform change analyses were used here to estimate change in abundance of aquatic guilds. Estimates of change in abundance in these guilds within specific reaches were assumed directly related to the percent and areal change in their preferred aquatic area (Table 4-25), and thus abundance. The estimates are limited, however, to associate habitat requirements of adult aged organisms with typical summer, low flow conditions. Detailed reviews of other important stressors were also discussed. These included the following:

- Effects of Impoundment and River Regulation
- Pattern of Habitats Created by Impoundment
- Effects of Channel Training Structures
- Effects of Dredging and Material Placement
- Effects of Environmental Management Program Habitat Projects
- Connectivity of UMRS Habitats
- Changes in the UMRS Basin
- Changes in UMRS Floodplain Land Use and Land Cover
- Changes in Emergent and Submersed Aquatic Vegetation
- Effects of Point-Source Discharges to the UMRS
- Effects of Non-Point-Source Discharges to the UMRS
- Fish Entrainment and Impingement at Electrical Generating Plants
- Exotic and Nuisance Species.

The results are extensive, but the obvious result was that many cumulative stressors are responsible for the current degraded state of the UMRS ecosystem. Effective river management and restoration must understand the changes caused to fundamental ecosystem drivers, and try to minimize or mitigate their impacts on an equal scale.

4.3.2.5.2 Habitat Needs Assessment

The Upper Mississippi River System (UMRS) Environmental Management Program (EMP) Habitat Needs Assessment (HNA) was designed to help guide future habitat protection and restoration efforts on the UMRS. This study built from the planform maps and predictions made in the Cumulative Effects study to include improved qualitative and quantitative estimates of habitat change from resource managers' observations and research of what was occurring below the water's surface and on the terrestrial habitat templates. To identify habitat needs, historical, existing, forecast, and desired future conditions were compared. Issues of scale are important in this regard because ecological processes, forecasts, and needs vary at the system, reach, and pool levels. In addition, a wide variety of habitat characteristics must be addressed including habitat fragmentation, connectivity, and diversity. To accomplish this assessment, a Geographic Information System (GIS) tool and a new floodplain vegetation successional model were developed. These tools allow geomorphic and land cover characteristics to be translated into the potential for species to occur.

Over time, the landscape, land use, and hydrology of the Upper Mississippi River and its basin have changed. Much of the grasslands, wetlands, and forests have been converted to agricultural use, which now accounts for 50 percent of the UMRS floodplain. Impoundment, channelization, and levee construction have altered the hydrologic regime and sedimentation patterns, resulting in loss of backwaters, islands, and secondary channels. While future without-project changes in broad geomorphic features are expected to be relatively small, habitat degradation is expected to continue. There is a broadly recognized need among resource managers and scientists for a more systemic and consistent effort to improve habitat quality, increase habitat diversity, and develop a closer approximation of pre-development hydrologic variability.

The Habitat Needs Assessment identified clear differences in habitat types and conditions among river reaches. Those differences are largely related to the amount and distribution of public land, degree of floodplain development, geomorphic form of the river, and effects of impoundment for navigation. The differences also suggest that habitat needs and restoration objectives will vary by river reach and pool.

The Habitat Needs Assessment yielded gross quantitative and qualitative estimates of habitat needs, both system-wide and within river reaches. These estimates provide the first approximation of a set of system-wide objectives for habitat protection and restoration. While they do not offer quantitatively precise goals, they served to focus future planning on the most important geomorphic processes, both system-wide and in specific river reaches. However, perhaps the greatest contribution of this study is the development of new and improved tools for future habitat planning. In particular, the GIS query tool will help evaluate the potential distribution of species and habitat area types throughout the UMRS. While the results of the Habitat Needs Assessment are not a substitute for the more detailed and spatially explicit planning that will be done at the pool scale, it has provided new tools for that planning.

Natural resource managers were surveyed for local knowledge of habitat conditions for the Habitat Needs Assessment. The managers identified aquatic habitat change, especially loss of backwater depth, which was not apparent in time-series photographs reviewed for the Cumulative Effects Study. More than 530 areas that were degraded and expected to decline further were identified.

Table 4-25. The overall change (+ = increase, - = decrease, NC = no change) in habitat for a particular guild during the study period (1930 to 2050).

Guild/Pool	Pool 4	Pool 5	Pool 5a	Pool 6	Pool 7	Pool 8	Pool 9	Pool 10	Pool 11	Pool 12	Pool 13	Pool 14	Pool 15	Pool 16	Pool 17	Pool 18	Pool 19	Pool 20	Pool 21	Pool 22	Pool 24	Pool 25	Pool 26
4.3.2.5.2.1.1 **quatic Vegetation**																							
Rooted Submersed Aquatic Vegetation	-	+	+	+	+	+	+	-	-	-	-	-	NC	+	-	-	-	NC	-	-	NC	-	-
Unrooted Submersed Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Floating Leaved Perennial Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Floating Leaved Annual Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Emergent Perennial Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Emergent Annual Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Macroinvertabrates																							
Lotic Erosional Macroinvertebrates	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lotic Depositional Macroinvertebrates	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lentic Limnetic Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Lentic Littoral Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Lentic Profundal Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Freshwater Mussels																							
Lotic Freshwater Mussels	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lentic Freshwater Mussels	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Fish																							
Rheophilic Fish	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Rheo-Limnophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Pelagic Rheo-Limnophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Limno-Rheophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Limnophilic Fish	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Pelagic Limno-Rheophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	+	-	-	-
Amphibians and Reptiles																							
Lentic Amphibians and Reptiles	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Lotic Amphibians and Reptiles	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
4.3.2.5.2.1.2 **aterfowl**																							
Diving Ducks	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Dabbling Ducks	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	+	-	-	-

The Cumulative Effects Study identified 58 locations in pools 4 through 26 influenced by one or more of nine geomorphic processes. Consultations with resource managers yielded an additional 347 areas in the same reach and an additional 125 areas in Pools 2 and 3, the open river, and the Illinois River. A total of 531 areas are expected to change.

4.3.2.5.3 Status and Trends Report

The Long Term Resource Monitoring Program completed a significant milestone report reviewing the Ecological Status and Trends of Upper Mississippi River System (USGS 1999), including a historical review and assessment of current conditions. Lubinski and Theiling (1999) developed a type of report card for the report (USGS 1999). They used dashboard-type dials indicating a range of ecological health from Degraded at the most impaired level or Unimpaired or Recovered at the "healthier" end of the scale. While useful for the broad categories considered:

- viable native populations and habitats,
- ability to recover from disturbance,
- ecosystem sustainability,
- capacity to function as part of a healthy basin,
- annual floodplain connectivity,
- ecological value of natural disturbances,

and the four river reaches considered:

- Upper Impounded Reach (Pools 1 – 13),
- Lower Impounded Reach (Pools 14 – 26),
- Unimpounded Reach (River Miles 201 – 0),
- Lower Illinois River (Peoria – Alton Pools),

the evaluation criteria were very general. The criteria were ranked as: Degraded, Heavily Impacted, Moderately Impacted, Unchanged/Recovered. The expected trend: Stable, Declining, Improving were also summarized. They did not have the required resolution to serve as indicators or endpoints required in an effective Adaptive Management program.

4.3.2.6 Environmental Consequences

In the without-project condition, past and present rates of environmental degradation would continue and the habitat loss projected in the Cumulative Effects Study (WEST 2000, ENV40) and Habitat Needs Assessment (USACE 2000a) would be realized. While the ongoing efforts to protect, maintain, and restore habitat would be beneficial for some native species and some specific locations, the current level of effort would not be sufficient to counteract the cumulative impacts affecting the river ecosystem. The without-project condition does not promote a fully functioning or sustainable ecosystem.

There have been many reviews of UMRS environmental changes and conditions, and most compare the condition of resources among the major river reaches. The changes on the Illinois River are frequently proposed as a harbinger of the potential future condition of the impounded reaches of the Mississippi River. Whether that potential is realistic is unknown, but Sparks et al. (1990) caution that there are ecological thresholds that act as breakpoints in the capacity of a system to thrive. That threshold was crossed once in the 1920s on the Illinois River, but it recovered in response to remediation measures in the 1930s. The Illinois River ecosystem crashed again in the 1950s and has never recovered fully. Many fish and mussels have recovered somewhat, but the expansive wetlands characteristic of a healthy Illinois River floodplain have not recovered from the multiple, continuing perturbations.

Is the Illinois River story a harbinger of conditions on the Mississippi River? It could be argued that the lack of aquatic plants and aquatic insects in southern river reaches indicates that the threshold has already been crossed. How far upstream these conditions occur is somewhat speculative, though. The river north of Rock Island, Illinois, is in relatively good shape, and restoration measures there are directed primarily at maintaining quality habitats in the sense of "protect the best." The remainder of the system is in various states of "restore the worst." The without-project condition will not restore the worst and it may allow the best to degrade.

4.3.2.7 Additional Considerations

Each ecosystem generates a different set of goods and services of value to human society. The UMRS is a large floodplain river ecosystem that provides a wide range of goods and services. It has been identified through multiple studies that, without increased intervention, the UMRS ecosystem will continue to degrade over time. This degradation will lead to a loss in quality and quantity of goods and services produced by the UMRS including:

- Municipal water supply
- Residential (groundwater) supply
- Industrial process water
- Industrial cooling water
- Residential and commercial building cooling water
- Irrigation water for agricultural crops
- Irrigation water or urban landscapes
- Livestock watering
- Hydroelectric power
- Commercial navigation
- Recreational boating
- Waste assimilation, purification
- Maintenance of aquatic and floodplain habitats
- Maintenance of biodiversity
- Production of human-edible food from fish, wildlife, vegetation
- Moderation of river valley climate
- Attenuation of floods
- Cycling of nutrients
- Carbon sequestering, protection of atmospheric gas composition
- Generation and renewal of floodplain soils
- Soils that support floodplain agriculture
- Construction materials and fiber from floodplain forests
- Medicinal compounds
- Genetic materials for agriculture and medicine
- Aesthetic beauty, spiritual, cultural values
- Recreational opportunities

4.3.2.8 Summary of Future Without-Project Ecosystem Conditions

The habitat management and restoration activities described in Sections 4.2.2.1 and 4.3.2.3 would likely continue at or near present levels (Table 4-26), but these actions have not prevented system-wide habitat degradation in the past and will not meet habitat needs in the future. Increased efforts to reverse impoundment effects on aquatic habitats, vegetation succession, and forest health will be required to sustain ecosystem values. Future ecosystem conditions were assessed in two ways, the Cumulative Effects Study and the Habitat Needs Assessment, to estimate the outcomes of expected without-project levels of environmental management. Regardless of what actions may be authorized, adoption of an integrated river management philosophy will improve natural resource management efficiency and outcomes.

Table 4-26. Summary of annual costs associated with the future without-project ecosystem management programs.

Feature	Annual Cost (millions)
Environmental Management Program	$16.5
Continuing Authorities Program	$4.0
Endangered Species Work	$1.4
Corps Environmental Stewardship	$1.0
Refuge Management	$9.0
State Conservation Programs	$2.0
Total	**$33.9**

The UMRS Cumulative Effects Study (WEST 2000, ENV40) was an expert panel quantitative assessment of historic geomorphic change in aerial photo images and other data. The assessment reviewed nine prominent geomorphic processes and revealed that backwaters and secondary channel loss were the most prominent changes of concern in most river reaches. While absolute acreages of backwater classes differ among reaches and absolute acreage loss may be small in some reaches, the proportional loss of backwaters exceeded 10 percent in more than half of the reaches examined. Several reaches are projected to lose from 20 to 30 percent of their backwaters over the next 50 years. Island loss and a resultant increase in open water was the largest change identified in between Pools 5 and 9. This implies a loss of habitat diversity and degradation of aquatic areas as they fill with island soils. System-wide summaries that predict small amounts of system-wide change mask the importance of change at the local scale. It is also important to reiterate that the geomorphic assessment analysis examined only planform change; loss of depth, loss of plants, and other factors affecting habitat quality were not quantitatively assessed.

Natural resource managers were asked to express their expected and desired future conditions for river resources during the first habitat needs assessment (HNA; USACE 2000b). As part of this exercise, it was necessary to assess the likely future without condition, based on their individual experience and sphere of knowledge. While their response indicated that there was inadequate systemic data to compare or contrast rates of change river-wide, they did indicate a continued downward trend in resource condition in areas in which they were familiar. These changes were largely due to impoundment effects from water level regulation, sedimentation, and loss of floodplain cover types (USACE 2000b).

The results of the qualitative analysis of habitat conducted for the Habitat Needs Assessment clearly indicate that resource managers are concerned about backwater sedimentation and secondary channel loss. When surveyed, river managers identified 16 geomorphic processes affecting river habitats in more than 500 site-specific locations (Table 4-27).

Over 65 percent of State Department of Natural Resources managers' comments referenced geomorphic processes that contributed to backwater or secondary channel loss. Some geomorphic changes are a systemic concern, whereas others are restricted to specific regions of the river based on unique geomorphic characteristics. In general, resource managers were concerned with loss of aquatic area, habitat quality, and species diversity.

Table 4-27. Occurrences of geomorphic processes affecting UMRS habitats as reported by natural resource managers.

Geomorphic Process	Number of Occurrences
Loss of Contiguous Backwaters	153
Loss of Secondary Channels	116
Loss of Isolated Backwaters	49
Tributary Delta Formation	43
Filling between Wing Dams	34
Loss of Contiguous or Isolated Backwaters	32
Wind-Wave Erosion of Islands	25
Island Formation	20
Island Dissection	15
Loss of Bathymetric Diversity	12
Loss of Contiguous Impounded	9
Shoreline Erosion	8
Loss of Tertiary Channels	5
Island Migration	4
Channel Formation	3
Delta Formation	3

Habitat quality and diversity are not likely to increase unless natural disturbances are restored, sediments are managed, exotic species are controlled, and other management measures are enacted. The present array of species and communities (many degraded) will likely be present within the project time frame. Depending on changes in agricultural product demand, agricultural conservation programs, and urban expansion, the presently degraded basin hydrology will likely persist. Current water quality standards would remain and water quality will likely be improved further with the enactment of regulations for Total Maximum Daily Loads (TMDLs) for non-point sources.

5.0 AFFECTED ENVIRONMENT

The Upper Mississippi River and Illinois Waterway comprise a very large and diverse area. At the basin scale, climate, geology, and land use are major determinants of basin hydrology, which exerts a strong control on the main stem river floodplain environment. At the river floodplain scale, there are more than 2.6 million acres distributed along 1,200 miles of river. The landscape is a diverse mix of aquatic and terrestrial environments and all the various wetlands and floodplains that interconnected them. The species diversity of common animals and plants is impressive, and we do not even know the extent of some of the more discrete plants and animals.

The river can be generally divided into four primary reaches (Lubinski 1999): The Upper Impounded Reach (Pools 1 – 13), the Lower Impounded Reach (Pools 14 – 26), the Unimpounded Reach (Below Pool 26 – Ohio River), and the Illinois River Reach. The Upper Impounded Reach supports a diverse mosaic of aquatic and terrestrial habitats. It has large open water expanses and complex braided channels and wetlands created by the dams. The floodplain is mostly connected (unleveed) with the river, and completely inundated in some lower pool areas. The Lower Impounded Reach is characterized by a relatively straight channel that transitions from the narrow floodplain in the upper parts to a broad (5 – 7 mile wide) reach at the downstream end. Backwater lakes and impoundment effects of the dams are not as prominent in the Upper Floodplain Reach. Secondary channels and island backwaters provide the majority of off-channel habitat. About one-half of the floodplain is protected by levees and agriculture accounts for most of that area. A band of riparian forest along the mainstem is the majority of natural habitat. The Unimpounded Reach is characterized by a single main channel with relatively few non-channel aquatic habitats. Channel training structures and dredging alone are used to maintain the navigation system in this reach. Many secondary channels have disappeared or been degraded by training structures and channelization. More than 80 percent of the 7 – 10 mile wide floodplain is isolated from the floodplain by levees. The Illinois River Reach is diverse, with the entire floodplain inundated downstream through much of Peoria Pool. The La Grange Pool has a mix of leveed and contiguous habitat and much of it is managed for wildlife. The Alton Pool is almost entirely leveed similar to the Unimpounded Reach. The relatively abundant isolated and contiguous backwater lakes are mostly degraded by fine sediment deposition and resuspension by waves.

The Upper Mississippi River System (UMRS) supports very large and diverse communities of people. The basin incorporates several of the Nation's largest cities, as well as the rural Midwest landscape that helps make the Nation competitive in international food markets. The Navigation System itself is a prominent feature of the Midwest environment, with a history that spans several generations, supports competitive international trade, and is poised to continue to support the Nation.

Navigation System and natural resource management have always been closely linked because of the many human uses and goods the system provides. Public land management is a critical aspect of protecting environmental resources and providing recreational opportunities for 11 million visitors per year. Because the system has provided these services for millennia, the cultural resources and evidence of our Nation's past are abundant. As the Navigation System infrastructure ages, it too becomes an emblem of the Nation's past.

Certain resources deserve special attention because they are rare or unique. These include the range of threatened and endangered species to non-native species introductions. Resources that are likely to be directly affected by the proposed action, including fisheries, submersed aquatic vegetation, freshwater mussels, bank erosion, backwater sedimentation, cultural resources, and economic resources, were specifically targeted as significant resources for in-depth study to better quantify impacts from navigation. Many resources were not affected by or minimally affected by the proposed actions. This section will discuss the existing conditions of the study area by first focusing on the natural environment, and then exploring the social and economic environment.

5.1 Upper Mississippi River Basin Scale Environment

5.1.1 Basin Area

The Upper Mississippi River Basin (UMRB) is actually a sub-basin of the entire Mississippi River (Figure 5-1). This sub-basin has a total drainage area of 490,000 square kilometers (189,000 square miles), about 15 percent of the entire Mississippi River basin (Gowda 1999). This total includes the Illinois Waterway drainage area of 74,900 square kilometers (28,900 square miles). The third major sub-basin, that of the Missouri River, is not included as part of this study.

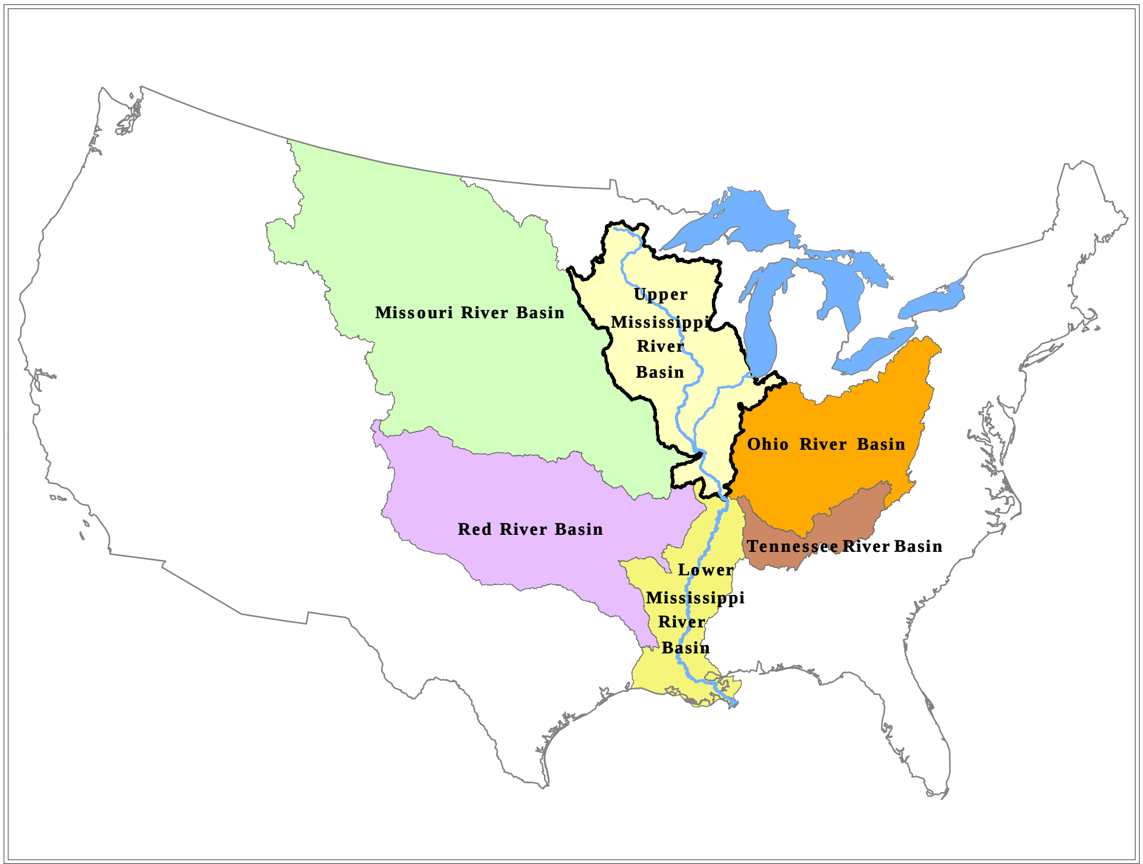


Figure 5-1. The Mississippi River Sub-basins.

5.1.2 Climate

The climate of the UMRB, which encompasses most of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, is humid continental, with warm, moist summers and cold, dry winters. The region lies in an area of regular cyclonic storm formation with frequent and often rapid weather changes related to the mixing of air masses of primarily Canadian and Gulf of Mexico origin (WEST 2000). Average monthly temperatures vary significantly throughout the year, with maximums in July and minimums in January. The majority of the precipitation (approximately three-fourths) occurs between April and October.

Average annual rainfall for the area is 91 centimeters (36 inches). Monthly average temperatures range from -12 to 0 ºC (12 to 32 ºF) for January to 22 to 27 ºC (70 to 80 ºF) in July, with a year-round average of about 11 ºC (52 ºF).

Generally, the total annual precipitation increases from north to south and contributes to making this one of the most important agricultural regions of the country. Flows comprised of runoff from the basin's stream network support navigation and hydroelectric plants and fulfill municipal, industrial, and agricultural water requirements. Runoff also influences river ecology in terms of hydrologic dynamics and sediment, nutrient, and contaminant delivery. The cold winters and ice generally result in closure of the Upper Mississippi River to commercial navigation above Lock and Dam 22 from roughly December 15 to March 15. Conditions on the Illinois Waterway typically allow year-round navigation.

5.1.3 Geomorphology

During the last Ice Age, four great glaciers advanced and retreated across most of the Upper Mississippi River drainage basin. The last of the glaciers left this area about 12,000 years ago. The movement of these great sheets of ice created the basin's gently rolling hills and level plains, studded with thousands of lakes. As the glaciers melted and receded northward, drift was deposited, forming till plains over the southern part of the basin and moraines, which are belts of hills, in other regions. The Driftless Area is a large region near the corners of southwest Wisconsin, Iowa, Illinois, and Minnesota that the last glaciers missed. The region has a unique geology and hydrology dominated by large hills and rocky outcroppings that are dissected by numerous spring-fed streams.

5.1.4 Land Cover/Land Use

The distribution of broad land use/land cover in the five UMRB States is shown on Figure 5-2. Agricultural land use dominates in Illinois and Iowa, and agricultural acreage increased most dramatically from initial land settlement to about 1920 (WEST 2000). The proportion of forestland is greatest in Minnesota, Wisconsin, and Missouri. However, the remaining forest cover is less diverse and considered a small fraction of that found in pre-settlement times (Theiling 1999). Missouri is the only State with a significant component of range/pasture land.

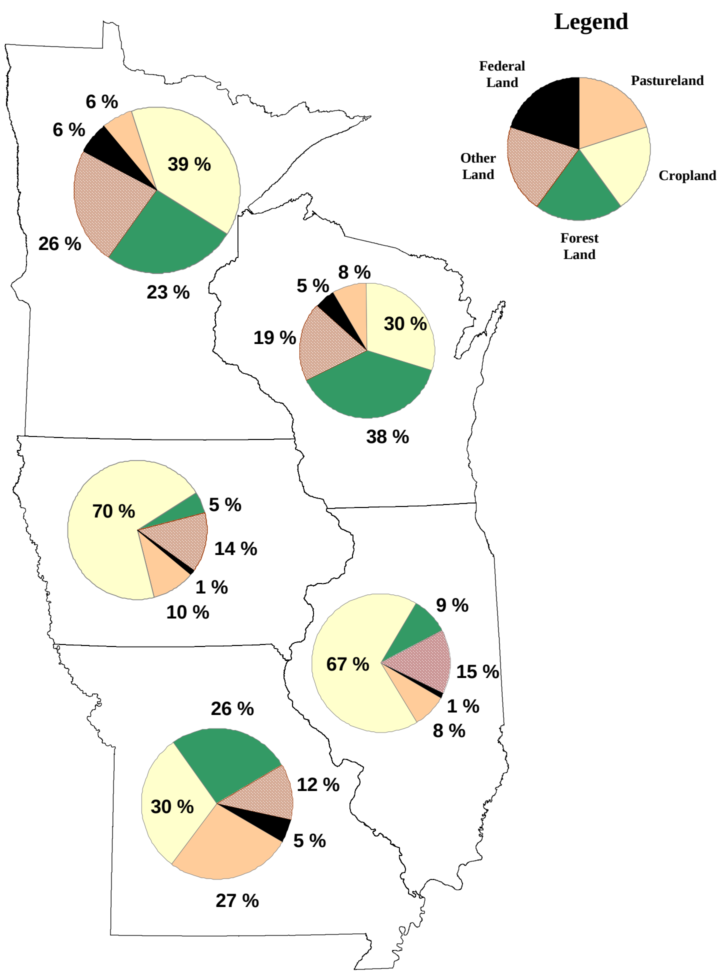


Figure 5-2. Upper Mississippi River Basin land cover and land use by State. Data Source NRCS 1992.

5.1.5 Hydrology

The basin hydrology is largely determined by climate, geomorphology, and land use. Prior to modern human disturbance, the basin was a mix of forest and prairie which affect runoff differently, and the northern part of the basin had different climatic influences which also affected river flow. There were essentially four hydrologic regions in the past, and modern development adjusted to those differences such that they are still apparent today (WEST 2000). The reaches are the Upper Impounded Reach north of Clinton, Iowa, which generally has spring peak floods that are a mix of snowmelt and runoff, an occasional fall flood, and low stable winter flows. The Lower Impounded Reach between Clinton and Alton, Illinois, is quite similar, but with a greater range of flows and more winter variability. The Unimpounded Reach south of the Missouri River is greatly influenced by the Missouri River and exhibits a bi-modal spring flood, one from spring rains, and another from mountain snowmelt. The lower Illinois River south of Hennepin, Illinois, had a long unimodal flood pulse lasting from spring through the summer, with the lowest flows in fall and winter. All the reaches were variously affected by development. Runoff from the developed land is more rapid, creating more hydrologic variability throughout the system (Figure 5-3). Dams impose an artificial stability to maintain minimal channel depths, so the discharge-stage relationship is decoupled in regulated reaches. In the Unimpounded Reach, channel maintenance and flood control measures have caused lower low stages and higher high stages for commensurate flows than in the past.

5.2 Upper Mississippi River System (UMRS) Scale Environment

The Water Resources Development Act of 1986 (WRDA 1986) officially recognized the UMRS as both a nationally significant ecosystem and transportation system. The UMRS lateral boundaries are defined by the full extent of the floodplains (toe-of-bluff to toe-of-bluff) for the Upper Mississippi River (UMR) (Minneapolis, Minnesota, to Cairo, Illinois) and the Illinois Waterway (IWW) (Chicago, Illinois, to Grafton, Illinois). By legal definition, Public Law 99-662, it also includes the navigable reaches of an additional four Midwestern Rivers: St. Croix, Minnesota, Black, and Kaskaskia. The "system" reference implies the functional relationship of these rivers with their associated terrestrial and aquatic resources. For the purposes of this study, the UMR-IWW Navigation System is used to specifically describe the narrow (300 to 500 meters wide) navigable main channel area (1,200 river miles) with a minimal depth of 9 feet established by the series of locks and dams (see Figure 1-2). Chapter 4 provides a thorough review of the historical and contemporary description of the UMR-IWW Navigation System. The UMR-IWW Navigation System is a major element contained within the UMRS ecosystem and exerts a controlling influence on the entire ecosystem's physical, chemical, and biological health.

5.2.1 Geomorphology

The geomorphic processes and features that characterize the UMRS are the result of geologic history, climate, and modern human engineering. The rivers themselves were formed millions of years ago and have evolved in response to geomorphological processes since the last Ice Age, some 12,000 years ago. Human engineering began in the mid-19th century, creating a new environment within which the river continues to evolve (Theiling 1999; WEST Consultants, Inc. 2000).

The ancient Mississippi River once flowed in a southeasterly direction through what is currently the Illinois River valley. Glacial action during the last Ice Age diverted the river into its current southerly course, thus separating the Mississippi and Illinois Rivers into their present positions (BCA, 1995; USGS 1999). Subsequent glacial activity and then their eventual northward retreat determined river flows, and various bedrock types influenced rates of incision and thus valley width. Soils in the basin generally originate from glacially outwashed sands and gravels of varying coarseness. Large deposits of windblown loess also can be found across the rich soils of the Prairie Peninsula or the modern Corn Belt.

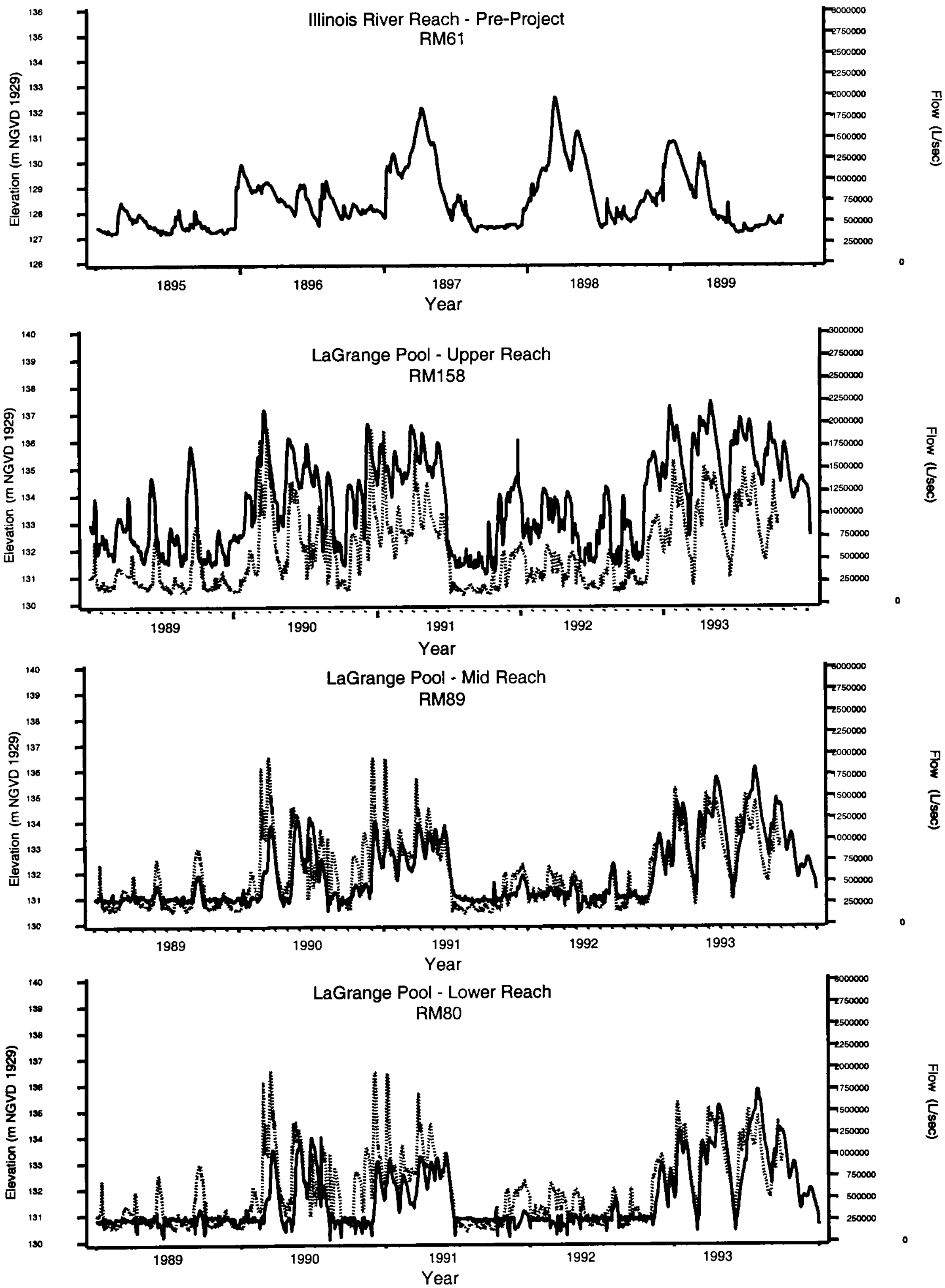


Figure 5-3. The rate of water delivery (i.e., flow routing) (discharge - dashed line) to the Illinois River has increased since the late 1800s. The frequency and amplitude of river stage fluctuations has also increased. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

Steep bluffs are the dominant landform delineating the Upper Mississippi River floodplain. Large and small tributaries of the Upper Mississippi River dissect the region. Major wetlands are found on the bottomlands of the Upper Impounded Reach that has not been extensively developed. Soils in the Minnesota and Wisconsin area are coarse and susceptible to erosion when disturbed. Logging and development in the region liberated sand and gravel through the stream network. The river valley is narrow and bounded by steep slopes. The terrain consists principally of rolling land, with elevations ranging between 85 and 590 meters (280 and 1,940 feet) above mean sea level.

Since glacial times, the ancestral river valleys have continued to fill slowly with sediment because modern flow rates are not sufficient to transport the glacial outwash (Nielsen et al. 1984). The area is underlain by about 610 meters (2,000 feet) of Paleozoic sedimentary rocks overlying the Precambrian basement. The unconsolidated sediments that fill the present Mississippi River Valley resulted from past glacial activity, wind, and modern river deposition. The pre-glacial Mississippi River bedrock valley is filled with over 30 meters (100 feet) of glacial and alluvial sediments. These typically consist of fine-grained floodplain deposits overlying coarse-grained channel, point bar and chutes and bar deposits. The deepest sections of the valley fill are composed of coarse-grained glacial valley deposits. This produces a typical section of alluvial silts and clays overlying fine to coarse sands and some gravel. These alluvial deposits are underlain by medium to coarse outwash sand and gravel. A coarser channel lag deposit containing gravel, cobbles, and even some boulders often will be encountered first at the maximum extent of modern river scour and fill and another immediately above the bedrock.

Geomorphic features have recently been used as the basis for a habitat classification system for the UMRS ecosystem (Wilcox 1993; USGS 2000). However, a few key elements are still needed to adequately delineate and differentiate among the various geomorphic features. An initial evaluation of the longitudinal geomorphological characteristics revealed 10 Upper Mississippi River geomorphic reaches (Figure 5-4) and two Illinois River reaches (great bend at Hennepin, Illinois, designates the geomorphically distinct upper and lower Illinois River). To better forecast geomorphic conditions, river managers still need detailed information on floodplain elevation, bathymetry, sediment budgets, tributary stream sediment delivery, and sources of sediment. The consideration and application of geomorphology by river managers is expected to allow for more informed and effective management toward a desirable future condition of the river system.

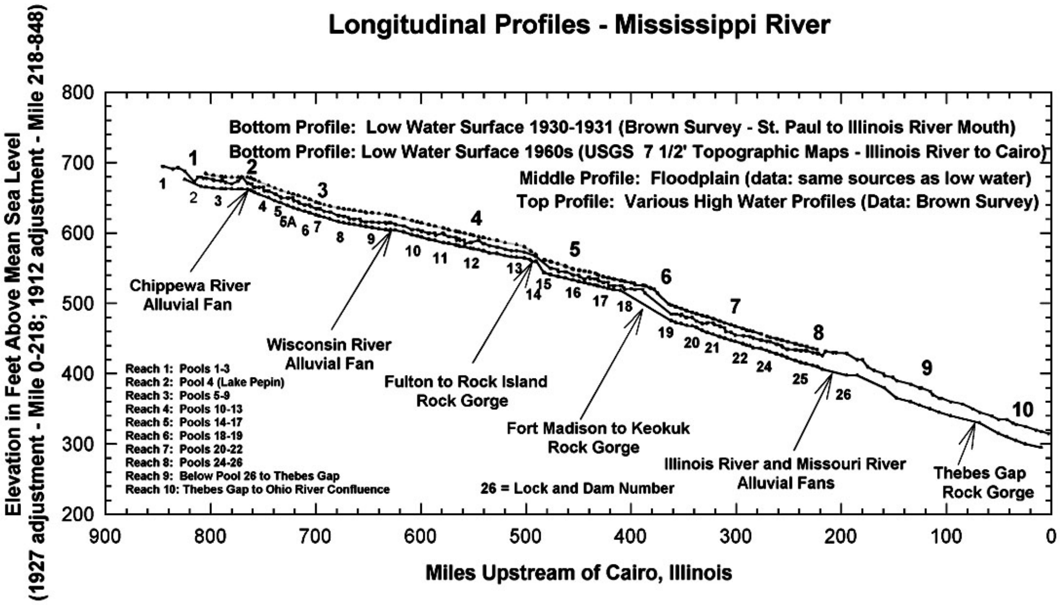


Figure 5-4. The Upper Mississippi River is divided into 10 geomorphically based reaches that reflect the river's adjustment to glacial events and other geological controls in the region. (WEST 2000).

Human actions have reshaped the geomorphic features and interfered with the natural geomorphic processes within the UMRS. Land use changes and river engineering are the two primary human interference mechanisms that have had a major effect on the current geomorphic state of the UMRS. River engineering for improved navigation has included clearing of snags, construction of channel training structures, impoundment by dams, dredging, and placement of dredged material. Each of these items is covered in detail under Section 9.1.2 Ecological Stressors. These human mediated actions have played a major role in shaping the present UMRS ecosystem.

5.2.2 Hydrology

There are 29 dams on the UMR and 8 dams on the IWW. The dams (except Locks and Dams 1 and 19) were constructed for the specific purpose of increasing low and moderate flow water surface elevations to maintain a continuous 9-foot navigation channel from St. Louis, Missouri, to Minneapolis, Minnesota, and Lake Michigan. Because Mississippi River dams are designed to maintain low-flow navigation, most are opened completely during high flow events.

Principal tributaries of the UMR are the Minnesota, St. Croix, Wisconsin, Rock, Iowa, Des Moines, Illinois, and Missouri Rivers and several smaller rivers and streams. In the 1,076 kilometers (669 miles) of river between the first lock, Upper St. Anthony Falls, and the last lock of the 9-Foot Channel Navigation Project, Lock 27, the Mississippi River falls 128 meters (420 feet) with an average slope of approximately 9.5 centimeters per kilometer (6 inches per mile). Average flow of the UMR ranges from 280 cubic meters per second (10,000 cubic feet per second) at St. Paul, Minnesota, to 4,955 cubic meters per second (175,000 cubic feet per second) at St. Louis, Missouri.

The two sections of the IWW differ quite significantly. While the upper IWW has an average width of 400 feet, the lower IWW is generally wider with a width of almost 1,400 feet near Grafton, Illinois, and has a much wider natural floodplain. The lower section occupies a glacial channel whose bed is approximately 100 feet above bedrock, while the upper section rests near the bedrock surface. In addition, the slope of the river varies considerably between these two sections. In the upper reach, the slope is approximately 18 inches per mile. In contrast, the lower reach has a slope of 1.8 inches per mile.

Principal tributaries of the Illinois River are the Des Plaines, Iroquois, Kankakee, Fox, Vermilion, Mackinaw, Spoon, Sangamon, and La Moine Rivers and several smaller streams along the waterway. The IWW has a total drainage area of 74,900 square kilometers (28,900 square miles), which empties into the Mississippi River at Grafton, Illinois. Median flow on the IWW ranges from 165 cubic meters per second (5,800 cubic feet per second) at Lockport, Illinois, to 490 cubic meters per second (17,200 cubic feet per second) near the mouth.

The geometry of the pools created by the dams is such that water level variation differs within each pool reach. In plan form, the dams impound greater open water area in the downstream portion of the pools where the floodplain has been inundated. In the middle pool areas, water depths are not as great, and island braided channels and shallow marshes exist. In the uppermost portion of each pool, the river maintains much of its pre-dam character with island braided channels and secondary channels (Figure 5-5). These plan form changes due to impoundment are most apparent in pools north of Pool 13.

Hydrologic variability within pool reaches is similar among the pools, and some examples from the UMRS and IWW are presented below. Water level variations in upstream portions of the pools generally respond closely to river discharge. The correlation between discharge and elevation decreases with proximity to the downstream dam. Some dams are operated such that lower pool drawdowns occur during moderate flow. Water levels in Pools 8 and 26 on the Mississippi River and the La Grange Pool on the Illinois River were examined with respect to hydrologic effects of impoundment.

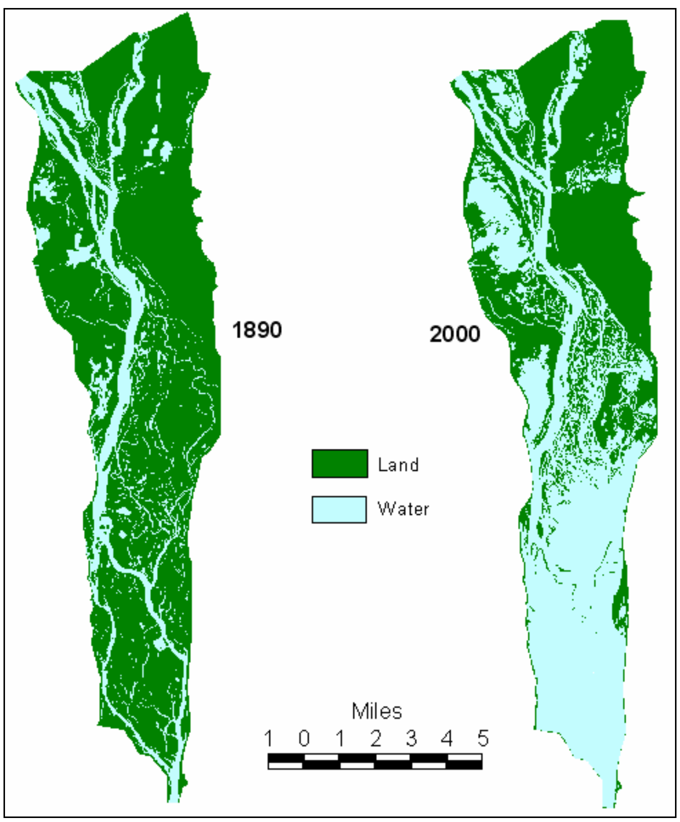


Figure 5-5. Effects of river regulation on the distribution of surface water in UMRS Pool 8.

Water surface elevation and river discharge at a location in what is currently Pool 6 was closely correlated prior to construction of the dams (r = 0.78; Figure 5-6, Panel A). When the dams were constructed, the discharge-stage correlation was disrupted. Water levels in the tailwater of Lock and Dam 7 correspond very closely to discharge at the gage located 24 miles upstream in Pool 6 (r = 0.91; Figure 5-6, Panel B). At the mid-pool gage (Figure 5-6, Panel C), the correlation is lower (r = 0.48). At the pool gage at Lock and Dam 8 (Figure 5-6, Panel D), the correlation is weakly negative (r = -0.11) because the pool is managed with a mid-pool control point and a drawdown of 1 foot during moderate flows.

Water surface elevation and river discharge at the confluence with the Illinois River were also closely correlated prior to construction of the dams (r = 0.98; Figure 5-7 Panel A), though the average range of variation was twice as great as in upstream reaches. When the dams were constructed, the discharge-stage correlation was disrupted. Water levels in the tailwater of Lock and Dam 25 correspond very closely to discharge at the gage located 13 miles downstream (r = 0.92; Figure 5-7, Panel B). At the mid-pool gage (Figure 5-7, Panel C), the correlation is lower (r = 0.63). At the headwater gage of Lock and Dam 26 (Figure 5-7, Panel D), the correlation is weakly negative (r = -0.06) because the pool is managed with a mid-pool control point and a drawdown during moderate flows. The average headwater elevation in Pool 26 masks the true range of drawdowns that can be as much as 6 feet and persist for weeks to months during moderate discharge.

Water surface elevations in the Illinois River were first modified by water diversions from Lake Michigan to divert urban wastes from the growing Chicago region. Water surface elevations were increased between 3 and 6 feet at the initial rate of discharge, but the flow was subsequently cut due to concern for lowering water levels in Lake Michigan. The dams did not increase water elevations appreciably over that of the diversion, but the artificially high stages were fixed by the dams. Hydrologic modifications, on average, are not as extreme in the La Grange Pool as in Pools 8 and 26 because the river frequently goes to “open river“ condition, where flow determines river stage (Figure 5-8). The average, however, masks daily fluctuations that have become much more rapid since the basin, floodplain, and river have been developed (see Figure 5-3). Gate operations at the Peoria Dam, in response to changing river flows, occasionally result in daily tailwater fluctuations of as much as 1 foot or more.

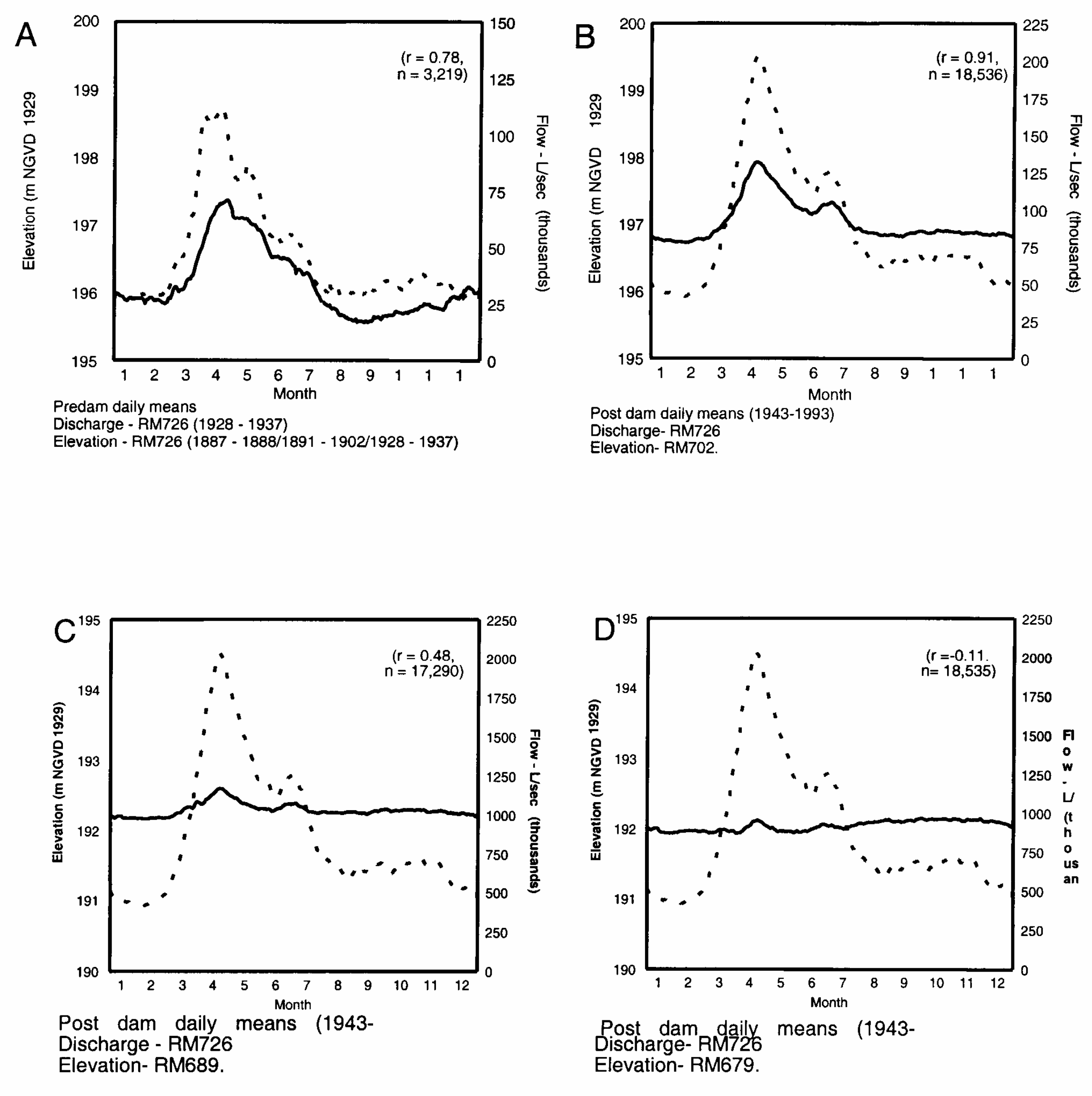


Figure 5-6. Discharge (UMR Pool 6) and elevation stage correlations in UMR Pool 8. Panel A presents the pre-dam relation, and panels B, C, and D show the post-dam change in upper Pool 8, middle Pool 8, and lower Pool 8, respectively. The mean post-dam stage increases somewhat and the range of variation is attenuated in the downstream direction. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

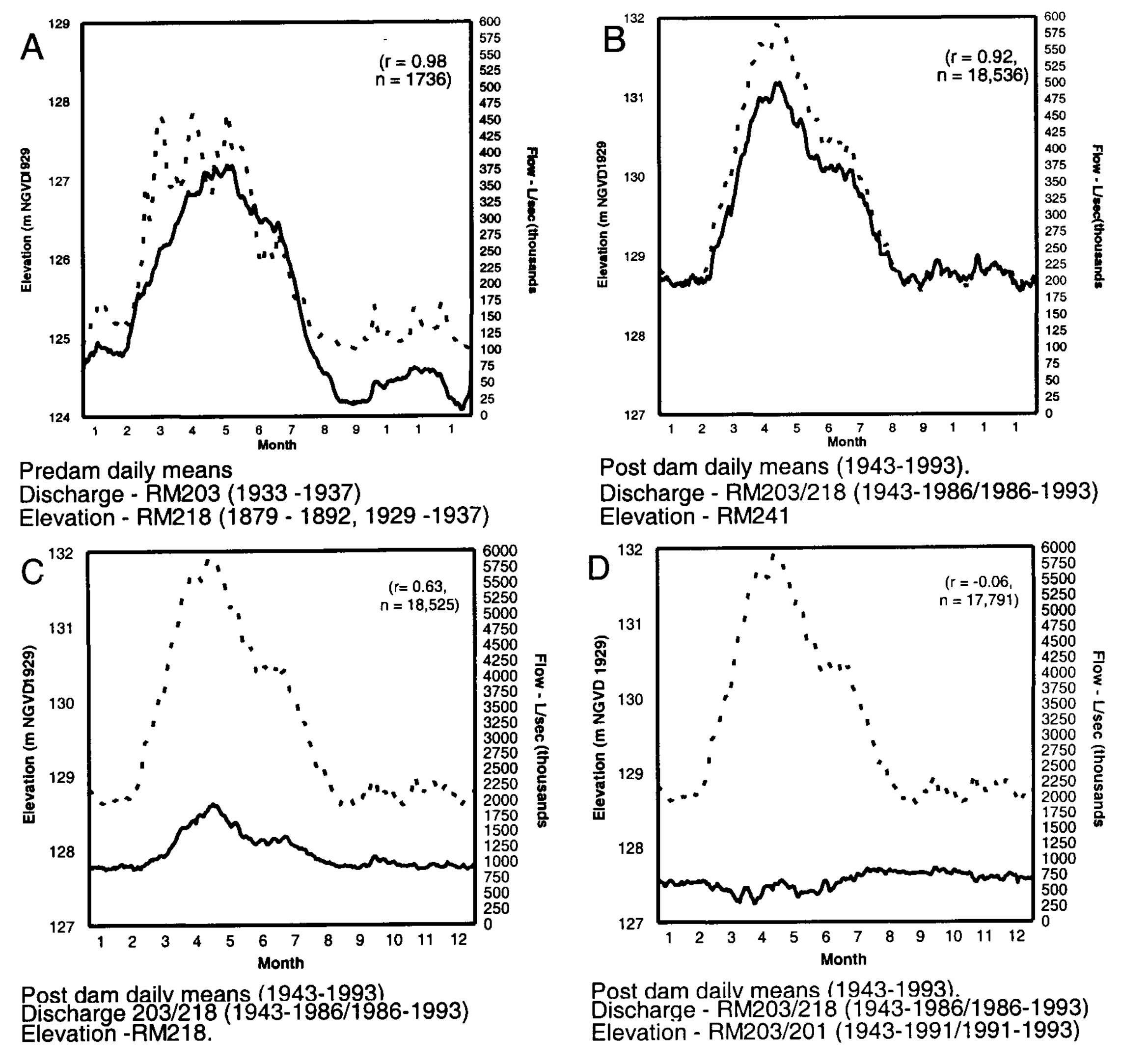


Figure 5-7. Discharge and elevation stage correlations in UMR Pool 26. Panel A presents the pre-dam relation, and panels B, C, and D show the post-dam change in upper Pool 26, middle Pool 26, and lower Pool 26, respectively. The mean post-dam stage increases somewhat and the range of variation is attenuated in the downstream direction. Maximum lower pool drawdowns up to 1.8 meters are masked by the mean. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

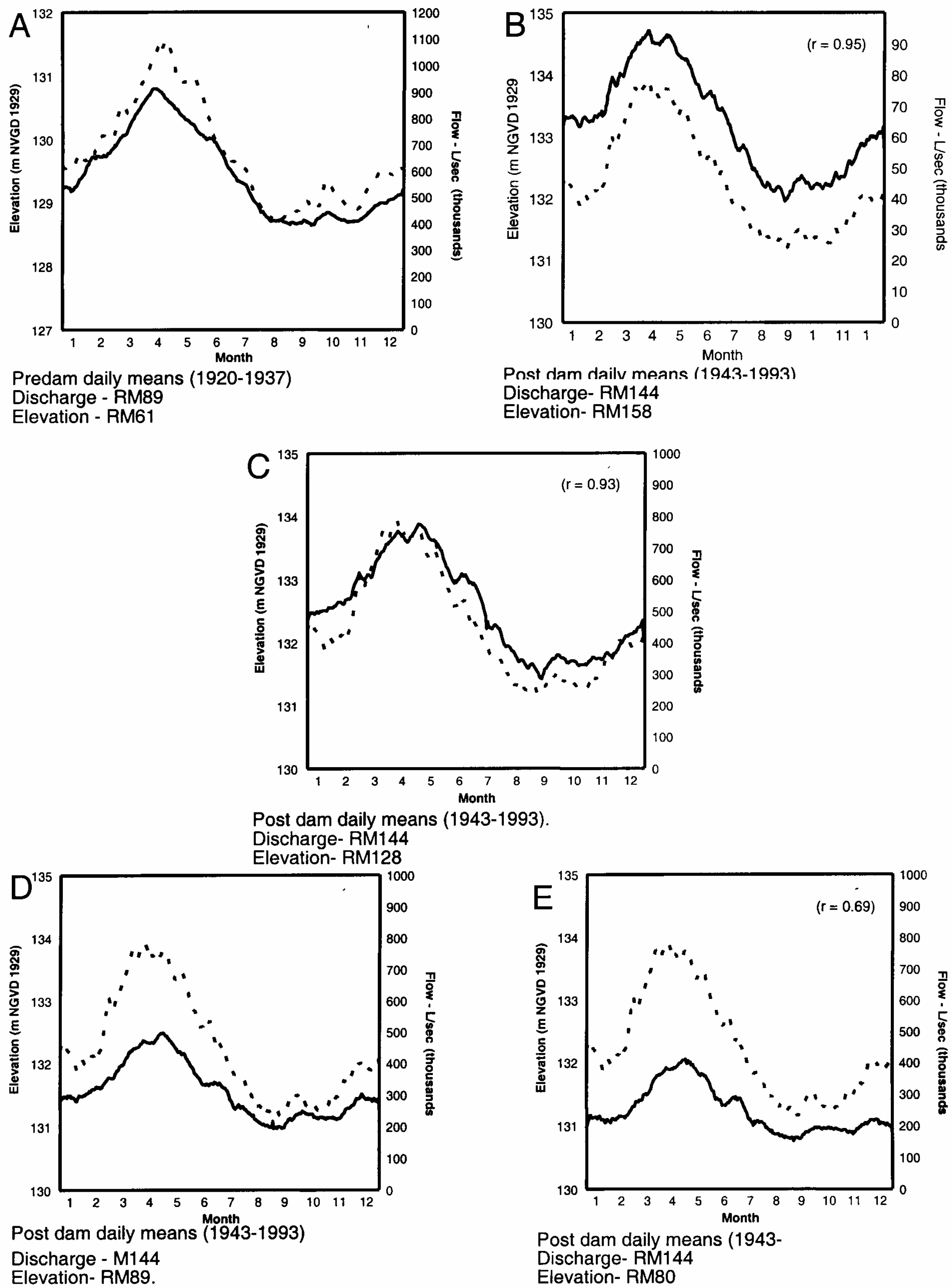


Figure 5-8. Discharge and elevation stage correlations in the La Grange Pool of the IWW. Diversions and impoundment increased the mean annual stage, and attenuated stage variation near the dam. The means mask changes in the rate and amount of variation. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

5.2.3 Sedimentation

A number of processes influence the overall erosion and movement of sediment throughout the system. The alteration of the watershed for agricultural and urban uses since Euro-American settlement, the channelization of tributary streams, and the construction of the locks and dams have accelerated sedimentation rates (Lubinski 1993; Bhowmik 1994). As a result of the permanent inundation of large areas of the river, sediments accumulated over widespread areas during the last 50 years are unconsolidated and easily resuspended by hydrodynamic forces (Gaugush and Wilcox 1994; Theiling 1995). The slackwater pools, created by the 9-Foot Channel Project, are also subject to greater wind fetch and wave action, which acts as a mechanism to resuspend sediment, altering turbidity levels and potentially playing a significant role in sediment movement and deposition in backwater and off-channel areas. Commercial and recreational navigation also resuspend this unconsolidated sediment, with similar effect.

5.2.3.1 Upper Mississippi River

The numerous bottomland lakes, backwaters, and sloughs along the river system, which prior to construction of the locks and dams were continually created, filled, and eroded by the changing river channel and natural hydrologic cycles, in many cases now serve as sediment traps. While these existing areas slowly fill with sediments, the river creates far fewer new backwaters due to its relatively fixed channel. One study found that sedimentation in Pools 4 to 10 was occurring at a rate of 2.5 to 5.0 cm per year and that approximately 25 percent of the water surface area that existed in 1939 had been converted to marshland (GREAT I 1980). The GREAT II (1980) study also indicated losses related to sedimentation in Pools 11 to 19. Results of these studies indicated that by the early 1980’s over 3,640 hectares [9,000 acres] of off-channel surface area had been converted to various vegetation types since inundation by dam construction. The Comprehensive Master Plan for the Management of the Upper Mississippi River reported predictions that between 22 and 49 percent of the remaining backwater habitat in these pools would be lost due to sedimentation in the next 50 years. In the lower pools, significant reductions in the cross-sectional area also have been experienced, further reducing the amount and overall diversity of habitat in the system.

More recent studies have identified similar, but somewhat smaller, rates of sedimentation. The UMR-IWW Cumulative Effects Study (WEST 2000) conducted a sediment budget analysis, and estimated backwater accumulation rates at 0.02 to 0.34 cm/yr. for various time periods from 1950 to 1995. An estimate from immediately post-impoundment (late-1930’s) to 1950 was 1.56 cm/yr. for lower Pool 11. WEST Consultants, Inc. (2000) also summarizes several other studies whose estimates generally agree with these rates. The authors concluded that generally decreasing sedimentation rates have resulted from modified land use practices in uplands, as well as sediment trapping by a growing number of tributary reservoirs.

Earlier studies, however, have been criticized for being biased toward depositional areas and not representative of average values. Recent randomized studies have shown much lower sedimentation rates (Rogala et al. 2003) and interesting hydrology related dynamics. During low flow years, sediment tended to accumulate in backwaters; in high water years, some backwaters were scoured by flood waters. The investigations suggest that sediment dynamics are very site-specific and dependent on many hydrologic and hydraulic factors.

Areas of particular concern are Lake Pepin in Pool 4, which has lost 12 percent of its 1930 volume, and Pool 19, which has lost 55 percent of its 1913 volume (Bhowmik et al. 1993). Just upstream of Lock and Dam 19, approximately 10 meters [32 feet] of sediment has been deposited since its construction (Bhowmik et al. 1993). Estimates made during the GREAT studies predicted that many of the Upper Mississippi River-Illinois Waterway’s backwaters would be lost to sedimentation in 50 to 200 years.

Considerable loss of off-channel areas in the open river (the Mississippi River reach between St. Louis and the mouth of the Ohio River; also termed the Middle Mississippi River) has also been described (Theiling 1995; Theiling et al. 1999). Theiling et al. (1999) examined six secondary channels in the open river reach, using historical aerial photography for four time periods from the early 1950s to 1994, and comparing acreage changes in three 'analytical landscape units': secondary channel, island, and main channel. The results of this analysis indicated that, though varying in degree and rate, all of the areas have shown a loss in aquatic area and a gain in terrestrial area; in some cases large areas of aquatic habitat have been lost. At low river stages, all secondary channel characteristics are lost. The 1993 flood in some cases acted to restore lost aquatic habitat, but not to a great extent. The authors noted that most of the changes appeared to occur between 1950/52 and 1975.

5.2.3.2 Illinois Waterway

The Illinois State Water Survey estimates that on average 8.2 million tons of sediment is deposited in the Illinois River Valley each year. The numerous bottomland lakes, ponds, and sloughs along the waterway, which were slowly filling with sediment under natural conditions, have been heavily affected by sedimentation related to changes taking place in the watershed and along the waterway. Recent studies by the Illinois State Water Survey indicate that backwater lakes along the Illinois Waterway on average have lost approximately 70 percent of their 1903 volume (Bellrose et al. 1983). Bhowmik and Demissie (1989) discuss the amount of sedimentation occurring in backwater lakes throughout the Illinois River and found an average annual sediment deposition between 20.5 mm and 53.3 mm yr^{-1}. This deposition is contributing to the conversion of backwater lakes to terrestrial habitat. Most sediment was estimated to be from uplands, but 40 percent may come from adjacent bluff lines. Illinois River backwaters are efficient sediment traps because the lower Illinois River Reach is extremely low gradient and wide with relatively little capability to scour sediment outside of defined channels. Fine sediment is carried into backwaters and floodplains with floodwaters; it drops from suspension in quiet backwaters that have filled significantly over recent time as a result.

The Corps of Engineers channel maintenance activities address sedimentation and shoaling occurring in the main channel of both rivers. Within the 506 river kilometers [314 miles] of the Rock Island District, over 50 chronic dredge cut sites exist which are being addressed through the development of dredged material management plans (DMMPs). These efforts result in total annual operations and maintenance expenditures of approximately $30 million and average dredging of approximately 345,000 cubic meters [450,000 cubic yards] of material. In addition, wing dams, closing dams, and other channel training structures have been placed and maintained to increase main channel depth during periods of low flows and to reduce chronic dredging needs. Within the Rock Island District, the structures are managed through the Committee to Assess Regulatory Structures (CARS) in coordination with the U.S. Fish and Wildlife Service. Similar programs are in place in the St. Paul and St. Louis Districts.

5.2.4 Habitats

Terrestrial and aquatic habitat development and maintenance are influenced by numerous biotic, abiotic, and natural or human-induced disturbance factors (Lubinski 1993). As a means to quantify habitat, river researchers and managers have proposed classification based on geomorphic, hydraulic, and/or land use characteristics (Lubinski 1993; Wilcox 1993; USGS 1999; WEST Consultants, Inc. 2000; USGS 2000; Nickles and Pokrefke 2000). For purposes of this discussion, more general reach descriptions will be used to describe broad patterns in habitat type and distribution.

5.2.4.1 Upper Mississippi River

The Upper Mississippi can be divided into three broad reaches: the upper impounded reach, from the head of navigation at Minneapolis/St. Paul, Minnesota, through Pool 13 at Clinton, Iowa; the lower impounded reach from Pool 14 through Pool 26 at Alton, Illinois; and the unimpounded reach from the confluence of the Missouri River to the mouth of the Ohio River at Cairo, Illinois (Lubinski 1993; USGS 1999).

The upper impounded reach (Figure 5-9) is characterized by a large proportion of off-channel aquatic habitat (secondary channels, which typically have flow-through, and backwaters, which may be contiguous or isolated but do not typically exhibit flow), relatively abundant and diverse aquatic vegetation, good water clarity, and few agricultural levees (Theiling 1999b). In general, the floodplain is narrow (1 to 3 miles), islands are more common than in other reaches, and woody terrestrial vegetation is more prevalent.

Figure 5-9. Upper Mississippi River Pool 7 located in the upper impounded reach.

The lower impounded reach (Figure 5-10) contains a greater proportion of main channel and channel border aquatic habitat, fewer off-channel areas, and a predominance of leveed agricultural land. It has been estimated that more than 50 percent of the floodplain area south of Pool 16 and on the two lower Illinois pools is leveed (Theiling 1999b). With the exception of Pool 19, aquatic vegetation is uncommon in this reach. The width of the river floodplain, with some exceptions, increases to about 5.6 miles on average (USGS 1999). In general, this reach is more uniform, with a fairly straight channel, and large, stable islands and secondary channels (Theiling 1999b).

The unimpounded, or open river reach, below St. Louis exhibits (Figure 5-11) a quite different character than the impounded reaches. The river becomes much wider (averaging 7 miles wide below Thebes Gap, the floodplain is up to 50 miles wide at the confluence with the Ohio River) and deeper, and in general displays a less complex mix of habitat types and little off-channel aquatic area. It has been estimated that 81 percent of the available aquatic habitat is comprised of main channel and main channel border, with 12 percent in isolated backwater and the remainder in secondary channels and contiguous backwaters (Theiling et al. 1999). The floodplain also is almost completely developed for agriculture. More than 80 percent of the floodplain is protected from flooding by levees. The levees in this reach are not overtopped or damaged during normal floods, but some extreme events have done so.

Figure 5-10. Upper Mississippi River Pool 24 located in the lower impounded reach.

Figure 5-11. The Upper Mississippi River unimpounded reach (open river).

Connected to the unimpounded reach is also the navigable portion of the Kaskaskia River with a 9 foot deep channel extending 36 miles from the Mississippi River upstream to Fayetteville, Illinois. The navigation project shortened the Kaskaskia River between its mouth and Fayetteville from 50.5 to 36.2 miles. Meanders were left as remnant channels, much of the channel excavated, and flow partially regulated by a lock and dam near the river mouth. Of the 18,000 acres of land and water associated with the Kaskaskia River Navigation Project, the majority consists of bottomland forest, dredged material disposal areas, cultivated land, channelized river, and remnant channels.

5.2.4.2 Illinois Waterway

As described above, the Illinois Waterway (Figure 5-12) is divided into two distinct geomorphic reaches, and each displays a correspondingly distinct habitat character. The upper reach is highly urbanized, and structurally similar to a smaller river, while the lower reach exhibits a low gradient, broad floodplain, narrow channel, and extensive backwaters (Lubinski 1993; Theiling 1999b). In general, the river has few islands and secondary channels. Backwater lakes have varying degrees of connectivity, depending on depth of connecting channels and river stage. Sediments are typically finer than those on the Mississippi River, and many backwater lakes have experienced large volume losses due to sediment deposition. The prevalence of fine sediments also contributes to a higher ambient suspended sediment load, reduced water clarity, and therefore little aquatic vegetation in the lower river reach (Theiling 1999b).

Figure 5-12. La Grange Pool located in the lower reach of the Illinois Waterway.

The Upper Illinois Waterway was not naturally connected to the Illinois River. The Chicago Sanitary and Ship Canal was constructed, however, during the late 1800s to connect the Chicago River to the Des Plaines River to shunt polluted water away from Chicago and to aid navigation through the Great Lakes. The diversion, as it is also known, reversed the flow of the Chicago River and augmented the Illinois River discharge through an interbasin water transfer. The volume of flow entering from Lake Michigan, initially about 7,200 cfs, has been the subject of many legal battles with other Great Lake interests and is now only about 1,500 cfs. The diversion increased water levels nearly 3 feet in Havana, about 200 miles downstream, and the dams currently maintain about the same stage year-round. The entire upper river is highly urbanized, with many industries and waste treatment facilities lining its banks. The channel sediments are highly contaminated in some areas. Surprisingly though, significant improvements in water quality are allowing the reach to be recolonized by fish and freshwater mussels. There is significant concern that the Canal provides a route for exotic species dispersal to and from the Great Lakes.

The lower reach of the Illinois River (Figure 5-12) is largely agricultural, with levees isolating about 55 percent of the floodplain (Theiling 1999b). A notable feature in this reach is Peoria Lake, a 20-mile-long tributary delta lake. Peoria Lake has experienced severe sediment deposition, and has been the site of several completed or proposed habitat restoration projects. Because of the gentle slope of the reach, the three lower pools (Peoria, La Grange, and Alton) are the longest on the system, averaging approximately 75 miles in length.

5.2.5 Water Quality

Similar to many of the Nation's major rivers, the Mississippi and Illinois River systems have a long history of impaired water quality attributable to contamination from industrial, residential, municipal, and agricultural sources. A detailed description of the past and current water quality conditions of the Upper Mississippi River is presented in Meade (1995) and in Soballe and Wiener (1999). Starrett 1972, Sparks 1984, and Theiling 1999a provide similar reviews for the Illinois Waterway.

Consideration of water quality encompasses a wide range of physical, hydrologic, and biological parameters, both natural and human-influenced. Watershed influences, including tributary streams, point and non-point pollution sources, flow alteration due to navigation structures, drought or flood events, and organism structure and function all influence water quality. Variations in land use practices, cover types, and watershed area will determine the level and type of sediment, nutrient, and contaminant inputs into the Mississippi and Illinois Rivers from their tributaries. Typical seasonal fluctuations in flow, as well as periodic extreme events, can have dramatic effects on water quality (Soballe and Wiener 1999).

A description of organic contamination in the Mississippi River is found in Barber et al. (1995). With as much as 2 to 4 percent of Mississippi River volume made up of municipal discharge, organic chemicals continue to be found in water and sediments throughout the system. Improvements to sewage treatment facilities in the last 25 years, particularly in large urban centers such as Minneapolis/St. Paul, Chicago, and St. Louis, have helped to reduce biological oxygen demand. Dissolved oxygen levels are generally good, reaching saturation in large areas of the Mississippi River; however, some areas south of the Missouri River confluence, as well as parts of the lower Illinois River, have exhibited relatively low dissolved oxygen concentrations (UMRCC 1993; Soballe and Wiener 1999). Off-channel areas with little flow can experience depressed levels of dissolved oxygen at certain times of the year.

Inorganic forms of nitrogen and phosphorus (nitrate, nitrite, orthophosphate, and ammonia) also pose a water quality concern. Sources of these substances include agriculture and municipal wastewater. High concentrations can result in fish kills, algae blooms, and human health effects. Since the Upper Mississippi River-Illinois Waterway drains the most intensively farmed region in the country, agriculture is the main contributor to the loads of these chemicals in the rivers. As much as 75 percent of nitrate is estimated to come from agricultural sources; however, municipal sources such as lawn fertilizer and household cleaners also contribute (Antweiler et al. 1995). Although the compounds are found both naturally and from human sources throughout the basin, the highest concentrations occur in the summer during and after fertilizers have been applied to farm fields. The implementation of the Conservation Reserve Program and many other incentive-based U.S. Department of Agriculture conservation initiatives and removal of a large amount of highly erodible lands from production have assisted in the reduction of runoff. Though not typically exceeding levels considered unsafe to human health, nitrate levels in the Upper Mississippi River are considered high (2-3 mg/l) (Soballe and Wiener 1999). High ammonia concentrations, likely due to sewage discharge or untreated runoff, have been observed in localized areas on the Mississippi and Illinois Rivers, and these can be lethal to certain aquatic organisms.

Sediment inputs and resuspension directly and indirectly affect water clarity. As noted elsewhere, the extensive agricultural use of a large portion of the Mississippi and Illinois River basins contributes

significantly to the ambient suspended sediment load in the rivers; this is especially evident below Pool 13 on the Mississippi River and in the lower three pools on the Illinois River. The prevalence of finer, more easily resuspended sediments on the Illinois River results in a comparatively more turbid environment. Since impoundment of the system for commercial navigation, the historic annual cycle of low water and drying and compaction of sediments has been altered, thus leaving sediments unconsolidated and more easily resuspended by natural or human influences. Current information on sediment and nutrient monitoring efforts in the UMR basin can be found at the following U.S. Geological Survey web site:
http://www.umesc.usgs.gov/data_library/sediment_nutrients/sediment_nutrient_page.html

5.2.6 Contaminants

The implementation of clean water laws, upland soil and habitat conservation, improved wastewater treatment, and changes to industrial and agricultural processes have resulted in generally fewer contaminants in the Nation's waterways. However, environmental contaminants and specific areas of the UMR system that are contaminated continue to be items of concern. Contaminants found in the system include heavy metals, pesticides, and synthetic organic compounds. The following paragraphs describe sources of environmental contaminants and known areas of concern and summarize the potential for effects on living organisms. The discussion is meant to be an overview of the current state of the system and relies on referencing specific sources of information.

In addition to fertilizers, agricultural pesticides are heavily applied throughout the region. Both insecticides and herbicides are currently used, with herbicides making up the majority (Goolsby and Pereira 1995). After World War II, organochlorine insecticide use became widespread. Like other agricultural practices, chemical use has changed and is continuing to change. First generation insecticides such as DDT or chlordane are insoluble in water and have higher potential to remain attached to sediment particles, thus attributing to their continued persistence (Goolsby and Pereira 1995). Many agricultural insecticides now are water-soluble and have half lives in the hours, thus making them less likely to affect aquatic insects (Mike Coffey, U.S. Fish and Wildlife Service, personal communication). Herbicides have also been documented to be in high concentrations in areas of the river, especially from May through July. With longer half lives, they have higher potential to remain attached to sediments; however, they are also generally less likely to have direct toxic effects to animals.

Environmental contaminants in the system include heavy metals and synthetic organic compounds with some specific areas known to have contaminated sediments. Examples include the highest PCB concentration in lower Pool 2 and elevated levels in Pools 3 through 6, as well as in Pool 15 (Steingraeber et al. 1994). Pools 2 through 4 also have elevated levels of cadmium and mercury in fine sediments (Beauvais et al. 1995). Garbarino et al. (1995) also describe heavy metals found within the Mississippi River and concentrations of lead, mercury, and associated metals found in Lake Pepin and in Pools 12, 19, and 26. The source of these heavy metals is both natural and from human activities. The lead and zinc found in the river can be attributed to two of the largest lead-zinc mining areas in the world that are along the Upper Mississippi River. Other heavy metals can be attributed to current or former use in major industries along the river. Synthetic organic contaminants such as PCB and chlordane are discussed in Rostad et al. (1995). They found that PCB concentrations in silts from the Illinois River were greater than those in the Mississippi River. Though many of these chemicals have now been banned in the United States, they are not easily degraded and continue to persist, often associated with fine sediments. Since they are not water-soluble and associate with sediments, the substances often bioaccumulate and can affect invertebrates, fish, birds, and mammals, including humans. Mayflies (*Hexagenia* spp.) are considered an important species to assess ecosystem contamination and have been studied to document substrate contamination by PCBs, mercury, and cadmium in reaches of the Upper Mississippi River (Steingraeber and Wiener 1995; Steingraeber et al. 1994; Beauvais et al. 1995).

5.2.7 Biota

The Upper Mississippi River System supports one of our Nation's most diverse and abundant assemblages of biota. The UMRS is home to over 200 aquatic macroinvertebrate species, 30 mussel species, 150 fish species, 73 reptile and amphibian species, over 300 bird species, over 50 mammal species, and more than 600 plant species. A general overview of these various species assemblages is presented in the following paragraphs. The system would benefit from a "biodiversity roundup" to complete and verify the floral and faunal lists.

5.2.7.1 Fish

Among commercially or recreationally important fauna, fish constitute the greatest proportion in terms of level of use and economic value generated (Gutreuter and Theiling 1999), and the sport and commercial fisheries have received considerable attention from the UMRS resource management agencies (UMRCC 1993). Among the vast historical assemblage of UMRS fishes (nearly 150 species, excluding rare or occasional species), a relatively small number have comprised most of the sport and commercial catch.

Important sport fish species include walleye (*Stizostedion vitreum*), sauger (*S. canadensis*), largemouth and smallmouth bass (*Micropterus salmoides, M. dolomieu*), bluegill (*Lepomis macrochirus*), and white/black crappie (*Pomoxis annularis / P. nigromaculatus*). Discernible trends in sport fish populations are difficult to observe, at least over long time periods, because of a lack of consistent data. A variety of abiotic and biotic factors affect year-class strength, and the variety of habitat types across the system also affects species composition and abundance. Water quality improvements on the Illinois River have generally benefited fish populations, but continuing sedimentation problems on the middle and lower river are likely to continue the degradation of fish habitat, particularly backwater areas (UMRCC 1993; Gutreuter and Theiling 1999).

Four species groups typically dominate the commercial fishery – common carp (*Cyprinus carpio*), smallmouth and bigmouth buffalo (*Ictiobus bubalus* and *I. cyprinellus*), channel, flathead and blue catfish (*Ictalurus punctatus, Pylodictis olivaris and I. furcatus*), and freshwater drum (*Aplodinatus grunniens*) (UMRCC 1993). The proportion of each of these species in the total catch has shifted somewhat over time, with carp becoming most common (Wiener et al. 1998). Historically, carp have been particularly abundant in the Illinois River commercial catch. Long-term monitoring by Illinois indicates that channel catfish abundance has generally increased since 1976, following commercial size limits (Bertrand 1995). The UMRCC (1993) predicted stable commercial fish demand and harvest in the 10-year period ending in 2003. The arrival of exotic Asian carps has nullified that prediction; in some reaches these exotics comprise a huge proportion of the catch. Resource managers have been trying to establish markets for the fish, but they are so abundant there is hardly any incentive to clean and ship them for the price offered.

5.2.7.2 Birds

The Mississippi and Illinois Rivers serve as major migration corridors for waterfowl and non-game birds, due in part to their north/south orientation and relatively contiguous habitat (Wiener et al. 1998). It has been estimated that nearly 300 species migrate through and/or reside in the UMRS every year (Korschgen et al. 1999). The diversity of species ranges from small neo-tropical migrants to waterfowl, colonial-nesting species such as herons and egrets, and raptors. Bald eagles (*Haliaeetus leucocephalus*) congregate in large numbers below locks and dams during the winter. Waterfowl are perhaps the most visible and certainly the most economically important species on the system. Large numbers of diving and dabbling ducks migrate through the system, and some species are common nesters (mallard, wood duck, hooded merganser, Canada geese). In addition to hunting, birdwatching and related non-consumptive recreational activities also generate significant revenue on the system.

Though waterfowl remain abundant, their numbers have declined since the 1950s, due primarily to habitat alteration or loss and pollution; these declines have been most evident on the Illinois River (Korschgen et al. 1999). Though population information on songbirds and other species is somewhat less intensively collected, trends on the UMRS appear to reflect those for other regions of the country, and are species-dependent. According to Breeding Bird Survey data for the period 1966 to 1994 for a large portion of the UMRS, of those species that showed significant change, 60 percent were trending upward.

Of the eight species of colonial waterbirds that nest within the UMR, great blue herons (*Ardea herodias*) and snowy egrets (*Egretta thula*) are perhaps the most common. Some monitoring of rookeries occurs, and populations of both species, along with double-breasted cormorants, appear to have declined in the 1970s and early 1980s. However, data from the Illinois portion of the Mississippi River indicates an increase in active heron and egret nests during the period 1983 to 1991 (Wiener et al. 1998). Habitat loss, contaminant effects, and human disturbance are all considered to have negatively affected colonial waterbird populations.

5.2.7.3 Mammals

American Indians and European trappers capitalized on the diverse and abundant assemblage of terrestrial and aquatic furbearing mammals that inhabit the UMRS. They found a seemingly endless food supply consisting of large mammals such as elk, bison, and white-tailed deer and small mammals such as squirrels, raccoon, muskrat, and beaver. European exploitation eventually led to the extirpation of the elk and bison; however, most of the remaining mammals have continued to thrive in and along the river.

Terrestrial mammals such as the white-tailed deer, red/gray fox, coyote, squirrels, raccoon, and opossum are found in abundance, primarily inhabiting the river’s floodplain and islands. Bobcat and black bear are occasionally observed in the upper reaches of the UMR, primarily above Pool 11. Aquatic mammals, such as the river otter, beaver, and muskrat, are commonly observed along the riverbanks or backwaters. A few species of bats rely on cavities in the floodplain forests for shelter and the abundant flying insects that are produced in and along the river.

Overall, mammal populations within the river corridor are considered abundant and healthy. However, there are few sources from which to draw on for a comprehensive assessment of the mammalian fauna along the UMRS. Dahlgren (1990) provides an assessment of recent trends in furbearer harvest within the refuge and States along the corridor. In general, most aquatic mammal populations showed a measurable increase in abundance following the creation of slackwater pools. Some declines noted in the early to late 1960s for mink and river otter were linked to PCB contamination of their primary food source, fish.

5.2.7.4 Mussels

Commercial harvest of mussels was conducted extensively for the first time starting in the late 1880s, to supply a burgeoning pearl-shell button industry. But this industry had effectively ceased to exist by 1930 due to over-exploitation, harvest restrictions, and the advent of plastics for use in buttons. In the 1950s, commercial harvest of mussels experienced a resurgence as new overseas markets emerged for cultured pearls (Tucker and Theiling 1999). Initially, only live shells were used to produce the nuclei required for the cultured pearl industry, but gradually the emphasis shifted to dead shells, although demand for live shells remains high (Tucker and Theiling 1999). Washboard (*Megalonaias nervosa*) and threeridge (*Amblema plicata*) mussels are most prevalent in the commercial harvest, and declines in these species, both in abundance and size of individuals, have been documented since the early 1980s (Whitney et al. 1997). A large-scale, but unexplained, die-off in mussels throughout the 1980s added to the concern over mussel populations (Blodgett and Sparks 1987). Dan Kelner (USACE, St. Paul District) prepared a distribution and relative abundance chart of UMRS mussels showing the status of populations in 2003 in support of this study. This can be found in Appendix ENV-I or Wilcox et al. 2004, ENV 54.

On the Illinois River, pollution has been well documented. After construction of the Chicago Sanitary and Ship Canal in 1900, untreated municipal waste impacted the river, contributing to the loss of the aquatic macroinvertebrate community and impacting freshwater mussels as well as other species such as fish and waterfowl (Theiling 1999a). Fish populations also declined, and Lerzak *et al.* (1994) described that fishes associated with sediment showed a high incidence of external abnormalities in the 1960's. Sampling in the 1990s revealed few fish abnormalities and a much more diverse fish community (Lerczac et al. 1994). A comprehensive mussel survey conducted by Starrett (1971) found that by the mid 1960's mussels had been extirpated from the upper river and nearly one-half of mussel species reported in the Illinois River were extirpated. Whitney *et al.* (1999) conducted a similar mussel survey in the mid 1990's and discovered mussels were once again colonizing the upper river, however the oldest individuals were only ten years old. The latter survey, reported no net loss in the total number of mussel species (23 total species) since the 1960's survey, however it was clear the overall mussel abundance had continued to decline in the lower river.

5.2.7.5 Aquatic Plants

Submersed, floating-leaved, and emergent aquatic plants play important roles in the Upper Mississippi River ecosystem (Rogers and Theiling 1999). Aquatic plants in the UMRS occupy habitats ranging from seasonally flooded to continuously flooded shallow aquatic areas. Aquatic plants contribute a significant fraction of the carbon that fuels the river ecosystem. Aquatic plants generate dissolved oxygen, stabilize the substrate, break waves and river currents, filter out suspended materials, provide substrate for algae and macroinvertebrates, and provide food and shelter for fish, waterfowl, and furbearers.

Perennial emergent aquatic plants such as cattail (*Typha* spp.), arrowhead (*Saggitaria* spp.), bulrush (*Scirpus* spp.), and bur reed (*Sparganium eurycarpum*) grow from large tubers and form dense stands. During 1989, emergent aquatic plants covered approximately 3,750 acres in the UMR, primarily in Pool 19 and north. Perennial emergent aquatic plants are rare on the Illinois River and in the southern pools on the UMR except in backwater areas with managed water levels.

Annual emergent aquatic plants such as smartweed (*Polygonium* spp.), wild millet (*Echinochloa crusgalli*), nut grass (*Cyperus* spp.), and beggartick (*Bidens ceruna*) occur in areas with fluctuating water levels, primarily along the margins of backwater areas. An exception is wild rice (*Zinzania aquatica*), which is an annual emergent aquatic plant that grows in deeper marsh areas. Annual emergent aquatic plants grow throughout the UMRS, when and wherever growing season water levels provide dewatered mud flats.

Floating leaved and submersed aquatic plants in the UMRS occur in shallow aquatic areas generally less than 1.5 meters deep. Floating leaved aquatic plants such as white water lily (*Nymphaea odorata*) and duckweed (*Lemna spp*.) primarily occur in quiet backwater areas. Submersed aquatic plants occur in dense beds in backwater areas and in patches along the main channel border areas in the UMR, again in Pool 19 and north. Submersed aquatic plants are rare on the Illinois River.

5.2.7.6 Terrestrial Vegetation

Terrestrial plants in the UMRS include diverse communities of species adapted to the wide range of ecological conditions found in the floodplain ecosystem. Plant species are generally distributed in relation to their soil moisture and flood tolerance, availability of light, and lack of competing species. Emergent wetlands and wet meadows develop in frequently inundated areas that maintain high soil moisture and on exposed mud flats along channel and backwater shorelines. Pioneering trees colonize new terrestrial soils, with willows dominating mud flats and cottonwoods developing on coarse dry soils. Pioneering species do not regenerate under their own cover, and without disturbance, they die out in 30 to 50 years. Pioneering trees, however, condition sites for future plant communities; they trap sediments and build soil with leaf fall and plant litter. Flood and shade tolerant communities, primarily mixed silver maple forests, develop under the cover of pioneering trees. In frequently flooded low elevation areas of the UMRS, mixed silver maple forests are self-sustaining climax communities. Oaks and less flood tolerant species develop on better drained soils, on higher elevations of the floodplain, and on terraces. Evidence suggests that, prior to major changes, floodplain forests graded through oak savannas to prairies from the river to the bluffs in much of the river system. Fire was once an important determinant of plant community composition on the UMRS floodplain.

UMRS floodplain plant communities have been highly exploited and manipulated over the last 150 years. The area available to natural communities has been reduced more than 50 percent in most river reaches, and areas not directly exploited are affected by river regulation and habitat degradation. Areas supporting dry prairies in the pre-settlement era were largely converted to crops, and forests were cut for lumber, heat and cooking, and steamboat fuel wood. Floodplain wetlands have been degraded by dredged material disposal, channel regulation, impoundment, and excessive sedimentation. Natural areas are currently largely restricted to public lands and narrow strips of land riverward of levees.

Terrestrial floodplain vegetation communities of the UMRS are highly valued for their wildlife and recreational benefits. They are also an important source of organic energy to aquatic food webs when plant litter is inundated by flood flows. They have a scenic aesthetic value that contributes to the high recreational value of the UMRS.

5.2.7.7 Macroinvertebrates

Macroinvertebrates comprise a wide range of river fauna, including insects (adult and immature forms), worms, some crustaceans, and some mollusks. Such organisms characteristically lack vertebrae and can be seen with the naked eye. They inhabit all aquatic areas of the rivers, including the water column, soft substrates, and surfaces of aquatic plants, rocks woody debris, and mussel shells. Macroinvertebrates are an important component of the river ecosystem, providing a rich source of food for fish and wildlife. They are also very sensitive to human activities and are often used as indicators of ecosystem integrity.

Current Long Term Resource Monitoring Program (LTRMP) data suggests that benthic macroinvertebrate abundance is generally low but improving in the pooled portions of the UMR. Most macroinvertebrate populations were nearly eliminated from the IWW after decades of severe pollution (Starrett 1972; Bellrose et al. 1983; Sparks 1984). However, there is recent evidence that some species may be returning in limited numbers (Sparks and Ross 1992).

5.2.7.8 Reptiles and Amphibians

Many species of frogs, turtles, snakes, and salamanders thrive in the aquatic and terrestrial habitats of the UMRS. The reptiles and amphibians generally prefer the slow-moving channels, backwaters, isolated pools, or moist terrestrial island habitats.

5.2.7.9 Nonindigenous Species

An increasing number of nonindigenous (non-native) species, including aquatic plants and animals, have invaded the UMRS (Table 5-1). The introduction, proliferation, and spread of nonindigenous aquatic species is largely mediated by human activities such as commercial navigation, aquaculture, recreational boating, sport fishing, aquariums and water gardening, and horticulture practices. Each new introduction is cause for concern for the ecological integrity of the UMRS since nonindigenous species have a longstanding history of creating widespread economic and ecological damage or loss. This topic is addressed in greater detail in Section 9.1.2 Ecological Stressors.

Table 5-1. Aquatic nuisance species of concern in the UMRS.

Fish	**Species**	**Native Region**
Black carp	*Mylopharyngodon piceus*	Asia
Bighead carp*	*Hypophthalmichthys nobilis*	Asia
Silver carp*	*Hypophthalmichthys molitrix*	Asia
Grass carp*	*Ctenopharyngodon idella*	Asia
Common carp*	*Cyprinus carpio*	Asia
Goldfish*	*Carassius auratus*	Asia
Ruffe	*Gymnocephalus cernuus*	Eurasia
Round goby	*Neogobius melanostomus*	Europe
Tubenose goby	*Proterorhinus marmoratus*	Europe
Asian weatherfish	*Misgurnus anquillicaudatus*	Asia
Plants		
Eurasian watermilfoil*	*Myriophyllum spicatum*	Eurasia
Purple loosestrife*	*Lythrum salicaria*	Eurasia
Common reed*	*Phragmites australis*	Europe/United States
Reed canarygrass*	*Phalaris arundinacea*	Europe/United States
Mussels		
Zebra mussel*	*Dreissena polymorpha*	Europe
Quagga mussel	*Dreissena bugensis*	Europe
Asian clam*	*Corbicula fluminea*	Asia
Plankton		
Spiny water fleas	*Bythotrephes cederstroemi* and *Ceropagis pengoi*	Europe
*Found above Lock and Dam 19		

5.2.7.10 Federally Listed Threatened and Endangered Species

In a letter dated January 12, 2004, the Corps of Engineers requested a listing of federally threatened and endangered species that could occur in the proposed project area. In a letter dated January 16, 2004, the U.S. Fish and Wildlife Service (USFWS) provided a list of ten Federally threatened or endangered species that may be found in the project area (Table 5-2). Three species, the pink mucket pearly mussel, fat pocketbook mussel and scaleshell mussel, were considered to be extirpated from the Upper Mississippi River System and were not considered in the Biological Assessment for this project. The Service provided a Biological Opinion (BO) for the Navigation Study on August 27, 2004. The BO determined that the project will not jeopardize the continued existence of the Indiana bat, decurrent false aster, pallid sturgeon, and Higgins eye pearlymussel, but will result in incidental take. If the project is approved, the Corps will comply with all provisions of the new BO, including implementation of the Reasonable and Prudent Measures and their implementing terms and conditions, as well as continued implementation of the Reasonable and Prudent Alternatives and Measures from the 2000 BO for the continued operation and maintenance of the 9-foot Navigation Project, considered the baseline for the Navigation Study. A brief description of the federally threatened and endangered species is provided in subsequent paragraphs. A more thorough analysis is provided on this topic in Appendix ENV-D the Corps' Biological Assessment and the Service's Biological Opinion, which were prepared under Section 7 of the Endangered Species Act.

Table 5-2. Federally Threatened and Endangered Species encountered in or along the Upper Mississippi River-Illinois Waterway.

Common Name	Scientific Name	Status
Decurrent false aster	*Boltonia decurrens*	Threatened
Higgins' eye pearly mussel	*Lampsilis higginsii*	Endangered
Pink mucket pearly mussel	*Lampsilis abrupta*	Endangered (Extirpated)
Winged mapleleaf	*Quadrula fragosa*	Endangered
Fat pocketbook mussel	*Potamilus capax*	Endangered (Extirpated)
Scaleshell mussel	*Leptodea leptodon*	Endangered (Extirpated)
Pallid sturgeon	*Scaphirhynchus albus*	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Threatened
Interior least tern	*Sterna antillarum*	Endangered
Indiana bat	*Myotis sodalis*	Endangered

Decurrent false aster (*Boltonia decurrens*)
The decurrent false aster is a federally listed, threatened floodplain species that occurs along a 400 km section of the lower Illinois River and nearby parts of the Mississippi River. *B. decurrens* is an early successional species that requires either natural or human disturbance to create and maintain suitable habitat. Its natural habitat was wet prairies, shallow marshes, and shores of open rivers, creeks, and lakes. In the past, the annual flood/drought cycle of the Illinois River provided the natural disturbance required by this species. The USFWS indicates that the species can be considered to occur anywhere in the Illinois River floodplain downstream of La Salle County, Illinois, and the Mississippi River in Jersey, Madison and St. Clair Counties, Illinois, and St. Charles County, Missouri. It occupies disturbed alluvial soils in the floodplains of these rivers. No critical habitat is listed for this species. Annual spring flooding created open, high-light habitat and reduced competition by killing other less flood-tolerant, early successional species. Field observations indicate that in “weedy” areas without disturbance, the species is eliminated by competition within 3 to 5 years.

Higgins’ eye pearly mussel (*Lampsilis higginsii)*
The Higgins eye pearly mussel was listed as an endangered species by the USFWS on June 14, 1976 (Federal Register, 41 FR 24064). The major reasons for the listing of *L. higginsii* were the decrease in both the abundance and range of the species. As stated in the original and the 2003 draft revision to the recovery plan, *L. higginsii* was never abundant and Coker (1919) indicated it was becoming increasingly rare around the turn of the century. The fact that there were few records of live specimens from the early 1900s until the enactment of the Endangered Species Act in 1973 was a major factor in its listing in 1976. A variety of factors have been listed as affecting *L. higginsii* over time including commercial harvest, impoundment from the project, channel maintenance dredging and disposal activities, changes in water quality from municipal, industrial and agricultural sources, unavailability of appropriate glochidial hosts, exotic species and disease.

There are ten Essential Habitat Areas identified for Higgins eye pearlymussel. These include; (1) the St. Croix River near Interstate; (2) the St. Croix River at Hudson, Wisconsin (River Mile 16.2 - 17.6); (3) the St. Croix River at Prescott, Wisconsin (River Mile 0 – 0.2); (4) the Wisconsin River near Muscoda, Wisconsin (Orion); (5) the UMR at Whiskey Rock, at Ferryville, Wisconsin, Pool 9 (River Mile 655.8 - 658.4); (6) the UMR at Harpers Slough, Pool 10 (River Mile 639.0 - 641.4); (7) the UMR Main and East Channel at Prairie du Chien, Wisconsin, and Marquette, Iowa, Pool 10 (River Mile 633.4 - 637); (8) the UMR at McMillan Island, Pool 10 (River Mile 616.4 - 619.1); (9) the UMR at Cordova, Illinois, Pool 14

(River Mile 503.0 - 505.5); and (10) the UMR at Sylvan Slough, Quad Cities, Illinois, Pool 15 (River Mile 485.5 - 486.0).

Winged mapleleaf (*Quadrula fragosa)*
The winged mapleleaf is an endangered mussel species of the central United States, federally listed in 1991. The USFWS acknowledges uncertainty with the taxonomic designation of the winged mapleleaf within its 1997 Recovery Plan, however they believed the winged mapleleaf met the ESA definition of species and thus was appropriate for its protection. Studies conducted since then have stated that *Q. fragosa* should be considered a separate species and is genetically distinct from the similar species *Q. quadrula*. In the UMRS, the winged mapleleaf is found only in the St. Croix River.

Pallid sturgeon (*Scaphirhynchus albus)*
Pallid sturgeon, like shovelnose sturgeon, inhabits comparatively large flowing rivers, but pallid sturgeon occur over a narrower range of conditions. In general they prefer greater turbidity, finer substrates, and deeper, wider channels; and they are more likely than shovelnose sturgeon to occur in sinuous reaches and near long-established islands and alluvial bars. The endangered pallid sturgeon (*Scaphirhynchus albus)* occurs in the Missouri River and the Mississippi River downstream from the mouth of the Missouri. The species formerly occurred in the Mississippi River at least as far upstream as Grafton, Illinois. A pallid sturgeon captured in the tailwater of Melvin Price Locks and Dam In 2000. The USFWS listed four reasons for the decline of the pallid sturgeon: (1) habitat loss, (2) commercial harvest, (3) pollution/contaminants, and (4) hybridization with the shovelnose sturgeon.

Bald eagle (*Haliaeetus leucocephalus)*
Now occurring again throughout most of the United States, the bald eagle was first listed as a federally endangered species in 1967. In 1995 the eagle was reclassified as threatened in all 48 conterminous states and in 1999 the USFWS proposed to delist the bald eagle in the 48 conterminous states; that proposal remains pending. Meanwhile, the bald eagle also occurs in Alaska and Canada, where it is not at risk, and is not protected under the Endangered Species Act, and in small numbers in northern Mexico.

Interior least tern (*Sterna antillarum)*
The interior least tern is a federally listed, endangered breeding migratory bird species that occurs in the Missouri River, Arkansas River, Mississippi and Ohio rivers, Red River, and Rio Grande River systems. The Mississippi Valley Division prepared a Biological Assessment to evaluate the effects of the Regulating Works Feature of the Mississippi River between the Ohio and Missouri Rivers and the Channel Improvement Feature of the Mississippi River and Tributary Project (USACE 1999b). That Biological Assessment and the USFWS's Biological Opinion for O&M of the 9-foot Navigation Project contain extensive reviews of the life history of the least tern that are hereby incorporated by reference.

On the Mississippi River the least tern is most abundant on the Lower Mississippi River, below Cairo, Illinois. In the Middle Mississippi River, the species is known to occur between St. Louis and the mouth of the Ohio River. Within this segment of river they are known to nest on Marquette Island (R.M. 50.5), Bumgard Island (R.M. 30), and Brown's Bar (R.M. 23) (Jones 2003). In addition, the St. Louis District recently constructed a least tern nesting island in Pool 26, just above Melvin Price Locks and Dam, that is showing promise as a nesting site. The wintering area of the interior least tern is unknown, however it is believed to be in Central and/or South America (USFWS 1990). No critical habitat is listed for this species. The only Mississippi River essential habitat occurs down stream of the proposed project (from Hwy 146 bridge, Missouri and Illinois, to Vicksburg, Mississippi).

Indiana bat (*Myotis sodalis)*
The Indiana is an endangered mammal species that has been found in 27 states throughout much of the eastern United States. The USFWS issued a "will likely adversely affect" Biological Opinion for Indiana

bats to the Corps for continued Operation and Maintenance of the 9-foot Navigation Channel Project on the Upper Mississippi River in 2000. However, while the project may affect individuals, the impacts will be offset by management actions proposed by the Corps or will be negligible, and will not rise to the level of incidental take (i.e., harm and harassment).

Indiana bats are associated with the major cavernous limestone (karst) regions of the midwestern and eastern United States. Indiana bats winter in caves or mines that satisfy their highly specific needs for cold (but not freezing) temperatures during hibernation. The fact that Indiana bats congregate and form large aggregations in only a small percentage of known caves suggests that very few caves meet their requirements. Exclusion of Indiana bats from hibernacula by blockage of entrances, gates that do not allow for bat flight or proper air flow, and human disturbance of hibernating bats have been major documented causes of Indiana bat declines.

5.2.7.11 State Listed Threatened and Endangered Species

The Corps assessed state-listed species occurring, or potentially occurring, within the study area. The objective of this assessment was to identify state-listed species potentially affected by changes in the UMR-IWW navigation infrastructure, assess potential systemic effects of increased traffic, and potential site-specific effects of construction on those species. Due to the large number of species, the species discussion and complete results of this assessment are found in Appendix ENV-L.

The natural resource agencies from each of the UMR-IWW States provided databases that included thousands of records of species, habitats, and ecosystems. In order to simplify the screening and assessment efforts the databases were first screened with the use of Geographic Information System (GIS) to focus on merely those species records within the floodplain as defined by the UMRS-EMP Long Term Resource Monitoring Program, 1989 land cover/land use GIS coverage. In addition to screening, the status of the species was determined and updated where necessary. Table 5-3 displays the number of species classified as endangered, threatened, or special concern in each state.

Table 5-3. Numbers of species listed as threatened and endangered in each state.

Listed Species	Wisconsin	Minnesota	Iowa	Illinois	Missouri
fish	21	21	15	31	52
mussels	18	30	14	27	24
invertebrates	24	49	15	25	62
mammals	2	15	7	8	11
birds	26	28	7	34	29
reptile/amphibian	10	14	19	22	28
plants	138	276	147	331	374

Species with a status that did not carry any protection were screened out. This included such listings as extinct, extirpated, status undetermined, no legal status, and “proposed” endangered, threatened or special concern. Screening also included habitats and listed ecosystems (such as “dry-mesic forest”). For the species remaining from this screening, information was reviewed on general habitat requirements. Species that do not at least partially depend at some point in their life on the floodplain or aquatic river habitats are less likely to be impacted and those that are mobile are less likely to be effected than non mobile species. The initial screening of species included each record found within the entire floodplain area. However, the potential effects of traffic increase would most likely be within the main navigation channel with some effects possibly extending to the channel border, bankline, and backwaters. Species considered to be at risk from the direct effect of traffic increase include mussels, fish and aquatic plants.

Traffic induced shoreline erosion may also effect species and has the potential to include impacts to floodplain terrestrial plants and animals.

Based upon this screening and using an Ecological Risk Assessment approach the following observations about State listed species were made:

Fish - The ecological risk assessment modeled the potential impact of increased traffic on lake sturgeon, pallid sturgeon, paddlefish, and blue sucker. Based on the habitat preferences of the state-listed fish, impacts to adults are not likely although impacts cannot be ruled out entirely. Fish species may be at risk of increased larval entrainment with an increase in traffic. However, it is not possible to quantify or confirm the extent that they may be impacted. Mitigation for the systemic effects of incremental navigation should offset these potential impacts to State listed threatened and endangered fish species.

Mussels - The results of studies of commercial navigation impacts to freshwater mussels show that the only factor in which traffic may affect the species is through direct contact. Although possible the likelihood of this occurring frequently is small and any impacts would be minor. Therefore, increased commercial navigation traffic on the UMRS is not likely to significantly effect state listed mussel species.

Aquatic Vegetation- There do not appear to be submergent aquatic plants listed that may be susceptible to impacts.

Nests and rookeries- The analysis found 2 records of heron/egret rookeries within 200 meters of sites identified with moderate to medium navigational erosion potential. One site in Pool 10 is 63.5 meters in length and described as a scarp <4ft in height. In Pool 9 the site is 163 meters in length and described as scarp >4ft in height. Protection of these sites would be addressed through mitigation.

5.2.8 Significant Environmental Resources

Significant ecological resources are structural components of the river ecosystem (i.e., habitats, plant and animal communities) and ecosystem processes (i.e., material and energy flows) that play an integral role in the functioning or structure of a healthy ecosystem. The following discussion will identify the significant ecological structures and processes of the UMRS.

5.2.8.1 Significant Ecological Processes

The health of the river ecosystem is dependent on interrelated physical, chemical, and biological processes. The physical processes of water flow and materials transport shape the river channels and floodplains and form the physical template of habitats. Biological processes of photosynthesis, consumption, respiration, growth, reproduction, and decomposition determine the flow of energy and materials through the food web and the abundance of life in the river ecosystem. These biological processes are mediated by physical conditions, particularly the hydrologic regime, the availability of nutrients, and the weather. The details of these relationships form the foundation for evaluating the ecological response to management actions. The science panel reviewing the plan formulation for this study recommended ecosystem models to predict ecosystem responses. Understanding the complexity of the task, they developed a conceptual model to help explain and understand the pathways linking ecological components (Lubinski and Barko 2003).

5.2.8.2 Water Flow

The process of primary importance to the river ecosystem is the flow of water, dissipating kinetic energy and conveying heat energy, sediment, particulate organic matter, organisms, and dissolved constituents. The continuously changing hydrologic regime results in conveyance of energy, organisms, and materials longitudinally down the stream drainage network and on down the main stem Mississippi River to the sea, and exchanges laterally between the river channels and the floodplains. This primary process of water flow is driven by the climate and weather events in the river basin.

Navigation structures affect the distribution of surface waters, the current velocity during low flow, and the distribution of current, but they do not greatly affect flow. The navigation pools are not storage reservoirs.

5.2.8.3 Material Transport

As mentioned above, moving water conveys sediment, particulate organic matter, organisms, and dissolved constituents. River flow conveys materials downstream and laterally between the floodplain and the main channel. Human activity throughout the river basin modifies the primary processes of water flow and materials transport through land use, dams, and river regulation. Many linked ecological processes involving the fate and transport of materials such as sediment and the plant nutrients nitrogen and phosphorus are driven primarily by the hydrologic regime, modified by human activities, and modified by biological activity.

5.2.8.4 Habitat Formation and Succession

The movement of water and sediment shapes the river channels and floodplains, making the physical template for the aquatic and floodplain habitats. River flow and sediment transport processes (under natural conditions) determine the geometry of the river channels and the formation of floodplain land features. Changes in river discharge and sediment transport from the basin result in changes in the geometry of river channels and floodplains over time. Although the island-braided form of the UMR has remained fairly stable over centuries (unlike the meandering middle and lower Mississippi River), smaller-scale changes in river geometry occur more frequently and affect the mosaic of habitats. Land use in the basin, impoundment and river regulation (i.e., dam operation that affects river flow and water levels), levees, and channel structures have altered the hydrologic regime and sediment processes, thereby altering the habitat formation and succession, resulting in the existing mosaic of UMRS habitats. Impoundment, levees, shoreline armoring by riprap, and channel structures have constrained the geometry of the river and reduced the natural changes in channel geometry and floodplain features that would otherwise occur. Floodplain areas that were once seasonally inundated are now continuously aquatic areas, impounded by the navigation dams. The large, open water areas in the lower parts of some navigation pools are subject to wind-driven waves that play an important role in shaping islands and shorelines and smoothing the river bottom. Impoundment has reduced current velocity in off-channel areas, resulting in accelerated deposition of sediment.

Vegetation is an important component of many aquatic and floodplain habitats in the UMRS. In addition to the changes in physical habitat conditions on the UMR imposed by human activity, floodplain vegetation succession has been altered. Impoundment of the navigation system and fire suppression nearly eliminated floodplain prairie areas. Higher floodplain groundwater levels reduced the areas where less flood-tolerant trees such as hickories and oaks can occur. The UMRS floodplain is now dominated by flood-tolerant trees such as silver maple and cottonwood. The reduced rate of formation of new floodplain land features has limited the amount of early successional stage communities such as willow thickets. Impoundment of the navigation pools initially resulted in increased areas of aquatic vegetation, but high minimum water levels and increased suspended sediments have generally reduced the abundance of aquatic vegetation.

5.2.8.5 Energy Flow and the Food Web

The important ecological process of primary production by algae, aquatic plants, and floodplain forest captures the energy of the sun through photosynthesis and provides the organic carbon-bound energy and materials needed by other forms of river life. Primary production in the UMRS is also controlled to a large extent by the hydrologic regime and the weather. The ecological processes of energy and materials transfer through the food web directly affect the abundance and distribution of life forms. The food web for aquatic life in the UMRS is based primarily on particulate organic matter, produced in tributary basins, in the floodplain, and by algae and aquatic plants. Invertebrates (such as mussels, mayflies and fingernail clams) and fish (such as gizzard shad) consume particulate organic matter and serve as prey for many other species. Bacteria and fungus decompose organic matter, breaking down large pieces into particulate matter and releasing the nutrients for use again by plants.

5.2.9 Significant Biological Resources

5.2.9.1 Keystone Species

Species are referred to as keystone if their contribution is disproportional to the overall production of an ecological system, either directly in terms of numbers, biomass, and energy flow, or indirectly through decomposition and nutrient recycling. This notion of species as keystone in relation to productivity has also been termed *ecological importance* (Pianka 1974). From this point of view, highly productive species of primary producers (e.g., phytoplankton, periphyton, submersed aquatic vegetation, and some emergent plants) and secondary producers (e.g., some zooplankton, benthic insects, and other benthic invertebrates) are examples of keystone species.

In the UMRS river floodplains, silver maple (*Acer saccharinum*) is a keystone species, providing the majority of the forest structure and biomass. Because of the abundance of photosynthetic production by algae and aquatic plants, and the large contribution of organic matter from the floodplain and tributaries to the main stem river, filter-feeding organisms that eat fine particular organic matter are important primary consumers. Among the invertebrates, the caddisflies, especially *Hydropsyche orris*, are abundant filter feeders occupying hard substrates. The large burrowing mayflies *Hexagenia limbata* and *Hexagenia bilineata* are filter feeders occupying silt and clay substrates. These filter-feeding macroinvertebrates provide food for many species of fish. They also cycle nutrients from the river back to the floodplain as the adults emerge and fly. Gizzard shad (*Dorosoma cepedianum*) may be the most abundant fish species in the UMRS by biomass and numbers. They are filter feeders and important prey to many other fish species.

The UMRS is a geologically old, large river system that served as a refuge for many aquatic species during glacial times. The river is also geographically located near the border between the prairie and eastern hardwood biomes. The valley and temperate microclimate along the river provide a pathway for northern dispersal of plants and animals. The result is that the UMRS is species rich, comprised of groups with similar adaptations and behavior, and is more complex than river ecosystems farther north. Because the UMRS is species rich, it is harder to identify keystone species than in simpler ecosystems, particularly for fish. A more useful approach may be to look at guilds or other species associations rather than individual species.

The loss of a keystone species can have effects on the remaining species in the ecosystem, depending on the characteristics of the ecosystem and the role of the species. Cascade effects occur when the local extirpation of one species significantly changes the population sizes of other species, potentially leading to other extirpations. Cascade effects are likely when the lost species is a "keystone predator," a "keystone mutualist," or the prey of a "specialist predator" (World Resources Institute 1999). In the case of the loss of a keystone predator, species diversity among prey may also decline. Some key predators in UMRS backwaters are bowfin, gar, northern pike, and largemouth bass. Mutualism is particularly significant on the UMRS due to the specific fish/host relationships with the glochidial stage of Unionid mussels. A commonly cited example is the construction of Lock and Dam 19 at Keokuk, Iowa, which created a barrier to upriver migration of skipjack herring. The disappearance of skipjack herring in the upper river is the primary suspect for extirpation of ebony shell mussels, which relied exclusively on the skipjack herring as a host species.

5.2.9.2 Sport and Commercially-Exploited Species
The UMRS supports popular and economically important sport and commercial fishing, hunting, and trapping. Walleye, sauger, channel catfish, bluegill, black crappie, and largemouth bass are the most commonly caught sport fish species on the UMR. Common carp, buffalo, channel catfish, and freshwater drum are the species most commonly caught and sold in the commercial fishery. Although the Illinois River once supported one of the most abundant freshwater river commercial fisheries in the world, that fishery has now declined to commercial extinction. Muskrat, mink, and beaver are the most commonly trapped furbearers. A number of waterfowl species and white-tailed deer are sought by hunters. Wood ducks, mallards, teal, and Canada geese are the most commonly hunted waterfowl. The canvasback duck was once abundant on the UMRS during migrations, declined markedly, and is now showing signs of recovery. Over 30 percent of the North American population of canvasback ducks make use of the UMRS during migrations.

5.2.9.3 Nonindigenous Species
Once established, nonindigenous species can assume a significant, yet often deleterious, role in the river ecosystem. Many nonindigenous species have effectively caused changes in community composition and ecosystem functions. The most ecologically significant invasive organism in the UMRS is the common carp (*Cyprinus carpio*). Carp have markedly altered the composition of the fish community, reduced the abundance of aquatic plants, reduced the abundance of macroinvertebrates, and increased suspended sediment concentrations in many parts of the UMRS by their bottom feeding. The most ecologically significant invasive macroinvertebrate is the zebra mussel (*Dreissena polymorpha*). This species was introduced to the UMRS in the early 1990s, via the Great Lakes and Illinois Waterway, and spread rapidly throughout most of the system. The zebra mussel can negatively affect water quality, including depletion of dissolved oxygen, and directly affect native mussels by attaching in large numbers to their shells and competing for food. Eurasian watermilfoil (*Myriophyllum spicatum*) is a nonindigenous aquatic plant now widespread in the UMRS that proliferates rapidly, displacing native plants and altering community structure and related food webs. Several invasive fish species, besides the common carp, now inhabit the UMRS, including grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix)* and round goby (*Neogobius melanostomus*) (see Section 9.1.2.10). Effects of these and other non-native fishes include competition for food and habitat, as well as introduction of exotic disease pathogens and parasites. Several nonindigenous species found in the UMRS are listed in Table 5-1.

5.2.9.4 Threatened or Endangered Species
Federal and State law mandates that listed species be given preferential treatment with regard to identifying, minimizing, or mitigating potential impacts. Therefore, such species must be considered significant biological resources under any Federal project. A separate biological assessment has been prepared for this protected group of species (Appendix ENV-D). State-listed species are addressed in Appendix ENV-L.

5.2.9.5 Significant Cultural Resources
Historic properties, traditional cultural properties, the existing navigation project infrastructure, port facilities, levees, agricultural areas, small communities, and urban areas are all significant cultural resources in the UMRS floodplain. To afford protection to known and unknown historic properties accorded by the NHPA for the programmatic approach of supplemental, site-specific environmental assessments, the Corps proposes to execute programmatic agreement documentation, as stipulated by 36 CFR Part 800.14(b)(ii) of the NHPA. The Draft Programmatic Agreement was developed collaboratively by the U.S. Army Corps of Engineers Mississippi Valley Division, St. Paul District, Rock Island District, and St. Louis District; and was coordinated with the U.S. Fish and Wildlife Service and State Historic Preservation Officers from Illinois, Iowa, Minnesota, Missouri, and Wisconsin (Appendix ENV-C). A

Programmatic Agreement (PA) is appropriate for the proposed Navigation Study navigation improvements, as regulated by 36 CFR Part 800.14(b)(ii) of the NHPA and the inclusion of the PA allows for public participation by review and comment on the Draft PA, as regulated by CFR Part 800.14(c)(2). Responses from the SHPOs and ACHP were considered in this Draft PA. Those on the Navigation Study mailing list were notified of the availability of the Feasibility Report/EIS with Draft PA for a programmatic approach to identify effects to historic properties, as part of the consultation process outlined in 36 CFR Part 800.8(c)(1). The appropriate and/or pertinent comments of all parties will be addressed, then one final PA will be provided to the signatories for execution by the signatories to this agreement. Comments were received from Iowa and Minnesota State Historic Preservation Officers and the U.S. Fish and Wildlife Service which were addressed in the Final PA (Appendix ENV-C). A copy of the signed (executed) PA will be in every NEPA document of the Navigation Study and related projects, as evidence of Corps compliance promulgated by the NHPA (Appendix ENV-C).

5.2.10 Land Management

5.2.10.1 USACE Managed Lands

Project lands in the three UMR Corps Districts total as follows: St. Paul, 50,500 acres; Rock Island, 93,600 acres; and St. Louis, 49,247 acres. The majority of these lands are outgranted to various individuals or entities for a variety of purposes, though the Corps maintains primary administrative authority and a stewardship role. As such, each Corps District responsibly manages its respective natural resources through conservation, maintenance, and enhancement practices. Guidance for the Corps management is provided in Federal legislation such as, but not limited to, the National Environmental Policy Act; the Comprehensive Environmental Response, Compensation and Liability Act; the Forest Cover Act; and the Historic Preservation Act. Additional guidance is dictated by agency policy and regulations. The Corps retains responsibility to provide protection of forest or other vegetative cover on these lands in compliance with Public Law 86-717 and to establish and maintain other conservation measures on these areas. Corps management programs are to promote future resources and to increase the value of such areas for conservation, recreation, and other beneficial uses, provided that management is compatible with other uses of the project. Specific management goals and objectives are included in each District’s Master Plans and Operational Management Plans (OMPs). Lands identified as particularly valuable for migratory waterfowl habitat are outgranted to the U.S. Fish and Wildlife Service for fish and wildlife management purposes via a cooperative agreement; a further portion of these lands is sub-granted to State conservation agencies for similar purposes. The U.S. Fish and Wildlife Service outgrants 83,638 acres in the Rock Island District, 43,400 acres in the St. Paul District, and 35,775 acres in the St. Louis District.

The Corps also leases a portion of its lands to private individuals for recreational or residential purposes. In the Rock Island District, approximately 565 private recreational and residential leases encompass 465 acres. In the St. Louis District, 18 cabin subdivisions (350 recreational cottage leases are still active) dot the riverbanks. In the St. Paul District, 810 such leases comprise a total of 500 acres. New leases are not being issued, but existing sites are maintained. If leased areas are relinquished by the lessee or revoked for violation of lease conditions, all site structures are required to be removed and the area returned to its original condition. Natural resource management prescriptions are implemented, which include closure or removal of the access road and conversion to natural habitat.

The three Districts operate and maintain 31 recreation areas along the river. Seventy-three additional recreation areas are located on Corps lands but are leased to other organizations that are responsible for operation and maintenance. Twenty-two major public parks are located along the river.

The St. Paul District manages one major recreation area, day use areas at 11 locks and dams, three boat ramps, and two visitor centers at Upper St. Anthony Falls and Lock and Dam 1. Blackhawk Park, about

25 miles south of La Crosse, Wisconsin, is the only full service Class A staffed campground/park that the District operates on the Mississippi River above Guttenberg, Iowa, and the District manages many real estate outgrants within this area.

The Rock Island District manages six Class A campgrounds (modern fee facilities), three Class C campgrounds (primitive fee facilities), six no-fee primitive campgrounds, 10 day-use areas with day-use fee boat ramps, 10 free day-use areas with boat ramps, 12 no-fee day-use areas with picnic shelters, five lock and dam overlooks, and one Class B project visitor center. In calendar year 1999, there were approximately 55 million visitor hours of use on Rock Island District Mississippi River Project lands and waters, with about 10 percent or 5.5 million visitor hours occurring at Corps-administered recreational facilities. Additionally, Rock Island District's shoreline management program administers 347 shoreline use and special use permits for private structures and recreational docks within 52 limited development areas, balancing the need for private recreational water access with the needs of and preservation of the Mississippi River's environment.

The St. Louis District manages seven recreation areas, 18 access areas, and five marinas. Eighteen cabin subdivisions (350 recreational cottage leases are still active) dot the riverbanks. The States of Illinois and Missouri operate three recreation areas and 17 accesses on Corps-owned land. The city of Alton, Illinois, operates one marina on Corps land. Local governments, as well as the States, operate an additional 23 access areas. The Rivers Project Office operates a regional visitor center at the Melvin Price Locks and Dam area and Class C visitor centers at Locks 27 and Kaskaskia Lock and Dam. Other recreational points of interest are the Mark Twain National Wildlife Refuge, the Lewis and Clark State Historical Park, the Riverlands Environmental Demonstration Area adjacent to the Melvin Price Locks and Dam, the multi-agency confluence greenway (Mississippi and Missouri Rivers), and the regional bike trail system. In calendar year 1999, there were approximately 13 million visitor hours of use on St. Louis District Rivers Project lands and waters, with about 50 percent or 6.5 million visitor hours occurring at Corps-administered recreational facilities.

5.2.10.2 USFWS - National Fish and Wildlife Refuge Management

As stipulated in Section 4.2.2.1.2, a major portion of the lands acquired for the 9-Foot Channel Navigation Project are outgranted to the U.S. Fish and Wildlife Service as part of refuges or managed by State conservation agencies. The UMRS encompasses four National Fish and Wildlife Refuges (NWR; USFWS 2003b). The Upper Mississippi River National Wildlife and Fish Refuge extends for over 260 river miles, from Lake Pepin in Pool 4, near Wabasha, Minnesota, to Lock and Dam 15 in Rock Island, Illinois. The refuge covers approximately 233,500 acres of floodplain habitats in Minnesota, Wisconsin, Iowa, and Illinois (USFWS 1987, 2003). The refuge is managed for a variety of purposes; in particular, migratory bird habitat, fisheries, and public interpretation and recreation. Also included in the Upper Mississippi Refuge complex is the 5,733-acre Trempealeau National Wildlife Refuge in Pool 6. Management and administration of these two UMR refuges is handled by four District offices in Winona, Minnesota, La Crosse, Wisconsin, McGregor, Iowa, and Savanna, Illinois.

The Mississippi National River and Recreation Area runs from above the head of navigation to the Dakota/Goodhue, Minnesota, County line and contains numerous significant habitat areas, regional parks and trails, and cultural/historic sites.

Moving farther south, the Mark Twain National Wildlife and Fish Refuge includes 29,223 acres extending from near Rock Island, Illinois, to St. Louis, Missouri, and the lower 10 miles of the Illinois River. The Mark Twain refuge also emphasizes habitat management for migratory birds, and consists of three management districts at Wapello, Iowa, Brussels, Illinois, and Annada, Missouri. The complex also includes the 3,751-acre Clarence Cannon National Wildlife Refuge in Pool 25.

The Illinois River National Wildlife Refuge consists of a complex of four refuges with a total of nearly 16,223 acres, including the Chautauqua, Meredosia, Emiquon, and Two Rivers Refuges, and the Cameron/Billsbach Unit. Management of the Illinois River Refuges emphasizes primarily habitat management for migratory birds.

5.2.10.3 NPS - National Wild and Scenic Rivers

Under the National Wild and Scenic Rivers Act, the National Park Service (NPS) is required to maintain a Nationwide Rivers Inventory. All Federal agencies are required to consult with the NPS on any activities that may adversely affect the wild, scenic, or recreational status of a listed river. The Nationwide Rivers Inventory includes over 100 rivers or river segments in the broader UMR basin in Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Within the Navigation Study area basin, these include the following rivers:

- Minnesota – Urban streams in the Twin Cities (Minnehaha Creek, Crow River); Mississippi River from St. Croix River confluence to Lock and Dam 1; seven segments of the Minnesota River, including the mouth at the Mississippi River.
- Wisconsin – Black and Chippewa Rivers and parts of the Wisconsin River.
- Iowa – Cedar, Maquoketa, Shell Fork, Turkey, Upper Iowa, Wapsipinicon, West Fork Des Moines, and Yellow Rivers.
- Illinois – Apple, Big Indian Creek, Big Muddy, Des Plaines, Fox, Illinois River (27-mile portion north and south of Peoria), Kankakee, Kishwaukee, Mackinaw, Mazon, Ohio River (140-mile portion from the confluence with the Mississippi River), Plum Creek, Sangamon, Sugar Creek, and Vermillion River.
- Missouri – Fabius River (north, middle and south forks).
- Wisconsin – St. Croix and Wisconsin Rivers.

These rivers will not be affected by the proposed navigation improvements.

5.2.10.4 NPS - National Parks

Three National Parks lie within or immediately adjacent to the UMRS: (1) Effigy Mounds National Monument, (2) St. Croix National Scenic Riverway, and (3) Mississippi National River and Recreation Area.

Effigy Mounds National Monument is in northeast Iowa. Effigy Mounds was established by presidential proclamation in 1949. The monument's 1,483 acres preserve a representative example of the prehistoric American Woodland Indian mound-building culture and protect wildlife, scenic, and other natural values of the area. Natural features in the monument include forests, tallgrass prairies, wetlands, and rivers.

The St. Croix National Scenic Riverway is a 252-mile-long corridor that consists of the St. Croix and Namekagon Rivers. The Riverway is one of the initial rivers designated under the Wild and Scenic Rivers Act of 1968. The Lower St. Croix River, added in 1972, includes a 24-mile section that is a commercially navigable part of the UMR-IWW. The St. Croix River is a unique area with a diversity of habitat and scenic beauty; it is home to two federally endangered mussel species, the Higgins eye mussel and the winged mapleleaf mussel. This is the only known population of winged mapleleaf left in the world.

The Mississippi National River and Recreation Area is a 72-mile river corridor through the Minneapolis/St. Paul metropolitan area. Congress added the Mississippi National River and Recreation Area to the National Park System in 1988 to represent the national significance of the Mississippi River. The Mississippi National River and Recreation Area's boundary includes 54,000 acres of river and adjoining land. Of those, only 43 acres are owned by the National Park Service. The Mississippi National River and Recreation Area partners with local governments and private agencies to preserve, protect, and enhance the significant historical, cultural, natural, scientific, economic, recreational, and scenic resources located in the corridor. Numerous public parks operated by other agencies are found within the boundaries of the area. These parks offer many types of educational programs, trails, picnic areas, and other activities.

5.2.10.5 State Lands

State lands in or adjacent to the project area are managed or designated for several purposes. These uses include recreation, wildlife/fisheries management, areas designated for research or habitat preservation, or for historic significance. State managed parks and conservation areas include approximately 50,585 acres on the Illinois River. Additionally, private hunting clubs manage areas for waterfowl hunting. The States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin manage over 192,230 acres for fish and wildlife purposes at more than 80 sites along the Upper Mississippi River. As mentioned earlier in this section, these often are Federal lands, but leased from the Corps of Engineers. Therefore, additional information on these areas may be found in the OMPs and Land Use Allocation Plans (LUAPs) for St. Paul and Rock Island Districts (USACE 1988c, 1989b) and in the St. Louis District's Rivers Project Master Plan for the management of the natural, cultural, and recreation resources on Federal lands (http://www.mvs.usace.army.mil/pm/riverplan/MasterPlan.html).

5.2.10.6 Native American Land

The Prairie Island Indian Reservation, located near Red Wing, Minnesota, in UMR Navigation Pool 3, is the only Native American landholding in the study area. The reservation's 1,200 acres along the river is owned and managed by the Mdewakanton Dakota Sioux. The Mdewakanton Dakota hold some land in fee title, and the Department of the Interior holds some land in trust for the tribe.

5.2.10.7 Levee and Drainage Districts

Agricultural, municipal, and industrial levees and drainage districts are most prevalent in the UMR below Clinton, Iowa, and the lower Illinois River below Peoria, Illinois (Table 5-4). Within the section of the UMR from Lock and Dam 13 at Clinton, Iowa, to the junction of the Ohio River at Cairo, Illinois, approximately 840,000 acres (51 percent) of the floodplain has been isolated by levees. Conversely, only 19,000 acres (4 percent) of the floodplain above Clinton, Iowa, has been isolated by levees. A similar trend exists within the Illinois Waterway. Below Peoria, Illinois, approximately 253,000 acres (61 percent) of floodplain area is leveed compared with only 5,000 acres (3 percent) above Peoria.

The levees are generally designed to protect human life and property by reducing or eliminating the threat from recurrent annual flood events. The interior of leveed areas is often networked with a system of tile lines, ditches, and pumps designed to remove excess water from surface runoff and seepage, allowing for the production of agricultural row crops, corn, and soybeans. About 15 percent of the area within levee districts is natural habitats other than agriculture. The amount of habitat in leveed areas is as follows:

- Open Water 28,000 acres
- Marsh 39,000 acres
- Grassland 38,000 acres
- Forest 71,000 acres

Agricultural levees are often of lower elevation than municipal and industrial levees and may be breached periodically.

Table 5-4. Leveed area and public lands distribution and abundance in the UMRS (USACE 2000b).

River/Pool/Reach	Total	Leveed Area		Public Ownership	
	Floodplain Acres	Total Acres	% of Floodplain	Total Acres	% of Floodplain
Upper Mississippi River (UMR)					
Pool 2	21,620	1,013	4.70%	4,723	21.80%
Pool 3	23,584	0	0.00%	10,468	44.40%
Pool 4	70,062	188	0.30%	19,893	28.40%
Pool 5	29,931	82	0.30%	18,616	62.20%
Pool 5a	16,887	5	0.00%	12,399	73.40%
Pool 6	25,011	5,968	23.90%	11,609	46.40%
Pool 7	41,543	0	0.00%	19,834	47.70%
Pool 8	47,110	1,400	3.00%	29,272	62.10%
Pool 9	52,166	2	0.00%	45,944	88.10%
Pool 10	39,863	274	0.70%	23,754	59.60%
Pool 11	31,959	222	0.70%	25,387	79.40%
Pool 12	21,981	1,084	4.90%	14,677	66.80%
Pool 13	85,287	8,408	9.90%	52,228	61.20%
Pool 14	65,840	22,042	33.50%	12,150	18.50%
Pool 15	10,307	2,067	20.10%	1,040	10.10%
Pool 16	33,906	4,090	12.10%	10,517	31.00%
Pool 17	80,554	59,925	74.40%	7,820	9.70%
Pool 18	126,123	46,436	36.80%	20,432	16.20%
Pool 19	123,312	37,156	30.10%	842	0.70%
Pool 20	70,402	47,513	67.50%	3,922	5.60%
Pool 21	61,081	39,918	65.40%	12,024	19.70%
Pool 22	88,643	68,340	77.10%	8,129	9.20%
Pool 24	88,774	65,245	73.50%	14,062	15.80%
Pool 25	89,071	50,677	56.90%	16,292	18.30%
Pool 26*	138,382	32,290	23.30%	3,633	2.60%
L&D 26 to Kaskaskia R.	278,559	209,221	75.10%	1,709	0.60%
Kaskaskia R. to Grand Tower	130,399	87,492	67.10%	27,471	21.10%
Grand Tower to Ohio R.*	264,095	65,917	25.00%	25,518	9.70%
Total UMR	**2,156,461**	**856,981**	**39.70%**	**454,361**	**21.10%**
Illinois Waterway (IWW)					
Lockport	15,433	0	0.00%	412	2.70%
Brandon	1,855	0	0.00%	0	0.00%
Dresden	6,076	0	0.00%	647	10.70%
Marseilles	25,503	0	0.00%	37	0.10%
Starved Rock	13,956	0	0.00%	0	0.00%
Peoria	131,476	4,952	3.80%	13,590	10.30%
La Grange	221,226	119,590	54.10%	39,599	17.90%
Alton	196,652	133,563	67.90%	21,104	10.70%
Total IWW	**612,177**	**258,105**	**42.20%**	**75,389**	**12.30%**

* GIS levee coverage incomplete (see IFMRC 1994)

5.2.11 Recreational Activities

A comprehensive examination of recreational activity and associated economic impact on the UMRS was conducted by Carlson et al. (1995), and unless otherwise cited, most of the information in this section is taken from that report. The report was based on survey data collected in 1990 and 1991. Not surprisingly, water-based activities dominate recreation use, with boating, boat fishing, and sightseeing being the most popular activities. Sixty-six to 75 percent of the recreational participants were from counties bordering the rivers, and most visits (75 percent) were day trips. The study estimated that over 12 million daily visits occurred throughout the UMRS during the study year.

5.2.11.1 Sightseeing

The popularity of sightseeing attests to the visual and aesthetic appeal of the UMRS, and river communities have made concerted efforts to capitalize on this appeal by providing interpretive, historical, and entertainment attractions to enhance visitors' experiences on the rivers. These local efforts have been supported and often facilitated by broader programs such as the American Heritage Rivers designation for the Mississippi River, the Mississippi River Parkway Commission, and the State of Illinois' initiatives for restoration and enhancement of the Illinois River. Viewscapes of the river are highly prized by homeowners, particularly in areas where high bluff topography allows unobstructed panoramas of the river landscape.

5.2.11.2 Boating

Recreational boating is the most popular and economically important recreational activity on the UMRS. Carlson et al. (1995) estimated recreational activity and expenditures on the UMRS. They estimated that over 12 million daily recreational visits to the UMRS took place in 1990. These visits supported over $1.2 billion in national economic impacts (1990 price levels) and over 18,000 jobs nationwide. Three related surveys relating to recreational boating were conducted in that study, from developed sites (over 600 sites), marinas (18,000 slips), and permitted docks (2,800 docks). Of the 12 million estimated daily recreational visits, over half (6.9 million) were boaters. These visits accounted for approximately 2.6 million boat trips on the UMRS during the study year.

The total number of recreational boats locked through on the UMRS (total for all locks, UMR and Illinois River) was 217,364 in 1999. Most boat trips on the UMRS remain within the navigation pool or river reach of origin, and do not include a lockage. Boating activity on the UMRS varies from year to year, depending in large part on the summer weather. Recreational boating activity on the UMRS has been increasing in number of boaters, number of boats (Johnson 1994; MNDNR 1997; Penaloza 1991), size and power of boats (Johnson 1994), number of docks and marina slips, and number of shore developments such as restaurants and hotels that support recreational boating.

5.2.11.3 Sport Fishing

Sport fishing, both from boats or shore/docks, nearly equals boating in popularity as a recreational pursuit on the UMRS. Several recreational use surveys conducted between 1972 and 1981 indicated that over 10 million sport fishing days occur annually on the Upper Mississippi River alone (UMRCC 1993). Though limited stock assessment efforts and creel survey data prevent reliable estimates of fish populations and harvest pressure, the sport fishery has with few exceptions remained strong historically, despite considerable annual fluctuations; trends are also highly species specific. Tournament fishing for largemouth bass and walleye/sauger began in the late 1980s and has become increasingly popular in some Illinois and Mississippi River pools.

5.2.11.4 Hunting

Hunting activity along the rivers consists almost exclusively of duck hunting; hunting for other game birds and small or big game animals does occur, but to a small extent. About 3 percent of the activities summarized in the Carlson et al. (1995) report consisted of duck hunting. Despite a relatively small public participation, waterfowl hunting has a devoted following, and management efforts on the rivers have aimed at improving or increasing waterfowl habitat. An example of this is the incorporation of water level management features in many Environmental Management Program Habitat Rehabilitation and Enhancement Projects (EMP-HREPs). These features allow manipulation of water levels in controlled areas to enhance growth of waterfowl food plants and maintain sufficient water levels for migrating ducks. A number of privately owned and managed waterfowl hunting areas also occur on the system.

5.2.11.5 Trapping

Dahlgren (1990) provides a comprehensive historical overview (1939-1989) of trapping on the Upper Mississippi River NWR, and this information likely is illustrative for the entire UMRS. His data indicate that trapping is also a relatively minor activity on the system, with an estimated 1,037 active trappers in 1988-89; the maximum estimated number was 2,137 in 1980-81. Muskrat (*Ondatra zibethica*) was the most prevalent species in the harvest, followed by beaver (*Castor canadensis*), mink (*Mustela vison*), and raccoon (*Procyon lotor*). Incidental catches of red fox (*Vulpes vulpes*), river otter (*Lutra canadensis*), and weasels (*Mustela spp*.) have also been reported. Beginning in 1955, data reflected activity by State, and showed that Wisconsin consistently had the highest number of licensed trappers, followed in order by Iowa, Minnesota, and Illinois. Despite the small number of trappers, the economic value of the fur harvest is substantial; it is estimated that the total value of the harvest for the years 1984 to 1989 was $2.3 million.

5.2.11.6 Other

A variety of pursuits comprise other recreational activities on the UMRS. These may include sightseeing (as noted above, the third most popular activity on the system), picnicking, hiking, waterskiing, camping, swimming, birdwatching, and ice fishing. Many of these activities are facilitated by the numerous established areas such as parks, campgrounds, and other recreational areas described above.

In terms of economic benefits of river-related recreational activities, Carlson et al. (1995) considered both recreation-related expenditures and overall economic impacts on a regional and inter-regional basis. Expenditure data included trip expenditures (expenses for items consumed during a trip) and durable goods expenditures associated with a trip. A number of factors influence the level of trip expenditures; trips involving boating typically resulted in greater expenditures, as did overnight trips. Residents tended to spend more than non-residents, and most spending occurred within 30 miles of the recreational site visited. Similarly, durable goods spending, on a per-trip average, was much greater at marina slips versus other sites surveyed. Developed recreation areas had the greatest overall spending. In considering regional economics, the authors considered only those durable goods purchased in UMRS corridor counties, as these purchases cannot in all cases be directly tied to recreation activity on the system.

The overall economic impact analysis related visitor spending to regional income and employment; the analysis considered direct, indirect, and induced effects of this spending. In addition to the regional context (the ‘regions’ being those 76 counties bordering the Illinois and Mississippi Rivers, and the entire 5-State area), the analysis also examined economic benefits to the Nation. It was estimated that, in the study year (1990), recreation activity generated $400 to $550 million in total output and 7,000 to 10,000 jobs regionally, and similarly $1.2 billion and over 18,000 jobs nationally.

5.2.12 Social and Economic Conditions

The purpose of describing the socioeconomic environment of a study area is to provide an understanding of the socioeconomic forces that shape the area. The study area is the geographic region in which the significant economic and social consequences of a project occur.

5.2.12.1 Population

Population is one of the parameters of community change. The changes in community population over time are one of several indicators of past and current trends in the community that influence its potential for growth. This growth will continue to reshape and determine future resource uses and needs.

Together, the 78 counties that comprise the study area contain nearly 5 percent of the Nation's population. The combined 1990 population of the Upper Mississippi River counties within the study area is estimated at 5,444,125, with nearly 83 percent of this population residing in urban areas. The 1990 population for the Illinois Waterway counties is estimated at 7,012,147, with over 95 percent residing in urban areas. Counties in the study area are expected to have population growth rates below the national average through 2010. Population for the entire study area is forecast to increase at a rate of 5 percent and 4 percent, respectively, from 1990 to 2000 and 2000 to 2010.

Little fluctuation in the population of the study-area communities is indicated. Most of the counties in the study area are projected to have a slight percentage increase in population through 2010. Population declines are forecast mostly in rural counties. A check of the 1995 mid-census counts indicates that the trends are in line with earlier projections.

5.2.12.2 Employment and Labor Force

Labor force defines the distribution of skills and the level of labor force participation by persons of working age in the community. Total employment for the study area is expected to exceed 8,200,000 by the year 2000 and 8,800,000 in 2010. This represents an increase of 9.3 percent in the total number employed in the study area by 2000. In the following decade, the labor force will grow again by about 6.7 percent.

The rate of employment will stay slightly ahead of population growth, resulting in additional jobs for residents of all ages. Job growth will vary among all counties. Changes in employment from 2000 to 2010 range from a gain of 20.6 percent in Dakota County, Minnesota, to a loss of 4.6 percent in Mercer County, Illinois. About 2 in 10 workers are employed in wholesale/retail industries, and more than 3 in 10 workers are employed in service industries. The manufacturing industry employs approximately 14 percent of workers in the study area.

Jobs in farming and manufacturing are expected to decline through 2010, while jobs in all other major industry groups will experience modest growth, producing an overall net gain in employment throughout the study area. Major industry groups for the study area include farming; manufacturing; transportation, communications, and public utilities; wholesale/retail trade; finance, insurance, and real estate; services; and other.

5.2.12.3 Income Level and Earnings

Income level identifies a community's market potential for various goods and services. It indicates the strength of a community as a revenue-producing source for local government, and is a general indicator of well-being. Employment will increase at a slightly higher rate than population growth, indicating that labor force participation will continue to increase. The increase in productivity per worker makes possible the increase in per capita income.

On the state level, average income levels are slightly higher than the national average, with per capita personal income in 2001 at $30,959, compared to the national average of $30,413. The income range among the states is from $27,225 in Iowa (89.5 percent of the national average) to $33,059 in Minnesota (108.7 percent of the national average). All of the area states are more dependent on manufacturing earnings than the nation as whole. With the exception of Iowa, the states derive about the same or less of their total earnings from agriculture.

For the counties in the study area, about 14 percent have per capita income above their respective state average, and about 17 percent are above the state and national average. Total employment for the study-area counties is expected to exceed 9.5 million by 2020, representing an increase of about 14 percent in the total number of employed. Manufacturing and service industries are the leading earnings producers in many counties in the study area. Jobs in manufacturing are expected to increase in 36 percent of the study-area counties by 2020, and jobs in service industries are projected to increase in approximately 56 percent of the counties. Jobs in farming are expected to decline through 2020.

Upper Mississippi River counties are economically diverse, receiving earnings from machinery manufacturing; food and beverage processing; and crop, dairy, and livestock production. Regional industries produce canned, frozen, and dairy foods, and manufacture broadcast equipment, construction equipment, agricultural machinery, ammunitions, chemicals, and aluminum sheet.

Agricultural and industrial production is the center of economic activity along the Illinois Waterway. Regional industries produce chemicals, fertilizers, petroleum products, earthmoving equipment and off-highway trucks, communication towers, plastics, plate and sheet metal, and diesel engines. Agricultural activities focus on crop production including corn, soybeans, feed grains, vegetables, and pumpkins. Other important activities along the waterway include meat processing and manufacturing of patio furniture, paper products, musical instruments, and appliances.

Manufacturing and service industries are the leading earnings producers in many counties in the study area. Even though employment in wholesale/retail trade is projected to increase, overall earnings in this industry group do not show a corresponding increase, as wages for these jobs tend to be at the lower end of the pay scale. Altogether, services, wholesale/retail, and manufacturing account for 68 percent of the payroll employees.

The presence of the rivers provides many benefits to the states and counties along the river corridor. Benefits are derived from the employment and income generated from transportation of goods, recreation, hydropower production, water supply for municipalities, commercial, industrial and domestic use. The waterways also contribute to regional and national economic development by offering a means of shipping bulky and heavy commodities at low cost.

Water transportation supports thousands of jobs throughout the river corridor, and the nation, in a variety of industries. Agricultural, mining and manufacturing industries, public utilities, waterside commercial development, and water-based recreational activities depend on the inland waterway as their major source of revenue.

5.2.12.4 Socioeconomic Resources

Throughout the study area, the Upper Mississippi River and Illinois Waterway are essential to the economies of the counties and States that they border. Nearly 80 million tons of commodities traverse the UMR and nearly 40 million tons travel on the IWW each year, making their way to other States, waterways, and for export. The people living and working in those places rely on the river system for their livelihood.

The presence of the rivers provides many benefits to the States and counties along the river corridor. Benefits are derived from the employment and income generated from transportation of goods; recreation; hydropower production; and water supply for municipalities and for commercial, industrial and domestic use. The waterways also contribute to regional and national economic development by offering a means of shipping bulky and heavy commodities at low cost.

Water transportation supports thousands of jobs throughout the river corridor, and the Nation, in a variety of industries. Agricultural, mining, and manufacturing industries; public utilities; waterside commercial development; and water-based recreational activities depend on the inland waterway for their livelihood. The Regional Economic Development study traced expenditures and transportation cost savings throughout the economy in terms of additional full-time employment, wage and salary income, and output of the value of the good produced. The analysis reported that within the study-area States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin, 21,891 man-years of employment are generated by water-based industries. This benefit also has an impact on other regions as well as the entire United States. In the States bordering the UMRS study area, income generated by these business activities is estimated to be over $509 million, and for the entire United States it is estimated to be over $1.2 billion. Inland water transportation generates thousands of jobs and millions of dollars in taxes for the State and Federal governments.

6.0 FORMULATION OF ALTERNATIVE PLANS

6.1 Formulation of Navigation Efficiency Alternative Plans

The formulation of navigation efficiency alternatives began by identifying measures that meet the planning objective of providing a safe, reliable, efficient, and sustainable UMR-IWW Navigation System over the planning horizon. This was an iterative process that started by identifying the universe of potential measures, and subjecting them to a qualitative screening process. The surviving measures were then subjected to a more detailed analysis screening process. The following sections provide a summary of this process. The details of this process can be found in the documents referenced throughout this section.

6.1.1 Categories of Potential Improvements

Navigation efficiency improvement measures can be categorized into either small-scale or large-scale improvements. “Small-scale” measures of reducing traffic congestion can generally be defined as any navigation improvement less costly than extending or constructing a new 1200’ lock. The small-scale measures were divided into the categories of “structural” measures (requiring some amount of construction to implement) and “nonstructural” measures (those not requiring construction, but rather procedural or policy changes). The overall performance (total lock transit time reduction) of small-scale measures is generally less effective and less efficient than demonstrated with the large-scale measures. Variables that affect the performance of the small-scale measures include site-specific operational conditions, flow conditions, weather conditions, time of day, experience of crew, direction of travel, etc. While some of these variables were identified during the study process, quantifying their impacts on time savings, safety, and implementation was not always possible. “Large-scale” measures involve constructing a new 1200’ lock or extending the existing lock to 1200’. Passage through a 1200’ lock can be accomplished in a single lockage as opposed to the current double lockage process. A full explanation of the various small-scale and large-scale measures can be found in the Engineering Appendix, the Economics Appendix, or the aforementioned references.

6.1.2 Screening of Measures

6.1.2.1 Small-Scale Measures

The small-scale measures development and screening process began in 1994 with the identification of 92 possible structural and nonstructural measures (Table 6-1). The host of measures is documented in the report entitled: *General Assessment of Small-Scale Measures* dated June 1995 (Engineering Technical Report EG-3). These measures were obtained from previous studies, Corps staff recommendations, and coordination with members of private industry, State resource and transportation agencies, the U.S. Fish and Wildlife Service, the U.S. Coast Guard, and the U.S. Environmental Protection Agency. Screening of the measures was conducted by various means. A qualitative method termed the “initial screening” paired down the measures that would later be subjected to a more quantitative effort termed “secondary screening”. Additional development and screening of measures occurred after secondary screening, resulting in the most promising small-scale measures for economic modeling. The screening results are summarized below, but are contained in more detail in a stand-alone report entitled: *Summary of Small-Scale Measures Screening*, dated April 1999 (EG-7).

Table 6-1. Comprehensive list of small-scale measures initially thought to have possible navigation efficiency improvement potential.

Identifying No.	Name of Small-Scale Measure
1	**SCHEDULING OF LOCK OPERATIONS**
1a.	N-Up/N-Down
1b.	Ready to Serve Policy
1c.	Industry Self-Help Policy
1d.	Scheduling Program
2	**ASSISTANCE TO LOCKAGES**
2a.	Helper Boats
2b.	Switchboats
2c.	Endless Cable System
2d.	Unpowered Traveling Kevel
2e.	Powered Traveling Kevel
2f.	Hydraulic Assistance
3	**IMPROVEMENTS TO APPROACH CHANNELS**
3a.	Approach Channel Widening/Realignment
3b.	Adjacent Mooring Facilities
3c.	Funnel-Shaped Guidewalls
3d.	Wind Deflectors
3e.	Extend Guidewalls
3f.	Add Guide Cells
3g.	Reconfigure Bull Nose
3h.	Radar Reflectors
3i.	Electronic Guidance System
4	**AREA-WIDE CHANNEL IMPROVEMENTS**
4a.	Remove/Adjust Bends, One-Way Reaches, Bridges
4b.	Improve Navigation Aids and Channel Markings
4c.	Innovative Dredging Strategies
4d.	Water Flow Management Policies
4e.	Increase Channel Width
4f.	Isolate Rec. Facilities & Marinas Away from Channel
4g.	Dual Channel at Restrictive Bridges
5	**TOW CONFIGURATION AND OPERATIONS**
5a.	Mandate Use of Bow Thrusters
5b.	Mandate Use of Prototype Bow Thrusters
5c.	Tow Size Standardization
5d.	Cooperative Equipment Sharing/Scheduling
5e.	Institute Waterway Traffic Management
5f.	Increase Number and Size of Fleeting Areas
5g.	Fuel Monitoring and Management
5h.	Use of Heavy Fuels
5j.	Improved Barge and Boat Hull Designs
5k.	Barge Stacking for Backhauls
5l.	Container Movement
5m.	New Backhaul Opportunities
5n.	Universal Couplers/Hand Winches
5o.	Increase Speed Limits in Restricted Reaches
5p.	Reduce Liability of Tow Operators for Damage
5q.	Require Minimum Crew Size and Training
5r.	Mandate Minimum Horsepower

Identifying No.	Name of Small-Scale Measure
6	**LOCK OPERATING EQUIPMENT/PROCEDURES**
6a.	Modify Intake Structures
6b.	Modify Discharge Structures
6c.	Modify Wall Ports
6d.	Install Self-Cleaning Trash Racks
6e.	Centralize Controls
6f.	Portable Controls
6g.	Automate Controls
6h.	Install Floating Mooring Bits
6i.	Upgrade Valve Operating Equipment
6j.	Upgrade Gate Operating Equipment
6k.	Install Gate Wickets in Miter Gates
6l.	Provide Explicit Operating Guides
6m.	Fenders, Energy Absorbers
6n.	Require Vessels to Stay Clear of Emptying/Filling System
6o.	Operate Dam Gates Based on Lockage
6p.	Lift Gates at Locks
7	**ICE CONDITIONS**
7a.	Mechanical Ice Cutting Device
7b.	Skin Plates
7c.	Air Bubbler System
7d.	Heat Plates
7e.	Heated Water Jet
7f.	Clear Ice from Barges
7g.	Ice Chutes
8	**RECREATIONAL VESSELS**
8a.	Recreational Vessel Bypass Lifts
8b.	Scheduling of Recreational Vessel Usage
8c.	License Recreational Craft Operators
8d.	Recreational Craft Landing Above and Below Lock
9	**COST ALLOCATION**
9a.	Apply Congestion Tolls
9b.	Allocation of Operations and Maintenance Costs
9c.	Low-Head Hydroelectric Units
9d.	Privatization of Lock Operations
9e.	Excess Lockage Time Charges
9f.	Lockage Time Charges
10	**OTHER**
10a.	Increase Lock Staffing
10b.	Automate Dam Controls
10c.	Radar at Lock
10d.	Real-Time Channel Depth and Weather Monitoring
10e.	Improved Lighting
10f.	Publish Lockage Times by User
10g.	Create Indraft
10h.	Operational Philosophy/Industry Attitude
10i.	Deepen River Upstream of Gates
10j.	Pilot Communication (Bulletin Board)
10k.	Closed Circuit Television (CCTV) at Lock
10l.	Wicket Gates in Dam
10m.	Automated Lockage System from Queue Point
10n.	Specified Navigation Season

6.1.2.1.1 Initial Screening of Small-Scale Measures

The universe of small-scale measures was developed using a brainstorming technique where very little evaluation was done to pair down the ideas; therefore, the measures have widely varying value. A significant amount of screening was required to reduce the list to the more promising measures. Corps planning guidance (Engineer Regulation (ER) 1105-2-100) defines four broad decision criteria: Completeness, Effectiveness, Efficiency, and Acceptability. From these, a set of eight qualitative screening criteria was developed to determine those measures most appropriate for further analysis. Table 6-2 lists these criteria and their relationship with the general criteria listed above.

Table 6-2. Small-Scale Measures Screening Criteria.

Specific Screening Criteria	Planning Guidance Criteria
1. No Potential to Reduce Lock Delay	Effectiveness/Completeness
2. Not Technically Feasible	Effectiveness
3. Not Safe	Acceptability
4. Not Environmentally Acceptable	Acceptability
5. Is Economically Inefficient	Efficiency
6. Is Not Cost Effective	Efficiency
7. Industry Cooperation	Acceptability
8. Addressed in O&M Program[i]	Completeness

[i] Whereas criteria 1 through 7 evaluate the merits of the small-scale measure itself, criterion 8 determines whether the measure has already been implemented or could be implemented through existing authorities of the Corps O&M Program.

The result of this initial screening was a substantial reduction of the 92 measures. The measure "Wicket Gates in Dam" (item 10l. in Table 6-1) was reclassified as a large-scale measure due to its large cost. The measures that survived the initial screening process are shown in Table 6-3 and described thereafter.

Helper Boats. Helper boats can reduce delays in approaching the lock and increase safety by reducing major accidents related to a tow's approach. Currently, helper boats are regularly available at a number of locks, and the majority of other lock sites can have helper boats available on relatively short notice. Existing Corps policy is only to recommend, not to mandate, the use of helper boats, such as during outdraft conditions. In general, most companies follow these recommendations in their own interest to increase safety and reduce delays.

Switchboats with Guidewall Extensions. This measure uses switchboats (SWB) in the 1,800- to 2,000-horsepower range to extract the first cut of double lockages along a 600-foot extended guidewall. This process allows faster extraction than the existing tow haulage and allows the chamber to be turned back faster. SWBs can also assist tows with their approach.

Switchboats with Remote Remake Areas. A short guidewall extension of roughly 300 feet would be provided, allowing the SWB to extract the cut, tie it off, uncouple, move to the other end of the cut, recouple, and then push upstream for remote remake. Removing the cut to a remote area allows the second cut to proceed away from the chamber so it can be turned back faster than in the existing condition. SWBs can also assist tows with their approach.

Industry Self-Help with Mooring Facilities or Guidewall Extensions. This measure combines industry self-help with mooring facilities or guidewall extensions. When implemented, a waiting tow ties off its barges and begins extracting unpowered cuts to the new mooring facility or guidewall extension.

Then, the powered cut can simply lock through and proceed away from the chamber, allowing it to be turned back faster than in the existing condition.

Congestion Fees. This measure seeks to improve system efficiency by charging a lockage toll to all commercial traffic. The toll would induce marginal users to leave the system, resulting in a net gain if the resulting reduction in system delays are greater than the negative impact to the diverted marginal users.

Table 6-3. Small-Scale Measures Surviving Initial Screening.

Measure
Towboat Power
Helper Boats
Switchboats
Industry Self Help
Tolls and Reports
Congestion Tolls
Excess Lockage Time Charges
Lockage Time Charges
Publish Lockage Times
Recreational Vessels
Scheduling of Recreational Vessel Usage
Recreational Craft Landing Above and Below Deck
Optimizing Decisions (Scheduling Program)
Extended Guidewall
Tow Haulage Equipment
Powered Traveling Kevel
Endless Cable
Unpowered Traveling Kevels [i]
Mooring Facilities (Adjacent to Lock Approach)
Crew Elements
Universal Couplers/Hand Winches
Permanent Deck Winches [iii]
Powered Ratchets [ii]
Minimum Crew Size with Training
Additional Personnel [iii]
Approach Channel Improvements [iv]

[i] As an outgrowth of discussions on the “Extended Guidewalls” and “Tow Haulage Equipment” measures, the “Unpowered Traveling Kevels” measure, once screened, was added to the list of surviving measures for its reconsideration.

[ii] The “Powered Ratchets” measure was initially considered infeasible due to unavailability; however, recent developments concerning this measure put it back in contention. The manufacture of a commercially available powered ratchet has been put into limited use by the navigation industry.

[iii] The “Permanent Deck Winches” and “Additional Personnel” measures were outgrowths of discussions on the other “Crew Elements” measures.

[iv] The “Approach Channel Improvements” measure was initially thought to have limited value. Later hydraulic model studies indicated that, on a site-specific basis, channel improvements might offer significant timesavings.

Excess Lockage Time Charges. This measure would charge a fee to users who have an "excessive" lockage time at a particular lock. A lockage involving excessive time would be determined against a standard time for the surrounding influences such as weather and daylight.

Lockage Time Charges. This measure would charge all vessels for lockage at a graduated level based on a per unit time basis. As a result, all tows, not just the slowest, would have an incentive to improve their locking efficiency to reduce the charge they receive. The fee, set at a lower level, would provide an incentive to improve lockage efficiency rather than to limit use of the system. However, collecting a fee has the potential to eliminate some traffic, especially with this measure since all tows would be charged a fee.

Publish Lockage Times. This measure would identify the towboats and towboat companies whose crews have the fastest and slowest lockage times. Although this measure does not involve a direct economic incentive or charge to reduce time, it informs the particular companies and the entire navigation industry of the performance of particular tows. Since it is in the best interest of all parties to reduce lockage times, this measure should assist companies and the industry in identifying the tow crews that perform the best and the tows that may need additional crew training, crew members, or equipment.

Scheduling of Recreational Vessel Usage. This measure would involve limiting recreational craft lockages to certain times of the day in order to minimize locking conflicts with commercial traffic. The existing navigation regulations (33 CFR 207.300) state that recreational craft shall be expedited by locking them with commercial craft provided both parties agree. If the lockage of recreational craft cannot be accomplished within the time required for three commercial lockages, a separate lockage of recreational craft is to be made.

Recreational Craft Landing Above and Below the Lock. This measure calls for boat ramp facilities in both pools at the lock in order to minimize the need for additional recreational craft lockages that can increase overall lock delays.

Scheduling Program. This measure would create time slots or appointments for lockages. The slots would be reserved by customers wanting to lock based on their individual schedule and the available time slots. The savings is realized by a tow not having to wait in a queue at a lock under the present, mostly first-come-first-served policy.

Extended Guidewalls with Powered Traveling Kevels with Additional Personnel. This measure combines rail mounted powered traveling kevels (PTK) with extended guidewalls. Two measures for improving the existing tow haulage operation were considered: PTK and endless cable. The PTK is preferred due to some precedent at other locks. The extended guidewalls allow the remake to occur completely outside the lock chamber, allowing it to be turned back faster than in the existing condition.

Extended Guidewalls with Unpowered Traveling Kevels. This measure combines two unpowered, rail-mounted kevels with extended guidewalls. The first cut is extracted from the chamber with the existing tow haulage system, during which time the bow and stern are attached to the kevels. Later, the powered cut faces up to the first cut and pushes it to the end of the extended 1,200-foot guidewall while the kevels assist with control. This allows the chamber to be turned back faster than in the existing condition.

Adjacent Mooring Facilities. Adjacent mooring facilities are structures that provide vessels a place to tie-off closer to the lock while waiting lock turn. This would reduce the time for fly and exchange type approaches.

Universal Coupler and Hand Winches. Industry continues to pursue improvements to the barge coupling system for time savings and increased worker safety. It was concluded that such an effort possibly resulting in a universal coupler could save time on the remake process.

Minimum Crew Size with Training. This measure provides an experienced crew that is large enough to handle a lockage and save time in the breaking and remaking of tows. Training could reduce the variability involved in the make-up process.

Permanent Deck Winches. Deck winches permanently attached to the decks of barges would be used in lieu of the steamboat ratchet to tighten the primary fore/aft couplings. Deck winches have been installed on barges with good success in terms of time savings and reduced personal injury cases.

Power-Operated Ratchet. A power-operated ratchet uses a 4-horsepower gas engine to power a hydraulic drive system that operates a specially designed wrench head to engage the steamboat ratchet. There has been some trial usage of these devices by the towing industry. In using this device, tows can be remade faster.

Minimum Crew Size with Training. This measure provides an experienced crew that is large enough to handle a lockage and save time in the breaking and remaking of tows. Training could reduce the variability involved in the make-up process.

Additional Personnel. Additional personnel would be added to a lock to assist in remaking the tow, reducing the time for the process.

Approach Channel Improvements. Approach channel improvements consist of many different channel structure-type measures or combinations of measures to increase safety and reduce lock approach time.

6.1.2.1.2 Secondary Screening and Development of Small-Scale Measures

Each of the surviving measures in Table 6-3 was evaluated for cost and performance (see detailed information in the UMR-IWW System Navigation Study report entitled, *Detailed Assessment of Small-Scale Measures* EG-6). Screening was based mostly on comparison of measures and reapplication of the criteria in Table 6-2. A brief description of the secondary screening results for each measure is provided in the following paragraphs.

Helper Boats. Helper boat assistance above that for the base condition was screened. They are part of the baseline and will continue to be included in the without-project condition at their present levels of use on the system.

Switchboats with Guidewall Extension. The measure was screened by comparison to PTK on a guidewall extension that has similar time savings at a significantly lower cost.

Switchboats with Remote Remake Areas. The measure was screened based on the completeness criteria due to concerns with viability of routine remote remake.

Stand-alone Switchboats Description and Screening. This measure emerged during the small-scale measures reevaluation process. It includes the use of two SWB's to pull cuts. One SWB would extract the cut and remove it to an awaiting tow for remake. The second SWB would ensure continuous service if the first was delayed. For high flow conditions, the first boat would extract the cut far enough for the second boat to position itself behind the cut to push it upstream for remote remake. SWBs can also provide bow assistance on downbound approaches. Stand-alone SWBs were retained for further plan formulation considerations.

Industry Self-Help with Mooring Facilities or Guidewall Extensions. This measure was screened by comparison to SWBs (above) that have better performance and less costs. Note that industry self-help without the additional infrastructure is a viable measure; however, it is limited to occur in the without-project future and only to the present levels of usage.

Congestion Fees. This measure was retained for further plan formulation consideration.

Excess Lockage Time Charges. This measure has mixed screening results. It was screened based on the completeness criteria, but reevaluated in the context of deck winch reevaluation (see Section 6.1.2.1.3). Determining what constitutes an excess lockage time presents some problems based on variability in conditions. The measure would be difficult to implement due to the high degree of variability in uncontrollable conditions affecting lockage times.

Lockage Time Charges. This measure is screened based on these implementability and acceptability issues. There would be difficult issues in a reliable billing system for assessing charges and likely unacceptability by the towing industry.

Publish Lockage Times. The measure was screened since it is unlikely to significantly reduce delays. .

Scheduling of Recreational Vessel Usage. This measure was screened based on effectiveness and acceptability. Implementing recreational scheduling does not appear to have an ability to reduce delays at the most congested locks on the system. Additional recreational craft can be handled by placing more craft in the chamber during a recreational craft lockage and during turnback situations.

Recreational Craft Landing Above and Below the Lock. This measure was screened based on effectiveness. Existing data do not strongly support the concept that additional landings will provide significant benefits in reducing the number of recreational lockages.

Scheduling Program Results. This measure was essentially screened, but still is discussed within the report. A possibility is that it will continue to be studied in parallel with any future recommendations from this report. Also see Section 6.1.2.1.3.

Extended Guidewalls with Powered Traveling Kevels with Additional Personnel Results. The measure reduces lockage time more significantly when additional personnel are provided. The measure was screened because it would be very unlikely that additional staff would be added at each lock for 24-hour, 7-day, 365-day operation. It is also screened based on economic comparison to stand-alone SWB's that are less expensive and have slightly better time savings.

Extended Guidewalls with Powered Traveling Kevels without Additional Personnel Description and Results. This measure emerged during the small-scale measures reevaluation process. It is similar to the same measure with additional personnel except that the additional personnel were not included and the time savings and costs were adjusted accordingly. The measure was screened based on economic comparison to stand-alone SWB's that are less expensive and have slightly better time savings.

Extended Guidewalls with Unpowered Traveling Kevels Results. The measure was screened based on the efficiency criteria. It is not recommended due to similar cost and lower performance than PTK on guidewall extensions.

Adjacent Mooring Facilities Results. This measure was retained for further plan formulation consideration.

Universal Coupler and Hand Winches Results. This measure was screened based on the completeness and effectiveness criteria. Due to the lack of existing technology for this application, combined with the investment cost to develop such a device, the measure was screened.

Permanent Deck Winches Results. This measure has mixed screening results. It was screened based on efficiency because it had higher costs and equivalent time savings to powered ratchets. Its merits were reevaluated since powered ratchets were eventually screened and the industry's demonstration of them being an acceptable and desirable feature.

- Deck winches were reevaluated as a likely response by the industry to increase efficiency instead of paying a fee for being inefficient at a lock (See Section 6.1.2.1.3).
- Deck winches will likely continue to be installed on barges or retrofitted to existing barges to some unknown degree. They will be included in the without-project condition to their present level of use.

Power-Operated Ratchet Results. This measure was screened based on effectiveness because power-operated ratchets were used on a trial basis with mixed results. They saved some time, but they were heavy and awkward to use. The industry has not widely implemented the measure likely because of its potential to increase injuries.

Minimum Crew Size with Training Results. This measure was screened since there is no guarantee that training above the present levels and staff increases would improve time savings.

Additional Personnel Results. This measure was screened by comparison to powered ratchets that offered greater time savings at a lower cost. The measure can also be screened because it would be very unlikely that additional staff would be added at each lock for 24-hour, 7-day, 365-day operation.

Approach Channel Improvements Results. This measure was screened based on efficiency. The measure was reevaluated in terms of cost and performance only to remain screened due to its generally high cost and low time savings.

6.1.2.1.3 Final Array of Small-Scale Measures

Several small-scale measures currently exist on the UMR-IWW to help improve safety, minimize environmental impacts or aid the efficiency of barge transportation. These measures include helper boats, industry self-help, permanent deck winches, powered ratchets, and lock operating procedures (N-up/N-down – a type of scheduling). These measures presently occur individually or in combination and are expected to continue at least at their current rates into the future. Therefore, for comparative alternative analysis theses small scale measures were considered to be part of the future without-project condition. The same set of small-scale measures will exist in the future with-project condition, but they will be adjusted for their overlap/conflict with the introduction of with-project large- and small-scale measures. Other with-project small-scale measures that will be used to form alternative plans include mooring facilities and switchboats.

Also, the restructured study re-evaluated the potential of non-structural small-scale measures as suggested by the original National Research Council review. The U.S. Department of Transportation, John A. Volpe National Transportation Systems Center and Corps re-examined the potential efficiencies of deck winches and excess lockage time charges, tradable permits and other traffic management systems, and congestion fees. The final array of small-scale structural and non-structural measures included in the formulation of navigation efficiency alternatives is described below.

- **Deck Winches and Excess Lockage Time Charges** – Deck winches were studied as a possible with-project alternative. The impetus for installation of winches was assumed to be the desire to avoid payment of an Excess Lockage Time Charge that would be imposed when component lockage times under the control of the operator exceeded a stated threshold. The idea is that the slowest operators are encouraged to improve their performance at the locks to avoid fee payment. It was assumed that they would do so by installing new equipment, such as deck winches, on all barges. Deck winches save about 4 minutes on the remake of a double-cut lockage. It costs about $4,000 to add four winches to a typical barge. This measure would not be cost effective in the case considered where all operators take this action; nor would it likely result in net benefit if smaller proportions of operators do so while others choose to pay the fees. The range of industry's estimated net present value costs for the five specified scenarios would be from $137.22 million to $158.26 million. The cost to track maneuver time performance data and levy and collect fees, would be insignificant compared to industry's and are estimated at $1.50 million, regardless of the scenario. The summary of benefits, costs and B/C ratios are outlined in Table 6-4.

Table 6-4. Benefit – Cost Ratios, Excess Lockage Time Fees.

	Scenario				
	1	2	3	4	5
NPV Benefit	$66,938,927	$77,595,001	$80,475,256	$82,038,163	$82,031,981
NPV Cost	$137,219,552	$153,122,341	$155,325,226	$158,263,339	$154,659,218
B/C Ratio	0.49	0.51	0.52	0.52	0.53

This measure does not produce positive net benefits for any of the scenarios, however it will be carried forward for evaluation as outlined in Chapter 7.

- **Tradable Permits and Other Traffic Management Systems** – The objective of traffic management is to smooth out tow arrivals at the locks by placing lockages in time periods of low demand for lockage. This assumes that the system has peak shipping times during the harvest season or other times of the year. This is not the case as shown in Figure 6-1, which reflects traffic flow at Lock 25 in 2002 (note that traffic reduces during the winter months due ice condition). This data are representative of traffic flow on the lower system and indicates a relatively constant demand across the normal navigation season.

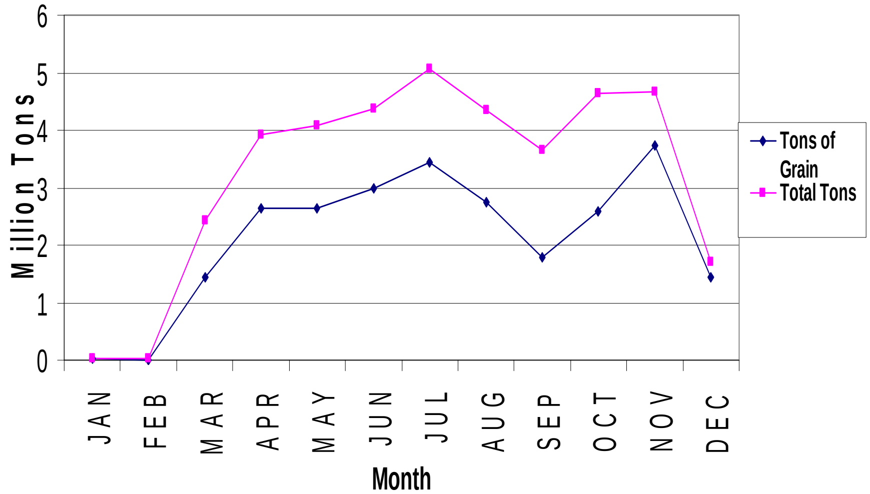


Figure 6-1. Traffic flow at Lock and Dam 25 during 2002.

The diverse operational, market, and environmental obstacles stand in the way of master scheduling systems on the UMR-IWW. The cargo shippers are highly responsive to world market and local economic pressures. Tow companies' operations are thus changeable on a daily basis. Volatility of the operating environment caused by weather and river conditions also contributes to great variability and lack of predictability in tow arrival times and lockage times as outlined below.

Operational Characteristics. Tows take empty barges upriver, dropping them off with local vendors who move barges to customers to load and pick up for southbound tows. Only 50 percent of northbound tows are pushing loaded barges. Southbound tows are predominantly loaded. Line-haul tows are the tows that "tramp" on the river, picking up and dropping off barges as ordered by the dispatchers from the various companies that dominate the commercial river traffic. Dedicated tows serving particular terminals on a regularly scheduled basis make up only about 10 percent of the total tows and carry mostly liquid cargoes, some aggregates, and coal. The implication of these operational characteristics to traffic management is that it is very difficult for most tows to predict with any precision, in advance of initiating the trip, when they will arrive at a lock. For most tows, each trip involves a different combination of stops for barge pickup and drop-offs. The number of stops may not be known even when the trip is initiated and even if known would involve variable times for barge pickup and drop-off. These operational characteristics would make the concept of master-scheduling nearly impossible.

Market Characteristics. Farm products (grain and meal) make up about 50 percent of the tonnage on the Upper Mississippi River and about 40 percent of the tonnage on the Illinois River. These products primarily are moved to the lower Mississippi River for export. Farm products are largely moved in response to market conditions including both international grain market conditions and regional barge rates. Grain is stored, including being stored in barges, to wait for favorable market conditions. This means that grain movements are not predictable in advance which means that long-term scheduling is not feasible without abandoning the business advantages of market timing. It also means that there are not predictable and recurring traffic peaks and off-peak periods. Without predictable traffic peak periods, schemes to smooth out traffic flow through congested period fees or incentives to move traffic into off-peak periods are not feasible.

Other Users. Commercial traffic is only one user of the system. A scheduling system would also have to accommodate government fleet, scheduled passenger vessels, and recreation craft. Recreational craft lockages account for an average of 15 percent of lockages (2000 LPMS database) at the lower five sites on the Mississippi River, and the distribution of recreation craft arrivals is indeterminate.

River and Weather Conditions. River and weather conditions affect the movement and speed of tows. These variable conditions include channel conditions related to high and low water, fog, ice, lightning, heavy rain, and wind. These variables make it difficult to predict exact arrival times at locks and increase the difficulty of long-term scheduling.

Lock Closures. Locks are subject to unscheduled outages due to equipment failures, weather conditions, and accidents. These occurrences are not predictable. Also, equipment failures are not always detectable or preventable by routine maintenance. Major rehabilitation is the most effective way to reduce but not eliminate unscheduled outages. Recurring major rehabilitation of the locks is part of the without-project condition, with effects on costs and reducing lock closures, in the economic analysis. Unscheduled outages would disrupt a scheduling measure by suddenly making the lock unavailable. Mississippi River locks average 50 unscheduled closures per year averaging about 10 hours in length.

Tradable permits is a type of scheduling tool that assigns a lockage time slot via paper ticket to a certain vessel at a certain lock. The permit is tradable. The primary reason for trading would be the expectation that the time slot does not match the vessel's schedule. There is wide variability in a vessel's schedule as described above, which would make the trading of permits a frequent occurrence during a trip. The number of trades would be so large and the trading would need to be so real-time that the management of such a system would be problematic. The implementation of the tradable time permits proposal was found to be highly impractical from the administrative, financial, and operational viewpoints. It is possible in some circumstances that tradable permits could actually decrease lock efficiency by causing available time to go unused. The analogy to the airport tradable permits lacks validity, because of the "tactical" and frequent trading of slots that would be necessary to address schedule volatility on the UMR – IWW. The daily tactical management of slots at airports addressing schedule disruptions is not addressed by a trading system. It is effective because of air controllers' authority over incoming flights and the nature of repetitive daily flight schedules, and works on a first come, first served basis. Similar tactical management occurs on the UMR – IWW to some extent through sharing of lock and queue status information, "n-up, n-down" sequencing of tows through locks, and informal appointments at nearby locks allowing efficient tow transits. Slot "trading" among the airlines only occurs at high capacity airports for strategic fiscal or operational reasons; the frequency of these trades is extremely low by comparison to what would be expected in a prospective system on the UMR – IWW. There was no cost and benefit analysis conducted for the foregoing reasons.

While it is clear that long term advance scheduling is not compatible with operations that can change on a daily basis, there appears to be an opportunity to put a more modest measure in place. An appointment system would give operators the ability to call ahead one or more locks and might be an effective alternative to master scheduling for reducing the variability and length of queuing times. This practice occurs now on an informal basis at some locks through the use of an online data recording system known as the Operations and Maintenance Navigation Information (OMNI) (see Section 4.3.1.4.5). The costs and benefits of an appointment system were not quantified. However, the potential savings of such a system would likely be limited to more efficiently conducted voyages, primarily from the standpoint of fuel consumption and scheduling of other necessities such as maintenance. This measure should be further investigated.

- **Congestion Fees –** The objective of congestion fees is to improve overall system efficiency by charging all users a lock usage fee, subsequently inducing marginal users (those that benefit the least from system use) to discontinue use of the system. While the traffic that is induced to leave the system would experience a loss as a result of the fees, the potential gain in the form of lower average delays for all remaining traffic could more than offset this loss from an overall system efficiency perspective. The impacts of shifting traffic off the waterway could be landside congestion, differential air quality impacts, and differential accident rates. There are no existing instances of fee-for-waterway use in the United States as a consequence of current law, which prohibits charge, or toll of any type for waterway use. Such a prohibition by current law, however, does not prevent the evaluation of such fee-for-use mechanisms. Corps guidance allows that alternative plans may propose necessary changes in such statutes, administrative regulations, or established common law. Congestion fees were carried forward for evaluation.
- **Switchboats (SWB)** – This nonstructural measure provides for two switchboats at selected locks to extract the first cuts of double lockages. Switchboats are full-size towboats (2,400 horsepower) that would be permanently stationed at a lock site. The switchboat would allow a barge cut to be removed to a location along the existing guidewall, to the end of the guidewall, or to an awaiting tow for

remote remake. Time savings increase with the distance from the lock, which requires weighted averaging for modeling purposes. Average time savings are approximately 8 minutes for double-cut lockages and costs are about $3.6 million/year-lock. Switchboats can also perform as helper boats to assist downbound tows with their approach to the lock. In March 2003, a comparison was made between stand-alone SWBs and extended guidewalls with power traveling kevels (EGW/PTK). The comparison showed that SWBs generally provided more savings and cost less than EGW/PTK. A comparison was also made between SWBs and EGW/PTK with added personnel, which similarly showed that SWBs performed better. Both EGW/PTK and EGW/PTK with added staff were screened by comparison to SWBs. Switchboats were carried forward for evaluation.

- **Mooring Facilities** – These are either buoys (downstream of the dam) or sheet-pile cells (upstream of the dam) that provide a closer location to the lock for tows awaiting lock turn. A mooring cell costs about $1,000,000 and a buoy costs about $50,000. Time savings range from 1 minute to 10 minutes, depending on vessel type, travel direction, and type of approach. Mooring cells were carried forward for evaluation.

6.1.2.2 Large-Scale Measures

The Reconnaissance Report (1991) for the Upper Mississippi River and Illinois Waterway recommended that large-scale measures at 16 sites could potentially be justified on the UMR system in the next 50 years. The 16 sites include Locks and Dams 11 through 25 on the Mississippi River and Peoria and La Grange on the Illinois Waterway and served as the starting point for this feasibility study. Large-scale measures include extending the existing lock and/or constructing a second lock at the critical lock sites. Construction of a navigation pass through existing dams was also considered as a measure to reduce delays to navigation at the dams for which it had application; however, this option was found to be not feasible. The analysis included developing and screening an array of feasible lock options and locations.

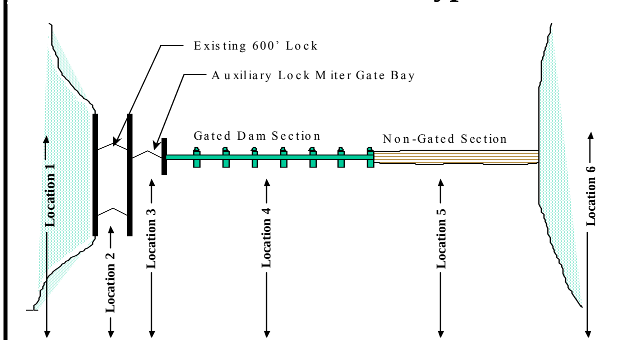
Several different lock design types (Types A, B, C, and R), generally with decreasing performance and reduced cost, were evaluated in the reports entitled, *Large-Scale Measures of Reducing Traffic Congestion, Conceptual Lock Designs*, February 1996, and *Interim Revised Lock Extension Design Concepts*, July 2000. These reports included development of concepts for two representative sites on the system. Lock 22 was selected as the rock founded site and Lock 25 as the sand founded site. Physical model studies were constructed and tested at these two sites. The details of this testing can be found in the reports titled, *Navigation Conditions at Lock and Dam 25, Mississippi River*; Technical Report CHL-97-28, September 1997, and *Navigation Conditions at Lock and Dam 22, Mississippi River* by Ronald T. Wooley, Technical Report CHL-97-27, October 1997. Concepts developed for these sites were then site adapted to the other 14 sites under study. Additional design work was completed for the lock extension type R lock and can be found in the report titled, *Interim Revised Lock Extension Design Concepts*, July 2000.

Several lock locations (Locations 1 through 6) at an existing lock and dam site as shown in the site plan on Table 6-5 were evaluated in the report, *Large-Scale Measures of Reducing Traffic Congestion, Location Screening*, July 1999. This report included a qualitative screening of the locations, and the surviving lock locations include either extending the existing locks to 1,200 feet or constructing a new 1,200-foot lock adjacent to the existing lock.

After qualitative, comparative, and quantitative screening of these options, as well as Plan Formulation screening, the surviving lock measures include either extending the existing locks to 1,200 feet or constructing a new 1,200-foot lock adjacent to the existing lock. The remaining lock locations and lock types are listed in Table 6-5.

Table 6-5. Final Surviving Lock Locations for lock extensions (X) and new locks (NL). All UMR Locks are proposed as "R" design types while IWW locks are "C" design types.

Lock Location and Types



Lock and Dam Sites	1	2	3	4	5	6
L/D 14		X				
L/D 15		X				
L/D 16		X				
L/D 17		X				
L/D 18		X				
L/D 20		X	NL			
L/D 21		X	NL			
L/D 22		X	NL			
L/D 24		X	NL			
L/D 25		X	NL			
Peoria	NL					
La Grange	NL					

6.1.3 Development of Cost Estimates

Lock costs include the construction costs of the lock, guidewall, channel work, real estate, relocations, and site-specific environmental mitigation. These construction costs include Preconstruction Engineering and Design (PED) (site-specific feasibility study), and plans and specifications totaling 15 percent of the construction costs, construction management costs at 10 percent of construction costs, and a 25 percent blanket contingency cost. Investment streams for lock construction were computed and combined with the costs of major rehabilitation, major maintenance, and annual operation and routine maintenance. Finally, since lock construction can cause delays to navigation traffic, the impacts to navigation during lock construction were computed for consideration in the cost comparisons of alternative plans.

A unit price-type cost estimate procedure was used instead of a Micro-Computer Aided Cost Engineering System (MCACES) format estimate. MCACES was considered for use; however, the cost and resources required to produce MCACES estimates for 16 lock sites, 6 lock locations, and several different lock types made this impractical for a systems level of study. As lock options survived screening, they received more and more detailed characterization and cost refinement that built on completed work – especially the unit-price type estimates. The unit-price type estimate adequately served the purpose of the System Study, which is to determine if investment in navigation efficiency measures is necessary and, if so, to what extent.

Individual unit prices for the cost estimates were based primarily on the *Report of the USACE Task Force on Design and Construction Innovations for Locks and Dams*, historical cost data from Melvin Price Locks and Dam, results from the Innovative Navigation Program (a Corps Research and Development community effort supported by the Districts, Divisions, and Corps of Engineers Headquarters to explore innovative and less costly ways to construct navigation projects), Braddock Dam replacement project, and Lock and Dam 24 protection cell.

An architectural-engineering firm checked samples of lock construction cost estimates by preparation of independent cost estimates in a report entitled *Independent Review of Concept Design Construction Costs*, June 2003 (EG-19). The largest disparity in bottom-line price (including contingencies) was about 10 percent between the independent estimates and the Corps' estimates. This check, resulting in a small difference in costs, validates the Corps' cost estimates. The primary purpose for this effort was to address concerns about the construction costs stated in the committee's (Water Science and Technology Board, Transportation Research Board, and National Research Council) review of the Upper Mississippi River-Illinois Waterway Navigation System Feasibility Report.

The potential for occurrence of any hazardous toxic radiological waste (HTRW) concerns was reviewed and considered to be a negligible cost.

The potential need for future lock replacement was investigated. None of the lock concepts were found to need replacement in the 50-year planning period given that they would receive major rehabilitation and maintenance as specified in the System Study.

Real Estate professionals within the Corps and from private contractors were engaged to support the engineering work group in the development of their respective cost estimates. Preliminary real estate appraisals were performed at each of the 12 lock and dam sites under consideration for potential improvements as a means to assess property values, easements, damages and relocation costs. The methodology and results of these appraisals are presented in the Real Estate Plan, provided as an appendix to this document.

Table 6-6 contains a summary of estimated cost for each individual measures that was carried forward for full evaluation.

Table 6-6. Costs of surviving Navigation Efficiency Measures at the critical Locks (2003 Price Level).

Lock Sites	Moorings[2]	Switchboats Annual Costs[3]	Lock Extensions[4]	New Locks[4]
25	NA	$3,950,000	$149,000,000	$240,000,000
24	DB Cell $1,200,000	$3,950,000	$144,000,000	$230,000,000
22	UB Buoy $58,000	$3,950,000	$119,000,000	$170,000,000
21	NA	$3,950,000	$136,000,000	$238,000,000
20	UB Buoy $58,000	$3,950,000	$121,000,000	$167,000,000
19	NA	N/a	NA	NA
18	UB Buoy $58,000	$3,950,000	$154,000,000	NA
17	NA	$3,950,000	$160,000,000	NA
16	NA	$3,950,000	$150,000,000	NA
15	NA	$1,975,000	$114,000,000	NA
14	DB Cell $7,400,000 UB Cell $1,200,000	$3,950,000	$127,000,000	NA
13	NA	$3,950,000	NA	NA
12	UB Buoy $58,000	$3,950,000	NA	NA
11	NA	$3,950,000	NA	NA
Peoria	NA	$3,950,000	NA	$206,000,000
LaGrange	DB Cell $1,200,000	$3,950,000	NA	$209,000,000

[1] The costs do not include annual O&M, Major Rehabilitation, delay cost to navigation during construction – if any, interest during construction. The measures in the table are those that survived several screening activities. These measures will be combined into alternative plans.

[2] Cost include PED, Construction, and site-specific environmental mitigation (Lock 14 DB only), channel cost (Lock 14 DB only), and contingencies. Mooring Cell or Buoy is indicated along with the direction of travel that the mooring is meant to assist. Buoy replacement costs at 5-year intervals is not included.

[3] Costs include the annual costs for two switchboats at each lock for a 275-day navigation season. Lock 15 has only one switchboat since the swing bridge on the downstream end of the lock would impair operations with two switchboats.

[4] Costs include PED, real estate, relocations, channel costs, construction, site-specific environmental mitigation, and contingencies.

6.1.4 Lock Construction Considerations

6.1.4.1 Lock Extension

The lock extensions are technically feasible; however, there are potential risks associated with impacting navigation since the construction is in the path of navigation. Most of the on-site lock extension construction would occur in approximately three 90-day wintertime navigation closures to allow uninterrupted construction work and to reduce the impacts to navigation due to the low traffic levels in the winter. For the five locks on the Mississippi River, the total construction schedule (depending on schedule alignments) could close the river for 10 consecutive winter seasons. The locks would be open for traffic with minor navigation restrictions and occasional closures during the remainder of each year of construction. The navigation restrictions were modeled as being mitigated by the implementation of temporary switchboats that would add efficiency (at added costs) to offset the minor restriction. There are other closures that occur during the navigation season that amount to about a 5 percent/year of lock closures over two navigation seasons. To facilitate the lock construction work, lockwalls and many other components would generally be constructed of prefabricated elements and installed in the wet without the use of a cofferdam and associated dewatering. In-the-wet construction and construction in general has inherent risks of delays due to weather, contractor performance, planning, execution, etc. If the construction activities were delayed beyond the winter closure period, navigation traffic would be delayed until completion of the specific construction activities.

6.1.4.2 New Locks

The construction of new locks occurs adjacent to the navigation path, which reduces their risk in comparison to lock extensions. For new locks at Locks 20 through 25, a significant amount of construction also occurs during the winter; however, the existing lock can feature scheduled openings in all but the last year of construction (due to the need to dewater both locks). It is doubtful that all traffic could be accommodated, but there would still be economic benefit. Also, the lock would be open for traffic with minor restrictions and closures during the remainder of each year of construction. The restrictions were modeled as being mitigated by the implementation of temporary switchboats that would add efficiency to offset the minor restriction due to construction interference. The closures during the navigation season amount to about a 1 percent/year period over three navigation seasons. The chance of construction delay for new locks and lock extension may be similar, but the consequences of prolonged construction schedules would be much worse for lock extensions. If construction delays occurred, related to construction of a new lock, the existing lock could be reopened for traffic in most situations.

6.1.5 Performance Considerations

There are two primary performance differences between lock extensions and new locks: the lock approach and the filling/emptying time. Location 3 locks (see Table 6-5)on the lower five locks on the Mississippi River would feature a riverside approach wall on the upstream end. This approach wall location with respect to the dam generally is considered safer than the present guidewall structure along the landside of the lock. Riverside approach walls are safer because they provide a physical barrier between the tow and the dam that would reduce the chance and consequences of tow mishaps that result in barges breaking loose from the tows and sometimes subsequently running into the dam. The approach wall also would allow downbound tows to better align themselves for faster lock entry and reduction of impact damage to miter gates and lockwalls resulting from the present lock entry alignment conditions. Also, better alignment would reduce impact damage to miter gates and lockwalls resulting from the present lock entry conditions.

The difference in filling/emptying time between the existing lock, lock extension, and new lock for Lock 25 are outlined in Table 6-7. The filling time for a new lock is approximately 8 minutes. The lock extension option has a filling time of approximately 12 minutes primarily because this alternative does not include extension of the filling/emptying culverts. Overall time savings for lock extensions versus the existing locks averages 49 minutes, and 53 minutes for new locks versus the existing lock. Lock extensions and new locks average costs (2003 price level) at Locks 20 through 25 are approximately $134 million and $209 million, respectively. A new lock has additional performance advantages resulting from two locks at a given site providing redundancy and recreation and small-craft lockage.

Table 6-7. Difference in filling/emptying time between the existing lock, lock extension, and new lock for Lock 25.

Lock Site	Lock Location	Lock Description, Type	Constr. Cost (millions in 1996 prices)	Nav. Season Closures due to Lock Construction	Average Time to Fill the Lock (minutes)
25	Existing Lock	600-foot lock	n/a	n/a	4.1
	Lock Extension, Location 2	1,200-foot lock, w/Extended Culvert, Type 2B	161	25%/yr over 2 nav seasons	8.0
		1,200-foot lock, w/out Extended Culvert, Type 2R	125	5%/yr over 2 nav seasons	12.1
	New Lock, Location 3	1,200-foot lock w/Extended Culvert, Type 3R	201	1%/yr over 3 nav seasons	8.0

6.1.6 Major Rehabilitation Considerations

Major Rehabilitations of locks were assumed to continue in the future. They would be conducted as required based on conditions at the projects and completion and approval of a report meeting the requirements of the Major Rehabilitation Program. The approximate costs and timing of Major Rehabilitation Projects were estimated for the purposes of this report. Major rehabilitation projects reduce the amount of lock closure time that is related to the reliability of lock components.

Locks that are not set to receive large-scale improvements in the future were estimated to require rehabilitation about every 25 years at a cost of approximately $30 to $42 million depending on the lock's length (600 ft or 1200 ft) and concrete condition.

Locks set to be extended would have major rehabilitation and lock extension construction forced into alignment in order to reduce costs and maximize lock service. Realigned major rehabilitation projects would cost approximately $11 million. After the lock extension is complete, major rehabilitations would still occur, but at 35-year intervals and cost approximately $30 to $36 million each.

The construction of a new lock on the Upper Mississippi River and major rehabilitation of the existing lock would also be forced into alignment in order to reduce costs and maximize lock service. Realigned major rehabilitation of the existing lock would cost approximately $8.5 million. After the new lock construction is complete, major rehabilitations of the new lock would still need to occur, but at 30-year intervals and at a cost of approximately $30 to $36 million each. The newly created auxiliary lock was estimated to not require another major rehabilitation in the planning period.

New locks at Peoria and LaGrange on the Illinois Waterway were considered for construction at later dates; therefore, major rehabilitation and lock construction could not be forced into alignment. Major Rehabilitation for each of these locks was considered to cost approximately $36 million and would be required to extend the service life until the time for construction of the new locks. Future rehabilitation of the new locks was estimated to occur approximately every 40 years at a cost of $30 to $42 million. An earlier construction start of either Peoria or LaGrange locks would offer the opportunity to force the alignment of major rehabilitation for the existing lock with the construction activities of the new lock. (All costs are in 2003 price levels).

6.1.7 Operation and Maintenance Costs Considerations

In the case of lock extensions, operation and routine maintenance costs were assumed to remain the same as in the without-project condition. For new locks, the cost for routine maintenance at each site was assumed to increase by approximately $240,000/year and the cost for operation at each site was assumed to increase by approximately $305,000/year (assuming staff increase to operate both locks). (All costs are in 2003 price levels).

6.1.8 Alternative Plans - Navigation Efficiency

The alternative plans were created by combining navigation efficiency measures into increasing levels of higher performing plans, often with increased costs. Locks were combined into groups such that all would receive the same measure for a given alternative plan. The lock groupings are: Peoria and La Grange, Locks 20 through 25, Locks 14 through 18, and Locks 11 through 13. For example, an alternative plan with new lock construction might be formulated to have new locks at each of Locks 20 through 25. Locks above Lock 13 can also be considered as a group because they are collectively referred to in the report as the non-critical locks – not in receipt of any efficiency measures. The reason for the other groupings can be found in Section 7.3.1 of the Economics Appendix. The alternatives listed below were carried forward for a full evaluation.

6.1.8.1 Alternative 1

No Action.

The no action alternative describes the future in the absence of additional Federal action. This includes continued use of efficiency measures of helper boats, industry self-help, permanently mounted deck winches, and N-up/N-down scheduling (described in Section 4.3.1). It also does not preclude routine operation and maintenance activities, to keep the system's components safe and operational, or periodic major rehabilitation activities to ensure the structural soundness and reliability of the existing system. The no action alternative forms the baseline against which navigation efficiency alternatives are measured. **Without Project condition would require no additional construction costs and subsequently no mitigation. However, this assumes continued annual operation and maintenance ($115-126M/yr), periodic Major Rehabilitation of Locks and Dams ($65M/yr) and continued environmental stewardship ($750K/yr) would continue.**

6.1.8.2 Alternative 2

Congestion Fees Implemented through a Lockage Fee (imposed on commercial traffic).

The objective of this form of congestion fees is to improve overall system efficiency by charging all users a lock usage fee, subsequently inducing marginal users (those that benefit the least from system use) to leave the system. While the traffic that is induced to leave the system would experience a loss as a result of the fees, the potential gain in the form of lower average delays for all remaining traffic could more than offset this loss from an overall system efficiency perspective. Congestion fees present an option for "internalizing" the external social cost of additional traffic at a navigation lock. Potential impacts not traditionally measured by Corps feasibility investigations--typically impacts associated with landside transportation modes--should not be ignored when considering the performance of any fee-for-use scheme. Specifically, these impacts could include such things as landside congestion, differential air quality impacts, and differential accident rates, all resulting from traffic shifted off the waterway. There are no existing instances of fee-for-waterway use in the United States as a consequence of current law, which prohibits charge or toll of any type for waterway use. Such a prohibition by current law, however, does not prevent the evaluation of such fee-for-use mechanisms. Corps guidance allows that alternative plans may propose necessary changes in such statutes, administrative regulations, or established common law. **First Cost of Infrastructure Improvements: $0M; Total Mitigation Cost: $0M; Annual Administration Cost: $2.5M; Completion Date: Continuous.**

6.1.8.3 Alternative 3

Nonstructural Measures – Deck Winches.

Installation of deck winches was evaluated as a means of generating additional operating efficiency. It was assumed that installation of winches would be motivated by the prospect of having to pay a fee if lockage time exceeded a specified threshold. A training program for barge operators and installation of deck winches are the two components of the measure. **First Cost of Infrastructure Improvements: $80M (training and equipment upgrades); Annual Administration cost: $12.5M; Completion Date: 2007.**

6.1.8.4 Alternative 4

Moorings (12, 14, 18, 20, 22, 24, and LGR); and Switchboats at Locks 20-25.

Moorings are tie-off facilities that allow the next tow to be served to wait closer to the lock chamber, thereby decreasing approach time. Switchboats would be employed as hired vessels permanently stationed on both the upstream and downstream sides of a lock. Switchboats would assist in handling the cuts of a double lockage, resulting in a shorter lockage time. **First Cost of Infrastructure Improvements: $84M; Annual SWB Operation Cost: $40.2M; Total Mitigation Cost: $93.4M; Total Average Annual Cost: $47.6M; Completion Date: 2009.**

6.1.8.5 Alternative 5

Moorings (12, 14, 18, 24, and LGR); Lock Extensions at Locks 20-25; and Switchboats at Locks 14-18, La Grange and Peoria.

This alternative incorporates the next level of capacity expansion, 1,200-foot lock extensions, at UMR Locks 20 through 25. It also includes switchboats at UMR Locks 14 through 18 to address potential induced traffic effects that may result from the downstream lock extensions. Moorings at UMR Locks 20 and 22 are eliminated with this alternative due to physical interference with lock extensions. On the Illinois Waterway, switchboats are also included at Peoria and La Grange. **First Cost of Infrastructure Improvements: $795M; Annual SWB Operation Cost: $33.8M; Total Mitigation Cost: $142.9M; Total Average Annual Cost: $112.7M; Completion Date: 2023.**

6.1.8.6 Alternative 6

Mooring (12, 14, 18, and 24), New Locks at 20-25, La Grange, and Peoria; Lock Extensions at 14-18; and Switchboats at Locks 11-13.

This alternative includes a high level of capacity expansion, new 1,200-foot locks, at UMR Locks 20 to 25, and also at Peoria and La Grange on the Illinois Waterway. On the Mississippi River, additional capacity expansion is also included in the form of 1,200-foot lock extensions at Locks 14 to 18, and switchboats at UMR Locks 11 to 13 to address potential induced traffic effects that may result from downstream lock improvements. Mooring at UMR Locks 20 and 22, and La Grange are eliminated with this alternative due to physical interference with lock improvements. New 1,200-foot locks at Locks 20 through 25 differ from the 1,200-foot lock extensions described in Alternative 5 in terms of both cost and performance. New locks, while representing the same chamber size as the lock extension, are more efficient than the extensions because of a faster filling and emptying system and dual lock advantages. However, this added performance comes at the price of higher construction expenditures. **First Cost of Infrastructure Improvements: $2.268B; Annual SWB Operation Cost: $7.8M; Total Mitigation Cost: $203.3M; Total Average Annual Cost: $191.2M; Completion Date: 2035.**

6.1.8.7 Alternative 7

Mooring (14, 18, and 24); New Locks at 14-18, 20-25, Peoria, and La Grange; Lock Extensions at 11-13.

This alternative includes the highest level of capacity expansion considered, new 1,200-foot locks, at UMR Locks 14 through 18 and 20 through 25 and at Peoria and La Grange on the Illinois Waterway. On the Mississippi River, additional capacity expansion is also included in the form of 1,200-foot lock extensions at Locks 11 to 13 to address potential induced traffic effects that result from downstream lock improvements. Mooring at UMR Locks 12, 20, and 22, and La Grange are eliminated with this alternative due to physical interference with lock improvements. **First Cost of Infrastructure Improvements: $2.5B.**

6.2 Formulation of Ecosystem Restoration Alternative Plans

The formulation of Ecosystem Restoration Alternatives began by identifying broad ecosystem goals that meet the planning objective of addressing the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System. This umbrella objective was further defined into systemic goals and site-specific objectives. These objectives were used to identify suitable types and numbers of ecosystem management and restoration measures. Combinations of the measures were then incorporated into the ecosystem restoration alternatives to insure the sustainability of the system. The following sections provide a summary of this process.

6.2.1 Establishing Ecosystem Goals and Objectives

It was determined at the outset of the restructuring of the Navigation Study that ecosystem restoration planning needed to be based on a strong set of ecologically and socially desired future ecosystem conditions. These desired future conditions are often described as definitive goals and objectives for the condition of the UMRS ecosystem. Successful restoration and management of complex systems such as the UMRS requires agreement among stakeholders on these ecosystem goals and objectives. Goals and objectives must be set at different levels (Figure 6-2). These levels range from broad systemic goals of sustainability to spatially and thematically explicit ecosystem objectives (e.g., increase backwater depth to 6 feet at river mile X).

At the highest level, the broad goal of system sustainability was defined by UMRS stakeholders (i.e., Navigation Environmental Coordinating Committee and Economic Coordinating Committee) in a vision statement that reads:

"To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System."

The following definition of sustainability was collaboratively developed and agreed to by the group as well:

"The balance of economic, ecological, and social conditions so as to meet the current, projected, and future needs of the Upper Mississippi River System without compromising the ability of future generations to meet their needs."

The vision statement helped structure the primary goal of the feasibility study, which is to outline an integrated dual-purpose plan to ensure the economic and environmental sustainability of the UMRS. Three planning objectives were identified to fully address this goal (see Section 1.3). The second Navigation Study planning objective was developed specifically to address ecosystem restoration:

Planning Objective 2. Recommend measures to address the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.

Vision Statement

"To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System."

Study Goal

Outline an integrated dual-purpose plan to ensure the economic and environmental sustainability of the UMRS.

Study Planning Objective

OBJECTIVE 2. Recommend measures to address the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.

Systemic Ecosystem Goals

(Grumbine: *What is Ecosystem Management?*)

1. Maintain viable populations of native species in situ
2. Represent all native ecosystem types across their natural range of variation
3. Restore and maintain evolutionary and ecological processes
4. Integrate human use and occupancy within these constraints

(UMRCC: *A River that Works and a Working River*)

1. Improve water quality for all uses
2. Reduce erosion and sediment impacts
3. Restore natural floodplain
4. Restore natural hydrology
5. Increase backwater connectivity with main channel
6. Increase side channel, island, shoal, and sand bar habitat
7. Minimize or eliminate dredging impacts
8. Sever pathways for exotic species introductions/dispersal
9. Improve native fish passage at dams

Site-Specific Ecosystem Objectives

UMRS Environmental Objectives Database containing 2,600 spatially explicit objectives.

Database Objective Category Structure

Functional
- Water Quality
  - Water Clarity
- Geomorphology
  - Backwater Depth
  - Water Level
  - Connectivity

Structural
- Pattern of Habitats
  - Aquatic Areas
  - Terrestrial Areas
  - Land Cover/Use
- Plants and Animals
  - Plants
  - Fish
  - Birds

Database Spatial Structure

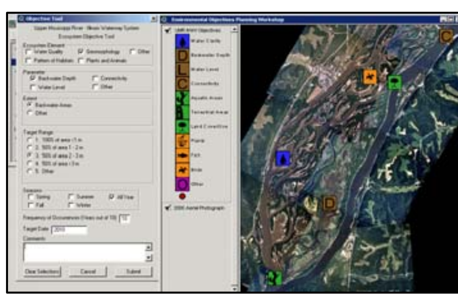


Figure 6-2. Navigation Study ecosystem goals and objectives structure.

Systemic ecosystem goals were adopted to more specifically address the condition and management of the river ecosystem (Table 6-8). Such broad goals for integrated and adaptive river management have been applied in many other river management situations worldwide. Resource managers and scientists also identified systemic goals specifically targeting the UMRS ecosystem (Table 6-9). These goals (captured in the UMRCC publication *A River That Works and a Working River*) were also adopted by the study to help further refine the UMRS systemic needs.

Table 6-8. Systemic ecosystem goals (Grumbine 1994).

1. Maintain viable populations of native species in situ
2. Represent all native ecosystem types across their natural range of variation
3. Restore and maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrologic processes, nutrient cycles, etc.)
4. Integrate human use and occupancy within these constraints

Table 6-9. UMRS systemic ecosystem goals (UMRCC 2000).

1. Improve water quality for all uses
2. Reduce erosion and sediment impacts
3. Restore natural floodplain
4. Restore natural hydrology
5. Increase backwater connectivity with main channel
6. Increase side channel, island, shoal, and sand bar habitat
7. Minimize or eliminate dredging impacts
8. Sever pathways for exotic species introductions/dispersal
9. Improve native fish passage at dams

At the most detailed level, measurable site-specific objectives for the condition of the river and floodplain ecosystems were identified. In developing these objectives, important ecosystem characteristics that can be affected by specific management actions were considered.

Improvements to the UMRS ecosystem can be accomplished by influencing the function and structure of the system. Ecosystem functions consist of ongoing processes (e.g., variable hydrology, sediment transport, etc.) that shape the structure (e.g., plant communities, distribution of aquatic habitats, etc.) of the system. Potential ecosystem improvements were identified and grouped into four categories of functional and structural elements (Table 6-10).

The functional elements include water quality and geomorphology. The structural elements consist of pattern of habitats and plants and animals. This hierarchical structure further breaks these elements down into additional ecosystem parameters of connectivity, backwater depth, land cover/use, etc. The UMRS Environmental Objectives Database used this structure to systemically capture a comprehensive inventory of site-specific ecosystem objectives.

Table 6-10. UMRS site-specific ecosystem objective categories.

Functional	Structural
• Water Quality	• Pattern of Habitats
o Water Clarity	o Aquatic Areas
• Geomorphology	o Terrestrial Areas
o Backwater Depth	o Land Cover/Use
o Water Level	• Plants and Animals
o Connectivity	o Plants
	o Fish
	o Birds

As part of the UMR-IWW Navigation Study, a series of regional workshops were conducted to collaboratively review, refine, and add to a database of spatially explicit ecosystem objectives (Figure 6-3). These workshops built upon previous objective setting exercises performed under the EMP Habitat Needs Assessment, Mississippi River Environmental Pool Plans, USFWS Comprehensive Conservation Plans, Cumulative Effects Study, Middle Mississippi River Stone Dike Alteration Study, UMRCC Reports, and related study efforts to develop specific, quantitative, local to regional scale environmental objectives for the UMRS.

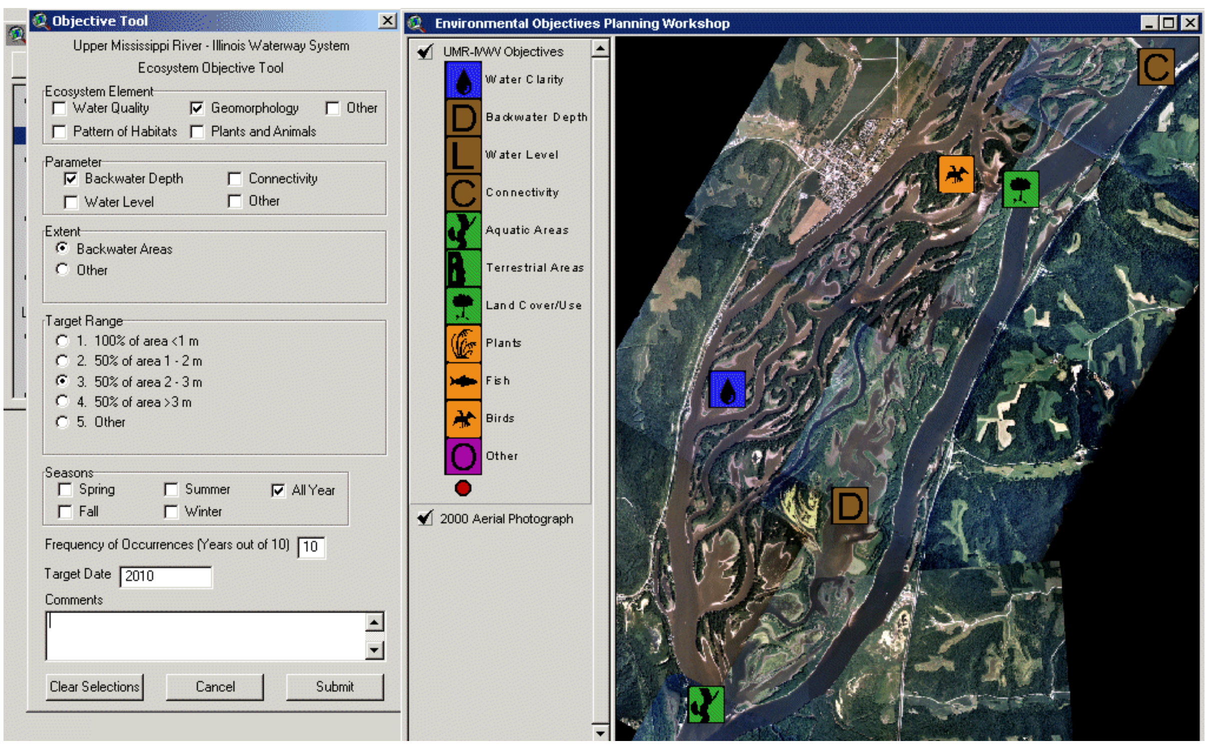


Figure 6-3. UMRS Site-Specific Environmental Objectives Database.

The final workshop report (DeHaan et al. 2002, ENV-50) provides a detailed explanation of the process and methodology that were followed to incorporate and build upon these previous objective setting exercises to create a standardized GIS database that provides comprehensive documentation and rationale for the UMRS environmental restoration objectives. This objective setting exercise resulted in almost 2,600 spatially explicit objectives for the condition of the river ecosystem (e.g., backwater depth, water level, connectivity, land cover/use, etc.). Additional information about the objectives making up the database is available in the Ecosystem Sustainability Appendix and the workshop report.

The process used to establish objectives is quite useful to account for numbers of practical projects, their general locations, sizes, shapes, and features. Benefits can be estimated based on the influence and performance of similar restoration efforts. The objectives identify locations to restore ecological conditions and processes to a recovered condition, a desired future condition. The objectives do not state that the entire system needs to be restored to natural habitat, but suitable habitats need to be available at a frequency and quality to maintain native species. For some species, habitat needs to be spaced as rest areas along migration corridors; for others, relatively high quality habitat in a small backwater lake can support resident populations. Corridors connecting habitat patches are important for population dispersal and seasonal movements. The rationale for the distribution of measures to address specific habitat needs is presented in Section 6.2.3.

Development of the comprehensive database of UMRS site-specific environmental objectives provided the information necessary to proceed to the next step of identifying appropriate ecosystem management and restoration measures.

6.2.2 Ecosystem Management and Restoration Measures

There are many management and restoration measures appropriate to the UMRS that have been applied or have potential application. These range in temporal and spatial scale from routine and frequent actions that affect smaller areas (e.g., daily operation of the gates at a dam), to infrequent actions that affect larger areas over longer periods of time (e.g., a pool-scale growing season drawdown to reestablish emergent aquatic plants).

A careful review of the objectives database reveals that the categories of environmental objectives in this study are uniformly distributed through the UMRS. Implementing management and restoration measures to address all the objectives would not achieve, or even approach, the presettlement condition because of the large amount of land isolated from the river by levees, hydrologic changes, and changes in ecosystem drivers at the basin scale. Implementing no, or few, environmental restoration measures would result in more environmental degradation of the types described above.

The process of identifying management and restoration measures that are likely to contribute to achieving the identified UMRS goals and objectives began with the development of an extensive table of almost 400 potential UMRS management actions for consideration (USACE 2002, Appd. 5). As part of the Environmental Objectives Planning Workshops, this table was reviewed, refined, and added to by participants, resulting in a comprehensive listing of measures related to identified ecosystem objectives (Table 6-11). The measures were specifically tailored to the UMRS objectives under consideration.

Using the results of the workshops, a relational database was developed to better identify the multiple linkages between UMRS ecological objectives and associated measures. The database assisted in rating the potential effectiveness of management actions and in grouping and developing overarching categories of UMRS management and restoration measures. Thorough review of the database and supporting information resulted in the selection of appropriate management and restoration measures for inclusion in the Navigation Study Ecosystem Restoration Alternatives.

Table 6-11. UMRS objective and associated management and restoration measures.

Ecosystem Objective	Management and Restoration Measure
Water Quality	
Water Clarity	Apply watershed BMPs (best management practices)
	Stabilize riverbanks
	Pool-scale drawdown to consolidate soft sediments
	Pool-scale drawdowns to promote emergent vegetation
	Minimize dredge disturbance/frequency
	Minimize dredge slurry return water
	Minimize bankside dredged material placement
	Stabilize dredged material
	Tributary reservoirs
	Speed and wake restrictions – recreational boats
	Establish and enforce safety zone for towboats
	Establish a permit system for tows over 9-foot draft
	Adjust sailing line
	Improve aids to navigation
	Additional mooring buoys
	Restore natural tributary meander areas through delta areas
	Minimize open water dredged material placement
	Tributary sediment traps
	Increase depth in main channel (reduce sediment resuspension)
	Require upper Illinois Waterway to meet EPA general use standards

As previously explained, approximately 400 regulatory, operational, and structural measures were identified and reviewed for their potential to address UMRS environmental objectives. Of these, 12 overarching categories of restoration measures were selected after considering input from UMRS stakeholders, coordinating committees, and the Navigation Study Science Panel (Table 6-12).

Table 6-12. UMRS ecosystem management and restoration measures.

- Island Building
- Island Protection
- Shoreline Protection
- Fish Passage
- Floodplain Restoration
- Water Level Management – Pool
- Water Level Management – Backwater
- Backwater Restoration (Dredging)
- Side Channel Restoration
- Wing Dam/Dike Alteration
- Improve Topographic Diversity
- Dam Point Control

As part of the review process, the relational database (described above) was used to better identify the multiple linkages between UMRS ecological objectives and associated measures. Table 6-13 provides a simplified depiction of the relation between the selected measures and the ecological objectives they address. Some measures are more broadly effective and address several objectives, and others are more specific and may address only a single objective, but these measures collectively represent general methods of management and restoration that could be employed to achieve the identified UMRS ecosystem objectives. Though not listed in the table, most of the restoration measures would also address plant, fish, and bird species objectives.

Table 6-13. UMRS ecosystem measures and related objectives.

Restoration Measure	Environmental Objective(s)	
	Functional	Structural
Island Building	Connectivity	Terrestrial Areas Aquatic Areas
Island Protection	Water Clarity	Terrestrial Areas Aquatic Areas
Shoreline Protection	Water Clarity	Terrestrial Areas Aquatic Areas
Fish Passage	Connectivity	Aquatic Areas
Floodplain Restoration	Connectivity	Terrestrial Areas Aquatic Areas
Water Level Management – Pool	Water Level	Aquatic Areas
Water Level Management – Backwater	Water Level	Aquatic Areas
Backwater Restoration (Dredging)	Backwater Depth	Aquatic Areas
Wing Dam/Dike Alteration	Connectivity	Aquatic Areas
Side Channel Restoration	Connectivity	Aquatic Areas
Improve Topographic Diversity	Water Level	Terrestrial Areas
Dam Point Control	Water Level	Aquatic Areas

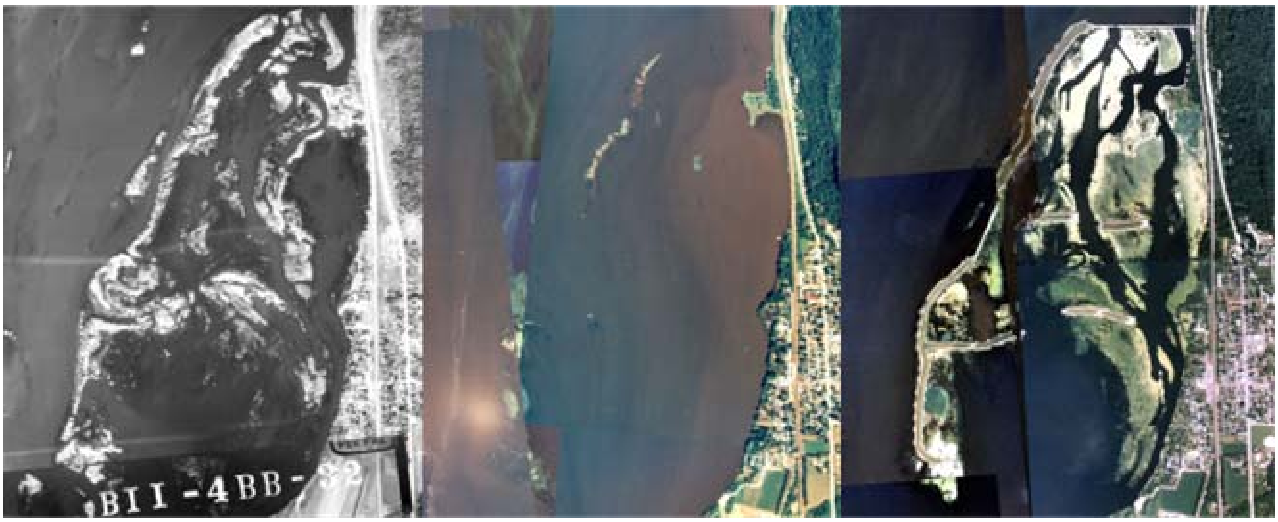
These measures were used as the building blocks of the Navigation Study Ecosystem Alternative Plans. The UMRS environmental restoration alternatives distribute management and restoration measures to address important ecosystem conditions and processes. An ideal plan would match the needs of resident and migratory animals, support native habitats, and provide ecosystem services important to people in the region. Further refinement of the combinations, timing, and placement of management and restoration measures will occur through adaptive management and detailed planning for major restoration projects. The following sections provide additional detail on the selected restoration measures.

6.2.2.1 Island Building

Islands are common features of the UMRS landscape, especially in the northern pooled reaches where the geology and glacial outwash created a classic island-braided channel form. This form is also common below some major tributaries and below floodplain constrictions at Rock Island, Illinois, and Keokuk, Iowa. Islands create off-channel areas that are sheltered from river currents and waves. These characteristics create conditions ideal for a variety of aquatic plants and highly productive wetlands. They also increase habitat diversity by providing conditions suitable for a variety of forest and wetland communities. In addition, they create ideal habitat for ground nesting birds, helping them avoid predation.

Many islands were present when the lock and dam system was completed. In some areas, islands have been lost due to erosion, and in other areas, they have grown as a result of sedimentation. Islands can be constructed in areas of high bed sediment transport by starting with a rock “seed island.” The river then deposits sediment below the “seed island” to create a larger island. Island building includes constructing islands from sediment (sand, clay, or silt) dredged from the bottom of the river to replace islands eroded by waves and river current. They may also be constructed in open water areas to create sheltered off-channel habitat to promote backwater communities. Past experience has led to designs that can protect large areas (>1,000 acres) with as little as 30 acres of island. Island construction can be done concurrently with channel maintenance dredging, providing beneficial use for dredged material and reducing channel maintenance costs. Proposed island restoration is most frequently identified in the upper pooled reaches where island erosion is most pronounced, but the action will have wide application in other river reaches to create wave breaks and store sediment from dredging projects that create deepwater habitat.

Pool 8 Islands HREP Phase II,
near Stoddard, Wisconsin

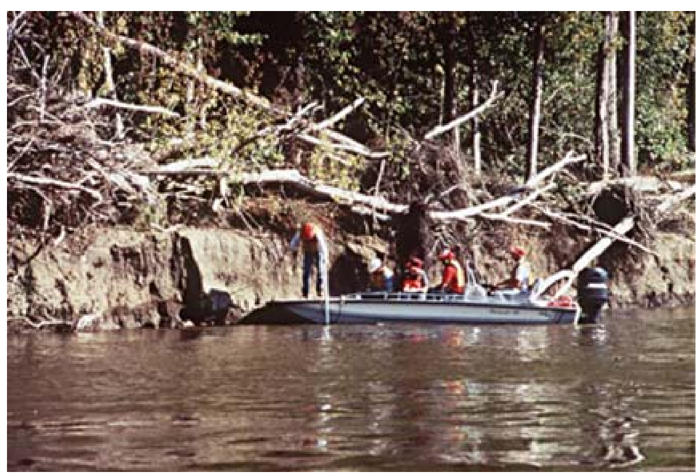


October 1961 August 1994 August 2000

6.2.2.2 Island and Shoreline Protection

Shoreline and island erosion are natural processes that characterize dynamic rivers. In the UMRS, shoreline erosion is exacerbated by commercial and recreational boats and by wind-generated waves in the impounded system. Shoreline erosion is a problem where it damages social resources, important habitats, or archeological resources.

Shoreline Erosion



Island and shoreline protection (either bankline or offshore revetments) includes armoring banks with stone or vegetation to prevent erosion. Erosional areas have been mapped and can be targeted for protection. This measure is viewed as a habitat protection measure that maintains existing conditions to the extent possible. This restoration measure will be applied widely throughout the river system.

Natural resource managers have identified numerous locations where island and bank erosion is threatening critical resources. Highly valuable forest stands such as heron and egret nesting colonies, eagle roosting trees, or rare bottomland hardwoods are targets for protection of terrestrial resources. Erosion of natural levees or islands is undesirable in locations where introduction of sediment laden river flow, bed load, or currents may degrade backwater habitat.

6.2.2.3 Fish Passage

As noted in the Fish Passage Work Group Report, there are at least 30 species of native migratory fish in the UMRS. Fish movement among pooled river reaches is critical for them to access high quality spawning, rearing, feeding, and winter habitat. Some notable species, such as eels and skipjack herring, migrate from the ocean to the headwaters; others are large river migrants that may travel throughout the Mississippi River Drainage (e.g., the Missouri, Ohio, Illinois, and Mississippi Rivers and their tributaries). There are also many species the make seasonal movements of a few miles to 30 miles or more to reach spawning or overwintering habitat.

UMR-IWW dams restrict upstream fish movement during most portions of a given year. Technical fishways, such as fish ladders, and naturalistic by-pass channels through spillways were the primary measures considered, although some benefits may be gained from modified dam operation and embankment lowering. The primary benefit is increased opportunities for seasonal fish migrations, but the recent introductions of exotic Asian carp are forcing biologists to reconsider the risk of allowing the exotic species to spread.

All UMR-IWW dams are eligible for consideration for fish passage measures, but some offer greater benefits, in terms of stream miles made available, habitat, and cost, than others. The best locations to provide fish passage connect large river reaches, especially tributary stream networks. A work group was formed to evaluate the problem and opportunities for fish passage. The group recommended 14 locations for initial consideration including 2, 4, 5, 8, 9, 10, 11, 13, 14, 18, 19, 22, 26, and Kaskaskia, with others to be considered later.

6.2.2.4 Floodplain Restoration

Floodplain habitats are integral components of large river ecosystems because of the seasonal flood pulse that inundates them and connects them to the river. Many species of plants and animals are adapted to this flood cycle and take advantage of habitat and food resources as they are made available. Many important sediment and nutrient transfers also occur when floodplains are inundated.

Floodplain Restoration: Spunky Bottoms, Illinois River Mile 80

Floodplain habitats throughout the UMRS have been altered for many reasons. In northern river reaches, dams spread water across low elevation floodplain areas to greatly increase aquatic habitat connectivity in the floodplain. Floodplain restoration in the north is a mix of protecting some areas with islands, connecting isolated backwaters, and restoring tributary channels. In southern river reaches, the floodplain is much more developed for crop production and flood protection, and is thus much more isolated from the river. Floodplain restoration in southern reaches includes a mixture of water level manipulation in management areas, wetland/habitat management in leveed areas (e.g., Wetlands Reserve Program (WRP), Conservation Reserve Program (CRP), etc.), or restoration of agricultural areas to aquatic, floodplain forest and prairie habitats. Restoration of privately owned floodplain areas requires landowner cooperation or acquisition of real estate interests from willing sellers and donors.

6.2.2.5 Water Level Management

Large river ecosystems such as the UMRS are characterized by seasonal cycles of flood and drought (or low flow). As mentioned above, a variety of ecological functions and processes are linked to this cycle. Development of water resources for hydropower or navigation typically alters and disrupts these natural cycles. Fortunately in the UMRS, the flood stage of the hydrograph is relatively unaltered, but low stages have been eliminated to support commercial navigation.

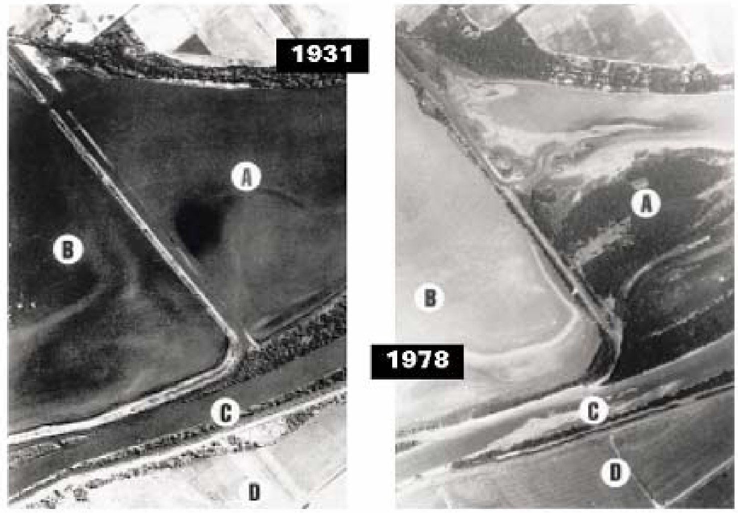
Pool-Scale Water Level Management

Water level management is a broad topic that includes maintaining water levels in the channel to support commercial navigation, modifications of the dam operating procedures for environmental benefits, or managing water levels in isolated management areas on the floodplain. Water level management in the navigation channel is the typical operating procedure that created and maintains the existing array of habitats. Modified dam operations for environmental benefits includes lowering water levels (drawdowns), changing flow distribution through dam gates, minimizing water level fluctuations, and changing control points. The greatest current interest of stakeholders considering water level management is drawdowns to expose sediment to establish emergent perennial or annual wetland plants in shallow aquatic areas. Pool-scale drawdowns can be accomplished while maintaining navigation. In some cases, advance dredging will be required to maintain adequate channel depths. The extent and duration of drawdowns used for alternative formulation purposes was 2 feet for 60 consecutive days to simulate natural low flow conditions and consolidate substrates and allow plant germination. Drawdown implementation will be adaptive to fit environmental conditions and stakeholder desires, so that drawdowns may be more or less extensive in time or space. Aquatic plants then provide structure and refuge for a variety of invertebrates and fish. Water level management in backwaters is a popular management action in some river reaches, but it is infrastructure- and labor-intensive, and may also exclude fish from important habitats.

6.2.2.6 Backwater Restoration (Dredging)

Large river ecosystems support a variety of habitats, of which backwaters are an important component. Backwater habitats support many popular sport fish, waterfowl, shorebirds, and wading birds. Backwaters are also quiet areas off the main channel where people and animals alike can seek refuge from the busy main channel environment.

Backwater Degradation and Loss



Many UMRS backwaters have been degraded by excessive amounts of sediment emanating from the basin, tributaries, and main stem sources. The degradation is in the form of loss of depth, poor sediment quality, poor water quality, and sediment resuspension that blocks light required by aquatic plants. The remedy to the problem can be in the form of backwater dredging, or backwater water level management discussed above. Backwater dredging typically consists of dredging channels with fingers extending from the main dredge cut to a depth of 6 to 8 feet deep. Past projects have dredged about 20 acres, which provides enough area for fish from larger areas to concentrate during winter and other harsh climate conditions. Sediment dredged to create depth can be used to enhance aquatic areas with islands, or terrestrial areas with increased topographic diversity and elevation, which promotes the growth of oaks and other mast tree species.

Although improved farming practices are now in place, backwater sedimentation and loss are especially pronounced in southern pooled reaches and in the Illinois River where sediment from the row crop dominated landscape continues to be excessive. Streambank erosion throughout the basin is another important source of sediment filling backwaters. Backwater restoration is required throughout the UMRS.

6.2.2.7 Side Channel Restoration

Side channels provide off-channel habitat that shelters fish and other animals from the harsh conditions of the main channel. In braided channel habitats of the northern river reaches, side channels are numerous and provide a variety of habitat conditions. Farther south, side channels are typically larger and more uniform in their configuration.

Side Channel Restoration

Side channels have been degraded by sedimentation and channelization. Where sedimentation is the issue, restoration includes dredging the upper and lower connections similar to what is done in backwaters. Restoration in response to channelization typically involves modifying channel regulating structures to increase connectivity and flow between the main and secondary channels.

In the Middle Mississippi River Reach, side channels have been created by notching the landward end of wing dams to allow flow between the bank and the island (see figure below). In most cases, work within the side channel may include constructing barbs to alter flow patterns or augmenting woody debris piles or other structures. Side channel restoration is needed throughout the UMRS.

6.2.2.8 Wing Dam/Dike Alteration

Wing dams are prominent channel regulating features common in main channel habitats. In northern river reaches, most wing dams are artifacts of earlier channel management efforts for the navigation project. They provide important habitat in channel border areas. In southern river reaches, and especially in the Middle Mississippi River Reach, wing dams are prominent features of the channel environment. They are used to concentrate flow in the main channel to reduce dredging needs. Wing dams are usually constructed in groups called dike fields. These areas are depositional zones that often fill from the bank outward toward the channel. Notching, lowering the profile, or altering the angle to the channel are some measures that can be used to increase habitat diversity in dike fields. The practice has met with great success in some river reaches.

Wing Dam/Dike Alteration

Dike alteration will be an important component of the restoration of the Middle Mississippi River Reach and will have beneficial application elsewhere in the system.

6.2.2.9 Improve Topographic Diversity

Increased floodplain water table elevation can result in the elimination of flood intolerant tree species that require a dry root zone. Improving topographic diversity simulates the ridge and swale topography of the natural floodplain by using material dredged from the channel. This newly elevated land area may then be planted with oaks and other mast trees.

6.2.2.10 Dam Point Control

UMR navigation dams have two operating procedures, dam point control and hinge point control. Water levels are maintained at specified stages at the dam or near mid-pool (hinge point), respectively. With hinge point control, at moderate discharge levels, water levels are reduced (drawn down) in the lower half of the pool. This reduces flooding at mid-pool and upper pool areas. This phenomenon has been incorporated into environmental management plans, as possible, with great success, but there could be greater benefits if managers had the option of using hinge point control or dam point control, depending on the management objectives in a given year. Switching to dam point control requires acquiring land or easements in mid-pool reaches that would be subject to increased flooding. Changing from hinge point control to dam point control would require no structural modifications to the dams.

Hinge point water level management (Figure 6-4) impounds water to the “maximum controlled pool stage” (A) during low flow periods. Water levels are lowered, which narrows the channel width at the dam during moderate flow (B) to limit the amount of land that may be flooded. The difference (C shaded area) is the approximate area that could be flooded more often with a shift to dam point control. Changing from hinge point control to dam point control while maintaining the same flat pool elevation would result in higher water levels for a given flow.

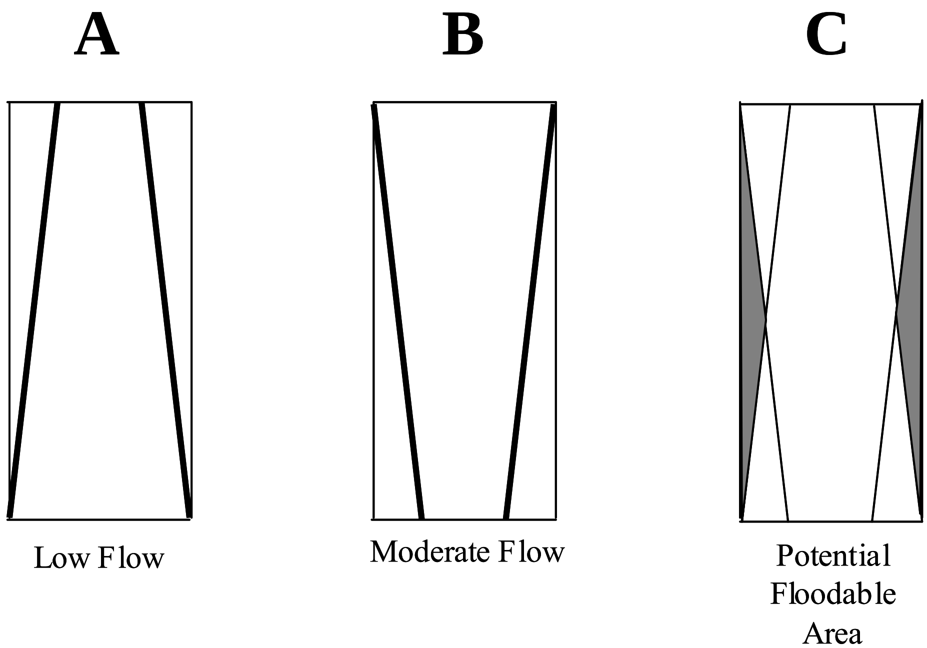


Figure 6-4. Probable changes in the distribution of surface water as a result of shifting from hinge point control to dam point control.

6.2.3 Rationale for Selecting, Combining, and Distributing Measures into Alternative Plans

Varying types and numbers of management and restoration measures were combined into alternative plans to address local, river reach, and system-wide needs of the UMRS ecosystem. Through collaborative work with UMRS stakeholders, coordinating committees, and the Navigation Study Science Panel, five alternative plans (Table 6-14) were developed to provide a range of ecosystem protection and restoration opportunities.

Table 6-14. UMR-IWW Navigation Feasibility Study Ecosystem Alternative Plans.

Alternative A.	No action/Without project (current environmental management activities and rehabilitation efforts continue at historic levels).
Alternative B.	Protect and maintain existing environmental diversity (current mosaic of habitat types and ecological diversity maintained into the future: no net loss).
Alternative C.	Restore the first increment of habitats most directly affected by the navigation project.
Alternative D.	Restoration to a level that includes management practices and cost effective actions affecting a broad array of habitat types.
Alternative E.	Restoration to include most environmental objectives that could be accomplished in the context of the navigation project.

The UMRS Environmental Objectives Database (DeHaan et al. 2003, ENV-50) provides an estimate for the desired future condition of the UMRS ecosystem. This desired future condition is also referred to as the UMRS Virtual Reference throughout the alternative formulation and evaluation process. This definition differs slightly from the Science Panel description, but is integral to the Virtual Reference as defined by the Science Panel.

Reference conditions normally describe the characteristics of a system least impaired by human activities and are used to define attainable biological or habitat conditions. On the UMRS, multiple reference conditions have been identified including pre-European (1800), pre-navigation (1850), pre-dam construction (1900), early post-dam construction (1940), or present conditions (2000). Because of the difficulty in selecting a single target reference condition for the UMRS ecosystem, a “virtual” reference condition has been constructed using a defined set of ecosystem attributes that comprise an estimate for the desired future condition of the system. Through information gathered from previous study efforts, stakeholders, and the Navigation Study Science Panel, the reference condition was developed by identifying and setting specific, quantitative, and local to regional scale environmental goals and objectives. This work resulted in the development of the UMRS Environmental Objectives Database (ENV Report 50) that provides a comprehensive estimate for the desired future condition of the UMRS ecosystem (i.e., UMRS Virtual Reference). The objectives from the database helped to identify measures that were distributed across alternatives considering planform area change estimates developed for the UMR-IWW Navigation System Feasibility Study Cumulative Effects Report (WEST 2000), the Upper Mississippi River System Habitat Needs Assessment (USACE 2000), and other information and considerations.

The predicted change in the planform area of main channel, secondary channel, contiguous backwaters, isolated backwaters, and island area, habitats directly affected by the navigation system, was used as a gauge for the allocation of measures across Alternative B. The measures were allocated at a level that approximated the projected loss of aquatic area features.

The allocation of off-channel measures (i.e., secondary channel, backwater, island, dike alteration, and floodplain restoration excluding land purchases) for Alternatives C, D, and E was based on the habitat requirements of species that are representative of other species using similar habitats. For example, bluegill movement to overwintering habitat provided a basis for the allocation of off-channel aquatic habitat measures because they are a relatively weak swimmer whose requirements meet or exceed most other lentic species' needs. Radio tracking data in Iowa (Iowa DNR 2000, 2003) documents seasonal movements up to about 8 miles, but most individuals tracked moved less than 3 miles. The simple schematic sketch (Figure 6-5) illustrates a distribution scheme that allocates projects in a hypothetical 10-mile river reach. At Alternative C, one off-channel habitat measure is allocated in 10 miles. For Alternative B, two off-channel measures are allocated in a 10-mile reach. Three off-channel measures are allocated under Alternative E. If there were more than three objectives for a given reach, they were included in the Virtual Reference. The Cumulative Effects Study (WEST 2000) historic planform area change estimate and the Habitat Needs Assessment (USACE 2000b) estimate of geomorphic change also informed, but did not drive, the allocation of projects across Alternatives C, D, and E.

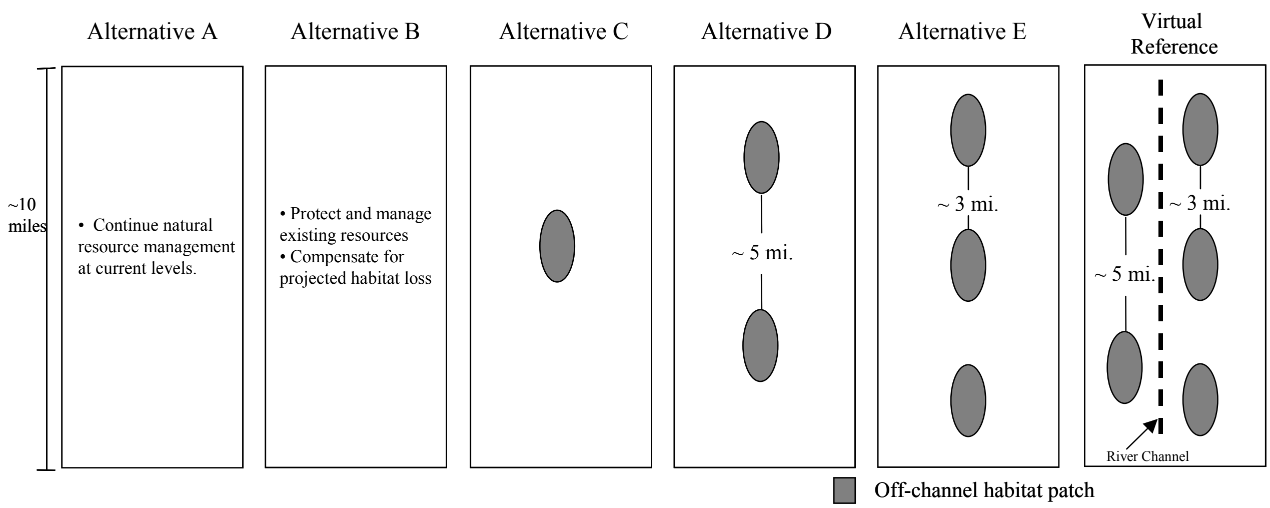


Figure 6-5. Distribution of off-channel habitat patches to meet bluegill habitat requirements (i.e., off-channel habitat every 3 to 5 miles; Iowa DNR 2001, 2003).

There were 98 sites identified for some sort of floodplain restoration. The objectives ranged from relatively small-scale connections into isolated backwaters in the Upper Impounded Reach to comprehensive levee district buy-outs and floodplain restoration in the lower river reaches. The floodplain restoration measures in the Upper Impounded Reach were allocated similar to other off-channel habitat restoration measures, and also informed by the estimate of loss of isolated backwater habitat presented in the Cumulative Effects Study (WEST 2000). The larger-scale floodplain restoration objectives were treated as a desire to restore large, contiguous blocks of habitat, either forest, grassland, wetlands, or, most likely, a mix of these cover types. The literature is mixed regarding the size of the "core area" required by specific species, and much work still needs to be done to determine the exact configuration of the "habitat blocks."

The spacing of these habitat blocks was allocated considering the home range characteristics of mallard ducks, which "range out about 25 miles from rest lakes searching for food" (Bellrose 1954). Bellrose (1954) recommended establishing refuges approximately 50 miles apart along migrational routes, like beads along a string of pearls. This density, or greater, of habitat should provide resting and feeding areas and, it is hoped, disperse birds to reduce the incidence of disease that occurs in overcrowded refuge areas. Similar to the rationale for off-channel aquatic habitat, this density of large floodplain habitat blocks should meet the needs of many migratory birds and other wildlife. The connections between habitat blocks will have to be considered later in the planning and adaptive management process.

The first increment of floodplain restoration is initiated in Alternative B, but it is only 1,000 acres in the Upper Impounded Reach. In Alternative C, the first increments of large-scale floodplain restoration are initiated, bringing the total to 16,000 acres. Alternatives D and E are the restoration levels where significant amounts of floodplain could potentially be restored, with 105,000 acres in Alternative D that achieves a suitable distribution of habitat along the migration corridor and 250,000 acres in Alternative E that achieves an optimal distribution of habitat along the migration corridor.

A fish passage interagency work group evaluated issues of habitat connectivity, migratory species in the UMRS, existing constraints to fish movement, potential measures to improve fish passage, and costs and benefits of providing fish passage (Wilcox et al. 2004, ENV-54). They conclude with recommendation for nature-like fish passage structures at 14 dam sites initially including 2, 4, 5, 8, 9, 10, 11, 13, 14, 18, 19, 22, 26, and Kaskaskia, with others to be considered later. The results are incorporated in Alternative D as fish passage measures at 14 locations. Fish passage measures at 19 additional locations are included in Alternative E and the Virtual Reference. A smaller number of fish passage structures were not included in Alternative B or C because of an identified threshold of need. That is, the systemic improvement of fish passage connectivity was not minimally obtained until fish passage was restored at the 14 identified locations.

A water level management work group was formed to evaluate the potential to lower water levels (drawdown), raise water levels, use multiple control points, modify flow distribution through dam gates, limit water level fluctuations, and induce flow into backwaters during winter. The group considered many factors, especially the hydrologic factors, impacts to other users, and costs to maintain a 9-foot channel depth (Landwehr et al. 2004, ENV-53). The major findings of the group resulted in recommendation to conduct growing season drawdowns at pools: 5, 7, 8, 9, 11, 13, 16, 18 19, 24, 25, and 26. They also recommend changing from hinge-point to dam-point control at pools 16, 24, and 25 to increase options for water level management, to modify flow distribution through gates to improve fish passage or provide attracting flow, and to minimize water level fluctuations on the Illinois Waterway. These drawdowns are included in Alternative B because they are likely a cost effective measure to increase sediment quality, water quality, aquatic plant production, and aquatic habitat. Changing control points at Pools 25 and 16 are included in Alternatives C and D and Pool 24 is added in Alternative E and the Virtual Reference. Pool 26 is not included in any alternative because of probable impacts to developed areas. Modifying flow distributions and minimizing water level fluctuations were determined to be issues that should be considered as part of an adaptive management scheme.

Wing dam and dike alterations are measures that change the configuration of channel training structures so they diversify or otherwise improve aquatic habitat in channel border areas. The structures range from relatively small, submersed structures in the Upper Impounded Reach to very large emergent structures in the Middle Mississippi River. Regardless of their size, alternations usually involve notching structures to allow river currents to scour and flow in more diverse patterns between structures. These measures were allocated similar to other off-channel habitat measures described above. In the Middle Mississippi River Reach, they are spaced slightly farther apart than in other reaches because resource managers believed that fish found in this river reach move greater distances.

Island and shoreline protection includes measures to protect the existing planform features of the aquatic and terrestrial features of the river. Typical measures include riprapped shorelines, but more environmentally sympathetic measures including offshore revetments, plantings (bioengineering), low gradient slopes, rock groins, and others are being incorporated. These measures may also be used to alter the overflow portions of the dams. Considering the desire to maintain the existing planform features, island and shoreline protection measures are included in Alternative B and carried through the others.

Measures to increase topographic diversity include the placement of dredged material, typically in ridges, on the floodplain to raise the root zone of flood intolerant mast trees. These measures are frequently complementary to channel maintenance and other restoration measures. They are included in Alternative B because of the probability to combine these objectives with other measures and channel maintenance activities.

6.2.4 Summary of Preliminary Costs

The potential costs of the UMRS ecosystem alternatives were developed through collaborative work with the UMRS Corps Districts and stakeholders. Estimates of alternative costs were arrived at by first identifying the average per project cost of UMRS ecosystem measures (Table 6-15). For example, a 30-acre island building project would cost approximately $3.5 million to build (including all labor and materials) and $250,000 to operate and maintain over 50 years (about $5,000 annually). The anticipated ecosystem measure expenses are based on the best available information including historical project costs and current UMRS material and labor costs. The Ecosystem Sustainability Appendix provides additional information on the methodology and sources of information used in assessing the costs of UMRS restoration measures.

Table 6-15. UMRS ecosystem measure costs in 2003 dollars.[a]

Ecosystem Restoration Measures	Project Footprint	Project Costs (50 years)	
		Measure	O&M
Island Building	30 Acres	$3,459,000	$247,500
Fish Passage	1 Site	$23,500,000	$1,500,000
Floodplain Restoration (Pools 1-13)	500 Acres	$1,000,000	$375,000
Floodplain Restoration (Rest of UMR-IWW)[b]	5,000 Acres	$25,000,000	$3,750,000
Water Level Management - Pool	1 Site	$4,504,000	$0
Water Level Management - Backwater	1,000 Acres	$3,400,000	$1,000,000
Backwater Restoration (Dredging)	20 Acres	$2,326,000	$0
Side Channel Restoration	100 Acres	$1,450,000	$575,000
Wing Dam/Dike Alteration	5 Structures	$785,000	$68,750
Island Protection	3000 Feet	$528,900	$82,500
Shoreline Protection	3000 Feet	$528,900	$82,500
Topographic Diversity	5 Acres	$767,500	$60,000
Dam Point Control	1 Site	$10,750,000	$2,250,000
Floodplain Restoration-Immediate Opportunities	5,000 Acres	$25,000,000	$3,750,000

[a]Costs do not include contingency or planning, engineering, and design costs.
[b]Floodplain Restoration (Rest of UMR-IWW) includes an additional $3,000/acre real estate cost.

A majority of floodplain restoration occurring in the system would include additional real estate at an average cost of $3,000 per acre for the UMRS. This real estate cost is included in the $25,000,000 per project cost of Floodplain Restoration (Rest of UMR-IWW) displayed in Table 6-15.

6.2.5 Formulation, Reformulation, and Screening of Alternative Plans

Working with the Navigation Study work groups, science panel, coordinating committees, States, and other stakeholders, the ecosystem alternatives were formulated and refined to better and more efficiently meet the identified range of ecosystem protection and restoration opportunities. This included establishing and evaluating potential ecosystem measure performance (e.g., area of influence, cost per acre, etc; Table 6-16). The Navigation Study environmental work groups performed a thorough investigation of potential fish passage and water level management projects to better formulate the distribution of these measures throughout the alternatives.

Table 6-16. UMRS ecosystem measure costs and benefits in 2003 dollars.

Ecosystem Measures	Project Footprint	Project Costs (50 years) Measure	O&M	Benefits Acres of Influence	Cost per Acre of Influence
Island Building	30 Acres	$3,459,000	$247,500	1,000	$3,500
Fish Passage[a]	1 Site	$23,500,000	$1,500,000	-	-
Floodplain Restoration (Pools 1-13)	500 Acres	$1,000,000	$375,000	500	$2,000
Floodplain Restoration (Rest of UMR-IWW)[b]	5,000 Acres	$25,000,000	$3,750,000	5,000	$5,000
Water Level Management - Pool[a]	1 Site	$4,504,000	$0	-	-
Water Level Management - Backwater	1,000 Acres	$3,400,000	$1,000,000	1,000	$3,400
Backwater Restoration (Dredging)	20 Acres	$2,326,000	$0	600	$3,900
Side Channel Restoration	100 Acres	$1,450,000	$575,000	100	$14,500
Wing Dam/Dike Alteration	5 Structures	$785,000	$68,750	10	$78,500
Island Protection	3000 Feet	$528,900	$82,500	240	$2,200
Shoreline Protection	3000 Feet	$528,900	$82,500	3	$176,300
Topographic Diversity	5 Acres	$767,500	$60,000	8	$96,000
Dam Point Control	1 Site	$10,750,000	$2,250,000	3,000	$3,600
Floodplain Restoration-Immediate Opportunities	5,000 Acres	$25,000,000	$3,750,000	5,000	$5,000

[a]Fish Passage and pool-scale Water Level Management benefits were assessed separately.
[b]Floodplain Restoration (Rest of UMR-IWW) includes an additional $3,000/acre real estate cost.

6.2.5.1 Area of Influence

The area positively affected by restoration measures was investigated to determine how well they could address the identified UMRS goals and objectives. This multi-District effort examined how habitat areas were influenced by anticipated or ongoing UMRS management and restoration activities. By reviewing existing restoration efforts, such as the Pool 8 Stoddard Island Building Project (Figure 6-6), the average area of influence was identified for a given project footprint. In this case, 26 acres of island building positively influenced approximately 800 acres of aquatic and terrestrial habitat. This and several other UMRS island building projects were used to develop the systemic average of 1,000 acres of influence for a 30-acre island building project (Figure 6-7). Using this methodology, the areas of influence were estimated for the remaining management and restoration measures displayed in Table 6-16 above. The Ecosystem Sustainability Appendix provides additional information on the methodology and sources of information used in assessing UMRS restoration measure area of influence.

Areas of influence identified for the restoration projects reflect only the direct habitat impacts of the measures. Overall, this may be considered a conservative estimate when one takes into account the restoration effort's more far-reaching effects on migratory species.

The area of influence of environmental management and restoration measures is highly variable, depending on the particular measure under consideration. Some measures have little impact beyond their actual construction or activity footprint; others may have a small footprint area, yet directly affect much larger areas. The influence area of all measures is complicated by the mobility of target organisms, which may move from very far distances to use habitats created by a project for a particular season or purpose. Or, there may be resident populations that benefit from the measure for their entire life cycle.

Figure 6-6. UMRS island building project and area of influence (Pool 8, Stoddard Islands).

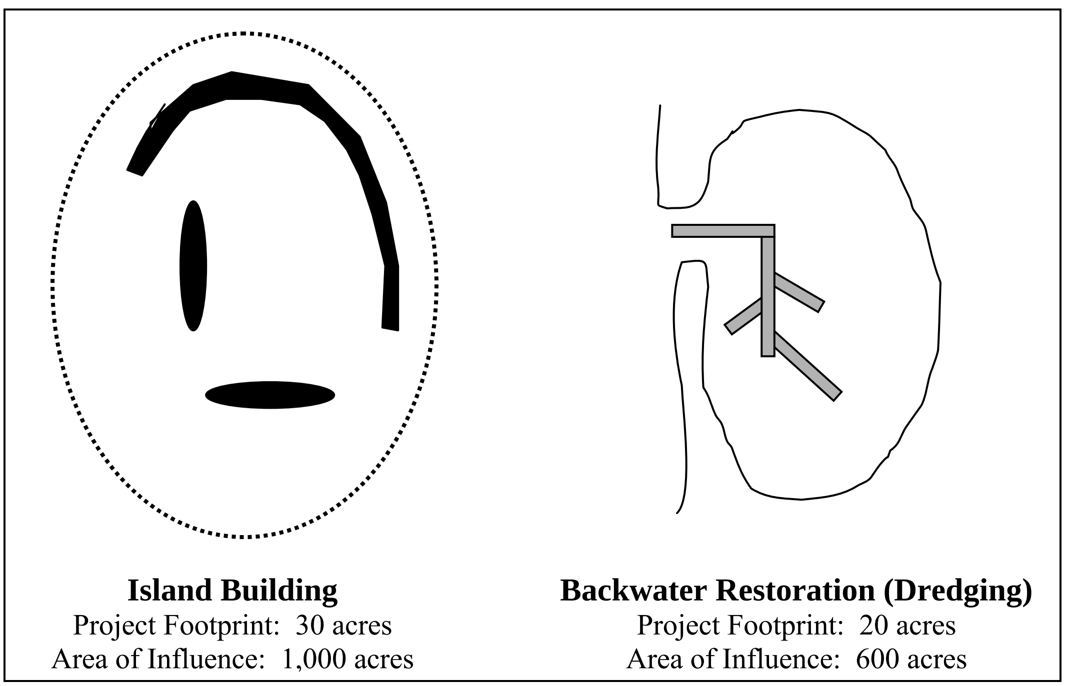


Figure 6-7. UMRS island building and backwater restoration area of influence.

The rationale for estimating the area of influence of each of the major categories of restoration measures will be discussed below.

6.2.5.1.1 Island Building

Islands are constructed for two primary reasons: (1) to create topographic diversity to break up large, open water areas with long wind fetch that generate waves and degrade water quality, or (2) to dispose of material generated to create deepwater habitat. Generally, multiple environmental needs are considered in their design, such that islands built to block wind fetch will acquire material from areas that also need deepwater habitat and vise versa.

Several completed restoration projects and advanced planning documents were referenced to determine the areas affected by islands. The first islands were poorly placed in that they affected only small "wind shadow" areas. Later project island designs created large barriers that encompassed much larger areas to create backwater-like habitats, with interior islands to add diversity and structure. The area of influence of the latter projects was much greater than the former. On the basis of the design and wind fetch modeling results of five projects, the area of influence of islands was estimated to be approximately 1:33 so that the standard 30-acre project used for plan formulation would affect about 1,000 acres.

6.2.5.1.2 Fish Passage

Prior to the implementation of the 9-Foot Channel Navigation Project, fish had relatively unimpeded access to the entire basin stream network. Natural barriers such as rapids and falls were the primary determinant of the distribution of fish stocks. Stronger swimmers, naturally, had greater home ranges and migration patterns. The first groups of fish typically considered in this context are the long distance migrants, but resident species also make seasonal movements from 5 to 30 miles. Barriers to these movements could prevent access to critical seasonal habitats.

The area of influence of fish passage measures incorporated the length and size of specific stream orders made accessible in a metric called the Longitudinal Connectivity Index (LCI). The LCI was created primarily as a planning tool to compare the relative value of providing fish passage at the barriers imposed by UMR-IWW navigation dams.

For a navigation dam fish passage structure, the LCI was estimated by tallying the size and length of moderate size tributaries (i.e., larger than third order) and the main stem portion of the river connected to the navigation dam's pool. Only the length of tributary streams accessible to main stem fish was used (i.e., stream lengths below tributary dams). Accessible stream lengths were multiplied by their stream order to weight their relative contribution. For example, a fifth order stream with a length of 120 kilometers would equate to an LCI value of 600 (i.e., 5 x 120 = 600). These values were tallied and added to the main stem LCI (e.g., main stem pool length of 55 kilometers x stream order of 9 = 495) to approximate the potential LCI made available by a fish passage structure.

The footprint of these measures is relatively small, but they may make literally thousands of miles of stream available. Thus, in one sense, the area of influence is the structure that fish swim through to traverse the barrier, while in another, it is the range of habitats made available. Two evaluation techniques can be used to help refine this effort: 1. fish tracking through built structures, and 2. fish tracking through the basin. Ultimately, stock improvements may be detected if more favorable habitat conditions are made accessible.

6.2.5.1.3 Floodplain Restoration

The area of influence of floodplain restoration is estimated at 1:1, meaning that 1 acre of habitat is restored for each acre in the project area. There may be measures constructed to influence the entire project area that actually have a very small footprint. A ring levee with a water control structure, for example, will have a small footprint, but the entire area it surrounds is the floodplain restoration bounds. The species that are influenced are numerous with many resident species that will be directly benefited. Many species may also travel long distances to use floodplain habitats for a short time during critical life stages. The direct area of influence is relatively easy to measure in this case, but the indirect benefits are difficult to measure.

6.2.5.1.4 Water Level Management

Water level management is conducted on at least two scales, pool scale using dam operations and backwater scale using pumps and levees. The direct area of influence can be relatively easily estimated as the area either inundated or exposed by dam operations or by the extent of a backwater project area. The former is estimated using elevation mapping and hydrologic models. The latter is estimated by project design features and pumping capability. The water level management work group evaluated the areal extent of drawdowns system-wide at various degrees (i.e., 1- to 4-foot drawdown). The areal extent of 2-foot drawdowns (which are incorporated in the Ecosystem Alternatives) was averaged to establish a 2,350-acre area of influence per pool. Several existing or planned projects were reviewed to estimate the influence of backwater projects. Even within the category of backwater projects, there are large-scale ones using permanent management levees and fixed pumps affecting thousands of acres compared to small backwaters isolated with temporary berms and drawn down with portable pumps affecting less than 100 acres.

6.2.5.1.5 Backwater Restoration (Dredging)

Backwater dredging is conducted primarily to improve water quality conditions for backwater fish. The activity typically includes dredging channels and holes in distinct backwater areas that have experienced high rates of sedimentation over time. It is known that fish make seasonal movements to these habitats, so that they may be attracted from many miles during certain critical time periods. The area of influence for this measure, however, was restricted to the area of the backwater lake in which dredging was conducted. Based on a range of experience with other projects, it was estimated that the average project would dredge 20 acres in a 600-acre lake for a 1:30 footprint to influence ratio.

6.2.5.1.6 Side Channel Restoration

Side channel restoration is meant to maintain flowing water channels adjacent to the main channel. The measures to accomplish this primarily include dredging and flow deflection structures at the upstream end of a side channel. There are usually structures constructed to increase flow and improve bathymetric and structural diversity within the channel. Because actions may be implemented throughout a side channel area, a 1:1 project area footprint to area of influence, similar to floodplain restoration, was used even though the actual constructed feature or dredge cut may be smaller. Also similar to other measures, fish may be attracted from many miles during certain times of the year, so the influence may extend to an entire fish population.

6.2.5.1.7 Wing Dam/Dike Alteration

The typical wing dam/dike alteration was estimated to include five structures that may affect 10 acres. This is a very rough estimate of the area that may be incorporated within a dike field. This represents the area where scour holes, sandbars, and flow refugia may be created. Although this is a relatively small area, the habitat may benefit species that travel extensively. While fish movements in upstream reaches may extend from 1 to 10 miles, the channel oriented fish species common in dike fields may move much greater distances.

6.2.5.1.8 Island and Shoreline Protection
Bankline protection measures are used to protect existing resources in the floodplain and on islands. The footprint of island and shoreline protection measures is the same, but the area of influence between them differs. This is because island protection was projected to the entire area of an island, whereas the shoreline was projected to protect only a few acres in the vicinity of the placed material. There is an obvious area of influence on the affected patches of land, but how this is translated to animals that use these resources is more uncertain. Again, local species will benefit most directly, but migratory or transient species may also benefit.

6.2.5.1.9 Topographic Diversity
Topographic diversity is similar to dike alteration in that the measure is very localized in a relatively small area, but may have wider benefits. The measure is important to recreate species diversity that has been degraded by hydrologic changes to the system. Thus, improvements in desirable tree species abundance may translate to resident and migratory birds. However, the relation between this site-specific measure and wider ranging species is tenuous, so a more conservative area of influence was used.

6.2.5.1.10 Dam Point Control
Dam point control refers to the location in a navigation pool where target water levels are maintained to achieve channel depth objectives. In some pools, this is at a mid-pool control point that results in lower pool drawdowns that expose or displace aquatic resources. The objective of this measure is to provide the capability to use either dam point or mid-pool control to benefit natural resource management priorities. The switch to dam point control requires land acquisition because some areas not previously affected by the project would be flooded under the new operating procedures. This area is readily modeled and the lands identified, so the footprint and direct area of influence of the project are easy to estimate. The indirect area of influence is much more difficult because fish may come from great distances to exploit flooded terrestrial areas, or energy transported from the floodplain to the river may be processed many miles away. The change in flood regimes can also directly and indirectly affect floodplain plant communities.

6.2.5.2 Navigation Study Environmental Work Groups
During the process of identifying and allocating measures among alternative plans, two environmental work group reports (i.e., Fish Passage and Water Level Management) were used to assist in prioritizing, sequencing, and potentially screening the occurrence of measures. The performance and efficiency of fish passage and pool-scale drawdowns occurring at various UMRS locations were evaluated. The water level management work group evaluated several parameters when assessing drawdown benefits and costs associated with UMR-IWW navigation pools. Benefit assessment included identifying the potential for varying drawdown depths to succeed, the area exposed (i.e., area of influence), and the impacts to infrastructure (e.g., water intakes). Costs were primarily related to supplemental dredging required to maintain navigation and connectivity to river facilities. Fish passage structures and locations (i.e., projects) were assessed by comparing habitat connectivity, need, and cost. Habitat connectivity was calculated for each pool by determining the length of tributaries to the first obstruction and the total water surface acres of the pool. The need for fish passage was quantified by comparing the frequency that the dam is in "open river" condition. Habitat connectivity and need were then compared to the cost of constructing and maintaining fish passage structures at each dam location. The results of the work group assessment were used to screen less efficient fish passage projects out of Alternative D. Less effective water level management projects were also screened out of Alternatives B through D.

6.2.5.3 Cultural Resources Management/Mitigation
The ecosystem management and restoration measures have a potential to affect significant historic properties including archeological resources, historic structures, and shipwrecks. Major efforts under this study have compiled and consolidated information on the location and potential for historic properties

(see list of reports earlier in this report). Actions are proposed to assess effects and integrate historic property management with ecosystem restoration. The actions will allow for the further identification and protection of significant historic properties being lost due to the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.

6.2.5.3.1 Impacts to Cultural Resources from Ecosystem Restoration Measures

There are over 7,000 recorded archeological sites within the ecosystem restoration study area. Analysis of archeological site locations, previously surveyed areas, and LSA data suggests that the potential for more undocumented archeological sites is high. Potential restoration measures are identified in Table 6-17 with observations regarding the potential to impact historic properties recorded.

Table 6-17. Ecosystem Restoration Measures Identified by Potential to Impact Historic Properties.

Cultural Resource Categories	Island Building	Fish Passage	Floodplain Restoration	WLM - Pool Scale	WLM - Backwater	Backwater Restoration	Side Channel Restoration	Wing Dam/Dike Alteration	Island Protection	Shoreline Protection	Topographic Diversity	Dam Point Control
Archeological	X	X	X	X	X	X	X	X	X	X	X	X
Shipwreck/Submerged	X		X	X	X	X	X	X	X	X		X
Structural/Engineering		X	X	X				X		X		

Evaluation of the ecosystem restoration measures included consideration of a wide range of direct and indirect effects. Archeological sites will most likely be directly affected by ground disturbance associated with excavation, dredging and disposal activities, plantings, and construction projects with associated machinery staging and access areas. Archeological sites may be indirectly affected by vandalism, looting, and/or erosion as a result of exposure due to changes in water level management practices. Shipwrecks may be impacted by any in-stream restoration or construction measure as well as ground disturbances associated with shoreline measures or floodplain measures within historic meander scars. Fish passage measures will directly affect certain lock and dams that contribute to the Upper Mississippi River Navigation Project, 1931-1948 and the Illinois Waterway Navigation Facilities historic districts. In addition, water level management, wing dam alteration, and shoreline protection measures have the potential to impact NRHP eligible channel construction structures (such as wind dams and shoreline protection) within UMR Navigation Pools 1-10.

6.2.5.3.2 Impacts to Cultural Resources from Operation and Maintenance of the UMR-IWW Navigation System

Historic Properties Management Plans (HPMP) developed by the Corps for the UMR and IWW provide a comprehensive program directing the management and protection of cultural resources at Corps operational projects. HPMP databases include fields recording site location, ownership, cultural affiliation, site type, National Register of Historic Places (NRHP) eligibility, and observed and potential impacts resulting from the operation and maintenance of the project. Information presented herein is based on HPMP queries of observed and potential impacts in order to assess the cumulative impact of the operation and maintenance of the projects to known archeological sites. A list of critical archeological historic properties identified by NRHP status, ongoing impact, and potential treatments is presented at the conclusion of this section.

The HPMPs have identified a suite of ongoing and potential impacts to each historic property as a result of the operations and maintenance of the projects. Summary tables identifying numbers of archeological sites by observed and potential impacts on the UMR and IWW are presented in Appendix ENV-C. Impacts include, but are not limited to, ground disturbance (e.g. erosion, excavation, and construction), compaction (e.g. from dredge disposal and riprap placement or levee construction) or removal from the research pool (e.g. permanent inundation, destruction, or illegal collection). These impacts are not mutually exclusive and can result from any combination of the following actions: commercial craft navigation, recreational craft navigation, commercial development, recreational development, federal maintenance, vandalism, natural resource management and other actions such as agricultural, industrial, municipal, and residential development activities. On average, historic properties have incurred impacts from three different types of actions and some sites have had impacts from as many as seven distinct sources.

6.2.5.3.2.1 Observed Impacts

Observed impacts to these UMR sites include wave action from commercial craft (n=126 sites), and recreational craft (n=215 sites), prop wash from commercial craft (n=1 site) and queuing from commercial craft (n=1 site). In addition, 291 sites have been impacted by federal maintenance of the UMR project including pool management (n=145 sites), dredge material placement (n=7 sites), permanent inundation (n=103 sites), federal navigation facilities (n=5 sites), and levee construction (n=31 sites). Commercial development has been observed to impact seven sites including fleeting facilities (n=6 sites) and loading facilities (n=1 site) while recreational development on the UMR has impacted 160 sites through the construction of federal campgrounds (n=42 sites), trail development (n=75 sites), and private campground development (n=43 sites). Other impacts include backwater pool management for natural resource projects (n=47 sites), other natural resource management activities (n=4 sites), forest management activities (n=2 sites), residential development (n=230 sites), municipal development (n=122 sites), agriculture (n=998 sites) and industrial development (n=79 sites). Vandalism has been observed at 669 sites including excavation (n=210 sites) and surface collection (n=459 sites).

Observed impacts to IWW sites include erosion from waves generated by commercial craft (n=258 sites) and recreational craft (n=267 sites). A total of 179 sites are located on natural resource managed lands. Recreational development on the IWW has impacted 45 sites through the construction of trails (n=8 sites) and parks/recreation areas (n=37 sites). Other impacts include forest management activities (n=33 sites), commercial (non-navigation) development (n=29 sites) residential development (n=23 sites), agriculture (n=318 sites) and borrow/quarry operations (n=21 sites). Vandalism has been observed at 6 sites.

6.2.5.3.2.2 Potential Impacts

Potential impacts to UMR sites include wave action from commercial craft (n=172 sites), and recreational craft (n=395 sites), prop wash from commercial craft (n=51 sites) and queuing from commercial craft (n=3 sites). In addition, potential impacts are identified for 300 sites as a result of federal maintenance of the UMR project including pool management (n=157 sites), dredge material placement (n=14 sites), permanent inundation (n=83 sites), federal navigation facilities (n=33 sites), and levee construction (n=13 sites). Commercial development may impact 53 sites including fleeting facilities (n=4 sites), loading facilities (n=28 sites), and non-navigation activities (n=21 sites, while recreational development on the UMR may potentially impact 245 sites through federal construction (n=47 sites), other construction (n=16 sites), and recreational use (n=182 sites). Other impacts include backwater pool management for natural resource projects (n=148 sites), other natural resource management activities (n=14 sites), forest management activities (n=28 sites), residential development (n=358 sites), municipal development (n=146 sites), agriculture (n=804 sites) and industrial development (n=78 sites). The potential for vandalism is documented at 2347 sites including excavation by collectors (n=1447 sites), surface collection (n=895 sites), and vandalism of shipwrecks (n=5 sites).

Observations were not made in the IWW HPMP regarding potential impacts to archeological sites. Inferences regarding potential impacts, however, can be drawn from the detailed observations made in the HPMP about existing land use and archeological site prioritization based on NRHP eligibility and location. It should be noted that the vast majority of the IWW archeological sites are documented in multiple land use zones and, as a consequence, are subject to multiple sources of potential impacts. There are a total of 323 archeological sites with all or part of their site areas presently being farmed. Of that number, 29 sites are listed or eligible for listing on the NRHP and 19 of those sites are located on the shoreline and are thus subject to both erosion and agricultural impacts. There are an additional 76 archeological sites that are under cultivation and have yet to have their NRHP eligibility determined.

There are 85 archeological sites located in an urban context and are potentially subject to private and commercial development impacts. Of that number, 16 have been determined eligible for listing to the NRHP and 11 of these sites are located in shoreline settings. As a result, in addition to potential development impacts, urban sites are potentially subject to shoreline erosion and vandalism.

There are 279 sites located all, or partially within, forested areas. A total of 31 sites within this category have been listed or determined eligible for listing to the NRHP and, of that number, 24 are located on the shoreline. An additional 140 sites in the forested category have yet to have their NRHP eligibility determined. Potential impacts to these sites include shoreline erosion and natural resource management actions or commercial resource management actions involving forest management.

There are 360 archeological sites located within or partially within wetland environments. Of that number 24 sites are listed or eligible for listing on the NRHP and 19 of these sites are on the shoreline. An additional 192 sites in wetland environments have yet to have their NRHP eligibility determined. Potential impacts to sites in the wetland category include shoreline erosion and natural resource management actions oriented toward wetland enhancement.

6.2.5.3.3 Stewardship of Critical Historic Properties

Tables 6-17 and 6-18 present summary information on the ongoing impact of the operation and maintenance of the UMR and IWW projects on 78 archeological sites. Detailed information on these sites is presented in Appendix ENV-C. The list is based on cultural resource management priorities established in the District HPMPs and by professional judgment of consulting firms and District archeologists. All 78 sites are located on public lands and are either listed, eligible for listing, or considered very likely to be eligible for listing on the NRHP. The identified threats are based on a combination of firsthand field observations and GIS analyses of HPMP data, land use data, and erosion models. The UMR sites in the MVR district have all been mapped with permanent datums established and monitoring initiated. These steps have been taken in order to determine whether they are eroding and, if so, at what rate.

Table 6-18. Stewardship Priorities of Critical Archeological Historic Properties Identified by District and Proposed Treatment.

Treatment	District			Total
	MVP	MVR	MVS	
Assess/protect	3	4		**7**
Eval/protect	16			**16**
Mitigation/Protection		16	5	**21**
Monitor		13		**13**
Monitor, Protect		1		**1**
Preserve		6		**6**
Protect	1			**1**
Test		13		**13**
Grand Total	20	53	5	**78**

A comparable approach needs to be initiated at all of the 78 sites where erosion has been identified as a threat. Additional threats have been identified and include development, agriculture, timber management, recreation, and cottage leasing (Table 6-19). In addition, exposure of the sites to increased public access as a result of these practices increases the likelihood of looting and vandalism. This is a serious management concern, especially at those sites where human remains, sacred objects, and traditional cultural properties may be present. The treatments identified in Table 6-18 focus on evaluation, monitoring, and mitigation including preservation, protection, and/or data recovery. It is anticipated that monitoring will identify the need to mitigate approximately 10 percent of these sites.

Table 6-19. Summary Totals of Threats to Critical Archeological Historic Properties Identified by District.

Threat	District			Total
	MVP	MVR	MVS	
Agriculture		2		2
Cottage Lease		1		1
Development, Looting		2		2
Erosion	4	27		31
Erosion, Looting	16	2	3	21
Looting			1	1
Managed Forest		1		1
No data		5		5
None		3		3
None (Already Protected)		2		2
None (Refuge Management)		1		1
Rec Area, Looting		6		5
Vandalism		1	1	2
Totals	**20**	**53**	**5**	**78**

6.2.5.4 Additional Ecosystem Alternative Components

Additional ecosystem alternative components include a systemic fleeting plan, forestry management, and the formulation of an adaptive management program. The systemic fleeting plan will examine existing fleeting areas and fleeting capacity and identify potential conflicts with resources of concern. The forestry management component will include an updated systemic forest inventory, procurement of high resolution floodplain elevation data, and applied research to enhance best management practices. The ecosystem alternatives will be implemented using a rigorous adaptive management process.

6.2.5.5 Adaptive Management

Making decisions to address and resolve the complex assortment of ecological needs and objectives within the UMRS should be conducted in the context of a long-term commitment to a policy of adaptive management. Adaptive management is a process that seeks to aggressively use management intervention as a tool to strategically probe the functioning of an ecosystem. Management measures are designed to test key hypotheses about the structure and functioning of the ecosystem. This approach is very different from a typical management approach of "informed trial-and-error" which uses the best available knowledge to generate a risk-averse, "best guess" management strategy, which is then changed as new information modifies the "best guess". Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management actions as tools to not only change the system, but as tools to learn about the system.

There are several elements both scientific and social that are vital components of adaptive management:
1. Management is linked to appropriate temporal and spatial scales
2. Management retains a focus on statistical power and controls
3. Use of computer models to achieve ecological consensus
4. Use embodied ecological consensus to evaluate strategic alternatives
5. Communicate alternatives to stakeholders for negotiation of a selection

Specific elements incorporated into the UMRS adaptive management program would include:
1. Organization
   - River Management Council
   - Science Panel
   - River Management Teams
2. Systemic Studies
   - Ecosystem Modeling (numerical and conceptual)
   - Information Needs Assessment
   - Biological data collection (example Fish Stock Assessment)
   - Physical data collection (bathymetry)
   - Etc.
3. Restoration Measure Evaluation
   - Island Building
   - Fish Passage
   - Side Channel Restoration
   - Etc.

The success of an adaptive management approach will require an open management process that seeks to include partners and stakeholders during the planning and implementation stages. Consequently, adaptive management must be a social as well as scientific process. It must focus on the development of new institutions and institutional strategies just as much as it must focus upon scientific hypotheses and experimental frameworks. Adaptive management attempts to use a scientific approach, accompanied by collegial hypotheses testing to build understanding, but this process also aims to enhance institutional flexibility and encourage the formation of the new institutions that are required to use this understanding on a day-to-day basis.

One of the main benefits of adaptive management is the development of an iterative and flexible approach to management and decision-making. This iterative approach emphasizes the fact that management actions can be viewed as experimental manipulations of the system of interest. The results of the manipulations can be monitored and future management decisions can be informed by the outcomes of previous decisions. Another important benefit of adaptive management lies in the opportunity for scientists and managers to collaborate in the design of novel and imaginative solutions to the challenges of managing complex and incompletely understood ecological systems. Alternative management actions can be stated as hypotheses and addressed from the perspectives of rigorous experimental design and decision analysis. The probable (possible) outcomes of management alternatives and the values of such outcomes can be estimated in relation to management goals and objectives. The adaptive approach recognizes that uncertainty is unavoidable in managing large-scale ecological systems. Importantly, uncertainty can be analyzed and exploited to identify key gaps in information and understanding. The results of such analyses of uncertainty can be used to efficiently allocate limited management resources to new research or monitoring programs.

6.2.6 Ecosystem Alternative Plan Costs and Cost Sharing

6.2.6.1 Alternative Plan Cost Estimates

Estimates of alternative costs were developed by first identifying the average per project cost of UMRS ecosystem measures (Table 6-15) (e.g., Island Building – 30-Acre Project – Construction: $3.5 Million). These costs were multiplied by the number of projects within a given alternative to determine the total ecosystem measure construction costs (Table 6-20).

Table 6-20. Ecosystem alternative cost estimates (over 50 years in 2003 dollars).

UMR-IWW Ecosystem Measure Construction Costs	**Cost ($1,000,000's)**				
Ecosystem Measure	**Alternative A**	**Alternative B**	**Alternative C**	**Alternative D**	**Alternative E**
Island Building	$0.0	$107.2	$235.2	$314.8	$401.2
Fish Passage	$0.0	$0.0	$0.0	$329.0	$775.5
Floodplain Restoration	$0.0	$2.0	$77.0	$496.0	$1,208.0
Water Level Management - Pool	$0.0	$54.0	$54.0	$54.0	$117.1
Water Level Management - Backwater	$0.0	$0.0	$3.4	$23.8	$30.6
Backwater Restoration (Dredging)	$0.0	$167.5	$321.0	$483.8	$628.0
Side Channel Restoration	$0.0	$84.1	$155.2	$213.2	$250.9
Wing Dam/Dike Alteration	$0.0	$14.1	$40.0	$50.2	$53.4
Island Protection	$0.0	$83.0	$83.0	$83.0	$83.0
Shoreline Protection	$0.0	$124.2	$124.2	$124.2	$124.2
Topographic Diversity	$0.0	$24.6	$24.6	$24.6	$24.6
Dam Point Control	$0.0	$0.0	$23.2	$23.2	$32.2
Total Construction Costs (with real estate)	$0.0	$660.8	$1,140.8	$2,219.8	$3,728.7
Contingency					
Contingency (35% construction costs)	$0.0	$231.3	$383.5	$677.2	$1,058.3
Adaptive Management Costs					
Adaptive Management	$0.0	$223.0	$369.8	$653.0	$1,020.5
Additional Costs					
Forestry Management	$0.0	$75.0	$87.5	$100.0	$125.0
Systemic Fleeting Plan	$0.0	$0.3	$0.3	$0.3	$0.3
Cultural Res. Management/Mitigation	$0.0	$26.8	$44.4	$78.4	$122.5
Planning, Engineering, Design, and Management Costs					
Planning, Eng., Design, and Admin (30%)	$0.0	$365.1	$607.9	$1,118.6	$1,816.6
Supervision and Administration (9%)	$0.0	$109.5	$182.4	$335.6	$545.0
UMR-IWW Ecosystem Alternative Costs	**$0.0**	**$1,691.7**	**$2,816.6**	**$5,182.8**	**$8,416.7**

A 35 percent contingency cost was then applied to the total construction cost, and additional costs were added for forestry management, a systemic fleeting plan, cultural resource management/mitigation, and adaptive management. Finally, a 30 percent planning, engineering, and design cost and a 9 percent supervision and administration cost were applied to the total above, and final ecosystem alternative costs were developed. The costs of the alternative components are based on the best information available (e.g., existing UMRS material, labor, and project costs). Additional information on development of the alternative plan cost estimates is provided in the Ecosystem Sustainability Appendix.

6.2.6.2 Cost Sharing

The cost of implementing the Ecosystem Restoration Alternatives will be shared between the Federal Government, States, and non-governmental organizations. The alternatives will include a combination of 100 percent Federal and cost shared measures. Several potential cost sharing options were developed and reviewed in an effort to fairly distribute the financial responsibility of the alternatives between the partner agencies and organizations (January 2004, Memorandum for Record: UMR-IWW System, Ecosystem Restoration – Discussion of Authorities and Cost Sharing Options). The following discussion explores USACE authority and cost sharing options, evaluates the options, and makes initial recommendations.

6.2.6.2.1 Background

As documented in Chapters 4 and 5 of the Feasibility Report, the environmental impacts of the human activities have resulted and continue to result in a decline in the environmental quality of the UMRS. The resource impacts include backwater and secondary channel sedimentation, altered hydrology, loss of connectivity of the floodplain to the river, impeded fish migration, loss of island habitat, endangered plant and animal species, and loss of native plant community diversity and abundance. Although large increments of ecosystem decline can be attributed to the construction and operation of the navigation system, there are many ecological stressors contributing to ecosystem degradation including land use changes, floodplain development, exotic species, sedimentation resulting from land use practices, construction of the levee system, and non-point source pollution. The Army Corps of Engineers currently has several mechanisms for addressing ecosystem issues:

a. Operations and Maintenance Activities. The UMR-IWW has a single authorized purpose of inland navigation. Therefore, funds appropriated for operation and maintenance of the system are limited to supporting the navigation purpose. This operation and maintenance responsibility must comply with environmental laws and policies regulating all Federal activities and responsible environmental stewardship of the system's land and water resources. This allows the Corps to avoid and minimize environmental impacts from operation and maintenance activities.

b. Environmental Management Program (EMP). The UMRS-EMP, authorized by the Water Resources Development Act (WRDA) of 1986 and amended in WRDA 1990 and WRDA 1999, is a systemic program to provide monitoring, research, and habitat restoration activities. Program accomplishments to date include: (1) the completion of 39 habitat restoration projects resulting in the direct physical restoration of approximately 60,000 acres of riverine and floodplain habitats; 21 more projects in various stages of design will add another 29,000 acres of restored habitat when implemented; (2) the collection of millions of data samples (primarily fish, water quality, vegetation, and invertebrates) critical to carrying out the trend analysis and applied research that is leading to enhanced understanding of the dynamics of large floodplain rivers and successful multi-purpose resource management; (3) the development of extensive digital databases and mapping products and the establishment of an information clearinghouse through which UMR System data and information can be universally accessed; and (4) a partnership between a multitude of Federal and State agencies, non-governmental organizations, and the general public. The authorizing legislation provides that EMP habitat projects are to be cost shared in accordance with Section 906(e) of WRDA 1986. Section 906(e) provides guidance on cost sharing for fish and wildlife enhancement projects forwarded to Congress for authorization. Under Section 906(e), projects on Federal refuge land and projects that benefit federally listed threatened or endangered species, species of national economic importance, species subject to international treaties, and anadromous fish are 100 percent Federal cost. As a matter of Administration policy under the EMP, only the habitat projects on National Refuge lands are 100 percent Federal for construction with operation and maintenance by the U.S. Fish and Wildlife Service or managing State agency. Other habitat projects are cost shared on a 65 percent Federal and 35 percent non-Federal basis. EMP is authorized at $33 million, but has only averaged $16 million over the last 10 years.

c. Section 1135 of WRDA 1986, As Amended. This legislation provides authority to review and modify the structures and operations of water resources projects completed by the Corps for the purpose of improving the quality of the environment when it is determined that such measures are feasible, consistent with the authorized project purposes, and will improve the quality of the environment in the public interest. The cost sharing for Section 1135 projects is 75 percent Federal and 25 percent non-Federal, and projects have a $5 million Federal funding limit and a $25 million per year annual nation-wide program limit.

d. Section 206 of WRDA 1996, As Amended. This legislation provides authority for the development of aquatic ecosystem restoration and protection projects that improve the quality of the environment in the public interest and are cost effective. The cost sharing for Section 206 is 65 percent Federal and 35 percent non-Federal, and projects have a $5 million Federal funding limit and a $25 million per year annual nation-wide program limit.

e. Section 204 of WRDA 1992, As Amended. This legislation authorizes the Corps to carry out projects for the protection, restoration, and creation of aquatic and ecologically related habitat in conjunction with dredging of authorized navigation projects. The incremental costs of the beneficial use of the dredged material for habitat creation are shared 75 percent Federal and 25 percent non-Federal. There is no per project limit on Federal cost, but the annual nation-wide program limit is $15 million.

Despite the significant accomplishments using these authorities, the ecosystem of the UMRS continues to decline, in part, as a result of the construction and operation of the Federal navigation project. Therefore, the Corps is undertaking a restructured feasibility study to address the navigation efficiency needs of the UMRS, the ongoing cumulative effects of navigation, and the ecosystem restoration needs with a goal of attaining an environmentally sustainable system. The current level of authority and authorized appropriations in the Environmental Management Program and national programmatic authorities and the limited environmental management activities available under a single-purpose navigation project have been insufficient for environmental needs on the Upper Mississippi River Navigation System. Therefore, the Feasibility Report recommends seeking an integrated dual-purpose project authorization that places the UMRS ecosystem needs on an equal footing with ongoing operation and maintenance of the UMR-IWW Navigation System.

6.2.6.2.2 Basic Cost Sharing Options for Ecosystem Restoration

There are three cost sharing options that may apply to measures within the Corps' area of responsibility that address the identified goals and objectives for restoration of the ecological integrity of the system. Impacts to be addressed could include loss of connectivity, loss of seasonal variation, and loss of connectivity to backwaters. Potential measures include fish passage, pool level fluctuations, environmental dredging, restoration of connectivity to backwaters, modification of training structures, and opening of side channels. Additional land acquisition could be included.

COST SHARING OPTION I: Share as Environmental Protection and Restoration Under Section 103(c) of WRDA 1986, As Amended. These measures would be identified as environmental protection and restoration cost and shared 65 percent Federal and 35 percent non-Federal. This is consistent with existing Corps policy to address any possible impacts of existing Corps projects as restoration. As such, it is consistent with the Comprehensive Everglades Restoration Plan (CERP) which includes many modifications to existing projects, although an important distinction may be that the Central and South Florida Project that is being modified historically had a project sponsor that had operational responsibility for portions of the project. Also, the special 50/50 cost sharing for the CERP is influenced by the fact that the plan has water supply as well as ecosystem restoration outputs. This approach would also be consistent with the cost sharing authorized for the Ohio River Ecosystem Restoration**.**

COST SHARING OPTION II: 100 Percent Federal as Addressing Ongoing Impacts of a Federally Constructed and Operated and Maintained Project. This "full Federal cost" approach would cost share in accordance with the cost sharing applicable to the existing project which is 100 percent federally funded. The Columbia River Fish Mitigation is an example of a 100 percent federally funded program to address fish passage impacts. In the Columbia River case, the appropriations are reimbursed from hydropower revenues, and fish passage was authorized in the original project authorizations although downstream passage facilities were not constructed. The Columbia River fishery program is also heavily influenced by endangered species considerations. The Missouri River Mitigation is another precedent for 100 percent Federal funding. One hundred percent Federal funding may be justified because the system has been recognized in statute by Congress as a nationally significant ecosystem and commercial navigation system. Other factors favoring Federal funding are the significant Federal investment in the basin in the 285,000 acres of Federal refuges and the presence of federally recognized, regulated, and protected resources including migratory birds and endangered species.

COST SHARING OPTION III: Cost Sharing as Enhancement of Fish and Wildlife Resources Under the General Guidelines of Section 906(e) of WRDA 1986. Although seldom used, this authority allows the Secretary of the Army, as part of a report to Congress, to recommend, at 100 percent Federal cost, activities to enhance fish and wildlife resources, when (1) such enhancement provides benefits that are determined to be national, including benefits to species that are identified by the National Marine Fisheries as of national economic importance, species that are subject to treaties or international conventions to which the United States is a party, and anadromous fish; (2) such enhancement is designed to benefit species that the Secretary of the Interior has listed as threatened or endangered under the Endangered Species Act, as amended; or (3) such activities are located on lands managed as a national wildlife refuge. The restoration measures that meet these criteria would be 100 Federal, and other restoration would be cost shared. Section 906(e) cost sharing was applied to the Environmental Management Program except that the 100 percent Federal funding has been limited to measures on land managed as a Federal refuge. The Section 906(e) application has also been modified for the EMP to provide for operation and maintenance of completed projects by the agency managing the land on which the project is located and 65 percent Federal and 35 percent non-Federal cost sharing for cost shared projects.

6.2.6.2.3 Criteria for Determining Cost Sharing

There are four options for determining those measures to be cost shared versus those measures to be funded at 100 percent Federal cost as presented below.

CRITERIA OPTION A: Measures attributable to addressing the ongoing and cumulative existing project impacts. This option is based on the premise that measures to address the ongoing and cumulative impacts of the navigation project should be 100 percent federally funded and that these measures should be identified through a quantification process. This approach would involve: (1) quantifying the impacts to the ecosystem based on a baseline (pre-project or immediate post-impoundment) but including the impact of pre-impoundment flow control measures (wing dikes); (2) determining what portion of these impacts is attributable to the project; and (3) formulating the most cost effective measures to address these impacts to be funded at 100 percent Federal cost. The Study Team concluded that the kind of analysis needed to implement this option would significantly add to the scope and time required for the feasibility study and would likely be inconclusive. Measures to meet the environmental goals and objectives that are not attributable to addressing the impacts of the navigation project would be cost shared 65 percent Federal and 35 percent non-Federal. While, as part of the feasibility study, the Corps and its partner agencies are identifying ecosystem restoration goals and objectives to achieve ecosystem integrity by assessing the stressors and impacts on the existing system and cumulative impacts, this assessment does not involve the degree of quantification and detailed accounting of cause and effect relationships that would be needed to implement this option.

CRITERIA OPTION B: Measures involving the modification of the structures and operations of the existing projects and measures on projects and lands included in the National Refuge System would be 100 percent Federal, and measures on other public lands or requiring land acquisition would be cost shared. This option is also based on the premise that measures to address the ongoing and cumulative impacts of the navigation project should be 100 percent federally funded and that these impacts are largely within the project limits including Refuge lands. Measures to meet ecosystem restoration goals and objectives that involve the modification of structures and operations of the project including such measures as fish passage, flow control structure notching, and pool fluctuations not requiring additional land acquisition would be 100 percent Federal. Also, measures that would be located on project lands or lands included in Federal Refuges would be 100 percent Federal. Operation and maintenance responsibility for the measure would be retained by the agency operating and maintaining the structure or managing the land or potentially could be provided by a non-Federal partner under a leasing arrangement. Measures to meet the established restoration goals and objectives that are outside the limits of the project lands but are related to the project and its adjacent floodplain including floodplain forest restoration, floodplain connectivity restoration, and isolated backwater restoration would be accomplished in a cost shared 65/35 ecosystem restoration program. The four ecosystem restoration alternatives under consideration range in cost from $1.7 billion for Alternative B to $8.4 billion for Alternative E. Under this option, the cost shared portion ranges from about $415 million for Alternative B, representing about 25 percent of the total cost, to about $2.9 billion for Alternative E, representing about 35 percent of the total cost. The increasing share of ecosystem restoration costs for the larger ecosystem restoration plans (Alternatives D and E) reflects the inclusion of large blocks of land acquisition and floodplain restoration in these plans that would be shared on a 65 percent Federal and 35 percent non-Federal basis. The study team proposes that the cost shared restoration program be authorized to provide for sponsorship by private not-for-profit environmental interests, credit for work-in-kind up to the limit of the non-Federal share, and carry-over of excess land value credits between projects.

CRITERIA OPTION C: Measures involving the modification of the structures and operations of the existing projects, measures on projects and lands included in the National Refuge System, and measures in backwater areas connected to the main river channel regardless of current ownership would be 100 percent Federal, and measures on other public lands or requiring land acquisition, other than connected backwater areas, would be cost shared. This option is the same as Option B, except that it adds 100 percent Federal funding for measures in backwater areas and side channels that are directly connected to the main channel, regardless of present ownership, and including the cost of land acquisition. This additional category of 100 percent Federal measures would address the disparity in the amount of Federal land between the reach of the Upper Mississippi River containing locks and dams versus the Illinois River and Middle Mississippi River. The four ecosystem restoration alternatives under consideration range in cost from $1.7 billion for Alternative B to $8.4 billion for Alternative E. Under this option, the cost shared portion ranges from about $210 million for Alternative B, representing about 12 percent of the total cost, to about $2.2 billion for Alternative E, representing about 26 percent of the total costs. The increasing share of ecosystem restoration costs for the larger ecosystem restoration plans (Alternatives D and E) reflects the inclusion of large blocks of land acquisition and floodplain restoration in these plans that would be shared on a 65 percent Federal and 35 percent non-Federal basis. The decrease in non-Federal share over Alternative B is a result of 100 percent Federal funding of backwater and side channel restoration within the navigation servitude in the Middle Mississippi River and Illinois River where Federal fee ownership is limited.

CRITERIA OPTION D: **Measures producing national benefits under the guidelines of Section 906(e) of WRDA 1986 would be 100 percent Federal.** The Section 906(e) guidelines most applicable to the UMRS are measures to benefit species subject to treaties or international conventions to which the United States is a party, measures on lands managed as a Federal refuge, and measures primarily benefiting Federal threatened or endangered species. Operation and maintenance responsibility for measures would be retained by the agency that operates and maintains the structure or manages the land or provided by a non-Federal partner under a lease arrangement. For measures on Corps of Engineers lands, operation and maintenance would be done by the Corps of Engineers or by a non-Federal partner under a lease. Measures not meeting the national benefits criteria would be cost shared as ecosystem restoration. Cost sharing for this option was not calculated, since it was dropped from consideration because it shifts the Federal nexus from the navigation project to species and land management definitions of Federal responsibility. In so doing, this cost sharing option would also likely skew the program toward species-based management rather than the broader and more appropriate objective of ecosystem sustainability.

6.2.6.2.4 Preferred Cost Sharing Arrangement

The preferred cost sharing arrangement is for a combination of 100 percent Federal and cost-shared 65 percent Federal and 35 percent non-Federal funding for implementation of the ecosystem restoration portion of the plan. The regional preference on the cost sharing criteria is Criteria Option C (hereafter referred to as Cost Sharing Option C). This option is endorsed by the five study area States and is also supported by the U.S. Fish and Wildlife Service. Cost Sharing Option C best reflects an appropriate Federal role in addressing the declines in the UMRS ecosystem resulting from the existing 9-foot channel navigation project including impacts on Federal refuges while providing for a significant cost sharing responsibility for the non-Federal partners, particularly where additional land acquisition is required. The 100 percent Federal funding is proposed for those ecosystem restoration measures that primarily address the ongoing impacts of the existing 9-foot navigation project. There are three primary reasons for recommending a large proportion of 100 percent Federal funding. The first is the extensive Federal resources and interests within the waterway including almost 285,000 acres of National Wildlife and Fish Refuges. More than 40 percent of North America's migratory waterfowl and shorebirds depend on the food resources and other life requisites that the system provides. Further, the beneficial effects of ecosystem restoration in the project area extend system-wide, benefiting the five lower Mississippi Valley states, the Gulf of Mexico and tributaries within the Valley. Therefore, the benefits of the ecosystem restoration plan accrue to the nation and not just the state or region. The second factor is the large role that the operation of the existing 9-foot navigation project has played in the environmental degradation addressed by the ecosystem restoration plan. There is a convincing body of research and documentation of the direct and indirect impacts resulting from the creation and ongoing operation and maintenance of the Navigation System. Congress has declared the UMRS to be nationally significant both as a navigation system and as an ecosystem. Therefore it is appropriate that the majority of the costs of sustaining the ecosystem as well as the navigation system be borne by the nation. The third reason is the interstate nature of the navigation system and the fact that it passes through five different states significantly complicating any cost sharing arrangements.

6.2.6.2.5 Application of Preferred Cost Sharing Arrangement

Measures involving modification of the structures and operations of existing projects; measures on Corps project lands and lands included in the National Refuge System; and measures in the main channel or directly connected backwater areas below the Ordinary High Water Mark will be 100 percent Federal regardless of current ownership. Measures on other public or privately owned lands would be cost shared 65/35.

This option was used to identify the following cost sharing grouping of alternative plan measures. The costs of these measures were then totaled to determine the overall portion of the Ecosystem Alternative Plans that are 100 percent Federal and cost shared 65/35.

Using Cost Sharing Option C methodology, ecosystem measures funded 100 percent Federal will include:
- Fish Passage
- Pool-Scale Water Level Management (Drawdown)
- Wing Dam/Dike Alteration
- Dam Point Control
- Island Building
- Side Channel Restoration

The following nonstructural measures will also be included as 100 percent Federal:
- Forestry Management
- Systemic Fleeting Plan
- Cultural Resources Management/Mitigation

Measures consisting of a mixture of 100 percent Federal and 65/35 cost share will include:
- Floodplain Restoration
- Topographic Diversity
- Backwater Water Level Management
- Backwater Restoration (Dredging)
- Island and Shoreline Protection

The adaptive management component of the alternative plans will also be partially cost shared. Specifically, performance evaluation on cost shared projects will be cost shared 65/35 by partnering agencies.

Operation and maintenance costs will be borne by the Corps for measures involving modification of structures or operations of existing Corps projects. These include Fish Passage, Pool-scale Water Level Management, Wing Dam/Dike Alteration, and Dam Point Control. O&M costs for the remaining measures will be borne by the partnering agencies managing the land.

As a component of the measures, real estate costs (e.g., land acquisition or easements) are borne by non-Federal interests that will receive cost sharing credit for their value.

Using this cost sharing methodology, 12 to 26 percent of the ecosystem alternative costs would be cost shared 65/35 percent (Table 6-21) and the remainder would be funded 100 percent Federal. The Corps would fund 2 to 14 percent of the Operation and Maintenance costs, and the remainder would be the responsibility of the partner agency managing the land (Table 6-22). The O&M cost estimates reflect all projects having a full 50-year duration of O&M.

Table 6-21. Ecosystem alternative costs in 2003 dollars ($ millions).

	Alternative A	Alternative B		Alternative C		Alternative D		Alternative E	
100% Federal	$0.0	$1,482.3	88%	$2,480.7	88%	$4,131.6	80%	$6,209.9	74%
Cost Shared (65/35)[a]	$0.0	$209.4	12%	$335.9	12%	$1,051.2	20%	$2,206.9	26%
Total		$1,691.7		$2,816.6		$5,182.8		$8,416.8	

[a]The non-Federal responsibility would be 35 percent of the costs shown in this line.

Table 6-22. Operation and maintenance costs in 2003 dollars ($ millions).

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Corps	$0.0	$1.3 2%	$8.0 6%	$29.9 12%	$60.9 14%
Non-Corps	$0.0	$76.0 98%	$125.6 94%	$227.4 88%	$360.1 86%
Total		$77.3	$133.6	$257.3	$421.0

6.2.7 Ecosystem Alternative Plans

After preliminary evaluation of the ecosystem measures and refinement of the alternative plans, five restoration alternatives were developed to address the identified needs of the UMRS ecosystem. The alternatives consist primarily of the ecosystem measures previously described (see Table 6-12 and Figure 6-8) and a rigorous adaptive management program, forestry management, and systemic fleeting plan.

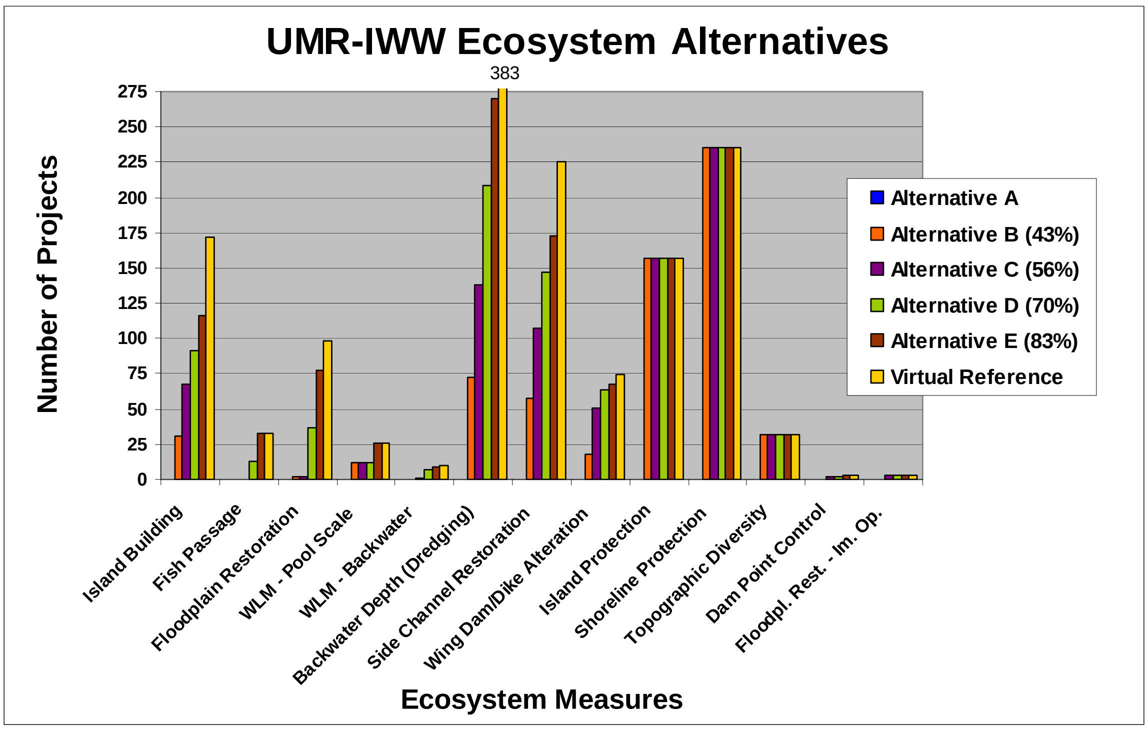


Figure 6-8. Number of ecosystem alternative measures (i.e., projects).

6.2.7.1 Alternative A

No Action/Without Project

- Continue current environmental management activities and rehabilitation efforts at historic levels.

Under this alternative, environmental degradation would continue and the habitat loss projected in the Cumulative Effects Study and the Habitat Needs Assessment would be realized. While the ongoing efforts to protect, maintain, and restore habitat would be beneficial, the current level of effort would not be sufficient to counteract the cumulative impacts affecting river resources. This alternative does not promote a sustainable system.

Primary Components

- Environmental Management Program ($16.5 million/year)
- Continuing Authorities Programs ($4.0 million/year)
- Endangered Species Work ($1.4 million/year)
- Corps Forestry Program and Environmental Stewardship ($1.0 million/year)
- Refuge Management ($9 million/year)
- State Conservation Programs ($2 million/year)
- NGO Initiatives

6.2.7.2 Alternative B
Protect and Maintain Existing Environmental Diversity

- Current mosaic of habitat types and ecological diversity maintained into the future: no net loss.

This alternative (Table 6-23) is structured to address projected habitat degradation, primarily in the form of habitat features seen in planform projection (e.g., islands, channels, backwater lakes, etc.). In the development of the alternative, the approximate areas and amount of habitat projected in the Cumulative Effects Study to be lost over the next 50 years would be either stopped or replaced. This is accomplished by armoring banks to prevent erosion of existing features or by recreating habitat features that will be lost. Habitat quality issues are addressed on large scales by pool-scale water level management and more locally through forest management plans. This alternative attempts to promote a sustainable system by protecting and maintaining the existing UMRS environmental diversity. The entire river management strategy requires an effective Adaptive Management plan for integrated river management.

<u>Primary Components</u>

- Build 31 Island Complexes
- Restore 2 Floodplain Areas
- Conduct Water Level Management in 12 Pools
- Restore 72 Backwater Areas
- Restore 58 Side Channels
- Alter 18 Wing Dam/Dike Structures
- Protect 392 Islands and Shoreline Areas
- Improve Topographic Diversity in 32 Areas
- Forestry Management Program
- Systemic Fleeting Plan
- Adaptive Management Program

Table 6-23. Alternative B – Number of ecosystem projects, costs, and benefits over 50 years.

Ecosystem Measures	Project Footprint	Number of Projects	Project Costs (Millions)		Benefits
			Measure	O&M	Acres of Influence
Island Building	30 Acres	31	$107.2	$7.7	31,000
Fish Passage[a]	1 Site	0	$0.0	$0.0	-
Floodplain Restoration (Pools 1-13)	500 Acres	2	$2.0	$0.8	1,000
Floodplain Restoration (Rest of UMR-IWW)	5,000 Acres	0	$0.0	$0.0	0
Water Level Management - Pool[a]	1 Site	12	$54.0	$0.0	-
Water Level Management - Backwater	1,000 Acres	0	$0.0	$0.0	0
Backwater Restoration (Dredging)	20 Acres	72	$167.5	$0.0	43,200
Side Channel Restoration	100 Acres	58	$84.1	$33.4	5,800
Wing Dam/Dike Alteration	5 Structures	18	$14.1	$1.2	180
Island Protection	3000 Feet	157	$83.0	$13.0	37,680
Shoreline Protection	3000 Feet	235	$124.2	$19.4	705
Topographic Diversity	5 Acres	32	$24.6	$1.9	256
Dam Point Control	1 Site	0	$0.0	$0.0	0
Floodplain Restoration-Immediate Opportunities	5,000 Acres	0	$0.0	$0.0	0
Additional Costs[b]			$1,030.9	$0.0	
	Total	**617**	**$1,691.7**	**$77.3**	**119,821**

[a]Fish Passage and pool-scale Water Level Management benefits were assessed separately.
[b]Additional costs are derived from Table 6-20 categories of adaptive management, forestry management, systemic fleeting plan, cultural resource management/mitigation, contingency, PED, and administration.

6.2.7.3 Alternative C

Restore the First Increment of Habitats Most Directly Affected by the Navigation Project

- This alternative initiates large-scale floodplain restoration at sites with capable cost-share partners. It also begins to address the minimal off-channel habitat needs of many aquatic species.

The development of this alternative is based on historic and projected change in aquatic habitats directly affected by the operation of the navigation project. All of the habitat protection measures of Alternative B would be carried into Alternative C (Table 6-24) and a minimal portion of the identified historic change in aquatic habitats would be addressed (see the rationale for distribution of projects above). Islands would be constructed to replace those that have been eroded, water level management would be used in areas that have a high likelihood of success, dredging would restore degraded backwaters and side channels and increase connectivity among aquatic habitats as desirable, and a program of rock work (bank stabilization, wing dams, etc.) would protect and improve habitat conditions. Several immediate opportunities for large-scale floodplain restoration would be undertaken to address the sustainability of resources that require both aquatic and floodplain habitats (e.g., floodplain spawning fishes, wading birds, many reptiles, etc.). Habitat quality issues are addressed on large scales by pool-scale water level management and more locally through forest management plans. This alternative attempts to promote a sustainable system by protecting and maintaining the existing UMRS environmental diversity and restoring the first increment of habitats most directly affected by the navigation project. The entire river management strategy requires an effective Adaptive Management plan for integrated river management.

Table 6-24. Alternative C – Number of ecosystem projects, costs, and benefits over 50 years.

Ecosystem Measures	Project Footprint	Number of Projects	Project Costs (Millions) Measure	O&M	Benefits Acres of Influence
Island Building	30 Acres	68	$235.2	$16.8	68,000
Fish Passage[a]	1 Site	0	$0.0	$0.0	-
Floodplain Restoration (Pools 1-13)	500 Acres	2	$2.0	$0.8	1,000
Floodplain Restoration (Rest of UMR-IWW)	5,000 Acres	0	$0.0	$0.0	0
Water Level Management - Pool[a]	1 Site	12	$54.0	$0.0	-
Water Level Management - Backwater	1,000 Acres	1	$3.4	$1.0	1,000
Backwater Restoration (Dredging)	20 Acres	138	$321.0	$0.0	82,800
Side Channel Restoration	100 Acres	107	$155.2	$61.5	10,700
Wing Dam/Dike Alteration	5 Structures	51	$40.0	$3.5	510
Island Protection	3000 Feet	157	$83.0	$13.0	37,680
Shoreline Protection	3000 Feet	235	$124.2	$19.4	705
Topographic Diversity	5 Acres	32	$24.6	$1.9	256
Dam Point Control	1 Site	2	$23.2	$4.5	6,000
Floodplain Restoration-Immediate Opportunities	5,000 Acres	3	$75.0	$11.3	15,000
Additional Costs[b]			$1,675.8	$0.0	
	Total	808	$2,816.6	$133.6	223,651

[a]Fish Passage and pool-scale Water Level Management benefits were assessed separately.
[b]Additional costs are derived from Table 6-20 categories of adaptive management, forestry management, systemic fleeting plan, cultural resource management/mitigation, contingency, PED, and administration.

6.2.7.4 Alternative D
Restoration to a Level That Includes Management Practices and Cost Effective Actions Affecting a Broad Array of Habitat Types

- This alternative expands large-scale floodplain restoration to suitable levels, initiates fish passage measures, and brings off-channel habitat restoration to a suitable level.

The development of this alternative is based on historic and projected change in aquatic habitats directly affected by navigation traffic or the infrastructure to support it and by the recognition that the aquatic and terrestrial components of river-floodplain ecosystems are inextricably linked by key functions and processes that drive the system. All of the habitat protection measures of Alternatives B and C would be carried into Alternative D (Table 6-25), and a suitable portion of the identified objectives for aquatic and floodplain habitats would be addressed (see the rationale for distribution of projects above). Islands would be constructed to replace those that have been eroded, water level management would be used in areas that have a high likelihood of success, dredging would restore degraded backwaters and side channels and increase connectivity among aquatic habitats as desirable, and a program of rock work (bank stabilization, wing dams, etc.) would protect and improve habitat conditions. Several immediate opportunities for large-scale floodplain restoration would be undertaken to address the sustainability of resources that require both aquatic and floodplain habitats (e.g., floodplain spawning fish, wading birds, many reptiles, etc.), and there would be efforts to increase the opportunity to restore and connect isolated floodplain habitats to achieve a more sustainable, naturally functioning, and complete river-floodplain ecosystem. In this alternative, longitudinal connectivity issues are introduced at some dams to provide greater opportunity for the movement of migratory fish. Habitat quality issues are addressed on large scales by pool-scale water level management and more locally through forest management plans. This alternative attempts to promote a sustainable system by protecting and maintaining the existing UMRS environmental diversity and restoring to a level that includes management practices and cost effective actions affecting a broad array of habitats and ecosystem processes. The entire river management strategy requires an effective Adaptive Management plan for integrated river management.

Table 6-25. Alternative D – Number of ecosystem projects, costs, and benefits over 50 years.

Ecosystem Measures	Project Footprint	Number of Projects	Project Costs (Millions) Measure	O&M	Benefits Acres of Influence
Island Building	30 Acres	91	$314.8	$22.5	91,000
Fish Passage[a]	1 Site	14	$329.0	$21.0	-
Floodplain Restoration (Pools 1-13)	500 Acres	21	$21.0	$7.9	10,500
Floodplain Restoration (Rest of UMR-IWW)	5,000 Acres	16	$400.0	$60.0	80,000
Water Level Management - Pool[a]	1 Site	12	$54.0	$0.0	-
Water Level Management - Backwater	1,000 Acres	7	$23.8	$7.0	7,000
Backwater Restoration (Dredging)	20 Acres	208	$483.8	$0.0	124,800
Side Channel Restoration	100 Acres	147	$213.2	$84.5	14,700
Wing Dam/Dike Alteration	5 Structures	64	$50.2	$4.4	640
Island Protection	3000 Feet	157	$83.0	$13.0	37,680
Shoreline Protection	3000 Feet	235	$124.2	$19.4	705
Topographic Diversity	5 Acres	32	$24.6	$1.9	256
Dam Point Control	1 Site	2	$23.2	$4.5	6,000
Floodplain Restoration-Immediate Opportunities	5,000 Acres	3	$75.0	$11.3	15,000
Additional Costs[b]			$2,963.0	$0.0	
	Total	**1,009**	**$5,182.8**	**$257.3**	**388,281**

[a]Fish Passage and pool-scale Water Level Management benefits were assessed separately.
[b]Additional costs are derived from Table 6-20 categories of adaptive management, forestry management, systemic fleeting plan, cultural resource management/mitigation, contingency, PED, and administration.

6.2.7.5 Alternative E
Restoration to Include Most Environmental Objectives That Could Be Accomplished in the Context of the Navigation Project

- This alternative achieves an optimal level of large-scale floodplain restoration, makes fish passage measures systemic, and achieves an optimal level of off-channel habitat restoration.

The development of this alternative is based on historic and projected change in aquatic habitats directly affected by navigation traffic or the infrastructure to support it and by the recognition that the aquatic and terrestrial components of river-floodplain ecosystems are inextricably linked by key functions and processes that drive the system. All of the habitat protection measures of Alternatives B, C, and D would be carried into Alternative E (Table 6-26) and an optimal portion of the objectives for aquatic and terrestrial habitats would be addressed (see the rationale for distribution of projects above). Islands would be constructed to replace those that have been eroded, water level management would be used in areas that have a high likelihood of success, dredging would restore degraded backwaters and side channels and increase connectivity among aquatic habitats as desirable, and a program of rock work (bank stabilization, wing dams, etc.) would protect and improve habitat conditions. Several immediate opportunities for large-scale floodplain restoration would be undertaken to address the sustainability of resources that require both aquatic and floodplain habitats (e.g., floodplain spawning fish, wading birds, many reptiles, etc.), and there would be efforts to increase the opportunity to restore and connect isolated floodplain habitats to achieve a more sustainable, naturally functioning, and complete river-floodplain ecosystem. Longitudinal connectivity issues are included at most dams in this alternative to provide greater opportunity for the unimpeded movement of migratory fish. Habitat quality issues are addressed on large scales by pool-scale water level management and more locally through forest management plans. This alternative attempts to promote a sustainable system by restoring to a level that includes most environmental objectives that could be accomplished in the context of the navigation project. The entire river management strategy requires an effective Adaptive Management plan for integrated river management.

Table 6-26. Alternative E – Number of ecosystem projects, costs, and benefits over 50 years.

Ecosystem Measures	Project Footprint	Number of Projects	Project Costs (Millions) Measure	O&M	Benefits Acres of Influence
Island Building	30 Acres	116	$401.2	$28.7	116,000
Fish Passage[a]	1 Site	33	$775.5	$49.5	-
Floodplain Restoration (Pools 1-13)	500 Acres	33	$33.0	$12.4	16,500
Floodplain Restoration (Rest of UMR-IWW)	5,000 Acres	44	$1,100.0	$165.0	220,000
Water Level Management - Pool[a]	1 Site	26	$117.1	$0.0	-
Water Level Management - Backwater	1,000 Acres	9	$30.6	$9.0	9,000
Backwater Restoration (Dredging)	20 Acres	270	$628.0	$0.0	162,000
Side Channel Restoration	100 Acres	173	$250.9	$99.5	17,300
Wing Dam/Dike Alteration	5 Structures	68	$53.4	$4.7	680
Island Protection	3000 Feet	157	$83.0	$13.0	37,680
Shoreline Protection	3000 Feet	235	$124.2	$19.4	705
Topographic Diversity	5 Acres	32	$24.6	$1.9	256
Dam Point Control	1 Site	3	$32.2	$6.8	9,000
Floodplain Restoration-Immediate Opportunities	5,000 Acres	3	$75.0	$11.3	15,000
Additional Costs[b]			$4,688.0	$0.0	
	Total	**1,202**	**$8,416.7**	**$421.0**	**604,121**

[a]Fish Passage and pool-scale Water Level Management benefits were assessed separately.
[b]Additional costs are derived from Table 6-20 categories of adaptive management, forestry management, systemic fleeting plan, cultural resource management/mitigation, contingency, PED, and administration.

7.0 EVALUATION OF ALTERNATIVE PLANS

7.1 Evaluation of Navigation Efficiency Alternative Plans

During the alternative plan formulation process, a number of possible combinations of measures were explored. Preliminary information concerning the resulting alternative costs and net benefits served as initial screening criteria to determine if the alternative warranted further attention. One such alternative, Alternative 7, was screened during the early evaluation phase. It was initially recognized that the magnitude of the additional system capacity expansion represented by Alternative 7 might be greater than the level that could be supported by the National Economic Development (NED) transportation savings. As a screening device for Alternative 7, model evaluations were completed for Alternative 6 under the most optimistic traffic scenario, Scenario 5. By examining the residual delays over the system, it was obvious that the small remaining delays could not provide the basis for additional system savings to the degree necessary to offset the additional costs associated with moving from Alternative 6 to Alternative 7. On the basis of this result, Alternative 7 was screened from further consideration.

Evaluation, like all other planning steps, is an iterative process. Section 6.1 Formulation of Navigation Efficiency Alternatives Plans contained some preliminary evaluations to aid in the screening process and final formulation of primary alternatives. This section contains the detailed evaluations of the primary alternatives.

7.1.1 System of Evaluative Accounts

The detailed evaluations will include the system of four primary accounts established in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G). These accounts have been devised to encompass all significant effects of a plan as required by the National Environmental Policy Act of 1969 (NEPA) and Section 122 of the Flood Control Act of 1970. The accounts established by the P&G include (A) national economic development (NED), (B) regional economic development (RED), (C) environmental quality (EQ), and (D) other social effects (OSE). The NED account is the major criteria that will be used for plan selection from the Federal perspective. For the purposes of this study, three additional accounts were established to include other important comparative considerations: (E) Contribution to Planning Objectives, (F) Acceptability, and (G) Adaptability. The remainder of this section provides a brief description of the major accounts and criteria followed by the resulting evaluation data and information generated for each.

A. National Economic Development (NED).

The National Economic Development (NED) information provides a measurement of the monetary impacts to the national economy. These impacts include both positive and negative effects. The positive impacts associated with the navigation efficiency alternatives are primarily transportation efficiencies (measured as transportation cost savings) and avoided major rehabilitation expenditures that would be required in the absence of certain lock improvements. The negative impacts include primarily the costs required to implement and operate each alternative, including site-specific and system mitigation costs. The financial impacts to the navigation industry resulting from the adverse effects during project construction are also included as negative NED impacts. Captured over the period of analysis, both positive and negative impacts are expressed as average annual equivalent values that incorporate standard discounting techniques and the current Federal discount rate. Annual net benefits are defined as the difference between annual benefits and annual costs. Positive net benefit numbers represent benefits to the Nation, and negative net benefit numbers represent a loss to the Nation. The following provides a brief description of the criteria organized under the NED account; those designated with an asterisk represent the most influential criteria

A1. Project Cost and A2. Total Average Annual Cost

Total navigation efficiency alternative plan costs include first costs of construction; channel work; real estate and relocations; operation and maintenance; major rehabilitation and site-specific environmental mitigation. The total average annual cost for each alternative is computed over the 50-year planning horizon. See Section 6.1.6 for alternative costs.

A3. Net Benefits

This evaluation recognizes the uncertainty associated with the future demand for waterway transportation and the lack of definitive data on demand elasticity for commodities shipped on the river, particularly grain. Five different scenarios represent the uncertainty in future demand for waterway transportation as described in Section 4.3.1.5. The uncertainty in demand elasticity is being represented by the use of three different economic modeling conditions. The question of demand elasticity centers on the issue of how the demand for waterway shipment of commodities responds to rising transportation costs. The condition reflecting an inelastic state is represented by the Tow Cost Model (TCM), while the ESSENCE Model represents the upper (E_{UB}) and lower (E_{LB}) bounds of an elastic condition. Net benefits were computed for each scenario and each assumption of elasticity, which results in 15 different economic conditions (given 5 traffic scenarios and 3 economic model specifications). A description of the modeling conditions and results is presented below.

As currently constructed, individual scenarios or economic conditions will not be evaluated with respect to numerical probability or likelihood of occurrence. A single most probable without-project condition, therefore, will not be identified. The intent is to evaluate alternatives across all scenarios and search for those that work well across a broad range. Such identification is uncommon in Corps feasibility studies; however, the scenario-based approach is consistent with the P&G, the procedural and analytical framework for Corps feasibility studies.

Paragraph 1.4.13 of the P&G presents guidance on dealing with risk and uncertainty in the evaluation of alternative plans, and Supplement 1 – *Risk and uncertainty –Sensitivity analysis* presents additional guidance. Paragraph 1.4.13 describes a situation of uncertainty as those in which potential outcomes cannot be described in objectively known probability distributions. The guidance indicates that plans and their effects should be examined to determine the uncertainty inherent in the data or various assumptions and "A limited number of reasonable alternative forecasts that would, if realized, appreciably affect plan design should be considered." The guidance goes on to endorse performing a sensitivity analysis of the estimated benefits and costs of alternative plans using these alternative forecasts.

Supplement 1 to the P&G also deals in some detail with this subject of assigning probabilities. It recognizes that there are situations of uncertainty where outcomes cannot be described in objectively known probability distributions because future demographic, economic, hydrologic, and meteorological events are essentially unpredictable because they are subject to random influences. This describes the situation with respect to 50-year forecasts of traffic on the Upper Mississippi River-Illinois Waterway (UMR-IWW) System. While the P&G certainly allows for assigning subjectively based probabilities to random future events, it does not endorse the approach and is very cautious in describing subjective probabilities, indicating such approach must be justified on a case-by-case basis and carefully qualified as subjective. The discussion in Supplement 1 indicates that P&G would clearly allow the treatment of alternative forecasts as equally probable for the purpose of sensitivity analysis.

Finally, the P&G indicates that the planner's primary role in dealing with risk and uncertainty is "to characterize to the extent possible the different degrees of risk and uncertainty and to describe them clearly so that decisions can be based on the best available information."

TOW COST (TCM): TCM has been developed over many years by the Corps and has been used in numerous feasibility reports and Environmental Impact Statements supporting construction authorizations for major investments in inland navigation improvements**.** The Tow Cost Model measures the benefits of waterway improvements as the savings in transportation costs in using the waterway over the alternative transportation method. The results of the Tow Cost analysis are displayed to assess the performance of these alternatives versus other major inland navigation investments nationwide using a common benefit evaluation methodology. The Federal Principals Task Force endorsed the use of existing economic models, such as TCM, while research and development on improved models moves forward but within the context of an adaptive management process that would review study results as new models are developed, tested, and accepted. The framework of the TCM assumes that individual waterway movements are not sensitive to the price of water transportation until the level of the next least costly mode of transportation is reached. At that point, zero quantity will be shipped. Alternative uses of the commodity (typically associated with a different destination and perhaps a different mode) and the possible substitution of supply regions are not recognized.

ESSENCE: The ESSENCE model introduces the notion that individual waterway movements are sensitive to the price of water transportation before the threshold level of the next least costly transportation mode is reached. This is the major contribution of ESSENCE in moving from the Corps traditional TCM framework to a framework that can be described as a spatial equilibrium. A spatial equilibrium framework would explicitly model producing and consuming regions for a commodity, and link these regions by means of the transportation costs and commodity prices. ESSENCE is not a fully developed spatial model. It does not explicitly model and link producing and consuming regions by the means described above; however, it takes a significant step by introducing the notion of transportation demand elasticity. The most controversial and weakest aspect of the ESSENCE model is the methodology for specifying the price responsiveness of the waterway movements. Rather than specifying a single elasticity value, ESSENCE evaluations incorporated an upper (E_{UB}) and lower (E_{LB}) bound of demand elasticity. After a review of existing efforts to estimate transportation demand elasticities, it was concluded that there are limited current data that address waterway transportation demand elasticity for the specific geographic region of this feasibility study investigation. A wide range of elasticity values, representing a variety of commodity group aggregations, transportation modes, geographic settings, and age of analysis were identified. Using these findings and analyst judgment, the ESSENCE upper and lower bounds were selected. (The selected values were –1.0 for grain and –0.5 for non-grain for the lower bound, and –3.0 for grain and –2.0 for non-grain for the upper bound.) The Corps has initiated a Navigation Economic Technologies (NETS) research program to further develop and incorporate the spatial equilibrium concept into future economic modeling efforts. One product of the NETS program that will be used in this study will be price elasticity information for water transportation. This information will be incorporated into the feasibility decision process as appropriate.

Model Results. The net benefits for each of the navigation efficiency alternatives have been evaluated for each of the 15 different economic conditions described above. The average annual net benefits in millions of dollars for each alternative for each economic condition are displayed in Table 7-1 in matrix format. Positive numbers represent benefits to the Nation and negative numbers represent a loss to the Nation. Each cell represents a net benefits computation for an economic condition defined by a scenario and elasticity assumption. Table 7-1 also includes a column titled positive net benefits or robustness, which is the extent to which the alternative is economically justified under a wide range of traffic scenarios and economic model assumptions. The columns titled maximum and minimum net benefits define the number of times that alternative contains the greatest or least net benefits for all 15 economic conditions. Figure 7-1 is a display of the net benefits for each economic condition in bar chart format. Alternative 1 exhibits no net benefits since there is no incremental cost above the without project condition.

Table 7-1. Average annual net benefits ($ millions) for navigation efficiency alternatives across the range of 15 possible economic conditions created by the use of five scenarios and three economic models. Columns to the right of net benefits depict alternative robustness across this range of 15 possible future economic conditions.

NET BENEFITS ($Millions)

Alt.	Model	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Pos. Net Benefits	Max. Net Benefits	Min. Net Benefits
1	EUB	0.00	0.00	0.00	0.00	0.00	0/15	0/15	7/15
	ELB	0.00	0.00	0.00	0.00	0.00			
	TCM	0.00	0.00	0.00	0.00	0.00			
2	EUB	20.00	44.56	62.04	63.93	70.24	15/15	14/15	0/15
	ELB	16.22	61.73	96.29	101.36	116.63			
	TCM	8.88	100.74	143.08	158.18	172.76			
3	EUB	-10.92	-11.74	-11.63	-11.85	-11.29	0/15	0/15	0/15
	ELB	-10.92	-11.74	-11.63	-11.85	-11.29			
	TCM	-10.92	-11.74	-11.63	-11.85	-11.29			
4	EUB	-33.36	-19.12	-10.02	-9.24	-6.20	8/15	0/15	0/15
	ELB	-28.03	3.99	21.55	22.19	28.24			
	TCM	-24.09	35.55	55.56	65.47	71.62			
5	EUB	-74.08	-40.70	-17.75	-17.19	-8.96	8/15	0/15	0/15
	ELB	-67.31	2.32	41.35	41.74	50.73			
	TCM	-63.59	71.31	115.01	110.65	121.97			
6	EUB	-132.03	-79.07	-42.68	-39.67	-22.92	7/15	1/15	8/15
	ELB	-126.15	-27.79	41.79	48.97	76.52			
	TCM	-126.15	45.13	131.44	157.01	188.98			

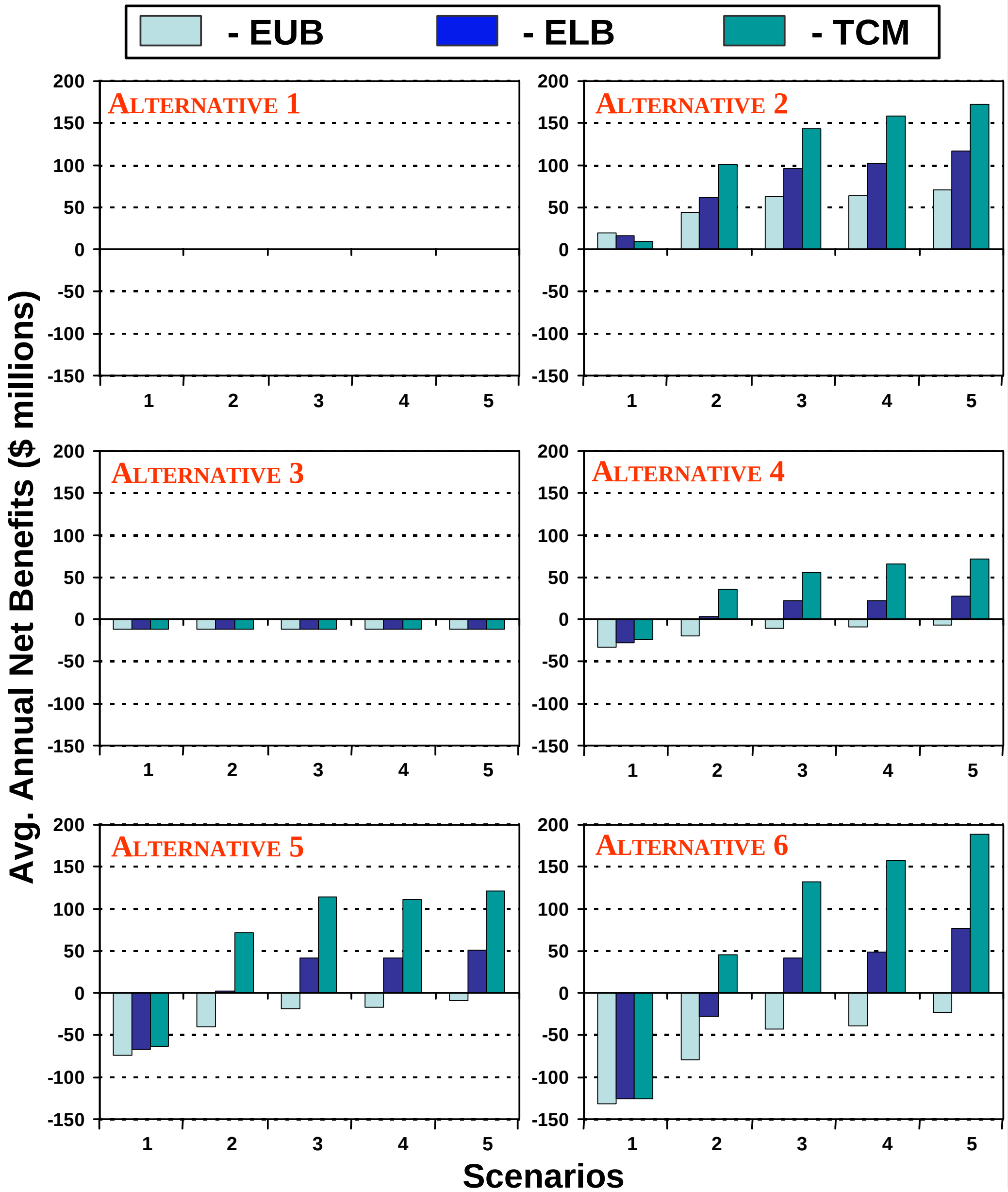


Figure 7-1. Average annual net benefits ($ millions) for navigation efficiency alternatives across the range of 15 possible economic conditions created by the use of five scenarios and three economic models.

The model results can also be displayed in terms of a measurement of risk or the potential economic costs of selecting or not selecting an alternative as measured in foregone benefits. The risk for each alternative and economic condition is displayed in bar chart format on Figure 7-2. The foregone benefits are computed as the difference in net benefits between a specific alternative and the alternative with the highest net benefits for that economic condition. For example, if the no action alternative is selected and economic conditions represented by Scenario 3 and the ESSENCE lower bound occur, the average annual net benefits foregone would equate to approximately $96 million. Conversely, if Alternative 6 were selected and economic conditions represented by Scenario 1 and the ESSENCE lower bound occur, the cost of making this decision would equate to approximately $142 million in average annual cost. Alternative 2 exhibits the least amount of risk since it has the highest net benefits across 14/15 economic conditions and served as the basis for risk computation for the majority of the economic conditions. It is important to emphasize that the relative differences in risk cost between and among alternatives, and not the absolute magnitudes of risk expressed for each alternative, are the meaningful measures. The risk cost derives directly from the computation of net benefits. In order to compare net benefits across alternatives, it is necessary to reflect values that assume a common reference point for discounting purposes. The year 2023 has been selected as this common reference point. If an earlier or later common reference point had been chosen for the net benefit, and correspondingly for the risk costs, the absolute magnitude of the net benefits would have been either smaller or larger. As a consequence, it is the relative differences in risk cost when comparing alternatives and the absolute magnitudes that are most meaningful.

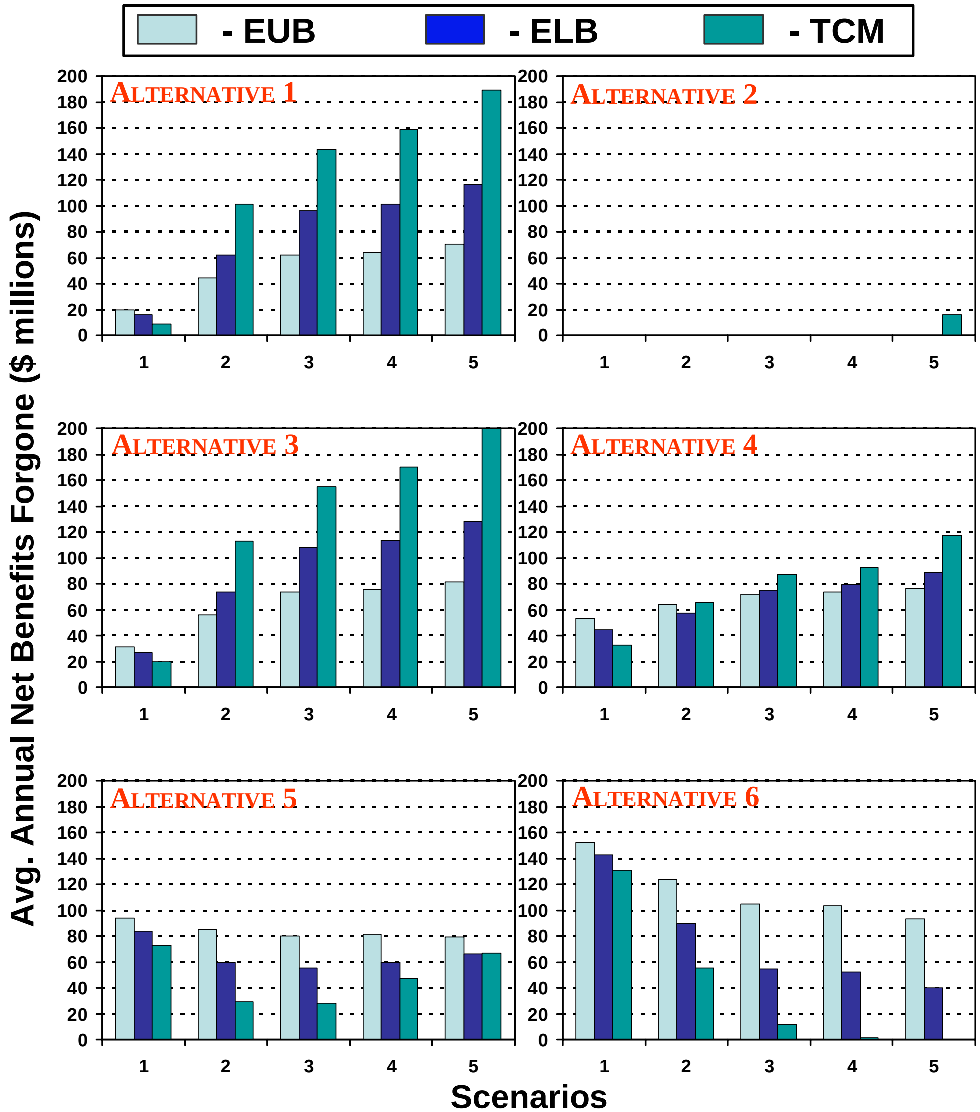


Figure 7-2. Alternative risk, expressed as the potential economic costs of selecting or not selecting an alternative as measured in foregone benefits.

B. Environmental Quality Effects

Both the site-specific and the systemic environmental consequences were assessed and monetized for each of the navigation efficiency alternatives. Avoid, minimize, and mitigation measures were considered for each alternative. The items in Table 7-2 represent the major environmental components of the proposed mitigation plan (see Chapter 10 and Appendix ENV-B for details). Evaluation criteria B9 on Table 7-3 provides a total mitigation cost for each respective alternative. Mitigation costs have been refined during the planning process, based on updated model results and input from the NECC. These refinements resulted in relatively minor changes in the mitigation cost for Alternatives 4, 5, and 6, and a sensitivity analysis determined that these did not alter the NED analysis or the selected plan.

Table 7-2. Description of avoid, minimize, and mitigation measures recommended to offset the incremental effects of additional commercial traffic resulting from the navigation efficiency alternatives.

Management Actions	Alternative Plans					
	1	2	3	4	5	6
Navigation Efficiency Measures						
(1) Congestion Fee Implemented through a Lockage Fee	NA	Refer to Section 6.1.6.2	NA	NA	NA	NA
(2) Deck Winches	NA	NA	Refer to Section 6.1.6.3	NA	NA	NA
(3) Moorings	NA	NA	NA	12, 14, 18, 20, 22, 24, & LGR	12, 14, 18, 24, & LGR	12, 14, 18, & 24
(4) Switchboats	NA	NA	NA	20, 21, 22, 24, & 25	14, 15, 16, 17, 18, PEO, & LGR	11, 12, & 13
(5) Lock Extensions	NA	NA	NA	NA	20, 21, 22, 24 & 25	14, 15, 16, 17, & 18
(6) New Locks	NA	NA	NA	NA	NA	20, 21, 22, 24, 25, PEO, & LGR
Avoid, Minimize, & Mitigation Measures						
(1) Bankline Erosion	NA	NA	NA	10.8 miles of shoreline protection	10.8 miles of shoreline protection	10.8 miles of shoreline protection
(2) Backwater and Side Channel Restoration	NA	NA	NA	31 Projects	31 Projects	31 Projects
(3) Submersed Aquatic Vegetation (SAV)	NA	NA	NA	2 miles of plant bed protection	7 miles of plant bed protection	9 miles of plant bed protection
(4) Fisheries	NA	NA	NA	9 Large-scale measures (1 backwater improvement, 8 dike alterations), and up to 270 small scale measures (woody debris anchors)	13 Large-scale measures (1 backwater improvement, 11 dike alterations, 1 fish passage structure), and up to 740 small scale measures (woody debris anchors)	24 Large-scale measures (2 backwater improvements, 21 dike alterations, 1 fish passage structure), and up to 620 small scale measures (woody debris anchors)
(5) Monitoring	NA	NA	NA	1 model validation study, 1 applied research study, site specific bioresponse studies, and a limited annual bioresponse monitoring program	1 model validation study, 1 applied research study, site specific bioresponse studies, and a limited annual bioresponse monitoring program	1 model validation study, 1 applied research study, site specific bioresponse studies, and a limited annual bioresponse monitoring program
(6) Historic Properties	NA	NA	NA	Systemic evaluation of bank erosion	Systemic evaluation of bank erosion and site specific evaluation of construction	Systemic evaluation of bank erosion and site specific evaluation of construction
(7) Other	NA	NA	NA	Administration and Project Maintenance	Administration and Project Maintenance	Administration and Project Maintenance
(8) Site Specific Mitigation	NA	NA	NA	1 Site	6 Sites	13 Sites

Table 7-3. Cost of avoid, minimize, and mitigation measures for each of the navigation efficiency alternatives.

Avoid, Minimize & Mitigation Measures	Mitigation Cost for Navigation Efficiency Alternative Plans					
	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
B1. Bank Erosion	$ -	$ -	$ -	$ 17,563,523	$ 17,563,523	$ 17,563,523
B2. Backwater & Secondary Channel	$ -	$ -	$ -	$ 29,390,769	$ 29,390,769	$ 29,390,769
B3. Plants	$ -	$ -	$ -	$ 3,306,020	$ 12,021,890	$ 16,530,098
B4. Fish	$ -	$ -	$ -	$ 13,167,619	$ 36,196,040	$ 59,156,934
B5. Env. Monitoring	$ -	$ -	$ -	$ 7,171,441	$ 9,400,000	$ 14,292,780
B6. Historic Properties	$ -	$ -	$ -	$ 9,500,000	$ 10,200,000	$ 10,590,000
B7. Site Specific Mitigation	$ -	$ -	$ -	$ 4,764,413	$ 15,127,011	$ 37,297,628
subtotal	$ -	$ -	$ -	$ 84,863,785	$ 129,899,233	$ 184,821,733
B8. Administration				$ 8,486,379	$ 12,989,923	$ 18,482,173
B9. Total Mitigation Cost	$ -	$ -	$ -	$ 93,350,164	$ 142,889,156	$ 203,303,906

C. Regional Economic Development (RED)

The income and employment benefits for each alternative were computed for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri along with the lower Mississippi Region and the rest of the United States. These income and employment effects are derived from direct construction expenditures required to implement an alternative and from the transportation efficiencies generated by the alternative. RED benefits for Scenario 3 are presented in Table 7-4 as average annual income from construction and average annual jobs created. RED information for Scenarios 2 and 5 was also computed and provided to the States. In general, the higher the investment alternative, the greater will be the benefits to the region. Alternative 2 results in negative effects to this sector of the regional economy because no construction expenditures are required to implement this alternative and transportation efficiencies are negatively influenced, at the regional level, by the fact that all traffic that remains on the system is required to pay the fee.

Table 7-4. Regional Economic Development Benefits for Scenario 3.

REGIONAL ECONOMIC DEVELOPMENT (RED) (2005-2035)

UMR-IWW System Navigation Feasibility Study

NAVIGATION EFFICIENCY ALTERNATIVES

Average Annual Income ($ millions) Scenario 3

TOWCOST Model (TCM)

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-57.7	14.0	17.4	18.0
Wisconsin	-12.6	4.4	6.9	8.9
Iowa	-39.9	11.8	16.6	23.8
Illinois	-76.8	35.5	71.2	100.3
Missouri	-16.1	15.9	20.1	32.7
L Miss	3.5	7.2	6.3	5.2
Rest of U.S.	79.0	-12.4	-32.7	-38.7
Total	-120.7	76.4	105.8	150.2

ESSENCE Lower Bound

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-37.2	9.3	11.7	12.5
Wisconsin	-8.2	3.2	5.3	7.7
Iowa	-25.9	8.0	12.2	19.6
Illinois	-49.6	29.1	60.1	90.3
Missouri	-10.3	14.6	18.4	31.0
L Miss	1.6	4.9	6.3	4.5
Rest of U.S.	50.7	-15.6	-12.8	-32.2
Total	-78.9	53.5	101.3	133.3

ESSENCE Upper Bound

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-20.8	5.0	7.3	8.4
Wisconsin	-4.5	2.3	4.3	7.0
Iowa	-14.3	5.1	8.8	16.3
Illinois	-27.7	24.3	52.4	83.2
Missouri	-5.3	13.1	17.1	30.0
L Miss	-0.2	6.3	6.5	6.2
Rest of U.S.	25.9	-16.5	-8.3	-19.3
Total	-46.9	39.7	88.2	131.8

Average Employment per Year (jobs) Scenario 3

TOWCOST Model (TCM)

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-595	173	248	275
Wisconsin	-168	76	129	184
Iowa	-428	173	323	514
Illinois	-771	497	1,057	1,581
Missouri	-197	332	354	595
L Miss	145	105	72	85
Rest of U.S.	1,944	-308	-823	-884
Total	-70	1,048	1,360	2,351

ESSENCE Lower Bound

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-378	113	168	200
Wisconsin	-107	55	102	159
Iowa	-272	123	256	449
Illinois	-491	418	902	1,441
Missouri	-125	308	324	566
L Miss	91	100	106	99
Rest of U.S.	1,256	-184	-419	-564
Total	-27	933	1,437	2,350

ESSENCE Upper Bound

Region	Alt 2	Alt 4	Alt 5	Alt 6
Minnesota	-211	67	110	142
Wisconsin	-60	43	82	143
Iowa	-151	85	205	399
Illinois	-275	358	792	1,334
Missouri	-69	292	302	547
L Miss	39	118	126	143
Rest of U.S.	689	-54	-165	-220
Total	-39	909	1,452	2,488

D. Other Social Effects (OSE)

This work evaluates and quantifies positive or negative impacts of waterway traffic versus rail for the categories of emissions, accidents, and noise and other community impacts (Tolliver 2000 and 2004). A positive number indicates a project benefit, while a negative number indicates a project cost or disbenefit. While the effects described here are potentially NED in nature, the level of input detail and lack of standardized measurement techniques within the Corps preclude these impacts from being considered in the NED formulation process.

D1. Emissions

The change in rail and waterway traffic emissions impacts attributable to each alternative can be quantified by comparing the gallons of fuel consumed in waterway and rail transportation for each alternative. Emission factors per gallon of fuel consumed can be used in developing the estimates.

The weighted-average waterway trip distance for incremental grain traffic ranges from 1,300 to 1,500 miles for the five traffic scenarios, with a mid-range estimate of 1,400 miles. The projected length of haul by rail is 1,400 miles (i.e., 60 percent to the Gulf of Mexico at 1,000 miles and 40 percent to the Pacific Northwest at 2,000 miles). The highest Revenue Ton Mile Per Gallon (RTMG) forecast for upper river movements under any traffic scenario is 368. Thus, the highest possible weighted-average RTMG for a river movement to New Orleans is 558, when both upper and lower river values are considered. In comparison, the fuel model predicts railroad revenue ton-miles per gallon of 636 and 684 for nonunit- and unit-train movements, respectively. Based on these inferences, the general conclusion of the analysis is that there is no evidence to suggest that the potential waterway investments would have a significant beneficial effect on annual fuel consumption. The emission of air pollutants is directly linked to fuel consumption. Therefore, it is unlikely that the potential waterway investments would have a significant beneficial effect on the emission of air pollutants.

D2. Accidents

Included in this data are estimates of the differential financial cost of accidents and fatalities resulting from waterway and rail transportation. The National Safety Council unit costs of $3.5 million and $44,000 are used in estimating fatality and injury costs, respectively. Annual costs are estimated for the with-project and without-project scenarios. If investments are made in Alternative 4, 5, or 6, the incremental traffic would move on the waterway instead of the railway. In Alternatives 4, 5, and 6, without-project accident costs are based on railroad accident factors, while with-project costs reflect waterway accident data. A two-step analysis process was followed for both modes: (1) estimate annual accidents, fatalities, and injuries for the incremental traffic and (2) multiply the annual events by the applicable unit cost per property damage, fatality, or injury.

Table 7-5 displays the projected change in accident costs for traffic Scenario 3 and for each alternative. As the tables show, the net change is very large for some alternatives; $39 million in year 2050 under Alternative 6, ESSENCE – Upper Bound. Negative signs associated with Alternative 2 (lockage fees) indicate that additional traffic would move on the railway instead of the waterway in the with-project condition, resulting in negative benefits.

Table 7-5. Projected change in accident costs for traffic Scenario 3, and for each navigation efficiency alternative.

Accident Costs (Injuries and Fatalities)
Scenario 3 (Millions of $)

TOWCOST Model (TCM)

Year	Alt 2	Alt 4	Alt 5	Alt 6
2025	-9.8	2.1	2.7	2.5
2035	-9.9	7.2	11.4	12.0
2050	-11.6	7.3	13.3	16.4

ESSENCE Lower Bound

Year	Alt 2	Alt 4	Alt 5	Alt 6
2025	-15.2	3.9	7.9	8.2
2035	-18.4	7.0	15.6	21.3
2050	-21.6	7.0	18.3	27.1

ESSENCE Upper Bound

Year	Alt 2	Alt 4	Alt 5	Alt 6
2025	-18.0	5.3	13.3	13.8
2035	-20.8	7.7	21.1	32.8
2050	-22.8	7.7	23.4	38.5

D3. Noise and Other Impacts

The change in rail and waterway traffic noise and other community impacts attributable to each alternative have been evaluated and quantified. Incremental railroad traffic will result in changes in traveler delay at railroad/highway crossings. A comprehensive analysis of grade crossing delay is beyond the scope of this study. However, several illustrations are presented based on probable routings. In the first illustration, half of the grain traffic to the Gulf of Mexico (or 30 percent of the incremental traffic) is assigned to the Union Pacific lines that run through East St. Louis, Pine Bluff, Arkansas, and several other cities en route to New Orleans. In the second illustration, all of the grain traffic to the Gulf of Mexico (or 60 percent of the incremental grain traffic) is assigned to UP lines.

The grade crossing delay and noise analysis procedures use the same database. Changes in noise levels are analyzed at the same crossings for the selected cities using the same number of incremental trains. Noise is an important community impact that is considered by the Surface Transportation Board in rail-line analyses. Incremental railroad traffic may result in three main types of noise: (1) locomotive (propulsive) noise, (2) train noise, and (3) horn noise. The following tables list the estimated crossing delay and noise impacts, assuming that 30 percent of the incremental grain traffic moves via the Gulf of Mexico route.

An example is used to illustrate the interpretation of the tables assuming 30 percent of the incremental grain traffic follows this route. Under Alternative 6 (TCM) in 2035, the projected reduction in housing units subject to railroad noise levels of 65dba or greater is 648, and 1,244,000 fewer highway vehicles would encounter grade crossing delays totaling 38,000 hours per year (Table 7-6).

Table 7-6. Crossing Noise and Delay impacts associated with Navigation Efficiency Alternatives using Scenario 3 traffic levels.

Crossing Noise and Delay Impacts
Scenario 3 - With 30% of Incremental Grain Traffic (YR 2035)

TOWCOST Model (TCM)

Impact	Alt 2	Alt 4	Alt 5	Alt 6
Housing units>65dba	451	451	648	648
Delay/yr. in hours	25,630	25,630	38,445	38,445
Vehicles delayed/yr.	829,264	829,264	1,243,897	1,243,897

ESSENCE Lower Bound

Impact	Alt 2	Alt 4	Alt 5	Alt 6
Housing units>65dba	648	241	648	837
Delay/yr. in hours	38,445	12,815	38,445	51,260
Vehicles delayed/yr.	1,243,897	414,632	1,243,897	1,658,529

ESSENCE Upper Bound

Impact	Alt 2	Alt 4	Alt 5	Alt 6
Housing units>65dba	648	451	648	1,016
Delay/yr. in hours	38,445	25,630	38,445	64,075
Vehicles delayed/yr.	1,243,897	829,264	1,243,897	2,073,161

E. Planning Objectives

The goals and objectives of the feasibility study are to outline an integrated plan to ensure the economic and environmental sustainability of the UMR-IWW Navigation System. The alternatives contained in Section 6.1.6 were formulated to meet these objectives. Outlined below are the definitions and evaluations of how well the alternatives meet each of the planning objectives.

OBJECTIVE E1. Provide for a safe, reliable, efficient, and sustainable UMR-IWW Navigation System over the planning horizon.

DEFINITIONS.

Safety: The safety of the towboat crews and lock personnel was paramount in the development of measures and alternatives. Locking massive 15-barge tows in all kinds of weather, 24 hours a day, 7 days a week is inherently dangerous. The benchmark floor for safety is to not allow navigation efficiency improvements that are less safe than current operating procedures. In the formulation of measures and alternatives, improvements to safety were considered and incorporated as appropriate.

Reliability: Reliability is defined as the ability to provide consistent lockage service throughout the navigation season or construction period for new improvements, with minimal disruptions to commercial and recreational traffic. Ensuring the reliability of the navigation system is analogous to maintaining a chain, whereby the system or chain is only as strong as the weakest link. The disruption of one lock essentially affects the entire system. The benchmark floor for reliability will be to not allow navigation efficiency improvements that are less reliable than current operating conditions. Increases in reliability were considered in the formulation of measures and alternatives.

Efficiency: The shipment of commodities on the system has national and regional economic implications. Grain and other commodity prices are very sensitive to transportation costs, and an efficient system is essential to maintaining a competitive transportation system. The benchmark floor for efficiency will be to not allow navigation efficiency improvements that are less efficient than the current system. The efficiency of navigation efficiency improvements is primarily measured by NED benefits.

Sustainability: The transportation system of the United States is a multi-modal system that requires the efficient interaction between rail, truck, air, and waterway modes of transport. The economy of the country and its competitiveness in world markets depend on a safe, reliable, and efficient transportation system. The role of the Federal Government is to provide for a transportation system that allows the free market society to maximize its use for economic gain to the country. Sustainability is defined as "The balance of economic, ecological, and social conditions so as to meet the current, projected, and future needs of the Upper Mississippi River System without compromising the ability of future generations to meet their needs." Meeting future needs of the system is defined as allowing for future growth to meet the needs of the region and the Nation. The benchmark floor for sustainability will be to not allow any navigation efficiency improvements that stifle growth on the system.

The following paragraphs provide evaluative information on how well the alternatives meet the planning objective E1.

Alternative 1: No Action. By definition, Alternative 1 serves as the benchmark for safety, reliability, and efficiency. The question of whether the no action alternative is sustainable depends on the future demand for waterway transportation. If increases in demand occur, the no action alternative would not meet the sustainability objectives.

Alternative 2: Congestion Fees Implemented through a Lockage Fee (imposed on commercial traffic). This alternative is safety and reliability neutral. It does provide more efficiency to the system, which is reflected in the NED computations. Alternative 2 improves efficiency by imposing a fee that drives marginal users off the system. However, it fails to meet the primary planning objective of ensuring an economically sustainable navigation system, since it constrains the future growth on the system.

Alternative 3: Excess Lockage Time Fees. This alternative could have safety implications by creating an incentive to move through the double lockage process faster. This alternative includes the installation of winches that may speed up the uncoupling and recoupling process; however, winches have resulted in some increases in back injuries as reported by industry. This alternative is reliability neutral. The NED benefits and efficiency measurement for this alternative are negative. This alternative is not sustainable due to the negative benefits created from its implementation.

Alternative 4: Moorings (12, 14, 18, 20, 22, 24, and LaGrange); Switchboats at Locks 20 through 25.

Safety (Alt. 4):

Moorings - Additional moorings would be either cells or buoys at select lock sites. The purpose of a mooring is to speed overall lock processing time by mooring the waiting tow closer to the lock to reduce its approach time. This would require a change in practice by the towboat operators that could have some associated mishaps until the use of the mooring became common practice. It is likely the towboat operators would take the time necessary to ensure safety rather than add any risk for the sake of efficiency. Therefore, moorings would not increase or decrease safety.

Switchboats - The use of switchboats to pull the first cut out of the lock chamber in lieu of the tow haulage unit would require different types of line handling. In the present condition, a lockman handles the tow-haulage equipment and cable to start the cut moving, and deckhands stop the cut movement by checking the head of the cut using a line and braking the cut at the stern using a separate line. Switchboats would replace the tow haulage activities and line work associated with head checking and braking of the cut. The crew of the switchboat would attach wires from the boat to the cut in order to pull and control it. On the surface, there would seem to be a trade-off of the safety of line handling using the present tow haulage method vs. the switchboat method of extracting first cuts. Switchboat introduction could have the potential for increasing personal injuries since more individuals (two deckhands and one towboat pilot) would be used on each switchboat. Overall, the safety of switchboats would depend on the experience and training of the towboat captain and crew.

Reliability (Alt. 4):
Moorings – The placement of the moorings in the System Study was coordinated with the towing industry, the eventual users. Despite the coordination efforts, some moorings may not get used to their fullest extent based on historical uses of similar mooring installations. Some moorings have been installed for the purposes of increasing efficiency, but the towboats do not always use them or they use them as a last resort. Not all the users find the moorings useful or better than mooring along the bankline. If this practice were to continue, then the reliability of the time savings modeled in the study would be reduced or the time savings would be completely eliminated. This will likely not be realized until the moorings are installed and the industry's reaction is studied under a variety of conditions such as varying river flows, weather, etc. The time savings of moorings were considered to be 100 percent reliable in the economic analysis, but overall moorings will not increase or decrease the reliability of the system since the reliability of the lock is not addressed.

Switchboats – The use of switchboats was modeled with two switchboats at each lock site. The primary purpose of using two boats was that if one were delayed in returning to the lock from a remote remake condition, the other would always be ready to service the next tow. Any use of switchboats would probably be implemented starting with one boat at a site and adding a second boat as required for reliability or to maximize time savings. Overall, switchboats will not increase or decrease the reliability of the system since the reliability of the lock is not addressed.

Efficiency (Alt. 4): Moorings and switchboats provide positive efficiency benefits to the system as measured by the NED benefits.

Sustainability(Alt. 4): Moorings and switchboats will be sustainable for low growth scenarios; however, they will not be sustainable for high growth scenarios.

Alternative 5: Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 through 18, La Grange and Peoria.

Safety (Alt. 5): The safety aspects of moorings and switchboats are contained in the Alternative 4 descriptions. Lock extensions at Locks 20 through 25 will eliminate double-cut lockages (approximately 75 percent of all lockages) and the associated personal-injury hazards at those sites. A double-cut lockage requires the breaking and remaking of as many as eight couplings made with wire ropes. The work involves laying the wire ropes, connecting them, and tightening them in an orderly manner. Three deckhands work together to complete this task that requires skill, strength, stamina, and safety awareness. Also, deckhands would not have to climb ladders onto the lock wall, and eventually climb down, in order to lock the first segment of the double-cut lockage. Finally, any tasks associated with tow haulage and checking the cut to full stop and their associated hazards (see switchboat discussion above for these hazards) would be eliminated. Lock extensions would eliminate these hazards for five locks. The overall risk of personnel injury to deckhands and lockhands would be reduced because there is reduced exposure to hazards. There could also be some additional safety benefits because the towboat crew would be more rested because of the less strenuous duties required in locking through 1,200-foot long locks.

Reliability (Alt. 5): The reliability aspects of moorings and switchboats are contained in the Alternative 4 description. Lock extensions reduce the number of operating cycles of machinery by eliminating the need for the double-cut lockage of tows. Reduced cycles affect the machinery life, related unscheduled lock closures, and intervals of major rehabilitation. All these beneficial effects were considered in the economic modeling. Lock extensions would improve the reliability of the system once they are completed and in service; however, performance would be less than a new lock. The filling and emptying system for the lock extensions relies on the system from the existing 600-foot lock. Filling and emptying from only 600 feet of a 1,200-foot lock would slow down processing time compared to a new lock.

Most of the on-site lock extension construction would occur in the wintertime to reduce the impacts to navigation. The lock would be closed for approximately 90 days for three consecutive winter seasons. For the lower five locks on the Mississippi River, the total construction schedule (depending on schedule alignments) could close the river for 10 consecutive winter seasons. The lower five locks can receive river traffic in typical winter months, but this would be impossible during lock extension activities due to conflicts with construction. (In contrast, for new locks, scheduled openings of the existing lock can be used to accommodate some winter traffic. See Alternative 6 for further explanation). The NED losses due to winter closure periods were considered in the economic model, but the long-term impact on businesses was not considered.

There is substantial risk in experiencing a reduction in reliability during construction of the lock extensions. In a situation where lock extensions were to experience construction delays, causing construction beyond the wintertime closure period, the consequences of navigation impacts would be large. Wintertime navigation closures were used to allow uninterrupted construction work. These were modeled as fixed durations of about 90 days each and then traffic would resume. If the construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. The chance of construction delay and the duration of delay were not considered in the economic model because both are uncertain.

Efficiency (Alt. 5): Moorings, switchboats, and lock extensions provide positive efficiency benefits to the system as measured by the NED benefits for some economic conditions.

Sustainability (Alt 5): Moorings, switchboats, and lock extensions will not be sustainable for low growth scenarios; however, they will be sustainable for high growth scenarios.

Alternative 6: Mooring (12, 14, 18, and 24); New Locks at 20 through 25, La Grange, and Peoria; Lock Extensions at 14 through 18; and Switchboats at Locks 11 through 13.

Safety (Alt. 6.): The safety aspects of moorings, switchboats, and lock extensions are contained in the Alternative 4 and 5 descriptions. New locks have the same benefits listed for lock extensions along with other safety advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. The existing 600-foot lock can be used for recreational craft and other small vessels. This separates the small craft from the large commercial tows. Also, their interferences on approaching the lock would be reduced, therefore reducing the chance of conflict between vessels. Sometimes recreation craft attempt to bump into line in order to lock through faster. This can cause delays to those expecting their lock turn and is not the safest of boating practices. Also, location 3 locks on the lower five locks on the Mississippi River would feature a riverside approach wall on the upstream end. This approach wall location with respect to the dam generally is considered safer than the present guidewall structure along the landside of the lock. Riverside approach walls are safer because they provide a physical barrier between the tow and the dam that would reduce the chance and consequences of tow mishaps that result in barges breaking loose from the tows and sometimes subsequently running into the dam. The approach wall also would allow downbound tows to better align themselves for lock entry, thus reducing impact damage to miter gates and lockwalls resulting from the present lock entry conditions.

Reliability (Alt. 6): The reliability aspects of moorings, switchboats, and lock extensions are contained in the Alternative 5 description. New locks have the same benefits listed for lock extensions along with other advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. This reduces the number of operating cycles that either lock must perform. The cycles are reduced because there would normally be no double lockages for the small lock, no recreation craft for the long lock, and fewer small commercial craft (600 feet long or less) for the long lock. Operating cycles are a major driver in the timing and need for lock major rehabilitation and repair. Most of this effect was captured in the economic modeling of new lock construction. The increase in recreational craft lockages that can be accommodated by the smaller lock was not considered because there are no reliable projections for the amount of recreation traffic increases. However, in general, recreational boaters are increasing in number.

Also, a second lock at the existing projects offers the opportunity to temporarily remove a lock from service for repairs that could result in restored performance. This convenience would allow both locks to operate at full output. (In contrast, for lock extensions, any reduction in performance due to malfunction is accepted and its associated repair delayed until the wintertime when navigation demand is reduced). This benefit was not captured in the economic model.

Also, in the event of future needs for major rehabilitation, a second lock would allow construction to occur during seasons other than the winter, which is the existing practice on the Upper Mississippi River. Construction work during better weather conditions will allow increased productivity and likely increased quality. This benefit was not considered in the economic model.

Most of the on-site lock extension construction would occur in the wintertime to reduce the impacts to navigation. The lock would be closed for approximately 90 days for three consecutive winter seasons. For Locks 14 through 18, there is minimal wintertime traffic, making the construction impact less than for lock extensions at Locks 20 through 25 in Alternative 5. The NED losses due to winter closure periods were considered in the economic model.

For new locks at Locks 20 through 25, a significant amount of construction occurs during the winter season. In all but the last year of construction of a new lock (due to dewatering of both locks), a scheduled opening(s) may be allowed to accommodate traffic that typically occurs on the lower five locks on the Mississippi River in the wintertime. It is doubtful that all traffic could be accommodated, but there would still be an economic benefit. This benefit was not captured in the economic model.

In a situation where lock extensions were to experience construction delays, causing construction beyond the wintertime closure period, the consequences of navigation impacts would be large. Wintertime navigation closures were used to allow uninterrupted construction work. These were modeled as fixed durations of about 90 days each and then traffic would resume. If the construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. The chance of construction delay and the duration of delay were not considered in the economic model because both are uncertain.

For new locks, a prolonged construction season would likely mean that the existing lock could still be opened on time for the navigation season. The chance of construction delay for new locks and lock extensions may be similar, but the consequences of a prolonged construction schedule would be much worse for lock extensions. This benefit was not captured in the economic model because the probability of occurrence of a prolonged schedule as well as its duration is uncertain.

Efficiency (Alt. 6): Moorings, switchboats, lock extensions, and new locks provide positive efficiency benefits to the system as measured by the NED benefits for some economic conditions.

Sustainability (Alt 6): Moorings, switchboats, lock extensions, and new locks will not be sustainable for low growth scenarios; however, they will be sustainable for high growth scenarios.

OBJECTIVE E2. Address cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.
An assessment of cumulative effects was conducted using an interdisciplinary team of experts and archival information concerning changes in the system since construction of the 9-foot channel project (ENV Report 40). The cumulative effects assessment provided the context against which to consider both the extent and significance of any direct or secondary effects that may result from the alternatives. This effort also contributed important information on the likely future (without) condition of the UMRS ecosystem. Objective E2 guided the development of alternatives for ecosystem restoration alternatives including modifications to the operation and maintenance of the navigation project for environmental considerations addressed in Section 6.2 of this report.

OBJECTIVE E3. Assure that any recommended measures are consistent with protecting the Nation's environment; avoiding, minimizing, or mitigating significant environmental, cultural, or social impacts.
The development of measures and alternatives took into consideration avoiding and minimizing environmental, cultural, and social impacts. Where impacts could not be avoided, a mitigation plan was developed and these costs are included in the NED development outlined above. An adaptive mitigation strategy was developed to address any significant construction site impacts or systemic impacts associated with any incremental impacts of traffic over the without-project condition. The mitigation strategy focused on the incremental effects from the implementation of any alternatives in the context of ongoing and cumulative effects referenced above.

Alternative 1: No Action. By definition, there are no additional environmental impacts above the without project condition.

Alternative 2: Congestion Fees Implemented through a Lockage Fee (imposed on commercial traffic). This alternative may result in positive environmental consequences on the waterway, since it has the potential to take traffic off the system. These effects have been quantified using the traffic effects models. However, they were not monetized for inclusion in the NED analysis. A preliminary assessment of environmental and social consequences resulting from shifting traffic to alternative transportation modes is described in the Other Social Effects section of this report.

Alternative 3: Excess Lockage Time Fees. No environmental impacts were assessed since incremental traffic is zero and there are no site-specific impacts.

Alternative 4: Moorings (12, 14, 18, 20, 22, 24, and La Grange); Switchboats at Locks 20 through 25. This alternative results in an incremental increase in traffic, which has been assessed and is included in the NED analysis. There are no site-specific mitigation costs for this alternative. The moorings may provide some unquantifiable positive benefits by allowing waiting tows to moor against a hardpoint rather than along the bankline. Switchboats may have some minor unquantifiable negative benefits due to the additional resuspension of sediment around the lock areas and additional potential fish entrainment.

Alternative 5: **Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 and 18, La Grange and Peoria**. This alternative results in an incremental increase in traffic and site-specific impacts, which has been assessed and is included in the NED analysis. The moorings and switchboats provide the same minor effects presented in Alternative 4. The lock extensions may result in some minor unquantifiable positive benefits early in the planning horizon by reducing the use of current waiting areas above and below the lock sites.

Alternative 6: **Mooring (12, 14, 18, and 24); New Locks at 20 through 25, La Grange, and Peoria; Lock Extensions at 14 through 18; and Switchboats at Locks 11 through 13**. This alternative results in an incremental increase in traffic and site-specific impacts, which has been assessed and is included in the NED analysis. The moorings and switchboats may provide the same minor effects outlined in Alternative 4. The lock extensions and new locks may result in some minor unquantifiable positive benefits by reducing the use of current waiting areas above and below the lock sites.

F. Acceptability

Acceptability is the workability and viability of the alternative plan with respect to acceptance by Federal, State and local entities; the general public; and compatibility with existing laws, regulations, and public policies (P&G Section VI.1.6.2(c)(4)). The feasibility study is not yet complete; however, observations have started to surface that provide some insight into the acceptability of the alternatives. For this study, we have organized stakeholder acceptability into the following categories:

F1. Institutional

This stakeholder group includes representatives holding official government positions representing the interests of the various Federal, State, and municipal agencies; for example, the five UMR States (Illinois, Iowa, Wisconsin, Minnesota, Missouri), their respective departmental representatives, Federal agencies (U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, U.S. Department of Transportation, U.S. Department of Agriculture), etc.

The Department of Transportation and the Department of Agriculture have expressed a desire for something other than the no action alternative and Alternative 2, although they have not yet endorsed any specific alternative. Current law prohibits Alternative 2, and current national policy calling for full use of all transportation modes to reduce congestions and facilitate economic growth makes institutional acceptance of this alternative doubtful. The Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. None of the States has yet endorsed a specific navigation efficiency alternative. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements.

F2. Social

This stakeholder group includes the general public and non-governmental organizations such as MARC 2000, Audubon, National Corn Growers, The Nature Conservancy, the towboat industry, Mississippi River Basin Alliance, etc. The primary alternatives were presented at a series of seven public meetings in October 2003 (Table 7-7). These meetings were structured to allow members of the general public to ask questions, voice their opinions on the study process or alternatives, submit written statements, and complete a comment form.

The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks.

Current national policy to maximize the capacity and efficiency of existing modes of commodity transportation makes institutional acceptability of this alternative plan doubtful. The Department of Transportation and the Department of Agriculture have indicated that Alternative 2 is incompatible with national policy that calls for efficient use of all transportation modes and incompatible with reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative. The navigation and agriculture non-governmental organizations have expressed negative comments, while the environmental interests have generally expressed the need to fully consider this alternative plan.

The following provides a brief summation of the general acceptability information obtained from the seven public meetings held during October 2003:

- Average attendance at the series was over 180 persons (see summary table for attendance numbers for the open house and formal presentation at each location).
- 57 percent of those that saw the slide presentation turned in a comment form.
- Of the 608 comment forms turned in:
    - Agriculture interest was the largest primary interest group at 34 percent, followed by other business/industry at 23 percent, and environmental interest at 15 percent.
    - About 62 percent of the persons returning comment forms were from an economic interest (including agriculture, waterborne industry, and other industries/business)
    - Personal interest was 8 percent and recreation was 4 percent of those who turned in a comment form. (5 percent did not answer.)
- Navigation Acceptability related questions – 5-point scale with a no answer option.
    - Over 79 percent said they understand how the study process was developed to arrive at the alternative plans presented.
    - Over 87 percent said they understand the principal navigation and ecosystem problems being addressed by the study.
    - Over 67 percent said they understand the process for evaluating navigation efficiency and ecosystem restoration alternatives.
    - Over 74 percent said they feel sustainability of the river system requires a balanced approach between economic and environmental interests.
    - Almost 84 percent said they feel collaboration is an important mechanism for a greater set of interests in this study to be heard.
    - Over 82 percent said they feel collaboration is critical to project success.
    - Over 68 percent said they feel the collaborative study approach will provide a recommendation that encompasses desired holistic approach.
    - Over 46 percent said they have attended a prior Navigation Study public meeting.

Other Observations:

- Over 80 percent agreed that the alternative plans presented reflect the study's dual purpose.
- Over 72 percent agreed that the alternative plans meet or address navigation efficiency and ecosystem restoration goals for the study.
- Almost 72 percent agreed that the study's balanced emphasis on economic and environmental sustainability is reflected in the alternatives.
- Almost 84 percent agreed that it is possible to sustain a healthy river ecosystem and continue commercial barge traffic.

- Almost 85 percent said the meeting was worth attending, while 6 percent were neutral, 2 percent disagreed, and 6 percent did not answer.

Table 7-7. Summary Table of October Public Meetings for UMR-IWW System Navigation Feasibility Study.

Location	Attendance	Q&As	Statements	Survey
STL	133 / 100	72	29	44
QUI	180 / 130	46	23	76
PEO	215 / 190	60	32	134
DAV	252 / 224	90	37	110
BLM	99 / 89	43	24	61
LAX	165 / 127	78	34	70
DBQ	218 / 198	67	42	113
TOTALS	1262 / 1058	456	221	608

- **Media Correspondents = 31 (Range 1 – 7)**
- **Congressional Representation = 18 (Range 0 – 4)**

Attendance numbers differentiate between Open House/Formal Presentation attendance.

G. Adaptability

Adaptability is defined as the ability to adjust the alternative based on changes in future conditions. It is the extent to which an alternative defers the commitment of resources or the degree to which the commitment is reversible. Alternatives that offer the greatest amount of flexibility could be viewed more favorably under a high degree of uncertainty or risk. Adaptability is an implementation tool that will be fully considered during development of the plan. For example, the adaptability of alternatives will be further augmented with supplemental or future assessments under NEPA. The following provides a brief description of possible adaptive approaches for each of the primary alternatives:

Alternative 1: Base condition.

Alternative 2: The implementation of congestion fees will require Congressional action and could be in place within a relatively short time frame (assumed to be 2 years). This alternative is very flexible in that, once authorized, it can be implemented or dismantled relatively quickly.

Alternative 3: Not justified for any of the economic conditions.

Alternative 4: The implementation timeline for this alternative is divided into a planning, engineering and design phase, and a construction phase. Each of these phases could be considered a decision point in an adaptive management type of process. For instance, a decision could be made to complete the planning, engineering, and design phase and then reevaluate the need for this alternative. This would minimize the risk by controlling the magnitude of the investment decisions. An advantage of the switchboats is that they can be put in place and removed in a relatively short amount of time.

Alternative 5: This alternative can also be divided into distinct phases for consideration in an adaptive management framework. Decision points could be established at the end of major building blocks and would serve as reevaluation points. For example, a recommendation could be to start only the planning, engineering, and design for Alternative 5. A reevaluation would be accomplished at a future decision point to confirm the initial investment decisions and proceed with construction.

Alternative 6: This alternative is similar to Alternative 5 in that distinct phases could be developed that would control the magnitude of the investment decisions.

7.2 Evaluation of Ecosystem Restoration Alternative Plans

7.2.1 Description of the Evaluation Process

The best plan cannot be selected from among a set of good plans unless we have some way to compare them. It is only by comparison that a plan is no longer good enough, or that a good plan becomes the best plan. The purpose of the comparison step is to identify the most important criteria to evaluate the plans and compare the various alternative plans across those criteria. Ideally, the comparison of plans concludes with a ranking of plans or some identification of the best course of action for the decision-makers. The comparison method must be transparent. That is, it must be easy to explain and easy for the stakeholders and decision-makers to follow and understand.

The selection of a recommended plan requires that individual alternative plans be compared against the without project condition and against one another using pre-established rules, criteria, and system of accounts. Alternative plan comparisons were largely driven by the evaluation of information generated during the formulation of the alternatives (e.g., costs, area of influence, etc.). Additional information regarding alternative completeness, social effects, and adaptability was also acquired and assessed.

Ecosystem restoration alternatives were evaluated under seven accounts of (A) National Ecosystem Restoration (NER) Benefits, (B) Environmental Quality, (C) Regional Economic Development, (D) Other Social Effects, (E) Contribution to Planning Objectives, (F) Acceptability, and (G) Adaptability. A brief description of each of these accounts is provided in Section 7.2.2.

The first account listed above (NER) is pursuant to Engineer Regulation (ER) 1105-2-100 and the next three are pursuant to the Principles and Guidelines (P&G) primary accounts to facilitate an evaluation process. Within these accounts, the four P&G evaluation criteria of completeness, efficiency, effectiveness, and acceptability are included to provide the primary basis of comparing and evaluating the ecosystem alternative plans. Completeness and effectiveness criteria are captured in the (B) Environmental Quality account. Additionally, these criteria are also included in the (E) Contribution to Planning Objectives account. Cost effectiveness measures within the (A) Environmental Benefits (NER) account provide measures of the alternative efficiency in meeting ecosystem objectives. The evaluation of social and institutional acceptability is included in the (F) Acceptability account.

7.2.2 System of Accounts, Evaluation Criteria, and Scores

The evaluation of ecosystem alternatives relied primarily on qualitative analyses and estimated quantitative outputs. The quantitative analysis relied primarily on assessment of environmental benefits and quality. The qualitative analysis focused on the predetermined criteria of adaptability, uncertainty, acceptability, and other social effects.

<u>Quantitative</u>
Alternative Costs
Acres of Influence
Cost Effectiveness
Ecosystem Completeness
Regional Economic Development (income and jobs)

<u>Qualitative</u>
Ecosystem Diversity
Ability to Address Upper Mississippi River Conservation Committee Ecosystem Objectives
Maintenance and Enhancement of Ecosystem Goods and Services
Contribution to Study Planning Objectives
Acceptability and Adaptability

The evaluation and comparison of ecosystem restoration alternatives require the consideration of a great deal of information developed over the past decade. To be most useful, it is important that this accumulation of information be effectively organized for consideration by team members, stakeholders, the public and decision-makers for use in the comparison step. The P&Gs and ER 1105-2-100 establish a system of primary accounts to facilitate a comparative process. These accounts have been devised to encompass all significant effects of a plan as required by the National Environmental Policy Act of 1969 and Section 122 of the Flood Control Act of 1970. The accounts include (A) Environmental Benefits - National Ecosystem Restoration (NER), (B) Environmental Quality (EQ), (C) Regional Economic Development (RED), and (D) Other Social Effects (OSE). All of the alternative plan effects are typically assigned to and displayed in one of these four robust categories. Strictly speaking, only the NER account is required. For the purposes of this study, three additional accounts were established to include other important comparative considerations: (E) Contribution to Planning Objectives, (F) Acceptability, and (G) Adaptability. The following descriptions of the accounts were developed to ensure interested parties were clear on the intent and application of these accounts in the alternative plan comparison process. Each of the seven accounts also has specific evaluation criterion and data that have been identified as the foundational elements of the ecosystem restoration alternative plan comparisons. Asterisks next to the specific criteria indicate their elevated importance in the final decision process.

A. Environmental Benefits-National Ecosystem Restoration (NER)

The environmental equivalent to the NED is the National Ecosystem Restoration (NER) benefits. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost-effective and justified to achieve the desired level of output. Typically, an ecological alternative would yield some measure of benefit expressed in terms of increased acres of habitat, percentage of improved functionality, or abundance of species X or Y, few of which lend themselves to a direct monetary amortization of benefit.

Traditional Corps of Engineers ecosystem restoration project evaluations include an assessment of increases in ecosystem (often habitat) quality and quantity as well as a cost effectiveness - incremental cost analysis pursuant to ER 1105-2-100. It was not feasible to exercise Habitat Evaluation Procedures (HEP), which quantitatively consider anticipated changes in both quantity and quality of habitat for specified target species, over the 1,200-river-mile-long project area. Likewise an incremental cost effectiveness analysis based on habitat units could not be conducted. These will be important tools in designing and sizing specific projects within defined river reaches and pools during the adaptive implementation phase.

In lieu of a formal HEP-based cost effectiveness analysis, the environmental benefits of the ecosystem restoration alternatives were assessed by examining their costs in comparison to the potential area of influence (acres). The cost effectiveness of fish passage and water level management elements of the alternatives were assessed separately from the other elements of the alternatives and then recombined in the final analysis in order to better assess the benefits offered by these two measures.

A1. Project Cost

- Costs associated with implementing the UMRS ecosystem alternative plans (Table 7-8).

Table 7-8. UMRS ecosystem alternative costs in 2003 dollars.

	Cost ($1,000,000's)				
	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
A1a. Total Cost	$0	$1,691.7	$2,816.6	$5,182.8	$8,416.7
A1b. Cost (without Fish Passage or WLM)	$0	$1,561.9	$2,686.8	$4,262.7	$6,272.8
A1c. Total Average Annual Cost (from 2005)	$0	$35.1	$58.4	$106.3	$174.5

A1a. Total Cost

- Total ecosystem alternative plan cost (without O&M).

A1b. Cost (without Fish Passage or WLM)

- Total ecosystem alternative plan cost (without fish passage or water level management).

A1c. Total Average Annual Cost (Base Year 2005)

- Average annualized cost of the ecosystem alternative plan over 50 years with a base year 2005.

A2. Environmental Benefits (Acres of Influence) (without fish passage and water level management)

- Potential area of influence (i.e., improvement) produced by the ecosystem alternative plans (Table 7-9). This does not include areas influenced by fish passage or water level management.

Table 7-9. Potential ecosystem alternative area of influence.

UMR-IWW Ecosystem Measure Benefits	Area of Influence (Acres)				
Ecosystem Measure	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Island Building	0	31,000	68,000	91,000	116,000
Fish Passage	0	0	0	287,236	577,815
Floodplain Restoration	0	1,000	1,000	90,500	236,500
Water Level Management - Pool	0	28,200	28,200	28,200	44,650
Water Level Management - Backwater	0	0	1,000	7,000	9,000
Backwater Restoration (Dredging)	0	43,200	82,800	124,800	162,000
Side Channel Restoration	0	5,800	10,700	14,700	17,300
Wing Dam/Dike Alteration	0	180	510	640	680
Island Protection	0	37,680	37,680	37,680	37,680
Shoreline Protection	0	705	705	705	705
Topographic Diversity	0	256	256	256	256
Dam Point Control	0	0	6,000	6,000	9,000
Floodplain Restoration - Immediate Opportunities	0	0	15,000	15,000	15,000
Total Area of Influence	0	148,021	251,851	703,717	1,226,586
Area of Influence (w/out Fish Passage and WLM)	0	119,821	223,651	388,281	604,121

Each alternative will influence varying amounts of the system depending on the type and quantity of measures included in the alternative. In this assessment, the acres of potential influence were identified for each measure and then totaled to identify the total area of influence for each alternative. Fish passage was assessed separately due to the reduced accuracy of associating area of influence with tributary length benefits and the potential to double-count its benefits with other measures. Water level management was also assessed separately because of the increased potential for double-counting the benefits of this measure. For example, the area of influence benefits of water level management and side channel restoration may occur in the same area.

***A3. Cost Effectiveness**
- The efficiency of ecosystem alternative plans in addressing the UMRS environmental needs. Efficiency was assessed by examining the cost effectiveness of fish passage, water level management, and the combined efficiencies of the remaining alternative measures.

A3a. Alternative Cost Effectiveness
- Alternative plan cost per acre of influence (A1b ÷ A2) (Table 7-10).

Table 7-10. Alternative plan cost effectiveness (i.e., cost per acre of influence).[a]

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
A1b. Alternative Cost (w/out Fish Passage or WLM)	$0	$1.6B	$2.7B	$4.3B	$6.3B
A2. Environmental Benefits (area of influence)	0	119,800	223,700	388,300	604,100
A3a. Alternative Cost Effectiveness (cost per acre)	$0	$13,000	$12,000	$11,000	$10,400

[a]Estimates of alternative cost effectiveness do not include fish passage or water level management costs and benefits.

The efficiency of ecosystem alternatives in addressing the environmental needs was assessed by examining their overall cost effectiveness (i.e., cost ÷ area of influence). This estimate of cost effectiveness was influenced primarily by the type and quantity of measures making up the alternative. That is, an alternative with a higher proportion of efficient measures would be more cost effective and have a lower cost per acre of influence. The costs and benefits of water level management and fish passage measures contained in the alternatives are evaluated below.

A3b. Water Level Management Cost Effectiveness
- The cost effectiveness of water level management measures included in the alternative plans.

Whereas the overall cost effectiveness of alternatives was affected mainly by the type and quantity of measures, measure cost effectiveness was influenced primarily be selecting more cost efficient locations for specific measures. By examining the cost and benefits of individual measures in each alternative, the most efficient level of investment could be determined. A detailed assessment of water level management was performed by a multi-District work group. The group examined the cost effectiveness of water level management modifications driven by acres affected, cost, and the likelihood of a successful 60-day drawdown. Water level management conducted in the 12 pools included in Alternatives B through D was determined to be more efficient than the 26 pools in Alternative E (Figure 7-3).

A3c. Fish Passage Cost Effectiveness
- The cost effectiveness of fish passage measures included in the alternative plans.

A comprehensive assessment of fish passage techniques and potential locations was also conducted by a technical work group. Fish passage sites were evaluated by examining added stream miles, surface areas of pools, projected costs, and the amount of time fish passage can currently take place (with gates out of the water). A longitudinal connectivity index (LCI: available stream length and size) value was used instead of area of influence due to the difficulty in converting stream lengths to estimates of area (see Section 6.2.5.1). Fish passage measures incorporated into Alternative D exhibit higher efficiencies than the measures in Alternative E (Figure 7-4). This is due to the work groups identifying the more efficient measure locations and having them incorporated into Alternative D. The locations were also selected based on existing need (i.e., percent of time the dam gates are out of the water: Figure 9-4). The 14 fish passage locations included in Alternative D have a cost per LCI of $9,100, whereas the cost per LCI of the 33 fish passage structures in Alternative E is $14,800.

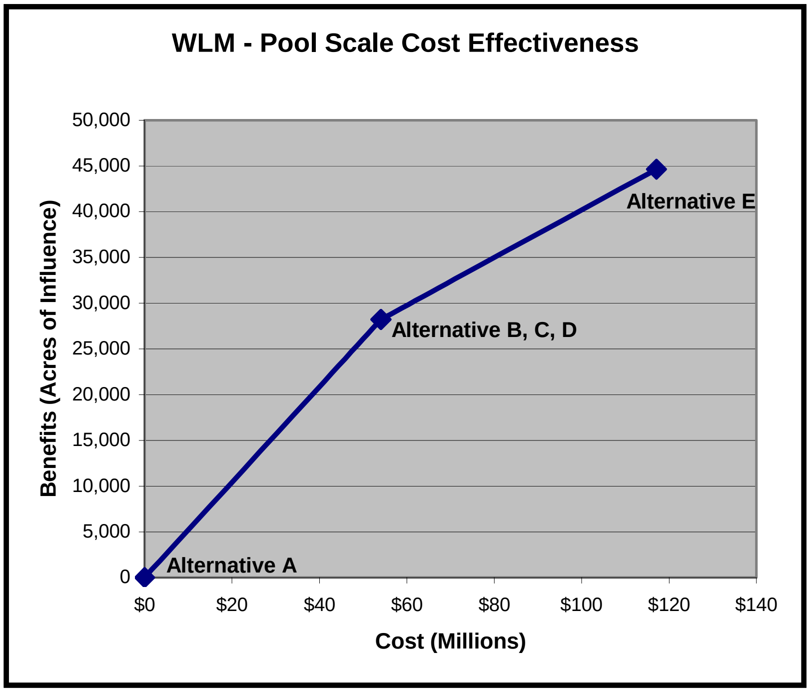


Figure 7-3. Water level management cost effectiveness.

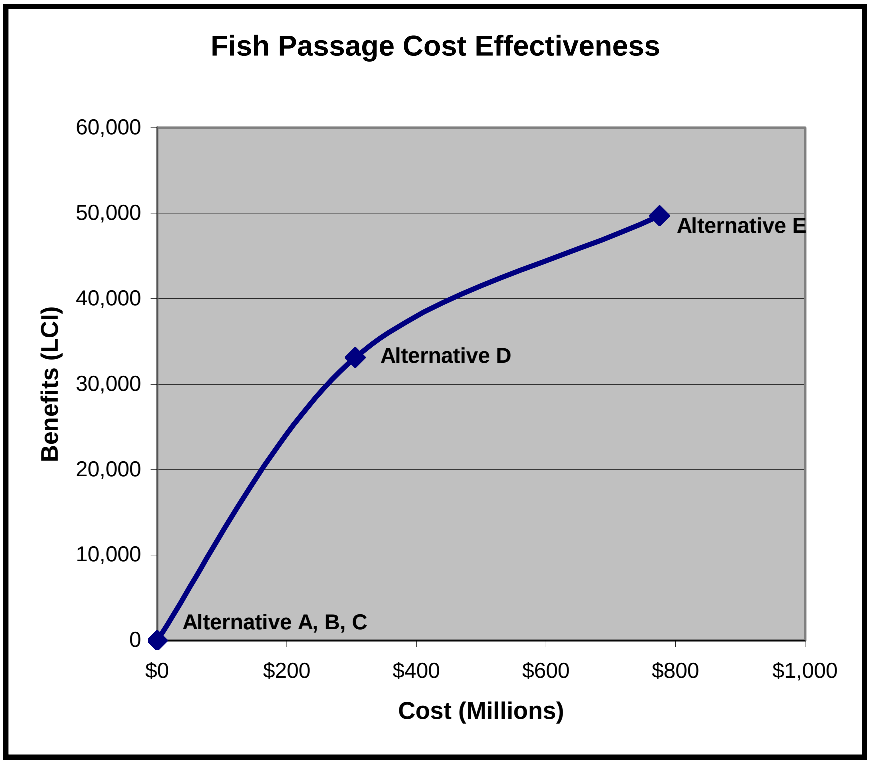


Figure 7-4. Fish passage cost effectiveness.

B. Environmental Quality

The obvious question that generally follows this type of ecological accounting is "How much is enough? or Is this output significant?" With these questions in mind, the assessment of ecosystem restoration alternatives has been designed around the spatially explicit ecosystem goals and objectives endorsed by the study team, regional stakeholders, and Science Panel convened for this study. These objectives represent a virtual reference or desired ecological condition for the UMRS.

Environmental quality effects were evaluated primarily by assessing ability of the alternative to fully address the needs of the UMRS ecosystem. By examining the number, type, and potential results of restoration measures, the completeness and diversity of ecosystem alternatives were quantitatively and qualitatively assessed. This process included identifying the extent to which the alternative plan:

- maintains or exceeds the existing condition,
- accounts for ecosystem needs identified in the virtual reference,
- accounts for nine essential UMRS ecosystem objectives identified in *A River that Works and a Working River* (UMRCC 2000) report, and
- affects ecosystem diversity.

*B1. Completeness

- The extent to which the ecosystem alternative plan meets the identified needs of the UMRS ecosystem.

B1a. Relation to Existing Condition (without-project comparison)

- Relation of the alternative to the existing condition (Table 7-11). The without-project condition is described in relation to the existing condition.

Table 7-11. Alternative plan relation to the existing condition.

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
B1a. Relation to Existing Condition	Lose Habitat	Maintain Habitat	Maintain/ Restore	Maintain/ Restore	Maintain/ Restore

The Cumulative Effects Study (WEST 2000) and Habitat Needs Assessment Report (USACE 2000b) describe the UMRS ecosystem condition as a state of continued habitat loss and degradation over time. In an effort to assess the completeness of the ecosystem alternative plans, they were evaluated against the existing condition. This evaluation identified whether they lost, maintained, or restored habitat in relation to current ecosystem conditions. It is estimated that the no action plan (Alternative A) will result in continued loss of habitat. Alternative B attempts to maintain the existing mosaic of habitat quality and quantity. Alternatives C through E result in increasing levels of restoration.

B1b. Proportion of the Ecosystem Measures

- The extent to which the alternative plan accounts for ecosystem needs identified in the virtual reference.

The UMRS Environmental Objectives Database was developed to provide an estimate for the desired future condition (i.e., virtual reference) of the UMRS ecosystem. This database was used to identify the type and quantity of management and restoration measures needed to achieve the virtual reference condition (Table 7-12). The proportion of virtual reference measures addressed by the ecosystem alternatives provides an initial estimate of the completeness of the ecosystem alternative plans. For example, Alternative C addresses 56 percent of the identified Virtual Reference measures collectively. It is important to keep in mind that both the cost and benefits of individual virtual reference measures vary greatly. That is, a fish passage structure costing in excess of $20 million is counted as a single reference, the same as a modest stream bank protection action.

Table 7-12. Number of ecosystem measures within each alternative.

Ecosystem Measure	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Virtual Reference
Island Building	0	31	68	91	116	172
Fish Passage	0	0	0	14	33	33
Floodplain Restoration	0	2	2	37	77	98
WLM - Pool Scale	0	12	12	12	26	26
WLM - Backwater	0	0	1	7	9	10
Backwater Restoration (Dredging)	0	72	138	208	270	383
Side Channel Restoration	0	58	107	147	173	225
Wing Dam/Dike Alteration	0	18	51	64	68	74
Island Protection	0	157	157	157	157	157
Shoreline Protection	0	235	235	235	235	235
Topographic Diversity	0	32	32	32	32	32
Dam Point Control	0	0	2	2	3	3
Floodplain Restoration - Im. Op.	0	0	3	3	3	3
Total	**0**	**617**	**808**	**1,009**	**1,202**	**1,451**
Percent of Total	**0%**	**43%**	**56%**	**70%**	**83%**	**100%**

B1c. UMRCC Environmental Objectives (River that Works Report)
- The extent to which the alternative plan accounts for nine essential UMRS ecosystem objectives identified in *A River that Works and a Working River* report (UMRCC 2000), a popular reference document with many stakeholder groups.

The UMRCC report, *A River that Works and a Working River*, identified nine environmental objectives vital to restoring and maintaining the health of the UMRS ecosystem (Table 7-13). Assessing the number of essential UMRCC objectives considered by each ecosystem alternative provides an additional estimate of their completeness in achieving the environmental needs of the system.

Table 7-13. Alternative contribution to essential UMRS ecosystem objectives.

Ecosystem Objectives (from River that Works Report)	Alt A	Alt B	Alt C	Alt D	Alt E
1. Improve Water Quality for all Uses	0	X	X	X	X
2. Reduce Erosion and Sedimentation Impacts	0	X	X	X	X
3. Restore Natural Floodplain	0	0	X	X	X
4. Restore Natural Hydrology	0	X	X	X	X
5. Increase Backwater Connectivity with Main Channel	0	X	X	X	X
6. Increase Side Channel, Island, Shoal, and Sand Bar Habitat	0	X	X	X	X
7. Minimize or Eliminate Dredging Impacts	0	X	X	X	X
8. Sever Pathways for Exotic Species Introductions/Dispersal	0	0	0	0	0
9. Improve Native Fish Passage at Dams	0	0	0	X	X

Although the spread of exotic species is not directly addressed by measures within the restoration alternatives, non-native species will maintain a high priority as a component of the ecosystem alternative plan's rigorous adaptive management program. This program will seek to acquire necessary information to contribute to better understanding of exotic species dispersal, effects, and potential means of control.

***B2. Ecosystem Diversity**
- A qualitative assessment of the alternative plan effect on ecosystem diversity (Table 7-14).

Ecological diversity is a complex concept because it can involve species, populations, communities, habitats, processes, and many other issues. In this evaluation, the alternatives were all presumed to affect overall ecosystem diversity to some degree. Rather than itemize species, habitats, and processes, systemic ecosystem goals (see Section 6.2.1) were used to represent the large array of ecosystem elements likely to be affected by each alternative at a programmatic level. These categories (Table 7-14) were then ranked low, moderate, or high based on their likelihood to influence ecological diversity. A low rank will likely maintain existing habitat conditions and populations, but will not restore floodplain function. A moderate rank restores some habitats and functions. A high rank restores significant habitats and functions. Each project will be evaluated in more detail using traditional Habitat Evaluation Procedures or other suitable means during detailed project design.

Table 7-14. Alternative effect on UMRS ecosystem diversity.

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
B2a. Maintain viable populations of native species in situ.	-	Low	Moderate	High	High
B2b. Represent all native ecosystem types across their natural range of variation.	-	Low	Moderate	High	High
B2c. Restore and maintain evolutionary and ecological processes.	-	Low	Low	Moderate	High
B2d. Integrate human use and occupancy within these constraints.	-	-	-	-	-

The proposed ecosystem restoration alternatives address population viability primarily through affecting physical conditions to achieve a desired habitat or organismal response (e.g., creating deepwater habitat will provide better overwintering conditions and thus increase fish populations because individual fish will be healthier and produce more, healthier offspring). Some measures also address diversity directly through planting (e.g., trees, grassland, marsh, etc.). Alternative A was not ranked because no action under this plan will affect native species, habitats, or processes, though ongoing programs may. Alternative B addresses a moderate level of diversity because it emphasizes processes that affect diversity. Alternative B includes water level management that will affect marsh communities, it creates topographic diversity that will increase forest community diversity, and it is also structured to maintain the existing abundance and quality of backwaters, secondary channels, islands, and channel border habitat. Alternative C addresses similar elements as Alternative B, but at a level that achieves the first increment of restoration. Floodplain restoration is also introduced in Alternative C, which is an initial effort to restore some of the evolutionary and ecological processes that occur in floodplain habitats. Alternatives D and E achieve the highest levels of diversity because they address an array of ecosystem components and processes, and by extension diversity, at environmentally suitable and optimal levels, respectively. All the ecosystem elements addressed in the other alternatives are addressed in Alternatives D and E, but the amount of effort allocated and the distribution of potential projects is greater. Alternative E is noted as having a slightly higher effect than Alternative D on restoring and maintaining evolutionary and ecological processes, primarily because it includes systemic fish passage and water level management.

All these alternatives will be designed and implemented within the constraints of human use and occupancy of the UMRS, but floodplain restoration will have more unavoidable human impacts than other restoration efforts. Floodplain restoration will require conversion of cropland to other uses, which could displace farmers willing to sell their land. However, some floodplain restoration objectives could be achieved through Federal agency, non-Federal agency, or landowner involvement. Pool-scale water level management will have minor short-term impacts on recreation, but these will be offset by the substantial benefits obtained from this measure. Other proposed measures will have little to no impact on the human uses of the UMRS. This includes commercial navigation, which will not be affected by the restoration measures. An integrated adaptive management framework will optimize coordination among river users and uses.

C. Regional Economic Development (RED)

The income and employment benefits for each alternative were computed for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri along with the Lower Mississippi River Region and the rest of the United States. This information is being presented at the request of the States and should assist them in formulating their respective position statements. RED benefits are presented as average annual income and average annual jobs created from 2005 to 2035. This time frame was used (rather than a 50-year time frame) due to limitations of the RED model. The RED assessment only considered income and employment directly related to alternative construction, which made up approximately 75 percent of the total alternative cost. This information was developed by the Tennessee Valley Authority using the REMI model.

The REMI model, constructed by Regional Economic Models Inc. of Amherst, Massachusetts, was used in this study to calculate the Regional Economic Development (RED) benefits of alternatives. RED benefits are presented as changes in gross regional product, income, output, and employment. These benefits are regional in nature, and are not included in the benefit to cost ratio. REMI models are econometric models with highly detailed input-output industry categories. The specific model constructed for this project is a multi-regional model, the regions being each of the five States in the Upper Mississippi River area (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), the Lower Mississippi Valley region, and the Rest of the Nation. Further details of the model can be found in the report entitled *Regional Impacts of Proposed Navigation, Ecosystem, and Flood Control Improvements on the Upper Mississippi River and Illinois Waterway* (TVA 2004, EC-19).

C1. Average Annual Income to the Five States

- The average regional income provided annually by the construction of ecosystem restoration alternatives from 2005 to 2035 (Table 7-15).

Table 7-15. Average annual income (millions).

Region	Alt A	Alt B	Alt C	Alt D	Alt E
Minnesota	$0.00	$3.30	$5.30	$8.20	$14.50
Wisconsin	$0.00	$4.10	$6.80	$11.30	$16.80
Iowa	$0.00	$2.50	$4.20	$7.70	$10.60
Illinois	$0.00	$9.90	$17.00	$30.80	$51.20
Missouri	$0.00	$2.90	$4.50	$8.20	$13.30
L Miss	$0.00	$0.80	$1.70	$2.00	$4.40
Rest of U.S.	$0.00	$4.50	$7.50	$10.10	$14.70
Total	**$0.00**	**$28.00**	**$47.00**	**$78.20**	**$125.60**

The income displayed in Table 7-15 does not include contingency, planning, engineering, design, or administration costs. Factoring in these additional components will increase the total annual income provided to the States.

C2. Average Annual Employment for the Five States

- The total number of jobs added or lost regionally each year due to alternative plan construction needs from 2005 to 2035 (Table 7-16).

Table 7-16. Average employment per year (jobs).

Region	Alt A	Alt B	Alt C	Alt D	Alt E
Minnesota	0	64	105	161	278
Wisconsin	0	78	128	212	314
Iowa	0	58	97	178	251
Illinois	0	148	248	449	741
Missouri	0	55	90	164	261
L Miss	0	15	14	-5	55
Rest of U.S.	0	50	77	18	184
Total	**0**	**468**	**759**	**1,177**	**2,083**

The income and employment benefits for each alternative are reported for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri along with the Lower Mississippi River Region and the rest of the United States. In general, the higher the investment in an alternative, the greater the benefits to the region.

D. Other Social Effects (OSE)

Other social effects were assessed primarily in the form of ecosystem goods and services maintained or enhanced by the alternative plans. Ecosystem management and restoration included in the alternatives increase or maintain ecosystem processes, biodiversity, biological productivity, and the carrying capacity of ecosystems to support human societies. The benefits of ecosystem management and restoration in Federal water resources planning language are called outputs. The outputs of ecosystem management and restoration are the net increases in ecosystem goods and services (e.g., water quality, nutrient processing, recreation, commercial fishing, etc.).

D1. Ecosystem Goods and Services

- Effect of the alternative plans on goods and services produced by ecosystem processes (Table 7-17).

Each ecosystem generates a different set of goods and services of value to human society. The UMRS is a large floodplain river ecosystem that provides a wide range of goods and services (Table 7-17). Overall, the ecosystem restoration alternatives would have a net positive effect on UMRS ecosystem goods and services including maintenance of biodiversity, cycling of nutrients, recreational opportunities, etc. Livestock watering and recreational boating are the only components that would be negatively affected by the alternatives, primarily through water level management (drawdown of the pool). These effects would be minimal based on the duration of the drawdown (i.e., 60 days every 5 to 7 years). Also, recreational boating would see an overall increase in benefits due to additional aquatic areas made accessible through alternative plan backwater and side channel restoration measures. The alternatives would have no effect on commercial navigation, water supply, hydroelectric power, and moderation of river valley climate.

UMRS ecosystem management actions are targeted toward increasing one or more of these ecosystem goods and services that are of value to human society and to other living resources of the river system. Each UMRS management action has certain scales of effect that can be estimated by magnitude, spatial extent, frequency of application, and duration of effect.

Not all UMRS management actions affect the pattern of habitats, although many do. Our ability to predict the ecological effects, effectiveness in achieving ecosystem objectives, and outputs of ecosystem management actions is presently fairly limited. We fall back on estimating changes in area of larger-scale physical habitat types as outputs of ecosystem management and restoration. We typically do not attempt to quantify outputs as the net changes in ecosystem goods and services.

In the future, as we apply adaptive ecosystem management and strive to develop a family of numerical ecosystem models, we may be able to develop an improved system of accounts quantifying the goods and services outputs of ecosystem management and restoration.

Table 7-17. Effect of alternatives on UMRS ecosystem goods and services.

Ecosystem Goods and Services	Alternative Effect		
	Positive	Negative	No Effect
Municipal water supply			X
Residential (groundwater) supply			X
Industrial process water			X
Industrial cooling water			X
Residential and commercial building cooling water			X
Irrigation water for agricultural crops			X
Irrigation water for urban landscapes			X
Livestock watering		X	
Hydroelectric power			X
Commercial navigation			X
Recreational boating	X	X	
Waste assimilation, purification	X		
Maintenance of aquatic and floodplain habitats	X		
Maintenance of biodiversity	X		
Production of human-edible food from fish, wildlife, vegetation	X		
Moderation of river valley climate			X
Attenuation of floods	X		
Cycling of nutrients	X		
Carbon sequestering, protection of atmospheric gas composition	X		
Generation and renewal of floodplain soils	X		
Soils that support floodplain agriculture	X		
Construction materials and fiber from floodplain forests	X		
Medicinal compounds	X		
Genetic materials for agriculture and medicine	X		
Aesthetic beauty, spiritual, cultural values	X		
Recreational opportunities	X		

E. Contribution to Planning Objectives

The goal of the feasibility study is to outline an integrated plan to ensure the economic and environmental sustainability of the UMR-IWW Navigation System. To fully address these feasibility study issues, the study team has identified the following three primary planning objectives:

1. Provide for a safe, reliable, and efficient UMR-IWW Navigation System over the planning horizon consistent with protecting the Nation's environment;
2. Address cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System; and
3. Measures are consistent with protecting the Nation's environment.

The ability of the ecosystem alternative plans to contribute to the study planning objectives was assessed (Table 7-18).

Table 7-18. Ecosystem alternative contribution to planning objectives.

Planning Objective	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
E1. Provide for a safe, reliable…	-	Neutral	Neutral	Neutral	Neutral
E2. Address cumulative impacts…	-	Partial	Partial	Yes	Yes
E3. Measures are consistent…	-	Yes	Yes	Yes	Yes

***E1. Provide for a safe, reliable, efficient, and sustainable UMR-IWW Navigation System over the planning horizon.**

- Positive/Neutral/Negative effect on this planning objective. Ecosystem Alternatives B through E were scored neutral for this objective. The measures included in the alternatives will not significantly affect the safety, reliability, or efficiency of the Navigation project.

***E2. Address cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.**

- Yes/Partial/No as to whether this planning objective is achieved. Alternatives B and C partially address the wide array of cumulative effects on the system. Alternatives D and E contain all the types of measures, implemented at a sufficient level, needed to address the variety of ongoing and cumulative effects. For example, loss of river connectivity both with its floodplain (latitudinal) and between pools (longitudinally) has been identified as a significant cumulative effect on the ecosystem. Alternatives D and E include fish passage and floodplain restoration at a level necessary to have systemic beneficial effects to address the connectivity issue. Alternatives B and C do not sufficiently address the connectivity issues.

***E3. Measures are consistent with protecting the Nation's environment.**

- Yes/Partial/No as to whether this planning objective is achieved. Ecosystem Restoration Alternatives B through E are consistent with protecting the Nation's environment.

F. Acceptability

Acceptability is the workability and viability of the alternative plan with respect to acceptance by Federal, State, and local entities; the general public; and compatibility with existing laws, regulations, and public policies (P&G Section VI.1.6.2(c)(4)). To be acceptable, a plan must have a perceived value, cost effectiveness, and high probability of success. There are many factors that can render a plan infeasible in the minds of individuals. These factors can generally be categorized as technical (engineering or natural world limitations), economic, financial, environmental, social, political, legal, and institutional.

The examination of stakeholder acceptability was organized into two categories:

1. Overall institutional and social alternative plan acceptability.
2. Acceptability of the partner requirements to aid in funding and implementing the alternative plans.

F1. Alternative Plan Acceptability

- Overall workability and viability of the alternative plan with respect to acceptance by Federal, State and local entities; the general public; and compatibility with existing laws, regulations, and public policies. The feasibility study is not yet complete; however, observations have started to surface that provide some insight into the acceptability of the alternatives. For this study, we have organized stakeholder acceptability of the alternative plan into the following categories:

F1a. Institutional

This stakeholder group includes representatives holding official government positions representing the interests of the various Federal, State, and municipal agencies. For example, the five UMR States (Illinois, Iowa, Wisconsin, Minnesota, Missouri), their respective departmental representatives, Federal agencies (U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, U.S. Department of Transportation, U.S. Department of Agriculture), etc.

The U.S. Fish and Wildlife Service has endorsed Ecosystem Alternative E through a formal letter submitted to the Corps. The States of Minnesota, Wisconsin, Iowa, and Missouri have also expressed interest in a modified version of Alternative E. Positions of the Federal agencies, States, and NGOs are presented in Chapter 13.

F1b. Social

- This stakeholder group includes the general public and non-governmental organizations such as MARC 2000, Audubon, National Corn Growers, The Nature Conservancy, towboat industry, Mississippi River Basin Alliance, etc. The ecosystem alternatives were presented at a series of seven public meetings in October 2003. These meetings were structured to allow members of the general public to ask questions, voice their opinions on the study process or alternatives, submit written statements, and complete a comment form.

Similar to the States, some environmental interests have expressed the desire for a modified version of Alternative E.

The following provides a brief summation of the acceptability information obtained from the seven public meetings held during October 2003:

- Average attendance at the series was over 180 persons.
- 57 percent of those that saw the slide presentation turned in a comment form.
- Of the 608 comment forms turned in:
  - Agriculture interest was the largest primary interest group at 34 percent, followed by other business/industry at 23 percent, and environmental interest at 15 percent.
  - Over 79 percent said they understand how the study process was developed to arrive at the alternative plans presented.
  - Over 87 percent said they understand the principal navigation and ecosystem problems being addressed by the study.
  - Over 67 percent said they understand the process for evaluating navigation efficiency and ecosystem restoration alternatives.
  - Over 74 percent said they feel sustainability of the river system requires a balanced approach between economic and environmental interests.
  - Over 80 percent agreed that the alternative plans presented reflect the study's dual purpose.
  - Over 72 percent agreed that the alternative plans meet or address navigation efficiency and ecosystem restoration goals for the study.
  - Almost 72 percent agreed that the study's balanced emphasis on economic and environmental sustainability is reflected in the alternatives.
  - Almost 84 percent agreed that it is possible to sustain a healthy river ecosystem and continue commercial barge traffic.

F2. Requirements of Partners

- Acceptability of the partner responsibility to aid in funding, implementing, and maintaining the ecosystem alternative plans under Cost Sharing Option C (Table 7-19).

Table 7-19. Partner cost share and operation and maintenance responsibilities.

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
Total Alternative Cost	$0	$1,692M	$2,817M	$5,183M	$8,417M
F2a. Cost Share ($)	$0	$209M	$336M	$1,051M	$2,207M
F2b. Cost Share (%)	0%	12%	12%	20%	26%
F2c. O&M (non-Corps) ($)	$0	$46M	$77M	$139M	$220M

Under Cost Sharing Option C, measures involving modification of the structures and operations of existing projects; on Corps project lands and lands included in the National Refuge System; and measures in the main channel or directly connected backwater areas below the Ordinary High Water Mark will be 100 percent Federal regardless of current ownership. Measures on other public or privately owned lands would be cost shared 65/35.

F2a and F2b. Cost Share
- Alternative plan Cost Sharing Option C cost share requirements of the partners (noted as total dollars and proportion of the alternative cost).

Under this option, partners will be required to cost share 12 to 26 percent of the ecosystem alternative cost (Table 7-19).

F2c. Operation and Maintenance
- Requirement of partners to fund and perform alternative plan operation and maintenance under Cost Sharing Option C. Partners will be responsible for $46 to $220 million of project O&M costs. The O&M costs displayed in Table 7-19 will appear lower than previous estimates because they account for the sequencing of projects during implementation. For example, if 20 percent of the projects are completed during the first 10 years, less than 20 percent of the O&M is required during this time period. Previous cost estimates were developed with all projects having a full 50-year duration of O&M.

On behalf of the five UMRS States, the Upper Mississippi River Basin Association has expressed support for Cost Sharing Option C. The U.S. Fish and Wildlife Service has also submitted a letter declaring its support for Option C.

G. Adaptability

Adaptability is defined as the ability to adjust the alternative based on changes in future conditions and our understanding of the system. Alternatives that offer the greatest amount of flexibility could be viewed more favorably under a high degree of uncertainty or risk. Adaptability is an implementation tool that will be considered fully during development of the recommended plan.

The implementation of ecosystem alternatives to address the complex assortment of ecological needs and objectives will be augmented using a rigorous adaptive management program. This process will seek to gather systemic information and monitor early projects to create the information tracking and feedback required in an adaptive management design. Using this process, the ecosystem alternatives will be more adaptable in testing and improving on the design and performance of measures and in establishing efficient sequencing of project implementation.

8.0 ENVIRONMENTAL EFFECTS OF PROPOSED ACTION

At the outset, it is useful to define the three major categories of impacts addressed in the Navigation Study: (1) direct, (2) indirect/secondary, and (3) cumulative. Direct effects are those that cause damage or mortality to a resource, e.g., larval or adult fish propeller entrainment, physical impacts to plants or shorelines due to passing vessels, or crushing/scraping of bottom-dwelling aquatic organisms. Indirect or secondary impacts are those that decrease the survival of a resource over time, or through their effect on a life requisite. Examples include suspended sediment effects on plant growth, mussel physiology, or deposition into backwaters and secondary channels; reduction or loss of spawning or overwintering habitat through sedimentation, velocity changes, or disturbance; and, effects of shifting waterborne commerce to alternative, land-based modes. Site-specific ecological effects from navigation improvements are presented in this chapter and in Appendix ENV-B. Finally, cumulative impacts, in the context of the Navigation Study, are defined as those that include incremental traffic effects in addition to all past, present and reasonably foreseeable future actions that have affected or will affect the UMR-IWW. Direct and indirect/secondary effects are presented in this chapter; cumulative effects are addressed in Chapter 9.

The environmental analyses were conducted in an ecological risk assessment framework; to the extent possible, uncertainties were characterized, allowing probabilistic estimates of identified resource impacts. This process enabled identification of those impact assessment model parameters which most contributed to overall uncertainty, pointing to areas of potential future data collection or further study. This chapter begins with an overview of the risk assessment process and how it was applied to the Navigation Study, as well as a general description of the overall impact assessment approach.

The remainder of Chapter 8 presents the impact assessment results for all combinations of resources and alternatives (systemic) and for the initial assessment of construction site impacts. Systemic results are described in terms of impact mechanisms, biological and socio-economic effects, irretrievable commitments of resources, and interaction with broader land use plans and policies in the study region.

Chapter 8 quantifies the environmental effects of the navigation efficiency measures. Environmental effects of the ecosystem restoration measures are addressed in Chapter 6 and 7.

8.1 Overview of Risk Assessment

An ecological risk can be defined as the probability of observing a specified adverse ecological impact, combined with some statement concerning its consequences or significance (Bartell 1996). Kaplan and Garrick (1981) described risk more generally as addressing three basic questions: What can go wrong? How likely is it to happen? And, what are the implications if it does? This simple description of risk provides a conceptual basis for the Navigation Study ecological risk assessment.

This NEPA assessment has been conducted in a manner consistent with the process prescribed in the Guidelines for Ecological Risk Assessment (USEPA 1998). The USEPA Guidelines were developed to promote consistent approaches to ecological risk assessments, identify key issues, and define terminology (Bartell 1996). The Guidelines develop a conceptual methodology for incorporating ecological principles into environmental decision-making (USEPA 1998). The Guidelines identify three components of an ecological risk assessment: problem formulation, analysis of exposure and ecological effects, and risk characterization (USEPA 1998) (Figure 8-1).

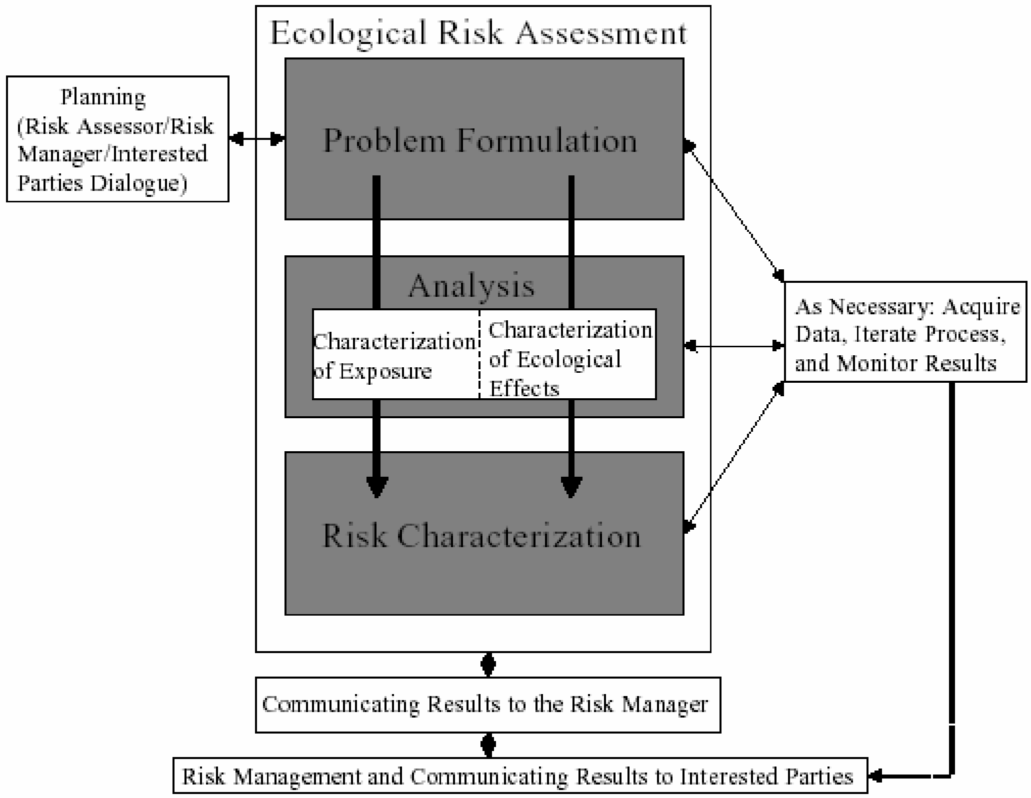


Figure 8-1. The three primary components of an ecological risk assessment (USEPA 1998).

8.1.1 Problem Formulation

Problem formulation for the Navigation Study ecological risk assessments consists of developing a conceptual model of the entire assessment process (Figure 8-2). The conceptual model outlines the nature and sources of stress to ecological resources, identifies ecological resources potentially at risk, specifies the ecological impacts of concern regarding these resources, identifies relevant data and information, and suggests models and methods of analysis that can be used to estimate risks. The problem formulation step emphasizes the need for discussion and participation among risk managers, risk assessors, and stakeholders in developing the overall design for risk assessment. Consistent with the USEPA Guidelines, detailed plans of analysis were developed for assessing ecological risk posed by commercial vessels to submerged aquatic vegetation, freshwater mussels, bank erosion, and fish in the UMRS. The overall conceptual model (Figure 8-2) was used to design separate, but interrelated, assessments of ecological risk for each of these resources.

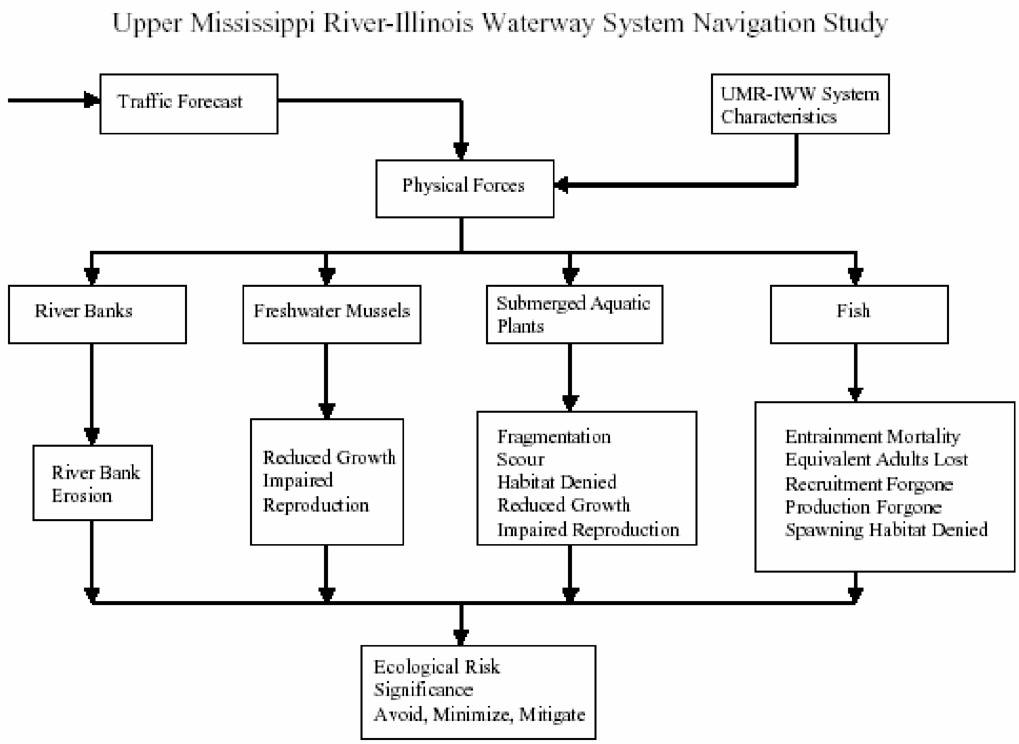


Figure 8-2. A conceptual representation of the connectedness of navigation physical effects and environmental effects through selected ecological components.

8.1.2 Exposure Analysis

In each ecological risk assessment, the ecological stressors take the form of the physical effects produced directly by commercial vessels navigating the UMR-IWW and indirect effects that result from these effects. To characterize current commercial traffic intensity, a baseline number of vessels passing through each pool each month was developed using 1992 lockage data. Existing fleet data were also analyzed to construct a data set that describes, by pool and by month, the relative distribution of vessels among categories of vessel direction, size, speed, load, and whether the vessel had an open wheel propeller or a Kort nozzle. This classification scheme produced 108 possible configurations of commercial vessels operating on the UMR-IWW. Alternative traffic scenarios were developed for the years 2000 through 2050, with projected trips/year made for each ten-year increment during this period. In developing and assessing alternative traffic scenarios, the 1992 fleet configurations were assumed to apply through the year 2050. The traffic that would result from navigation efficiency Alternatives 4, 5, and 6 (Chapter 6) were the sources of potential ecological risks and the subject of the assessment.

To perform the assessment, two additional assumptions were made in addition to the constant fleet composition previously described: One, the assessment examined the potential effects of these vessels for three flow regimes that corresponded to the 5th, 50th, and 95th percentile of monthly discharges recorded historically for each pool. Two, the commercial vessels were assumed to navigate 90% of the time on the charted sailing line and 5% on each of the left and right extremes of the navigation channel. This second assumption was based on a meeting with navigation industry representatives and Corps operations personnel. These assumptions determined, in part, the estimates of the physical effects imparted by the different traffic scenarios.

The direct physical effects imposed by operating commercial vessels include increases in river current velocity, return currents, or drawdown; pressure changes and shear stresses associated with the propeller jet; shear stresses associated with the hull movement; shear stresses on the bed sediments beneath the vessel; and bed shear stresses extending to the channel borders and backwaters. The risk assessment did not specifically address the recognized direct physical impacts of vessels in turning basins or fleeting areas where, for example, turning propellers might mechanically disrupt sediments. The primary indirect physical effect assessed for commercial (and recreational) vessels was sediment resuspension. These physical effects were quantified by performing laboratory experiments on physical replicas of river segments; making direct measurements on selected pools; and developing mathematical models to quantify the frequency, magnitude, extent, and duration of the physical effects. These estimated effects constitute the “exposure” that can produce probable ecological impacts (i.e., risk).

To summarize the physical effects across the UMR-IWW, each pool was spatially subdivided into “cells” within a geographical information system (GIS). Each cell was assigned a unique identification code in relation to its pool location in river miles and distance of its center point left or right of a reference line (looking downstream), usually the middle sailing line (e.g., 135R5250 = 135 m to the right of the sailing line at River Mile 525.0). Cell dimensions are 10-m wide by 0.5-miles in length in the Long Term Resource Monitoring Program (LTRMP) trend pools (UMR Pools 4, 8, 13, and 26, and the IWW LaGrange Pool) and extend from the water surface to the river bottom. In the non-trend pools, cell dimensions are 10-m wide by 1.0-miles in length. A pool can consist of thousands of cells depending on overall pool dimensions, which vary with seasonal changes in river discharge and stage height.

Values of the physical effects were developed for each cell by executing the physical effects models for all 108 possible vessel configurations, three water stage heights, and three sailing line positions. The model results (e.g., current velocity, wave height) for each cell were stored as a series of data sets in the GIS.

8.1.3 Analysis of Ecological Effects

The possible adverse ecological effects were identified for each of the assessments (e.g., aquatic plants, mussels, fish, and bank erosion). These effects included commercial traffic-induced increases in fish early life stage mortality, degradation or loss of fish spawning habitat, physical breakage of submerged aquatic vegetation, impacts on the growth and reproduction of submerged aquatic vegetation, and impacts on the growth and reproduction of freshwater mussels. The increased likelihood of direct entrainment of fish larvae into the propeller jets of commercial vessels posed a risk of incremental increases in fish mortality.

Vessel-induced changes in current velocities or alterations in sediment substrate might reduce the quantity and quality of suitable habitat for certain spawning guilds of fish in the UMR-IWW. Sudden increases (or shifts in direction) of current velocity or increased wave heights resulting from vessel passage might physically uproot or break submerged aquatic plants. Increases in suspended sediment concentrations resulting from commercial traffic might reduce the available underwater light and inhibit photosynthesis. Reduced photosynthesis implies fewer carbohydrates available for allocation to growth and vegetative reproduction. Increased suspended sediments might also impair the filter feeding capabilities of freshwater mussels, including several threatened and endangered species that inhabit the UMR-IWW, which would affect mussel growth and reproduction. The objective of the Navigation Study ecological risk assessment was to estimate these direct ecological impacts for alternative commercial traffic scenarios.

The risk assessments did not quantitatively examine possible indirect ecological impacts from commercial vessels. For example, an obligate life stage of freshwater mussels requires a period of attachment to fish; therefore, traffic-related reductions in fish abundance or diversity could, in theory, have an indirect negative impact on mussel reproduction. Several fish species utilize submerged aquatic vegetation for spawning, foraging, or protection from predation. Traffic-related reductions in submerged aquatic vegetation might indirectly impact fish.

8.1.4 Risk Characterization

The potential ecological risks posed by commercial traffic were estimated using the models of ecological effects and the models that quantified the magnitude, extent, and duration of the physical effects produced by commercial vessels. The alternative traffic scenarios provided the input data (e.g., vessels/day, vessel and barge configuration, direction, speed, draft) for the physical effects models. The results of the physical effects models provided the inputs to the ecological models that estimated the corresponding impacts for each traffic scenario.

This report describes many of the estimated ecological impacts as conservative, single-value estimates. Conservative, in this sense, refers to the likely overestimation of impacts as the result of pessimistic assumptions and parameter values used to calculate the impacts. Statements concerning the range of impacts and sources of uncertainty are also briefly provided for each resource of concern. Detailed considerations of uncertainty and probable impacts are presented in Appendix ENV-E. Both single-value estimates and probabilistic estimates were used to characterize ecological risks in this assessment.

8.1.5 Characterizing Uncertainty

The explicit identification and quantification of uncertainties distinguishes ecological risk assessment from more conventional environmental assessments performed under the National Environmental Policy Act (NEPA). Once quantified, these uncertainties are included in the assessment calculations to produce probabilistic estimates of ecological impacts (i.e., risks).

In the Navigation Study assessment, uncertainties enter the analysis in the form of bias and imprecision in the estimates of future traffic intensity, in the characterization of physical effects generated by specific vessel configurations, and in the estimated ecological responses to those effects. Uncertainties also enter in the form of the simplifications and assumptions that are inherent to environmental assessments. Another important aspect of the risk assessment process is that the resulting risk estimates can be analyzed using numerical methods to identify and rank-order the importance of specific sources of uncertainty to the overall assessment results. These rank-orders can be used to effectively design additional studies or data collection to provide the greatest return per unit investment in refining the risk estimates.

Bias and imprecision are possible for each general component of the Navigation Study ecological risk assessments: traffic projections, physical effects models, and ecological effects models. The nature and sources of bias and imprecision associated with each aspect of the UMRS risk assessments were addressed during the Navigation Study. Where possible, uncertainties were quantified, incorporated into the calculations of ecological impacts, and included in the assessment of impacts.

8.1.6 Sources of Uncertainty

At least two types of uncertainty are inherent to the assessment process: uncertainty about the exact structure and formulation of models, and uncertainty about the values used in model calculations. The following sections briefly describe these kinds of uncertainty in relation to the Navigation Study ecological risk assessment.

8.1.6.1 Model Uncertainty

Model uncertainty results from the incomplete understanding of the phenomenon being modeled and includes the necessary simplifications, assumptions, and formulations used to derive the models of physical effects and ecological effects. Model uncertainty can also result from arbitrary choices of how much (or how little) detail to explicitly include in the model (i.e., aggregation error).

8.1.6.2 Parameter Uncertainty

Parameter uncertainty refers to the accuracy and precision of the values used to perform model calculations. Uncertainty in model parameters can result from the absence of directly applicable data, the variability in available data, inappropriate sampling, and/or incorrect data analysis and interpretation. Parameter uncertainty will, of course, influence the accuracy and precision of any modeled estimate of risk. Therefore, describing and quantifying uncertainty associated with model parameters was an important part of this overall risk assessment process.

To characterize uncertainties in model parameters, available data and information were reviewed and evaluated. Clearly, species-specific and site-specific data, whenever available, should be used to quantify parameter uncertainty. In the absence of site-specific information, data from similar larger river systems and species were used to develop parameter values. In some cases, best professional judgment was used to formally characterize uncertainty associated with model parameters. The nature and sources of uncertainties associated with parameter estimates was documented as part of the Navigation Study risk assessment process (Appendix ENV-E).

8.1.6.3 Quantifying Uncertainty

Bias and imprecision associated with model parameter estimates and initial conditions have been addressed by defining input parameters as statistical distributions where reasonable and possible. Distributions were developed using existing data and professional judgment.

8.1.6.4 Propagating Uncertainties

Repeated model calculations using values selected randomly from their representative distributions (i.e., Monte Carlo methods) were used to propagate parameter uncertainties through the models. These results characterized the implications of incomplete data on the estimated impacts of commercial vessels on the ecological resources of concern. Single-value estimates of impact, made with conservative estimates of parameter values, can yield results that are unrealistically pessimistic. The Monte Carlo simulations permitted the determination of the degrees of conservatism involved with the single-value estimates of ecological impact. Results of the Monte Carlo methods summarized as distributions of possible impact are consistent with quantitative, probabilistic risk assessment (e.g., Bartell et al. 1992, Bartell 1996).

8.2 Impact Assessment Approach

Council on Environmental Quality (CEQ) Guidelines (40 CFR Parts 1502.20, 1508.28) directs the tiering of environmental documents to avoid repetition to consider specific issues. The Guidelines address an Environmental Impact Statement (EIS) done at early project stages that considers need or site selection. This programmatic approach is appropriate for broad program or policy statements, which eventually lead to more specific assessments within these broad areas. The Navigation Study Feasibility Report and Programmatic EIS (PEIS) considers a recommended set of improvement measures (resulting from a qualitative and quantitative screening process), and the timing of potential implementation of these measures, for the entire UMR-IWW System. Thus, if the Feasibility Report recommendation is accepted and implemented, then supplemental, site-specific assessments will be prepared for each location where improvement measures are to be constructed.

A similar approach will be used for cultural resources documentation. Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA) and its implementing regulations 36 CFR Part 800: “Protection of Historic Properties,” establishes the primary policy, authority for preservation activities, and compliance procedures. The NHPA ensures early consideration of historic properties preservation in Federal undertakings and the integration of these values into each agency's mission. To afford protection to known and unknown significant historic properties resulting from the implementation of any Navigation Study improvements, the Corps negotiated a Programmatic Agreement (PA) among the Corps of Engineers' Mississippi Valley Division, St. Paul District, Rock Island District, and St. Louis District; the U.S. Fish and Wildlife Service; the Illinois, Iowa, Missouri, and Wisconsin State Historic Preservation Officers; and the Advisory Council on Historic Preservation, regarding the implementation of the Upper Mississippi River-Illinois Waterway System Navigation Study. As regulated by 36 CFR Part 800.8(c)(1), the draft PA was made available within this environmental document (Appendix ENV-C) for review and comment by the State Historic Preservation Officers, the Advisory Council on Historic Preservation, Native American Indian Tribes and other interested parties. Reviews and comments were considered in the final PA. The executed PA will be provided to all signatories to this agreement, appended to the Navigation Study Feasibility Report and PEIS Record of Decision (ROD), and included in any subsequent Navigation Study documentation that addresses potential effects to historic properties.

8.3 Construction Site Impacts

8.3.1 Assessment Approach

Site-specific analyses were conducted to evaluate potential impacts of the proposed construction measures at locks and dams (L/Ds) on the UMR and IWW. These are L/Ds 11-25 on the UMR, and Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria and La Grange on the IWW. The reader is referred to the Engineering Appendix and Appendix ENV-B for detailed descriptions of all the lock and dam sites. At the time of these assessments, potential improvements at the upper Illinois sites (those above Peoria) were still under consideration, thus they were included. These sites are no longer under such consideration. The primary purpose was to assist the study team in formulating a recommended plan by providing quantitative measure or qualitative evaluation of environmental impacts and estimated habitat replacement costs. Detailed analysis of site-specific impacts, based on any recommended/authorized measures, will not be possible until detailed design information for those measures is available. Should future construction activities be recommended, detailed site-specific evaluations will be completed for each incremental step towards completion of the action. Site surveys will be conducted by Corps personnel or contracted specialists to determine the potential for environmental impacts and environmental assessment will be prepared for site specific construction. These detailed evaluations will be documented in tiered Environmental Assessments (EAs).

The Habitat Assessment Team (HAT) included representatives from the Rock Island and St. Louis Districts of the U.S. Army Corps of Engineers; the U.S. Fish and Wildlife Service-Rock Island Field Office; and the Mid-Continent Ecological Science Center-Biological Resource Division (U.S. Geological Survey), Ft. Collins, Colorado. The HAT regularly coordinated with state and federal resource agencies and other interested parties through the NECC.

Quantitative evaluations (L/Ds 20-25, Peoria, LaGrange) were accomplished using the Habitat Evaluation Procedures (HEP), while a qualitative evaluation was made at the remaining locks and dams and through evaluation of potential endangered species impacts, socio-economic impacts, and mussel surveys. HEP is a nationally recognized evaluation method developed to quantify the impacts of habitat changes made by land and water development projects. It provides information to compare the relative value of different areas at the same point in time and the relative value of the same area in the future. Documented Habitat Suitability Index (HSI) models are used in HEP to determine the quality portion of the formula. The HSI values are multiplied by area to calculate Habitat Units (HUs). The changes in HUs for species and their habitats are reported as the results in a HEP evaluation. Included in that process are creation of a study team, formation of objectives and selection of evaluation species, followed by inventory design and data gathering. A group of 27 species was chosen to represent those aquatic and terrestrial habitats that may be impacted by the project. The HAT coordinated each step of the process with interested parties including state and federal biologists in species selection and data gathering. Detailed description of the site-specific habitat assessment can be found in Fristik et al. (1998, ENV 7), which is included as Appendix ENV-B.

8.3.2 Construction Alternatives

A range of possible new lock locations was evaluated in the habitat assessment. These alternative locations are depicted in Figure 8-3. Additional information concerning these lock locations and the screening process can be found in Section 6.1.2.2.

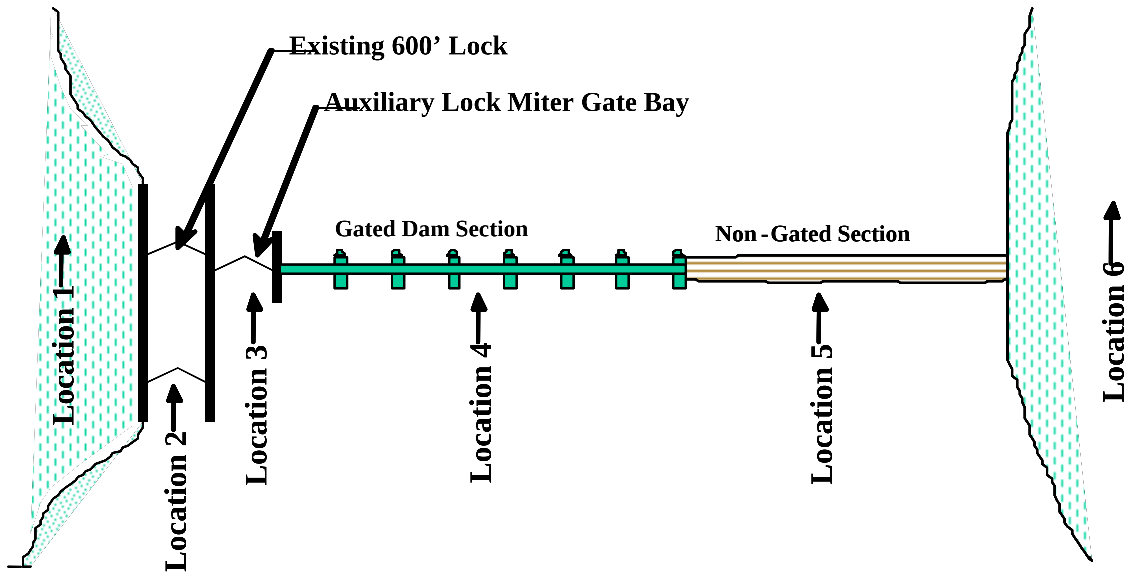


Figure 8-3. Example of alternative new lock locations at a typical existing lock and dam site.

8.3.2.1 Construction Impacts

Construction impacts from any of the project alternatives were considered to include footprint impacts from construction and impacts of any required staging area or construction activity. In addition to the "footprint" impacts of major construction measures, the following potential impacts were also evaluated:

- Loss of benthic and riparian habitat in and adjacent to the construction site.
- Changes in the lock and/or dam structure that could alter tailwater velocities, depth or substrate composition.
- Changes in lock approach patterns that could cause towboats to increase bank erosion or benthic disturbance, or require dredging for new channel alignment.
- Changes to terrestrial or shoreline areas due to bankline excavation, borrow or staging area locations.

Dredged material placement sites were not evaluated because potential locations at the time of the analysis were very speculative. It is assumed that upland placement in agricultural fields would help to avoid and minimize adverse environmental impacts. Future detailed site-specific evaluations will include a selection and evaluation process for disposal of dredged material.

8.3.2.2 Water Quality

Construction materials would consist of physically stable and chemically non-contaminating material such as corrosion-resistant steel and concrete. The proposed work will be evaluated during follow-on detailed site-specific assessments including preparation of site-specific EAs that will include compliance with Sections 404 and 401 of the Clean Water Act. Construction would be bound by the requirements and conditions set forth in *Guide Specification, Civil Works Construction for Environmental Protection*, CW-1430, July 1978, Section 7.3, but certain loss of paint chips, residue, and other materials to the aquatic environment is inevitable. However, any effects are anticipated to be minimal and short term.

8.3.2.3 Noise

Heavy machinery would temporarily increase noise levels during project construction. Depending on the project site, this noise level increase may affect adjacent properties. Noise impacts are further discussed in Section 8.7.9.

8.3.2.4 Air Pollution

Impacts to air quality may occur from activities during construction and may include such sources as exhaust emissions, volatile paint solvents, fugitive particles from sandblasting, and dust particles from concrete removal. These impacts would be temporary and not result in significant or permanent violations of air quality standards.

8.3.2.5 Hazardous, Toxic and Radioactive Waste (HTRW)

The potential for HTRW remediation at lock and dam sites was not investigated as part of the site-specific habitat assessments. Although the potential is thought to be minimal, this aspect would be thoroughly investigated as part of more detailed future investigations. A primary data source would be the Corps' Environmental Review Guide for Operations (ERGO) reports, which address environmental site concerns and management at facilities.

8.3.2.6 Effects on Recreational Use

Recreational boat ramps and public land exist adjacent to many of the lock and dam sites. Additionally, recreational fishing is common in lock and dam tailwaters. Depending on the site and construction alternative, there may be negative impacts to recreation facilities and activities in the immediate vicinity of the site. Impact to recreation facilities and recreationists will be evaluated in detail during site-specific assessments. Detailed descriptions of potential site-specific recreational boating impacts are included in Appendix ENV-J.

8.3.2.7 Effects on Scenic Qualities

The aesthetic appeal of any construction activity is low. However, construction will be temporary and not significantly diminish the aesthetic resources of the surrounding areas. Detailed descriptions of potential site-specific scenic impacts are included in Appendix ENV-B, where applicable.

8.3.2.8 Changes to Land Cover and Terrestrial Habitats

Habitat and land cover changes depend on the construction alternative and site. Impacts may include the clearing of bottomland forest or filling of wetlands, from either staging during construction or the construction footprint itself. Bottomland hardwood forest exhibited the greatest losses in terms of habitat unit changes (considering only large-scale measures). In many cases, they would be cleared for use as staging areas and would be replaced after construction. In some cases, bottomland forest would be converted either to a lock facility or aquatic habitat. Potential wetland impacts and habitat losses were limited to Locks and Dams 20, 25 and LaGrange. Impacts to wetlands were limited due to the lack of the habitat within potential construction sites.

8.3.2.9 Changes to Aquatic Habitat

Changes to aquatic habitat include modifications due to placement of the lock wall, guidewall, or guard wall. If installed, there may be impacts to main channel border habitat landward of the proposed new lock wall where decreased velocity, siltation and sedimentation would likely occur. Velocities and depths within the dam tailwaters may be locally modified by construction of the lock or associated dam gate changes.

8.3.2.10 Potential Effects at Each Lock and Dam Site

Each lock and dam site was evaluated using the Corps traditional HEP. The site-specific HEP provides a detailed reporting of the results of environmental investigations and analysis including affected acreage, HSI, and Average Annualized Habitat Units (AAHU) by species. The remainder of this section provides a brief summary of the HEP results for each of the lock and dam sites under consideration. Appendix ENV-B provides a more detailed description of the HEP methodology and results. The replacement cost estimates shown in subsequent tables (2003 dollars) are not to be considered as actual values of these habitats, they are merely a best available estimate of cost to compensate for the habitat impacted. In no way can all habitat functions or values be replaced. Where a 0 is given for main channel border habitat it reflects a gain in habitat and no replacement required. That gain resulted from a loss in other habitats and therefore does not accurately reflect habitat impacts. Switchboats, a non-structural measure, are proposed at L/Ds 20-25 for Alternative 4 and at L/Ds 11-13 for Alternative 6. Switchboats are full-size towboats (2,400 horsepower) that would be permanently stationed at a lock site, one on either side of the dam. The switchboat would allow a barge cut to be removed to a location along the existing guidewall, to the end of the guidewall, or to an awaiting tow for remote remake. Switchboats would have minor and insignificant localized effects on ecological resources.

8.3.2.10.1 Lock and Dam 20

Alternatives evaluated at this site included lock Locations 2, 3, and 4 (see Figure 8-3) as well as installation of a wicket gate. Impacts at L/D 20 include losses of bottomland forest and secondary channel habitats and alteration of main channel border. Results of the HEP show that Location 4 has the least adverse environmental impacts. It does not impact bottomland forest habitat or negatively affect secondary channel habitat, but does include the loss of habitat units in main channel border. Although a decrease in value of any habitat is undesirable, main channel border is considered abundant throughout the system. Loss of bottomland forest from construction at Locations 2 or 3 is permanent. The measure to construct a wicket gate has the most detrimental environmental effects. It includes the permanent loss of an island, which affects bottomland forest and secondary channel habitat.

Regarding small-scale measures, mooring cells are proposed both upstream and downstream. The downstream cells would be especially valuable in alleviating shoreline impacts from tows which currently push into the bank adjacent to Canton. If they were implemented, selected mooring cell locations would be evaluated in detail for potential environmental impacts. Remote remake areas would be in the same general locations as mooring cells, but would involve different structures.

Summary of AAHU Changes at Lock and Dam 20

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4	Wicket Gate
Bottomland Forest	-21.55	-10.05	No Impacts	-16.00
Side Channel	3.22	3.22	3.22	-13.06
Main Channel Border	U= 73.68* D= -1.71	U= 32.38* D= -20.85	U= -3.56 D= -20.78	D= 68.09*

*Equates to an increase in AAHUs resulting from a habitat conversion from bottomland forest and side channel to main channel border.

The nature of proposed dredge areas and lock wall extensions is virtually identical to those associated with the large-scale measures, thus habitat impacts to channel border and shoreline areas are expected to be similar. Three submerged wing dikes are also proposed upstream of the lock, to help alleviate outdraft conditions. These would require detailed evaluation if implemented, but their effects would likely mirror those predicted at other sites, likely increasing sedimentation and decreasing flow velocity.

Lock and Dam 20 Habitat Replacement Costs

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4	Wicket Gate
Bottomland Forest	$1,265,700 - 2,648,700	$590,600-2,046,000	No Impacts	$928,200-2,347,400
Main Channel Border	0	0	$536,000	0
Side Channel	0	0	0	$3,275,500
Mussels	No known concentrations	No known concentrations	No known concentrations	No known concentrations
Endangered Species	Bald eagle, Indiana bat (minimized without wicket)	Bald eagle, Indiana bat (minimized without wicket)	Bald eagle, Indiana bat (minimized without wicket)	Bald eagle, Indiana bat (minimized without wicket)

* The 0 in side channel reflects a slight increase in habitat value resulting from the project and no habitat replacement is required.

8.3.2.10.2 Lock and Dam 21

Alternatives evaluated at this site included lock Locations 2, 3, and 4 as well a series of submerged wing dikes that would be placed extending from the bankline to just beyond the far edge of the approach channel. Their purpose is to reduce the magnitude of outdraft or flow from the bankline to the dam gates which misaligns downbound tows with the lock chamber. Placement of a new lock in Location 4 would involve replacing gates in the overflow section of the dam. Impacts at L/D 21 include losses of bottomland forest and alteration of main channel border. Location 4 at this site has the least adverse environmental impacts to bottomland forest; however, it does impact main channel border habitat. Gate replacement within the overflow section could also impact mussel beds on the right descending bank. Location 3 has fewer impacts to main channel border but includes twice the magnitude of impacts to bottomland forest.

Summary of AAHU Changes at Lock and Dam 21

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4
Bottomland Forest	-60.24	-60.24	-30.34
Main Channel	No Impacts	No Impacts	-0.23
Main Channel Border	U= 48.67* D= -59.78	U= 48.31* D= -23.12	U= .75 D= -27.45

*Equates to an increase in AAHUs resulting from a habitat conversion from bottomland forest to main channel border.

Mooring or remote remake facilities are proposed both up- and downstream of the lock. Currently, Orton Island, approximately 1.5 river miles downstream experiences shoreline damage from mooring tows. Mooring cells would be beneficial at this location. With the exception of the downstream, mid-channel dredge area, proposed approach channel improvements are identical to those included in the large-scale measures. These improvements include bankline excavation and a series of 5 submerged dikes on the upstream approach. The HEP analyses indicated a small gain in main channel border habitat units, assuming reduced velocity due to the dikes, but at the same time a loss in bottomland hardwoods due to the excavation. Other velocity-related affects associated with new lock construction are projected to be similar with small-scale construction, as they are primarily related to guide or guard wall construction. Lockwall extensions are also included under the proposed approach improvement measures.

Lock and Dam 21 Habitat Replacement Costs

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4
Bottomland Forest	$3,088,800- 6,429,900	$3,088,800- 6,429,900	$1,582,100- 3,252,600
Main Channel Border	$83,400	0	$250,100
Mussels	Potential beds right bank up and down stream	Potential beds right bank up and down stream	Potential beds right bank up and down stream
Endangered Species	Bald eagle, Indiana bat, 2 mussels potential	Bald eagle, Indiana bat, 2 mussels potential	Bald eagle, Indiana bat, 2 mussels potential

8.3.2.10.3 Lock and Dam 22

Alternatives evaluated at this site included lock Locations 2, 3, and 4, including possible construction of a series of wing dikes on the upstream right descending bank. Their purpose is to reduce outdraft conditions and benefit tows on their downbound approach. Impacts at L/D 22 include clearing of bottomland forest for staging, impacts caused by the placement of wing dikes in the main channel border upstream from the lock and by channel changes/dredging in locations upstream and downstream. A known mussel bed and State-designated mussel sanctuary exist downstream from the lock outside the impact area. Additional mussel surveys were conducted within proposed construction areas in October 1997. Those surveys found a possible mussel bed located on the right descending bank upstream from the lock.

Summary of AAHU Changes at Lock and Dam 22

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4
Bottomland Forest	-48.90	-48.90	-48.90
Main Channel	No Impacts	No Impacts	U= -.29 D= 1.38
Main Channel Border	U= -284.07 D= -33.22	U= -284.42 D= -31.96	U= -292.44 D= -41.61

Each lock location alternative has equal HU impacts for bottomland forest. This is because each includes impacts to the same areas for staging. If the staging area could be relocated or reduced in size those impacts could be avoided or minimized. Upstream impacts to main channel border are quite large due to the dike field proposed for the area, and occur equally for each proposed lock option. A mussel bed would potentially be impacted. Downstream impacts to main channel border are similar and all result from the guidewall extension and reduced velocities associated with it. Unlike location 2 or 3, the location 4 alternative includes impacts to main channel habitat with a downstream increase in AAHUs and minor upstream loss.

Pertinent small-scale measures include mooring cells or remote-re-make facilities both up- and downstream. Shoreline damage would be particularly alleviated along the Missouri shoreline downstream of the lock. If proposed for implementation, these facilities would be evaluated in detail. Approach improvements duplicate those proposed as large-scale measures, but do not include the main channel dredge areas. Hence estimated habitat impacts would likely be the same for the upstream dike field (a loss due to eventual conversion to semi-terrestrial habitat) and lockwall extensions (velocity reductions landside of the wall).

Lock and Dam 22 Habitat Replacement Costs

Habitat Type	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4
Bottomland Forest	$2,486,100–4,859,000	$2,486,100–4,859,000	$2,486,100–4,859,000
Main Channel Border	$2,680,000	$2,680,000	$2,822,900
Mussels	Bed upstream in proposed wing dam field	Bed upstream in proposed wing dam field	Bed upstream in proposed wing dam field
Endangered Species	Indiana bat, Bald eagle, mussels	Indiana bat, Bald eagle, mussels	Indiana bat, Bald eagle, mussels

8.3.2.10.4 Lock and Dam 24

Alternatives evaluated at this site included lock Locations 2, 3, and 4. Impacts at L/D 24 include losses of bottomland forest and alteration of main channel border. Each lock location has the same impact to bottomland forest resulting from the staging area. If the staging area could be relocated or reduced in size, those impacts could be avoided or minimized. Location 2 has the fewest impacts to main channel border resulting from impacts behind the guidewall, but these could potentially be decreased by measures to provide flow behind that wall.

Mooring facilities are generally adequate upstream. Downstream mooring cells would be beneficial on the Clarksville riverfront and on the opposite shoreline along Clarksville Island. These and any remote re-make facilities would be evaluated on a case by case basis. Remaining channel improvements include lockwall extensions, and re-shaping of the bankline immediately above the existing guidewall. Loss of AAHUs would be expected due to velocity reductions and sedimentation behind the walls; the bank excavation would primarily be in a developed area, and impacts would likely be minimal.

Summary of AAHU Changes at Lock and Dam 24

Habitat Type	**Location 2**	**Location 3** (Selected Plan - Alternative 6)	**Location 4 (with gate in auxiliary bay)**	**Location 4 (without gate in auxiliary bay)**
Bottomland Forest	-4.71	-4.71	-4.71	-4.71
Main Channel Border	U= .08 D= -29.47	U= .11 D= -44.19	U= -7.84 D= -34.97	U= -5.24 D= -59.10

Lock and Dam 24 Habitat Replacement Costs

Habitat Type	**Location 2**	**Location 3** (Selected Plan - Alternative 6)	**Location 4**	
Bottomland Forest	$295,300	$295,300	$295,300	
Main Channel Border	$333,500	$416,900	Without gate $667,000	With gate $416,900
Mussels	Potential mussel bed downstream	Potential mussel bed downstream	Potential mussel bed downstream	
Endangered Species	Indiana bat, Bald eagle, Decurrent false aster, Fat pocketbook Avoid Bald eagle perch trees during staging	Indiana bat, Bald eagle, Decurrent false aster, Fat pocketbook Avoid Bald eagle perch trees during staging	Indiana bat, Bald eagle, Decurrent false aster, Fat pocketbook Avoid Bald eagle perch trees during staging	

8.3.2.10.5 Lock and Dam 25

Alternatives evaluated at this site included lock Locations 1, 2, 3, and 4. Impacts at L/D 25 include losses of bottomland forest and non-forested wetland habitats, as well as alteration of secondary channel and main channel border habitat. A mussel survey located a possible bed on the right descending bank that would be impacted by construction at Location 1. There was also a concentration of mussels found near the first dam gate upstream from the overflow section of the dam; this area would be impacted by a replacement gate. Location 1 has the most extensive impacts resulting from lock construction landward of the existing lock. Impacts to bottomland forest would be the greatest with construction at Location 1 and include removal of trees utilized by the bald eagle during feeding. That measure also impacts the secondary channel (Sandy Slough) and impacts the mussel bed located upstream. Of the alternative lock locations, Location 4 with gate replacement through the auxiliary lock is the least environmentally damaging. It has the least impacts to bottomland forest and no secondary channel impacts. Impacts to bottomland forest could be minimized through relocation of the staging area. Non-forested wetland impacts are minimal, and losses to main channel border could be minimized.

Summary of AAHU Changes at Lock and Dam 25

Habitat Type	Location 1	Location 2	**Location 3** (Selected Plan - Alternative 6)	**Location 4** (with gate in auxiliary bay)	**Location 4** (without gate in auxiliary bay)
Bottomland Forest	-51.61	-5.39	-13.57	-14.56	-14.56
Main Channel Border	U= 40.96* D= 78.13*	U= -.02 D= -36.08	U= -.25 D= -41.30	U= -2.2 D= -15.52	U= -1.52 D= -28.01
Non-forested wetland	No Impacts	No Impacts	No Impacts	-.04	-.04
Side Channel	-3.79	No Impacts	No Impacts	No Impacts	No Impacts

Regarding small-scale measures, mooring and remote re-make facilities are proposed both up- and downstream. The Missouri shoreline downstream of the lock would be spared damage with mooring cell placement. Channel excavation would be much reduced, particularly upstream, due to the absence of new lock construction at Location 1. Lock wall extensions are proposed, as well as a small area of bank re-shaping adjacent to the upstream guard wall. Downstream wall extension and bank excavation would likely result in the same negative impacts as observed in the large-scale analysis.

Lock and Dam 25 Habitat Replacement Costs

Habitat Type	Location 1	Location 2	Location 3 (Selected Plan - Alternative 6)	Location 4	
Bottomland Forest	$2,636,800	$337,500 Minimizable	$843,800 Minimizable	$843,800 Minimizable	
Side Channel	$1,083,900	Side Channel impacts avoidable	Side Channel impacts avoidable	Side Channel impacts avoidable	
Non Forested Wetland	No gate replacement	No gate replacement	No gate replacement	$83,400 Gate replacement impact	
Mussels	Mussel Bed Upstream	Mussel bed is avoidable	Mussel bed is avoidable	Potential mussel bed upstream	
Main Channel Border	0	$416,900	$416,900	W/O gate $333,500	With gate $166,800
Endangered Species	Bald eagle perch trees, Indiana bat	Potentially avoid impacts	Potentially avoid impacts	Potentially avoid impacts	

8.3.2.10.6 Peoria Lock and Dam

Alternatives at this site included construction at Locations 1 or 2. Impacts at Peoria Lock and Dam include the temporary clearing of bottomland forest for staging and main channel border impacts due to placement of the lock. Rock Island District staff conducted exploratory brail surveys for mussels and did not find any concentrations in the area. Impacts to bottomland forest habitat are the same for both alternatives and are a result of staging area requirements. The impacts could be avoided or minimized with relocation or resizing of the staging area. Location 2 has greater impacts to main channel border due to velocity changes behind the guidewall downstream of the lock. Those impacts may be minimized by maintaining flow in that area.

Summary of AAHU Changes at Peoria Lock and Dam

Habitat Type	Location 1 (Selected Plan - Alternative 6)	Location 2
Bottomland Forest	-14.45	-14.45
Main Channel Border	U= -0.28 D= 0.34	U= -0.04 D= -12.68

Impacts to bottomland forest habitat are the same for both alternatives and are a result of staging area requirements. With relocation or resizing of the staging area the impacts could be avoided or minimized.

Location 2 has greater impacts to main channel border due to velocity changes behind the guidewall downstream of the lock. Those impacts may be minimized by maintaining flow in that area.

Upstream of the lock there are limited opportunities for mooring or re-make facilities. The downstream bankline would be protected from current damage with the placement of mooring cells. Guidewall extensions are limited upstream due to the highway bridge; there is the possibility of constructing wing or vane dikes in this area to re-align currents and protect the bridge piers. These would need further environmental evaluation if implemented. There is no proposed channel realignment related dredging.

Peoria Lock Habitat Replacement Costs

Habitat Type	Location 1 (Selected Plan - Alternative 6)	Location 2
Bottomland Forest	$717,900	$717,900
Main Channel Border	$99,300	$198,700
Mussels	No known concentrations	No known concentrations
Endangered Species	Indiana bat, Decurrent false aster	Indiana bat, Decurrent false aster

8.3.2.10.7 La Grange Lock and Dam

Alternatives at this site included construction at Locations 1 or 2. Impacts at this site include clearing of bottomland forest and conversion to main channel border, a levee setback that impacts wetlands, and conversion of agricultural fields to main channel border. No known mussel beds exist in the area. Due to the extensive channel changes proposed, both construction alternatives at this site include extensive impacts to bottomland forest and non-forested wetlands. Location 2 has slightly fewer impacts to bottomland forest.

Summary of AAHU Changes at LaGrange Lock and Dam

Habitat Type	Location 1 (Selected Plan - Alternative 6)	Location 2
Bottomland Forest	-61.15	-50.98
Main Channel Border	U= 104.32* D= 65.48*	U= 29.36* D= -0.08
Non forested Wetland	-9.57	-9.57

* Equates to an increase in AAHUs resulting from a habitat conversion from bottomland forest. Due to the extensive channel changes proposed, both construction alternatives at this site include extensive impacts to bottomland forest and non-forested wetlands. Location 2 has slightly fewer impacts to bottomland forest. The increases seen to AAHUs of main channel border species are largely driven by that losses of other habitat types. It should be noted that this is the only location that suitable water conditions for Western chorus frog were located during sampling. Habitat was located in the non-forested wetland.

Mooring facilities would be beneficial downstream to alleviate damage on the right descending bank where the bank is presently eroding; some sites are also under consideration upstream. Opportunities for remote re-make facilities are limited. The large channel excavation area upstream would remain as a small-scale measure, along with the series of dikes on the opposite shoreline. The HEP evaluation showed large habitat impacts to bottomland forest. No channel changes are proposed downstream.

LaGrange Lock Habitat Replacement Costs

Habitat Type	Location 1 (Selected Plan - Alternative 6)	Location 2
Bottomland Forest	\$3,126,500-\$6,534,000	\$2,636,800-\$6,044,300
Main Channel Border	0	0
Non-Forested Wetland	\$1,417,400	\$1,417,400
Mussels	No known concentrations	No known concentrations
Endangered Species	Indiana bat, Decurrent false aster, Bald eagle	Indiana bat, Decurrent false aster, Bald eagle

8.3.2.10.8 Upper Lock and Dam Sites

Less detailed, qualitative assessments were conducted for the upper UMR-IWW lock and dam sites. Separate assessments, each somewhat different in character, were conducted for the Mississippi and Illinois.

8.3.2.10.8.1 Mississippi Locks and Dams 11-19

Two 1-day meetings were held in June 1997 with pertinent resource agency personnel to discuss resources of concern and potential construction impacts at these locks. The approach taken was to utilize planning maps, other existing information, and resources of concern originally identified at initial interagency site visits conducted in 1994. Agency participants were asked to update the latter pieces of information as appropriate, and all the assembled information was then used to make a general determination of impacts. Descriptions of those sites are included in detail in Appendix ENV-B. Because there are site-specific mitigation costs associated with the placement of a mooring cell at Lock and Dam 14, a more detailed description follows.

Lock and Dam 14 - The mooring cell at Lock and Dam 14 requires considerable dredging in association with its creation. Due to the lock's location on a bend and existing flow conditions, considerable maneuvering is required on approaches here. The lock is adjacent to Smith's Island, which in turn separates it from the LeClaire Canal, a historically and environmentally sensitive side-channel area. A small lock at the downstream end of the canal serves recreational and Corps maintenance fleet traffic. An additional complication at this site is a proposed hydropower project, which has been under consideration for some time but still awaits a final decision. If this proposal were implemented, all flow would need to be diverted when it is in operation.

Considerable dredging is proposed to alleviate the approach problems; the majority would be upstream. A portion of the upstream dredging coincides with identified secondary habitat for the endangered Higgins' Eye mussel; possible presence of this species, as well as other mussel resources in the area, would need to be confirmed with detailed surveys. The Higgins' eye Mussel Recovery Plan identifies River Mile 494.0-496.4 left bank and River Mile 492.0-493.0 left bank as Secondary Habitat for the species. An environmental assessment prepared for approach improvements at Lock and Dam 14 mentions a "rich mussel bed" at river mile 494-496 left bank. More detailed impact assessments would also require information on fisheries. The upstream tip of Smith's Island would also be lost to dredging; this portion is non-forested wetland. Resource agency personnel also pointed out that a large portion of the island is proposed for staging or placement, and this would be unacceptable due to wetland impacts. The agencies also suggested rock placement at various locations in the main channel and in LeClaire Canal itself, to provide submerged structure and flow diversion. The environmental mitigation costs were estimated at $4,764,412 to mitigate the effect on main channel border habitat.

8.3.2.10.8.2 Upper Illinois River Locks and Dams (Lockport to Starved Rock)

Initial Navigation Study planning determined that large-scale measures would not be warranted above Peoria Lock and Dam on the Illinois River, due primarily to current and projected commercial traffic levels. Thus, consideration of possible improvements at sites above La Grange focused on small-scale measures, and these are primarily non-structural. Consideration of these measures took place at a series of on-site meetings on December 10-11, 1996. In attendance at these meetings were study team members, lockmasters, an industry representative, and a representative from the Illinois Department of Natural Resources. The discussions focused on existing approach conditions and other time-consuming elements of the lockage process at each site. Natural resource concerns were generally limited, but a brief site-by-site summary is presented in Appendix ENV-B.

8.3.2.10.9 Cultural Resources

Potential effects to archeological historic properties from site-specific navigation improvements have been documented by the Corps at UMR Locks 11-22, 24, and 25 (13 complexes) and at IWW Locks T.J. O'Brien, Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria Rock, and LaGrange (8 complexes). Site-specific data obtained by limited geomorphologic testing, background and documentary research, and architectural and engineering surveys at the lock complexes on the UMR and IWW were reported.

The IWW lock and dam sites were studied in 1996 (Martin et al. 1998) and the UMR lock and dam sites were studied in 1997 (Benn and Anderson 1997) for their archeological potential. Of the 8 lock and dam sites on the Illinois Waterway, the T. J. O'Brien Lock, Lockport Lock, and Marseilles Lock and Canal have no potential for buried historic properties. At the 13 lock and dam sites within the Rock Island and St. Louis districts, all were determined to have some potential for buried historic properties, except for Locks and Dams 14, 26, and 27, and Lock 19. The Corps has documented and reported the approximate locations of 454 submerged or inundated boats, structures, or navigation markers on the UMR and the approximate locations of 71 submerged boats, structures, or navigation markers on the Illinois Waterway (Jensen 1992, Swift 1995, Custer and Custer 1997). These submerged or inundated historic properties are potentially eligible to the National Register of Historic Places (NRHP).

All Navigation Study proposed navigation improvements are within, or very close to, NRHP eligible multiple property districts boundaries delineated in the Illinois Waterway Navigation Facilities and the Upper Mississippi River Navigation Project, 1931-1948 Nomination Forms. The proposed Navigation Study measures/alternative plans including extended guidewalls, adjacent mooring facilities, and new lock locations will result in adverse effects to individual and contributing resources within the historic districts by destroying or modifying original fabric, components, machinery, equipment, structures, and other as yet unidentified architectural and engineering objects and elements. The potential for buried archeological, submerged, and inundated historic properties has been documented and a potential for adverse effects may occur. The referenced registration forms and reports have been finalized and approved, then archived by the Corps and placed in permanent files of the appropriate State Historic Preservation Office(s) (SHPO(s)) as evidence of compliance promulgated under Section 106 of the National Historic Preservation Act, as amended and its implementing regulations 36 CFR Part 800: "Protection of Historic Properties."

8.4 Effects of Increased Commercial Navigation on Backwater and Secondary Channel Sedimentation

8.4.1 Navigation Traffic Input Data

The number of tows projected to move over the study area waterway system was calculated from input parameters used in and calculated results from the Spatial Equilibrium Model (SEM). The SEM's primary purpose is to calculate the Net Economic Development (NED) benefits of water transportation on the impounded UMR and the IWW navigation system. The model also calculates the total number of tons of cargo on the waterway system by calculating the tons through each pool on the system. These tons are used to compute the number of tows on the waterway system.

The number of tows by lock from the Corps of Engineers 1992 Lock Performance Monitoring System (LPMS) data are an input to the model as is the number of tons for 1992. The simple calculation of tons per tow is performed and assuming that the tow configuration and the average load per barge on the system will not change over time this actual ratio is divided into the projected tons to derive the projected number of tows by lock. These data are subsequently used as input to the environmental models.

The river segment downstream of Lock 27 is within the study area but is considered open river since there are no dams. The presence of open river conditions is important because it is associated with a significantly different configuration compared to the pools above Lock 27. The tow configuration for all pools upstream of Lock 27 is on average 15 barges per tow. Tows in the open river, on average, have 25 barges. This means that the tons reported by the SEM come from both the large and small tow configurations. In order to calculate the total number of tows in the open river pool a more detailed calculation is needed.

It was assumed that upbound traffic approached Lock 27 as a large tow configuration. The tow would be re-fleeted to the smaller size to pass through the lock. The downbound tows would also be re-fleeted to the larger size to continue southwards. Traffic data from 1996 (USACE 1997a) was used to determine the relative percentages of barge types used to transport various commodities on the open river. These percentages were applied to the tons in the pool downstream of Lock 27 to derive the tows.

8.4.2 Hydraulic Disturbances

Commercial navigation traffic on the UMR and the IWW creates hydraulic disturbances in the form of changes in current velocity and direction, altered water levels, resuspension of sediments, and scour of the river bed. These disturbances tend to increase with decreasing size of the waterway, which means that the IWW generally has greater disturbances than the UMR. The change with waterway size also applies to changing river stages, with low flow impacts being greater than those at high flows. Altered flow velocities from navigation occur from the propeller jet and as a result of the barges that displace a large volume of water as the tow moves through the water. Altered water levels from navigation occur in the form of waves and drawdown. Resuspension of sediments tend to be greatest beneath the tow as a result of the propeller jet and in shallow, near shore zones as a result of wave activity. Scour of the riverbed is most significant near and beneath the tow as a result of the propeller jet. Before discussing each of the hydraulic disturbances, descriptions are provided for the physical model used for determining the disturbances, the analytical system model NAVEFF (NAVigation EFFects), the GIS layout of the waterway, and the rollup of the results.

8.4.2.1 Modeling of Navigation Effects - Physical Model

Many aspects of the hydraulic disturbances that are known to occur within the UMR-IWW were evaluated in the Navigation Effects Flume, constructed specifically for this study. The flume is 122 m long by 21.3 m wide by 1.2 m deep and is equipped with pumps to simulate river flow and a towing carriage to maintain consistent speed and alignment of the model tow. The model size was 25 times smaller than the actual river. Two cross-sections were studied in the model; one at Clark's Ferry on the UMR and the other at Kampsville on the IWW. The model towboat was a correspondingly-scaled model of an actual vessel (the MV Benyaurd) and had two propellers, main and flanking rudders, and could be fitted with either open wheel or Kort nozzle propellers. Model results were verified with field data taken by the Illinois State Water Survey at Clark's Ferry and Kampsville (Bhowmik et al., 1998). Details of the model tests are presented in Maynord and Martin (1997, ENV 3), Maynord and Knight (1998, ENV 5), and Maynord (2000a, ENV 19).

8.4.2.2 NAVEFF Model

The NAVEFF (NAVigation EFFiciency) model was developed for a system wide evaluation of the UMR and IWW to determine the hydraulic disturbances of commercial navigation traffic along the main channel of the waterways. A wide range of tow sizes and drafts, tow speeds, direction of travel (up or downbound), type of propellers, sailing line positions, and stages in the river were used as inputs. Three tow sizes of 1X3 (1 barge wide by 3 barges long), 2X4, and 3X5 were used to simulate the range of tow sizes found on the river. Three drafts of loaded (2.74 m draft), mixed, and empty (0.61 m draft) were used to simulate the range of drafts. Three tow speeds of 5, 6.5, and 8 mph and 3, 5, and 7 mph were used on the UMR and IWW, respectively. Propellers were either open wheel or Kort nozzles. Kort nozzle propellers are surrounded by a streamlined cylinder that increases performance at tow speeds typical of those used on the UMR and IWW. Open wheel propellers have no cylinder. Kort nozzles are most frequently found on larger horsepower towboats with open wheel propellers most frequently found on lower powered towboats. The combinations of direction (2), speed (3), size (3), draft (3), and propeller type (2) resulted in 108 different tow configurations to represent the various tows on the river.

Varying river stage was addressed by conducting NAVEFF computations for stages corresponding to flows that were exceeded 5, 50, and 95 percent of the time. Varying sailing line position was addressed by selecting left, middle, and right sailing lines that were used 5, 90, and 5 percent of the time, respectively. Combinations of stage (3) and sailing line (3) resulted in 9 different applications of NAVEFF using the 108 combinations of tow configurations in each pool of the system.

The power used by the towboat to push the selected tow size and draft at the selected speed and direction was determined using techniques given in Maynord (2000b, ENV 24). This power was used to determine the velocity exiting the propeller jet for river bed scour and sediment resuspension computations and the discharge through the propeller jet for larval fish entrainment.

At each cell in the pool, NAVEFF computes maximum velocity change during the tow passage (m/sec), maximum drawdown (m), maximum wave height (m), maximum scour depth (m), and maximum shear stress (pascals). The maximum velocity change during the tow passage results from different mechanisms depending on the distance of the cell from the tow and will be discussed subsequently.

8.4.2.3 GIS Layout of Waterway

A fundamental starting point for eventual application of the hydraulic modeling consisted of segmenting the entire system into 'cells' based on position in the channel and depth profile (bathymetry). The bathymetry of the various pools on the UMR and IWW was described by cross-sections at 0.5 mile intervals in the 'trend' pools on the UMR and 1.0 mile intervals in the 'non-trend' pools on the UMR and all pools on the IWW. [*NOTE: The Upper Mississippi River System Environmental Management Program (UMRS-EMP), Long-Term Resource Monitoring Program (LTRMP) detailed study pools are generally referred to as the 'trend' pools. All other pools are termed 'non-trend'. The trend pools are Pools 4, 8, 13, 26, and river miles 31-74 of the Open River reach below St. Louis on the Mississippi River; and, the La Grange Pool on the Illinois Waterway. Existing physical and biological data are generally more abundant for these 'trend' pools. Further information on the UMRS-EMP and LTRMP may be found in USACE (1997b). 'Trend pool' may be used interchangeably with 'LTRMP study pool'*].

Each cross-section was divided into 10m wide cells from the left to right bank, with the cells laid out from a reference line which was the middle sailing line for the initial set of left, middle, and right sailing lines. To the right and left of the reference line, the grid began with cell 5Rxxxx which stood for a 10 m wide cell that had the center of the cell 5 meters right of the reference line. The cell was located at river mile xxx.x. This was done left and right of the reference line until the limits of the bathymetry or some limiting elevation was reached. The 10 m cell width was chosen because it allowed some definition to variation in physical effects across the width of the tow. The 10 m wide cells resulted in 3 cells describing the width of a standard 15 barge tow. In each cross-section specific cells were designated as the left, middle, and right sailing line. The hydraulic disturbances were determined for each cell in the cross-section for all 108 tow combinations and for all nine combinations of stage/sailing line.

8.4.3 Rollup of Hydraulic Disturbances

Having 108 tow types for 3 sailing lines and 3 stages for each cell produced a large amount of data. For example, the NAVEFF output file for Pool 13 for a medium flow and middle sailing line (one of the nine NAVEFF output files for each pool) had over 609,000 lines of output. The data for each hydraulic disturbance were summarized or 'rolled up' by developing a histogram of a large sample of tow events. To determine the sample tow events, existing tow traffic data extracted from the LPMS were used to develop the probability of occurrence of the 108 tow types. Knowing the probability of the different tow types, the probability of the 3 stages occurring in any given month, and the probability of the 3 sailing lines allowed developing a statistical rollup of tow events that exhibited the correct probability of occurrence. In each pool, 5000 samples were extracted randomly to provide statistical significance to the results and to prevent significant variation in the histogram. Because the flow varies from high flow months like April to low flow months like August, histograms were developed for each navigable month of the year. A sample histogram for wave height for cell ID 185R5435 located in Pool 13 of the UMR is shown in Table 8-1. Cell IDs used on the UMR and IWW define the distance from a reference line and the river mile. The reference line is generally, but not always, close to the middle sailing line. Cell ID 185R5435 is 185 m right (looking downstream) of the reference line and located at river mile (RM) 543.5. The 11 values in Table 8-1 were saved for each cell, for each hydraulic disturbance, and for each navigable month of the year. In this manner, a cumulative probability curve for each disturbance was provided by cell and by month.

Table 8-1. Maximum wave height in Pool 13, UMR, Cell ID 185R5435, April.

Probability of exceedance by a single tow	maximum wave height, m
1	0.04*
0.9	0.05
0.8	0.06
0.7	0.08
0.6	0.08
0.5	0.1
0.4	0.11
0.3	0.11
0.2	0.14
0.1	0.16
0	0.22**

* Minimum wave height of 5000 events
** Maximum wave height of 5000 events

8.4.3.1 Changes in Current Velocity and Direction

8.4.3.1.1 Propeller Jet and Near Tow Velocities

The majority of towboats on the UMR and IWW have twin propellers with diameters up to about 2.8 m. Towboat power for 3X5 barge tows will range from as low as 1800 hp to greater than 6000 hp. Velocities exiting the propellers can reach 6.0 m/sec or greater near the center of the jet and decay with lateral and longitudinal distance from the jet. The propeller jet equations in NAVEFF define the time history of near-bed velocity as the tow passes and are presented in Maynord (2000a, ENV 19).

In addition to the propeller jet, the displacement of water by the barges causes a rise in velocity beneath the bow of the tow. The bow velocity is relatively short lived and increases with decreasing depth/draft and with increasing tow speed and is relatively constant across the width of the barges. The rise in velocity at the bow of the barges is much greater than the return velocity that is discussed subsequently.

Beneath the tow, the NAVEFF model outputs the maximum near-bed velocity change from either the propeller jet or from the displacement effects at the bow of the tow. For a 3 barge wide tow (which is 3 cells wide) at the center cell (10m wide), the propeller jet will generally produce the maximum velocity change. For the two cells on either side of the center cell that are underneath the 3 barge wide tow, the maximum velocity change will generally result from the maximum bow velocity.

Maximum near-bed velocity change at RM 543.5(UMR Pool 13) for an upbound, 3X5, loaded tow with Kort nozzles is shown in Table 8-2 for the 10m wide cell located at the middle sailing line for low, medium, and high flows. The Table 8-2 data are from the NAVEFF runs and are not the result of the rollup discussed previously.

The rollup values for probabilities of 0.9, 0.5, and 0.1 for cell 35R5435 are shown in Table 8-3 and include the effects of all 108 tow types, 3 stages, and 3 sailing lines. By comparing Table 8-2 and Table 8-3, it can be seen that the large fast tows on the middle sailing line shown in Table 8-2 produce large effects compared to the median tow (50%) from the rollup in Table 8-3. Table 8-3 shows that changes in a high flow month like April are less than a low flow month like August.

Table 8-2. Maximum near-bed velocity change versus stage versus tow speed, Cell ID 35R5435.

Stage	Tow speed, m/sec (mph)	Depth at cell, m	maximum near bed Velocity Change, m/sec
low	2.24(5)	4.46	0.98
medium		4.92	0.87
high		6.26	0.65
low	2.91(6.5)	4.46	1.28
medium		4.92	1.13
high		6.26	0.85
low	3.58(8)	4.46	1.87
medium		4.92	1.44
high		6.26	1.04

Table 8-3. Near-bed velocity change versus probability of exceedance by a single tow, Cell ID 35R5435.

Probability of exceedance by a single tow	April- Near bed Velocity Change, m/sec	August Near bed Velocity Change, m/sec
0.9	0.12	0.18
0.5	0.64	0.86
0.1	1.11	1.30
Max. of any combination	1.87	1.87

8.4.3.1.2 Return Velocity

A tow moving in a navigation channel displaces water and creates a flow of water (called return velocity) in a direction opposite to that of the tow. With the exception of the very wide sections upstream of some dams, return velocity is present over the entire cross-section of the river. The magnitude of the return velocity is primarily dependant on the tow speed, the channel cross-section (area and average depth), and the submerged cross-sectional area of the tow. Return velocity generally increases for decreasing blockage ratio N (ratio of channel cross-sectional area to vessel cross-sectional area). Typical N for 3 wide loaded barges at RM 543.5 in Pool 13 of the UMR is about 22 at low flow. Typical N at RM 85.0 in La Grange Pool on the IWW is about 11 at low flow. Return velocity is greatest at about one tow width away from the tow centerline and decreases toward the shoreline. As N decreases, the distribution of return velocity from tow to shore becomes more uniform. Duration of return velocity is about equal to the time required for the tow to pass a fixed point in the channel.

Away from the tow, the maximum velocity change output by the NAVEFF model is equal to the return velocity and is not influenced by the propeller jet. The rollup values from two cells on the right descending bank at RM 543.5 in Pool 13 on the UMR are shown in Table 8-4 for cell IDs 185R5435 and 125R5435 which are 150m and 90m, respectively, from the middle sailing line.

Table 8-4. Rollup values of maximum velocity change (equal to return velocity for these cells) in Pool 13, UMR.

Probability of Exceedance by a single tow	Cell ID 185R5435, Maximum Velocity Change, m/sec		Cell ID 125R5435, Maximum Velocity Change, m/sec	
	April	August	April	August
0.9	0.02	0.03	0.04	0.05
0.5	0.08	0.12	0.12	0.17
0.1	0.15	0.20	0.21	0.29

Rollup values from the shoreline cell on the right descending bank at RM 85.0 in La Grange Pool on the IWW are shown in Table 8-5 for cell IDs 105r0850 and 55r0850 which are 120m and 70m, respectively, from the middle sailing line. The La Grange values, although greater than the Pool 13 values, reflect that tow speeds are less on the IWW than on the UMR. Were speeds equal on the two rivers, the La Grange rollup values would have been significantly greater than the Pool 13 UMR values.

Table 8-5. Rollup values of maximum velocity change (equal to return velocity for these cells) in LaGrange Pool IWW.

Probability of Exceedance by a single tow	Cell ID 105R0850, Maximum Velocity Change, m/sec		Cell ID 55R0850, Maximum Velocity Change, m/sec	
	April	August	April	August
0.9	0.03	0.03	0.05	0.05
0.5	0.11	0.12	0.14	0.17
0.1	0.26	0.27	0.33	0.35

8.4.3.2 Wake Waves

Short period waves generated by tows are primarily a function of tow speed, hull form, and distance from the tow. Vessel draft affects wave height but to a lesser extent than speed or distance. Maximum wave heights for varying vessel speed and varying distance from the tow are shown in Table 8-6 from the NAVEFF program (not from rollup) for a 3X5 loaded tow on the middle sailing line and low stage at RM 543.5 in Pool 13 of the UMR.

Table 8-6. Maximum wave height for varying speed and distance at RM 543.5 on the UMR for a 3X5 loaded tow.

Tow Speed, m/sec (mph)	Cell ID	Distance from tow, m	maximum wave height, m
2.24(5)	75R5435	40	0.10
	125R5435	90	0.07
	185R5435	150	0.06
2.91 (6.5)	75R5435	40	0.20
	125R5435	90	0.14
	185R5435	150	0.11
3.58 (8.0)	75R5435	40	0.35
	125R5435	90	0.24
	185R5435	150	0.20

The rollup values for maximum wave height are shown in Table 8-7 for these same 3 cells.

Table 8-7. Rollup of maximum wave height for cells at RM 543.5 on UMR for April.

Probability of exceedance by a single tow	Maximum Wave Height, m, by Cell ID		
	75R5435	125R5435	185R5435
0.9	0.08	0.06	0.05
0.5	0.16	0.12	0.10
0.1	0.25	0.20	0.16

8.4.3.3 Drawdown

Drawdown is the lowering of the water surface as a result of passage of a tow. Duration of drawdown is about equal to the time required for the tow to pass a fixed point in the channel. Drawdown and the previously discussed return velocity occur simultaneously and are the result of the tow displacing a large volume of water as it moves through the waterway. Drawdown magnitude primarily depends on tow speed, channel cross section (area and average depth), and the submerged cross-sectional area of the tow. Other factors, such as tow length and shape of the bow, play a lesser role in defining drawdown magnitude. Like return velocity, drawdown is greatest at the tow and decreases toward the shoreline and the distribution of drawdown becomes more uniform from tow to shore as blockage ratio N decreases.

All other factors being equal, drawdown on the UMR will be less than on the IWW due to the IWW's smaller channel size. Drawdown is primarily of interest at the shorelines and at the mouth of backwaters and secondary channels for its potential effects on fish spawning sites and/or stranding of fish larvae. Maximum drawdown for varying vessel speed at the shoreline cell are shown in Table 8-8 from the NAVEFF program (not from rollup) for an upbound 3X5 loaded tow on the middle sailing line and low stage at RM 543.5 in Pool 13 of the UMR.

Table 8-8. Maximum drawdown at the shoreline cell for varying speed at RM 543.5 on the UMR for a 3X5 loaded tow at middle sailing line and low stage. (cell is 150 m from tow)

Speed, m/sec (mph)	Maximum Drawdown, m at cell 185R5435
2.24(5)	0.05
2.91(6.5)	0.09
3.58(8)	0.16

Table 8-9 provides the histogram values for maximum drawdown for cell 185R5435 for the month of April and August.

Table 8-9. Histogram of maximum drawdown at cell 185R5435.

Probability of exceedance by a single tow	Maximum Drawdown, m, by Month	
	April	August
0.9	0.01	0.01
0.5	0.03	0.04
0.1	0.06	0.08

8.4.3.4 River Bed Scour

River bed scour was most significant near the path of the tow and increased with (a) decreasing depth, (b) increasing speed, (c) increasing tow size, (d) decreasing bed material size, and (e) decreasing waterway size. The maximum scour can result from the propeller jet velocity or the velocity peak at the bow of the barges discussed previously. Table 8-10 shows the maximum scour for an upbound 3X5 loaded tow with Kort nozzles on the middle sailing line at 3 flows for RM 543.5 in Pool 13 of the UMR. Cell 35R5435 is the cell located under the centerline of the tow and cell 45R5435 is under the 3 barge wide tow and adjacent to 35R5435.

Table 8-10. Maximum river bed scour versus stage versus tow speed, Cells 35R5435 and 45R5435, 3X5 upbound, loaded tow with Kort nozzles.

Stage	Tow speed, m/sec (mph)	Depth at cell, m	Cell ID, maximum scour, m	
			35R5435	45R5435
low	2.24(5)	4.46	0.07	0.07
medium		4.92	0.06	0.06
high		6.26	0.03	0.03
low	2.91(6.5)	4.46	0.14	0.08
medium		4.92	0.07	0.07
high		6.26	0.06	
low	3.58(8)	4.46	0.22	0.08
medium		4.92	0.17	0.08
High		6.26	0.07	0.07

8.4.4 Typical Values in LTRM Study Pools

To demonstrate typical values of these hydraulic disturbances along the river, cross-sections were selected from each study pool. The selected sections were intended to represent typical channel widths in the pool. Large pooled areas upstream of the dams were not used. Values of the disturbances are presented for the left and right bank of each selected section for maximum velocity change, waves, and drawdown. Values are also presented for the middle sailing line cell for maximum velocity change and maximum river bed scour (Table 8-11).

The 3 values shown in Table 8-11 for each location are 1) value from an upbound 3X5 loaded tow with Kort nozzles at low flow on the middle sailing line at the fastest speed (8.0 mph on the UMR and 7.0 mph on the IWW), 2) rollup value for the month of August for a probability of exceedance by a single tow of 50%, and 3) rollup value for the month of August for a probability of exceedance by a single tow of 10%. The first value for the 3X5 tow is close to the maximum value for that cell and has a probability of occurrence of less than 1%. The only tows that would produce values exceeding the first value would be the same tow located on left or right sailing line or possibly the same tow at the medium flow on the left or right sailing line. August was used for the rollup values because it is a low flow month and will result in the largest values of the parameter. Table 8-11 reflects that the analysis treated Pool 26 in two segments (upper and lower) to reflect traffic differences above and below the confluence of the IWW.

8.4.5 Sediment Resuspension and Transport to Backwaters/Secondary Channels

8.4.5.1 Effects of Increased Traffic

The magnitude of the hydraulic disturbances, described above for a single tow event, does not change with increasing traffic and the typical values of the hydraulic disturbances shown in Table 8-11 apply to existing and increased levels of traffic. The only physical effects whose magnitude does change with increased traffic are the delivery of sediment to secondary channels and backwaters, and bank erosion, which will be discussed subsequently. All of the biological effects are dependent on the magnitude of increased traffic and use the increased frequency of the hydraulic disturbances in determining the biological effect.

8.4.5.2 NAVSED Model

NAVSED (NAVigation SEDimentation) is the analytical system model used to compute sediment concentration versus time due to the hydraulic disturbances created by commercial navigation traffic. The sediment concentrations result from the combined influences of propeller and bow velocities under the tow, return currents, and short period waves propagating from the tow to the shore. NAVSED uses the magnitude of the disturbances from NAVEFF as input for calculating concentration. The concentration given is the combined concentration of both fines (silt; smaller, lighter particles) and sand (larger, heavier particles). As in the NAVEFF model, NAVSED evaluates 9 combinations of 3 stages and 3 sailing lines for each cell and 108 tow configurations. Details of the NAVSED model are provided in Copeland et al. (2000) and Parchure et al. (1999, ENV 20).

8.4.5.3 Methodology for Calculating Sedimentation of Secondary channels and Backwaters

As the various modeling efforts progressed for the Navigation Study, it was determined that in the LTRMP study pools (4, 8, 13, 26, Open River, La Grange), the volume of sediment *delivered* to backwaters or secondary channels could be calculated as the result of resuspension of channel bed materials from towboats. Sufficient physical data was available in the non LTRMP study pools to link the results from the LTRMP study pools to individual backwater and side channel openings in the non LTRMP study pools to make a determination of the potential for tow-induced sediment delivery (Nickles and Pokrefke 2000, ENV 27). Using the NAVEFF (Maynord 1996; 1999, ENV 14) program developed for the UMRS, towboat impacts in the main channel could be determined. This included propeller jet effects, generation of return currents from the towboat, drawdown along the channel border areas, and waves from the tow. The NAVSED (Copeland et al. 2000) program takes output from the NAVEFF program and computes resuspension of the designated channel bed material due to the velocity changes created by the return currents and propeller jets and the towboat inducted waves. For the backwater and secondary channel sedimentation, specific cells were identified and associated to specific inlets, and the NAVSED computations were conducted for the 108 tow configurations, 3 flow conditions, and 3 sailing channel locations. The drawdown from the NAVEFF model and output from the NAVSED program was then fed into the BACKSED (BACKwater SEDimentation) program (Pokrefke et al. 2003, ENV 41) which computed the volume of sediment resuspended in each identified inlet cell each month per tow. Those volumes then fed into a program (also used for the UMRS biological models) that rolled up the probabilities associated with tow configurations, flows, and sailing lines to identify various probability levels of sediment delivered to the backwater or secondary channel. The value used in the backwater and secondary channel sedimentation has been based on the median or 50 percent rollup value. This value represents a reasonable mix of various tow configurations and normal, overall impacts.

Table 8-11. Typical values of maximum velocity change (MVC), wave height, drawdown, and river bed scour (MRBS). RDB = right descending bank; LDB = left descending bank; and MSL = middle sailing line.

Pool	River Mile (RM), cell ids for left bank, right bank, and middle sailing line (depth at MSL)	Maximum Velocity Change (m/sec)		Maximum Wave Height (m)		Maximum Drawdown, (m)		MVC (m/sec)	MRBS (m)
		LDB	RDB	LDB	RDB	LDB	RDB	MSL	MSL
4	RM 792 55L7920, 55R7920, 5L7920(5.19 m)	1.19[1] 0.23[2] 0.50[3]	1.42 0.24 0.55	0.31 0.15 0.21	0.28 0.13 0.20	0.67 0.08 0.20	0.65 0.08 0.19	2.74 0.64 1.18	0.36 0.02 0.11
4	RM 788 95L7880, 75R7880, 15R7880(7.34 m)	0.53 0.13 0.29	0.71 0.17 0.39	0.22 0.11 0.16	0.28 0.14 0.20	0.24 0.05 0.11	0.32 0.06 0.14	0.86 0.43 0.69	0.04 0.002 0.01
4	RM 762 35L7620, 175R7620, 35R7620(6.58 m)	0.44 0.14 0.32	0.30 0.10 0.22	0.27 0.13 0.18	0.20 0.10 0.14	0.20 0.05 0.12	0.14 0.04 0.08	0.98 0.58 0.80	0.07 0.01 0.05
8	RM 700 155L7000, 105R7000, 5L7000 (6.26 M)	0.26 0.11 0.19	0.34 0.14 0.24	0.20 0.11 0.16	0.22 0.13 0.16	0.13 0.04 0.08	0.16 0.04 0.10	1.04 0.60 0.85	0.07 0.01 0.05
8	RM 696 195L6960, 125R6960, 5R6960 (6.97 M)	0.17 0.07 0.13	0.23 0.11 0.19	0.18 0.10 0.14	0.21 0.12 0.15	0.08 0.03 0.05	0.11 0.04 0.07	0.91 0.50 0.75	0.05 0.008 0.03
8	RM 691 205L6910, 145R6910, 75L6910 (4.15 M)	0.41 0.18 0.31	0.31 0.13 0.23	0.21 0.12 0.15	0.17 0.10 0.12	0.19 0.06 0.11	0.15 0.05 0.09	2.26 1.12 1.72	0.27 0.07 0.27

[1] value for an upbound 3X5 loaded tow at fast speed (8.0 mph on UMR,7.0 mph on IWW) with Kort nozzles, [2] rollup value for probability of 50%, [3] rollup value for probability of 10%.

Table 8-11 (continued). Typical values of maximum velocity change (MVC), wave height, drawdown, and river bed scour (MRBS). RDB = right descending bank; LDB = left descending bank; and MSL = middle sailing line.

Pool	River Mile (RM), cell ids for left bank, right bank, and middle sailing line (depth at MSL)	Maximum Velocity Change (m/sec)		Maximum Wave Height (m)		Maximum Drawdown, (m)		MVC (m/sec)	MRBS (m)
		LDB	RDB	LDB	RDB	LDB	RDB	MSL	MSL
13	RM551	0.17[1]	0.25	0.17	0.21	0.09	0.12	0.94	0.05
	215L5510, 135R5510, 15R5510	0.07[2]	0.11	0.09	0.12	0.03	0.04	0.52	0.005
	(6.82 M)	0.12[3]	0.18	0.12	0.16	0.03	0.08	0.77	0.03
13	RM 543.5	0.22	0.33	0.15	0.20	0.11	0.16	1.87	0.22
	255L5435, 185R5435, 35R5435	0.08	0.12	0.09	0.11	0.03	0.04	0.86	0.04
	(4.46 M)	0.13	0.20	0.11	0.14	0.06	0.08	1.30	0.10
13	RM 536	0.10	0.25	0.15	0.24	0.06	0.11	1.22	0.10
	325L5360, 85R5360, 5L5360	0.05	0.12	0.08	0.14	0.02	0.04	0.70	0.02
	(5.50)	0.08	0.20	0.11	0.20	0.04	0.07	0.98	0.06
96	RM 239	0.13	0.07	0.19	0.14	0.06	0.04	0.87	0.04
	165L2390, 415R2390, 5R2390	0.04	0.03	0.11	0.08	0.02	0.01	0.41	0.001
	(7.23 M)	0.08	0.05	0.15	0.10	0.04	0.02	0.69	0.04
96	RM 231	0.38	0.43	0.17	0.18	0.19	0.21	2.52	0.23
	195L2310, 215R2310, 35R2310	0.11	0.12	0.10	0.10	0.03	0.04	0.81	0.03
	(4.08 M)	0.17	0.20	0.12	0.14	0.07	0.08	1.56	0.17
96	RM 222	0.35	0.27	0.20	0.18	0.17	0.14	1.75	0.17
	165L2220, 175R2220, 25L2220	0.14	0.13	0.11	0.10	0.04	0.04	0.81	0.04
	(4.71 M)	0.24	0.25	0.15	0.13	0.09	0.08	1.20	0.09

[1] value for an upbound 3X5 loaded tow at fast speed (8.0 mph on UMR,7.0 mph on IWW) with Kort nozzles, [2] rollup value for probability of 50%, [3] rollup value for probability of 10%

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Table 8-11 (completed). Typical values of maximum velocity change (MVC), wave height, drawdown, and river bed scour (MRBS). RDB = right descending bank; LDB = left descending bank; and MSL = middle sailing line.

Pool	River Mile (RM), cell ids for left bank, right bank, and middle sailing line (depth at MSL)	Maximum Velocity Change (m/sec)		Maximum Wave Height (m)		Maximum Drawdown, (m)		MVC (m/sec)	MRBS (m)
		LDB	RDB	LDB	RDB	LDB	RDB	MSL	MSL
26	RM 217 335L2170, 555R2170, 5L2170 (9.85 M)	0.05[1] 0.02[2] 0.04[3]	0.03 0.02 0.03	0.15 0.09 0.12	0.12 0.07 0.09	0.03 0.01 0.02	0.02 0.008 0.01	0.60 0.36 0.49	0.01 0.0004 0.006
26	RM 210 325L2100, 195R2100, 55L2100 (9.08)	0.06 0.03 0.05	0.05 0.03 0.05	0.16 0.09 0.12	0.16 0.09 0.14	0.04 0.01 0.02	0.03 0.01 0.02	0.66 0.40 0.55	0.02 0.0007 0.01
26	206 295L2060, 825R2060, 5R2060 (10.58)	0.04 0.02 0.03	0.02 0.01 0.02	0.15 0.09 0.13	0.11 0.06 0.08	0.03 0.01 0.02	0.02 0.006 0.01	0.55 0.33 0.45	0.01 0.0003 0.004
31	RM 154 105L1540, 55R1540, 5L1540 (4.45)	0.97 0.11 0.27	1.45 0.17 0.40	0.16 0.05 0.11	0.20 0.06 0.13	0.41 0.03 0.08	0.56 0.04 0.10	3.01 0.44 1.02	0.28 0.004 0.06
31	RM 118 125L1180, 95R1180, 25L1180 (3.71)	1.07 0.11 0.29	0.91 0.10 0.25	0.16 0.05 0.11	0.15 0.04 0.10	0.43 0.03 0.08	0.38 0.03 0.07	3.76 0.56 1.27	0.28 0.01 0.07
31	RM 85 135L0850, 105R0850, 15L0850 (4.48)	0.89 0.12 0.28	0.86 0.12 0.27	0.15 0.04 0.10	0.15 0.04 0.10	0.36 0.03 0.08	0.36 0.03 0.08	2.66 0.53 1.12	0.28 0.01 0.06

[1] value for an upbound 3X5 loaded tow at fast speed (8.0 mph on UMR,7.0 mph on IWW) with Kort nozzles, [2] rollup value for probability of 50%, [3] rollup value for probability of 10%

As emphasized above, this study only determined how much sediment is delivered to the specified inlets. It is believed that some or all of those sediments may simply pass through the area, or may settle out to be possibly resuspended and removed from the backwater or secondary channel during annual high flow events. Also, the computations and resulting sedimentation quantities are only the result of towboat navigation resuspending from the channel bed material. These computations do not include the ambient sediments passing into backwaters or secondary channels when tows are not passing the inlet, sediment quantities carried into these areas during flood events, or the impacts of wind- or recreational vessel-generated sediment loads.

The methodology described was accomplished for all of the UMR LTRMP study pools. One necessary input parameter available in the study pools, but not in the remaining pools, was the discharge into the inlet. For the study pools those values for the low, medium, and high flows were obtained by conducting two-dimensional numerical model studies. This information was needed for computations conducted in the BACKSED program.

Going through the sedimentation computations using NAVEFF and NAVSED provides channel and channel border information to use in the BACKSED program. The BACKSED program treats any backwater that has flow through it (i.e., an inlet, at least one through channel, and an outlet) identically to a secondary channel. Therefore, in the BACKSED program the backwaters and secondary channels with flow through them not only include sediment delivered by drawdown, but also the through-flow water having sediment concentrations that have been elevated by the tow. The through-flow movement of sediment often dominated the amount of sediment delivered and explains why the highest values of delivered sediment were often found in areas with large through-flow discharges.

Single-opening backwaters are treated differently, since for any stage condition, there is no flow from the main channel into the backwater; therefore, such backwaters have different mechanisms of sediment delivery than through-flow backwaters. On a single-opening backwater with no through-flow, the only mechanism delivering sediment to the backwater is the drawdown of the water level at the inlet by the tow. Drawdown causes relatively sediment-free water to leave the backwater, which is replaced by water having sediment concentrations that have been elevated by the passing tow. Therefore, as the water surface stabilizes and the volume of water removed from the backwater flows back into it, the water that flows into the backwater may have concentrations greater than ambient concentrations in the backwater.

8.4.5.4 Existing Conditions

Before the effects of the various proposed alternatives can be addressed, the without project conditions must be considered. For this effort, traffic conditions for the year 2000 and year 2050 were computed based on the 50 percent rollup values (see section 8.4.3). Using the volumes of sediment resuspended by towboats for the 108 tow configurations the load of sediment into a backwater or secondary channel was computed in acre-feet/year. Then, by taking the area of the backwater or secondary channel, the rate that sediment was delivered into the area was computed in cm/year. These quantities were then used to qualitatively categorize the impacts that sediment resuspended by towboats had to backwaters and secondary channels (Pokrefke et al. 2003, ENV 41).

Establishment of the levels of significance was important to the categorization of impacts. For the volume of sediment entering any one inlet to a backwater or the inlet to a secondary channel, the level of significance was determined to be an annual volume of 1.0 acre-foot/year or greater for that area to have a medium potential for impacts from towboats. Relative to annual volumes no criteria was established for high potential impacts to backwaters or secondary channels. Based on previous studies (Simons, et al. 1981), it was decided that a rate of sediment delivered to backwaters or secondary channels of less than 0.1 cm/year would produce negligible potential for impacts, a rate of delivery of more than 0.1 and less than 1.0 cm/year would produce medium potential for impacts, and a rate greater than 1.0 cm/year had a high potential for impacts (Table 8-12). One final method to evaluate the potential for impacts was taking the inlet width into consideration. Using the annual load delivered to an inlet and dividing by the width of the inlet produced a unit load for the inlet. Based on a review of the computed data, it was determined that a unit load value of 0.01 acre-feet/year/meter would be used as a level of significance to categorize a medium potential impact. This unit annual load was used in the extrapolation process from the trend-pools to the non-trend-pools. Table 8-13 presents the various levels of potential impacts. Backwaters and secondary channels were evaluated for without project conditions and project alternatives 2, 4, 5, and 6. The without project condition and each project alternative had 5 traffic scenarios (TS) that were least favorable, less favorable, central, favorable, and most favorable. Each of the TS was evaluated for years 2000-2050 in ten-year increments.

Table 8-12. Levels of significance for sediment delivered to backwaters and side channels.

	NEGLIGIBLE IMPACT POTENTIAL (BLUE)	MEDIUM IMPACT POTENTIAL (YELLOW)	HIGH IMPACT POTENTIAL (RED)
VOLUME	< 1.0 acre-ft/year	> 1.0 acre-ft/year	No criteria
By RATE	< 0.1 cm/year	> 0.1 cm/year and < 1.0 cm/year	> 1.0 cm/year
By UNIT VOLUME	< 0.01 acre-ft/year/m	> 0.01 acre-ft/year/m	No criteria

Table 8-13. Impacted backwaters and secondary channels

POOL No. or NAME	BW or SEC No.	RIVER MILE and SIDE	W/O PROJECT COLOR*/ WITH PROJECT COLOR**	NAVIGATION CHART NAME
MISSISSIPPI RIVER				
2	BW8	826.6-RIGHT	YELLOW/YELLOW	River Lake
2	BW10	823.5-RIGHT	YELLOW/YELLOW	Spring Lake
3	BW2	801.8-RIGHT	YELLOW/YELLOW	Brewer Lake
3	SEC1	811.8-RIGHT	YELLOW/YELLOW	Prescott Island
5	BW2	752-RIGHT	YELLOW/YELLOW	Island No. 42 (just upstream of Zumbro River)
5	BW4	747-LEFT	YELLOW/YELLOW	Belvidere Island
6	BW1	728-RIGHT	YELLOW/YELLOW	Black Bird Slough
8	BW2	696-RIGHT	YELLOW/YELLOW	Target Lake and Broken Arrow Slough
8	BW6	687-RIGHT	BLUE/YELLOW	Island 120
8	SEC8	690.5-RIGHT	YELLOW/RED	Lawrence Lake area
9	BW4	671-RIGHT	YELLOW/YELLOW	Big Slough
9	SEC3	671-LEFT	YELLOW/YELLOW	Battle Island
10	BW10	620-RIGHT	YELLOW/YELLOW	Frenchtown Lake
11	BW1	614-LEFT	YELLOW/YELLOW	Island No. 189 and Cassville Slough
11	BW3	612-RIGHT	YELLOW/YELLOW	Goetz Slough
13	BW11	533-LEFT	YELLOW/YELLOW	Mound Island and Dark Slough
13	SEC8	543-RIGHT	YELLOW/YELLOW	Big Soupbone Island
13	SEC12	533-RIGHT	YELLOW/YELLOW	Big Cook Island
ILLINOIS WATERWAY				
DRESDEN ISLAND	BW2	280-LEFT	YELLOW/YELLOW	Treats Island
MARSEILLES	SEC1	261-RIGHT	YELLOW/YELLOW	Waupecan Sugar Island
MARSEILLES	SEC-A	256-RIGHT	YELLOW/YELLOW	Barry Island
STARVED ROCK	SEC1	239-LEFT	YELLOW/YELLOW	Hitt and Mayo Islands
STARVED ROCK	SEC2	236-RIGHT	YELLOW/YELLOW	Sheehan Island
PEORIA	BW10	201- RIGHT	YELLOW/YELLOW	Spring Lake
PEORIA	SEC2	195-RIGHT	YELLOW/YELLOW	“gravel pit”
PEORIA	SEC-A	208-LEFT	YELLOW/YELLOW	Hennepin Island
PEORIA	SEC-B	204-LEFT	YELLOW/YELLOW	Upper Twin Sisters Island
PEORIA	SEC-C	203-RIGHT	YELLOW/YELLOW	Lower Twin Sisters Island
LAGRANGE	BW2	123-LEFT	YELLOW/YELLOW	Lower portion of Quiver Lake
LAGRANGE	BW4	113-LEFT	YELLOW/YELLOW	Grand Island
LAGRANGE	BW5	96-LEFT	YELLOW/YELLOW	Sangamon Bay
LAGRANGE	BW6	95-LEFT	RED/RED	Sugar Creek Island
LAGRANGE	SEC1	149-RIGHT	RED/RED	Turkey Island
LAGRANGE	SEC3	140-LEFT	YELLOW/YELLOW	Coon Hollow Island
LAGRANGE	SEC6	122-LEFT	YELLOW/YELLOW	Quiver Island
ALTON	BW2	28-RIGHT	YELLOW/YELLOW	Hurricane and Diamond Islands
ALTON	SEC-B	46-RIGHT	YELLOW/YELLOW	Buckhorn Island
ALTON	SEC-D	39-LEFT	YELLOW/YELLOW	Fisher Island
ALTON	SEC-E	38-RIGHT	YELLOW/YELLOW	Twin Islands
ALTON	SEC-F	31-LEFT	YELLOW/YELLOW	Willow Island

*For traffic scenario and year having highest traffic
**For project alternative, traffic scenario, and year having highest traffic.

8.4.5.5 Without Project Conditions

- In Pool 4, of the 10 backwaters, all backwaters had negligible potential for impacts for the without project conditions for all TS and all years. There were no secondary channels delineated in this pool. The rate that sediment was delivered to the backwaters was significantly less than 0.1 cm/year. The low values computed for Pool 4 were mainly due to the fact that the bed material was mostly noncohesive, sand-type sediment.
- In Pool 8, of the 5 backwaters, 1 backwater had medium potential for impacts for the without project conditions for all TS and all years. Of the 8 secondary channels, 1 channel had medium potential for impacts for all TS and all years. The rate that sediment was delivered to backwaters varied up to 0.18 cm/year; while the rate sediment was delivered to secondary channels varied up to 0.79 cm/year.
- For Pool 13, of the 10 backwaters, 1 backwater had a medium potential for impacts without project for all TS and all years. Of the 12 secondary channels, 1 channel had medium potential for impacts for all TS and all years. Another secondary channel had medium potential for impacts for all TS and all years except for year 2050 in the Least Favorable TS. In the backwaters the rate of sediment delivered varied up to 0.56 cm/year. One particular backwater inlet had a sediment load into the backwater of 14.3 acre-feet/year. The sediment delivered to the secondary channels varied up to 0.32 cm/year.
- In Pool 26, all 9 backwaters and all 8 secondary channels had negligible potential for impacts without project for all TS and all years. The rate that sediment was delivered to backwaters and secondary channels was significantly less than 0.1 cm/year.

In summary, based on these computations, it appears that towboats contribute a very small percentage of the overall documented sedimentation rates in backwaters and secondary channels on the pooled portion of the UMR.

For the La Grange Pool, the IWW LTRMP study pool, the following potential impacts were determined for the without project traffic conditions:

- Of the 7 backwaters, 2 had a medium potential and 1 had a high potential for impacts without project for all TS and all years. Another backwater reached medium potential for impact in about year 2020 for all TS except least favorable. Of the 7 secondary channels, 2 had a medium potential and 1 had a high potential for impacts for all TS and all years. The rate that sediment was delivered to backwaters with negligible or medium potential for impacts varied up to 0.20 cm/year. The backwater with a high potential for impacts had delivery rates of up to 2.5 cm/year. In the secondary channels the areas that had negligible or medium potential for impacts had sediment delivery rates of up to 0.58 cm/year. The secondary channel with a high potential for impacts had a sediment delivery rate ranging from 120 cm/year to 203 cm/year. A filling rate of 120 cm/year indicates a high rate of sediment delivery, which probably passes through the secondary channel. If the sediment did not pass through and the secondary channel was 1.2 m deep, it would have filled in one year.

In summary, the delivery rates due to tows on the IWW are greater than those computed on the pooled section of the UMR.

For the Open River study reach, RM 31 to 74, the following potential impacts for the without project were determined:

- Of the 7 backwaters and 2 secondary channels, all areas had negligible potential for impacts for all TS and all years. This portion of the UMR has noncohesive, sand-type bed material, numerous dikes (wing dams), large channel cross-sections resulting in small drawdowns, and a navigation channel located well away from the inlets to backwaters or secondary channels.

8.4.5.6 With-Project Conditions

The proposed alternatives being considered for the Navigation Study were used to address the potential for impacts to backwaters and secondary channels as the result of change in commercial towboat traffic with the different alternatives. The process first considered UMR Pools 4, 8, 13, and 26; the La Grange Pool on the IWW; and the Open River LTRM reach on the UMR. Once computations and analysis of these pools were accomplished, the results were extrapolated to the remaining pools on the UMR and IWW and the remaining open river portion of the UMR.

For the UMR LTRMP pools the following potential impacts were determined:

- In Pool 4, of the 10 backwaters, all backwaters had negligible potential for impacts for all project alternatives, all TS, and all years. There were no secondary channels delineated in this pool. For all alternatives the rate that sediment was delivered to the backwaters was significantly less than 0.1 cm/year. None of the alternatives produced a change from the without project traffic projections.
- In Pool 8, of the 5 backwaters, 1 backwater had medium potential for impacts for all project alternatives, all TS and all years. One backwater reached medium potential for impacts in Alternative 6, Central TS. Of the 8 secondary channels, one channel had medium potential for impacts for project alternatives 2, 4, and 5. This same secondary channel reached a high potential for impacts in Alternative 6, Central TS. The rate of sediment delivered to backwaters varied up to 0.26 cm/year . For the secondary channels the rate of sediment delivered varied up to 1.1 cm/year for the secondary channel with high potential for impact. The project alternative produced changes in one backwater (negligible to medium) from the without project traffic for Alternative 6 and produced changes in the 1 secondary channel (medium to high) from the without project traffic projections for Alternative 6.
- Of the 10 backwaters in Pool 13, 1 backwater had a medium potential for impacts for all project alternatives, all TS, and all years. The rate that sediment was delivered to backwaters varied up to 0.77 cm/year for the alternatives. Of the 12 secondary channels, 1 channel had medium potential for impacts for all project alternatives, all TS, and all years. Another secondary channel had medium potential for impact except for the later years of the Least Favorable TS in all project alternatives. The sediment delivery rates for secondary channels varied up to 0.45 cm/year. None of the alternatives produced a change in potential impacts from the without project traffic projections for both backwaters and secondary channels.
- In Pool 26, of the 9 backwaters, all backwaters had negligible potential for all project alternatives, all TS, and all years. Upstream and downstream of the confluence of the Illinois and Mississippi Rivers, the sediment delivery rate to backwaters was significantly less than 0.1 cm/year. All 8 secondary channels also had negligible potential for impacts for all project alternatives, all TS, and all years. The sediment delivery rate to secondary channels upstream and downstream of the confluence of the Illinois and Mississippi varied was significantly less than 0.1 cm/year. None of the alternatives produced a change from the without project traffic projections for both backwaters and secondary channels.

In summary, of the with project conditions, of the 34 backwaters in the UMR trend pools, 3 had medium potential for impacts from towboat traffic; and 2 secondary channels out of 28 total also had medium potential for impacts; and 1 secondary channel out of 28 total had high potential for impacts. The rate that sediment is re-suspended by towboats and delivered to backwaters and secondary channels was greater for Alternatives 4, 5, and 6 than for the without project traffic conditions. However, the sediment that towboats contribute will still be a small percentage of the overall documented sedimentation trends in backwaters and secondary channels on the pooled portion of the UMR.

For the La Grange Pool, the following potential impacts were determined:

- Of the 7 backwaters, 2 backwaters had a medium potential and 1 backwater had a high potential for impacts for all project alternatives, all TS, and all years. A fourth backwater reached a medium potential for impacts for all project alternatives, all TS except least favorable, in years 2020-2030 or later. The rate that sediment was delivered for backwaters with negligible or medium impact potential varied up to 0.21 cm/year. Two of the 3 backwaters with a medium impact potential were based on at least one inlet to each backwater having a yearly volume of greater than 1.0 acre-foot/year. For the one backwater with a high potential for impact, the rate delivered varied up to 2.5 cm/year. Of the 7 secondary channels, 2 channels had a medium potential and 1 had a high potential for impacts for all project alternatives, all TS, and all years. Sediment delivered to secondary channels with negligible or medium impact potential varied up to 0.59 cm/year. The secondary channel with a high impact potential had a rate of 210 cm/year for Alternative 6. Such an extreme value should only be viewed as an indicator and was the result of shallow depth, soft sediment at the sailing line, small channel cross section, and sailing line near the secondary channel opening. None of the alternatives produced a change from the without project traffic projections for both backwaters and secondary channels.

For the Open River reach, the following potential impacts were determined:
- for impacts for all project alternatives, all TS, and all years. None of the alternatives produced a change from the without project traffic projections.

For the remaining UMR non-trend pools, the following potential impacts were determined:
- No backwaters or secondary channels were identified in Pool 1.
- In Pools 2, 3, 5, 5A, 6, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, and 25 there were 146 backwaters and 35 secondary channels delineated. In these pools, 10 backwaters and 2 secondary channels had medium potential for impacts.
- Pool 2 had 2 backwaters; Pool 3 had 1 backwater and 1 secondary channel; Pool 5 had 2 backwaters; Pool 6 had 1 backwater; Pool 9 had 1 backwater and 1 secondary channel; Pool 10 had 1 backwater; and Pool 11 had 2 backwaters with medium impact potential.
- All of the backwaters and secondary channels in Pools 5A, 7, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, and 25 had negligible potential for impacts.

For the remaining IWW pools, the following potential impacts were determined:
- In Dresden Island, Marseilles, Starved Rock, Peoria, and Alton Pools there were 35 backwaters and 24 secondary channels delineated. In these pools 3 backwaters and 12 secondary channels had medium potential for impacts.
- In Dresden Island Pool, 1 backwater had medium impact potential.
- In Marseilles Pool, 2 secondary channels had medium potential for impacts.
- In the Starved Rock Pool, 2 secondary channels had medium potential for impacts.
- In the Peoria Pool, 1 backwater and 4 secondary channels had a medium impact potential.
- There was 1 backwater and 4 secondary channels in the Alton Pool that had a medium potential for impacts.

For the remaining open river area of the UMR, the following potential impacts were determined:
- In the reaches from RM 172 to 203; from RM 140 to 172; from RM 106 to 140; from RM 74 to 106; and RM 1 to 31 there were 27 backwaters and 5 secondary channels delineated. In these 5 reaches all of the backwaters and secondary channels had negligible potential for impacts.

8.4.6 Summary

In reviewing the results of this study, consider again that only the sediment volumes delivered to inlets of backwaters and secondary channels were computed. Also, the volumes and rates of filling computed were only the result of bed material re-suspended by towboats. Sediment delivered due to ambient flow, wind, recreational vessels, or flood events are not included in this analysis. Therefore, the emphasis for these computations is on the potential for impacts from towboats to backwaters and secondary channels. Such designated areas should be reviewed and analyzed geomorphically to determine what has occurred in those areas in the past, and assess current sediment dynamics. This will give a reasonable evaluation of the overall performance of a backwater or secondary channel to carry the input sediments through the area and back to the main river channel. For example, it is possible that most of the secondary channels designated at having medium or high impact potential have virtually all of their introduced sediment loads pass directly through the channel, with little or no (even short-term) deposition.

Conversely, sediments introduced into backwaters have the potential for longer retention. Once the sediments pass through the inlet channels and reach lower velocity areas, they could remain in those areas. Sediments deposited in these low energy environments could remain there for an undetermined period of time. It is possible that yearly-normal or above-normal flow events (floods) will re-suspend the sediments and move them down the system. There is also the potential for wind waves or recreational vessel-induced waves to re-suspend these sediments. However, the ultimate fate or distribution of the sediments delivered into backwaters or secondary channels was not addressed in this effort.

For UMR Pools 1 through 26, the following summarizes the results of the study to determine potential impacts to backwaters and secondary channels:

- 180 backwaters were identified and addressed.
- For without project conditions, 12 backwaters were determined to have medium potential for impacts from towboats. This represents 7 percent of the 180 backwaters considered.
- With project alternatives, one backwater reached medium potential for impacts for Alternative 6.
- 63 secondary channels were identified and addressed.
- For without project conditions, 5 of these secondary channels were determined to have medium impact potential from towboats. This represents 8 percent of the 63 secondary channels considered.
- With project alternatives, the number of secondary channels with medium and high impact potential was unchanged.

For the IWW pools, the following summarizes the results of the study to determine potential impacts to backwaters and secondary channels:

- 42 backwaters were identified and addressed.
- For without project conditions, 7 backwaters were determined to have medium or high impact potential from towboats. This represents 17 percent of the 42 backwaters considered.
- With project alternatives, the number of backwaters with medium and high impact potential was unchanged.
- 31 secondary channels were identified and addressed.
- For without project conditions, 15 of these secondary channels were determined to have medium or high impact potential from towboats. This represents 48 percent of the 31 secondary channels considered.
- With project alternatives, the number of secondary channels with medium and high impact potential was unchanged.

For the UMR open river reach, the following summarizes the results of the study to determine potential impacts to backwaters and secondary channels:

- 32 backwaters were identified and addressed.
- All backwaters were determined to have negligible potential for impacts from towboats for the without project and proposed alternatives.
- 7 secondary channels were identified and addressed.
- All secondary channels were determined to have negligible potential for impacts from towboats for the without project and proposed alternatives.

For the UMR-IWW System, the following conclusions are presented:

- In the UMR pools, the rate that sediment is re-suspended by towboats and delivered to backwaters and secondary channels is only a very small portion of the total sediment load.
- On the UMR pools, mitigation is proposed for those backwaters or secondary channels that would be impacted by the traffic associated with the proposed alternatives.
- The backwaters and secondary channels in the IWW pools have a greater potential for being impacted than those in the UMR pools.
- On the IWW pools, Alternatives 4, 5, and 6 will increase the delivery rates due to tows on the IWW backwaters and secondary channels.

A summary of the specific backwaters and secondary channels determined to have either a medium or high potential for impacts from towboats is presented in Table 8-12. That table presents the pool number (UMR) or pool name (IWW); the name of the area as shown on the appropriate navigation chart; the classification as a backwater (BW) or secondary channel (SEC); the river mile and side of the channel, left or right looking downstream; and the impact potential.

8.5 Biological Effects

8.5.1 Fisheries

8.5.1.1 Larval Fish Mortality

Because of the difficulty in accessing larval fish mortality resulting from tow passage using field studies, a series of physical force studies and biological response studies were designed by a fisheries working group to address this question. Natural resource agencies expressed four areas of concern: (1) the effects of pressure changes resulting from the rapid mixing of the water column in the prop wash, (2) the effects of hull shear, (3) the effects of entrainment through the propellers, and (4) drawdown and associated larval fish stranding. These four areas of concern were evaluated in a series of studies conducted for the Navigation Study. Figure 8-4 provides a flow diagram for all the studies conducted for each of the four major areas of concern for potential larval fish mortality expressed by natural resource agencies. Figure 8-4 gives an indication of the complexity of these studies. For example, to determine if shear from the hull of a moving tow resulted in larval fish mortality, both physical and biological studies were conducted. First, the shear from a moving commercial towboat was calculated (Maynord 2000a, ENV 19). Biological studies were then conducted to determine if the calculated shear levels were high enough to cause mortality of larval fish (Keevin et al. 2000a, ENV 34). The shear values were also compared with previously published values for shear related larval fish mortality (Morgan et al. 1976; Maynord 2000c, ENV 23). These studies indicated that the shear levels produced by a moving tow did not cause significant mortality. However, if the shear levels were found to have caused significant mortality, then larval fish density data from the UMR would have been used to determine the percentage of the existing density that was killed. Density data were taken from two sources, a field study conducted in Pool 26 of the UMR and the lower Illinois Waterway (Gutreuter et al. 1999, ENV 29), a field study conducted in Pools 18, 22, and 26 of the UMR (MACTEC 2002), and a compendium of larval fish density data for the UMR (Bartell and Rouse-Campbell 2000, ENV 16). Additional larval fish field data was collected in 2001 in support of fisheries modeling efforts.

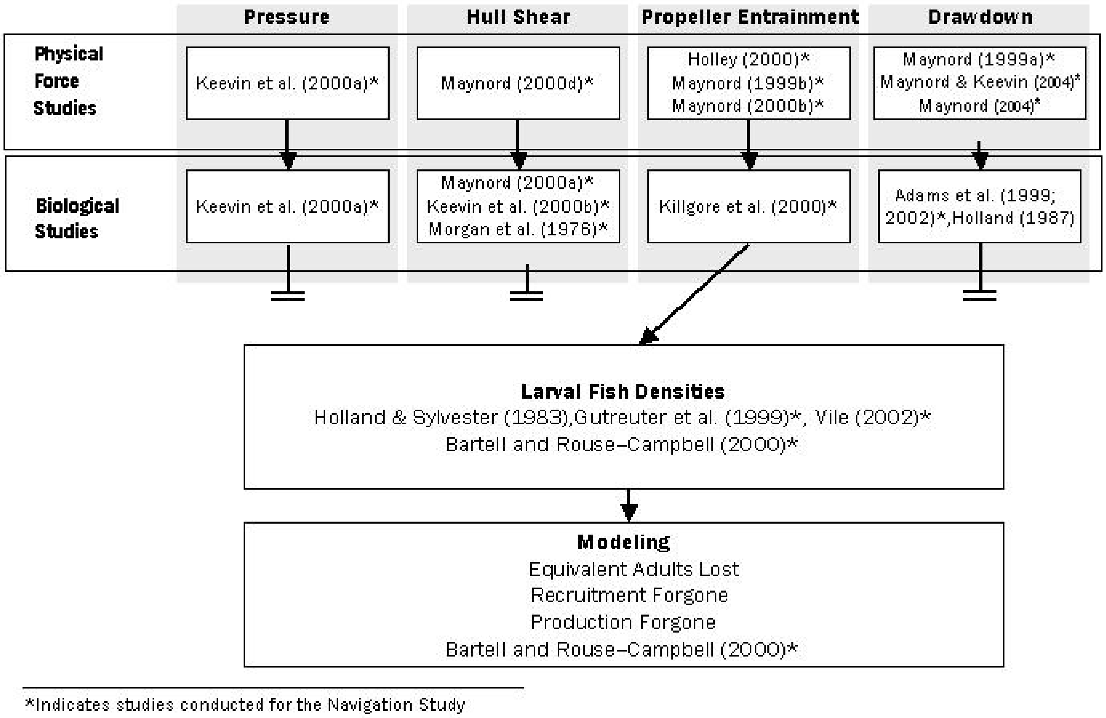

Figure 8-4: Flow Diagram of Larval Fish Studies

Once the number of larval fish killed was determined, then these values were incorporated into existing models to calculate equivalent adults lost, recruitment forgone, and production forgone (Bartell and Rouse-Campbell 2000, ENV 16). In order to assess the ecological risks to fish associated with the incremental increase in commercial navigation traffic, 28 fish species were selected as representative of the total UMRS fish fauna (Table 8-14). This list of 28 species was assembled as a result of a process begun by the fish technical work group, and then reviewed and refined via numerous interagency meetings and workshops held throughout the Navigation Study. The fish species selected for this ecological risk assessment include species that have different life history strategies as well as species important to both the commercial and recreational fishery, important forage species, and species listed as threatened or endangered or other similar category. Availability of current data was also an important consideration in species selection.

Table 8-14. UMRS fish species evaluated for impacts from increased commercial navigation traffic.

bigmouth buffalo	Black crappie	blue catfish	bluegill	blue sucker
channel catfish	Freshwater drum	Flathead catfish	goldeye	shovelnose sturgeon
largemouth bass	mooneye	paddlefish	northern pike	River carpsucker
sauger	smallmouth bass	smallmouth buffalo	Spotted sucker	shorthead redhorse
walleye	white bass	bowfin	common carp	emerald shiner
gizzard shad	shortnose gar	white crappie		

8.5.1.1.1 The Effects of Pressure Changes Induced by Commercial Navigation Traffic on Mortality of Fish Early Life Stages

Commercial navigation traffic is responsible for rapid mixing of the water column (Stefan and Riley 1985). Fish can be drawn from the surface and transported to the river bottom resulting in increased ambient pressure or drawn from the river bottom and moved to the surface, resulting in decreased ambient pressure. Since early life stages of fish have poor swimming capability and are fragile, they are vulnerable to rapid changes in ambient hydrodynamic pressure resulting from vertical movement within the water column (Hickey 1979; Pearson et al. 1989).

In a controlled laboratory study (Keevin et al. 2000b, ENV 35), mortality of fish early life stages was measured in a pressure vessel to simulate pressure changes associated with entrainment in the propwash of a towboat and subsequent vertical displacement within the water column. Mortality was measured for five fish species: larval bigmouth buffalo (*Ictiobus cyprinellus*), larval blue catfish (*Ictalurus furcatus*), larval walleye (*Stizostedion vitreum*) juvenile bluegill (*Lepomis macrochirus*), and juvenile largemouth bass (*Micropterus salmoides*). Three pressure change regimes, or cycles, were created to simulate fish entrainment and vertical displacement within the propeller wash behind tow boats. All pressure measurements were reported in absolute pressure (gage pressure + atmospheric pressure, 101.3 kPa STP).

- Cycle 1 - Pressure was gradually raised to 446.1 kPa over 1 hr, held for 30 min. and returned to atmospheric pressure in 5 sec.
- Cycle 1 simulated rapid depressurization of depth-acclimated fish from entrainment in towboat propwash, drawing larvae and juveniles from the river bottom and moving to the surface in 5 sec. The 1-hour gradual pressure increase and 30 min. holding time were used to acclimate fish to pressures experienced at a depth of 35.2 m, followed by a return to atmospheric pressure (surface) in 5 sec.
- Cycle 2 - Pressure was raised to 446.1 kPa within 5 sec, held for 10 sec, and returned to atmospheric pressure in 5 sec.
- Cycle 2 simulated rapid water column mixing and entrainment of surface-acclimated fish to pressures experienced at a depth of 35.2m and rapid transport back to the surface.
- Cycle 3 - Pressure was raised to 446.1 kPa within 5 sec, held for 30 min. and returned to atmospheric pressure in 5 sec.
- Cycle 3 simulated rapid transport of fish from surface waters to pressures experienced at 35.2 m for 30 min. and rapid depressurization transport to the surface.

There was no significant difference between fish exposed to any of the three pressure regimes and controls. The maximum pressure change tested, 344.8 kPa, equivalent to a 35.2 m displacement of fish within the water column, did not cause significant mortality of larval or juveniles. Since 35.2 m exceeds depths in the UMR navigation channel, the range of pressure changes that could be experienced by early life stages during towboat mixing of the water column, will not result in significant mortality. Based on the results of this study and other published studies (Bishai 1961; Blaxter and Hoss 1979; Ginn et al. 1978; Kedl and Coutant 1976) with a variety of fish species and early life stages, it appears that the range of pressure changes experienced by early life stages during towboat mixing of the water column will not result in significant mortality. As such, the pressure induced mortality was not included as a parameter during larval fish mortality modeling (equivalent adults lost, recruitment foregone, and production foregone models).

8.5.1.1.2 The Effects of Hull Shear Induced by Commercial Navigation Traffic on Mortality of Fish Early Life Stages

Increased commercial navigation traffic subjects organisms using the waterway to an increased frequency of potentially damaging physical effects caused by tow traffic. It has been suggested that the fluid shear field adjacent to the hull of the tow may impact aquatic organisms. Shear stress is the force per unit area that results from differences in velocity from one point in the water to an adjacent point. Shear is defined as the velocity difference between two adjacent points divided by their distance.

In order to evaluate the effects of hull shear it was necessary to first calculate the hull shear created by a moving tow because those data were not available. The results of this computational study are reported in Maynord (1998). The biological response, in this case mortality, of early life stages of fish in response to shear was studied in a Couette cell (Keevin et al. 2000a, ENV 34). Couette cells have commonly been used to evaluate the effects of shear stress conditions on mortality and biological processes for a variety of aquatic organisms (i.e., Latz et al. 1994; Mead and Denny 1995; Thomas and Gibson 1990, 1992) including larval fish (Morgan et al. 1976). Mortality was measured for three shear stress levels at three exposure times for five fish species: larval shovelnose sturgeon (*Scaphirhynchus platorynchus*), larval bigmouth buffalo, larval blue catfish, juvenile bluegill, and juvenile largemouth bass.

Larval fish mortality values (Keevin et al. 2000a, ENV 34) were compared with calculated barge hull shear stress levels (Maynord 1998, Maynord 2000b, ENV 24) to determine the potential for mortality of fish early life stages due to commercial navigation traffic. There was no significant mortality of shovelnose sturgeon, blue catfish, bluegill, and largemouth bass at shear stress levels produced by barges in the UMR. However, the hull of a high- speed tow (4.0 m/sec) with a 1.22 depth/draft ratio will produce a shear stress of 250 dynes/cm^2 in 5% of the zone beneath the tow. This is the only area in the water column where hull shear stress values approached, but did not exceed, levels causing significant ($P<0.05$) mortality of bigmouth buffalo larvae. Therefore, it is unlikely that barge hull shear stress will result in substantial mortality of larval or juvenile fishes.

Based on the results of the of the study conducted for the Navigation Study (Keevin et al. 2000a, ENV 34; Maynord 2000c, ENV 23) and the published literature (Morgan et al. 1976), it is unlikely that barge hull shear stress will result in substantial mortality of larval and juvenile fishes. Therefore, hull shear induced mortality was not included as a process in the larval fish mortality modeling.

8.5.1.1.3 The Effects of Shoreline Drawdown Induced by Commercial Navigation Traffic

Water flow dynamics associated with moving commercial navigation vessels result in shoreline drawdown (water recedes from the shoreline; Bhowmik et al. 1993). These brief dewatering periods generally last 2-3 min (Holland 1987). The magnitude of drawdown depends on vessel speed, submerged cross-sectional area of the vessel, and the channel cross-section. Shallow and constricted channels increase drawdown. If a vessel travels close to the riverbank, drawdown will be higher in the region between the vessel and bank than it would have been if the vessel was in the middle of the channel (Bouwmeester et al. 1977). Bhowmik et al. (1981) measured vertical drawdown for 27 tow passage events during 1980-1981 on the Mississippi and Illinois rivers. Drawdown elevation averaged 0.08 m (range 0.03-0.21 m) on the Illinois River for 19 events and 0.06 m (range 0.02-0.10 m) on the UMR for 8 events. The drawdown resulting from vessel passage is followed by a rise in water level back to ambient levels. Typical rates of drawdown (vertical fall of water level per unit time) for channel sizes, tow sizes, and tow speeds found on the UMR are about 0.25-0.5 cm/sec based on field data presented in Bhowmik et al. (1998). Higher speed tows closer to the shoreline produce values of around 0.75 cm/sec.

Maynord (2004, ENV 45) determined that the average shoreline area exposed or dewatered decreases in a downstream direction as the UMR channel becomes larger (Table 8-15). Peak larval density and diversity occur during the months of May and June. During May, there was a 90% probability that 3.9 hectares or less of shoreline would be dewatered by a passing towboat in Pool 4, 5.5 hectares or less in Pool 8, 4.4 hectares or less in Pool 13, and 0.5 hectares or less in the portion of Pool 26 above the IWW confluence. During the month of June, there was a 90% probability that 4.4 hectares or less of shoreline would be dewatered in Pool 4, 5.8 hectares or less in Pool 8, 4.5 hectares or less in Pool 13, and 0.6 hectares or less in Pool 26. Typical values decrease from 0.49 m in Pool 8 (May, 90% exceedance tow) to 0.05 m in Pool 26 (May, 90% exceedance tow). The width of the dewatered zone is less in May than in July. The higher flows in May cause larger cross sections which result in less drawdown.

Commercial vessel passage may strand young fishes during drawdown and subsequent dewatering of littoral areas (Holland and Sylvester 1983; Nielsen et al. 1986), but actual field observations of stranding are sparse. In laboratory studies, Holland (1987) evaluated the effects of experimental dewatering on eggs and larvae of walleye and northern pike (*Esox lucius*). Eggs and larvae were exposed to air for 2 min at intervals of either 12, 6, 3, or 1 hr. (representing 2-24 tows/day) from the time just after fertilization to 10-14 days post-hatch. A single dewatering event (2 min air exposure) did not cause mortality of eggs of walleye or northern pike, but significant mortality of larvae of both species occurred at dewatering frequencies of 1 and 3 hours, the latter being equivalent to mean passage of 8 tows per day. Holland (1987) used a flow-through aquarium system that prevented fish from moving out of the dewatered zone as water receded. Adams et al. (1999) evaluated the potential for stranding during simulated shoreline drawdown in a laboratory flume for larval shovelnose sturgeon, paddlefish (*Polyodon spathula*), bigmouth buffalo, largemouth bass, and bluegill. Stranding was measured at three vertical drawdown rates (0.76, 0.46, and 0.21 cm/s) and two bank slopes (1:5 and 1:10). Blue catfish, shovelnose sturgeon, and paddlefish were not tested at both bank slopes. Susceptibility to stranding varied among species and was independent of drawdown rate. At a slope of 1:5, shovelnose sturgeons had the highest stranding percentage (66.7%), followed by paddlefish (38.0%), bluegills (20.0%) bigmouth buffalo (2.2%), and largemouth bass (0.0%). At 1:10, blue catfish had the highest stranding percentage (26.7%), followed by largemouth bass (15.3%), bluegills (5.3%), and bigmouth buffalo (0.0%).

Holland (1987) found significant mortality of larval walleye and northern pike using a flow-through aquarium system. Under natural conditions, it is not known if individual larvae or eggs would be subject to repeated dewatering. Adams et al. (1999; 2000, ENV 22) found that the likelihood of stranding was related to the behavioral response of fishes to drawdown. Species that typically occur in littoral and backwater areas swam with the current or passively drifted; whereas, the young of main-channel fishes, such as sturgeons and paddlefish, exhibit positive rheotaxis (i.e., movement into flowing water) and were more likely to become stranded. Adams et al. (1999; 2000, ENV 22) suggested that main-channel species such as shovelnose sturgeon and paddlefish larvae that were highly vulnerable to stranding in their study are usually found in the main channel (Wallus et al. 1990) and not in the littoral zone where they would be susceptible to stranding. In addition, the dewatered zone itself is very narrow possibly limiting repeated stranding. During May and June, the peak larval fish density period, the dewatering zone ranges from 0.05 m (Pool 26, May) to 0.53 m (Pool 8, June) for 90% of tow passages. With the exception of Pool 8, the average width of dewatered shoreline during May and June is less than 0.4 m (Table 8-15) for 90% of tow passages.

8.5.1.1.4 The Effects of Backwater and Secondary Channel Drawdown Induced by Commercial Navigation Traffic

During passage of commercial tow traffic in navigation channels, the water level is lowered alongside the tow, which is commonly referred to as drawdown. Drawdown magnitude increases with increasing tow speed, increasing tow size, and decreasing channel size. Drawdown duration is about twice the time required for a tow to pass a fixed location. This duration relationship results in a large fast tow producing a large but short-lived drawdown while the same large tow traveling at a lesser speed will produce a lesser maximum drawdown but having a longer duration.

Drawdown from tow traffic is one of the few physical effects of tows that can propagate large distance from the main navigation channel. Drawdown can extend up backwaters, secondary channels, and tributaries entering the main channel. Maynord (2004, ENV 45) measured drawdown at ten backwaters and secondary channels in the La Grange Pool of the IWW. Drawdown decayed with distance from the entrance channel within the backwater/chute but could be measured at considerable distances from the entrance. At the longest channel, Bath Chute, drawdown could be clearly detected at ll.6 km from the point of origin, although the magnitude was significantly reduced. Sangamon-1 measurements provide an example of the decay rate. At the entrance to Sangamon-1 the drawdown was 0.138 m, at 600 m from the entrance it was 0.042 m, and at 1,350 m from the entrance it was 0.013 m.

Table 8-15. Shoreline area and average width of shoreline exposed during water level drawdown from commercial tows, Upper Mississippi River, March-August, 50 and 10% probability of exceedance.

Trend Pool	Pool River Miles	Miles of Shore In Pool	Area of shoreline exposed in pool during drawdown by passage of a single tow, sq m / Average width of dewatering, m											
			March		April		May		June		July		August	
			P_e=0.5*	P_e=0.1	P_e=0.5	P_e=0.1	P_e=0.5	P_e=0.1	P_e=0.5	P_e=0.1	P_e=0.5	P_e=0.1	P_e=0.5	P_e=0.1
4**	753.0-764.5 & 785.5-796.5	70.5***	no navigation		16870 0.149	37910 0.334	19577 0.172	39303 0.346	23350 0.206	44162 0.389	21609 0.190	47989 0.423	31951 0.282	75196 0.663
8	679.5-702.0	69.0	36746 0.331	68803 0.619	24012 0.216	51052 0.460	26586 0.239	54592 0.491	30925 0.278	58321 0.525	30499 0.275	61272 0.552	34298 0.309	74569 0.671
13	523.0-556.5	102.0	22366 0.136	51452 0.313	21732 0.132	40024 0.244	23431 0.143	43747 0.266	25962 0.158	44918 0.274	26792 0.163	51602 0.314	43514 0.265	84031 0.512
26 ****	218.0-241.0	71.0	2950 0.026	6558 0.058	2330 0.021	4610 0.041	2644 0.023	5132 0.045	3266 0.029	6289 0.055	3916 0.035	7439 0.066	10753 0.095	20415 0.180
26	203.0-217.5	45.0	2394 0.033	5224 0.072	1740 0.024	3394 0.047	2046 0.028	3671 0.051	2517 0.035	4746 0.066	3038 0.042	5402 0.075	5858 0.081	10999 0.152

* Percentage of tows exceeding this value of area exposed
** Pool 4 values do not include Lake Pepin which has very little drawdown at the shoreline.
*** Miles of shore in pool includes 50% increase to account for shoreline irregularities
**** Portion of Pool 26 above Illinois Waterway confluence

Maynord (2004, ENV 45) determined the magnitude of drawdown at the inlets of backwaters and secondary channels on the UMR-IWW for trend pools 4, 8, 13, 26 (above the confluence of the IWW), 26 and the La Grange Pool based on the NAVEFF model (Maynord 1996; 1999, ENV 14). Drawdown was modeled for the probability of exceedances by a single tow of 0.5 (50% of the time the value would be exceeded), 0.1, 0.05, 0.02, and 0.01 (99 values would be less than the calculated value and 1 time the value would be larger) for the month of June. June was selected for this analysis because it is representative of the spawning period of many species, especially centrarchids (sunfish, crappie, and bass). Table 8-16 provides drawdown data for Pool 8 of the UMR. The worst-case backwater (BW6) in Pool 8 experienced a 0.09 m drawdown for a 0.5 probability of exceedance (50% of the tows were less than 0.09 m and 50% of the tows were greater than that value) and a 0.2 m drawdown for a 0.01 probability exceedance. The worst case secondary channel (SC7) experienced a 0.05 m drawdown for a 0.5 probability of exceedance and a 0.12 m drawdown for a 0.01 probability of exceedance. Table 8-17 provides data for backwater and secondary channels in the La Grange Pool of the Illinois River. The worst-case backwater or secondary channel in the La Grange Pool (BW9) experienced a 0.041 m drawdown for a 0.5 probability of exceedance and a 0.182 m drawdown for a 0.01 probability of exceedance.

Drawdown along the length of backwaters and secondary channels has the potential to make otherwise suitable habitat unavailable for nesting and to strand larval and juvenile fishes during drawdown events. The amount of habitat within secondary channels and backwaters that would otherwise have been suitable for spawning but is impacted by repeated drawdowns is unknown due to the lack of adequate bathometric survey data for those habitats on the UMR-IWW. However, spawning fish, especially centrarchids generally tend to spawn at water depths greater than the navigation induced drawdowns observed on the UMR-IWW (Maynord 2004, ENV 45) and they generally avoid spawning in areas that are repeatedly dewatered. Species that spawn in or on submerged aquatic vegetation, which would generally be deeper than the modeled drawdown zones, would also be unaffected. As previously noted in the shoreline dewatering discussion, larval and juveniles of typical backwater fish species have behavioral adaptations to avoid being stranded by receding water levels (Adams, et al. 1999, Adams et al. 2000, ENV 22); thus, minimizing adverse effects.

Table 8-16. Drawdown (m) versus probability of exceedance for backwaters and secondary channels in Pool 8 for June.

Backwater/ Secondary Channel	Cell id	Drawdown, m				
		$P_e = 0.5$*	$P_e = 0.1$	$P_e = 0.05$	$P_e = 0.02$	$P_e = 0.01$
BW1	85L6985**	0.055	0.103	0.115	0.152	0.153
BW1	135L7005	0.050	0.092	0.111	0.150	0.151
BW1	105L7015	0.038	0.067	0.079	0.101	0.102
BW2	225R6965	0.027	0.047	0.054	0.070	0.071
BW3	345L6890	0.037	0.075	0.119	0.166	0.167
BW3	185L6910	0.069	0.120	0.139	0.188	0.189
BW3	295L6920	0.037	0.065	0.084	0.115	0.116
BW3	75L6940	0.055	0.097	0.116	0.157	0.158
BW3	175L6945	0.050	0.089	0.116	0.162	0.163
BW3	235L6950	0.029	0.050	0.058	0.076	0.077
BW4	135R6905	0.051	0.115	0.173	0.220	0.221
BW6	95R6870	0.092	0.199	0.301	0.382	0.383
BW6	95R6875	0.089	0.212	0.266	0.341	0.357
BW6	245R6880	0.055	0.124	0.183	0.235	0.236
SC1	195R7010	0.036	0.068	0.082	0.112	0.113
SC2	195R6995	0.036	0.074	0.085	0.112	0.113
SC3	185L6960	0.032	0.055	0.066	0.082	0.091
SC4	285R6950	0.025	0.043	0.051	0.066	0.067
SC6	205R6915	0.038	0.067	0.083	0.116	0.117
SC7	135R6905	0.051	0.115	0.173	0.221	0.222
SC8	265L6885	0.051	0.099	0.140	0.224	0.225

* probability of exceedance by a single tow
** Cell id shows this inlet is at River Mile 698.5 on the left side of the river looking downstream

Table 8-17. Drawdown (m) versus probability of exceedance for backwaters and secondary channels in Pool 31 (La Grange Pool) for June.

Backwater/ Secondary Channel	Cell ID	Drawdown, m				
		P_e = 0.5*	P_e = 0.1	P_e = 0.05	P_e = 0.02	P_e = 0.01
BW1	75L1240**	0.027	0.088	0.099	0.121	0.133
BW2	75L1230	0.030	0.088	0.099	0.120	0.132
BW3	85L1150	0.025	0.068	0.079	0.092	0.106
BW4	65L1130	0.033	0.090	0.105	0.123	0.147
BW5	105L0920	0.032	0.088	0.116	0.137	0.152
BW5	65L0960	0.038	0.106	0.131	0.155	0.163
BW5	105L0980	0.032	0.087	0.105	0.125	0.130
BW6	65L0950	0.041	0.112	0.140	0.173	0.182
BW8	65L0830	0.030	0.083	0.092	0.112	0.117
SC1	55L1220	0.028	0.084	0.097	0.114	0.127
SC2	175L0870	0.028	0.076	0.091	0.113	0.116
SC3	95L1400	0.024	0.061	0.077	0.087	0.093
SC5	75L1360	0.026	0.069	0.080	0.090	0.103
SC6	255L0860	0.020	0.056	0.069	0.083	0.083
SC?	105R1430	0.023	0.064	0.074	0.085	0.098
SC?	115R1490	0.031	0.089	0.108	0.119	0.142

* probability of exceedance by a single tow
** Cell ID shows this inlet is at River Mile 124.0 on the left side of the river looking downstream

8.5.1.1.5 The Effects of Larval Fish Entrainment by Commercial Vessels

The incremental increases in larval fish entrainment and mortality were estimated for commercial vessels that navigate the Upper Mississippi and Illinois Rivers. Thirty fish species were selected as representative of the diverse fish communities that characterize these two large rivers (Appendix ENV-F). These species of fish were selected to include different life histories, varied spawning behaviors, different trophic guilds, and diverse ecological functioning (e.g., forage fish species, keystone predators), and to include species important to the commercial and recreational fisheries within the UMR-IWW.

Larval entrainment mortalities were estimated for the UMR (including the open river reach) and the IWW for future traffic projections provided by the Tow Cost Model (TCM) Alternatives 1, 2, 4, 5, and 6; and the Essence Model (EM) Alternatives 4, 5, and 6. Five separate traffic scenarios were developed on the basis of different economic assumptions for each of the TCM and EM alternatives. TCM Alternative 1 specifies the without-project traffic projections for each of the five economic scenarios. Each of the Essence Alternatives includes without-project traffic estimates for each of the corresponding economic scenarios. Entrainment mortalities were estimated for each of the economic scenarios for each TCM and EM traffic projection. However, Alternative 2 reflects the impacts of congestion fees charged to the navigation industry. Generally, Alternative 2 resulted in future traffic projections that were less than the without-project conditions. The net negative results in entrainment are not reported here, but are summarized in a supporting appendix (Appendix ENV-F).

Briefly, entrainment mortalities were estimated for each of the 28 species for each month of the spawning season in each pool of the UMR-IWW and the Open River Reach. The numbers of fish larvae potentially entrained and killed by commercial vessels navigating on the rivers were calculated as the product of the volume of water entrained by the vessels, the concentration of larvae in this volume, and the fraction of entrained larvae likely to die as the result of the hydrodynamic forces in the propeller zone (Appendix ENV-F). The volume of water entrained was determined by the number of vessels projected to navigate in each pool and the rates of water pulled through the propeller zone for vessels of different configurations (e.g., number of barges, horsepower, load) and operating characteristics (e.g., direction, speed) (Appendix ENV-G). The average numbers of vessels/day navigating each pool were projected for each of the commercial navigation improvement alternatives (i.e., TCM and Essence). The concentrations of larvae were developed for the 28 fish species from field data that were collated for different pools and months (Appendix ENV-F). The fraction of entrained larvae estimated to die as a result of entrainment was estimated as a function of the shear forces generated by the different vessels (Appendix ENV-G) and the results of experimental entrainment of selected representative larvae under controlled laboratory conditions (Killgore et al. 2000a, ENV 30; Appendix ENV-G). Appendix ENV-F presents the detailed results of the larval entrainment calculations that have been summarized in the following paragraphs.

Fish characteristically produce large numbers of eggs and larvae. Most of this reproductive output is lost to different sources of mortality, including entrainment by commercial vessels. To aid in interpreting significance of the large numbers of larvae estimated to be killed by commercial vessel entrainment, these larval mortalities were extrapolated to corresponding estimates of lost future adults (Horst 1975, Goodyear 1978), numbers of individuals that would fail to recruit to fisheries (i.e., "recruitment forgone", Jensen 1990), and biomass that would not be produced (i.e., "production forgone, Jensen et al. 1988). The detailed descriptions of these extrapolation models are provided in Appendix ENV-F. Necessary parameter values for the extrapolation models were derived from data collected as part of the Navigation Study, from published studies on the species of interest or data for closely related species and other large river systems. These extrapolations were made for each pool and month based on the estimated entrainment mortalities for the TCM and Essence Alternatives. The extrapolations of lost future adults, recruitment forgone, and production forgone have been summarized to characterize the collective incremental impacts of the different scenarios and alternatives for the UMR, the IWW, and the combined system (Appendix ENV-F).

Incremental increases in larval mortality were calculated by comparing entrainment mortalities for the Tow Cost Model Alternatives and the Essence Model Alternatives with mortalities projected for future conditions without any improvements to the navigation infrastructure (i.e., the without-project conditions). The TCM and EM without-project impacts were compared with their corresponding with-project impacts to calculate incremental increases in larval entrainment. Incremental increases in larval mortality were calculated for 10-year intervals beginning with year 2000 and ending with 2050; this 50-year interval defines the proposed project period. Entrainment effects were estimated directly for these decadal years; entrainment effects were extrapolated across project years that occur between the direct assessments.

The potential risks posed to fish populations by entrainment of fish larvae by commercial vessels were characterized by estimating the incremental increases in numbers of adult fishes that would not be produced as a result of the incremental increases in larval mortality (i.e., equivalent adult loss (EAL)). Table 8-18 summarizes the total number of EALs estimated for each economic scenario and TCM Alternatives 4, 5, and 6. Table 8-18 summarizes the EALs for all navigations pools. The EALs of five species including the common carp, bowfin, gizzard shad, emerald shiners, and shortnose gar are not included in Table 8-18, but are reported in Appendix ENV-F). These species were removed on the basis of being ecologically or recreationally undesirable (e.g., carp, gar, bowfin) or because the species represents forage fish (e.g., shad, emerald shiners) that would likely not be included in mitigation planning. Note that the totals are for the five years listed in the table. The actual numbers of EALs for the entire project planning horizon can be interpolated across each of the 10-year periods between the values listed in Table 8-18. Nevertheless, inspection across the tabulated values enables convenient comparisons across the economic scenarios and model alternatives.

The decadal year totals listed in Table 8-18 range from zero (i.e., identical without- and with-project traffic) to more than~339,000 fish, depending on economic scenario and TCM Alternative. The results generally show that incremental effects on EALs increase across economic scenarios within each TCM Alternative. The exception appears for the “favorable” economic scenario, for which impacts are less than those projected for the “central scenario,” although these differences diminish for Alternatives 5 and 6. For each economic scenario, incremental effects increase from TCM Alternative 4 to 6. Within each scenario and alternative, the impacts on EALs appear greatest for years 2040 or 2050. The effects are projected to be greater in the Upper Mississippi River than in the Illinois River. For example, using the most favorable economic scenario, Alternative 6 suggests an annual average of ~56,200 EALs for the Upper Mississippi River and 348 for the Illinois River. The differences across scenarios and alternatives are due solely to the spatial and temporal patterns of incremental differences in traffic projected by the Tow Cost Model. All other inputs to the entrainment calculations are the same, regardless of scenario and TCM alternative. An important point is that the potentially billions of entrained larvae translate into substantially fewer adults lost through larval entrainment mortality because natural (or at least non-vessel induced) mortalities account for considerably greater losses to these populations as larvae progress to young-of-year, and then to adult fish.

The 28 species are differentially impacted by entrainment and entrainment effects differ geographically as well. Table 8-19 summarizes the EAL results by species and geomorphic river reach for the Central Scenario of TCM Alternative 6 for year 2040. Note that these results include the five species not included in Table 8-18; therefore, the total number (230,109) does not agree with the corresponding value of 84,003 listed in Table 8-19. The near three-fold difference underscores the contribution to the modeled impacts of the five species excluded from Table 8-19, especially bowfin, carp, emerald shiner, and gizzard shad. Non-excluded species potentially at risk include channel catfish, freshwater drum, mooneye, and sauger. Table 8-19 also shows that incremental impacts generally increase with distance downriver. For the most part, greater impacts are projected for navigation pools 16-27, although some species suffer greater incremental entrainment losses in pools 9-15, e.g., black crappie, spotted sucker, white bass, and white crappie. The Open River Reach shows greater impacts than the Illinois River, although the open river impacts are not as substantial as observed for pools 9-15 or 16-27. The greater Open River impacts partly reflect the occurrence of four larger classes of vessel types that do not navigate the Upper Mississippi or Illinois Rivers. These spatial differences in incremental entrainment losses, expressed as EALs, result from spatial differences in traffic projections and different pool-specific estimates of larval density for the 28 species.

Table 8-20 presents the incremental impacts on EAL for the Essence Model (EM) Alternatives 4, 5, and 6. The patterns of impacts for the different economic scenarios and across the Essence Alternatives are similar to those observed for the TCM alternatives (Table 8-18 and Table 8-20). Impacts increase from least to most favorable economic scenario and from EM Alternative 4 through 6. Projected EM impacts are greater for the UMR; EM impacts are higher for years 2040 and 2050. However, the incremental increases in traffic projected by the EM are noticeably greater than the TCM projections. As a result, the projected entrainment impacts for the EM alternatives, summarized as lost future adults, are ~10-50% greater than the corresponding TCM effects, depending on the scenario and alternative selected for comparison. For example, the most favorable economic scenario for Essence Alternative 6 projects an annual average of ~68,000 EAL compared to the 56,200 projected for the corresponding TCM scenario – an ~20% difference. The important point is that the EM results provide a sensitivity analysis of the TCM projections. Despite the structural differences between these two economic models, their underlying assumptions, and the challenges in parameter estimation, the resulting traffic projections of the TCM and EM do not differ by orders of magnitude, except for comparisons of the least favorable economic scenarios, where the comparative impacts are small for both models.

The spatial patterns of projected impacts for the central scenario of EM Alternative 6 are listed for year 2040 (Table 8-21). The pattern is similar to that described for the corresponding TCM alternative (Table 8-19) where greater impacts are projected for pools 9-15, pools 16-27, and the Open River reach. In contrast, the comparative incremental increases in traffic associated with the EM projections in turn produce higher estimates of EALs and suggest that additional species might be at risk, including paddlefish, northern pike, river carpsucker, and shovelnose sturgeon.

Similar patterns of results were estimated across the TCM and EM alternatives and associated economic scenarios for the assessment endpoints of recruitment forgone and production forgone (Appendix ENV-F). Importantly, the incremental impacts on future lost adults or individuals that fail to recruit to maturity as the result of larval entrainment mortality can be used to develop mitigation plans for the selected project alternative.

Many sources of variability and uncertainty influence the estimation of the potential impacts of commercial navigation on larval entrainment mortality. Uncertainties also affect the extrapolation of mortalities to lost adults, lost recruits, and production forgone. For example, estimation of the parameters required by these models frequently necessitated extrapolation across species. These kinds of uncertainty have been initially addressed by characterizing the many input parameters required for the calculations as statistical distributions. Repeated calculations (i.e., Monte Carlo methods) have been performed using values sampled independently from the distributions to estimate corresponding distributions of entrainment mortality and subsequent extrapolations to distributions of lost adults, lost recruits, and production forgone (Appendix ENV-F).

Detailed, quantitative sensitivity analyses of the distributions of larval fish mortalities and extrapolation model results have identified the specific parameters that contribute most of the uncertainty in characterizing the impacts of entrainment by commercial vessels on the Upper Mississippi and Illinois Rivers (Appendix ENV-F). Not surprisingly, spatial and temporal variability in larval densities contribute importantly to variability in estimates of larval entrainment. The species-specific parameter that defines the fraction of entrained larvae that are killed by the physical effects in the propeller wash is another key source of uncertainty in estimating entrainment mortality. The species-specific and life stage-specific natural mortality parameters are important in extrapolating entrainment mortality to future lost adults. The species-specific estimates of fish growth rate are important determinants of both recruitment forgone and production forgone. Appendix ENV-F provides a more detailed summary of the sensitivity and uncertainty analyses performed to characterize the impacts of uncertainty on risk estimation in relation to larval entrainment.

Table 8-18. Incremental increases in equivalent adults lost for TCM Alternatives 4, 5, and 6 (with five species excluded from the analysis).

Summary of equivalent adults lost (EAL) for Tow Cost Model Alternatives 4-6 and Scenarios 1-5.
(Units: # adult fish); five species excluded from summary

Economic Scenario	Year	Alternative 4			Alternative 5			Alternative 6		
		UMRS	IWW	Total	UMRS	IWW	Total	UMRS	IWW	Total
1 Least Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	103	0	103	9	32	41	0	0	0
	2020	0	0	0	155	17	172	104	0	104
	2030	7	0	7	174	21	195	319	0	319
	2040	70	0	70	251	15	266	552	422	974
	2050	13	42	55	201	70	271	397	120	517
	Total	193	42	**235**	790	155	**945**	1,372	542	**1,914**
2 Less Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	119	0	119	53	23	76	47	0	47
	2020	408	68	476	997	230	1,227	387	11	398
	2030	19,576	81	19,657	21,001	309	21,310	21,015	81	21,096
	2040	17,785	73	17,858	45,459	258	45,717	49,148	695	49,843
	2050	15,787	128	15,915	39,346	483	39,829	42,645	596	43,241
	Total	53,675	350	**54,025**	106,856	1,303	**108,159**	113,242	1,383	**114,625**
3 Central	2000	0	0	0	0	0	0	0	0	0
	2010	501	4	505	16	0	16	16	0	16
	2020	19,743	52	19,795	20,258	113	20,371	19,728	33	19,761
	2030	9,348	173	9,521	34,506	282	34,788	36,231	221	36,452
	2040	20,446	33	20,479	49,615	238	49,853	83,496	1,001	84,497
	2050	25,154	9	25,163	53,764	142	53,906	88,749	634	89,383
	Total	75,192	271	**75,463**	158,159	775	**158,934**	228,220	1,889	**230,109**
4 Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	488	0	488	9	22	31	0	0	0
	2020	22,146	84	22,230	22,400	147	22,547	22,093	61	22,154
	2030	623	167	790	28,006	266	28,272	29,893	238	30,131
	2040	21,030	58	21,088	54,412	253	54,665	94,882	1,021	95,903
	2050	1,317	12	1,329	47,854	185	48,039	80,225	632	80,857
	Total	45,604	321	**45,925**	152,681	873	**153,554**	227,093	1,952	**229,045**
5 Most Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	614	0	614	0	0	0	0	0	0
	2020	8,733	4,343	13,076	29,735	460	30,195	8,729	186	8,915
	2030	22,319	135	22,454	62,002	277	62,279	65,093	229	65,322
	2040	35,451	41	35,492	95,761	195	95,956	139,674	1,034	140,708
	2050	29,091	0	29,091	84,018	188	84,206	123,773	639	124,412
	Total	96,208	4,519	**100,727**	271,516	1,120	**272,636**	337,269	2,088	**339,357**

Bowfin, carp, emerald shiner, shad, and shortnose gar excluded from consideration

Table 8-19. Incremental impacts of TCM Alternative 6 (Central Scenario) on future lost adults for year 2040.

TCM Alternative 6 (Central Scenario) - Impacts on Equivalent Adults Lost (#Fish) for Year 2040									
		Mississippi River Pools					Illinois Waterway Reaches		
	Species	USA-3	4-8	9-15	16-27	Open River	Lower	Middle	Upper
1	Bigmouth Buffalo	1	6	21	45	18			
2	Crappie	140	700	3,334	1,202	72	26	24	16
3	Blue Catfish	0	0	325	654	13	0	0	0
4	Bluegill	4	99	1,491	2,098	4	2	2	1
5	Blue Sucker			8	3	1	0	0	0
6	Channel Catfish	214	27	1,693	7,237	160	58	57	34
7	Drum	162	379	3,926	6,932	111	40	39	25
8	Flathead Catfish	35	11	268	878	40	14	14	8
9	Goldeye	1	0	0	0	0	0	0	0
10	Sturgeon	17	237	722	1,168	486	14	13	
11	Largemouth Bass	1	1	28	120	41	2	2	1
12	Mooneye	16	93	1,137	1,450	235	9	0	0
13	Paddlefish	23	168	521	841	318	13	0	0
14	Pike	56	292	861	950	361	14	13	7
15	River Carp Sucker	12	117	410	830	86	11	11	7
16	Sauger	390	122	877	1,917	94	14	13	8
17	Smallmouth Bass	1	1	18	79	30	2	1	1
18	Smallmouth Buffalo	3	19	68	141	56	1	1	1
19	Spotted Sucker	448	511	14,046	4,542	945	147	142	0
20	St Hd Red Horse	16	27	705	291	55	10	9	6
21	Walleye	68	21	152	332	16	2	2	1
22	White Bass	160	3,715	5,499	3,673	55	70	68	23
	TOTAL	**1,768**	**6,546**	**36,110**	**35,383**	**3,197**	**449**	**411**	**139**
	Percent of River	2.13	7.89	43.50	42.63	3.85	44.94	41.14	13.91
Total Mississippi River =		**83,004**					**Total IWW =**		**999**
	Total UMR-IWW =	**84,003**							
	%UMR =	**98.81**						**%IWW =**	**1.19**

Table 8-20. Incremental increases in equivalent adults lost for Essence Alternatives 4, 5, and 6. (with five species excluded from the analysis).

Summary of equivalent adults lost for Essence Model Alternatives 4, 5, and 6
(Units: # adult fish) ; Five species excluded from summary.

Economic Scenario	Year	Alternative 4 Essence			Alternative 5 Essence			Alternative 6 Essence		
		UMRS	IWW	Total	UMRS	IWW	Total	UMRS	IWW	Total
1 Least Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	4,033	199	4,232	458	419	877	321	2	323
	2020	2,807	186	2,993	7,588	1,188	8,776	3,865	58	3,923
	2030	4,036	286	4,322	12,725	1,010	13,735	19,355	367	19,722
	2040	3,736	385	4,121	12,650	1,481	14,131	18,925	6,449	25,374
	2050	2,323	237	2,560	7,796	902	8,698	12,570	3,003	15,573
	Total	16,935	1,293	**18,228**	41,217	5,000	**46,217**	55,036	9,879	**64,915**
2 Less Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	5,284	234	5,518	586	658	1,244	397	2	399
	2020	8,046	338	8,384	16,094	1,043	17,137	8,016	250	8,266
	2030	22,232	613	22,845	39,790	1,547	41,337	60,124	712	60,836
	2040	13,916	617	14,533	57,622	4,805	62,427	89,670	12,474	102,144
	2050	13,225	416	13,641	49,572	1,747	51,319	74,965	5,082	80,047
	Total	62,703	2,218	**64,921**	163,664	9,800	**173,464**	233,172	18,520	**251,692**
3 Central	2000	0	0	0	0	0	0	0	0	0
	2010	6,826	304	7,130	846	676	1,522	2,449	0	2,449
	2020	22,442	422	22,864	34,888	1,311	36,199	25,008	149	25,157
	2030	15,310	528	15,838	55,761	1,884	57,645	83,429	953	84,382
	2040	17,393	802	18,195	52,774	3,126	55,900	120,843	17,338	138,181
	2050	19,426	498	19,924	54,123	2,207	56,330	115,802	8,616	124,418
	Total	81,397	2,554	**83,951**	198,392	9,204	**207,596**	347,531	27,056	**374,587**
4 Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	6,471	282	6,753	779	630	1,409	598	7	605
	2020	22,702	407	23,109	35,603	1,256	36,859	24,525	921	25,446
	2030	8,381	441	8,822	48,152	1,678	49,830	77,309	379	77,688
	2040	16,778	759	17,537	53,291	2,943	56,234	126,994	16,377	143,371
	2050	0	511	511	43,498	2,177	45,675	101,281	8,662	109,943
	Total	54,332	2,400	**56,732**	181,323	8,684	**190,007**	330,707	26,346	**357,053**
5 Most Favorable	2000	0	0	0	0	0	0	0	0	0
	2010	7,063	307	7,370	778	759	1,537	562	10	572
	2020	10,789	325	11,114	37,920	1,487	39,407	11,476	60	11,536
	2030	14,924	412	15,336	66,604	1,679	68,283	103,158	448	103,606
	2040	17,515	804	18,319	76,620	3,080	79,700	154,167	17,153	171,320
	2050	16,630	666	17,296	68,883	2,519	71,402	139,129	9,154	148,283
	Total	66,921	2,514	**69,435**	250,805	9,524	**260,329**	408,492	26,825	**435,317**

Bowfin, carp, emerald shiner, shad, and shortnose gar excluded from consideration

Table 8-21. Incremental impacts of Essence Alternative 6 (Central Scenario) for future lost adults in year 2040.

Essence Alternative 6 (Central Scenario) - Impacts on Equivalent Adults Lost (#Adults) for Year 2040									
		Mississippi River Pools					Illinois Waterway Reaches		
	Species	USA-3	4-8	9-15	16-27	Open River	Lower	Middle	Upper
1	Bigmouth Buffalo	1	6	27	77	43	6	3	2
2	Crappie	98	738	4,038	1,962	170	594	316	180
3	Blue Catfish	0	0	410	1,069	31	0	0	0
4	Bluegill	5	100	1,668	3,855	10	47	25	14
5	Blue Sucker			10	4	2	0	0	0
6	Channel Catfish	187	31	2,282	11,877	382	1,326	735	392
7	Drum	150	386	4,806	11,250	267	953	505	293
8	Flathead Catfish	31	12	358	1,423	96	319	173	89
9	Goldeye		0	0	0	0	0	0	0
10	Sturgeon	22	266	828	1,949	1,159	300	161	
11	Largemouth Bass	2	1	37	198	97	51	28	14
12	Mooneye	18	104	1,457	2,395	564	210	0	0
13	Paddlefish	29	187	594	1,400	761	295	0	0
14	Pike	58	325	973	1,585	863	310	170	85
15	River Carp Sucker	13	127	513	1,329	207	260	139	77
16	Sauger	275	135	1,114	3,142	227	333	175	95
17	Smallmouth Bass	1	1	24	131	71	34	19	9
18	Smallmouth Buffalo	3	20	85	244	133	42	11	6
19	Spotted Sucker	430	608	18,652	8,058	2,265	3,411	1,828	0
20	St Hd Red Horse	16	31	934	513	132	228	121	69
21	Walleye	48	23	193	545	39	58	30	17
22	White Bass	175	3,917	5,568	5,923	133	1,632	875	272
	TOTAL	1,562	7,018	44,571	58,929	7,652	10,409	5,314	1,614
	Percent of River	1.30	5.86	37.23	49.22	6.39	60.04	30.65	9.31
Total Mississippi River =		119,732					Total IWW =		17,337
Total UMR-IWW =		137,069							
	%UMR =	87.35						%IWW =	12.65

8.5.1.2 Adult Fish Mortality

8.5.1.2.1 Winter Mortality due to Tow-Induced Displacement of Fish from Protected Habitats

The passage of commercial navigation traffic results in changes in river flow patterns. Many UMR fishes, especially young-of-the-year, require low velocity habitats for overwintering due to their diminished swimming ability at low water temperatures. Low velocity habitats in river channels include the downstream side of wing dams and scour holes at the distal ends of wing dams, scour holes or sand ridges in channels, and downstream of any structures which obstruct water currents. Natural resource agencies expressed concern that hydraulic disturbances resulting from increased commercial navigation traffic might cause fish displacement from these low-velocity habitats during cold-water periods. Displaced fish will continue to drift with the river current or they will actively or passively find and utilize another low velocity habitat. If fish continue to drift, survival is doubtful. Loss of volitional control over swimming is the standard endpoint used in acute temperature tolerance tests. Risks to vessel propeller entrainment, predation, and other lethal factors would greatly increase. If fish find and utilize another low-velocity habitat after displacement, then increases in traffic levels may have little additional effect on over wintering fish (Sheehan et al. 2000a, ENV 32).

Studies were designed to determine if navigation traffic was capable of displacing fish from protected near-shore areas (Sheehan et al. 2000a, ENV 32). Studies were conducted to determine the velocities required to move young-of-the-year channel catfish and bluegill from protected areas under cold-water conditions (Sheehan et al. 2000b, ENV 33). Physical force studies were then conducted in a laboratory flume to determine velocity conditions behind a wingdam and in the scour hole associated with the wingdam with and without towboat traffic (Maynord 2000d, ENV 21).

In laboratory studies, Sheehan et al. (2000b, ENV 33) determined the following median displacement velocities (DV50) for channel catfish and bluegill (Table 8-22).

Table 8-22. DV50 (Displacement Velocity) determinations at 1, 2 and 4°C for Channel catfish and bluegill. DV50's are the peak velocity (m/s) of a velocity change profile, similar to that of a passing barge, necessary to displace 50% of fish from their position within a test chamber. DV50s determined using Probit analysis, p=probability of Pearson's Chi-square test of goodness-of-fit (Finney 1971)

Species	Temperature (C)	DV50 (m/s)	95% C.I.	p
Channel Catfish	1	0.08	0.01-0.36	0.33
	2	0.18	0.11-0.23	0.28
	4	0.30	0.25-0.35	0.95
Bluegill	1	0.09	0.06-0.12	0.38
	2	0.09	0-0.17	0.11
	4	0.16	0.13-0.20	0.04

Maynord (2000d, ENV 21) conducted a physical model study to measure velocity downstream of a typical UMR dike before and during passage of a model tow for typical winter flow conditions. Upbound versus downbound tows and tows near the dike as well as far from the dike were evaluated. The results of Maynord's study, when compared to Sheehan's displacement velocities, indicate that large areas of existing habitat behind the study wingdam currently experience velocities that exceed displacement velocities under ambient conditions without navigation traffic for young-of-the-year channel catfish and bluegill during periods when the water is in the 1-2 °C range. With the exception of an area immediately behind the wingdam, close to the shoreline, all ambient velocities exceeded 0.10 m/sec and ranged from

0.10-0.50 m/sec. Maynord (2000d, ENV 21) found that upbound tows near the dike (77 m from the centerline of the tow to the waterline on the dike) produced the greatest change in velocities, whereas downbound tows near the dike produced only minor velocity changes. Upbound tows in the thalweg (230 m from the centerline of the tow to the waterline on the dike) produced only minor changes with large areas near the bankline showing no velocity changes. Downbound tows in the thalweg produced little effect with large areas showing no velocity change.

If ambient velocities are great enough to displace young-of-the-year channel catfish and bluegill under existing conditions (without navigation traffic) it is quite possible that fish seek out low velocity microhabitat behind wingdams during cold-water conditions. Because fish are continuously exposed to navigation traffic-induced velocity changes, they may also seek out low velocity habitats protected from navigation-related velocities. If this is the case, incremental impacts in navigation traffic would have little additional effect.

Sheehan's displacement values were established for small young-of-the year fish. Larger fishes may not be affected by what amounts to minor velocity changes under worst case conditions (upbound tows near the dike). It is known that scour holes at wingdam tips and areas behind wingdams are "packed" with fish during the winter months. It is assumed that fish use these low velocity habitats during the winter as their swimming abilities decrease with decreasing water temperatures (Beamish 1978). Winter navigation traffic is restricted (at a somewhat reduced level) to the lower portions of the UMR and IWW.

8.5.1.2.2 Mortality of Adult Fish Entrained into Towboat Propellers

Most towboat propellers are greater than 2.4 m in diameter and create major turbulent hydraulic forces in navigable waterways. Jet velocities from a propeller can exceed 6 m/sec (Maynord 1999; Maynord 2000e, ENV 25), entraining high volumes of water and possibly organisms that occur in the vicinity of the sailing line that cannot avoid the low-pressure area immediately in front of the propellers. Fish entrained through a towboat propeller can be struck by the blade, and are subjected to rapid changes in pressure, shear stress, and turbulence (Cada 1990). Prior to initiating a study of propeller entrainment mortality, a group of fishery sampling experts were convened as a working group to help develop a sampling plan. After considerable discussion on sampling techniques and safety, it was concluded that trawling behind a towboat was the most efficient sampling methodology available at that time.

Based on the choice of trawling as a sampling methodology, rockhopper trawling was conducted behind 41 towboats navigating Pool 26 of the Mississippi River and the Alton Pool of the Illinois River during 1996-97 to determine if adult fish were being killed by commercial navigation traffic. Two dead gizzard shad *Dorosoma cepedianum* were collected in October 1996, and one dead gizzard shad was collected in November 1996 (Gutreuter et al. 1999, ENV 29). Based on the results of these 41 entrainment samples containing 3 dead gizzard shad, the authors suggested that an average of 9.5 adult gizzard shad are killed or seriously injured by entrainment through towboat propellers per kilometer of tow travel, with an 80% confidence interval of 3.8-22.8 adult fish/km of tow travel. Entrainment kills were observed only during Autumn 1996 when water temperatures were falling, suggesting a seasonal effect, but lack of seasonal replication and low sample size left this uncertain. Gutreuter et al. (1999, ENV 29) also observed additional recently killed adult gizzard shad, shovelnose sturgeon *Scaphirhynchus platorynchus*, and smallmouth buffalo *Ictiobus bubalus* in their 110 ambient (not sampled behind a moving towboat) trawl samples. They developed a statistical method to estimate entrainment mortality from the combined entrainment and ambient samples. The second augmented mortality estimate was 14.3 adult fish/km of tow travel with an 80% confidence interval of 0-26.7 fish/km of tow travel. The ancillary mortality estimates for shovelnose sturgeon and smallmouth buffalo were 2.4 fish/km of tow travel, with 80% confidence intervals of 0-6.0 fish/km of tow travel.

Application of the Gutreuter et al. (1999, ENV 29) entrainment study for impact assessment and mitigation planning was limited by the substantial range of the confidence interval that bounds the mortality estimates, extrapolation of ambient sampling data, and uncertainty of seasonal effects. In addition, the fish technical team was unaware that the study design would have to address an extremely rare event. In recognition of these uncertainties, the Corps funded additional sampling to obtain a larger sample size; thus, narrowing the confidence interval of the mortality estimate and evaluating seasonal effects.

Gutreuter and Vallazza (2002) completed an additional 114 usable entrainment samples while following tows on Pool 26 of the Mississippi River and Alton Pool of the Illinois River During 2000 and 2001. A single freshly injured and moribund skipjack herring *Alosa chrysochloris* was recovered during an entrainment sample on 1 August 2001. Combining the 1996-97 and 2000-01 data, they estimated entrainment mortality rates of 2.52 fish/km of towboat travel (80% confidence interval, 1.00-6.09 fish/km) for gizzard shad and 0.13 fish/km (0.00-0.41) for skipjack herring. Revised ancillary estimates of mean entrainment mortality rates were 0.53 fish/ km (0.00-1.33) for both shovelnose sturgeon and smallmouth buffalo.

Gutreuter et al. (1999, ENV 29) suggested that: "The rockhopper trawl proved to be an extremely effective fish capture device for use in these large river channels, but it strained only a small fraction of the propeller wash. Therefore we were left with the problem of detecting extremely rare events. Any future efforts should therefore address ways to increase the probabilities of detection. This can be accomplished by increasing the area of the trawl mouth and optimizing the position of the trawler in the propeller wash." Based on this suggestion, a trawling study was designed that used the towboat itself as the sampling platform, in an attempt to filter a larger volume of water that had passed through the towboat propellers.

Using this concept, Killgore et al. (2004, ENV 56) evaluated potential entrainment of fish through towboat propellers within the same sampling areas as the Gutreuter studies (Gutreuter et al. 1999, ENV 29; Gutreuter and Vallazza 2002; Gutreuter et al. 2003), Pool 26 of the Mississippi River and the Alton Pool of the lower Illinois River. Fish were collected with a specially designed net constructed of synthetic materials that could withstand turbulent forces. The net was deployed from a twin-screw river towboat and positioned to filter only the propeller wash. A total of 139, ten-minute trawls were taken during four seasonal sampling periods. The mean (±SE) speed (kmh) and distance (km) traveled per trawl were 7.7±0.1 and 0.82 ± 0.01, respectively. A total of 4,567 individuals comprised of 15 species were collected. Clupeidae (shad) was the dominant family, and gizzard shad was /the dominant species (96% of total catch). Catches were higher in the summer at both locations, particularly in the Illinois River (13.8 ±4.3 and 132.7±44.8 fish/km in Pool 26 and Illinois River, respectively). Except for three adult fish collected below Lock and Dam 25 during winter (common carp, mooneye, and shovelnose sturgeon), all of which were non-injured, no fish were collected at water temperatures less than 1°C. Low wintertime fish abundance in the channel was confirmed by Johnson et al. (2004a, ENV 60) who conducted seasonal hydroacoustic surveys of the main-channel of the lower Illinois River (R.M. 0.8, Grafton, Illinois).

Of the 15 species collected during the study, three species (skipjack herring, gizzard shad, and white bass) comprised 107 individuals that exhibited injuries or were dead upon collection. The most common visible injuries were head amputation (80.2%) and ventral laceration from the anal fin to the spinal column (11.0%). With one exception, all injured or killed fish had visible net marks on their body. A 400 mm TL skipjack herring was beheaded, and the skull was partially crushed, suggesting it had been struck by a rotating propeller. This single event is equivalent to 0.01 fish/km of towboat travel. Net-induced injuries caused decapitations and lacerations, and were obvious for all other dead fish. Mortality rate of all killed or injured fish, including obvious net-induced injuries, was 0.5 and 1.0 fish/km of towboat travel for Pool 26 and the Illinois River, respectively. Gizzard shad comprised the majority of dead fish, and mortality was highest during the summer sampling period.

There are a number of studies suggesting that fish have a propensity to move away from moving towboats and avoid approaching fishing vessels (Lowery et al. 1987; Soria et al. 1996). Todd et al. (1989) observed radio-tagged channel catfish *Ictalurus punctatus* moving in response to oncoming towboats in the Illinois River. Hydroacoustic studies on the Cumberland River (Lowery et al. 1987) indicated that fish move from the main channel toward shore in response to barge passage. Fish displayed a distribution pattern typical of periods of no traffic within approximately 25 min following tow passage. Some fish, probably paddlefish and gar, moved almost immediately into the tow propwash after a barge passed. Keevin et al. (2004a, ENV 61) conducted a hydroacoustic study (summer, 38 tow passage events; fall 48 events; winter 37 events; and spring 29 events) to determine the response of fish in the main channel to towboat passage when compared to periods of no passage. They found that tracked fish showed statistically significant movements away from towboats, moving deeper and horizontally away. Avoidance within 10 m of a moving tow was high during all seasons except winter, when low water temperatures apparently contributed to less avoidance behavior. However, there were fewer fish in the main channel of the Illinois River during the winter and spring sampling periods (Johnson et al. 2004a, ENV 60).

Killgore et al.'s (2004, ENV 56) study suggests that instantaneous mortality of fish entrained through the propellers of moving towboats is negligible and only gizzard shad appear to be susceptible to entrainment in any measurable number. If the feasibility study is approved, additional entrainment studies using the Killgore et al. (2004, ENV 56) sampling methodology, adjusting net size to eliminate net injury/mortality, will be conducted in other reaches of UMR to further validate the Corps' conclusion that impacts to adult fish associated with propeller entrainment do occur but are not significant.

8.5.1.2.3 Adult Fish Mortality During Lockage of Commercial Navigation Traffic

Locks are known to have large numbers of fish that would be susceptible to injury or mortality during locking. For example, a survey of five 366 m (1,200 ft.) locks on the Ohio River produced fish abundance estimates ranging from 10,340-17,887 fish in a rotenone survey and from 11,543-14,962 fish in hydroacoustic surveys (Hartman et al. 2000). A hydroacoustic study at Lock and Dam 25 on the UMR found that fish counts varied seasonally (0-14,356) (Johnson et al. 2004b, ENV 57). There was a concern that towboats, within the confined area of a lock, may continuously recirculate the lock's water volume, potentially exposing the fish to multiple propeller entrainment events. Maynord (2004, ENV 45) found that the average upbound towboat passed 49% of the lock water volume through the propellers and the average downbound loaded tow passed 228% of the lock's water volume through the propellers. The confined flow fields within the lock, with high shear stress and pressure changes, may also be responsible for fish injury and mortality.

Keevin et al. (2004b, ENV 58) conducted a study at Lock and Dam 25, a representative 183 m (600 ft.) lock on the UMR to: (1) determine the magnitude of adult fish mortality during locking, and (2) determine the barge-related and lock-related factors contributing to mortality. During the study, 361 fish were killed during 80 towboat lockages. The majority of fish mortalities were gizzard shad *Dorosoma cepedianum* (279, 77% of total mortality) and freshwater drum *Aplodinotus grunniens* (47, 13%). The remaining mortality (35, 10%) was spread among ten species: paddlefish *Polyodon spathula* (2), shortnose gar *Lepisosteus platostomus* (2), common carp *Cyprinus carpio* (4), smallmouth buffalo *Ictiobus bubalus* (6), bigmouth buffalo *Ictiobus* cyprinellus (3), blue catfish *Ictalurus furcatus* (5), channel catfish *Ictalurus punctatus* (3), white bass *Morone chrysops* (4), sauger *Stizostedion canadense* (4), and walleye *Stizostedion vitreum* (2). The lockage of the towboat Beverly Ann was responsible for 17% of the total observed mortality and four towboats (Beverly Ann, Bill Barry, Floyd H. Blaske, and Senator Sam) were responsible for 46% of the mortality. Thirty-two (40%) lockages resulted in no observed mortality. Poisson regression showed that mortality was related to water temperature, depth of water in the lock, horsepower, number of barges, and time of year. An exact Kruskal-Wallace test showed comparable mortality distributions for Kort and open nozzles, for up- and down-bound tows, and for various loading configurations.

The largest number of species killed (11) was observed during the April sampling period when fish were presumably making spawning movements or moving from over- wintering habitat. In addition to the typical mortality of gizzard shad and freshwater drum observed during the other sampling seasons, sport fish (walleye, sauger, and white bass), commercial species (bigmouth buffalo, smallmouth buffalo), and species of special concern (paddlefish) were also killed. In general the number and the species that were killed by entrainment in the lock chamber do not exceed any known ecological threshold and represent a small portion of the total population of these species in tailwater fisheries.

Johnson et al. (2004b, ENV 57) suggested that locks do not provide suitable habitat for the development of resident fish populations. Water levels are constantly raised and lowered during lockage of commercial navigation traffic, hydraulic turbulence is excessive within the lock, and towboats entrain high volumes of water (Maynord 1999; 2000b, ENV 24). However, Johnson et al. also suggested that locks may be attractive to fish because they provide slackwater refugia from the harsh environmental conditions that occur in the adjacent tailwaters (Bodensteiner and Lewis 1992). It is a common practice of the lock masters to leave the downstream lock gates open while waiting for up-bound tows to arrive at the lock; thus, facilitating fish access to the lock chamber from the adjacent tailwater. However, a potential avoid and minimize measure being explored to reduce locking mortality would be to simply close the locks between lockages; thus, keeping fish out of the lock. The spring appears to be a critical period, when efforts to ameliorate locking mortality should be made by operating lock gates in a way that reduces the amount of time upstream migrating fish can enter the lock chamber. Studies can be carried out to determine if closing the lock gates between lockages is an effective measure to reduce locking mortality.

8.5.1.2.4 Spawning Habitat

Effects on fish spawning habitat were assessed using modifications of Habitat Suitability Index (HSI) models for nine species of fish: emerald shiner, spotted bass, paddlefish, freshwater drum, black crappie, walleye, lake sturgeon, largemouth bass, and sauger (Bartell et al. 2003a, ENV 38). These species were selected to represent the different life history strategies or reproductive guilds of fish in the UMR-IWW (Appendix ENV-F).

The risk hypothesis was that increased sediment scour and changes in water current velocities caused by increasingly frequent passages of commercial vessels might negatively impact spawning habitat suitability. Changes in water current velocities and sediment scour associated with each of the 108 possible vessel configurations were calculated using a model developed to calculate the hydraulic forces associated with a passing commercial vessel (Maynord 1999). These physical parameters are components of the spawning HSI models for the selected fish species; other environmental factors (e.g., depth, temperature) are also part of the baseline habitat analyses (i.e., zero commercial traffic), but these factors are not influenced by navigating vessels. Vessel-induced changes in the values of water current velocity and sediment scour were estimated for TCM Alternatives and used in the HSI models to characterize the potential effects of increased commercial traffic on fish spawning habitat quality and quantity.

The vessel-induced impacts on spawning habitat were calculated separately for each of the modeled species using an hourly time step for the entire year. The impacts summarized here were integrated over the entire year for the without- and with-project traffic projections. The incremental impacts are summarized as percentage changes in the product of habitat suitability and habitat area for each of the nine species. Habitat suitability ranges between zero (not useful for spawning) to 1.0 (optimal spawning habitat). The habitat area is calculated as acres of non-zero habitat suitability summed for each of the LTRM Pools 4, 8, 13, 26A, 26B, and La Grange separately addressed in this assessment.

Within each of the LTRM pools, different amounts of available spawning habitat were estimated for each of the nine species. In Pool 8, for example, the following acreages of spawning habitat (in parentheses) are available for emerald shiner (1,098), spotted bass (200), freshwater drum (1,001), black crappie (514), and largemouth bass (360). These differences reflect the specific spawning requirements of each species as equated in each HSI model (Bartell and Rouse-Campbell 2003a, ENV 38). Independent of commercial traffic, the baseline model results further demonstrate that spawning habitat opportunities differ across the navigation pools for each species. For example, the number of available acres for spotted bass spawning is estimated as 539 in Pool 4, 201 in Pool 8, 22 in Pool 13, 77 in Pool 26, and 77 in the La Grange Pool.

The following paragraphs describe the incremental impacts of TCM Alternatives 4, 5, and 6 on spawning habitat. The TCM results are presented for the central economic scenario and year 2040. For this scenario and year, the incremental impacts on percentage decreases in spawning habitat were less than 20%. The largest impacts on spawning habitat were estimated for Pool 26A and LaGrange. For TCM Alternative 4, the impacted species in these pools included emerald shiner (6%), spotted bass (10%), freshwater drum (9%), and black crappie (16%). Habitat for lake sturgeon spawning was also affected in Pool 26A by ~6%. Walleye spawning habitat was impacted in Pool 4 (13%). Largemouth bass habitat was impacted in Pool 13 (8%). Zero incremental impacts on spawning habitat resulted from the analysis for the species in Pool 8. The detailed results of the entire assessment for all TCM alternatives are presented in Appendix ENV-F.

Incremental percentage losses in habitat generally increased from TCM Alternative 4 through 6. For example, loss in lake sturgeon habitat was ~6% in pool 26A for TCM Alternative 4 compared to ~12% loss computed for Alternatives 5 and 6. Similarly, freshwater drum habitat loss was estimated as ~3% in Pool 4 for Alternative 4. This impact increased to ~9% for Alternatives 5 and 6 in Pool 4. The pattern consistently indicated a larger increase in the incremental effects between Alternative 4 and 5, compared to the increase between Alternative 5 and 6. This pattern of relative increases in impacts on spawning habitat largely reflects the incremental increases in traffic projections among TCM Alternatives 4, 5, and 6.

The calculation of the incremental percentage decrease in spawning habitat was averaged over space (entire pool) and time (one year). Actual impacts are calculated hourly for each GIS cell of potential spawning habitat for each species in each of the LTRM pools. It is possible that local areas were more severely impacted for shorter periods of comparatively intense traffic. These local impacts, while calculated as part of the overall methodology, might not be accurately reflected in the annual average summary of total pool impacts presented here.

Despite the possibility of more severe localized impacts, the small overall percentage impacts suggest that increased traffic projected for TCM Alternatives 4, 5, and 6 will not likely affect the spawning success of the modeled species, unless the species is severely limited by available spawning habitat. Generally the effects of commercial navigation on spawning habitat are less significant to fisheries than larval entrainment by tows.

8.5.2 Aquatic Plant Community

Aquatic plants can be affected by navigation traffic through several impact mechanisms (Bartell et al. 2000a, ENV 17). Vessel wake waves and changes in current velocity and direction can cause entangling and breakage of plants. Sediment resuspended by passing vessels reduces underwater light and can reduce photosynthesis, growth, and reproduction by plants. A summary of the risk assessment of the effects of navigation on submersed aquatic plants conducted for this Navigation Study are provided in

Appendices E and H. A detailed description of the approaches and models used in this assessment is contained in Bartell et al. (2000a, ENV 17) and Bartell and Rouse-Campbell (2003, ENV 38).

The robust emergent aquatic plants such as arrowhead, bulrush, and cattail (*Sagittaria* spp., *Scirpus* spp., *Typha* spp., respectively) grow in stands that resist wave action and water exchange, limiting their vulnerability to navigation traffic effects. Historically they would have grown along the main channel border, but due to altered water levels and wind and boat waves they are sparse or non-existent today. Emergent plants tend to be more common in the backwaters but altered water levels create difficult growing conditions and even here the threat to the remaining beds is genuine. Further, they grow above the water surface and thus are not affected by light limitation imposed by suspended solids in the water. Floating-leaved aquatic plants grow in backwater areas generally protected from wind, currents, and the hydraulic disturbances from commercial traffic. Thus, the assessment did not include emergent or floating-leaved aquatic plants.

Commercial towboat and barge traffic projections have been developed for "without project" future conditions (years 2000, 2010, 2020, 2030, 2040, and 2050), without any major improvements to the UMR-IWW Navigation System. Future traffic projections have also been developed for the alternative navigation improvement scenarios, for the same target years. In this assessment, the risks posed by commercial traffic projected for TCM Alternatives 2, 4, 5, and 6, as well as Essence Model Alternatives 4, 5, and 6 were evaluated. TCM Alternative 1 specifies the without-project traffic projections for each of five economic scenarios. Without-project traffic scenarios were also provided for each of the EM alternatives. To perform this component of the ecological risk assessment, projections of annual traffic provided by the TCM and EM were disaggregated to vessels per day for each month and navigation pool.

8.5.2.1 Modeling the Physical Effects of Traffic

The hydraulic disturbances resulting from all possible configurations of a passing commercial tow were calculated for the main channel and channel border areas of the UMR-IWW using the NAVEFF model (see Section 8.4.2.2). The characteristics that define a particular vessel configuration include the direction of travel (upbound, downbound), vessel speed (slow, medium, fast), vessel size (small, medium, big), barge loads (empty, mixed, full), and propeller type (Kort nozzle, open wheel). The existing fleet data were analyzed and resulted in 108 different vessel configurations; each vessel configuration was assigned a code value (1-108) that identifies its particular combination of attributes. These fleet characteristics, developed by Corps economists, are presumed not to change over the study period (through the year 2050). The output from the NAVEFF model was used to calculate the magnitude and duration of sediment resuspension resulting from a passing commercial tow in the sediment resuspension model (NAVSED) (see section 8.4.5.2).

Wave height and currents produced by passing vessels were simulated for 108 vessel configurations, using NAVEFF and a cell-based geographic information system (GIS) for Pools 4-19. The potential for physical damage to plants was assessed by comparing these results of current velocity and wave height calculated by the NAVEFF model (Maynord 1996) to screening criteria developed for SAVs. A cell failed if the screening criteria of 0.75 m/s for velocity or 0.2 m for wave height were exceeded. The screening calculations were performed for nine combinations of river water level and vessel sailing line. The cell identification numbers for potential physical damage to plants were retained for use in generating a GIS map of potential physical impact sites. These sites are included in the impacts areas GIS and are used in planning measures to avoid and minimize the impacts of increased navigation traffic on aquatic plants.

Prevailing wind and the amount of open water were considered as screening criteria for SAV mitigation. The NavSAV model applied prevailing wind direction, speed, time of the year, and National Weather Service data for each Pool to identify those cells most affected by wind generated waves during the growing season. If wind velocity and fetch created waves greater than or equal to 0.2 meters for 15 days of 100 days (during growing season), then these cells were not mitigated. Under these conditions it is assumed that wind is more significant in the resuspension of sediment than commercial navigation.

8.5.2.2 Plant Breakage

The effects of vessel-induced wake waves and changes in current velocity were examined for two species of submersed aquatic plants, American wild celery (*Vallisneria americana*), and Eurasian water milfoil (*Myriophyllum spicatum*), in a set of laboratory experiments (Stewart et al. 1997, ENV 1). These species were selected because of their distribution and ecological importance in the main channel borders of the UMR and because they represent two distinct plant growth forms. Wild celery has ribbon-like leaves and grows from a basal rosette. Water milfoil has finely-divided leaves, grows from apical meristem, and often forms a canopy at the water surface.

The laboratory experiments on the effects of current velocity on plants within a flume (Stewart et al. 1997, ENV 1) indicated that a current velocity greater than or equal to 0.25 m/sec caused breakage in the plants. Laboratory experiments of the effects of both waves and current on plants revealed that current velocities equal to or greater than 0.25 m/sec forced plants downward in the water column, reducing their vulnerability to waves. At lower current velocities, plant damage increased with wave height. Observations of the plants in the flume indicated that the increased plant damage from waves at lower velocities was related to plant entanglement. The laboratory experiments indicated that at lower current velocities (below 0.25 m/sec), waves greater than 0.2 m caused plant breakage.

The plants used in the experiments were grown in a greenhouse in standing water conditions and were not acclimated to growth in flowing water. Stem and leaf tensile strength measurements on wild celery and sago pondweed obtained from Pool 8 of the UMR indicated that plants grown in the wild are stronger, and probably less prone to breakage than laboratory-grown plants of the same species (Stewart et al. 1997, ENV 1). Therefore, the laboratory finding of incipient plant breakage at 0.25 m/sec of current velocity appeared too conservative as a threshold velocity for plant breakage. As a result of a literature review, the current velocity threshold for plant breakage was established at equal to or greater than 0.75 m/sec (Bartell et al. 2000a, ENV 17).

A literature review indicated that a wave height of 0.23 m was associated with reduced plant density and plant height (Bartell et al. 2000a, ENV 17). Therefore, the wave height threshold for breakage of plants was established at 0.2 m, consistent with results of laboratory studies.

The potential for plant breakage is predicted to occur in Pools 4 through 13. The criteria for change in current velocity (0.75 m/sec) and wave height (0.2m) were used to develop a simple rule-based model to evaluate the potential for physical damage of aquatic plants due to hydraulic disturbances produced by passing vessels (Bartell et al. 2000a, ENV 17). The model was used to evaluate all potential plant growth areas within the main channel borders of UMR Pools 4 through 19. Potential plant growth areas were defined as UMR main channel border areas with a mean depth of 1.5 m or less. This depth was selected based on the depth distribution of submersed aquatic plants in the UMR from LTRMP data.

Of the possible combinations of location and vessel configuration, those combinations that failed either the current velocity or the wave height screening criteria were small percentages (<1.5%) of the total area of the potential plant growth. A total of 1,235 GIS cells (areas) in the main channel borders of Pools 4 through 19 are estimated to be subject to commercial vessel wake waves >0.2 m high and/or vessel-induced current velocities >0.75 m/sec. More than 90 percent of these sites failed the screening due to wake wave heights. In the thousands of screening trials performed, wave heights predicted by the NAVEFF model for commercial vessels were all below 0.3 m.

Main channels and channel border areas that are subject to wind-driven waves might prove to be poor habitat for submerged aquatic plants. These areas might be justifiably removed from the set of potential plant habitats included in the assessment of commercial traffic impacts on plant growth. To address this issue, critical fetch lengths were calculated in relation to seasonal patterns of wind velocity and direction for the navigation pools on the Upper Mississippi River. Values were calculated for thresholds of wind exceedance probabilities of 5, 10, 15, and 20 percent. These thresholds were determined for wind-driven wave heights that exceed the 0.2 m used in the screening of commercial vessel wake waves. The sets of GIS cells that were likely to be impacted by wind-driven waves were tabulated and used to identify the intersection with the set of cells physically impacted passing vessels and the set of cells where vessel-induced sediment resuspension might reduce plant growth (i.e., decreased light availability). Computer generated maps of these impacted cells can assist in the mitigation planning process. The results of these analyses are summarized in Appendix ENV-H.

Additional analyses identified main channel and channel border areas that are possible subject to plant breakage by commercial vessel wake waves only, by eliminating the sites that have a wind-driven wave energy regime that frequently produces waves >0.2 m high. This further screening reduced the number of potential plant breakage cells due to commercial navigation traffic to 427. Details of this analysis are provided in Appendix ENV-H.

The remaining identified cells with potential plant breakage were retained for use in generating a GIS map of potential physical impact sites (Figure 8-5 and Figure 8-6). These sites will be inspected in the field for potential plant growth and will be considered in planning measures to avoid and minimize the impacts of increased navigation traffic on aquatic plants (see Section 10.5.2).

The potential for increased plant breakage due to increased traffic exists, because more passing tows would produce more wake waves. The 0.2 m wave height screening criteria is a conservative level of disturbance at which plant breakage can be expected to begin. With increased wave heights and increased number of waves, more damage to plants might occur.

8.5.2.3 Effects on Growth and Reproduction

The impacts of sediment resuspension by navigation traffic on plant growth and reproduction were assessed using the results of the NAVEFF model (Maynord 1996), the NAVSED model (Copeland 1999, ENV 37), a literature review, laboratory experiments (Doyle 2000, ENV 28), and numerical models of plant growth and vegetative reproduction (Bartell et al. 2000a, ENV 17; Best and Boyd 1999a - d).

Available models for assessing the effects of increased suspended solids on submersed aquatic plants were reviewed. A submersed aquatic plant growth model (Best and Boyd 1996, Best and Boyd 1999 a - d), originally developed for hydrilla (*Hydrilla verticillata*), was modified and calibrated for two plant species that occur in the UMR (Bartell et al. 2000a, ENV 17). American wild celery and sago pondweed (*Potamogeton pectinatus*) were selected as representative species for plant growth modeling because they are common and important species in the UMR, information in the literature on their growth is useful for model calibration, and because they exhibit different growth forms.

Monthly average suspended sediment concentrations (mg/L) were calculated from UMR ambient suspended sediment data. Daily traffic rates, tow configurations, and inter-arrival times were developed for Pools 4-19 using the traffic TCM and EM traffic projections.

Sediment resuspension by passing vessels was estimated using NAVEFF and NAVSED models. Time series of daily suspended sediment concentrations were constructed for the May through September growing season for the without-project condition and for each of the economic scenarios in the proposed TCM and EM alternatives. The suspended sediment concentrations were first converted to estimates of

Secchi depth (m) using regression equations developed for UMR Pools 4, 8, and 13. Secchi depths were then transformed to light extinction coefficients (Bartell et al. 2000a, ENV 17). Daily values of incident solar radiation, temperature, ambient suspended solids, and light extinction coefficients specific to Pools 4-19 and each project alternative were input to the plant growth models for *Vallisneria* and *Potamogeton*. The time series of daily light extinction coefficients developed for each pool and navigation improvement scenario and alternative replaced the nominal (ambient) pool-specific values for the model.

To assess each traffic scenario and alternative, plant growth was simulated for the GIS cell that exhibited the maximum predicted sediment resuspension per vessel passage for each of three water depths (0.5, 1.0, and 1.5 m) in Pools 4-19. Within-pool impacts on plant growth were linearly interpolated using a sediment index calculated separately for each GIS cell in the three depth categories. This index is the ratio of cell-specific sediment resuspension divided by the resuspension of the maximally impacted GIS cell.

For each plant species and traffic alternative, simulations were performed for the six years of traffic projections (2000, 2010, 2020, 2030, 2040, and 2050) for each of the three depth classes (0.5 m, 1.0 m, and 1.5 m), and for each of three sediment concentration percentiles (10%, 50%, and 90%) obtained from the distribution of results from the NAVSED model. Using the three values allows for the calculation of an interval of impacts on submersed aquatic plants, consistent with quantitative risk assessment. The 10^{th} and 90^{th} percentiles of the sediment resuspension estimates represent the tails of the distribution; these concentrations will occur infrequently. The 50^{th} percentile defines a median or average concentration, assuming a normal distribution. This section reports results for the 50^{th} percentile of sediments. Detailed results for the 10^{th} and 90^{th} percentiles of sediment resuspension are provided in Appendix ENV-H.

Table 8-23 and Table 8-24 summarize the maximum incremental impacts of TCM and EM Alternatives 4, 5, and 6 on (living) plant biomass for wild celery and sago pondweed growing at depths of 0.5, 1.0, and 1.5 m. The results are summarized across navigation pools 4-19 for project year 2040 and the most favorable economic scenario. This scenario and year correspond to the highest traffic projections across the Alternatives and provide an estimate of the most severe incremental effects for the Alternatives 4, 5, and 6. The results are reported for simulations based on the 50^{th} percentile of modeled sediment resuspension by commercial vessels. The entire set of model results are presented in Appendix ENV-H.

8.5.2.3.1 Traffic impacts on growth of *Vallisneria*

The incremental impacts on wild celery growth generally increased across TCM and EM alternatives 4, 5, and 6 (Table 8-23). Within each traffic alternative, the highest percent reductions in growth were estimated for pools 4, 5, 8, 9, 11, 13, and 19. Pool 13 indicated the greatest incremental impacts on wild celery growth. For Pool 13 locations where water depths were ~0.5 m, plant growth might be incrementally reduced by nearly 30 percent (e.g., TCM Alternative 6) for the with-project traffic conditions compared to without-project growth. However, the impacts were negligible or zero for Pool 13 locations characterized by depths of 1.0 – 1.5 m. Incremental effects on wild celery growth in Pools 9 and 11 ranged from approximately 3 to 12 percent across the TCM and EM alternatives. Modeled impacts were on the order of 5 percent or less for Pool 19. Again, the highest impacts were projected for locations at 0.5 m in depth. In contrast, the estimated incremental impacts on wild celery growth increased with increasing depths for Pool 4 for both the TCM and EM alternatives. However, the impacts on growth were on the order of 5 percent or less in Pool 4.

Figure 8-5 illustrates the locations of main channel and channel border GIS-cells in a lower section of Pool 13 where non-zero incremental impacts on the growth of wild celery were projected. The map inset shows the location of this section within Pool 13. The results were obtained for the most favorable economic scenario for TCM Alternative 6; these results are also for year 2040 and are based on simulations that used the 50^{th} percentile sediment resuspension estimates. Figure 8-5 indicates a fairly large number of locations within this section of Pool 13 where plant growth might be suppressed. This section of Pool 13 was selected for presentation because it exhibits the largest number of impacted locations. The figure legend indicates that most of the non-zero impacts are on the order of 10 percent or less, although a few locations are impacted by more than 20 percent (consistent with Table 8-23).

Figure 8-6 shows the same section of Pool 13. However, the GIS cells where impacts on plants are projected either from physical damages from passing vessels or from wind-driven waves have been removed from the analysis. Clearly, the locations in this section of Pool 13 that might well require mitigation are few in number compared to the impacts suggested by Figure 8-5.

8.5.2.3.2 Traffic impacts on growth of *Potamogeton*

The modeled traffic impacts on *Potamogeton* paralleled those of *Vallisneria* for the most favorable scenario and year 2040 across TCM and EM Alternatives 4, 5, and 6 (Table 8-24). Not surprisingly, given the different growth form of the pondweed, the impacts on this species were less than for wild celery. The patterns of impact were similarly observed for navigation pools 4, 5, 8, 9, 11, 13, and 19. The maximum incremental effects were similarly recorded for Pool 13. However, the impacts on pondweed were on the order of 15 percent or less, compared to the almost 30 percent reductions modeled for wild celery. Table 8-24 underscores the relatively small incremental impacts projected for this scenario for pondweed. The detailed pondweed results for other scenarios and years for the TCM and EM alternatives are presented in Appendix ENV-H. These appended results demonstrate incremental impacts that are on the order of those listed in Table 8-24 or less.

8.5.2.3.3 Effects on reproduction

The results of the plant growth model simulations indicated that increased traffic resulting from the TCM and EM Alternatives did not affect the vegetative reproduction of either wild celery or sago pondweed. For both submerged aquatic plant species and all future years, there was little or no difference between the number of tubers produced during the growing season as a result of traffic due to the without-project conditions and the number produced due to traffic resulting from the alternative scenarios. Therefore, only results related to submerged aquatic plant growth are presented. The magnitudes of modeled effects on tuber production suggest that the projected future commercial traffic will exert minimal year-to-year impacts on the contribution of vegetative reproduction to aquatic plant population sizes in the main channel borders of the UMR.

8.5.2.4 Probabilistic Risk Assessment

An important phase in assessing traffic impacts on submersed aquatic plants was to incorporate the assessment methodology into a framework that characterizes risk in probabilistic terms. Where possible, the impact of the specific sources of uncertainty on the estimated risks to submerged aquatic plant growth and reproduction were quantified using methods of sensitivity and uncertainty analysis. More detailed, probabilistic assessments were performed for selected locations and traffic scenarios identified in this assessment and are presented in Appendix ENV-E. Parameters used in the calculations that are imprecisely known were defined as statistical distributions. Monte Carlo simulation methods were used to propagate these uncertainties through the model calculations to produce distributions of impacts on growth and vegetative reproduction in relation to specific traffic scenarios. These distributions of results can be used to estimate the probability of different magnitudes of impact in a manner consistent with probabilistic risk estimation.

8.5.2.5 Combined Effects on Plant Populations

An analysis of the reduction in the total production capacity of the wild celery and sago pondweed growing in main channel border areas due to the traffic in the UMR was conducted for the different scenarios under study. The analysis consisted of using the total biomass that was predicted to grow in each cell (from Pools 4 to 19) that had a water depth of up to 1.5 m and the area of each cell. The production capacities from individual cells were added up to determine the total production capacity for the without- project and TCM and EM Alternatives 4, 5, and 6. The reduction in production capacity was estimated for each scenario and alternative compared to the without-project condition. Prevailing wind and the amount of open water were considered as screening criteria. The NavSAV model applied prevailing wind direction, speed, time of the year, and National Weather Service data for each pool to identify those cells most affected by wind generated waves during the growing season. If wind velocity and fetch created waves greater than or equal to 0.66 foot for 15 days of 100 days (during growing season), then these areas were eliminated. Under these conditions it is assumed that wind is more significant in the resuspension of sediment than commercial navigation. The NavSAV model was used to identify areas affected by commercial tows. A total of 11 areas in Pool 13 were identified as at risk from increased navigation Alternative 4. Alternative 6 traffic levels were predicted to affect SUV in 33 areas in five Pools. Mitigation for these areas is found in Chapter 10.

Table 8-23. Projected maximum incremental percentage decreases in growth of *Vallisneria* for the most favorable economic scenario of the Tow Cost Model and Essence Model Alternatives 4, 5, and 6. Results are calculated using the 50th percentile sediment resuspension values for project year 2040.

UMRS	0.5 m						1.0 m						1.5 m					
Navigation	TCM Alternative			Essence Alternative			TCM Alternative			Essence Alternative			TCM Alternative			Essence Alternative		
Pool	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
4	0.1	0.5	0.8	-0.1	0.1	0.5	0.5	2.6	3.9	-0.3	0.7	2.5	0.6	3.2	5.0	-0.4	0.5	3.2
5	3.0	9.4	12.9	-0.1	7.2	9.7	2.6	6.3	9.4	-0.8	5.2	6.9	0.0	0.0	0.0	0.0	0.0	0.0
5A	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.8	3.0	-0.2	1.7	2.9	0.5	0.3	0.9	0.0	0.3	0.4
6	0.3	0.8	1.1	0.0	0.3	0.7	1.4	3.6	4.9	-0.1	1.1	2.9	0.3	0.6	0.6	0.1	0.1	0.2
7	0.0	0.3	0.3	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.9	0.3	0.3	0.7
8	0.8	4.2	4.6	0.0	1.2	3.1	-0.2	3.0	3.6	0.4	1.5	3.1	0.3	0.5	0.7	0.1	0.3	0.3
9	4.1	8.3	11.7	2.1	3.7	6.9	0.0	1.9	3.1	0.5	1.4	3.0	0.1	0.2	0.3	-0.1	0.1	0.3
10	0.4	3.9	4.2	1.0	1.1	2.8	0.9	2.0	2.7	0.3	0.7	2.8	0.0	0.1	0.1	0.0	0.0	0.1
11	2.5	6.1	10.7	0.4	4.2	10.2	-0.6	0.9	2.3	0.2	1.3	3.0	0.0	0.1	0.1	0.0	0.0	0.1
12	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.0	0.0
13	7.4	22.4	28.7	2.5	15.8	23.7	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.3	0.4	0.2	0.2	0.5	0.0	0.2	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
15	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.3	0.8	1.0	-0.1	0.6	1.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
17	0.3	0.6	1.1	0.3	0.8	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	2.1	3.7	4.5	-1.6	2.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 8-24. Projected maximum incremental percentage decreases in growth of *Potamogeton* for the most favorable economic scenario of the Tow Cost Model and Essence Model Alternatives 4, 5, and 6. Results are calculated using the 50th percentile sediment resuspension values for project year 2040.

UMR	0.5 m						1.0 m						1.5 m					
Navigation	TCM Alternative			Essence Alternative			TCM Alternative			Essence Alternative			TCM Alternative			Essence Alternative		
Pool	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
4	0.1	0.2	0.3	0.0	0.1	0.2	0.1	0.5	0.7	-0.1	0.1	0.5	0.0	0.9	1.8	-0.1	0.0	0.8
5	1.2	4.0	5.8	0.0	3.2	4.2	0.5	1.5	2.3	-0.1	1.3	1.7	0.0	0.1	0.1	0.0	0.1	0.1
5A	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.9	0.0	0.3	0.6	0.7	1.3	2.2	0.0	0.9	1.4
6	0.1	0.3	0.5	0.0	0.1	0.3	0.2	0.7	1.0	0.0	0.3	0.7	0.6	2.3	2.9	0.1	0.6	1.3
7	0.0	0.2	0.2	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.5	3.9	0.4	1.6	3.0
8	0.4	2.2	2.4	0.0	0.6	1.6	0.2	1.0	1.1	0.0	0.3	0.6	1.9	4.1	5.7	0.4	1.1	3.1
9	1.9	3.6	5.3	0.9	1.4	3.0	0.4	0.9	1.2	0.2	0.3	0.8	2.9	7.3	8.1	0.6	3.5	5.4
10	0.2	1.9	2.1	0.5	0.6	1.4	0.2	1.0	1.2	0.2	0.3	0.9	-0.1	0.7	0.9	0.2	0.1	0.7
11	0.7	2.3	4.2	0.6	2.0	4.2	0.2	0.6	1.0	0.1	0.4	1.1	0.1	0.3	0.3	-0.1	0.1	0.4
12	--	--	--	--	--	--	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.0	0.0
13	3.2	10.0	14.3	0.4	6.7	11.4	4.0	9.6	13.5	0.0	5.8	10.7	0.0	0.2	0.2	0.0	0.1	0.2
14	0.0	0.1	0.2	0.1	0.1	0.2	0.1	0.9	0.9	0.5	0.8	1.7	0.1	0.2	0.2	0.1	0.1	0.2
15	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.1	0.3	0.4	0.0	0.2	0.4	0.3	1.0	1.0	0.1	0.8	1.4	0.0	0.1	0.1	0.0	0.1	0.1
17	0.1	0.2	0.4	0.1	0.3	0.4	0.3	0.7	1.9	0.4	1.0	1.3	0.0	0.0	0.1	0.0	0.1	0.1
18	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.4	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0
19	0.9	1.5	1.8	-0.4	1.0	2.0	2.4	4.1	4.7	-1.3	2.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0

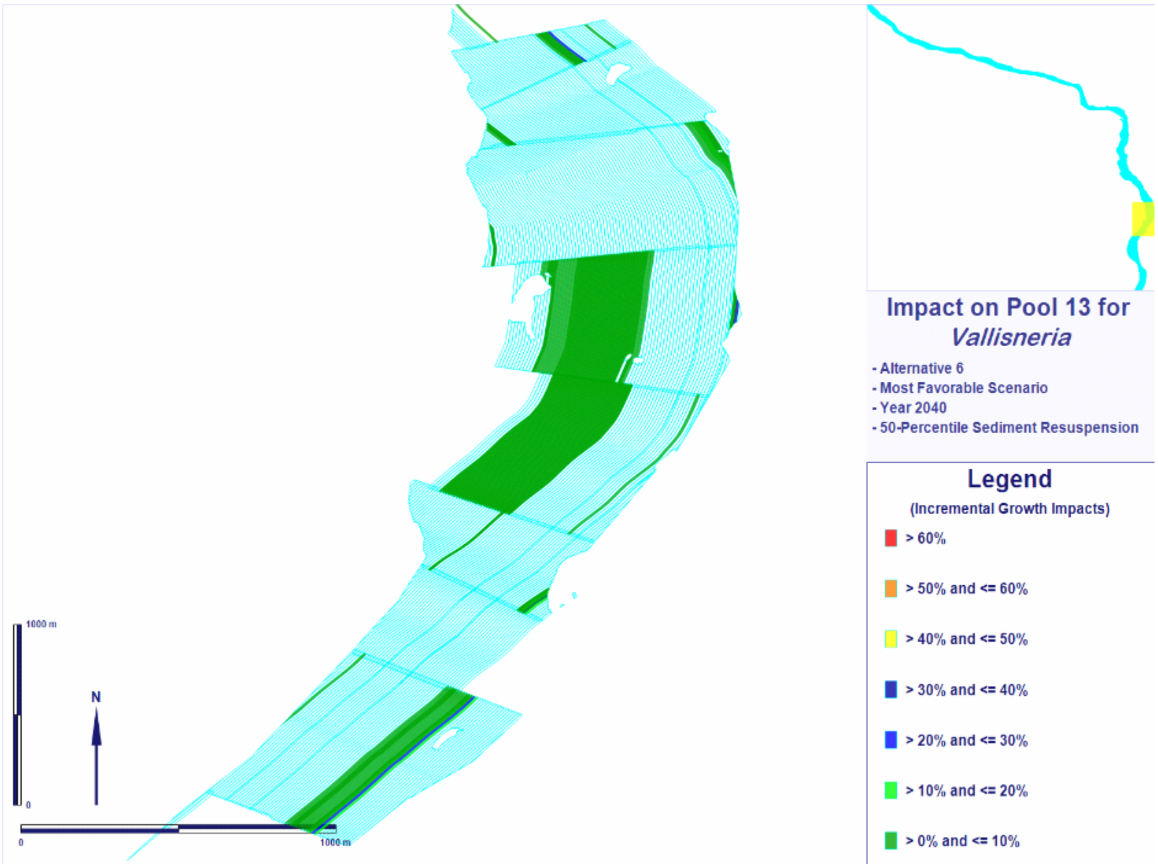

Figure 8-5. GIS cells for a section in Pool 13 where *Vallisneria* growth might be impacted by sediment resuspension for TCM Alternative 6.

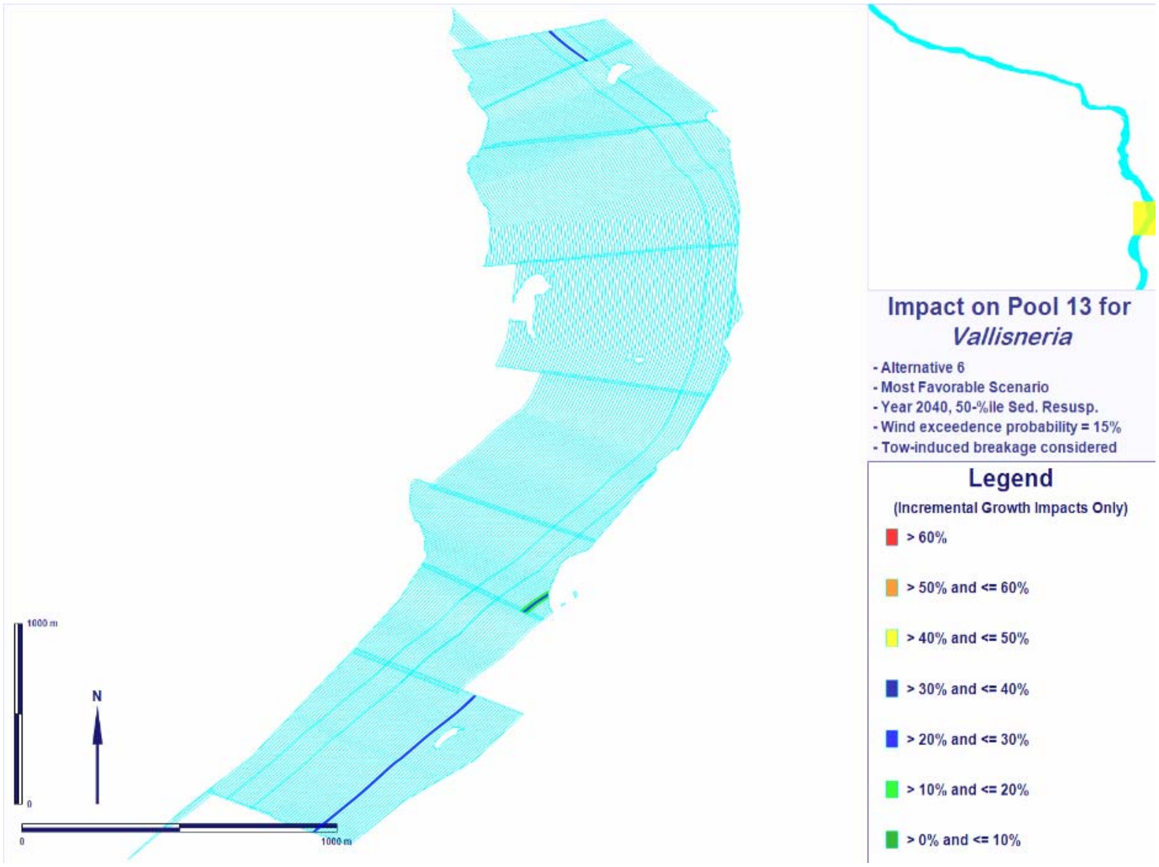

Figure 8-6. Remaining GIS cells for a section in Pool 13 where *Vallisneria* growth might be impacted by sediment resuspension for TCM Alternative 6. Cells in Figure 8-6 where plant growth might be impacted by wave-induced waves or where plants might be subject to physical breakage by passing commercial vessels are not shown.

8.5.3 Freshwater Mussels

Commercial navigation traffic on large inland waterways can cause brief episodes of increased turbulence and suspended solids, both of which are potentially deleterious to essentially sessile, filter-feeding freshwater mussels. Predicting the consequences of commercial navigation traffic, especially incremental increases in traffic, is difficult due to the intermittent, brief nature of changed physical conditions.

Two approaches were used during the Navigation Study to address potential impacts of increased navigation traffic on freshwater mussels. In the first approach, laboratory studies were conducted by Payne et al. (2000, ENV 31) to determine the effects of navigation traffic-induced changes in velocity and suspended solids on a variety of freshwater mussel physiological parameters. In the second approach, a bioenergetics model was developed by Bartell et al. (2003b, ENV 39) to model the effects of increased sediment loads on the three-ridge mussel (*Amblema plicata*).

8.5.3.1 Mussel Health

Previous laboratory studies by Aldridge et al. (1987) and Payne and Miller (1987) indicated that aspects of physiological energetics, including filtration rate, respiration rate, nitrogen excretion rate, O:N (oxygen:nitrogen) ratio, and tissue condition index, are sensitive indicators of potential deleterious consequences of traffic effects on mussels. Aldridge et al. (1987), using very high suspended solids concentrations and frequencies of disruption, showed an additive effect of increased suspended solids to turbulence and provided evidence that the frequency of intermittent disturbance was important. In their short-term experiments, upward shifts in O:N by mussels in the most severely stressed treatment groups proved to be the best indicators of shifts toward a negative bioenergetic balance. In longer term studies of turbulence effects (Payne and Miller 1987), mussels under the most severe stress (continuous high turbulence) showed reduced tissue-to-shell mass ratios.

As part of the Navigation Study (Payne et al. 2000, ENV 31), turbulence effects were investigated in an experiment long enough to elicit such tissue condition index changes, using an array of frequencies of exposure treatments that spanned the range likely to be encountered by mussels in the UMR. Frequency of intermittent exposure to high turbulence levels had no relationship to deleterious condition changes in terms of filtration rate, respiration rate, nitrogen excretion rate, O:N, or tissue condition index. Additional short-term laboratory experiments were conducted to investigate additive effects of suspended solids to turbulence, using frequencies of exposure and levels of suspended solids much more realistic than those of Aldridge et al. (1987). High concentrations of TSS (total suspended solids) used in the UMR-IWW study (120mg/l) were more realistic than concentrations (600-750 mg/l) used by Aldridge et al. (1987). Likewise, lake sediment used for TSS was more realistic than the abrasive diatomaceous earth used by Aldridge et al. (1987).

Evidence of an additive effect of suspended solids was more equivocal than in the harsher experiments of Aldridge et al. (1987). Physiological disruption was slightly greater when high suspended solids concentration accompanied intermittent turbulence. The tendency was for downward shifts in nitrogen excretion and upward shifts in O:N. However, this tendency was not manifest in all species within an experiment or among experiments for particular species. Although some statistically significant shifts were measured, major changes in metabolic condition generally were not indicated. No changes in tissue condition occurred. Studies of shell valve gape behavior indicated that mussels sometimes responded to navigation traffic effects by slightly closing their shell for a brief period. However, such behavior varied substantially among mussels and for an individual over time.

In general, physical habitat disruption associated with routine navigation traffic tends to elicit minor shifts upward in O:N and measurable changes in shell gape behavior (Payne et al. 2000 ENV 31). These are relatively subtle physiological responses consistent with the subtlety of brief, infrequent episodes of turbulence and elevated TSS. Although such responses can be elicited and measured, their biological significance appears to be slight. The results of this study suggest that the levels of increased navigation traffic associated with proposed project alternatives will not have significant physiological impacts on freshwater mussels in the UMR.

8.5.3.2 Growth and Reproduction

A comprehensive bioenergetics model for the three-ridge mussel was developed by Bartell et al. (2003b, ENV 39) to evaluate the effects of water velocity changes and increased suspended sediment levels induced by increased navigation traffic. The impacts of traffic-induced sediment resuspension on mussel growth and reproduction were assessed for five locations (i.e., cells) in Pool 13 where mussel beds are known to occur, three locations in Pool 26A, one location in Pool 26B, and 15 locations in the La Grange Pool. The three-ridge mussel was chosen because it is an important commercial species, it is common and widespread throughout the UMRS, and there was a considerable database for model development and evaluation.

The mussel growth model was used to evaluate six hypothetical traffic alternatives that characterized a wide range of improvements to the navigation infrastructure. These alternatives did not exactly match the TCM or EM Alternatives 4, 5, and 6. However, the projected incremental increases in vessels/day in the hypothetical scenarios bracketed those values estimates for the TCM and EM alternatives (Table 8-25). Using the values estimated for the most favorable economic scenario, the number of vessels/day projected for TCM Alternatives 4 and 5 are similar in magnitude to hypothetical Scenarios 1 and 2. However, traffic estimates for TCM Alternative 6 are slightly greater (~1-2 vessels/day) than hypothetical alternative 6 for Pools 13 and 26. The comparisons between the hypothetical traffic scenarios and the Essence alternatives are similar to TCM comparisons with scenarios 1-6. Essence Alternative 6 projects greater incremental increases in traffic for these pools compared to the TCM Alternative 6. Similarly, Essence Alternative 5 indicates greater traffic than TCM Alternative 5 for Pool 26 and La Grange, but not for Pool 13. Essence Alternative 4 suggests slightly greater increases in traffic than TCM Alternative 4 for LaGrange; the Essence and TCM values are nearly identical for Pool 26; and finally, the TCM values exceed those of the Essence in Pool 13. Appendix ENV-I contains detailed results of the mussel model simulations.

Similar to the approach used in the plant growth impact assessment, three different sediment concentrations, obtained from the distribution of results from the NAVSED model (Maynord 1999, NAV 14), were used in the assessment of increased commercial traffic resulting from selected navigation improvement alternatives on freshwater mussel growth and reproduction: the 10^{th}, 50^{th}, and 90^{th} percentile sediment concentrations. Results using the 50^{th} percentile sediment concentrations, those most likely to occur, are the most important and are presented below.

8.5.3.2.1 Mussel Growth

Mussel growth and biomass were modeled as tissue dry weight, shell dry weight, and total dry weight (tissue dry weight + shell dry weight) (Table 8-26 through Table 8-28). Results for the with-project conditions were subtracted from those resulting from the without-project conditions for each alternative to determine the incremental impact (termed ‘project reduction’ in the summary tables) on mussels resulting from hypothetical alternatives 1 – 6.

Traffic associated with the hypothetical alternatives 1 – 6 usually had the highest impacts on mussel growth and reproduction during the project year 2040; therefore, the year 2040 using the 50^{th} percentile sediment concentration is used as an example in the following discussion. Summary tables are provided for the year 2040 for each alternative using the 10^{th}, 50^{th}, and 90^{th} percentile sediment concentrations (Table 8-26 through Table 8-28).

Impacts on mussel growth as a result of traffic increases from Alternatives 1 – 6 were lowest in Pool 26. The highest impacts on mussel growth due to traffic associated with the six hypothetical alternatives occurred in the La Grange Pool. For all alternatives, the highest impacts on mussel growth in Pool 13 occurred in the mussel bed location identified as GIS cell 15R5565, a mussel bed located only 15 m from the sailing line. At this location, decreases in tissue dry weight were on the order of 3-4% across the hypothetical alternatives 1-6. Therefore, the impacts of the TCM Alternatives 4 would be expected to be similar in magnitude (Table 8-25). However, the expected effects of TCM Alternatives 5 and 6 would be somewhat greater given the comparison of the incremental increases in vessels/day compared to alternatives 1-6 for Pool 13, year 2040. Traffic associated with alternatives 2, 3, and 4 had the highest effects on shell dry weight in the mussel bed at GIS-location 15R5565. Shell dry weight decreased ~3.4% as a result of modeling alternatives 2 and 3 and ~3.7% for alternative 4 model results. All of the simulated alternatives affected mussel total dry weight in mussel bed 15R5565 (between 3 and 4% decrease); however, the highest impacts were associated with alternative 4 (~4%). Comparing traffic values (Table 8-25), the expected effects for TCM Alternative 4 should be similar in magnitude to the hypothetical alternatives 2, 3, and 4. The expected impacts of both the TCM and Essence Alternatives 5 and 6 would be slightly increased as a result of an additional 2-3 vessels/day, on average.

In Pool 26, the highest modeled impacts on mussel growth occurred in the mussel bed identified as Cell ID 175L2335 (Tables 4-25 through 4-28). When the 50th percentile sediment concentrations were used, there were negligible effects on tissue dry weight, shell dry weight, or total dry weight in mussel bed 175L2335 located in Pool 26. Even assuming the 90th percentile sediment concentrations, impacts on mussel growth at this location were less than 4% for hypothetical Scenarios 1-6. The incremental increases in the average number of vessels/day projected for the TCM Alternatives 4-6 are within the range of the modeled hypothetical alternatives. Thus, the impacts of the TCM alternatives on mussel growth at this location should be similarly negligible. However, the anticipated incremental impacts would be greater for mussel growth subject to the comparatively larger increases in traffic associated with Essence Alternatives 5 and 6.

In La Grange mussel bed 35L1130, traffic associated with Alternatives 4 and 5 had the highest impacts on mussel tissue dry weight. Tissue dry weight decreased 3.3%. The highest impacts on shell dry weight in mussel bed 35L1130 occurred as a result of Alternative 3 traffic (4.5%). Impacts on total dry weight were highest in mussel bed 35L1130 due to traffic resulting from Alternative 3 (4.4%) sediment concentrations. Similar to the comparisons of projected traffic for Pool 26, the hypothetical alternatives directly addressed by the mussel growth model include values associated with the most favorable economic scenario of TCM Alternatives 4-6. Therefore, the impacts of the TCM alternatives on mussel growth at this location would be similar or less than the results for the hypothetical alternatives. In contrast, the comparatively greater values of traffic associated with Essence Alternative 6 indicate the potential for greater impacts on mussel growth for the La Grange mussel bed in 35L1130.

All of the alternatives affected mussel tissue dry weight in La Grange mussel bed 15R1160; however, impacts were highest for alternative 3 (up to a 7.6% decrease). Highest impacts (6.3% decrease) on shell dry weight on mussels in bed 15R1160 occurred due to traffic resulting from Alternative 3. In mussel bed 15R1160, total dry weight decreased 6.4% as a result of traffic due to Alternative 3. Similar (or lower) magnitudes of impact would be expected for the TCM alternatives based on comparison of the projected traffic intensities (Table 8-25). Greater incremental impacts on mussel growth would be expected for traffic volumes characteristic of Essence Alternative 6, however.

8.5.3.2.2 Mussel Reproduction

Mussel reproduction is presented as the cumulative reproductive effort, which is the sum of the energy allocated to reproduction over each 10-year period. Results for the mussel bed(s) in each pool in which the highest impacts occurred, by alternative, are presented in Table 8-29.

In mussel bed 15R5565 in Pool 13, alternative 5 and 6 traffic caused the highest decrease in cumulative reproductive effort, decreasing from 4.2 to 10.6% using the 50th percentile sediment concentrations. Impacts on mussel reproduction as a result of traffic levels associated with hypothetical Alternatives 1 – 6 were lowest in Pool 26. In mussel bed 175L2335 in Pool 26, there were no effects on mussel reproduction with any of the alternatives. In the LaGrange Pool in mussel bed 35L1130, traffic associated with alternative 3 caused a 2.8% decrease in mussel reproductive effort, while alternative 4 and 5 traffic caused a 1.5% decrease. Traffic resulting from Alternative 3 caused the highest decrease in mussel reproduction (3.5%) in LaGrange mussel bed 15R1160. Analogous to the results of the comparative impacts on growth, the expected effects of TCM traffic alternatives on reproduction should be similar or less in magnitude compared to the hypothetical traffic alternatives. The Essence Alternative 6 traffic intensity may more severely impact the energy available for mussel reproduction.

The results of both the physiological study (Payne et al. 2000, ENV 31) and the bioenergetics model (Bartell et al. 2003b, ENV 39) indicate that the effects of increased traffic resulting from alternatives B, E, F, J, K, and L (early traffic projections) will have minimal impacts on freshwater mussels. Given the similarities in traffic intensities between these hypothetical alternatives and TCM Alternatives 4, 5, and 6 for the three pools evaluated in this assessment, it appears that impacts on mussel growth and reproduction would be minor for the traffic associated with the TCM Model projections. Impacts might be more severe for Essence Alternatives 5 and 6 compared to the corresponding TCM alternatives. Because it is recognized that mussels are both an important economic (commercial species) and ecological resource for the UMR-IWW, a field study is currently being designed to validate the results of the comprehensive bioenergetics modeling effort and laboratory studies. The results of the field validation studies will be coordinated with the cooperating state and federal resource agencies, and incorporated as appropriate in future planning, management and/or mitigation activities for mussels.

Table 8-25. Comparison of vessels/day for hypothetical traffic alternatives and the Tow Cost Model Alternatives 4, 5, and 6 (assuming the most favorable economic scenario for the TCM alternatives.

							Most favorable economic scenario					
Pool 13	**Hypothetical traffic alternative**						**Tow Cost Model**			**Essence Model**		
Year	**1**	**2**	**3**	**4**	**5**	**6**	**4**	**5**	**6**	**4**	**5**	**6**
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
2020	0.7	1.7	1.7	1.7	2.6	2.6	0.3	1.1	0.3	0.3	1.2	0.3
2030	0.8	1.9	1.9	1.9	2.9	2.9	0.9	2.4	2.4	0.4	2.0	3.2
2040	0.9	2.2	2.2	2.2	3.0	3.0	1.4	3.7	5.2	0.4	2.1	4.6
2050	0.9	2.3	2.3	2.3	3.1	3.1	1.2	3.2	4.6	0.4	1.9	4.2
Pool 26												
Year												
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2	0.0
2020	1.4	3.3	3.4	3.6	4.7	4.4	0.4	1.3	0.4	0.7	2.3	0.7
2030	1.6	3.7	4.0	4.2	5.4	4.9	1.2	2.7	2.8	1.1	4.1	5.5
2040	1.7	4.1	4.7	4.9	6.1	5.3	1.6	4.3	6.0	1.5	5.3	11.0
2050	1.8	4.5	5.9	5.8	6.7	5.5	1.4	3.9	5.3	1.4	4.8	8.9
Lagrange												
Year												
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0
2020	0.0	0.0	0.2	0.3	0.3	0.0	0.1	0.1	0.1	0.1	0.3	0.0
2030	0.0	0.0	0.3	0.5	0.5	0.0	0.0	0.1	0.1	0.1	0.4	0.1
2040	0.0	0.0	0.6	0.9	0.9	0.0	0.0	0.1	0.3	0.2	0.6	3.4
2050	0.0	0.0	1.5	1.3	1.3	0.0	0.0	0.1	0.2	0.2	0.5	1.8

Table 8-26. Tissue Dry Weight (g) for Mussels in Pool 13 (Cell ID 15R5565), Poo1 26 (Cell ID 175L2335), and the LaGrange Pool (Cell IDs 15R1160 and 35L1130) for the Year 2040 and the Percent Decrease Resulting From Traffic Due to hypothetical alternatives 1-6.

Percent of Sediment Concentrations	Without Project	Alt. 1	Proj. Red.	% Decr.	Alt. 2	Proj. Red.	% Decr.	Alt. 3	Proj. Red.	% Decr.	Alt. 4	Proj. Red.	% Decr.	Alt. 5	Proj. Red.	% Decr.	Alt. 6	Proj. Red.	% Decr.
Pool 13, Cell ID 15R5565																			
10%	3.07	3.07	0	0	3.07	0	0	3.07	0	0	3.07	0	0	3.06	0	0	3.06	0	0
50%	2.76	2.67	0.09	3.26	2.66	0.11	3.98	2.66	0.11	3.98	2.65	0.11	3.98	2.67	0.09	3.26	2.67	0.09	3.26
90%	2.23	2.11	0.13	5.83	1.88	0.35	15.69	1.88	0.35	15.69	1.85	0.39	17.49	1.66	0.57	25.56	1.66	0.57	25.56
Pool 26, Cell ID 175L2335																			
10%	5.52	5.53	0	0	5.52	0	0	5.52	0	0	5.52	0	0	5.52	0	0	5.52	0	0
50%	5.52	5.52	0	0	5.52	0	0	5.52	0	0	5.52	0	0	5.52	0	0	5.52	0	0
90%	4.86	4.8	0.06	1.23	4.73	0.13	2.68	4.69	0.17	3.49	4.69	0.17	3.49	4.65	0.21	4.32	4.65	0.21	4.32
LaGrange Pool, Cell ID 35L1130																			
10%	6.29	6.29	0	0	6.29	0	0	6.27	0.02	0.32	6.28	0.01	0.16	6.28	0.01	0.16	6.29	0	0
50%	3.69	3.63	0	0	3.63	0	0	3.43	0.19	3.15	3.5	0.12	3.25	3.5	0.12	3.25	3.63	0	0
90%	1.95	1.97	0	0	1.97	0	0	1.81	0.14	7.18	0	1.98	100	0	1.95	100	1.97	0	0
LaGrange Pool, Cell ID 15R1160																			
10%	6.14	6.14	0	0	6.14	0	0	6.13	0.01	0.16	6.14	0	0	6.14	0	0	6.14	0	0
50%	3.02	2.99	0.03	0.99	2.99	0.03	0.99	2.79	0.23	7.61	2.9	0.12	3.97	2.9	0.12	3.97	2.99	0.03	0.99
90%	1.86	1.88	0	0	1.88	0	0	1.72	0.14	7.53	0	1.86	100	0	1.86	100	1.88	0	0

Table 8-27. Shell Dry Weight (g) for Mussels in Pool 13 (Cell ID 15R5565), Poo1 26 (Cell ID 175L2335), and the LaGrange Pool (Cell IDs 15R1160 and 35L1130) for the Year 2040 and the Percent Decrease Resulting From Traffic Due to hypothetical alternatives 1-6.

Percent of Sediment Concentrations	Without Project	Alt. 1	Proj. Red.	% Decr.	Alt. 2	Proj. Red.	% Decr.	Alt. 3	Proj. Red.	% Decr.	Alt. 4	Proj. Red.	% Decr.	Alt. 5	Proj. Red.	% Decr.	Alt. 6	Proj. Red.	% Decr.
Pool 13, Cell ID 15R5565																			
10%	79.40	79.36	0.04	0.05	79.38	0.02	0.03	79.38	0.02	0.03	79.37	0.03	0.04	79.36	0.04	0.05	79.36	0.04	0.04
50%	72.11	69.99	2.12	2.94	69.66	2.45	3.39	69.66	2.45	3.39	69.48	2.63	3.65	70.01	2.1	2.91	70.01	2.10	2.91
90%	59.79	56.67	3.12	5.22	51.15	8.64	14.45	51.15	8.64	14.45	50.36	9.43	15.77	46.14	13.65	22.83	46.14	13.65	22.83
Pool 26, Cell ID 175L2335																			
10%	145.7	145.8	0	0	145.7	0	0	145.7	0	0	145.7	0	0	145.7	0	0	145.7	0	0
50%	145.7	145.7	0	0	145.7	0	0	145.7	0	0	145.7	0	0	145.7	0	0	145.7	0	0
90%	129.6	128.2	1.4	1.08	126.4	3.2	2.46	125.6	4	3.09	125.6	4	3.09	124.6	5	3.86	124.6	5	3.86
LaGrange Pool, Cell ID 35L1130																			
10%	166.6	166.6	0	0	166.6	0	0	166.6	0	0	166.7	0	0	166.7	0	0	166.6	0	0
50%	102.3	102.5	0	0	102.5	0	0	97.8	4.5	4.39	99.31	2.99	2.93	99.31	2.99	2.93	102.5	0	0
90%	62.04	62.34	0	0	62.04	0	0	58.41	3.63	5.85	3.85	58.19	93.79	3.85	58.19	93.79	62.34	0	0
LaGrange Pool, Cell ID 15R1160																			
10%	163.1	163.1	0	0	163.1	0	0	162.7	0.3	0.18	163	0	0	163	0	0	163.1	0	0
50%	87.76	86.94	0.82	0.93	86.94	0.82	0.93	82.24	5.52	6.29	84.85	2.91	3.31	84.85	2.91	3.32	86.94	0.82	0.93
90%	59.83	60.41	0	0	60.41	0	0	56.28	3.55	5.93	3.82	56.01	93.61	3.82	56.01	93.61	60.41	0	0

Table 8-28. Total Dry Weight (g) for Mussels in Pool 13 (Cell ID 15R5565), Poo1 26 (Cell ID 175L2335), and the LaGrange Pool (Cell IDs 15R1160 and 35L1130) for the Year 2040 and the Percent Decrease Resulting From Traffic Due to hypothetical alternatives 1-6.

Percent of Sediment Concentrations	Without Project	Alt. 1	Proj. Red.	% Decr.	Alt. 2	Proj. Red.	% Decr.	Alt. 3	Proj. Red.	% Decr.	Alt. 4	Proj. Red.	% Decr.	Alt. 5	Proj. Red.	% Decr.	Alt. 6	Proj. Red.	% Decr.
Pool 13, Cell ID 15R5565																			
10%	82.46	82.42	0.04	0.05	82.45	0.01	0.01	82.45	0.01	0.01	82.44	0.02	0.02	82.42	0.04	0.05	82.42	0.04	0.05
50%	74.87	72.67	2.20	2.94	72.31	2.56	3.42	72.31	2.56	3.42	72.12	2.75	3.67	72.68	2.19	2.92	72.68	2.19	2.92
90%	62.02	58.78	3.24	5.22	53.03	8.99	14.49	53.03	8.99	14.49	52.21	9.81	15.82	47.81	14.21	22.91	47.81	14.21	22.91
Pool 26, Cell ID 175L2335																			
10%	151.3	151.3	0	0	151.2	0.1	0.07	151.3	0	0	151.3	0	0	151.2	0.1	0.07	151.2	0.1	0.07
50%	151.2	151.2	0	0	151.2	0	0	151.2	0	0	151.2	0	0	151.3	0	0	151.3	0	0
90%	134.5	133	1.5	1.11	131.2	3.3	2.45	130.3	4.2	3.12	130.3	4.2	3.12	129.2	5.3	3.94	129.2	5.3	3.94
LaGrange Pool, Cell ID 35L1130																			
10%	172.89	172.9	0	0	172.9	0	0	172.9	0	0	173	0	0	173	0	0	172.9	0	0
50%	105.9	106.1	0	0	106.1	0	0	101.2	4.7	4.44	102.8	3.1	2.93	102.8	3.1	2.93	106.1	0	0
90%	63.99	64.31	0	0	64.31	0	0	60.22	3.77	5.89	3.85	60.14	93.98	3.85	60.14	93.98	64.31	0	0
LaGrange Pool, Cell ID 15R1160																			
10%	169.1	169.2	0	0	169.2	0	0	168.9	0.2	0.19	169.1	0	0	169.1	0	0	169.2	0	0
50%	90.78	89.93	0.85	0.94	89.93	0.85	0.94	85.03	5.75	6.33	87.75	3.03	3.34	87.75	3.03	3.34	89.93	0.85	0.94
90%	61.69	62.29	0	0	62.29	0	0	58	3.69	5.98	3.82	57.87	93.81	3.82	57.87	93.81	62.29	0	0

Table 8-29. Cumulative Reproductive Effort (kJ) for Mussels in Pool 13 (Cell ID 15R5565), Poo1 26 (Cell ID 175L2335), and the LaGrange Pool (Cell IDs 15R1160 and 35L1130) for the Year 2040 and the Percent Decrease Resulting From Traffic Due to hypothetical alternatives 1-6.

Percent of Sediment Concentrations	Without Project	Alt. 1	Proj. Red.	% Decr.	Alt. 2	Proj. Red.	% Decr.	Alt. 3	Proj. Red.	% Decr.	Alt. 4	Proj. Red.	% Decr.	Alt. 5	Proj. Red.	% Decr.	Alt. 6	Proj. Red.	% Decr.
Pool 13, Cell ID 15R5565																			
10%	4.1	4.1	0	0	4.1	0	0	4.1	0	0	4.09	0.01	0.24	4.09	0.01	0.24	4.09	0.01	0.24
50%	3.3	3.15	0.14	4.24	3.01	0.29	8.79	3.01	0.29	8.79	2.99	0.31	9.39	2.94	0.35	10.61	2.94	0.35	10.61
90%	2.22	1.97	0.25	11.26	1.7	0.52	23.42	1.7	0.52	23.42	1.68	0.54	24.32	1.55	0.67	30.18	1.55	0.67	30.18
Pool 26, Cell ID 175L2335																			
10%	7.59	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0
50%	7.59	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0	7.59	0	0
90%	6.95	6.89	0.06	0.86	6.8	0.15	2.16	6.77	0.17	2.45	6.77	0.17	2.45	6.75	0.2	2.88	6.75	0.2	2.88
LaGrange Pool, Cell ID 35L1130																			
10%	9.34	9.34	0	0	9.34	0	0	9.34	0	0	9.35	0	0	9.35	0	0	9.34	0	0
50%	5.31	5.33	0	0	5.33	0	0	5.16	0.15	2.83	5.23	0.08	1.51	5.23	0.08	1.51	5.33	0	0
90%	3.22	3.24	0	0	3.24	0	0	3.08	0.14	4.35	0	3.22	100	0	3.22	100	3.24	0	0
LaGrange Pool, Cell ID 15R1160																			
10%	9.21	9.22	0	0	9.22	0	0	9.21	0.01	0.11	9.21	0	0	9.21	0	0	9.22	0	0
50%	4.87	4.86	0.01	0.2	4.86	0.01	0.2	4.7	0.17	3.49	4.78	0.09	1.85	4.78	0.09	1.85	4.86	0.01	0.2
90%	3.14	3.16	0	0	3.16	0	0	3	0.13	4.14	0	3.14	100	0	3.14	100	3.16	0	0

8.5.4 Other Macroinvertebrates

The effect of commercial navigation on macroinvertebrate communities in general has not been extensively studied. Eckblad (1981) and Seagle and Zumwalt (1981) did examine the effects of commercial tow passage on macroinvertebrate communities of the UMR. Seagle and Zumwalt (1981) examined the effect of tow passage on aquatic macroinvertebrate drift of Pool 26. Macroinvertebrates often release from river substrates and become part of the "drift" in response to disturbances or stress. Macroinvertebrate drift has been examined to assess disturbances to aquatic systems (Seagle and Zumwalt 1981). Although study results may have been influenced by unusually high seasonal discharge during sampling, Seagle and Zumwalt (1981) did not observe any consistent effect of tow passage on macroinvertebrate drift density and number of taxa drifting. Evidence also indicated that macroinvertebrates had not been swept from substrates or induced to drift as a result of water turbulence caused by navigation traffic. Similarly, field studies by Eckblad (1981) on Pool 9 of the UMR showed no significant differences in invertebrate drift attributable to commercial tow traffic. It should be noted that main channel areas where commercial tow traffic is located are typically dominated by unstable sand substrates, especially on the UMR, and generally do not contain abundant and diverse macroinvertebrate communities.

Eckblad (1981) did state that benthic macroinvertebrate populations may be reduced in areas exposed by drawdown during tow passage. The magnitude and spatial extent of traffic-induced drawdown, as it relates to larval fish, is described in Section 8.5.1. Drawdown associated with tow traffic under the with-project condition could potentially affect invertebrate communities through de-watering of nearby shallow areas. The magnitude of individual drawdown events would not be expected to differ between the with- and without-project condition; however, the frequency of these events could increase somewhat in certain locations within some pools.

These studies would suggest that increased tow traffic on the UMR and IWW under the with- project condition would not have a substantial adverse effect on macroinvertebrate communities of the UMR and IWW, relative to the without-project condition.

8.5.5 Wildlife

8.5.5.1 Mammals

The effects of commercial navigation on mammalian wildlife of the UMR and IWW have not been extensively studied. Terrestrial and aquatic mammals are commonly observed along the river banks and island areas. However, such locations are generally no closer than the periphery of main channel. With the exception of locations where the sailing line is in close proximity to bankline areas, mammals would generally not be subject to turbulence and drastic current shifts associated with commercial navigation.

Increased tow traffic under the with-project condition could increase erosion of islands and shoreline areas, relative to the without-project condition, through an increase in wake wave frequency. However, any minor increase in erosion would not be expected to substantially reduce the quantity or quality of habitat utilized by mammals along the UMR and IWW. Commercial navigation along the UMR and IWW can disturb mammalian wildlife during transit, typically through triggering a "flight response." However, such disturbances also will occur under the without-project condition. These disturbances would not be expected to occur with enough additional frequency under the with-project condition to affect population levels of mammals along the UMR and IWW.

8.5.5.2 Birds

Similar to mammals, potential impacts to birds would be confined to the main channel and its immediate environment. Neo-tropical migrants almost exclusively use riparian and terrestrial habitats adjacent to the rivers, and it is not expected that the project would adversely affect these habitats. Potential site-specific construction activities could affect bottomland hardwood forest or other habitats important to neo-tropical migrants, as well as waterfowl; these impacts are addressed in Section 8.6. Potential localized impacts to birds due to bank erosion are discussed in Section 8.6.6.1.

Concerns have been expressed over barge disturbance to resting or feeding waterfowl, and consequent impacts on waterfowl energetics. Barges constitute one of several potential disturbance factors; others include recreational boating (includes hunting and fishing) and shoreline activities (Havera et al. 1992). Havera et al. (1992) examined human disturbance to waterfowl in Pool 19 of the UMR, and found that, with some seasonal variation, barges generally caused the least amount of disturbance to waterfowl. The authors cited one study which demonstrated that recreational boating activity closer than approximately 450 m causes diving ducks to take flight. Although barges could at times approach waterfowl at distances closer than this, it is likely that the nature of barge movement versus recreational boats would not be as much of a disturbance. It is not expected that increased traffic would pose a significantly greater disturbance factor to resting or feeding waterfowl.

8.5.5.3 Reptiles and Amphibians

Compared to species of greater sport or commercial interest, little emphasis has been placed on studying reptiles and amphibians of the UMRS. Amphibians and reptiles are more commonly found in lentic environments (i.e., standing water; WEST 2000, ENV 40). Lentic species are generally not found in main channel or similar areas that would be subject to turbulence and drastic current shifts associated with commercial navigation. However, lentic areas (e.g., backwaters, pools) connected to the main channel may be subject to drawdown during passage of commercial tows. Drawdown associated with tow traffic under the with-project condition could potentially affect amphibian young through de-watering of the near-shore zone. The magnitude of individual drawdown events is not expected to differ between the with- and without-project condition, but an increased frequency of such events could contribute to potential impacts.

Amphibian and reptile populations are likely to decline in the future in areas where backwaters are being lost or degraded (WEST 2000, ENV 40). However, the quality and quantity of lentic habitat (e.g., backwaters, pools, etc) available under the with-project condition is not expected to be substantially different than that under the without-project condition once appropriate mitigation measures are in place. Thus, additional tow traffic associated with the with-project condition is not expected to have a significant adverse affect to amphibian and reptile populations through degradation of backwater habitat.

Likewise, the amount of lotic habitat (that associated with flowing water) available under the with-project condition would not be expected to be substantially different than that under the without-project condition. Moreover, WEST (2000, ENV 40) states that amphibian and reptile populations that relate to lotic habitat will likely remain stable in the future.

8.6 Bank Erosion

The U.S. Army Corps of Engineers funded a comprehensive study of the UMRS to investigate the extent of existing bank erosion, the probable processes that are causing bank erosion, and the potential for further bank erosion related to commercial navigation traffic resulting from proposed improvements to the navigation system. A detailed summary of this investigation is found in Bhomik et al. (1999, ENV 8) and Landwehr and Nakato (1999; ENV 9).

8.6.1 Erosion Mechanisms

The dominant erosion mechanisms operating on the UMR and IWW today include:

- Piping caused by flood recharge of banks and back of bank water sources.

- Slope stability failures caused by undercutting due to waves, tractive force scour at high flows, piping, stage changes from flow variations and hydraulic structures, and moisture conditions in the bank.
- Tractive force scour caused by high flows is generally accepted as a dominant mechanism on any alluvial stream like the UMR. Simons et al. (1979) stated that "… in most instances when considering the instability of alluvial rivers, it can be shown that approximately 90 percent of all river changes occur during 5 to 10 percent of the time when large flows occur."
- Wave erosion caused by vessels can be dominant in areas where traffic levels are high. Due to the lower amplitude and much less frequent occurrence from commercial tows, waves caused by vessels (short period) are predominantly produced by recreational vessels. Erosion from this mechanism would likely be greatest near metropolitan areas. Soil type plays a critical role in determining whether short-period waves produce significant erosion at a given site.
- Wave erosion caused by wind, primarily in the lower portion of UMR-IWW pools, can be dominant where fetch distances are large. Wind waves are considered a dominant mechanism based on the many reservoirs experiencing wind wave erosion throughout the country, and the presence of large impoundments on the lower portion of UMR-IWW pools.

Other, less dominant or local mechanisms include the annual freeze/thaw cycle, ice and debris, overbank drainage, and propeller jet scour in small radius bendways and bridge approaches. Of unknown significance is the impact of sediment overloading from tributary streams that is widely reported on the UMRS.

8.6.2 Current Erosion Conditions in UMR-IWW

Human actions have significantly altered the UMRS, and any evaluation of bank erosion causes and mechanisms must consider the impact of these changes. At low flow, the UMR-IWW is a series of impoundments separated by low-head navigation dams. The UMR-IWW impoundments differ from typical reservoirs because the UMR-IWW impoundments are shallow, limiting wave heights and reducing their ability to trap sediments. As flows increase, the effect of the navigation dams on the flow profile diminishes and the system begins to look like a natural, free-flowing river over most of its length.

Operation of the navigation system to maintain water levels as constant as possible to facilitate navigation, particularly during low-flow periods, has the potential to reduce bank erosion in areas where the energy potential has been lowered (most prevalent in the immediate impounded areas upstream of the dam structures). Even though the hydraulic energy may be lower during some hydrologic events, the actual length of shoreline exposed to periodic wetting and drying has increased as a result of permanent inundation of areas in the floodplain. A potential source of erosion due to impoundment is the large pool created upstream of the navigation dams which increases fetch lengths and therefore may increase the occurrence and/or magnitude of wind wave erosion. Additionally, inundation may have exposed cultural (archeological or historical) resource sites to frequent hydraulic forces such as wind waves that had previously had only infrequent exposure to flooding.

A significant portion of the impounded UMR bankline has been artificially armored to protect urban areas, agricultural levees, and railroad embankments. Based on the field survey, conducted as part of this study and summarized below, approximately 33% of the banks along the main navigation channel of the impounded UMR and 10% of the banks along the main navigation channel of the IWW are artificially (riprap, riverwall) or naturally (rock outcrop) protected. The abundance of existing bank protection along the main navigation channel of the UMR, in combination with impoundment effects, has largely restricted the lateral meandering of the river resulting in a relatively stable bank line through much of the system, particularly near metropolitan areas.

8.6.3 Scope of USACE Investigation

In order to assess current and future erosion conditions, the USACE conducted a bank erosion study of the UMR-IWW. The study was conducted in three main phases: (1) a review of pertinent literature; (2) a field survey to document current erosion conditions along the banks of the Upper UMR and IWW; and (3) the development of a methodology to predict where future erosion may occur due to increased levels of commercial traffic operating on the system, resulting from improvements to the navigation system. The first two study components are discussed below (Sections 8.6.3.1 – 8.6.3.5). The results for item (3) are presented in section 8.6.5.

8.6.3.1 Summary of Literature Review

At the initiation of the Bank Erosion Study, an extensive literature review of available pertinent data, research, and opinions regarding the processes of bank erosion along the UMR and IWW was conducted (Maynord and Martin 1996). Special emphasis was placed on selecting methodologies that could be used to identify and differentiate between the various mechanisms contributing to bank erosion throughout the system, as well as a means of establishing the relative significance of each mechanism.

Minimal modeling effort relating boating activity to bank recession was found by the literature review. Recurring throughout the literature was the recommendation of bank protection in locations where there were active erosion sites and forces exceeded threshold criteria. In some cases, where the dominant cause was traffic, restrictions on vessel size, speed, or proximity to the shoreline were also recommended.

The literature search revealed that much of the research concerning navigation effects has been in reference to the design of bank protection. Research containing actual relationships between navigation processes and bank erosion were rare and often unverified in the field. Only two articles were identified which presented a shoreline retreat model related to wave energy. One, Grigor'eva (1987), was unverified and showed a conceptual method for bank reworking due to wind waves only. The second, Nanson et al. (1993), was a study conducted on the Gordon River in Australia. The authors measured erosion rates while recreation boats passed a site. A good correlation was found between wave power or wave height and erosion. Based on their observations, they developed a set of maximum wave height thresholds for various soil types and recommended appropriate vessel speed restrictions.

The lack of applicable models and need for further research was expressed in many articles. This situation is best described in an article by Pilarczyk et al. (1989):

> "*The mechanisms of bank erosion and the stability of protection structures subject to hydraulic loading are complex problems. The understanding of erosion processes and failure mechanisms of structures is still in a rudimentary stage, and it is not yet possible to describe many important phenomena and their interactions by theory*."

Wuebben (1983), Bekendam et al. (1988), and other authors recognized that predicting the actual magnitude of damages at a site is not possible at this time. Wuebben (1983) attempted to estimate areas that could be affected by navigation.

8.6.3.2 Summary of Previous UMRS Investigations

The literature review identified several previous investigations of bank erosion for the UMR and IWW. A brief description of the major conclusions resulting from representative studies is below, presented in chronological order.

Karaki and van Hoften (1975) studied the resuspension of bed sediments by tows and wave effects from tows and recreational vessels on the UMRS. The authors report that:

"*the effects of increase in waves on river banks will depend on bank stability, and river bank form. Most sections of the river system have had wave wash from winds and boats for many years and are quite stable. Additional waves of the same heights generated by increased traffic are not likely to cause any significant increased rates of bank erosion where none is presently evident. Also, any river bank area that is being eroded by waves will continue to be affected, at an accelerated rate. The effects of fast moving boats are more destructive to river banks than waves from slower moving towboats.*"

Bhowmik and Schicht (1980) evaluated twenty-four severely eroded sites along the IWW as part of an investigation of the effects of increased Lake Michigan diversion into the IWW. The authors hypothesized as to the causes of the erosion at each site. The authors concluded the following:

"*On the basis of present and anticipated flow conditions and of measured and estimated hydraulic parameters, bank stability analyses at each study reach were made following different accepted procedures. Stability analyses indicate that as far as the flow hydraulics are concerned, bank erosion along the Illinois River will not be affected by the proposed increase in diversion. In all probability, the main cause of the bank erosion of the Illinois River is the wave action caused by the wind and/or waterway traffic.*"

From the GREAT III study (Morris 1982), bank erosion was determined from mappings of the UMR from Saverton, MO, to Cairo, IL. "The results of the mapping of the high bankline indicate there have been only small changes over the 22 years studied." Above St. Louis no changes were found, which was attributed to the many locks and dams. The GREAT III study further concluded that bank erosion is not a significant factor in the total sediment budget of the river. This report also stated that the Corps of Engineers revetment program has resulted in the high bank being in virtual equilibrium.

Spoor and Hagerty (1989) evaluated bank erosion sites along the IWW. The authors investigated 31 sites, 20 where previous erosion had been observed by Bhowmik and Schicht (1980) and 11 considered more typical of those found on the waterway. The authors concluded that the majority of failures could be attributed to seepage mechanisms. According to the authors, wave action from wind or vessels was not a significant cause of bank erosion; this conclusion differed from that of the studies by Bhowmik.

Johnson (1994) evaluated the recreational boating impacts on bank erosion in Pool 4 of the UMR. Transects from 5 locations (3 located on the main channel and 2 located on a secondary channel) were surveyed approximately 15 times from 1989–1994. The transects in the secondary channel remained stable over the study period, while the main channel transects showed shoreline recession of 3.0 to 4.3 meters over this time frame. During the study, commercial traffic remained steady or slightly declined, whereas recreational boating increased. The erosion rates indicated increases in erosion during the recreational boating season in the main channel. The author concluded, "From the results of the field investigations, it can be concluded that recreational boating on the UMR Main Channel is the contributing influence most responsible for the documented high rate of shoreline erosion."

8.6.3.3 Summary of Field Survey

In order to assess existing bank conditions, the St. Paul, Rock Island, and St. Louis Corps Districts conducted an extensive field survey of bank erosion along the entire length of the UMR and IWW. A report entitled "Bank Erosion Field Survey Report of the Upper UMR and IWW," was published by the USACE in January 1999 (Bhowmik et al. 1999, ENV 8).

The research team included scientists and engineers from the Illinois State Water Survey (ISWS), the University of Iowa – Iowa Institute of Hydraulic Research (IIHR), and the Corps' Rock Island, St. Paul, St. Louis, and Huntington Districts. The principal authors for the field survey report were the ISWS and IIHR. A consulting geomorphologist also participated in the trip on the UMR.

The field survey was conducted in the fall of 1995 and covered reaches from RM 854 to RM 0 on the UMR, and from RM 286 to RM 0 on the IWW. The research team assessed bank conditions on both banks of the main channel along both rivers, and took detailed information at seventy-two selected erosion sites (43 on the UMR, 29 on the IWW) where they formed opinions as to the causative erosion mechanisms affecting each site. In addition, the study team mapped the entire length of the main channel border, for both rivers, in terms of the current level of erosion (severe, moderate, or minor erosion, stable bank, naturally or artificially protected, etc.). Based on this survey, there were approximately 115 bank miles on the IWW and 240 bank miles on the UMR that were classified as severely eroded (and thus were considered to be actively eroding). This represents approximately 14 percent of the UMR and 20 percent of the IWW.

8.6.3.4 Summary of Field Survey Observations for the UMR

Bank failure and erosion conditions on the UMR showed significant flood impacts. Analyses of surficial soil samples showed the banks were mantled by primarily sand and gravel in the upper reach of the UMR river (Pools 1-13), silt and sand in the middle reach (Pools 14-26), and clay and silt in the lower (unimpounded) reach. Most of the bank failure and erosion sites showed flood damage as the dominant erosion cause. Surficial, wave-induced erosion and erosion associated with direct barge impact, propeller wash and cabling to trees was present at some fleeting and mooring sites and lock approach areas.

Because of the Great Flood of 1993, most of the bank erosion sites investigated, in particular along the middle and lower study reaches, showed such vividly apparent flood impacts that it was extremely difficult to identify any wave-induced rework and transport except at a few fleeting and mooring sites. The lower study reach downstream from the Missouri River confluence also indicated apparent flood impacts of the floods of 1994 and 1995. Major floods have occurred along the study area at an approximate interval of every 5 to 10 years; for example, the Flood of 1952, the Flood of 1965, the Flood of 1969, the Flood of 1973, the Flood of 1986, and the Great Flood of 1993. Flood effects appeared to be much more significant than other erosion mechanisms.

Based on the individual geomorphological and hydraulic site characteristics, erosion potential of traffic-induced waves was estimated for each of the 49 study sites. However, there was no means to estimate bank retreat due to waves from this field reconnaissance study. As stated above, the Great Flood of 1993, the Flood of 1994, and the Flood of 1995 had left extensive erosion scours and encompassed most of the secondary failure and erosion features due to other causes.

On the basis of the field study, approximately 14 percent of the UMR banks along the main channel border were estimated to be actively eroding in 1995.

8.6.3.5 Summary of Field Survey Observations for the IWW

For the selected sites on the IWW (80 bank sections from 29 sites), the research team observed multiple erosion processes at most of the selected bank sections. The most frequently identified erosion mechanisms were seepage, stage fluctuations, flood flows, navigation traffic, wave activities, eddies and disturbed flows.

As part of the field data collection on the IWW, the study team identified the probable cause or causes of erosion at all bank sections where measurements were taken. The probable causes were organized for evaluating the percentage of each cause identified at the 80 bank sections. The data from the 80 bank sections indicated that:

- Although large floods could be the dominant cause of erosion on natural rivers, this study found erosion at many bank sections located within the normal range of stage fluctuation (between the ordinary high water level and normal pool stages) which cannot completely be attributed to large floods. Among these bank sections, 27 percent of the bank sections showed erosion occurring only at high stages while 63 percent had erosion occurring at stages within the normal range of stage fluctuations. The rework and transport processes, as caused by waves and currents, are significant during these stages.
- 74 percent of the selected erosion sites showed evidence of seepage effects. About 26 percent of these bank sections had piping holes or springs, the remaining 48 percent had wet sub-aerial benches.
- 28 percent of the selected erosion sites had small scarps on the bench that could have been formed by waves, seepage, or a combination of these factors.
- 24 percent of the selected erosion sites showed evidence of traffic-induced disturbance. These include impact from direct physical contact and undercutting of submerged banklines near fleeting areas.
- 10 percent of the selected erosion sites showed erosion associated with eddy/disturbed flow induced by riparian trees or gravel.
- 11 percent of the selected erosion sites had the presence of surface drainage; five bank sections were located adjacent to water bodies (lakes, borrow pit).
- 4 percent of the selected erosion sites showed erosion associated with weathering (freeze/thaw) of surficial soils.

On the basis of the field study, approximately 20 percent of IWW river banks along the main channel border were estimated to be actively eroding in 1995.

8.6.4 Commercial Navigation Effects on Bank Erosion

The site evaluations conducted during the field survey provided an estimate as to the relative significance of commercial navigation effects in the context of bank erosion processes on the UMR and the IWW. Physical effects generated by commercial navigation traffic, such as drawdown, waves, return flow, propeller jets, and disturbed local flows have the potential to produce erosion. The field survey team concluded that bank erosion caused by commercial navigation could be significant in mooring and fleeting areas, some lock approach and waiting areas, and in some very narrow channel reaches.

Summary of potential commercial navigation effects and their significance on the UMRS:

- Short-period waves from commercial navigation may not be a significant cause of erosion on the UMRS because of the low wave height and infrequent occurrence, as compared to recreational vessels.
- The importance of tow drawdown causing slope failures or piping is unknown. Wuebben (1983) reported that vessel-induced drawdown could cause liquefaction of streambeds. Since drawdown magnitude is highly correlated with blockage ratio (channel area/vessel area), it is almost certain that if drawdown causes failures, these failures will be most frequent in the upper reaches of the UMRS where channel sizes are smallest.
- It is possible that in straight reaches (where vessels can travel at higher speed) of the UMRS upper reaches, where blockage ratios are small, transverse stern waves form and cause significant attack of bank lines.

- Propeller wash was assigned a less dominant role in causing erosion because the UMRS literature was relatively quiet on this issue. Propeller jet scour is generally limited to unprotected low-radius bendways or bridge crossings with difficult approaches. It is likely that in the upper reaches of the UMRS, the smaller channel sizes result in greater occurrence of propeller jet effects.
- The pattern that emerges from these statements is that bank erosion resulting from commercial navigation transiting the system will be most prevalent in areas where channel sizes are smallest or in larger channels where navigation is close to erodible bank lines.

8.6.5 Potential Impacts Due to Streambank Erosion

Upon completion of the field survey, a follow-up study was initiated to utilize the site-specific field observations to assess the risk of bank erosion due to increased commercial navigation traffic for the study area. The scope of the follow-up study included the construction of a GIS database of information collected during the field survey; the development of a screening model to identify locations where there is a high, medium, or low risk of commercial navigation contributing to bank erosion; and the system wide implementation of the model. The results of the follow-up study were published in a report entitled "Identification of Potential Commercial Navigation Related Bank Erosion Sites" (Landwehr and Nakato 1998, ENV 9).

8.6.5.1 Identification of Potential Impacts

At the present time, no computational method exists for linking a commercial vessel with chosen hull shape, traveling at a chosen speed in a channel of chosen depth and chosen cross-sectional area and shape with banks of a chosen height and materials, to a predicted occurrence of erosion. Therefore, there is no existing computational modeling technique, nor did this study purport to develop one, that can predict or quantify bank erosion based on physical effects associated with commercial navigation. The method developed for this study attempted to identify sites where there is a *potential* for commercial navigation induced forces to contribute to bank erosion.

The potential for commercial navigation induced erosion relates directly to the water motions that vessels create and that are capable of attacking banks. These include return currents, water level drawdown, short period and transverse stern waves, and propeller wash. In addition, fleeting activities and temporary mooring, associated with tows waiting for lockage, could have the potential to produce localized impacts.

The potential for significant drawdown and return currents is highly related to the channel blockage ratio (channel area/vessel area) and is most significant in the IWW and upper reaches of the UMR where channel dimensions are smallest. Since the existing bathymetric data are not sufficient to compute the blockage ratio for all sections of the bank in the system, the channel top width (bank to bank) at low flow conditions was used in the screening model to represent the potential for vessel drawdown and return current related erosion.

The potential for vessels to produce significant wave heights at the bankline is related to the distance the vessels operate relative to the bank, and the speed, size, direction and draft of the vessel. The Economics Work Group of the UMR-IWW Navigation Study has identified little variability (between navigation pools) in the speed at which tows transit the system. In addition, the most frequently occurring tow size operating on the system pools is 1,200 feet in length (three barges wide by five long) with a maximum draft of 9 to 9.5 feet. Since the speed, draft, and maximum size of the tows operating in the pooled reaches of the UMR and IWW are consistent between pools, the distance from the sailing line to the bank line at low water was used as the significant parameter in the screening model for the risk of wave attack due to commercial vessel movement.

Propeller wash has the potential to produce erosion in small radius bendways, and in narrow channel sections where the transiting tow is forced to perform additional maneuvering. The potential risk for direct propeller wash of the bank was represented in the screening model by the radius of curvature of the bend, as well as the channel top width and distance to the sailing line at low flow conditions.

The screening model was applied to the GIS database (the main channel bankline for the UMR and IWW was divided into approximately 10,000 segments in the GIS database), resulting in a numeric score for each section of the main channel bankline. A complete description of the screening model formulation and application is contained in the bank erosion follow-up study report (Landwehr and Nakato 1998, ENV 9). The numeric score represents the relative potential for commercial navigation related bank erosion at a bank section with respect to other bank sections. The bank sections with the highest score represent the highest potential, and the bank sections with the lowest scores the lowest potential.

The field survey, conducted as part of this study effort, concluded that approximately 14 percent of the banks of the UMR and 20 percent of the banks of the IWW were actively eroding at the time of the survey. Based on the site descriptions and observed erosion mechanisms, it was concluded that approximately 1 in 5 (20 percent) of the selected erosion sites on the UMR showed signs of navigation induced disturbance. Similarly, approximately 24 percent of the selected erosion sites along the IWW showed signs of navigation induced disturbance.

Assuming that the sites selected during the field survey and the observed erosion mechanisms are representative of the erosion processes occurring at the other actively eroding sections throughout the system, approximately 2.8 percent (14 percent of system actively eroding × 20 percent of erosion sites being impacted by commercial navigation) and 4.8 percent (20 percent × 24 percent) of the UMR and IWW banks, respectively, are actively eroding in areas where forces generated by commercial navigation are a contributing mechanism. Therefore, the "high" potential areas were defined as those areas most susceptible to commercial navigation related bank erosion, which are represented by 2.8 percent (UMR) and 4.8 percent (IWW) of the system (i.e., the bank sections with the highest scores from the screening model). In addition, areas used for temporary mooring and fleeting were also defined as having a high potential for commercial navigation related bank erosion. The balance of the actively eroding areas was then divided evenly into the medium and low risk categories. Therefore, (14 percent-2.8 percent)/2 = 5.6 percent of the UMR and (20 percent-4.8 percent)/2 = 7.6 percent of the IWW were identified as having a medium potential for navigation related bank erosion.

The classification (high, medium, or low) of each section of the bank line was generated and loaded into the GIS database for mapping. The model results, by pool, were presented on 43 large maps as part of the bank erosion follow-up study report (Landwehr and Nakato 1998, ENV 9), and are summarized, below, in Table 8-30 and Table 8-31 for the UMR and IWW, respectively. In the tables, the "Total Bank Length" is the bank length of each pool (both the right and left banks) upon which the screening model was applied. The "High Potential Length" and "Medium Potential Length" are the bank lengths of each pool identified by the model as being high and medium risk for commercial navigation related bank erosion. The "Protected Length" is that portion of the high and medium risk areas that were identified as naturally or artificially protected (rock outcrop, revetment, unerodible rocky bluffs, river wall, rip-rapped, etc.) during the 1995 field survey. Only the high and medium potential areas were identified on the maps, with the balance of the main channel border having a low potential for commercial navigation related bank erosion. Additionally, the locations of temporary mooring sites and barge facilities were indicated on the maps and are considered high potential areas.

Table 8-30. Predicted UMR bank erosion sites.

Pool	Total Bank Length (ft)	High Potential Length* (ft)	% High Potential	Protected Length (ft)	% Protected	Medium Potential Length (ft)	% Medium Potential	Protected Length (ft)	% Protected
4	446,800	66,427	14.9%	17,529	26.4%	47,729	10.7%	9,338	19.6%
5	125,211	15,059	12.0%	7,518	49.9%	24,900	19.9%	2,230	9.0%
5a	70,233	10,163	14.5%	3,907	38.4%	13,360	19.0%	1,761	13.2%
6	130,346	13,790	10.6%	6,416	46.5%	23,724	18.2%	13,098	55.2%
7	107,498	14,052	13.1%	12,382	88.1%	11,916	11.1%	0	0.0%
8	185,790	9,699	5.2%	3,836	39.5%	33,172	17.9%	12,786	38.5%
9	257,996	30,663	11.9%	11,369	37.1%	56,867	22.0%	16,420	28.9%
10	309,395	17,676	5.7%	10,846	61.4%	40,101	13.0%	12,539	31.3%
11	276,330	9,569	3.5%	2,702	28.2%	5,405	2.0%	0	0.0%
12	244,670	10,826	4.4%	6,884	63.6%	6,829	2.8%	3,577	52.4%
13	256,954	9,252	3.6%	3,050	33.0%	17,525	6.8%	5,140	29.3%
14	268,716	31,946	11.9%	6,824	21.4%	4,849	1.8%	0	0.0%
15	101,619	0	0.0%	0	0.0%	3,359	3.3%	2,164	64.4%
16	222,181	12,639	5.7%	0	0.0%	5,327	2.4%	875	16.4%
17	211,416	8,944	4.2%	1,778	19.9%	9,830	4.6%	2,170	22.1%
18	254,455	3,419	1.3%	0	0.0%	9,538	3.7%	536	5.6%
19	421,210	13,716	3.3%	5,826	42.5%	6,790	1.6%	0	0.0%
20	225,430	15,624	6.9%	1,205	7.7%	1,766	0.8%	1,766	100.0%
21	165,141	4,005	2.4%	0	0.0%	3,453	2.1%	0	0.0%
22	249,199	1,909	0.8%	0	0.0%	0	0.0%	0	0.0%
24	294,143	13,145	4.5%	0	0.0%	14,799	5.0%	5,221	35.3%
25	311,522	0	0.0%	0	0.0%	2,360	0.8%	0	0.0%
26	408,812	11,881	2.9%	11,881	100.0%	566	0.1%	0	0.0%
open	2,216,453	220,296	9.9%	148,889	67.6%	16,775	0.8%	15,997	95.4%
Sum	7,761,518	544,697	7.0%	262,840	48.3%	360,939	4.7%	105,618	29.3%

Unprotected High Length: 281,857 (3.6%) Unprotected Medium Length: 255,322 (3.3%)

Table 8-31. Predicted IWW bank erosion sites.

Pool	Total Bank Length (ft)	High Potential Length* (ft)	% High Potential	Protected Length (ft)	% Protected	Medium Potential Length (ft)	% Medium Potential	Protected Length (ft)	% Protected
Alton	819,422	7,155	0.87%	118	1.65%	13,924	1.70%	2,746	19.72%
LaGrange	789,809	76,871	9.73%	12,078	15.71%	134,856	17.07%	264	0.20%
Peoria	556,496	50,989	9.16%	4,913	9.63%	23,825	4.28%	0	0.00%
Starved Rock	122,964	10,915	8.88%	4,478	41.03%	7,405	6.02%	2,080	28.09%
Marseilles	280,102	52,096	18.60%	18,622	35.75%	32,221	11.50%	9,071	28.15%
Dresden Island	164,926	26,328	15.96%	6,558	24.91%	21,548	13.07%	7,926	36.78%
Sum	2,733,719	224,354	8.21%	46,767	20.85%	233,778	8.55%	22,087	9.45%

Unprotected High Length: 177,587 (6.5%) Unprotected Medium Length: 211,691 (7.7%)

*** Includes Fleeting Areas**

8.6.5.2 Limitations of Approach

The methodology used to identify potential commercial navigation related erosion sites was based on the potential for navigating tows to produce significant forces at the bank line, as well as the locations of near shore tow activity (fleeting and mooring areas, barge terminals). The actual rate of erosion at the identified sites is dependent on the nature of the bank materials and sub-aqueous conditions, potential commercial navigation effects, and other erosion mechanisms affecting the site. Multiple erosion mechanisms were identified as affecting the stability of the bank sections at nearly all sites visited during the field survey. At many locations along the system, the natural erosion and deposition of materials would dominate and may completely mask the effects of commercial navigation.

8.6.6 Resources of Concern and Sources of Data

The focus of the bank erosion study was on potential impacts to terrestrial resources. Related impacts to aquatic resources (due to erosion and transport of bank sediments, increased turbidity, sedimentation, etc.) are addressed by other environmental study components looking specifically at impacts on fish, mussels, plants, and backwater sedimentation. Terrestrial resources of concern include: historical properties, threatened/endangered species, high quality or special habitats (bottomland hardwood forests, islands), and the general availability of a diverse mixture of habitat types within the floodplain of the UMRS.

8.6.6.1 Potential Impacts to Bottomland Forest and Habitat Availability

To determine the potential for impacts to bottomland hardwood forests and general habitat availability, the 1989 EMTC land cover/land use GIS database was used to characterize the land cover along the banks of the main channel as well as the high and medium potential areas for commercial navigation effects. Land cover information was available for pools 4 through 26 on the UMR (RM 797 - 201), the trend reach portion of the open river (RM 31-74), and the LaGrange and Peoria Pools of the IWW (RM 80 - 231). Tables L.1 through L.26 of Landwehr and Nakato (1998; ENV 9) present the total length of the main channel bankline bordered by the various land cover types. In addition, the total lengths for the high and medium erosion potential areas are listed along with the length of those banks that were identified as protected during the 1995 field survey.

To screen for potential impacts on the availability of individual land cover types, the unprotected length of the medium and high risk areas was totaled. In order to make a comparison with the general availability (total acreage within the natural floodplain) of a land cover type in the pool, the unprotected, at risk, length was multiplied by a uniform width of 10 feet. This represents a conservative estimate of the potential erosion that could occur, due to the incremental increase in commercial traffic, and is used here as a screening tool to look for land cover types that may be disproportionately at risk. Tables L.1 through L.26 of Landwehr and Nakato (1998; ENV 9) present the results of this analysis in terms of the potentially affected area (assuming the 10 ft. erosion width), the total acreage of that land cover type present in the pool (based on 1989 data), and the percentage of the available acreage potentially affected. A threshold of 0.5% was used to identify land cover types that may be impacted at a level that would potentially affect the overall availability of a particular land cover (habitat) type. Using this threshold, the following land cover types were identified:

Land Cover Type	Pools Exceeding 0.50%
Sand	4, 5, 5a, 6, 7, 8, 9, 10, 12, 13, 14, 19, LaGrange
Amorpha (Indigobush)	4, 7

The relative abundance of sand along the banks of the main channel is often related to the placement of dredged material. Table 8-32 summarizes the potential effect for Pools 4 through 26 on the UMR. Approximately 40 percent to 70 percent of the main channel bankline for each pool is classified as *Acer* (Maple) or other bottomland forest types. Any proposed mitigation for loss of bottomland hardwoods would be based on actual observed erosion at the identified sites, not on the 10-ft. erosion width used for the screening analysis above.

Table 8-32. Summary of potential land cover impacts from navigation related bank erosion in Upper Mississippi River Pools 4 – 26.

Type	General Class	Total Unprotected Length in High and Medium Risk Areas (ft)	Eroded Area assuming uniform 10 foot erosion of unprotected, at risk areas (acres)	Total Land Cover Acreage In Pool (acres)	Percent of Available Land Cover
General Classes					
Agriculture		884.9	0.20	379,882.22	0.00%
Emergents-Grasses/Forbs		3,429.5	0.79	6,715.58	0.01%
Grasses/Forbs		41,068.1	9.43	59,740.14	0.02%
Sand/Mud		39,010.3	8.96	2,116.24	0.42%
Urban/Developed		31,810.1	7.30	59,478.24	0.01%
Woody Terrestrial		342,001.4	78.51	228,041.17	0.03%
Total		458,204.3	105.19	735,973.6	0.01%
Detailed Classes					
Agriculture	Agriculture	884.9	0.20	379,882.22	0.00%
Leer/Phalar/Scirp/Lythr/Phrag	Emergents-Grasses/Forbs	0.0	0.00	77.85	0.00%
Leersia/Sagittaria	Emergents-Grasses/Forbs	2,618.3	0.60	2,780.95	0.02%
Sag/Sparg/Typ/Scirp/Leer/Phrag	Emergents-Grasses/Forbs	0.0	0.00	568.58	0.00%
Sagittaria/Phalaris	Emergents-Grasses/Forbs	161.2	0.04	106.64	0.03%
Sagittaria/Scirpus/Leersia	Emergents-Grasses/Forbs	650.1	0.15	915.63	0.02%
Scirpus/grasses/forbs	Emergents-Grasses/Forbs	0.0	0.00	1,267.70	0.00%
Scirpus/Leersia	Emergents-Grasses/Forbs	0.0	0.00	847.48	0.00%
Scirpus/Polygonum	Emergents-Grasses/Forbs	0.0	0.00	150.74	0.00%
Grass	Grasses/Forbs	937.2	0.22	1,593.60	0.01%
Grasses/forbs/shrubs	Grasses/Forbs	1,093.3	0.25	449.88	0.06%
Hay Meadow	Grasses/Forbs	0.0	0.00	1,853.79	0.00%
Leersia	Grasses/Forbs	38.2	0.01	2,097.70	0.00%
Leersia/Phalaris	Grasses/Forbs	0.0	0.00	55.27	0.00%
Leersia/Polygonum	Grasses/Forbs	479.0	0.11	680.78	0.02%
Meadow	Grasses/Forbs	0.0	0.00	867.32	0.00%
Mixed forbs and/or grasses	Grasses/Forbs	26,062.8	5.98	20,541.16	0.03%
Nettles	Grasses/Forbs	1,130.7	0.26	392.69	0.07%
Pasture (heavily grazed areas)	Grasses/Forbs	0.0	0.00	2,118.25	0.00%
Phalaris	Grasses/Forbs	7,559.8	1.74	6,420.81	0.03%
Polygonum	Grasses/Forbs	0.0	0.00	462.87	0.00%
Rdside-levee/grass/forbs/shrub	Grasses/Forbs	2,985.2	0.69	21,029.31	0.00%
Scirpus/Phalaris	Grasses/Forbs	710.6	0.16	913.13	0.02%
Vines as dense overgrowth	Grasses/Forbs	71.3	0.02	263.57	0.01%
Mud	Sand/Mud	138.3	0.03	367.80	0.01%
Sand	Sand/Mud	38,872.0	8.92	1,748.44	0.51%
Developed	Urban/Developed	13,206.4	3.03	30,014.92	0.01%
Developed park	Urban/Developed	811.9	0.19	1,876.76	0.01%
Revetted Bank	Urban/Developed	403.7	0.09	165.77	0.06%
Urban	Urban/Developed	17,388.1	3.99	27,420.78	0.01%
Acer	Woody Terrestrial	126,806.0	29.11	75,142.13	0.04%
Acer/Populus and/or Salix	Woody Terrestrial	23.0	0.01	125.90	0.00%
Amorpha	Woody Terrestrial	5,056.0	1.16	294.75	0.39%
Brush	Woody Terrestrial	3,411.3	0.78	3,203.13	0.02%
Forest-mesic (moist soil sp.)	Woody Terrestrial	176,892.1	40.61	116,855.61	0.03%
Forest-upland (dry soil sp.)	Woody Terrestrial	8,216.4	1.89	15,892.09	0.01%
Populus	Woody Terrestrial	1,625.0	0.37	3,214.51	0.01%
Salix	Woody Terrestrial	8,658.2	1.99	5,970.69	0.03%
Salix and/or Populus	Woody Terrestrial	0.0	0.00	158.44	0.00%
Salix and/or Populus - grass	Woody Terrestrial	0.0	0.00	219.55	0.00%
Shrub/grass/forbs	Woody Terrestrial	11,313.4	2.60	6,962.86	0.04%
Shrub/Scirpus	Woody Terrestrial	0.0	0.00	1.52	0.00%
Total		458,204.3	105.19	735,973.6	0.01%

8.6.6.2 Potential Impacts to Islands

The consideration of islands as a resource, regardless of land cover or other resources present, relates to the potential loss of habitat diversity provided by islands and the potential for the introduction of additional flow and sediment into backwater and secondary channel areas. Islands were identified where a reasonable amount of erosion, in the high or medium risk areas, would lead to loss or dissection of the island. Examples include: small islands in the impounded portion of the navigation pools; small, main channel islands; and islands with interior aquatic areas. In addition, the heads of islands on the outside of bends and crossovers, potentially subject to propeller wash and other navigation effects, were identified due to the potential for increased diversion of water and sediment into the adjacent backwater or secondary channel areas.

The potential for loss of island habitat is presented in Table 8-33. The table shows the following: (1) total acreage of islands in each pool, (2) the total, unprotected bank length of the islands meeting the criteria above and classified as having a high or medium potential for commercial navigation effects and (3) the potentially affected area, assuming an erosion width of 10 feet over the identified areas (as in the previous analysis on land cover types). For Pools 4 through 26 on the UMR, this potentially affected area represents less than 0.10 percent of the total island area within these pools.

Approximately 40 percent of the total high and medium potential length within the UMR occurs along islands; however, comparison of the total, unprotected length of the high and medium potential areas reveals that 76 percent of these areas occur along islands. This high occurrence of the unprotected, high and medium potential areas along the islands of the UMR is due to the relative absence of existing bank protection along islands. This trend, in the location of unprotected areas, does not hold true for the IWW due to the relatively small number of islands present on that system.

Table 8-33. Summary of potential navigation related bank erosion impacts to islands.

River	Pool	Total Unprotected Length* (ft)	Eroded area** (acres)	Total Area of Islands in Pool*** (acres)	Percent of Total Island Area
Upper Mississippi River	4	12,827	2.9	5,444	0.05%
	5	19,444	4.5	2,277	0.20%
	5A	4,964	1.1	4,216	0.03%
	6	3,657	0.8	1,683	0.05%
	7	3,333	0.8	3,995	0.02%
	8	15,670	3.6	7,434	0.05%
	9	11,133	2.6	11,129	0.02%
	10	14,471	3.3	10,410	0.03%
	11	1,093	0.3	4,437	0.01%
	12	3,806	0.9	4,196	0.02%
	13	2,500	0.6	4,297	0.01%
	14	0	0.0	3,408	0.00%
	15	984	0.2	1,259	0.02%
	16	4,999	1.1	3,433	0.03%
	17	5,345	1.2	2,922	0.04%
	18	502	0.1	5,047	0.00%
	19	1,883	0.4	6,195	0.01%
	20	0	0.0	1,907	0.00%
	21	1,537	0.4	6,194	0.01%
	22	1,545	0.4	1,924	0.02%
	24	0	0.0	3,855	0.00%
	25	0	0.0	7,011	0.00%
	26	0	0.0	6,386	0.00%
	Open River	0	0.0	16,467	0.00%
	Total	**109,691**	**25.2**	**125,526**	**0.02%**
Illinois Waterway	Alton	1,354	0.3	2,463	0.01%
	LaGrange	11,238	2.6	NA	NA
	Peoria	3,043	0.7	1,530	0.05%
	Starved Rock	740	0.2	357	0.05%
	Marseilles	1,263	0.3	158	0.18%
	Dresden Island	2,580	0.6	260	0.23%
	Total	**20,218**	**4.6**		

* Represents unprotected length of High and Medium Potential Areas.
** Assuming uniform 10 foot Erosion of unprotected, at risk, areas
*** Values for the pooled region of the UMR taken from the Cumulative Impacts Study; Values for the Illinois Waterway and open river portion of the UMR developed using EMTC Land Cover Information and NWI Land/Water Information.

8.6.6.3 Potential Impacts to Historic Properties

The Programmatic Agreement (PA) between the St. Paul, Rock Island, and St. Louis Districts, U.S. Army Corps of Engineers, the SHPOs from Wisconsin, Minnesota, Illinois, Iowa, and Missouri, and the Advisory Council on Historic Preservation identifies how the Corps will satisfy its responsibilities under Section 106 of the National Historic Preservation Act of 1966, as amended and its implementing regulations 36 CFR Part 800. Included in the PA are measures for determining effects to significant historic properties from both site specific and systemic impacts from the proposed alternatives. Supporting investigations will be conducted in a phased-approach consisting of Phase I survey, Phase II testing, and Phase III treatment. Phase III treatment of a historic property may include preservation, avoidance, or mitigation of the loss of the property through some form of data recovery such as, but not limited to complete excavation of an archeological site or the detailed documentation of a standing structure.

There are 26 NRHP eligible archeological sites that will require field verification and bank erosion assessment. In addition, there are 67 archeological sites that are potentially eligible for inclusion to the NRHP that will require field verification, bank erosion assessment, and archeological testing to determine NRHP eligibility, when necessary. It is anticipated that archeological testing will only be necessary in those instances where bank erosion is documented. There are approximately 32,000 meters of potential bank erosion areas that have not been surveyed but are considered to have high potential for undocumented cultural resources. A combination of monitoring and field investigation will be required. There are approximately 87,000 meters of potential bank erosion areas that have not been surveyed that have medium potential for undocumented cultural resources. These areas will require some form of monitoring and, if necessary, field investigation. Finally, approximately 218,000 meters of unsurveyed potential bank erosion areas have been identified as having low or no potential to impact undocumented cultural resources. In addition, approximately 3,700 meters of the low potential bank erosion areas have some form of bank protection. Further cultural resource evaluation is not recommended for any of the low/no archeological potential locations. Details regarding systemic and site-specific evaluation and mitigation are provided in Chapter 10.

8.6.6.4 Potential Impacts to Social Resources

The majority of railroad, bridge, and highway embankments have been artificially protected from erosion. Commercial vessels transiting the system are not expected to negatively impact these areas. However, a number of temporary mooring sites lie along railroad embankments. In the past, direct physical contact from commercial vessels has resulted in damage to some of these embankments requiring remedial action. The location of these mooring sites is not expected to change as a result of the proposed project alternatives. Usage of these temporary mooring sites may initially decrease as a result of improvements to the navigation system, but are expected to return to current levels as traffic increases.

8.6.6.5 Potential Impacts to Threatened and Endangered Species

The potential impacts to listed threatened and endangered species, and other resources of concern were investigated as part of separate efforts. As part of that effort, a spatial analysis was performed comparing the sites identified as moderate or high potential for erosion to known heron rookeries, bald eagle nests, and information contained in the state natural heritage databases. Results of this investigation are described in Appendices ENV B and ENV L.

8.6.7 Summary of Potential Impacts

Due to the limitations of the current understanding as to the interdependency of bank erosion processes, and the uncertainties of hydrologic conditions over the next 50 years, it is not possible to estimate (with any reasonable degree of accuracy) the rate of bank erosion associated with a given project alternative. Instead, the study has sought to identify areas on the system where additional traffic disturbances may result in further erosion and to identify significant natural and cultural resources present at those sites. Implementation of avoid, minimize, and mitigation measures designed to offset these potential impacts would be based on the timing of system improvements, and the projected increases in commercial navigation use within a given river reach.

Based on the above analyses, the following potential impacts to natural and cultural resources were identified:

- <u>Threatened and Endangered Species</u> - This includes one eagle nest and two heron rookeries on the UMR and two locations with a state (Illinois) and federally-threatened plant species on the Illinois River totaling approximately 5000 feet of bankline.

- <u>Floodplain Forest</u> - Through a spatial analysis using land cover data and the bank erosion coverages, those areas classified as upland forest were selected. Upland forest totals 8,217 feet of bankline on the Mississippi and 233 feet of bankline on the Illinois River. Considering mesic forest, there were 245,340 feet of bankline on the UMR, and 135,451 feet on the Illinois River.

- Islands - A total of 105,521 feet of bankline on the Upper UMR and 18,301 feet of bankline on the Illinois River was identified.

- Social Resources- There may be isolated impacts to infrastructure, private property, or other developed areas adjacent to erosion areas. Protection of these areas will depend on identification and determination of the significance of the impact. It was estimated that there are up to 2,000 feet of bankline that may require protection.

- Historic Properties - Historic properties costs were determined based on assumptions derived from GIS archeological site and geomorphological data and from historic properties management plans for each of the three Corps' Districts. To date, there are 37 known archeological sites on the UMR and 86 known archeological sites on the IWW that are located adjacent to bank erosion areas and will require archeological evaluation. Projections about newly recorded archeological sites based on known site frequency data indicate that archeological surveys will document approximately 40 new sites on the IWW and the UMR, respectively. It is assumed that 40% of the combined total of newly recorded and known archeological sites will require testing to determine eligibility for inclusion to the National Register of Historic Places. Of that number, it is anticipated that 20 percent will be determined eligible and require mitigation.

In many instances, there are overlaps with resources found in the same location. For example, the cover type on some of the islands identified as susceptible is upland forest and some islands have historic properties on them. Through use of spatial analysis these overlaps have been identified and were considered as part of avoid, minimize, and mitigation planning.

8.7 Socio-Economic Impacts

This section addresses the anticipated socio-economic impacts of the proposed alternative plans for reducing traffic congestion and improving navigation efficiency (Navigation Alternatives 4 and 6) and the potential impacts of the proposed ecosystem restoration measures (Alternative D*) on the Upper Mississippi River and Illinois Waterway.

8.7.1 Community and Regional Growth

Navigation Alternatives 4 and 6 - The existence of a cost-effective, efficient transportation system created by the locks and dams on the UMR-IWW System has provided stimulus for the growth of river communities and the entire Midwest region. Midwest producers rely on low-cost river transportation to compete in world markets. The UMR-IWW System have proven to be an efficient and cost-effective means of transporting a variety of goods and are vital to our national economy. The Upper Mississippi River navigation system provides a low cost transportation route for interregional and international trade, and it has allowed the rural agricultural-based economy of the Midwest to flourish by providing an outlet for markets out of the region (Bray et al. 2004). Maintaining the efficiency of the navigation system is also important to the economy of the local areas. The ability of tons of consumer goods to reach local communities in the study-area states via the river system positively impacts the lives of the residents of those states (Bray et al. 2004).

The UMR-IWW System provides many benefits to the regions, states, and counties along the river corridor and the Nation as a whole. Benefits are derived from the employment and income generated from transportation of goods, recreation, hydropower production, and water supply for municipalities, commercial, industrial and domestic use. The existing system generates an estimated $0.8 billion to $1.2 billion (2001 prices) of annual transportation cost savings (using 2000 traffic levels (see Section 4.2.1.8). Improvements to the system would help to provide for continued growth opportunities, and allow the region to remain competitive in regional, national, and international markets. Mooring cells and switchboats would not be expected to have a significant direct impact on community and regional growth. Overall, the large-scale improvements would help to provide for continued growth opportunities in the local communities where the lock sites are located. Community and regional growth are impacted directly and indirectly by the effects of construction activity, expansion of existing firms, and establishment of new firms within the region.

Regional benefits are linked to/controlled by the magnitude of construction alternatives. For Alternative 6, construction would occur at several locations throughout the study area. Direct construction expenditures result in indirect impacts in the local economy. Most of the construction benefits from income and employment would be site-specific as they would accrue to the states and cities located adjacent to the construction sites. The additional money spent in local areas could have the potential to stimulate some community and regional growth and development throughout the river corridor.

Ecosystem Restoration - For Alternative D* the potential exists for approximately 1,010 ecosystem restoration measures to be built in a variety of locations throughout the study area. All measures, except pool water-level management, involve some type of construction, be it small or large projects. Direct construction expenditures result in indirect impacts in the local economy. Much of the construction benefits would be site-specific as they would accrue to the states and cities located adjacent to the construction sites; however, the additional money spent in local areas would have the potential to stimulate community and regional growth and development in the local areas, as well as throughout the river corridor.

Construction costs per ecosystem measure range from over $500,000 to approximately $25 million. The total construction expenditures for all of the recommended restoration measures in Alternative D* are estimated to be $5.126 million. Positive impacts to the Upper Mississippi regional economy would be expected to result from the direct economic changes that would occur following the construction of the ecosystem measures recommended in Alternative D*. As an example, output provided from the REMI model shows that for the $106 million in construction dollars expended in the five-state region in 2005, the gross regional product (GRP) would be nearly $175 million.

8.7.2 Community Cohesion

Navigation Alternatives 4 and 6 - Overall, no significant impacts on community cohesion throughout the river corridor would be expected from the proposed Alternatives 4 and 6. Navigation efficiency measures would not result in permanent changes to the population of any community, segment or separate parts of the communities or neighborhoods, change income distribution, cause relocation of residents, or significantly alter the quality of life.

Land use surrounding the locations where new locks and lock extensions would be built is shared by agricultural, industrial, residential, commercial and recreational interests. The degree of impact and acceptability or opposition would be related to the willingness and cooperation of the landowners involved.

Public acceptability of the proposed measures varies according to stakeholder group. Stakeholder groups representing the interests of Federal, State and municipal agencies, non-governmental organizations, and the general public have provided insight into the acceptability of the alternatives through various public outreach efforts conducted throughout the study. Comments received from our stakeholder groups expressed overall support for the dual purpose preferred plan, and appreciation of the collaborative framework and decision process. Endorsements received from the Governors of the 5-state study area supported the proposed plan, and requested that implementation be integrated, balanced, adaptive, collaborative, and fairly funded. The principal concerns of the USEPA centered on implementation and funding issues. The USFWS strongly supports creation of the dual-purpose authority and the adaptive management approach. Overall, feedback from the remaining public was wide-ranging and indicated support of both non-structural and structural navigation efficiency measures, plus concern about the health of the environment and support for environmental alternative E.

Ecosystem Restoration - Overall, no significant impacts on community cohesion throughout the river corridor are anticipated from the environmental restoration measures in Alternative D*. The proposed restoration measures would be expected to positively impact community cohesion by attracting visitors and recreationists from other communities to the wildlife areas, and to result in an improved quality of life in the area. In the REMI model, this improvement in quality of life is an indirect economic impact due to the increased comparative advantage of the areas as a place to live (Bray et al. 2000). The improved quality of life would increase the attractiveness of the area for those already living there and for the people that would likely migrate into the areas where ecosystem measures have been built. However, this improvement in quality of life, along with increased employment at construction sites in an area, could lead to negative impacts on the existing community, its resources, and its infrastructure as people migrate to the area.

8.7.3 Displacement of People

Navigation Alternatives 4 and 6 - On a system-wide basis, displacement of people is not a significant issue. No residential relocations would be required for the construction of the new lock facilities or lock extensions proposed in Alternative 6. Alternative 4 options occur within the waterway and are not an issue for displacement.

Ecosystem Restoration - On a system-wide basis, displacement of people is not a significant issue. Residential relocations could become an issue for areas involved with the floodplain restoration measure as this potentially could result in buyouts. The amount of land required for this measure of Alternative D* and the number of affected property owners would be addressed in a site-specific analysis.

8.7.4 Property Values and Tax Revenues

Navigation Alternatives 4 and 6 - The proposed alternatives would not be expected to have a significant direct impact on property values or resulting tax revenues. Increasing traffic through improved navigation efficiency has the potential for affecting property values at sites where there are residential properties located adjacent to existing locks. Impacts would be based on perceptions that more traffic on the river may diminish the desirability of a riverfront property and, therefore, make the real estate less desirable in the eyes of prospective buyers. This would be more prevalent near the locks or cells. Alternative 4 would not impact property values or tax revenues as these actions occur within the waterway. Alternative 6 could have minor impacts on property values and tax revenues. The use of agricultural land for staging areas during construction would temporarily remove that land from crop production, resulting in a short-term impact on tax revenues.

Any long-term effects on property values and tax revenues would be related to community and regional growth. Inland water transportation generates thousands of jobs and millions of dollars in taxes for the state and Federal governments. The UMR and IWW are an important source of tax revenue for the Inland Waterways Trust Fund, providing about 40 percent of total fuel-tax collections into the fund (Bray et al. 2004).

Ecosystem Restoration - Overall, none of the measures included in Alternative D* are projected to have major, long-term direct impacts on property values in any of the reaches throughout the study area. Any long-term effects on tax revenues would likely be related to community and regional growth. The Upper Mississippi River system provides billions of dollars in revenue annually from the millions of visitors that hunt, fish, boat, sightsee, or visit the river that, in turn, result in an increase in state and local sales tax revenue through purchases of goods and services. The river system also generates thousands of jobs and millions of dollars in taxes for State and Federal governments. Any increase in recreational visitors that may result would mean more dollars spent in local retail establishments, resulting in an increase in tax revenues for the surrounding community.

Increases or decreases in property values could occur as a result of the potential for land acquisitions associated with the floodplain restoration and dam point control measures. Such actions could affect revenues for taxing districts. Presently, not all of the indirect and induced effects of this alternative, as they relate to property values, are known. Changes in the viewshed and any potential resulting impacts on property values and taxes revenues for property owners adjacent to the river or restoration area cannot be fully determined at this time. Assessment of any potential impacts would be addressed in a site-specific evaluation.

For the floodplain restoration measure, it is estimated is that approximately 105,000 acres of agricultural land (15,000 for immediate opportunities and 90,000 for future use) would need to be acquired from Reaches 2, 3 and 4. This is less than 10 percent of the existing floodplain acres in those reaches that would be removed from the tax roles.

8.7.5 Public Facilities and Services

Navigation Alternatives 4 and 6 - The proposed alternative would positively impact public facilities and services. The UMR-IWW System is a vital component of the national transportation infrastructure. With timely and appropriate improvements, it will continue to serve recreational, commercial and environmental interests over the long term. The system provides recreation opportunities to the residents of the states through which the rivers flow. Any impacts involving access to public parks and boat ramps, loading docks, river terminals, homes, businesses and industries, tourism events and attractions, marinas and recreation areas would be temporary during project construction. Impacts would be evaluated during site-specific assessment.

Swing-span vehicle bridges, located at some lock and dam sites, would open more frequently with an increase in navigation traffic, causing more delays for vehicles using these bridges to cross the river.

Ecosystem Restoration - The UMRS, as a whole, is a vast resource used by thousands of recreationists every year, and the restoration measures of Alternative D* could indirectly improve recreation experiences throughout the river corridor. The area provides endless opportunities for boating, waterfowl hunting, fishing, swimming, wildlife observation, photography, plus activities that are enhanced by proximity to water such as hiking, picnicking, bird watching, camping, and water sports. Public access to these recreational activities throughout the river corridor would not be hindered or interrupted by the recommended ecosystem measures of Alternative D*.

For all reaches of the study area, only positive impacts to public facilities and services would be expected to result from the enhancement of recreational boating opportunities associated with the backwater restoration (dredging) and side channel restoration measures included in the recommended alternative.

Any potential site-specific impacts to public facilities and services involving the use of public parks, boat ramps, river terminals, ferry boats, tourism events and attractions, marinas, and recreational areas would be addressed in a site-specific assessment.

8.7.6 Business and Industrial Growth

Navigation Alternatives 4 and 6 - An increase in business and industrial activity would occur throughout the river corridor during construction activities associated with Alternative 6. Long-term impacts would be related to community and regional growth, as well as the growth of the transportation industry and related businesses. Development associated with the proposed navigation efficiency alternatives is not likely to cause displacement of existing businesses or industries. The expansion of navigation efficiency through large-scale improvements with Alternative 6 may serve as a catalyst for the development or expansion of businesses, industries and terminals in the river corridor.

Alternative 6 would require some temporary construction activity, resulting in a short-term increase in business and industrial activity in the areas surrounding the specific project sites. A portion of the increase would be attributable to the purchase of materials and supplies, and the remaining increase would result from purchases made by construction workers (e.g., meals, lodging, etc.).

Ecosystem Restoration - Impacts to business and industrial growth are generally evaluated in terms of economic impacts to the local and regional economy. Direct impacts are those that produce immediate measurable changes, and indirect impacts are those that result in some measurable net change in economic activity over time as a result of the project.

An increase in business and industrial activity would occur throughout the river corridor during construction activities associated with Alternative D*. Development associated with this environmental restoration alternative is not likely to cause displacement of businesses or industries. The most likely long-term impacts to business activity would be related to tourism and recreational activities where increases in visitations and activity by recreationists could serve as a catalyst for the development of small retail businesses that would serve the site users.

All ecosystem measures included in Alternative D*, except pool scale water-level management, would require some temporary construction activity, resulting in a short-term increase in business and industrial activity in the areas surrounding the project. A portion of the increase would be attributable to the purchase of materials and supplies, and the remaining increase would result from purchases made by construction workers (e.g., meals, lodging, etc.).

8.7.7 Employment and Labor Force

Navigation Alternatives 4 and 6 - The new locks and lock extensions proposed in Alternative 6 would increase area employment at the individual site locations. In general, most of the construction activities would take place during the wintertime. Lock extensions would require an approximate a 90-day construction period for three consecutive winter seasons, and new locks would require the 90 day period for 10 consecutive winter seasons (Section 6.1.4). The supply of labor in the project areas would determine the need for immigration of workers during the anticipated construction period. Workers would likely be hired through local labor pools to fill project-related jobs; however, skilled laborers may need to be brought in from other areas. Increased employment at construction sites brings spending to the area creating increases in local income. Direct construction expenditures result in indirect impacts in the local economy as money spent on construction activity, labor and materials generates additional income and employment in a multiplier fashion. In larger construction projects, impacts can range from the local or regional construction area as purchases are made over long distances (Bray et al. 2000). Information on Regional Economic Development benefits was developed by the Tennessee Valley Authority using the REMI model. Using the output from the Tow Cost Model-Scenario 3, the employment and income effects that are derived from direct construction expenditures required to implement Alternative 6 are estimated to be about $184 million in average annual income and over 3,100 in average annual jobs created within the region comprised of the five-states in the study area (Section7.1.1 C). The overall impact of construction employment for Alternative 4 would be less as these measures are smaller in scope and size, so the duration of any increase in employment period during the construction phase would be shorter.

A more complete assessment of potential positive and negative impacts to employment and income in the local, regional and national economies would be found in the discussion of national and regional economic development in the Economic Appendix.

Ecosystem Restoration - All but two ecosystem measures of the proposed alternative would temporarily increase area employment at the individual site locations. Direct construction expenditures result in indirect impacts in the local economy as money spent on construction activity, labor and materials generates additional income and employment in a multiplier fashion.

The overall impact of construction employment throughout the study area would vary as some states have more or larger measures that would be built. Some jobs created by construction of the ecosystem measures would be temporary until the projects are completed. Permanent jobs attributable to the construction of the ecosystem measures would occur as the projects develop and draw more visitors to the areas, and spin-off businesses are established. For Alternative D*, the REMI model estimated that the five-state region would gain about 2,747 jobs in 2005 and by 2035 that number would increase to 4,762; personal income is projected to increase from nearly $105 million in 2005 to over $470 million in 2035. On an annual basis, this equates to an average regional income of $66.1 million and an average number of jobs created of nearly 1,200 for the five-states in the study area.

8.7.8 Farm Displacement.

Navigation Alternatives 4 and 6 - No farms or farmsteads would be displaced by the implementation of either Alternative 4 or 6. At some locations, agricultural land could be used for staging areas during construction which would temporarily remove that land from crop production. However, following project completion the land would be returned to its original use.

Ecosystem Restoration - It is anticipated that there would be a high potential for farm displacement at locations where floodplain restoration measures or dam point control measures would be implemented. These measures require the purchase of lands or easements; however, the land to be purchased would be very site-specific and any adverse impacts would be addressed within a supplemental NEPA document. It is estimated that the total amount of farmland that could be acquired (approximately 105,000 acres) is less than 10 percent of the total floodplain acres in Reaches 2, 3 and 4. This impact is considered to be relatively minor as it would affect a small portion of the total amount of farmland (1,026,379 acres) in those reaches. No farmsteads would be displaced by the construction of any of the other recommended ecosystem measures. A desirable goal for implementation would be that no prime and unique farmland would be impacted.

8.7.9 Noise Levels.

Navigation Alternatives 4 and 6 - Overall, there would be no significant impacts to noise levels in the UMR-IWW System. Construction activities would be site specific and only those locations would experience a temporary increase in noise levels. The proposed improvements would help commercial tows move more quickly through the locks, and the resulting increase in traffic could cause noise impacts for homes, businesses, or recreation areas that are located adjacent to the lock sites. Some noise impacts would be mitigated by eliminating the breaking and making of tows, which is a relatively noisy operation at the locks. The proposed improvements would result in less waiting of tows near the locks, which should reduce noise at the existing waiting areas.

Ecosystem Restoration - Overall, no significant long-term impacts to noise levels in the UMR-IWW System would result from implementation of the recommended ecosystem Alternative D*. Construction activities would be site specific and only those locations would experience a temporary increase in noise levels. Any potential elevation of noise levels resulting from increased recreational activities would also be site-specific; however, most recreational activities would probably take place away from heavily populated or residential areas. All site-specific impacts would be further addressed in a supplemental document.

8.7.10 Aesthetics.

Navigation Alternatives 4 and 6 - Construction of Alternative 4 and 6 and the resulting increase in navigation traffic would not significantly impact the aesthetics of the river corridor and would not diminish the viewscape of most public areas or local communities. Concern had been expressed about construction at one of the lower river locations where it was felt that construction of a longer lock at the existing location would impinge upon the enjoyment and view of the river by local residents and tourists. A proposed change in the location of the potential new lock structure alleviates that concern.

Ecosystem Restoration - Aesthetics relates to potential visual impacts resulting from a proposed project. Essentially, the restoration features recommended for assimilation in each of the reaches of the study area would be planned and constructed to augment the natural areas and open space, to be aesthetically pleasing, and to enhance the overall viewscape.
The project areas within each reach that are designated for ecosystem measures would mostly be rural in nature with limited development, and would result in fairly minor impacts to the aesthetic resources of the areas. Construction activities would negatively impact the viewscape in most areas during the short-term project construction phase. In project areas where the island protection and shoreline protection measures are incorporated, the viewshed would be altered by large sections of riprap along the bankline.

The recommended Alternative D* ecosystem measures would be expected to create long-term positive aesthetic impacts that would enhance scenic beauty and other natural amenities, provide for public wildlife-oriented recreation and education opportunities, restore and enhance a mosaic of wetlands, and create a vibrant ecosystem.

No long-term adverse impacts to the aesthetics of the river corridor are anticipated, and it is expected that the proposed ecosystem measures would not diminish the viewscape of most public areas or local communities.

8.7.11 Created Resources

Navigation Alternatives 4 and 6 can be found in Section 10.5 and 10.6.
Ecosystem Restoration can be found in Section 6.2.

8.7.12 Natural Resources

Navigation Alternatives 4 and 6 can be found in Section 8.3.2, 8.4, 8.5, and 8.6.
Ecosystem Restoration can be found in Chapter 6.2.

8.7.13 Air Quality

Navigation Alternatives 4 and 6 can be found in Section 8.3.2.4.
Ecosystem Restoration can be found in Section 9.3.1.8.

8.7.14 Water Quality

Navigation Alternatives 4 and 6 can be found in Section 8.3.2.2.
Ecosystem Restoration can be found in Section 9.3.1.9.

8.7.15 Life, Health and Safety.

Navigation Alternatives 4 and 6 - Overall, the proposed alternatives would eliminate some of the hazards of transiting the river locks and congestion at the locks, thereby improving the safety conditions for towing industry and lock personnel. The mooring cells associated with Alternative 4 would not increase or decrease safety. Switchboat introduction could have potential for increasing personal injuries since more workers would be used on each boat, and the overall safety would depend on the experience and training of the towboat captain and crew. With Alternative 6, the lock extensions would reduce exposure to hazards associated with the locking process thus reducing the overall risk of personnel injury. The new locks would allow the existing 600-foot lock to be used for recreation craft and other small vessels, separating them from the large commercial tows. Also, interferences on approaching the lock would be reduced, thereby reducing the chance of conflict between vessels (Section 7.1.1 E).

Increased navigation capacity on the system has the potential to increase hazardous spills on the river and lead to more accidents between craft on the river. For example, the projected change in accident costs (injuries and fatalities) for Alternative 6, as estimated by the Tow Cost Model for traffic scenario 3, shows an increase in accident costs from $2.5 million in 2025 to $16.4 million in 2050 (Section 7.1.1 D). A report on the analysis of energy, emission, and safety effects of the proposed UMR-IWW projects concluded that although more research is needed to firm up potential emission, safety and noise impacts along the river corridor, an increase in other transportation modes could have greater societal costs than an increase in navigation transportation (Tolliver et al. 2000). The potential impacts of these conditions have been studied by the study's economic work group, and the results have been documented in technical reports and are discussed in the Economics Appendix.

A hazardous, toxic and radioactive waste (HTRW) compliance assessment would be conducted prior to construction at a site-specific location and, if deemed necessary, would be addressed in a supplemental document.

Ecosystem Restoration - No adverse impacts to life, health or safety would be expected to result from the implementation of the ecosystem measures recommended in Alternative D*. An HTRW compliance assessment would be conducted prior to the implementation of any measure at a site-specific location and, if deemed necessary, would be addressed in a supplemental document.

9.0 CUMULATIVE EFFECTS

The Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500-1508) implementing the procedural provisions of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. § 4321 et seq.) define cumulative impact as:

> "…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non federal) or person undertakes such other actions" (40 CFR § 1508.7).

Cumulative effects analysis recognizes that the most serious environmental impacts may result from the combination of individually minor effects of multiple actions over time, rather than the direct or indirect effects of a particular action (CEQ 1997). Cumulative effects or cumulative impacts analyses began to be conducted in the early 1980s, but only recently have these analyses been examined in terms of their importance, effectiveness, and the challenges in their conduct. The challenges in assessing cumulative impacts derive in part from (1) incomplete identification of the ecological stressors, i.e., system perturbations (Canter 1999) or actions that alter ecological processes (USEPA 1997); (2) limited data and information of suitable quality that describe the individual stressors; (3) imperfect and uncertain understanding of the potential interactions among stressors in determining cumulative ecological impacts; (4) spatial and temporal scales relevant to the overall assessment; and (5) limited understanding of the resilience of potentially affected resources to past, present, and future stress.

The CEQ has suggested frameworks for incorporating cumulative effects analyses (CEA) into the environmental impact assessment process, and steps for conducting the CEA (CEQ 1997). These frameworks are shown in Table 9-1and Table 9-2. Incorporation of CEA should begin with the NEPA scoping process, and continue throughout the descriptions of the affected environment and the environmental effects of the action. Individual steps in conducting a CEA are also tied to these three major components of the NEPA process. Three fundamental elements typically characterize CEA (Spaling and Smit 1993 in Canter 1999): 1) a cause or source of change (perturbations); 2) the process of change as reflected via the pertinent system structure or processes; and 3) the result of the change (effect).

Table 9-1. CEQ framework for conducting cumulative impact assessments (CEQ 1997).

1. Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions. The effects of a proposed action on a given resource, ecosystem, and human community include the present and future effects added to the effects that have taken place in the past. Such cumulative effects must also be added to effects (past, present, and future) caused by all other actions that affect the same resource.
2. Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (Federal, non-Federal, or private) has taken the actions. Individual effects from disparate activities may add up or interact to cause additional effects not apparent when looking at the individual effects one at a time. The additional effects contributed by actions unrelated to the proposed action must be included in the analysis of cumulative effects.
3. Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected. Environmental effects are often evaluated from the perspective of the proposed action. Analyzing cumulative effects requires focusing on the resource, ecosystem, and human community that may be affected and developing an adequate understanding of how the resources are susceptible to effects.
4. It is not practical to analyze the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful. For cumulative effects analysis to help the decision-maker and inform interested parties, it must be limited through scoping to effects that can be evaluated meaningfully. The boundaries for evaluating cumulative effects should be expanded to the point at which the resource is no longer affected significantly or the effects are no longer of interest to affected parties.
5. Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries. Resources typically are demarcated according to agency responsibilities, county lines, grazing allotments, or other administrative boundaries. Because natural and sociocultural resources are not usually so aligned, each political entity actually manages only a piece of the affected resource or ecosystem. Cumulative effects analysis on natural systems must use natural ecological boundaries and analysis of human communities must use actual sociocultural boundaries to ensure including all effects.
6. Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects. Repeated actions may cause effects to build up through simple addition (more and more of the same type of effect), and the same or different actions may produce effects that interact to produce cumulative effects greater than the sum of the effects.
7. Cumulative effects may last for many years beyond the life of the action that caused the effects. Some actions cause damage lasting far longer than the life of the action itself (e.g., acid mine drainage, radioactive waste contamination, species extinctions). Cumulative effects analysis needs to apply the best science and forecasting techniques to assess potential catastrophic consequences in the future.
8. Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters. Analysts tend to think in terms of how the resource, ecosystem, and human community will be modified given the action's development needs. The most effective cumulative effects analysis focuses on what is needed to ensure long-term productivity or sustainability of the resource.

[1]From: CEQ. 1997. Considering cumulative effects under the National Environmental Policy Act. Council on Environmental Quality, Executive Office of the President, Washington, D.C. 64 pages + appendices.

Table 9-2. Steps in cumulative effects analysis (CEA) to be addressed in each component of environmental impact assessment (EIA).

EIA Components	CEA Steps
Scoping	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals. 2. Establish the geographic scope for the analysis. 3. Establish the time frame for the analysis. 4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
Describing the Affected Environment	5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses. 6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds. 7. Define a baseline condition for the resources, ecosystems, and human communities.
Determining the Environmental Consequences	8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities. 9. Determine the magnitude and significance of cumulative effects. 10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects. 11. Monitor the cumulative effects of the selected alternative and adapt management.

[1]From: CEQ. 1997. Considering cumulative effects under the National Environmental Policy Act. Council on Environmental Quality, Executive Office of the President, Washington, D.C. 64 pages + appendices.

The Navigation Study CEA endeavored to follow the frameworks and components just described. The study scoping process resulted in the incorporation of a cumulative effects study, which focused on the cumulative effects associated with the historical and continued operation of the 9-Foot Channel Project (WEST 2000). The final study report consists of a geomorphic assessment (Volume 1) and an ecological assessment (Volume 2). This comprehensive assessment provides a detailed quantification of historical planform (a two-dimensional picture, i.e., not including depth or elevation) changes in the Upper Mississippi River (UMR) and the Illinois Waterway (IWW) and the corresponding impacts on flora, fauna, and ecological processes. Essentially, the WEST (2000) assessment describes the cumulative effects of the existing project on channel morphology and ecology and develops predictions of geomorphic and ecological conditions for the year 2050.

The geographical extent is broadly defined by the Upper Mississippi River Drainage Basin. However, the primary impacts on resources of concern are associated with the main channel, secondary channels, and backwaters of the UMR and IWW. The pertinent time scale for assessing cumulative impacts spans approximately 110 years, and dates from 1940, when the lock and dam system was largely constructed and operational, through 2050, the end of the project planning horizon.

This chapter will briefly review the affected environment, which was described in detail in Chapter 5, describe the ecological stressors that have shaped and will continue to shape the natural and human environments of the Upper Mississippi River System (UMRS), and then consider the Navigation Study impacts, presented in Chapter 8, in terms of their cumulative effects. The final section makes recommendations based on system sustainability, and identifies a comprehensive ecosystem restoration program for significant cumulative impacts to compensate for cumulative impacts including the ongoing effects of the operation and maintenance of the 9-Foot Channel Project.

9.1 Affected Environment

9.1.1 Important Resources, Ecological Processes, and Human Communities

Chapter 5 presents a detailed description of the Upper Mississippi River Basin and the Upper Mississippi River System in terms of formation over geological time; physical, environmental, and cultural characteristics; social and economic conditions; and multi-purpose management. The chapter concludes with the identification of significant ecological processes and resources, and in particular those resources that may be affected by the proposed project. These resources, which became the focus of study for direct and indirect impacts, also form the components of the cumulative effects assessment. These resources consist of the following:

- Aquatic plants, fish, freshwater mussels, and other macroinvertebrates.
- Sediment resuspension and transport to backwaters and secondary channels.
- Floodplain forest, cultural resources sites, and other habitats of concern adjacent to the river.

The Navigation Study Cumulative Effects Study (WEST 2000) examined many of the same resources, albeit in a much more comprehensive manner, and in the context of change over time and predicted future condition. The study utilized a mix of qualitative and quantitative methods to conduct the analysis, beginning with a thorough review and compilation of pertinent existing data, including all practically available historic and contemporary mapping and photogrammetric data. Historic photographs from approximately 1930, 1940, 1975,and 1989 were used to construct patterns of change for aquatic habitats (e.g., backwaters, secondary channels, etc.) since construction of the lock and dam system, and to help forecast future geomorphic and ecological conditions through 2050.

9.1.2 Ecological Stressors in the UMRS

9.1.2.1 General

Ecological stressors result from natural events or human actions that cause a subsequent population, community, or ecosystem level response. The goal of characterizing stressors is to determine whether the resources, ecosystems, and human communities of concern are approaching conditions where additional stresses will have an important cumulative effect (CEQ 1997). Figure 9-1 illustrates a flowchart of potential ecological stressors in the UMRS. Stressors may be temporary (i.e., seasonal drought) or permanent (i.e., channelization or impoundment). In many cases, stressors serve to benefit one population or community while adversely affecting another. Generally, those occurring for a short duration at a localized site are of less concern than those occurring for an extended time over a wide geographical region.

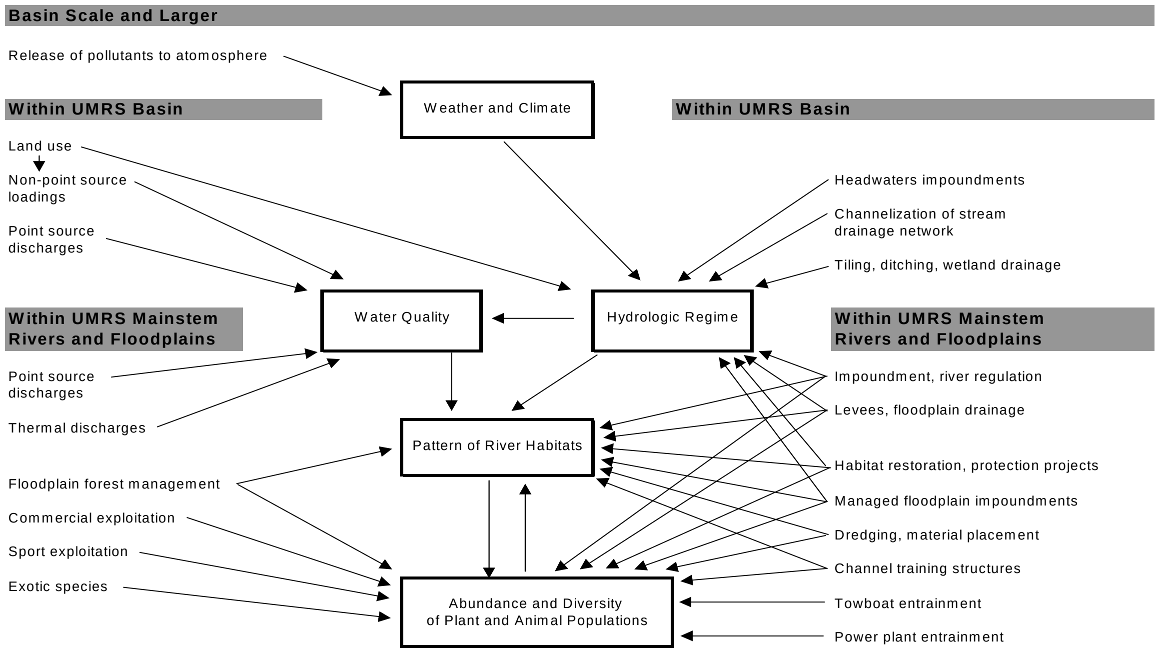

Figure 9-1. Human activities that affect the Upper Mississippi River System Environment (WEST 2000).

The ecological response to stressors is often highly variable, dependent to a large degree on the resilience or integrity of the population, community, or ecosystem being considered. As ecosystem components are stressed, resilience may be degraded and, in turn, integrity compromised. Stress effects can be synergistic or additive, and thus a multi-dimensional or cumulative analysis is necessary to account for such interactions.

Terms such as "ecosystem health" or "integrity" are becoming more common, but remain difficult to clearly define. These concepts have, however, been addressed for the UMRS in recent years. In 1994, an international conference was conducted on the topic of applying ecological integrity principles to management of the UMRS (Lubinski 1995). The conference resulted in several suggested principles for a scientifically based definition of river health. These principles were reviewed and expanded upon by Lubinski (1999), resulting in six criteria for assessing ecosystem health of the UMRS. These criteria, abbreviated, are as follows: 1) ecosystem supports habitats and viable plant and animal populations similar to predisturbance populations; 2) ability to return to preexisting condition after natural or human disturbances; 3) ecosystem is self-sustaining; 4) the river can function as part of a healthy basin; 5) an annual "flood pulse" connects the main channel and its floodplain; and 6) infrequent natural events – floods and droughts – are able to maintain ecological structure and processes. The most recent review of the approach to ecosystem management, the UMRS Environmental Science Panel (Lubinski and Barko 2003, ENV 52), affirmed past management and recommended an adaptive management for the continuing assessment and management of the system. The UMRS currently exists in various states of health; some reaches have been more extensively altered and degraded than others. This section provides a general overview of ecological stressors within the UMRS, which have tested and will likely continue to test the integrity of the UMRS ecosystem under existing and future conditions.

9.1.2.2 Land Cover/Land Use

Changes in land cover/land use show a clear gradation on the UMRS, increasing in the downriver direction. Figure 9-2 depicts presettlement and contemporary land cover in selected Upper Mississippi and Illinois River geomorphic reaches. Figure 9-3 presents an image of changes common below Rock Island and Peoria, Illinois. Agricultural development and navigation improvements are the two anthropomorphic actions that have largely transformed lands adjacent to the UMRS. For example, the logging or flooding of floodplain forests, draining of wetlands, building of levees, and plowing of prairies have caused a direct reduction in the amount and diversity of available aquatic and terrestrial habitat. Habitat loss or isolation has modified the form and function of the UMRS ecosystem, causing shifts in terrestrial and aquatic species distribution, population size, and community composition. Land use changes have generally served to fragment, limit, and simplify the various endemic species assemblages. Many of the ecological stressors described in this section are directly or indirectly associated with the changes in land cover and land use patterns that continue to dominate the basin. Several studies address the historical land cover/land use transformation process and resulting consequences (Illinois Dept. of Energy and Natural Resources 1994; USGS 1999; Nelson et al. 1998; WEST 2000; USACE 2000).

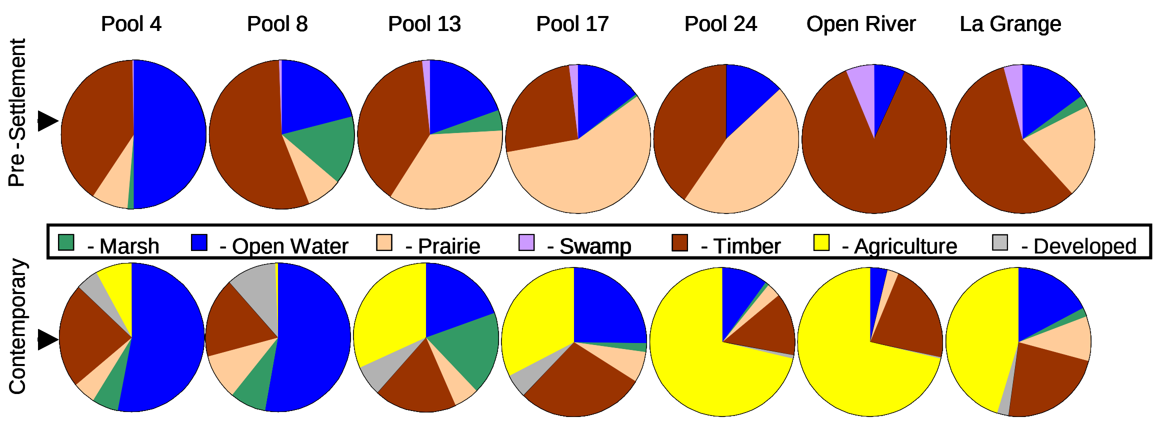

Figure 9-2. Land cover change in selected UMRS reaches between presettlement (ca. 1800-1830) and contemporary (1989) periods (USACE 2000).

9.1.2.3 Connectivity

Connectivity, in a landscape ecology context, is the degree to which habitats remain contiguous and "patchiness" is limited. It is the opposite of fragmentation or parceling of habitat into isolated patches. Modifications of habitat connectivity or patch size can strongly influence species abundance and movement patterns (Turner 1989). Korschgen et al. (1999) suggested that habitat patch distribution and abundance should be an area of further study, via "gap" analysis, on the UMRS relative to waterfowl and other migratory bird populations. Actions or disturbances that serve to restrict or eliminate connectivity often impose artificial limitations on the natural migration of water, sediments, nutrients, and aquatic species. Therefore, reductions in connectivity can impose stress on a wide variety of ecological processes or populations. The two prevalent structural limitations to aquatic habitat connectivity within the UMRS are levees and dams.

Floodplain connectivity is a significant issue because seasonal inundation of the floodplain provides for the exchange of water, sediment, nutrients, and organisms among a mosaic of habitats and thus enhances biological productivity (Sparks 1995, Bayley 1995, Junk et al. 1989). Levees generally reduce the lateral connectivity within the system by preventing the seasonal inundation of the floodplain. Approximately 40 percent of the entire UMRS floodplain has been isolated by levees (see Table 5-4), with the majority occurring below Rock Island on the Mississippi River and below Peoria on the Illinois River. Levees have provided for the conversion or isolation of approximately 1 million acres in the floodplain.

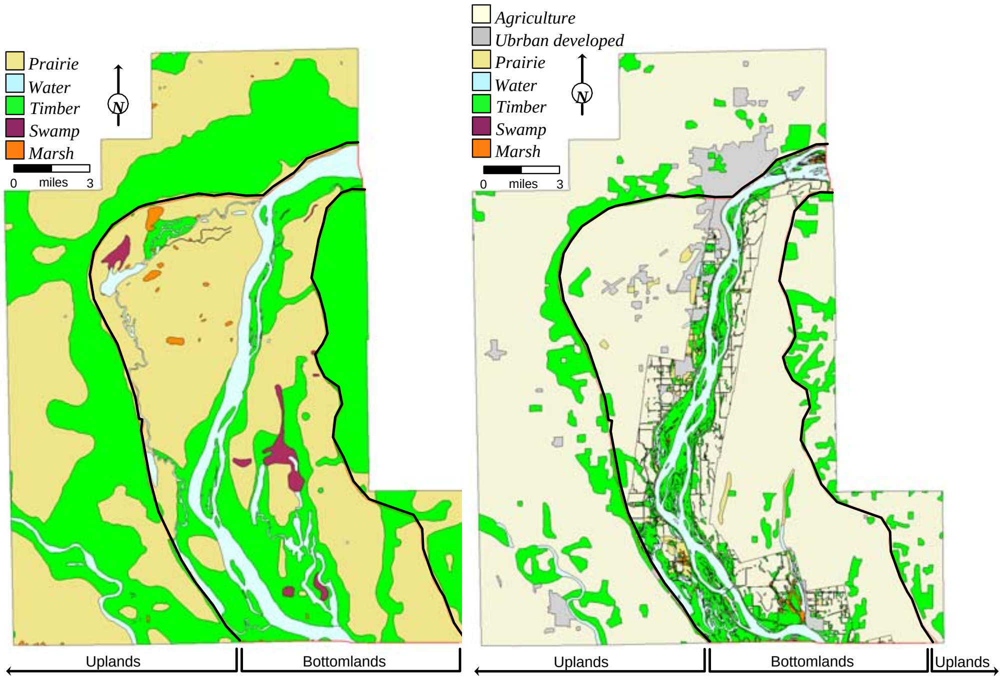

Figure 9-3. Presettlement (left image; ca. 1820s) and contemporary (right image; 1989) land cover for the Pool 17 reach of the Upper Mississippi River illustrates the changes to prairie, forest, and wetland abundance and distribution (USACE 2000). The effect is common below Pool 15.

The UMR-IWW Navigation System currently has 37 operational dams, 29 on the Upper Mississippi River and 8 on the Illinois Waterway, that reduce the longitudinal connectivity within the system by restricting the inter-pool movements of fish species. The degree to which these dams limit connectivity varies. Figure 9-4 depicts the annual percent probability (1965-95) that UMR dams are in uncontrolled condition (gates out of the water). Reduced current velocity upstream of the dams has increased rates of sedimentation, decreasing bathymetric diversity in the impounded section, backwaters, and secondary channels. The dams were not designed for flood attenuation, but rather to prevent low water levels associated with the summer drawdowns or periodic drought events. They essentially support a more stable, yet elevated, water level. Restricted fish passage can disrupt migration behavior, spawning, access to foraging and wintering areas, and may combine to limit growth, recruitment, overwinter survival, and population size. Evidence for these effects on UMR fish populations is limited, especially since fish managers have yet to be able to develop reliable standing crop estimates for any of the floodplain river fish species. Fish species most likely affected by restricted movements include lake sturgeon, paddlefish, American eel, Alabama shad, skipjack herring, blue sucker, blue catfish, northern pike, white bass, walleye, and sauger. Depending on the controlled discharge capacity of the navigation dams and the timing of fish migrations, the window of opportunity for upriver passage varies markedly between dams and fish species. The presence of multiple dams reduces the cumulative probability of successful upriver migration for long-distance migrants. Opportunity for upriver fish passage through dams is greatest during uncontrolled conditions (i.e., gates out of the water) due to the lower velocities through the dam gate openings (Wilcox et al. 2004, ENV 54). The frequency, timing, and duration that dams are in the uncontrolled condition are highly variable.

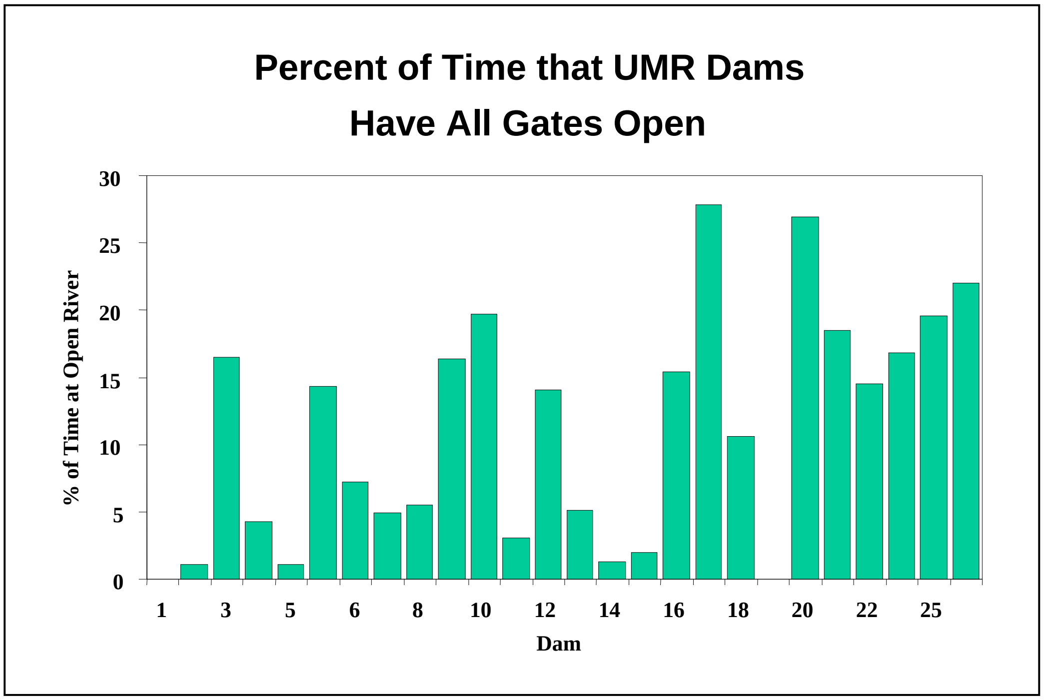

Figure 9-4. Frequency that Upper Mississippi River-Illinois Waterway System dam gates are opened with maximal potential fish passage (USGS 1999).

9.1.2.4 Channel Training Structures

Channel training structures include a variety of rock structures (i.e., wing dams, closing dams, bank revetment) designed to maintain the alignment and depth of the navigation channel and to stabilize the riverbanks. Channel training structures prevent channel avulsion (i.e., forcible separation) and the formation of new channels and islands. The net effect is considerably more boulder substrate in the river, a deeper main channel, less woody debris from caving banks, and fewer and less-frequently changing river features such as secondary channels, sandbars, and islands. Closing structures decrease water flow into secondary channel or backwater habitats, which often results in rapid filling with sediments during floods and isolation during low water events. As a result, channel training structures have artificially stabilized the processes that serve to modify habitat. Although the primary purpose of such structures is to preserve or enhance the navigation channels, they have also been used effectively to provide some ecological benefits. Newer structures, such as bendway weirs, chevron dikes, and other innovative, environmentally sympathetic designs, have been developed recently and are being studied to assess their effectiveness to maintain navigation and to determine their habitat value (e.g., feeding substrate for invertebrates, low-velocity shelter for fish). Older structures have also been redesigned, mostly by notching, to increase flow in the dike field and subsequently increase habitat diversity.

9.1.2.5 Impoundment

The construction of the locks and dams caused the permanent inundation of extensive portions of the floodplain in some areas (Figure 9-5) and created a series of slackwater "pools." The extent of floodplain inundation is generally greater in the downstream portions of the navigation pools, creating open impounded areas in many, and leaving the upper portions of the navigation pools in a relatively natural riverine state. High elevation features of the floodplain (e.g., natural levees, terrace remnants) became islands upon inundation. Secondary and tertiary channels, which were only seasonally flowing prior to impoundment, became continuously flowing channels. Littoral processes of shoreline erosion and sediment transport have greatly modified the lower parts of the navigation pools since impoundment. The deeper, submerged channel areas have filled with sediment, and many islands were eroded away. Extensive impounded areas in the lower parts of the navigation pools have lost much of their bathymetric diversity and now have relatively uniform depths.

The increased water levels following impoundment formed extensive shallow aquatic and wetland habitat in the formerly seasonally inundated floodplain. The higher and continuous water levels in the floodplain soil profile resulted in a modified floodplain forest that is now dominated by mostly flood-tolerant trees such as silver maple (*Acer saccharinum*). The higher groundwater table has restricted the rooting depth of trees growing in the floodplain, making them more vulnerable to wind throw. Wind throw of trees has accelerated island and shoreline erosion processes in portions of navigation pools where the floodplain surface is near the water level, primarily in the downriver half of the navigation pools.

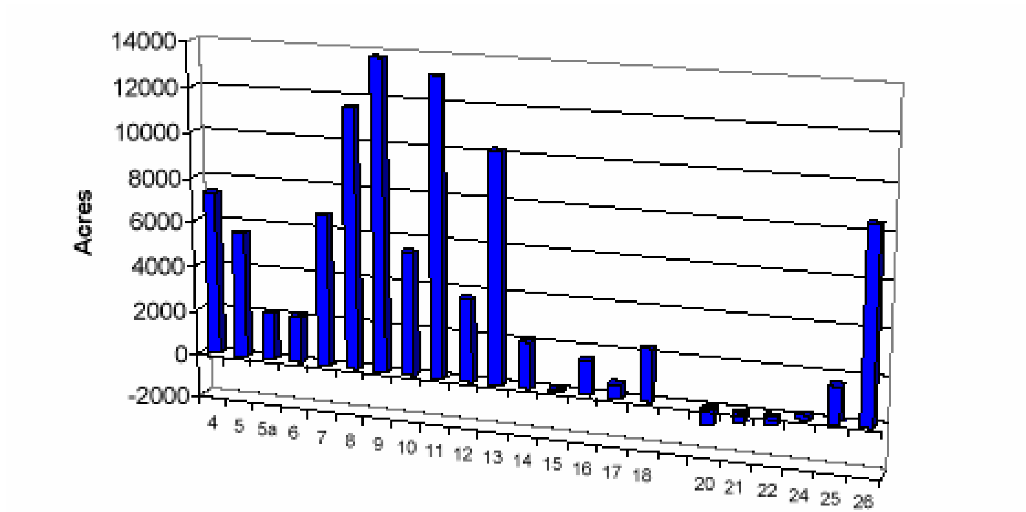

Figure 9-5. The change in acres of open water in Upper Mississippi River pooled reaches attributable to impoundment.

9.1.2.6 Altered Hydrologic Regime

The ecological diversity and integrity of large floodplain rivers is closely associated with the hydrologic regime. The seasonal flood pulse and intermittent periods of low flow strongly influence the habitat structure, trophic base, and biotic interactions (Sparks 1995). The stressors discussed in the preceding paragraphs have acted to suppress the hydrologic regime of the UMRS by restriction of the seasonal flood pulse, elimination of the intermittent low flows, and restriction of channel migration. Within the last decade, several scientific publications have further increased awareness and understanding of the adverse environmental effects of a restricted hydrologic regime (Junk et al. 1989; Sparks 1995; USACE 1995b; Wiener et al. 1998; USGS 1999; see also Landwehr et al. 2004, ENV 53).

9.1.2.7 Contaminants

Contaminants, which may include heavy metals, pesticides, or synthetic organic compounds, degrade water quality and can accumulate in sediments and biota. Section 5.2.6 summarizes several important studies on the subject, many specific to the UMRS. Examples of studies documenting the historical trends in contamination within the UMRS include Fremling and Claflin 1984, Sparks 1984, Meade 1995, USGS 1999, and WEST 2000. Through most of the 20th century, the UMRS was subject to unrestricted disposal of raw sewage and industrial wastes. Large areas downriver from major metropolitan areas were rendered inhospitable for many native species due to anoxic conditions or high concentrations of ammonia, heavy metals, and polychlorinated biphenyls (PCB's). Since the mid- to late-1970s, water and sediment quality has greatly improved, attributable primarily to adoption of national water quality standards and enforcement of the 1972 Clean Water Act, requiring the elimination and/or secondary treatment of point sources of municipal and industrial waste. Despite these gains, the UMRS remains subject to contamination from agricultural, industrial, municipal, and residential sources, with most input characterized as non-point in nature. Agriculture is the dominant land use in the basin, and chemical fertilizer and herbicide application rates are among the highest in the Nation (Meade 1995).

Contaminants can have chronic or acute (lethal) effects, depending on the rate of exposure and the particular organism affected. Persistent exposure to these substances makes it likely that they will accumulate within the tissues of aquatic organisms. Bioaccumulation is possible in fish species that are continually exposed and feed upon contaminated aquatic insects. The accumulation of toxins in fish occasionally requires issuance of consumption advisories, especially for bottom-feeding fish with high body fat content. As benthic filter-feeding organisms, freshwater mussels are particularly vulnerable to contaminants dissolved in water, associated with suspended particles, and deposited in bottom sediments. Thus, freshwater mussels can bioaccumulate contaminants to concentrations that greatly exceed those dissolved in water (U.S. Fish and Wildlife Service, unpublished data). Other species that feed upon these contaminated organisms would in turn be exposed to magnified concentrations of contaminants. For spawning fish, contaminated sediments may expose their eggs or juveniles to toxic substances.

The central region of the Upper Mississippi River Basin (i.e., the Corn Belt) is the greatest contributor of nitrogen and phosphorus compounds to the Gulf of Mexico hypoxic zone (Figure 9-6). The hypoxic zone is a large region of poor water quality at the Mississippi River Delta. The ecological and economic impacts are substantial (Interagency Hypoxia Committee 2000).

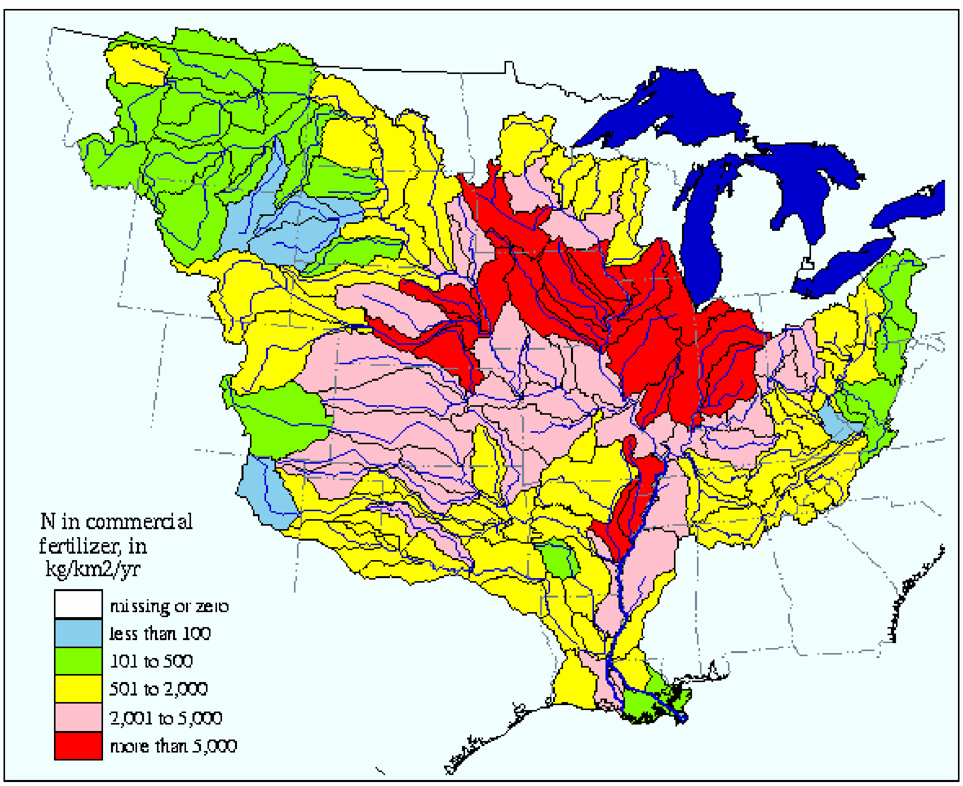

Figure 9-6. Mississippi River sub-basin nutrient contributions to the Gulf of Mexico hypoxic zone.

9.1.2.8 Sedimentation
Sedimentation is likely to continue to be one of the most significant threats to the integrity and long-term health of the UMRS ecosystem. Given the dominance of agriculture in the basin, upland runoff of sediments remains widespread, though more conservation-minded farming practices in the last 10 to 15 years have apparently led to a general decrease in sedimentation rates (WEST 2000). The UMRS is particularly vulnerable to sedimentation, not only because it drains such a vast land area but because its system of locks and dams and leveed floodplain inhibit the river's natural sediment transport and distribution capacity. Sediment deposition in off-channel areas ultimately results in a loss of habitat diversity, which in turn affects species abundance and diversity. In addition to adverse impacts in backwaters, sediment also accumulates in the main channel of the river, requiring significant annual expenditures on dredging to maintain the 9-foot navigation channel.

9.1.2.9 Resource Consumption
Consumptive exploitation of aquatic resources for recreational and commercial purposes can limit the abundance and distribution of certain UMRS species. Such utilization primarily affects fish, waterfowl, and mussels that have substantial recreational or commercial value. Over-exploitation is certainly less common than it was during the first half of the 20th century, before the era of science-based resource management, but illegal harvest of valuable resources such as paddlefish and sturgeon caviar or freshwater mussels can still be a problem. The five UMRS States have for some time individually and collectively monitored and regulated the impact of recreational and commercial harvest of fish, waterfowl, and mussels through the sale of licenses, established harvest seasons, and restrictive size/bag limits. There is no reason to believe that these efforts will cease, and it will be important for agencies to increasingly consider consumptive use in light of other cumulative stressors such as pollution or exotic species.

9.1.2.10 Introduced Exotics
As it affects interspecific competition among UMRS flora and fauna, the introduction, dispersal, and proliferation of numerous exotic species is having an increasing impact. Exotic introductions have resulted from maritime and interstate commerce, recreational boating, sport fish stocking, and accidental releases associated with the aquaculture industry, bait business, and horticultural practices. In many cases, the impact of exotic species introduction and proliferation can extend beyond a specific native species or population to the entire ecosystem. To date, control practices for exotic species have been largely unsuccessful in the UMRS. Among the introduced exotics discussed in Section 5.2.7.9, the common carp and zebra mussel are perhaps the two species that have had the most significant impact, but the impacts of the Asian carp have probably not yet been fully displayed. Studies have been initiated or are planned to assess and evaluate control measures for zebra mussels and other recently introduced exotic species such as the round goby and Asian carp. It has been suggested that commercial navigation traffic facilitated the spread of the zebra mussels upstream from the Illinois Waterway. The distribution of other exotic fish species could expand if fish passage measures are pursued at dams on the system.

Recently acclimated Asian carp (bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*)) pose potentially significant threats to the system. The fish were introduced in southern aquaculture management and have migrated widely through the system. Lock and Dam 19 has, until now, blocked significant movement upstream on the UMR. There is great concern over their migration into the Great Lakes through the IWW. Currently, Asian carp have become a significant part of the total fish biomass in many areas. They are unmarketable and impede the ability of commercial fishers to catch marketable species.

9.1.2.11 Riverside Development

Industrial, municipal, and other types of development in and along the UMRS is likely to increase in response to an ever-increasing human population. Induced human development often creates a “ripple effect” which ultimately affects other ecosystem components. During early settlement of the UMRS, large areas of undisturbed woodland, wetland, and prairie were converted for agricultural production or other types of utilization. Current development pressures come in the form of conversion of the last remaining areas of these habitats for commercial, industrial, or housing development. Direct and indirect effects of such development include habitat alteration or loss, withdrawal from or discharge into the river, and increased runoff from impermeable surfaces. Withdrawal of river water has been identified as a source of mortality for planktonic life forms such as phytoplankton, zooplankton, ichthyoplankton, and drifting benthic macroinvertebrates (WEST 2000). Discharge of thermally, organically, or chemically enriched waters from industrial/municipal secondary treatment facilities continues to be a major concern. Withdrawal and discharge demands are likely to increase. The Federal Energy Regulatory Commission (FERC), U.S. Environmental Protection Agency (EPA), and State resource agencies have primary responsibility for the regulation, monitoring, and enforcement of withdrawals and discharges. In most cases, guidelines have been established, permits are issued, and periodic inspections are conducted to evaluate compliance.

9.1.2.12 Barge Fleeting

The environmental effects of fleeting have not been comprehensively assessed, but there are impacts that raise concern. Tying barges off to trees can cause many forms of damage, from directly knocking the trees down to stripping bark and making them more susceptible to pests or disease. There is also the factor of barges scraping the bottom of the river in shallow channel border areas. This is where freshwater mussels and other benthic fauna may be affected by direct contact or prop wash. There are hydraulic and propeller strike impacts in fleeting areas from the frequent movement of towboats dropping off and picking up barges. Finally, there are aesthetic impacts where large numbers of barges degrade the view from riverfront towns or natural areas. In recent years there has been an increase in proposed fleeting initiatives that conflict with refuge management objectives. The current study recommends a systemic evaluation of fleeting needs.

9.1.2.13 Commercial Navigation

Commercial barge traffic, in aggregate, has increased steadily on the UMRS since 1950. Barge traffic itself, and activities associated with the operation and maintenance of the 9-foot navigation project, may impose a variety of stressors on the UMRS ecosystem (Sparks et al. 1979; Rasmussen 1983; WEST 2000). Many of these stressors have been discussed in detail in the preceding chapters. In general, stressors commonly identified or attributed to commercial navigation traffic include physical forces (i.e., shear, pressure), wave induced shoreline erosion, drawdowns, entrainment mortality of planktonic life forms, and sediment resuspension. The physical effects and ecological risk assessments summarized in Section 8 are among the most aggressive ever completed. In addition, less common stressors such as periodic accidents, chemical or petroleum spills, or disruptive noise levels associated with commercial navigation are also considered in the cumulative assessment.

The primary purpose of the UMR-IWW Navigation Feasibility Study was to evaluate the need for improvements to the existing system to accommodate a predicted future increase in commercial barge traffic. Subsequently, the primary focus of this PEIS is to evaluate the impact of the proposed improvements, especially as they pertain to increased commercial barge traffic. A comprehensive and detailed assessment of the environmental consequences of commercial navigation traffic is presented in Chapter 8 of this document.

9.1.2.14 Bank Erosion

Bank erosion is a natural process occurring along every river, stream, and creek. A natural river system meanders across its floodplain through the processes of bank erosion and deposition. This meandering, in turn, produces different types of aquatic habitats. If the natural process of bank erosion is halted, the dynamic cycle of habitat creation and loss would also cease. In severe cases, bank erosion can threaten the loss of cropland, forest, or riparian zones, as well as residential areas or municipal facilities. Such losses can adversely affect plant and animal uses of aquatic and terrestrial bankline areas, cultural resources and historic properties located adjacent to the bankline, and human uses of bankline areas. In addition to direct impacts to bankline areas, erosion may also have indirect impacts, such as contributing to sedimentation-related problems, and affecting recreational uses and aesthetic qualities of the river. The physical effects assessments summarized in Section 8 have contributed significantly to our understanding of these processes.

9.1.2.15 Dredging and Material Placement

Dredging and material placement are routine maintenance activities carried out by the Corps for the purpose of ensuring adequate depth for commercial navigation traffic. WEST (2000) provides a detailed history of the Corps dredging operations in the UMRS and addresses the impacts of dredging and material placement. The issue has long been a subject of natural resource coordination, which over the years has led to the development of Programmatic Memoranda of Understanding between the Corps and coordinating agencies (USACE 1996a, USACE 2003b). An interagency team in the Rock Island District recommended and conducted investigations of dredging and dredged material disposal impacts on sediment transport, terrestrial vegetation succession, freshwater mussels, benthic macroinvertebrates and fishes between 1997 to the present to further understand the issue. An interim report (MACTEC 2003a) summarizes the progress to dates. The results indicate little long-term impact from dredging and documents plant community response to material placement over many years. The following paragraphs will provide a general overview of maintenance dredging activities and their respective role as ecological stressors.

Available records indicate that dredged material has been placed on approximately 8,531 acres of UMRS aquatic and floodplain habitat. This area is approximately 0.9 percent of the non-agricultural and non-urban UMRS aquatic and floodplain area (WEST 2000). The total area where dredged material has historically been placed could be more than double the area than the available records indicate, given that dredging has been conducted since the late 1860s, and much of the area between wing dams was filled with dredged material.

Dredging results in a temporary and localized increase in downstream suspended solids concentration. However, dredging does not add significantly to ambient suspended solids concentrations in the UMRS (WEST 2000). Over 90 percent of the material dredged from main channel dredge cuts on the UMR is sand-sized material or larger, carrying very small concentrations of contaminants (e.g., heavy metals and organics). Contaminants are primarily adsorbed to finer silt and clay sized particles that typically are found in lower velocity areas downstream of metropolitan areas. On the Illinois River, much finer and more contaminated material is dredged than from the UMR. Although no detailed analysis has been conducted, it is believed that channel maintenance dredging mobilizes only a small fraction of the sediment contaminants in the UMR and IWW (WEST 2000).

Dredging disturbs main channel habitat, disrupting resident benthic macroinvertebrates and temporarily leveling the dune and swale bed forms ("sculpted" areas on the bottom, formed by hydraulic forces; they provide protected resting areas for some fish). However, channel bed forms reform rapidly. Moreover, most main channel dredge cut areas have unstable sand substrate that supports few species of mussels or other macroinvertebrates (MACTEC 2002, 2003b). Benthic macroinvertebrates recolonize disturbed riverbed areas through downstream drift, but may take at least one, and in the case of unionid mussels, several growing seasons to recolonize to predisturbance densities.

Placement of dredged material in shallow aquatic, wetland, and floodplain terrestrial areas changes habitat conditions at all but routinely used dredged material placement sites. Existing substrates, vegetation cover, and associated organisms are buried with washed sand. The rate of flora and fauna recolonization is dependent on a variety of factors (WEST 2000). However, this process is typically slow as the resulting sand deposits are generally unfavorable for recolonization by plants. Locations for dredged material placement vary by Corps District, but the general trend is toward placement out of the floodplain to minimize reintroduction of material, as well as maximize beneficial uses, such as island construction.

9.1.2.16 Recreational Boating

Recreational boating traffic affects the river environment in several ways, including noise, effects on water quality, sediment resuspension, effects on aquatic plants, disturbance of wildlife, bank erosion, disturbance of fish spawning, displacement of fish from shallow areas, fish entrainment mortality, and socioeconomic effects (Johnson 1994). The effects of recreational boating traffic on sediment resuspension and aquatic plants were examined in this study using an ecological risk assessment approach (Appendix ENV-J). A detailed assessment of the effects of recreational boating is included as Appendix ENV-J. In considering the effects of recreational boating traffic in a cumulative impacts context, this section presents a summary of these effects and their relationship to other ecological stressors, in particular commercial navigation.

9.1.2.16.1 Assessment Approach

The ecological stressors associated with recreational boating are primarily the hydraulic and acoustical disturbances (e.g., wake waves, propeller jet, noise) produced by passing boats, and the secondary effects of these disturbances such as sediment resuspension and bank erosion. The intensity and the spatial and temporal occurrence of these stressors are related directly to boating traffic. A recreational boating traffic forecasting and allocation model, a navigated areas Geographic Information System (GIS), an on-water survey of the UMRS recreational boating fleet, field experiments of wake wave generation and sediment resuspension, and literature review were done to characterize ecological stresses imposed by recreational boating traffic and to characterize risks (Appendix ENV-J). For this analysis, five vessel classes were differentiated: jet ski, fishing boat, medium powerboat, large cruiser, and houseboat.

The boating traffic forecast and allocation models, and the navigated areas GIS, provided the initial conditions of passage events/day/boat class/area that drive the hydraulic effects models for wake waves and sediment resuspension. Data on sediment concentrations were used as input to models simulating effects on aquatic plant growth and reproduction. The wake wave estimates by vessel class, the navigated areas GIS, and the bank erosion GIS were used to identify areas vulnerable to accelerated bank erosion. Estimates of the water entrained through recreational boat propellers were used to assess the relative impact of recreational boats on entrainment losses of fish.

Many unknown or poorly quantified factors may ultimately influence future recreational boating levels on the UMRS. Some of these factors include the future conditions of infrastructure that supports recreational boating on the rivers, and the overall environmental quality of the rivers and adjacent public lands. Other factors include social and economic conditions. Unconstrained traffic growth projections were made, assuming that access facilities, traffic intensity, and natural resource/economic conditions would not limit growth of boating activity on the UMRS.

The total projected growth in boating trips from the year 2000 to 2050 is 19.6 percent for the UMRS as a whole, ranging from 16.0 percent for the Mississippi River (Rock Island Corps District) to 22.3 percent for the Illinois River. These system-wide figures compare very closely with the U.S. Forest Service's nationwide regional demand projections for powerboating (English et al. 1993). In that study, powerboating was projected to increase by 20 percent from 1987 to 2040 in the North region (which includes the five States bordering the UMRS plus 15 other Great Lakes and East Coast States). However, the approach taken for the UMRS suggests that sub-regional growth is expected to vary substantially. Pool-level growth projections for the UMRS range from approximately 4 percent to over 40 percent across the system. The major portion of the projected growth is expected to occur in a few concentrated areas near metropolitan areas.

9.1.2.16.2 Areas Navigated by Recreational Boats on the UMRS

A GIS database of areas navigated by the different classes of recreational boats throughout the UMRS was developed through a series of workshops with people familiar with recreational boating use in their respective reaches of the system (Rust 1996a). Navigated areas were identified for each class of recreational boats, and identified as high-, medium-, or low-use areas relative to each navigation pool and river reach. Additional maps for seasonal use by vessel class were prepared for pools where the local experts identified seasonal (i.e., spring, summer, fall) differences in the spatial distribution of boating activity.

9.1.2.16.3 Allocation of Trips/Day and Vessel Passage Events/Day to Navigated Areas

The estimated numbers of boat trips per day by boat class in each navigated area throughout the UMRS were incorporated into a GIS database. This was accomplished by allocating the trips/pool/day/boat class across all the navigated area polygons in a pool for each boat class, to the high, medium, and low use area polygons following a 60 percent, 30 percent, and 10 percent allocation formula, respectively. The number of vessel passage events per day past any shoreline point was estimated by calculating distance traveled, using navigated polygon length (longest axis), information on the duration of boat trips, the amount of time spent operating on the water (from previous studies of boating on the UMRS), and the average operating speed of each boat class, as observed in the 1996 survey (Rust 1996b).

By combining the information described above, an average boat trip involves active time on the water of about 3 hours. Average active time and average operating speed (see below) were used to estimate distance traveled. Distance traveled and navigated area polygon length were used to estimate number of boat passage events per day for use in calculating sediment resuspension by boat wake waves in near-shore zones (see below).

After evaluation of the literature and the available data, it was determined that a predictive model for each vessel class was beyond the needs and the scope of the Navigation Study. Predictive wake wave models typically are based on the wave formed by a single vessel moving at a constant speed at a certain distance from the sailing line. A wide range of recreational boat hull types and operating speeds occur on the UMRS, and they do not follow distinct sailing lines. With these considerations, a table of maximum expected wave heights at distances from the sailing line for each class of recreational vessel was developed for use in conjunction with the navigated areas GIS, instead of a more detailed numerical model.

Recreational powerboats typically generate a series of about 12 wake waves during each passage event, of which the third wave usually has the maximum wave height. Recreational boat wake wave "trains" typically pass in about 24 seconds. In contrast, commercial tows generate wake wave trains that last about 7 minutes with 200 waves (Appendix ENV-J). These characteristics are typical for individual vessel passage events, and describe single wake wave trains. On the UMRS, most boat wake waves occur as single vessel passage events, except at peak times (e.g., holidays or weekends) in a few high-use areas.

9.1.2.16.4 Hydraulic Disturbances by Recreational Traffic

9.1.2.16.4.1 Sediment Resuspension

Wake waves from recreational boats can resuspend river bottom sediment as they travel through shallow water to reach shore. Resuspended sediment is maintained in suspension by turbulence in the water. Coarser particles settle out quickly, while finer particles remain in suspension longer. A numerical model was developed to simulate wake wave-induced sediment resuspension (Knight et al. 2000b, ENV 43).

9.1.2.16.4.2 Bank Erosion

An analysis was performed to assess correlation between locations of observed erosion with estimated wave heights produced by recreation craft in those areas. Approximately 57 percent of the unprotected main channel bankline was classified as moderately or severely eroded in areas where recreation craft produce up to 40-centimeter-high wake waves, whereas approximately 20 percent of this unprotected main channel bankline was classified as stable. Based on the results of this analysis, there appears to be a positive relationship between the height of waves generated by recreation craft reaching the bank and the occurrence of bank erosion along the main channel borders of the UMR.

Banklines vulnerable to erosion by recreational boat wake waves were identified according to a high/medium/low classification scheme, similar to that used in the bank erosion study and the backwater sedimentation study that was used to assess the potential effects of increased commercial navigation traffic. The classification was based on boat wake wave heights reaching the banklines.

Large cruisers operating within 300 ft of the bankline are the class of recreational vessels considered to produce the highest potential for bank erosion. Medium powerboats operating within 300 feet of the bankline or large cruisers operating 300 to 500 feet from the bankline are considered to pose a medium potential for bank erosion. All other vessel types are considered to pose a low potential for bank erosion, regardless of the distance at which they are operating from the shoreline (the next highest wave height was 16 centimeters for fishing boats within 100 feet).

The actual rates of bank erosion produced by recreational vessels are directly related to the traffic intensity. Banklines with a high potential for erosion that occur in areas with high boat traffic rates are probably eroded faster than in low traffic areas. Johnson (1994) found high rates of bank erosion in a UMR main channel reach with high recreational boat traffic rates, and much lower bank erosion rates in a nearby secondary channel that carries less boat traffic.

9.1.2.16.4.3 Propeller Entrainment of Water

The amount of water entrained through recreational boat propellers was estimated to compare to the amount of water (and fish) entrained through commercial towboat propellers. The amount of water entrained through the propeller is related to the propeller diameter, the pitch (distance the propeller would advance through the water in one rotation without slipping), and slip (the percent loss of forward travel due to friction of the hull and propeller with the water) (Table 11 Appendix ENV-J).

The existing (year 2000) and forecast (year 2040) recreational boating traffic estimates by pool and boat class, average on-water trip length from Carlson et al. (1995), and average observed on-water operating speeds (Rust 1996b) were used to calculate the total miles traveled by each class of boat during the April through August fish spawning season. An industry estimate (J. Bierman, Polaris Industries, Spirit Lake, Iowa, personal communication) was used to estimate the total amount of water entrained by personal watercraft. The estimates of miles traveled were multiplied by the typical water entrainment rates for each boat class to estimate the total amount of water entrained (Table 12 Appendix ENV-J).

Examination of the estimates summarized in Table 13 in Appendix ENV-J suggests that recreational vessels entrain a volume equal to approximately one-third (0.32) of the volume entrained by commercial vessels navigating the Upper Mississippi River in the year 2000. The recreational vessels entrain nearly one-sixth (0.15) of the volume entrained by commercial vessels on the Illinois Waterway. In the year 2040, the corresponding fractions are 0.34 for the Upper Mississippi River and 0.12 for the Illinois Waterway. These results indicate that recreational vessels appear to entrain volumes similar in magnitude to volumes entrained by the commercial vessels on the UMR-IWW.

9.1.2.16.5 Ecological Effects

9.1.2.16.5.1 Effects on Aquatic Plants

Recreational boaters navigate in the main channel, in secondary channels, and in backwater areas on the UMRS. In contrast, commercial tows navigate only in the main channel and larger secondary channels connecting to port and fleeting areas. Because recreational boats travel closer to shorelines and in backwater areas, they can cause plant breakage and resuspension of sediments in shallow areas due to action of wake waves. The resuspended sediment and reduced underwater light can limit plant growth and reproduction. Recreational boats operating in shallow areas can directly damage aquatic plants with propellers, and the propeller jets can resuspend sediment. The focus of the study of effects of recreational boat traffic on aquatic plants was limited to the main channel borders, in order to assess the cumulative effects of this stressor in context with the effects of commercial navigation traffic. There was no attempt to estimate the effects of recreational boats operating in shallow backwater areas.

Screening for potential recreational boat wake wave impacts on plant breakage indicates that most potential plant growth zones in the main channel border areas are vulnerable. Figure 9-7 is an example map illustrating the potential plant growth zones in a portion of Pool 13 that receive recreational boat wake waves equal to or greater than 20 cm maximum height, and where breakage of aquatic plants may occur. Only wake waves from medium powerboats and large cruisers have potential for damaging aquatic plants in the main channel border areas. Wake waves from the other classes of recreational boats were lower and probably do not result in breakage of aquatic plants.

Impacts on plant growth were estimated by interpolation and using the results of the impacts of commercial traffic on plant growth. Specifically, maximum growth of plants is assumed to occur under conditions of zero sediment resuspension from traffic. Using the recreational boating traffic forecast, the sediment concentrations associated with the maximum traffic impact for cells in each pool were simulated. For each of these maximum effect cells, the corresponding estimates of live and total biomass plant growth were obtained for the 50th-percentile sediment concentration and 1-meter water depth using the same plant growth models used to assess the effects of commercial traffic (see Appendix ENV-H). Two elements allowed estimation of the plant growth that would occur as a result of the traffic from each vessel type, in each navigated area polygon, and in each zone of a given pool: 1) using the sediment concentrations and plant growth model results for each of the two plant species, wild celery and sago pondweed, available for each pool between UMR Pool 4 and Pool 13; and 2) the assumption that an inversely linear relationship between plant growth and sediment concentration is valid. A GIS database of estimates of total (live and dead) plant biomass reductions due to sediment resuspension by recreational traffic was developed, in conjunction with the navigated areas GIS.

Pool-wide impacts on plant growth from each vessel type were then estimated using a weighted averaging scheme that used the areas and number of navigated areas polygons with high, medium, and low traffic intensities and identified impact areas in buffer zones around each polygon.

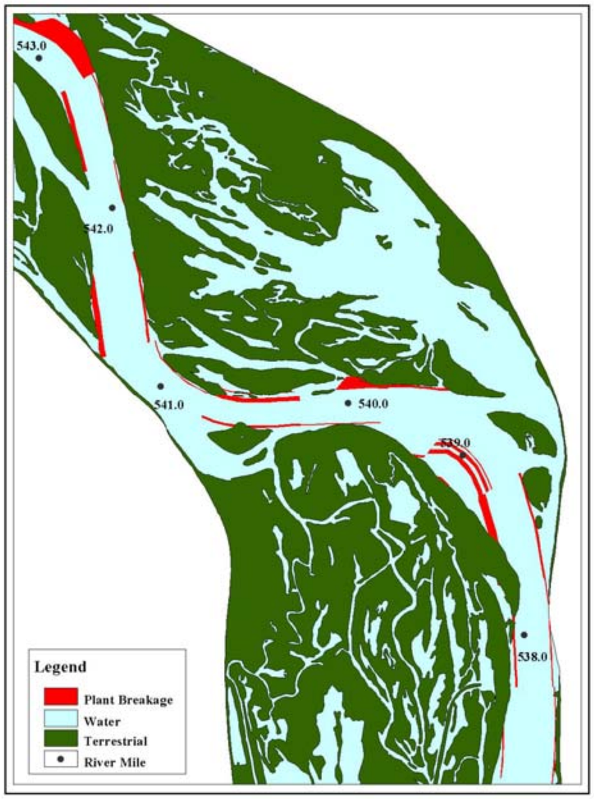

Figure 9-7. Recreational boat impacts on Pool 13 channel border habitats.

Recreational boating traffic by large cruisers on the UMRS is predicted to produce the most sediment resuspension and suppression of growth for both wild celery and sago pondweed. Tables of plant growth reduction estimates are provided in Appendix ENV-J. The greatest estimated impacts on the growth of wild celery are predicted due to large cruisers in the main channel border areas of Pools 4, 7, 8, 9, and 10, with nearly a 100 percent decrease in growth. Suppression of wild celery growth by large cruisers is predicted to be significant in most of the other pools as well. Large cruiser traffic is estimated to exert the most impact on the growth of sago pondweed in main channel border areas of Pool 10, again with nearly a 100 percent decrease in growth. It is estimated that large cruiser traffic would also have severe impacts on the growth of sago pondweed in the main channel border areas of most of the other pools.

Medium powerboats are predicted to exert the most impact on the growth of wild celery in Pools 4, 6, 7, 8, 9, 10, and 11, with more than a 60 percent decrease in plant growth. Wild celery growth is predicted to be significantly decreased in most of the other pools from the passage of medium powerboats. Medium powerboats are predicted to exert the most impact on the growth of sago pondweed in Pools 9, 10, and 11, with more than a 60 percent decrease in growth. Sago pondweed growth in most of the other pools is also predicted to be significantly affected by medium powerboat traffic. Fishing boats are predicted to exert the most impact on the growth of wild celery in Pools 4, 8, and 10, with nearly a 10 percent decrease in growth. Fishing boats are predicted to have the most impact on the growth of sago pondweed in Pool 10, with about a 5 percent decrease.

Because they usually generate low-amplitude wake waves, passage of houseboats, jet skis, and pontoons is not likely to suppress the growth of aquatic plants in UMR Pools 4 through 13.

These results indicate that the risk assessment models are conservative, because some submersed aquatic plants persist in the main channel borders of Pools 4, 7, 8, 9, and 10 where recreational boat traffic is high and the models indicate near complete suppression of plant growth due to sediment resuspension. Although sediment samples were obtained and analyzed in the main channel border areas, sediment types are not homogeneous in the channel border areas, and some areas have sediment that is resistant to resuspension (sand without much fines).

Submersed aquatic plants that grow in the main channel borders of the UMR tend to occur in different growth forms (small mounded patches) than the extensive beds in backwater and impounded areas (McConville et al. 1998). These patches are resistant to current and may also be more resistant to the hydraulic stresses imposed by navigation traffic than plants growing in areas without much wave action and current. These patches trap sediment and result in mounds that elevate the plants above the surrounding substrate, enabling them to obtain more light than plants growing in deeper water. This growth form, once established, may allow submersed plants in the main channel borders to grow in more turbid conditions.

The results also indicate that wake waves and sediment suspended by recreational boat traffic are significant stressors on submersed aquatic plants in the main channel borders of the UMR.

9.1.2.16.5.2 Effects on Fish

Recreational boats operate at higher speeds and can kill fish by direct impingement with propellers. Fish that swim near the surface in channel areas, such as gars and paddlefish, are at greatest risk. Although no studies of fish mortality induced by recreational boating traffic have been conducted, paddlefish in the UMRS are found with wounds indicative of recreational boat propellers (S. Zigler, U.S. Geological Survey, Biological Resources Division, La Crosse, WI, personal communication).

Fish eggs, larvae, and juveniles can be killed by entrainment through recreational boat propellers and jet pumps. The impact mechanisms include acceleration/deceleration, change in pressure, shear, and direct impingement of fish on propellers. The stresses imposed on fish eggs and larvae and juveniles entrained in the propeller flow include acceleration/deceleration, change in pressure, shear, and the potential for direct impingement. These hydraulic stresses and potential for impingement on fish entrained through recreational boat propellers are probably greater than on fish entrained by commercial vessel propellers (see Sections 8.5.1.1.1, 8.5.1.1.2, and 8.5.1.2.2) given that recreational boat propellers are much smaller and rotate much faster than propellers on towboats. The percent survival of fish eggs, larvae, and juveniles entrained through recreational boat propellers is probably lower than the survival of fish entrained through towboat propellers.

Table 12 Appendix ENV-J summarizes the amounts of water estimated to be entrained by six classes of recreational vessels for the impounded reaches of the Upper Mississippi River and the Illinois Waterway for the April–August recreational boating season. Importantly, many UMR-IWW fish species spawn during this period. Entrainment volumes were estimated for recreational traffic intensities for the baseline year 2000 and the year 2040. Corresponding summaries were developed for volumes entrained by commercial vessels (Table 13 Appendix ENV-J).

Examination of the estimates summarized in Table 13 suggests that recreational vessels entrain a water volume equal to approximately one-third (0.32) of the volume entrained by commercial vessels navigating the Upper Mississippi River in the year 2000. The recreational vessels entrain nearly one-sixth (0.15) of the volume entrained by commercial vessels on the Illinois Waterway. In the year 2040, the corresponding fractions are 0.34 for the Upper Mississippi River and 0.12 for the Illinois Waterway. These results indicate that recreational vessels appear to entrain volumes similar in magnitude to volumes entrained by the commercial vessels on the UMR-IWW. These results also suggest that corresponding rates of fish entrainment mortality induced by recreational boating traffic may be a stressor of similar magnitude to fish entrainment mortality induced by commercial vessel traffic.

9.1.2.16.5.3 Effects on Mussels

Recreational boats can affect mussels and other macroinvertebrates through scour by propeller jets and by wake waves and sediment resuspension. Recreational boats on the UMRS have relatively shallow draft and may disturb only limited areas where mussels occur. Shallow areas along beaches are most frequently scoured by recreational boats as boaters apply power to beach their boats and depart from shore.

9.1.2.16.5.4 Effects on Wildlife

Recreational boating activity can have a variety of effects on wildlife (Liddle and Scorgie 1980; York 1994). The visual presence and sound of recreational boats causes fright-flight reactions in fish, birds, and furbearers. The degree of disturbance and energetic costs depend on the species, time of year, and the acclimation tolerance to boating traffic. Large aggregations of migrating waterfowl can be flushed by recreational boats, at a potentially large energetic cost to individuals. The flushing distance seems to be variable, depending on the species and time of year. Prescriptive and voluntary refuges have been established in a number of areas frequented by migrating waterfowl along the UMRS to limit disturbance by recreational boaters. Nesting birds along the river, such as ospreys and eagles, exhibit behavioral indications of disturbance when recreational vessels approach too closely. Increased suspended sediment in near-shore zones reduces feeding efficiency and increases energetic cost of foraging for sight-feeding fish and for fish-feeding birds. Reduced growth of submersed aquatic plants due to sediment resuspended by recreational boats limits food and cover for fish and waterfowl. Intensive beach use by recreational boaters probably limits nesting habitat and nesting success by turtles.

9.1.2.16.5.5 Effects on Water Quality

In addition to the sediment resuspension by boat wake waves described above, recreational boating traffic affects water quality by release of nutrients from the resuspended sediment (Moss 1977; Munawar et al. 1991; Yousef et al. 1978; Yousef et al. 1980) and from the release of unburned fuel and combustion products into the water (Schenk et al. 1975). Two-cycle outboard engines discharge as much as 30 percent of fuel used unburned into the water, along with combustion products. The advent of unleaded gasoline, and significantly more efficient and cleaner-burning outboard engines, has reduced discharge of petroleum products from boat engines.

9.1.2.16.6 Social and Economic Effects of Recreational Boating Traffic

9.1.2.16.6.1 Recreational/Commercial Traffic Conflicts

Early recreational boating on the UMRS consisted of either muscle- and wind-powered craft or larger excursion vessels. The powerboat segment has grown considerably in the last two decades. Conflicts between recreational boaters and commercial navigation exist, with respect to lockage, navigation safety, and aesthetics.

9.1.2.16.6.2 Use of Locks

A correlation analysis of conflicts for lockage between recreational and commercial vessels, using lock performance monitoring system (LPMS) data (USACE 1999a), found that the greatest lockage delay times for commercial tows occur at locks with the highest commercial traffic and the lowest recreational traffic. Locks with the most recreational boat traffic had low levels of commercial traffic delay. These sites also appear to more efficiently lock recreational boats, as measured by the number of boats per lockage. The study concluded,

> "*Based on data trends, correlation analysis, and recreational craft lockage capacity, it does not appear that there are significant conflicts between commercial and recreational users of the UMR navigation system which result in increasing commercial delays*."

9.1.2.16.6.3 Navigation Safety

Large rivers such as the Mississippi and Illinois Rivers can pose significant safety hazards to recreational boaters. The fast currents and eddies in the main channel take many inexperienced boaters for unexpected rides. Woody debris and snags are always present. Recreational boaters can collide with the locks and dams and with the submerged wing dams. The "backrollers" in the dam tailwaters are hazardous to boaters who enter the restricted safety zones below the navigation dams. Moored barges and unlighted channel buoys are hazards to recreational boaters operating at night. Towboats pushing barges are faster than they appear, and pilots have limited ability to rapidly stop or turn. Many recreational boaters do not take appropriate action to yield the right-of-way or to pass tows safely. Incidents with intoxicated boat operators are unfortunately common. Many new boat owners purchase larger, high-speed boats and operate them with little training or experience. Despite the increased efforts of States, counties, and the Coast Guard to improve water safety, these situations result all too often in recreational boating accidents, loss of property, and loss of life.

In examining documented recreational vessel accidents involving commercial craft, it was found that the incidence of such events is quite low, at least in recent years. The expected increase in both recreational and commercial traffic will probably result in some increase in accidents, but it is expected to be minor.

9.1.2.16.6.4 Quality of Experience

Commercial navigation on the UMRS is appealing to many, as indicated by the many visitors to the locks and dams, towboat "spotters," and the widespread interest in navigation history. But to others, these features, and commercial vessels themselves, detract from the aesthetic appearance of the river. Recreational boaters, particularly in smaller vessels, are justifiably wary of passing tows because of their deceivingly fast speed, looming bulk, the accompanying drawdown and wake waves along shorelines, and the powerful prop wash and standing wake waves. With a potential increase in commercial traffic, some users may perceive some further diminishment in the aesthetics of their river experience.

9.2 Baseline Condition for Cumulative Effects Assessment

In light of the stressors just described, their combined effects on the physical and ecological conditions of the UMRS, and the perceived resilience of the system in absorbing or adapting to these stress effects, it is now possible to describe a "baseline condition" against which to weigh the implications of incremental, commercial traffic-induced impacts. Description of this baseline also draws on the conclusions and recommendations of the WEST 2000 Cumulative Effects Study, as well as the Long Term Resource Monitoring Program (LTRMP) Status and Trends Report (USGS 1999).

9.2.1 Physical and Hydrologic Condition

The effects of the 9-Foot Channel Navigation Project have been well documented and will likely remain the subject of continued study and debate. Variability in stage has been reduced as more stable water levels are maintained to support commercial navigation. The species, habitat, and process implications of the loss of floodplain connectivity have been termed moderate to high on the Mississippi River and degraded on the Illinois River (USGS 1999). Construction of river training structures, which began in the late 1800s, has narrowed and deepened the channel and increased sediment deposition in channel border areas, with these effects being most evident in the lower pools and the open river. Levees have isolated the rivers from their former floodplains, and much of this floodplain area has been converted to agricultural use. The result of sediment deposition and levee construction has been a loss of off-channel aquatic habitat as well as floodplain forest, wet meadow, and overall terrestrial habitat diversity.

Overall sediment transport capability has been diminished, and sediment deposition has increased, particularly in off-channel areas and in the lower portions of pools. Sedimentation may, in turn, contribute to poor water quality through increased turbidity. A steady increase in population and concurrent development of the riverside environment has contributed to water pollution, particularly downstream of major metropolitan areas. However, increases in water quality have substantial positive effects in recent years. Sediment and pollution effects have been particularly detrimental on the Illinois River, although legislatively driven efforts to improve water quality (i.e., the Clean Water Act) have substantially improved this particular condition on both rivers.

Though sedimentation effects (at least in terms of new deposition) have decreased in the last 10 to 15 years, it is not projected that sedimentation will lessen as an issue on the UMRS, particularly on the lower impounded portion (below Pool 14) of the Mississippi River and the lower Illinois River. A concerted multi-agency effort, on a broad watershed scale, will be required to examine, address, and reduce the sources of sediment input. It will also be important to maintain habitat rehabilitation programs to restore and improve sediment-affected habitats. Sedimentation affects not only the amount of habitat, but also the diversity and quality of remaining habitats.

The system has, to some extent, reached an equilibrium point after initial post-impoundment improvements in some aspects and declines in other river conditions. By all measures of river health, the system currently exhibits a generally declined ecological condition. The degree of decline varies by pool or river reach, and it is generally agreed that the Illinois River has been most severely affected. This system still has the capacity to recover, as the Illinois River has to some degree (Theiling 1999). This has happened in certain portions or with certain species or habitats, most notably fish and some macroinvertebrate response to improved water quality, floodplain forest regeneration in the unimpounded reach, and vegetation response to experimental water level drawdowns (USGS 1999).

9.2.2 Ecological Condition

9.2.2.1 Habitat Condition

There have been general decreases in off-channel habitats and increases in main channel and open water areas, although this varies by pool or reach (WEST 2000). Above Pool 13, the Mississippi River still exhibits an island-braided form, with good aquatic habitat diversity. From Pool 16 and below, and into the open river, off-channel areas become scarcer, and thus aquatic habitat tends to be more uniform. Island loss is most pronounced in the lower portions of pools in some reaches. Dredging and dredged material placement cause primarily short-term impacts to aquatic and terrestrial habitats, and efforts have increased to conduct long-term planning for these activities such that habitat impacts will be minimized. The Upper Mississippi River System Environmental Management Program, Habitat Rehabilitation and Enhancement Projects (EMP-HREP) have been the most concerted effort to restore and enhance aquatic habitats on the UMRS. The Corps' small environmental restoration project authorities are also being used to address mainstem problems.

On the Illinois River, habitat conditions have historically been considered more degraded than those on the Mississippi River. As described in Section 5.2.4, sediment and pollution effects have been severe; water quality has improved somewhat over time. Very little contiguous off-channel aquatic habitat remains, and what does remain is greatly affected by sedimentation. A predominance of fine sediments exacerbates the problems of sediment resuspension and turbidity.

9.2.2.2 Species Populations

As described in Chapter 5, freshwater mussel populations have been adversely affected by a number of factors, including overharvest, pollution, siltation, and recently, the exotic zebra mussel. Mussel habitat for both lotic (flowing water) and lentic (still water) species has remained stable or increased above Pool 12, and decreased somewhat in Pools 13 through 26. Numerous site-specific mussel surveys have been conducted, but systemic data and monitoring remains incomplete, with the exception of some endangered species monitoring. The full impact of the zebra mussel on the native mussel fauna is yet to be determined, at least on a macro scale; the presence of zebra mussels has been documented throughout the UMRS, but large fluctuations in geographic distribution and density have also been noted. Commercial navigation traffic is one among several dispersal mechanisms for zebra mussels; continued monitoring and assessment of zebra mussel population dynamics will be necessary to fully evaluate the role of, and possible response to, commercial traffic in terms of zebra mussel dispersal.

For some fish species, the carrying capacity has likely been reduced as the result of decreases in the quantity, quality, or access to suitable spawning habitat, available food resources, or overwintering areas (overwintering habitat has been cited by some river biologists as a key limiting factor for fish populations). At the same time, some fisheries resources have increased in population abundance and diversity in response to diminished ecological stressors (i.e., contamination) (Lerzak 1995). Similarly, habitat restoration efforts (e.g., backwater dredging, fish nursery areas) and natural flood events (e.g., the 1993 flood) have demonstrated that substantial fisheries improvements can occur through enhancing and restoring habitat or recreating natural hydrologic conditions (Sparks 1995). The WEST (2000) study summarized historic changes and current conditions of fish habitat by guild.

Aquatic vegetation status varies by pool, but is currently abundant only north of Pool 14. Since impoundment, submersed vegetation has declined due to sediment effects, particularly in the lower impounded reaches of the Mississippi River and on the Illinois River. Wind fetch effects also have negatively affected some of the pools above Pool 14.

A large number of exotic and nuisance species have become established in the UMRS, and have been summarized elsewhere in this document and in WEST (2000). In some cases, these species have had a substantial impact on native populations of fish, plants, or invertebrates through competition for resources, displacement, or introduction of alien pathogens that harm native species. Common examples include purple loosestrife, Eurasian watermilfoil, the common or European carp, several other Asian carp species, and the zebra mussel. These species can be difficult or impossible to eradicate, and it is likely that they will persist into the indefinite future, with varying consequences for native flora and fauna.

9.2.2.3 Ecological Processes

Fragmented longitudinal connectivity caused by navigation dams has affected species movements; some dams form complete barriers to fish movement while others permit movement under only certain flow or operating conditions. Interruption of fish passage has geographically limited some populations. Processes described in Chapter 5 – water flow, material transport, habitat formation and succession, and energy flow and food web – have been variously affected as the UMRS has aged. Water flow has changed in response to the lock and dam system and levees; flows have become more uniform, concentrated in the main channel. Material transport capability has changed; the lock and dam system does not allow a free flow of materials and encourages deposition. Formation and succession of habitats such as islands and off-channel areas has been altered as erosional and depositional forces have been influenced by impoundment of the system. Finally, flow of energy has probably changed in response to changes in vegetation abundance and composition and changes in the hydrologic regime and distribution of surface water. All of these processes are dynamic and would likely change rapidly in response to changed environmental or hydrologic conditions.

9.2.3 Socioeconomic Condition

Overall, socioeconomic conditions on the UMRS have improved dramatically since construction of the Nine-Foot Channel Project. The advent of large-scale, relatively cost-effective transportation of bulk commodities has, in turn, caused an increase in agricultural, commercial, and industrial development on or adjacent to the system. From 1930, when the project began, to the mid-1970s, tonnage shipped on the Mississippi River increased 120-fold (Merritt 1984). The project also evolved into a vehicle for significant employment during the height of the Depression (O'Brien et al. 1992).

Within three major areas (agriculture, commercial, and industrial development), most sub-sectors are expected to gain in employment at least through 2010, with the exception of farming and manufacturing. Likewise, population growth is expected to continue at a modest rate on most of the study area, particularly in urban areas.

The rivers heavily influence the economies of their adjacent counties and States, providing benefits from a variety of river-related activities and supporting thousands of related jobs. At the same time, both large and small river communities have capitalized on their riverside locations to promote and develop recreational, tourism, and aesthetic opportunities. According to Brey et al. (2000), the actual market area for the UMRS extends well beyond the five States that encompass the project study area, to include a total of 30 States and 2 Canadian Provinces. However, within the five UMRS States, Illinois is forecast to receive the largest potential benefit from any alternatives that may be implemented, as all alternatives involve construction in that State and Illinois is already a heavy user of the river system.

9.3 Cumulative Impact with Project Alternatives

With any project improvements, and thus increased efficiency, more commercial traffic is projected to transit the system during the course of a year. The study environmental impact assessment has focused on assessing the effects to resources of concern of this projected incremental increase in traffic. Therefore, the cumulative impact assessment will center around the additive or synergistic effects of increased commercial traffic on the significant biological and cultural resources of the UMRS, using as a baseline the resource conditions described in the preceding section/paragraphs. These significant resources were also identified and described more broadly in Chapter 5, and evaluated for likelihood of direct and/or indirect impacts of navigation traffic in Chapter 8.

9.3.1 Physical/Biological Resources

9.3.1.1 Fish

The potential for direct mortality to individuals and indirect effects (e.g., habitat alteration) on population productivity contribute to the cumulative impacts on fish in the UMRS. Many, if not all, of the ecological stressors described in Chapter 8 affect fish directly, indirectly, or in combination. In evaluating the cumulative impacts on fish in the UMRS, broad-scale impacts to fish populations in general should be distinguished from more localized species-specific impacts. Larger-scale, systemic cumulative impacts may negatively influence the distribution, abundance, and diversity of fish populations throughout the UMRS. In contrast, species- or site-specific impacts may be confined to certain habitat types, sections of river, or guilds of species. In assessing cumulative impacts, it must be recognized that some stressors will negatively affect fish in general (e.g., severe pollution), while other forms of stress (e.g., conversion from lotic to lentic environments) might benefit some fish species, while other species are negatively affected.

The cumulative impacts of multiple stressors might reduce the carrying capacity for fisheries resources in the UMR-IWW System. These examples underscore the observation that stressed fish populations can respond rapidly to even short-term alleviation of specific stressors; as carrying capacities increase in relation to diminished stress, many fish can rebound quickly to realize these capacities.

The concept of “compensatory reserve” is important in understanding the potential cumulative impacts of multiple stressors on fisheries resources. Fish populations, in general, suffer high rates of mortality of eggs and larvae, yet these populations can remain in approximate equilibrium as each adult need only replace itself during its lifespan. Incremental increases in stress-induced mortality might be compensated by increases in survival of the remaining individuals, because of less competition for food, cover, and other factors. As long as fish losses are within this compensatory reserve, there will likely be little measurable effect on the adult population. Historical observations have demonstrated the rather sudden and catastrophic collapse of fish populations where mortality or reduced production capacity compromised the compensatory reserves (i.e., Lake Michigan lake trout, North Atlantic cod fishery). While this concept is widely accepted in fisheries management, it remains nearly impossible to quantify this reserve for any of the 140+ UMRS fish species or the UMRS fishery as a whole. Given the adverse economic and/or ecological consequences of drastic decreases in population sizes, the evaluation of cumulative impacts to fish and fisheries should be conservative in approach. Conservatism is also warranted by the sparse data and information available to assess cumulative impacts. With the continued operation and maintenance of the 9-Foot Channel Project, it is unlikely that main channel navigation characteristics will fundamentally change. Associated rock channel training structures will not decline in the future as a result of the proposed action. There are also no substantial adverse changes to fisheries proposed for routine channel operation and maintenance. However, the cumulative impact on main channel ichthyoplankton (i.e., fish eggs and larvae) can be expected to increase in proportion to anticipated increases in entrainment by commercial/recreational vessels and impingement and entrainment by the increased water demands of industrial/municipal water intakes.

The average annual incremental losses of future adult fish due to entrainment of fish larvae by commercial vessels have been conservatively estimated for 25 representative fish species, without project and for each of the six project alternatives. The cumulative impacts over the 50-year project period (i.e., 2000 to 2050) of vessel induced loss of future adults have been similarly estimated for the six project alternatives. Large numbers of fish eggs or larvae found in the main channel planktonic drift include reproductive outputs that have been displaced from main channel borders or backwaters, the preferred spawning habitats of many fish species in the UMRS. These eggs and larvae would not likely survive regardless of possible entrainment by commercial vessels. To be consistent with a conservative evaluation of potential impacts, the entrainment of these eggs and larvae has been included in the overall assessment. In contrast, impacts to several species, including the freshwater drum, might be more substantial, because they spend most of their life history in the main channel environment.

The greatest potential for cumulative fishery impacts likely results from the continued degradation or loss of critically important habitat; for example, backwaters and secondary channels. A large number of the UMRS fish species depend on these areas for reproduction, early development, feeding, and overwintering; WEST noted three fish guilds that will likely be adversely affected by a continued loss of off-channel habitat. However, efforts in the last 10 to 15 years to restore or enhance critical off-channel habitats, including fisheries habitat, are expected to continue into the indefinite future. These programs will have some ameliorating effect on the impact of increased commercial traffic, which has the potential to exacerbate the degradation or loss of valuable fish habitat in the UMRS. Hence, the cumulative impacts of commercial traffic, added to other past, present, and predicted future stressors, may further diminish the longer-term diversity and abundance of fish in the UMR-IWW System.

9.3.1.2 Submersed Aquatic Plants

The two primary modes for cumulative submersed aquatic vegetation (SAV) impacts are from decreased light penetration due to increased turbidity levels (with resultant impacts to growth or reproduction) and physical damage resulting from increased water velocities. Wind- or vessel-generated waves can contribute to both the physical damage and sediment resuspension. The cumulative effect of land use/land cover, impoundment, and commercial/recreational navigation have collectively elevated the ambient turbidity levels such that SAV is scarce to nonexistent in the Illinois River and in the Mississippi River below Pool 13. Pollution is another factor that contributed to the virtual disappearance of aquatic plants on the Illinois River. Large areas of open water, particularly in Pools 7 through 10, exacerbate wind effects on plants as fetch lengths are increased. Loss or degradation of backwaters will also continue to limit the abundance of SAV. As noted above in the section on fish, continued implementation of habitat rehabilitation and restoration projects will likely contribute to some increase in SAV populations, at least in managed areas. Also, recent data (in the last 3 to 5 years) indicate that modified farming practices have had a role in reducing sediment inputs, and this trend is also expected to continue.

The proposed action is likely to contribute to adverse impacts on SAV through sediment resuspension and wave action (i.e., impacts to growth and direct breakage; no impact was determined on reproduction via reduced tuber production). The effects of increased traffic will be experienced predominantly above Pool 13; traffic effects are not expected to be substantial below Pool 13, but continued investigations will attempt to determine the extent and distribution of SAV in Pools 14 through 19 and the potential for traffic effects in these pools. Long-term data on plant beds from four areas in Pool 19 indicates wide fluctuations from year to year, but generally the same trend for each area. In the 1980s, these data depict increases in bed area, followed by steep declines through the early 1990s, with gradual increases from 1993 to 1996. The recent trend likely reflects the effects of the 1993 flood. Pool 13 itself could be considered a "threshold" pool in terms of suspended sediment levels and the ability to support SAV. Thus, slight increases in plant impacts due to commercial traffic may cause this threshold to be exceeded, resulting in major losses of plant populations within the pool.

Diversity and abundance of submersed aquatic plants are affected by a variety of environmental and physical factors, and are subject to considerable fluctuation in space and time. Drought and flood effects have been well documented (Rogers and Theiling 1999). Given this natural variability, and the need for continued research and data acquisition on plant populations, increased navigation traffic is expected to continue to contribute an additional, albeit minor (especially in Pools 4 through 13 where predicted traffic increases are smallest), negative effect on an already stressed resource. Lack of an impact finding on tuber production and survival does not point to cumulative effects through reduced reproduction.

9.3.1.3 Mussels

Unionid mussels are perhaps one of the most heavily affected biological resources found within the UMRS. Their overall abundance and diversity have generally declined by more than 50 percent in the last century. Their dramatic decline is primarily a result of their sensitivity to numerous stressors, especially pollution, impoundment, and exploitation. Several of these stressors will continue to threaten the viability of the UMRS mussel resource; indications are that the relatively recent introduction of the exotic zebra mussel will likely add to this threat.

Laboratory and field investigations conducted for the mussel impact assessment concluded that the proposed action is unlikely to contribute to additional adverse impacts on mussels.

9.3.1.4 Other Macroinvertebrates

The macroinvertebrate fauna consists of a variety of life forms and habitat requirements. Some groups prefer rock substrates, others are bottom-sediment dwellers, while others are closely associated with aquatic vegetation; within each of these broad groupings, further habitat specificity can occur (Sauer and Lubinski 1999; WEST 2000). Data on macroinvertebrate populations is very limited; systematic sampling of these organisms (fingernail clams and burrowing mayflies) only began with the LTRM program in the early 1990s, so long-term trends are difficult to determine on a widespread basis. Data compiled from 1992 to 1998 show a clear preference of the two study species for non-channel habitats, and total densities were consistently highest in Pool 13. Somewhat long-term data (yearly collection since the early 1970s) from Pool 19 has indicated wide fluctuations in macroinvertebrate populations, and evidence that extreme weather events, and related hydraulic conditions, have affected these fluctuations (Sauer and Lubinski 1999). In other pools, and particularly on the Illinois River, pollution has likely been a major factor affecting macroinvertebrate populations.

Based on a literature review and assessment of potential impact mechanism related to tow passage, it was determined that navigation traffic would have a negligible impact on macroinvertebrates. In the future, it is expected that continued improvements in water quality will benefit macroinvertebrates, and some preliminary studies of innovative channel training structures have demonstrated benefits in terms of benthic invertebrate species richness.

9.3.1.5 Waterfowl

Waerfowl populations in general, given their migratory nature, can be affected by a wide range of factors, many quite external to the UMRS (e.g., habitat conditions on breeding or wintering grounds, harvest pressure and regulation). The UMRS is a major flyway for migratory waterfowl, and some species also breed in the system; for example, the mallard, wood duck, and hooded merganser.

Diving duck use of the system is determined in large part by aquatic plant and macroinvertebrate distribution and abundance. Diving ducks have historically been most abundant in Pools 5, 7, 8, 9, 13, and 19; a strong relationship between scaup (*Aythya marila, A. affinis*) numbers and fingernail clam (*Musculium transversum*) abundance has been observed in Pool 19 (USGS 1999). Divers can be found frequently in open water areas in and adjacent to the main channel. Future abundance of diving ducks will be determined in part by the occurrence of suitable aquatic vegetation, particularly tubers, which are another preferred food source. Dabbling ducks also rely on aquatic vegetation (more so emergent species) and invertebrates and are found more often in off-channel areas and backwater lakes. Dabbling duck populations generally decline on the lower pools as off-channel areas become scarce. On the Illinois Waterway, waterfowl populations in general have been adversely affected by losses of aquatic plants and invertebrate populations; duck numbers have remained relatively depressed, with dabblers virtually absent, and divers estimated at about 500,000 birds (Theiling 1999).

The navigation impact analyses considered hazing or other disturbance as the only potential traffic-related impact mechanism for waterfowl. It was concluded that no appreciable impact would occur to waterfowl from the potential increased passage of commercial vessels. Projected increases in recreational traffic, particularly as they may affect off-channel areas, could pose more of a disturbance threat to waterfowl in the future. Unpredictable factors outside the UMRS, primarily habitat-related, will continue as the primary influence on waterfowl populations, and it is not expected that incremental increases in commercial navigation traffic will add directly to cumulative impacts. However, traffic effects on plant populations could indirectly affect waterfowl through denial of habitat and food resources.

9.3.1.6 Backwaters and Secondary Channels

Sedimentation is the primary stressor that contributes to the declining health of these two important UMRS habitat types. While land use/land cover changes and impoundment largely influence the sediment load and deposition rates, a number of factors can influence the conveyance or distribution of sediments within the various river reaches. Shoreline erosion and resuspension of sediments in and along the main channel by commercial or recreational vessels can potentially result in the remobilization of depositional material, which may subsequently be transported into sensitive backwaters and secondary channels.

Numerous investigations have examined sediment dynamics and budgets in the UMRS; WEST (2000) attempted to incorporate several of these, along with a comprehensive summary of historical planform data. The WEST study also developed a sediment budget. The information is much too extensive to repeat here, and the reader is referred to the original report (Volume 1). It is clear that significant areas of backwaters and secondary channels have been lost due to sediment deposition since impoundment. These losses are most pronounced in the Mississippi River pools below Pool 13, and on the entire Illinois Waterway. However, in summarizing their results and those of several past studies, WEST (2000) noted a definite downward trend in sediment deposition in backwaters.

Development of the UMRS for commercial navigation, starting in the late 1800s, originally aimed to maintain sufficient depth for vessels by concentrating flow in the main channel via the use of wing dams and closing structures. This practice continued along with construction of the locks and dams, and the presence of these structures has contributed to altered sediment dynamics and deposition into off-channel areas.

For most of their study reaches, WEST (2000) forecast that contiguous and isolated backwaters would continue to be lost through 2050. The only reach in which this was not forecast to occur was Pools 5 through 9, and this is due primarily to continued erosion of islands resulting in increased aquatic area. Consultation with UMR resource managers also identified contiguous backwaters and secondary channels as the two most prevalent areas of predicted future loss (USACE 2000a). The impact assessment for this study identified a total of 11 backwaters and secondary channels on the Mississippi River with a medium potential for impact from increased tow traffic; similarly, 20 such areas were identified on the Illinois River. The Illinois River is particularly susceptible to filling of off-channel areas due to its generally finer-grained sediments and narrow width. Given the documented historical loss of these areas, and forecasts of continued loss into the future, the predicted impacts due to tow passage are determined to have a cumulative impact to this important resource.

9.3.1.7 Floodplain Forest

The development of the UMRS floodplain for agriculture, and logging for fuel wood and lumber, resulted in widespread conversion of the historic forest/prairie mosaic. Today, this cover type is confined primarily to a narrow strip on the riverward side of agricultural levees. Species composition of the remaining forest has also become less diverse, due in part to altered hydrology, a loss of the seasonal "flood pulse", and the effects of periodic severe flooding, particularly the flood of 1993; this is especially evident in the decline of mast-producing species such as oaks and hickories. Bank erosion also has affected floodplain forests to some degree.

Habitat enhancement and restoration projects are increasingly including mast-tree planting components as a project future. These efforts, while worthwhile, are limited in nature; significant restoration of bottomland hardwood forests may not be possible without acquisition of large tracts of land and restoring connectivity with the river floodplain. These efforts are expected to continue into the future.

Potential impacts to floodplain forests were considered in this study as part of the bank erosion study component. Overall, a relatively small percentage of the existing floodplain forest was identified as possibly being at risk due to vessel-induced erosion. However, because of the importance of this cover type, identified sites would be further assessed as part of a project recommendation. Projected increases in commercial traffic, with project, are not expected to constitute a cumulative impact to this resource.

9.3.1.8 Air Quality

National recognition of the need to address air quality problems began in the 1960s, and resulted in passage of the original Clean Air Act in 1963, and its succeeding amendments. Ambient air quality, at least in rural areas and in most urban areas, remains generally good despite the degree of population growth and industrial and commercial development in the UMRS. Some large urban areas, notably Chicago, the Twin Cities metropolitan area in Minnesota, and the St. Louis metropolitan area, continue to exceed EPA standards for some criteria pollutants as of 1998 (see http://www.epa.gov/oar/oaqps/greenbk). Barge and rail transportation were brought under EPA regulatory authority with the 1990 Clean Air Act amendments. Tiered emissions standards are now in place for locomotives, and the EPA recently proposed rulemaking for commercial vessels.

Given that commercial vessel emissions are considered a small component in overall air quality, and that new emissions standards will be in place by approximately 2010 for these vessels, it is not foreseen that an increase in commercial traffic would pose a cumulative impact to air quality. The effects of a shift to alternative transportation modes, in the absence of waterway improvements, was addressed by Tolliver (2000 and 2004).

9.3.1.9 Water Quality

As discussed earlier in this chapter, water pollution has constituted a major environmental stressor on the UMRS. Similar to air quality, historical disregard for discharge of pollutants into water bodies was recognized relatively recently, and addressed by landmark legislation that dramatically improved the UMRS, among many other degraded systems throughout the Nation. The Illinois River continues to exhibit degraded water quality, despite regulatory efforts, and the recent focus of concern throughout the system has shifted from point sources to non-point discharges. The cumulative effects of inadequately treated sewage and polluted runoff have been dramatically demonstrated in the hypoxic conditions in the Gulf of Mexico, the scope of which has become more apparent in the last 8 to 10 years (USEPA 2001).

Currently, water quality problems may arise on a site-specific basis, and similar to air pollution, problems tend to be most prevalent in the vicinity of major metropolitan areas. During large rainstorms, combined sewer overflows can overwhelm municipal sewage treatment facilities resulting in overflow of untreated sewage in urban areas of the UMRS. State and Federal regulations require municipalities and industry to meet strict guidelines, and with few exceptions, enforcement of these standards is strict. Along with the advent of Federal initiatives on improving water quality on a watershed scale (e.g., Clean Water Action Plan), it is expected that overall water quality in the UMRS will continue to show improvement in the future. Response to isolated spill incidents is under Coast Guard jurisdiction, and historically such incidents have been rare.

This study did not examine actual emissions from tows into the water, or disposal of garbage or other waste products. Such releases can emanate from both commercial and recreational craft, and in fact combustion by-products are more prevalent from recreational craft due to the relative inefficiency of their engines. From a cumulative impacts standpoint, this study examined the potential for increased hazardous spill incidents with a project, and concluded that there is little change in the risk of accidental spills with any of the project alternatives.

9.3.1.10 Land Use/Land Cover

Since impoundment, agriculture has been the major land use in the UMRS; the proportion of soybeans, as compared to other major crops, has gradually increased since that time (WEST 2000). This dominance is expected to continue into the foreseeable future. Increased emphasis on acquisition of floodplain lands for restoration purposes and nonstructural flood mitigation may reduce somewhat the proportion of land under production, but these changes may be balanced out by increases elsewhere. Any recommended plan under the navigation study will not pose a cumulative impact on land use/land cover; any site-specific construction impacts would be minor in scope.

9.3.1.11 Sedimentation

Mechanisms of sediment input, and the fate of these sediments, have been touched on in several of the preceding resource categories. The geomorphological development, basin and floodplain land use, and historic management of the Illinois River have resulted in a very high level of sedimentation effects; a low gradient, fine sediments, narrow channel, and main stem levees have all contributed to considerable loss of off-channel areas and silting in of backwater areas.

WEST (2000) found evidence that sediment inputs to the system have decreased since about 1950, due to improved agricultural practices and the construction of tributary reservoirs that trap sediments. The investigators also cited decreased dredging quantities since impoundment. Presently, sediment transport conditions were estimated by a budgeting exercise that considered a number of factors affecting input, storage, removal, and transport out of individual pools (WEST 2000). This exercise included the estimated backwater accumulation rates, and rates calculated from other studies, referred to in Section 5.2.3.1. Sediment loading from tributaries has decreased when comparing two broad time periods – post-impoundment to the mid-1950s, and mid-1950s to the present, and overall the sedimentation rate has decreased by at least a factor of two.

The dynamics of sediment transport, to some extent, remain unknown, and any trends and predictions can be upset by unpredictable events such as major floods or the uncertainty of future human activity in the watershed; thus the trajectory of the river and its floodplain, in terms of sediment accumulation and landscape change, remains somewhat uncertain (Soballe and Weiner 1999). The effects of navigation traffic, and the proposed project, do not directly affect sediment input and accumulation to the system; indirectly, an analysis of induced agricultural development indicated that the project would not cause appreciable increase in tilled land, and thus indirectly contribute further to runoff of sediments.

9.3.2 Social Resources

9.3.2.1 Population Characteristics

Following construction of the lock and dam system, many new residents migrated to the newly developed towns along the rivers. For the time period 1985-2000, population growth was fairly stable in the 78 counties along the rivers that comprise the study area. Current population projections indicate that growth will remain stable over the next several decades.

9.3.2.2 Public Facilities and Services

The lock and dam system is a public facility that has been used by both industry and recreation interests. Improving the system would temporarily affect the use of the locks and dams during construction; however, future impacts would be positive in maintaining and enhancing this vital component of the national transportation infrastructure. Ecosystem restoration would ensure that the river system continues to provide opportunities for recreation experiences throughout the river corridor into the future.

9.3.2.3 Employment and Labor Force

Construction of the locks had a major positive impact on employment and the labor force, both locally and regionally. Daily operation of the lock and dam system draws from the labor force around the site-specific locations. Proposed construction activities for navigation and ecosystem improvements would likely draw on a regional labor force, increasing employment opportunities throughout the area. Future employment increases would be related to employment opportunities that would develop stemming from improvements to the navigation system or the ecosystem.

9.3.2.4 Business and Industrial Activity

Water access critically influenced business and industrial development. In early years, the rapid growth of population in the region greatly accelerated demand for manufactured products, which significantly increased local business and industrial activity. Following the years of major expansion, growth in business activity tapered off and has been stable over the past several decades. Future impacts would be related to community and regional growth, as well as to growth of the transportation industry and related businesses.

9.3.2.5 Farm Displacement

Initial construction of the lock and dam system likely affected agricultural land, as that was the basic land use along the river at that time. From time to time, agricultural land has been used for placement sites and staging areas during construction; however, impacts have been minor since the land was returned to its original use following project construction. Future navigation improvements are not expected to result in the loss of additional agricultural land or farmsteads. A potential for future farm displacement exists at locations that would require acquisition of floodplain acres for ecosystem restoration measures. The recommended ecosystem management and restoration plan identified a total of 105,000 acres of floodplain restoration over 50 years. This is approximately 10 percent of the leveed floodplain.

9.3.2.6 Tax Revenues/Tax Base

A considerable increase in tax revenues from purchases being made for construction activities would have been experienced in the past. An increase or decrease in real estate value due to improvements at a site would change the tax base of a city and county; however, no appreciable changes are expected due to future improvements. Any long-term future impacts would be related to business and industrial growth.

9.3.2.7 Local Property Values

Changes in land use or zoning that affect property values and taxes have been minor following the completion of the lock and dam system. Long-term impacts would be related to community and regional growth and are undeterminable at this time.

9.3.2.8 Individual and Family Changes

Changes in daily living and movement patterns, social networks, and leisure opportunities as a result of the construction of the lock and dam system have been minor, and no significant changes in these areas are anticipated.

9.3.2.9 Regional Growth

The lock and dam system was a catalyst for significant growth of river communities and the entire Midwest region. Improvements to the navigation system and construction of the ecosystem restoration measures would provide positive impacts to regional growth that can be expected to continue into the future as a result of the direct and indirect effects of construction activity, expansion of existing firms, and establishment of new firms within the region

9.3.2.10 Aquatic Oriented Recreation

The lock and dam system has provided positive changes in the availability of this resource for leisure opportunity. Recreational vessel traffic is a significant component of total system traffic. Water-based activities dominate recreation use throughout the UMR-IWW, with over 12 million daily visits occurring in the most popular activities of boating, boat fishing, and sightseeing. These visits supported over $1.2 billion in national economic impacts (1990 price levels) and over 18,000 jobs nationwide. Overall, the ecosystem restoration alternative would have a net positive effect on UMRS ecosystem goods and services including aquatic oriented recreational opportunities. Recreational boating could be negatively affected by the water level management alternative, however, recreational boating would see and overall increase in benefits due to additional aquatic areas made accessible through alternative plan backwater and side channel restoration measures.

9.3.3 Cultural Resources

The systemic impact of increased commercial navigation on significant cultural resources has been determined to be bank erosion as a result of waves, drawdown, prop wash, and near-shore activity such as fleeting, temporary mooring, and barge terminals. Approximately 420,000 meters of potential bank erosion areas were evaluated for the Corps by Bear Creek Archeology (BCA) of Cresco, Iowa on the UMR and the Illinois State Museum Society (ISM) of Springfield, Illinois on the IWW. These investigations determined that there are 26 known National Register of Historic Places (NRHP) eligible archeological sites and 67 potentially eligible sites located adjacent to potential bank erosion areas. Bank erosion monitoring has been initiated at some of these sites and up to 50 meters of shoreline erosion has been documented to have occurred on or adjacent to the archeological sites over the last seventy years. It is anticipated that bank erosion resulting from increased commercial navigation will likewise increase and that the cumulative effect will be negative impacts to both documented and undocumented archeological sites.

The UMR and IWW project areas include NRHP eligible multiple property nominations for the Upper Mississippi River 9-Foot Navigation Project, 1931-1948 and the Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945. The Upper Mississippi River 9-Foot Navigation Project 1931-1948 nomination recognizes 25 multiple property historic districts, delineates the district boundaries, categorizes the 158 contributing and 409 noncontributing resources within those districts, and defines architectural and engineering significance. The Chicago to Grafton, Illinois, Navigable Water Link, 1839-1945, nomination identifies 8 historic districts and 72 contributing resources within those districts. Site-specific measures will result in potential adverse effects to individual historic districts or contributing resources. These adverse effects will be treated in accordance with stipulations in the Programmatic Agreement (PA) in full compliance with the NHPA, however the cumulative effect of multiple site-specific measures and adverse effects may result in negative impacts to the NRHP eligibility status of the UMR and IWW multiple property nominations.

9.4 Summary of Cumulative Impacts

Based in large part on the cumulative effects assessment conducted for the Navigation Study by WEST (2000), and other sources, a qualitative assessment of potential cumulative effects was conducted for three major resource categories. The objective of this assessment was to consider, in accordance with CEQ guidelines, the effects of the proposed action in light of all past, present, and reasonably foreseeable future actions. The period of assessment included the time period immediately following construction of the 9-Foot Channel Project up to the end of the Navigation Study planning period (2050). Numerous ecological stressors were evaluated in the context of their historical effects and contribution to the current state of the UMRS. The assessment acknowledged the tremendous changes brought about by construction of the 9-Foot Channel Project, many of them negative, and in some ways still manifested today (Table 9-3 and Table 9-4). Where significant cumulative effects are forecast, measures will be incorporated into the overall mitigation planning process to avoid, minimize, or mitigate for these impacts.

Table 9-3. Historic change in UMR planform features from pre-dam to post-dam periods (MC = main channel, SC = secondary channel, CB = contiguous backwater, IB = isolated backwater, AI = area of islands, PI = perimeter of islands, TOW = total open water).

Pool	Years	MC	SC	CB	IB	AI	PI	TOW
		acre	acre	acre	acre	acre	ft	acre
4	1930 - 1973	1,600	-75	5,508	277	-1,273	211,500	7,310
5	1930 - 1973	1,004	911	3,629	71	-1,638	194,900	5,614
5A	1930 - 1973	-208	504	1,579	232	-3,969	119,150	2,107
6	1930 - 1973	-210	414	634	1,215	-1,107	-2,200	2,053
7	1930 - 1973	83	5,185	1,376	129	-7,806	107,950	6,773
8	1930 - 1940	1,654	4,407	5,933	250	-8,070	845,580	12,245
9	1930 - 1973	462	9,444	3,835	42	-15,173	84,710	13,783
10	1930 - 1973	171	1,327	4,094	-95	-2,509	513,929	5,496
11	1930 - 1949	9,249	2,958	1,697	-690	-2,144	171,500	13,213
12	1930 - 1940	896	2,421	758	-390	-1,598	274,250	3,685
13	1930 - 1975	7,399	933	2,862	-977	-5,982	-353,200	10,216
14	1930 - 1940	601	182	1,525	-233	-139	323,000	2,075
15	1930 - 1937	-17	35	39	-3	-57	-16,000	55
16	1930 -1975	137	586	497	293	-1,512	37,800	1,513
17	1930 - 1940	40	184	191	232	-109	43,500	646
18	1930 - 1940	2,716	-835	1,550	105	-1,849	60,400	3,536
19	1930 - 1940	-2,853	156	-521	330	-257	68,180	-2,888
20	1930 - 1975	-871	195	-12	31	38	-3,650	-657
21	1930 - 1975	-434	-489	594	-101	-76	24,280	-430
22	1930 - 1975	-61	-479	151	18	-345	15,500	-371
24	1930 - 1989	-28	-552	438	380	368	84,250	238
25	1930 - 1989	61	-450	1,913	90	976	282,460	1,614
26	1930 - 1975	5,496	715	956	1,279	1,499	253,000	8,446
	TOTALS	**26,886**	**27,675**	**39,225**	**2,483**	**-52,731**	**3,340,790**	**96,270**

Table 9-4. Predicted change in UMR planform features from pre-dam to post-dam periods (MC = main channel, SC = secondary channel, CB = contiguous backwater, IB = isolated backwater, AI = area of islands, PI = perimeter of islands, TOW = total open water).

Pool	Years	MC	SC	CB	IB	AI	PI	TOW
		acre	acre	acre	acre	acre	ft	acre
4	1989 - 2050	-236	0	-1,021	-47	744	230,520	-1,304
5	1989 - 2050	362	-360	1,108	0	-647	-123,226	1,110
5A	1989 - 2050	84	-68	459	-3	533	35,589	472
6	1989 - 2050	84	-68	459	-3	533	35,589	472
7	1989 - 2050	88	-373	155	32	283	24,934	-98
8	1989 - 2050	889	-467	55	64	-2,541	-329,382	541
9	1989 - 2050	340	932	1,082	0	-2,025	-157,658	2,354
10	1989 - 2050	389	279	-1,316	123	-311	-178,393	-525
11	1989 - 2050	-1,973	-193	144	-53	60	-27,835	-2,074
12	1989 - 2050	295	0	-145	-4	-152	0	146
13	1989 - 2050	0	0	-62	-159	367	0	-221
14	1989 - 2050	0	0	-329	-59	0	-137,055	-388
15	1989 - 2050	0	0	0	0	0	0	0
16	1989 - 2050	192	266	-6	-87	0	40,070	365
17	1989 - 2050	0	-69	0	-53	77	4,200	-122
18	1989 - 2050	-361	0	-406	-38	287	28,070	-805
19	1989 - 2050	-1,165	-539	-250	-95	1,089	-70,190	-2,049
20	1989 - 2050	0	-55	0	-12	0	0	-67
21	1989 - 2050	-74	-323	-226	-11	0	0	-634
22	1989 - 2050	0	-91	-54	-14	0	0	-159
24	1989 - 2050	-105	-62	-33	-21	-100	803	-221
25	1989 - 2050	-174	-69	-42	-23	140	7,705	-308
26	1989 - 2050	-105	-404	-248	-385	0	0	-1,142
	TOTALS	**-1,470**	**-1,664**	**-676**	**-848**	**-1,663**	**-616,259**	**-4,657**

9.4.1 Biological Resources

Cumulative impacts were predicted for fish, submerged aquatic vegetation, and backwaters/secondary channels on the Mississippi and Illinois Rivers. With the exception of fish, these impacts are predicted to be minor; the proposed project would continue to contribute to an already degraded fisheries resource. In general, these impacts could be offset by an adaptive environmental restoration approach that focuses on the re-creation or enhancement of key processes (periodic drawdown, connectivity) and habitat features that have been degraded or lost.

Specifically, mitigation that focuses on perceived constraints on fish population size may be a useful approach to addressing potential cumulative impacts; estimating sufficient compensation for calculated direct impacts to fish may prove problematic, and an approach that emphasizes the enhancement of fish production and survival would address the effects of entrainment mortality and long-term population viability. “Systemic” measures such as improved fish passage at dams, alternative pool level management, and changes to navigation operations have been proposed to address direct navigation impacts; with appropriate monitoring and maintenance, these measures can also provide long-term benefits over the duration of the project life.

Submersed aquatic vegetation populations have been adversely affected by a number of factors, including commercial and recreational boat traffic. Additional traffic on the system is predicted to add to historic declines in SAV, and synergistically, could affect food and cover resources for other river organisms such as fish and invertebrates. Efforts to reduce sediment input from the surrounding watershed, in addition to mitigative measures such as island construction, revetments, and alternative pool level management, would likely benefit aquatic plant populations.

Vessel-induced resuspension and transport of sediments to off-channel areas was determined to be a threat to approximately 35 specific sites on the system. While a relatively small proportion of the total number of areas studied (just over 300), this predicted level of impact comes against a background of historic and current degradation and loss of off-channel areas. Ameliorative measures include reduction of sediment inputs, and protective barriers and/or restoration of degraded areas.

9.4.2 Social Resources

Nearly all socioeconomic factors evaluated would likely benefit from positive impacts in a cumulative sense. The acquisition of farmland for ecosystem restoration measures would have negative effects on potential grain yields as agriculture fields were taken out of production. Increases in noise levels during construction would be a negative future impact for both ecosystem restoration and navigation system improvements.

9.5 Ecosystem Sustainability in the Context of Cumulative Effects

The analysis and understanding of cumulative effects acting on the UMRS ecosystem presented above provided an important context for developing the ecosystem restoration alternatives. The documented historic change in land cover (habitat) diversity, resulting from cumulative effects, informed the creation of a virtual reference for ecosystem sustainability. The identification and quantification of habitat altering processes that will continue to affect the system in the future helped establish both the level and type of measures needed for ecosystem maintenance and restoration.

The without-project future for the UMRS ecosystem would include fewer backwater acres, less water depth in non-channel habitats, degraded forest structure and land cover diversity (see Table 9-3, Table 9-4, and WEST Consultants Inc. 2000), and uncoordinated floodplain management. UMRS natural resource mangers and the public emphasized this degradation of aquatic habitat quality when surveyed for the Upper Mississippi River Habitat Needs Assessment (USACE 2000). The natural resource managers identified deep backwaters, grasslands, hardwood forests, and marsh habitats as most threatened. River regulation, sedimentation, and floodplain development were rated as the primary stressors. The public identified water quality, sedimentation, and backwater and wetland degradation as significant problems. The game and non-game animals that depend on the diverse river ecosystem would decline commensurate with the decline of river habitats (WEST Consultants Inc. 2000).

There has been a gradual decline in the UMRS ecosystem health, or quality. Current levels of environmental management and restoration have not prevented system-wide habitat degradation in the past and will likely not meet existing habitat needs in the future. Increased efforts to reverse impoundment effects on aquatic habitats, vegetation succession, and forest health will be required to sustain ecosystem values.

The ecosystem restoration alternatives developed for this study were structured to address aspects of a sustainable ecosystem associated with the Navigation project. Various level of investments and combination of measures were considered in developing ecosystem restoration Alternatives (Figure 9-8). It is important to note that none of the UMR-IWW Navigation Feasibility Study ecosystem restoration alternatives fully achieves virtual reference condition because many issues are beyond the reach of the navigation system. True sustainability can only be met through the integration of upland and mainstem resource objectives and management actions. Integrated planning will be required to optimize the national benefits achieved from efficient and effective adaptive river management.

The adaptive implementation of a dual-purpose authority including the recommended Ecosystem Restoration Alternative will contribute significantly in offsetting the cumulative effects including the ongoing effects of operation and maintenance of the navigation project.

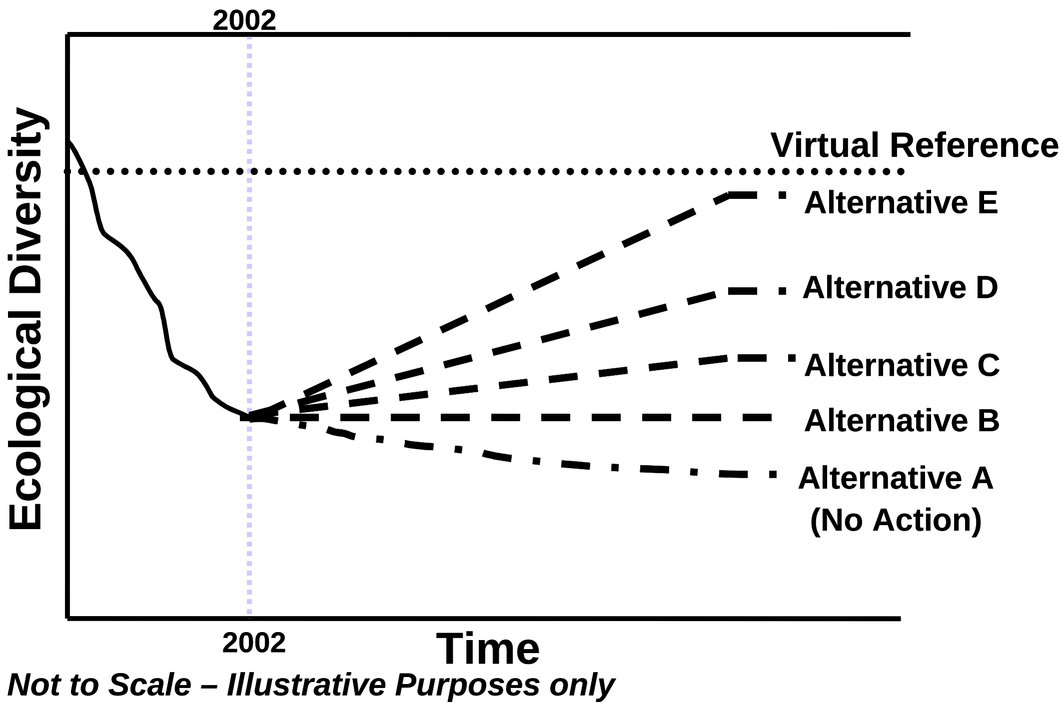

Figure 9-8. Schematic representation of how environmental alternatives help achieve desired ecosystem conditions (no scale implied).

10.0 ADAPTIVE MITIGATION

This chapter characterizes significant resources and associated adverse impacts; describes potential avoid, minimize and mitigation measures; and provides mitigation cost estimates (in Year 2003 dollar values) for implementation of navigation efficiency measures (Alternative 4, Alternative 6, and Alternative 4 & 6) for the Navigation Study. A programmatic mitigation strategy was not developed for ecosystem restoration measures (Alternative D prime) (D*) due to the anticipated overall beneficial environmental effects of ecosystem restoration. However, prior to implementing any ecosystem restoration measure, a site-specific evaluation will be made, including National Environmental Policy Act (NEPA) documentation that could describe appropriate mitigation. Mitigation strategies were developed for Navigation Alternatives 4, 5, 6, and 4 & 6 including the recommended plan, to support the National Economic Development (NED) analysis. Mitigation strategies were not developed for Alternatives 1, 2, and 3 because these alternatives would have no construction or site-specific impacts, nor will they result in any increased traffic effects.

10.1 Development of the Mitigation Strategy

The Council on Environmental Quality (CEQ) has identified five components to mitigation. These include: 1) avoiding the impact altogether by not taking a certain action or parts of an action; 2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; 3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and 5) compensating for the impact by replacing or providing substitute resources or environment. Under an adaptive management strategy, the adaptive mitigation plan will be revisited over the project life to ensure that mitigation measures are appropriate over time. Further refinement of the combinations, timing, and placement of management and restoration measures will occur during detailed planning for individual mitigation projects and during monitoring.

Avoid and minimize measures were considered as part of this analysis through the No Project alternative and through measures such as scheduling, tradable permits, speed regulation, and alteration of sailing line. The following measures were considered infeasible in terms of their effectiveness and likelihood of implementation and enforcement: scheduling, speed regulation, and alteration of sailing line. Distance from sailing line is an important input parameter in determining potential impacts, given that relatively small adjustments could result in considerable impact reductions. However, in examining planform data and the prevalence of existing navigational structures, even small adjustments were physically impossible, or presented the possibility of simply "shifting the problem" to another location. A further description of these alternatives and why they were eliminated from detailed study can be found in Chapter 6.

Other minimize measures such as scheduling have been recommended. An appointment system, which gives operators the ability to call ahead one or more locks to schedule locking times, now occurs on an informal basis at some locks during busy periods. The opportunity to expand the use of such an appointment system was explored as a minimization measure but was determined to be ineffective (USACE 2003). The Corps will also continue to update the Operation and Maintenance of Navigation Installations (OMNI) Reports posted on the Internet. This web page describes vessel locations and queued vessel information for the inland navigation system (including the Upper Mississippi River-Illinois Waterway (UMR-IWW) system). This real-time information aids commercial navigators in self-scheduling and to some degree minimizes traffic congestion.

There are many restoration measures to compensate for unavoidable impacts of the proposed action. A detailed description of most of the measures identified within this mitigation plan can be found in Chapter 6. Those mitigation measures not described in that chapter are detailed in this mitigation plan.

Making decisions and creating a mitigation strategy to address and resolve the complex assortment of ecological needs and objectives within the UMR-IWW should be conducted in the context of a long-term commitment to a policy of adaptive management. Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses mitigation actions as tools not only to address project-related impacts but also to learn about those impacts. Adaptive mitigation actions have the leeway to modify mitigation features and measures based on field results and future river conditions to ensure mitigation is effective. This chapter identifies mitigation measures that are considered appropriate by today's standards. Through the adaptive management process, it is expected that individual measures will change with time but the need to mitigate for specific components of the plan at the locations described within this chapter will remain constant.

There are two main components to the mitigation plan for the Navigation Study. The first component is the mitigation for the site-specific impacts from construction of the measures. The second component is mitigation for the impacts as a result of an incremental increase in navigational traffic on the system. The five major parts of the incremental effects mitigation strategy include:

Fisheries
Submersed aquatic plants
Bank erosion
Backwater and secondary channel sedimentation
Historic properties

The need for an adaptive approach to mitigation was identified early in the planning process. A collaborative adaptive mitigation process is particularly important when complex processes are involved or the potential magnitude of the impacts is large. A successful adaptive mitigation approach must include appropriate oversight and interaction with regulators and the affected public. These issues are detailed in the Institutional Arrangements (Section 14.3.7) and the Environmental Effects (Chapter 8) parts of this report.

This plan is based on numerous internal discussions and presentations/coordination with the Navigation Environmental Coordination Committee (NECC) from 1997 to 2004. The plan describes appropriate mitigation based upon adverse ecological effects of the recommended alternative identified through scientific study and consultation with regional experts. The Corps is committed to completing appropriate mitigation for those lost ecosystem functions and values resulting from increased navigation and is willing to work with other agencies and programs collaboratively in the future to take advantage of mitigation opportunities that were not identified specifically within this document.

10.2 Timing of Implementation

The planning horizon for the Navigation Study is 50 years, during which technological and scientific advancements will likely improve our ability to identify and mitigate for adverse impacts. Alternative 4 mitigation would begin with the authorization and funding of the Navigation Study. The mitigation implementation schedule was developed so that mitigation measures would be in place to affect incremental increases in traffic resulting from the alternative. Implementation of the mitigation measures was planned so that they could be monitored and adjusted during the planning horizon (see Figure 10-1). As Alternative 4 mitigation is implemented, planning, engineering, and design will begin for Alternative 6 mitigation. This phased implementation strategy is referred to as Alternative 4 & 6 or the selected plan.

The CEQ NEPA Task Force (CEQ 2003) suggests that the effectiveness of adaptive management hinges upon: 1) the ability to establish clear monitoring objectives, 2) agreement on the impact threshold being monitored, 3) the existence of a baseline or the ability to develop a baseline for the resources being monitored, 4) the ability to see effects within an appropriate time frame after the action is taken, 5) the technical capabilities of the procedures and equipment used to identify the measure changes in the affected resource and the ability to analyze the changes, and 6) the resources needed to perform the monitoring and response to the results. These objectives would be considered throughout the implementation of the adaptive mitigation plan.

Mitigation will involve planning, construction, targeted research studies, and monitoring. The baseline conditions for the long-term evaluation of the mitigation efforts will be established through pre-construction studies. Both Pre- and Post-construction studies will continue throughout the planning and construction of mitigation measures to assess their effectiveness. In the final phase, performance monitoring will be used to assess the long-term effectiveness of mitigation measures so that changes can be made if these do not perform as expected over time.

This approach will be used to establish objectives, thresholds, and baseline conditions. Performance monitoring results will be presented in 5-year summary reports (Figure 10-1). These monitoring results, the assessment of project effectiveness, and the need for action will be reviewed periodically through an interagency coordinating committee.

	Year									
	1-10		11-20		21-30		31-40		41-50	
Construction - Alternative 4	■	■	■	■	■	■				
Construction - Alternative 6			■	■	■	■	■			
Construction - Alternative 4 & 6	■	■	■	■	■	■	■			
Construction – Mitigation Alt. 4	■	■	■	■	■					
Construction – Mitigation Alt. 6			■	■	■	■				
Construction – Mitigation Alt. 4 & 6	■	■	■	■	■	■				
Nav Effects validation studies[1]	■									
Model validation[2]	■									
Pre-construction studies	■	■	■							
Post-construction studies		■	■		■					
Long term performance monitoring			■	■	■	■	■	■	■	■

[1]Validation studies are needed to confirm effects of navigation for main channel effects on fishery.
[2] Field reconnaissance is required to verify that model-predicted impact areas and refine appropriate site specific mitigation measures to protect submersed aquatic vegetation and bank erosion.

Figure 10-1. General schedule for environmental mitigation and adaptive management performance monitoring compared with the construction schedule for Alternative 4, Alternative 6, and Alt 4 & 6.

10.2.1 Staged Mitigation

Uncertainty is a confounding factor in the assessment of mitigation under an adaptive management framework. The recommended plan for this study is a staged implementation of Alternative 4 (switchboats and mooring cells) and Alternative 6 (new locks) with decision points for proceeding to lock construction. The mitigation measures were divided into two stages identified as Alternative 4 and Alternative 6 to describe appropriate mitigation for this staged implementation. The combination of these stages results in Alternative 4 & 6.

Alternative 4 Mitigation – First stage mitigation to offset the site-specific impacts and the effects of the incremental increase in traffic for Alternative 4. Alternative 4 includes moorings at Locks 12, 14, 18, 20, 22, 24 and La Grange, and switchboats at Locks 14, 15, 16, 17, 18, 19, La Grange, and Peoria. Alternative 4 mitigation is independent of Alternative 6.

Alternative 6 Mitigation – Second stage mitigation to offset the site-specific impacts and the effects of the incremental increase in traffic for Alternative 6 (if implemented). Alternative 6 includes moorings at Locks 12, 14, 18, and 24; new locks at 20, 21, 22, 24, 25, La Grange, and Peoria; lock extensions at 14, 15, 16, 17, 18; and switchboats at Locks 11, 12, and 13. Planning and design of Alternative 6 mitigation features will be done commensurate with Alternative 6 lock design.

Alternative 4 & 6 Mitigation – Mitigation is staged to coincide with implementation of Alternative 4 & 6. If Alternative 6 lock improvements are initiated at some point in the future, mitigation measures identified for Alternative 6 will be added to those already under way for Alternative 4 mitigation. For discussion of the rational and economic consequences of this alternative see Chapter 14.

10.3 Site-Specific Effects

Site-specific analyses were conducted to evaluate potential impacts of the proposed construction measures at locks and dams on the UMR and IWW (Table 10-1). Site-specific mitigation cost was calculated based upon large-scale measures (new locks and lock extensions) identified in Alternative 6. Alternative 4 contains no large-scale measures, but a mooring cell at Lock and Dam 14 would require mitigation. At the time of these assessments (1996), potential improvements upstream of Lock and Dam 14 on the UMR and upstream of Peoria were still under consideration, and they were included in these analyses. These sites are no longer under such consideration, and mitigation for these sites is not included in this plan.

Table 10-1. Site-specific mitigation average cost for Alternative 4, Alternative 6, and Alternative 4 & 6.

Alternative 4

Lock Site	Measure	Cost
14**	Mooring Cell	$4,764,413
		$4,764,413

Alternative 6 and Alternative 4 & 6

Lock Site	Measure	Cost*
La Grange	New Lock	$6,247,653
Peoria	New Lock	$686,075
25	New Lock	$1,260,664
24	New Lock	$712,208
22	New Lock	$6,352,563
21	New Lock	$4,759,351
20	New Lock	$1,318,331
18	Lock Extension	$595,552
17	Lock Extension	$3,215,979
16	Lock Extension	$714,662
15	Lock Extension	$714,662
14	Lock Extension	$5,955,516
14**	Mooring Cell	$4,764,413
		$37,297,628

* Environmental costs for locks 20-25, Peroria and La Grange are the average of the ranges provided in the Site Specific Habitat Assessment Report (Fristik et al. 1998, ENV 7).

**Lock and Dam 14 requires considerable dredging in association with the cell with $4,764,413 in additional mitigation cost.

The primary purpose of the site-specific assessment was to assist the study team in formulating a recommended plan by providing a quantitative measure or qualitative evaluation of environmental impacts and estimated habitat replacement costs. Detailed analysis of small- and large-scale site-specific impacts, based on any recommended/authorized measures, will not be possible until detailed design information for those measures is available. Should future construction activities be recommended, detailed site-specific evaluations will be completed for each incremental step towards completion of the action. This would include mooring cell construction, lock extensions, and new locks. Site surveys will be conducted by Corps personnel or contracted specialists to determine the potential for environmental impacts, and environmental assessments will be prepared for site-specific construction. These detailed evaluations will be documented in tiered environmental assessments (EAs).

Quantitative evaluations (Locks and Dams 20 through 25, Peoria, La Grange) were accomplished using the Habitat Evaluation Procedures (HEP), while a qualitative evaluation was made at the remaining locks and dams and through evaluation of potential endangered species impacts, socio-economic impacts, and mussel surveys. A Habitat Assessment Team (HAT) was used to perform the HEP analysis. This team included representatives from the Rock Island and St. Louis Districts of the U.S. Army Corps of Engineers; the U.S. Fish and Wildlife Service-Rock Island Field Office; and the Mid-Continent Ecological Science Center-Biological Resource Division (U.S. Geological Survey), Fort Collins, Colorado. The HAT regularly coordinated with State and Federal resource agencies and other interested parties.

HEP is a nationally recognized evaluation method developed to quantify the impacts of habitat changes made by land and water development projects. It provides information to compare the relative value of different areas at the same point in time and the relative value of the same area in the future. Documented Habitat Suitability Index (HSI) models are used in HEP to determine the quality portion of the formula. The HSI values are multiplied by area to calculate Habitat Units (HUs). The changes in HUs for species and their habitats are reported as the results in a HEP evaluation. Included in that process are creation of a study team, formation of objectives and selection of evaluation species, followed by inventory design and data gathering. A group of 27 species was chosen to represent those aquatic and terrestrial habitats that may be affected by the site-specific construction of the navigation improvement projects. The HAT coordinated each step of the process with interested parties including State and Federal biologists in species selection and data gathering. A detailed description of the site-specific habitat assessment can be found in Fristik et al. (1998, ENV 7), which is included as Appendix ENV-B.

Construction impacts from any of the project alternatives were considered to include footprint impacts from construction and impacts of any required staging area or construction activity.

In addition to the “footprint” impacts of major construction measures, the following potential impacts were also evaluated:

- Loss of benthic and riparian habitat in and adjacent to the construction site.
- Changes in the lock and/or dam structure that could alter tailwater velocities, depth, or substrate composition.
- Changes in lock approach patterns that could cause towboats to increase bank erosion or benthic disturbance, or require dredging for new channel alignment.
- Changes to terrestrial or shoreline areas due to bankline excavation, borrow, or staging area locations.

Dredged material placement sites were not evaluated because potential locations at the time of the analysis were very speculative. It is assumed that upland placement in agricultural fields would help to avoid and minimize adverse environmental impacts. The Corps will fully coordinate any potential land use with the U.S. Department of Agriculture and the respective State agencies as required under the Farmland Protection Policy Act (Public Law 97-98). Future detailed site-specific evaluations will include a selection and evaluation process for disposal of dredged material.

Results of the HEP analysis for site-specific impacts are presented in Appendix ENV-B. In general, bottomland hardwood forest exhibited the greatest losses in terms of habitat unit changes from Alternative 6. In many cases, bottomland hardwood forest would be cleared for use as staging areas and would be replaced after construction. In some cases, bottomland forest would be converted to either a lock facility or aquatic habitat. Bottomland hardwoods are considered a scarce and valuable resource on the UMR-IWW System, and impacts to them should be avoided or minimized to the extent possible. Implementation of Alternative 4 would reduce potential site-specific impacts to the mooring cell construction area.

The site-specific effects of lock construction on significant historic properties have been determined to be adverse effects to National Register of Historic Places (NRHP) eligible locks, dams, and associated guidewalls on the UMR and the IWW. Potential adverse effects may also result from ground disturbance associated with mooring areas, machinery staging areas, and spoil placement sites. Mitigation measures will be developed in consultation with the appropriate State Historic Preservation Offices (SHPOs) and Tribal Historic Preservation Offices (THPOs) as proposed in the Programmatic Agreement (PA) and will include any one or a combination of the following strategies: avoidance, preservation, and/or data recovery. In addition, the Corps will produce and promote a 3-hour film on the history and significance of the Upper Mississippi River/Illinois River and the waterway systems in consultation with the SHPO(s)/THPO(s).

10.4 Incremental Traffic

The system (non-site-specific) component of this mitigation strategy is based upon the concept of incremental traffic. Incremental traffic is defined as the expected increase in traffic that would occur over time as a result of the construction or implementation of a navigation efficiency measure. An increased efficiency is expected to lead to an increase in commercial traffic for those alternatives that do not drive traffic off the system (Alternatives 4, 5, and 6). The study's environmental impact assessment has focused on assessing the effects to resources of concern of this projected incremental increase in traffic. Therefore, mitigation will center around the additive or synergistic detrimental effects of increased commercial traffic on the significant biological and cultural resources of the UMR-IWW System, using the modeled Future Without Project traffic level as a baseline condition for mitigation. The incremental effects are measured in terms of increased tows per day by pool (Figure 10-2).

Several models were used to forecast the amount of navigation traffic in order to identify incremental traffic for Alternatives 4, 5, and 6 (Figure 10-2). Mitigation costs were calculated based upon traffic forecasts generated by the Tow Cost Model (TCM), the Essence Upper Bound (EUB) model, and the Essence Lower Bound (ELB) model. These models predicted annual traffic use over the 50-year project life for the current navigation system as well as the different alternatives proposed. Once this baseline traffic was established, an incremental change in traffic was determined for each alternative. This was used in various evaluation models to determine the incremental traffic effects on fisheries, submersed aquatic vegetation, bank erosion, backwater and secondary channel sedimentation, and historic properties.

CEQ guidance suggests that the reasonable worst-case scenario be assessed when there are gaps in relevant information or scientific uncertainty. There is considerable uncertainty in forecasting future navigation traffic on the system. To compensate for this uncertainty in mitigation planning, a reasonable worst-case scenario analysis was conducted as well as a sensitivity analysis considering other traffic forecast scenarios. This analysis resulted in TCM Most Favorable Economic Scenario (Scenario 5) traffic being used for Alternative 4 mitigation planning and EUB Most Favorable Economic Scenario (Scenario 5) traffic being used for Alternative 6 mitigation planning. These scenarios were combined to create Alternative 4 & 6.

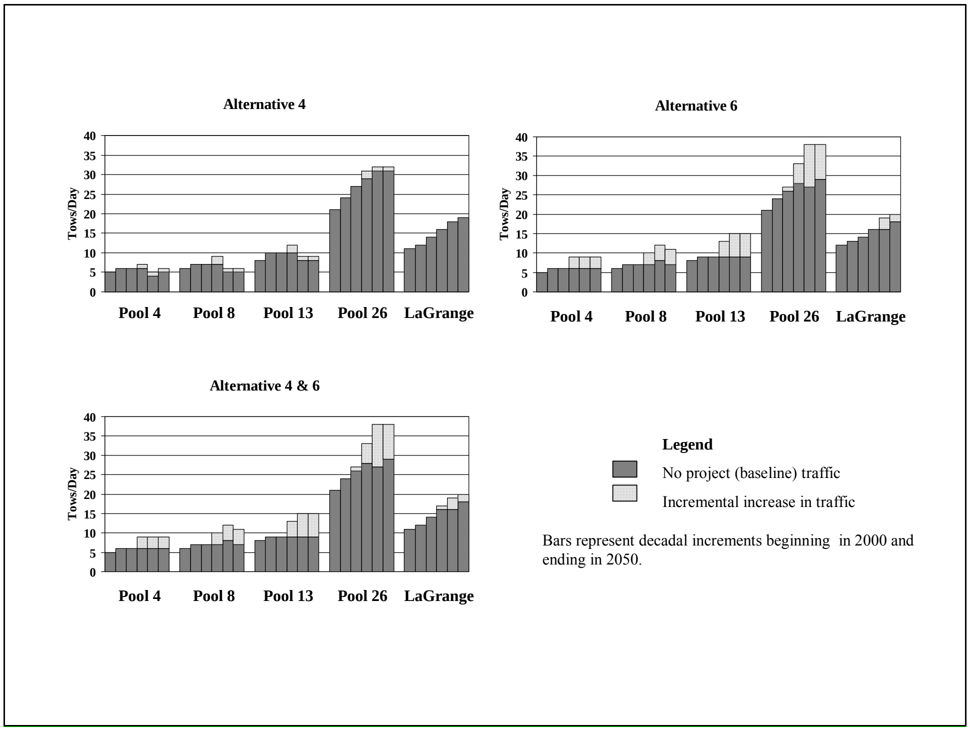

Figure 10-2. Projected increase in the number of tows per day for selected lock sites. These graphs include baseline and incremental traffic for the estimated reasonable worst-case scenarios for Alternative 4, Alternative 6, and Alternative 4 & 6.

10.5 Incremental Traffic Effects

Along with site-specific effects, incremental traffic effects were also evaluated to identify any detrimental effects to the significant resources of concern. Incremental effects were identified through literature research, laboratory and field studies, and risk-based modeling to quantify these effects on fisheries, submerged aquatic vegetation (SAV), backwaters and secondary channels, bank erosion, and historic properties.

10.5.1 Fisheries Resources

The assessment of fisheries impacts was based upon a review of the scientific literature, completion of laboratory and field studies, development of mathematical models, and coordination with State and Federal resource managers. Targeted research studies generated 17 reports dealing specifically with assessment of fisheries impacts resulting from commercial navigation traffic. These studies are summarized in Chapter 8. A mitigation strategy based upon incremental effects of increased traffic on fish was accomplished using the NavLEM model (Bartell et al. 2000a, ENV 16).

Much of the literature review and many of the laboratory/field studies were conducted to provide information for the NavLEM model to assess the risk of incremental navigation traffic on larval fish entrainment. The larval entrainment model used the results from larval fish density studies, physical studies, and projected traffic levels to predict the larval mortality of fish species under various combinations of navigation improvement alternatives and future traffic scenarios. Appendix ENV-F contains a sensitivity analysis of these input parameters. Larval mortality estimates were subsequently extrapolated to estimate equivalent adult loss (EAL), recruitment foregone (RF), and production foregone (PF). This assessment is further described in Chapter 8 and Appendix ENV-F. These four model output parameters provide the basis for assessment of the spatial and temporal trends as well as the magnitude of fisheries impacts in the UMR-IWW System. An important point considered when calculating fisheries replacement value was that the potentially billions of entrained larvae translate into substantially fewer adults lost through larval entrainment mortality, because natural mortalities account for considerable losses to these populations as larvae progress to young-of-the-year, then to adult fish that suffer additional (non-vessel induced) mortality throughout their lifespan. The NavLEM model was used to quantify the effects of commercial tows on fisheries, and American Fisheries Society fisheries values (Southwick and Loftus, 2003) were used as the basis for assigning fisheries mitigation cost.

The cost of mitigation was calculated through a stepped mitigation assessment process as follows:

Step 1 – determine the RF for 24 fish species of concern using the NAVLEM
Step 2 – identify value of a 4 inch fish using American Fisheries Society (AFS) valuations
Step 3 – determine how many 4 inch fish are required to get one recruit for each fish species
Step 4 – apply AFS valuations to the total number of fish required to produce the number of RFs as a result of the incremental increase in traffic to come up with a mitigation cost
Step 5 – apply the mitigation cost to habitat projects that benefit the 24 species of concern and distribute these habitat projects and measures in the areas most affected by commercial traffic
Step 6 – perform bioresponse monitoring to ensure mitigation projects and measures function over time

An incremental analysis and best buy determination will be conducted as part of the final site and mitigation feature design and selection during the implementation phase. This planning will be done simultaneously with the ecosystem restoration component of the Navigation Study. Table 10-2 shows a mitigation strategy to offset and compensate for fishery losses incurred under Alternatives 4 and 6. The actual location of these measures and alternatives will focus on reaches with the greatest projected fisheries impacts. The exact location of each measure will be determined using the stepped approach described above.

Five species, including the common carp, bowfin, gizzard shad, emerald shiner, and shortnose gar, which are abundant in the system, were modeled but not considered for mitigation on the basis of being ecologically or recreationally undesirable (e.g., common carp, gar, bowfin) or because the species represent forage fish (e.g., shad, emerald shiner) and are not at risk.

Mitigation distribution was based upon the effect of traffic on 24 species of fish (Table 10-3 and Table 10-4). The allocation of mitigation resources was geographically weighted based upon these regional effects. Any structure constructed under Alternative 4 would not be removed if Alternative 6 were implemented at some point in the future. These increased costs are part of the risk of deferring a navigation recommendation pursuant to adaptive management.

Significance is a term often associated with things of value. It is often difficult to reach consensus on its application although most have a general understanding of the term's meaning. This is primarily because we each assess value differently. Some can see only monetary value, while others apply less tangible measures (i.e., ecological, aesthetics, recreational, intrinsic). Environmental resources are one of those entities for which it is especially difficult to apply, or agree upon, value and significance. The NECC struggled to define significance as it relates to the various environmental resources and the impacts from commercial navigation. The significance of the fisheries component has been especially problematic since there is a lack of reliable population estimates and a poor understanding of fisheries dependence, response, and reliance on key environmental variables (i.e., habitat, hydrology, connectivity). Therefore, significance was assessed with the best available information. By focusing on the production of wild fish in natural habitats, this habitat replacement cost approach provides an ecologically-based alternative to hatchery-based replacement cost for both quantifying and monetizing fish resources injuries (Strange et al. 2004).

Table 10-2. Summary of potential fisheries mitigation measures and quantity based upon traffic forecasts by reach.

Reach	Potential Measures	Alt 4	Alt 6	Alt 4 & 6	Units
Upper St. Anthony – Pool 3	Large woody debris anchors	210	575	575	Structures
Pools 4-8	Large woody debris anchors	250	250	250	Structures
	Backwater imp. (dredging)	0	5	5	Acres
Pools 9-15	Backwater imp. (dredging)	20	20	20	Acres
	Modified pile dike	5	10	10	Structures
	Large woody debris anchors	1000	1000	1000	Structures
	Dike alterations	0	30	30	Structures
	Gravel Bar	30	60	60	Acres
Pools 16-27	Fish nursery area (2)	0	180	180	Acres
	Backwater imp. (dredging)	0	25	25	Acres
	Modified pile dike	0	5	5	Structures
	Large woody debris anchors	770	770	770	Structures
	Dike alterations	5	30	30	Structures
	Side channel restoration	10	50	50	Acres
	Gravel bars	30	40	40	Acres
Open River	Modified pile dike	5	10	10	Structures
	Dike alterations	0	10	10	Structures
Lower IWW	Side channel restoration	0	110	130	Acres
	Large woody debris anchors	0	0	250	Structures
Middle IWW	Side channel restoration	0	50	55	Acres
	Large woody debris anchors	5	0	200	Structures
Upper IWW	Side channel restoration	0	20	30	Acres

Table 10-3. TCM Alternative 4 worst-case scenario – Impacts on Recruitment Foregone (Number of Fish) for Year 2040

		Mississippi River					Illinois Waterway		
	Species	**USA-3**	**4-8**	**9-15**	**16-27**	**Open River**	**Lower**	**Middle**	**Upper**
1	goldeye	0	0	0	0	0	0	0	0
2	lake sturgeon	0	0	0	1	0	0	0	0
3	paddlefish	0	1	1	2	0	0	0	0
4	shovelnose sturgeon	1	4	7	11	3	0	0	0
5	flathead catfish	5	1	9	33	1	0	0	0
6	northern pike	45	67	117	128	36	0	0	0
7	white crappie	21	210	666	255	15	0	1	1
8	black crappie	26	255	808	310	18	0	1	1
9	largemouth bass	25	15	74	355	89	0	1	1
10	blue catfish	0	0	216	428	7	0	0	0
11	walleye	66	47	185	439	23	0	0	0
12	bigmouth buffalo	16	94	231	507	210	0	0	0
13	smallmouth bass	47	29	139	672	168	0	1	1
14	blue sucker	90	149	2,201	780	166	0	0	0
15	channel catfish	93	11	211	1,026	18	0	1	1
16	sauger	184	131	511	1,215	63	0	1	1
17	smallmouth buffalo	42	256	628	1,374	570	0	1	1
18	river carpsucker	65	284	637	1,422	155	0	2	3
19	white bass	307	2,006	2,221	1,528	22	1	3	2
20	spotted sucker	929	1,438	21,232	7,520	1,599	6	32	0
21	shorthead redhorse	2,035	3,198	35,154	16,118	3,348	12	75	80
22	freshwater drum	1,033	1,675	12,908	23,959	411	3	19	21
23	bluegill	134	1,538	18,903	24,571	52	0	3	4
24	mooneye	1,483	3,122	20,518	28,584	4,637	2	0	0
	TOTAL	**6,648**	**14,531**	**117,576**	**111,236**	**11,612**	**24**	**143**	**117**
	Percent of River	2.5%	5.6%	44.9%	42.5%	4.4%	8.4%	50.5%	41.1%

Total Mississippi River =	261,603	Impact Index RF	Total IWW = 283
Total UMR-IWW =	**261,886**	1,000 to 5,000	
%UMR =	**99.9%**	5,000 to 15,000	**%IWW =** **0.1%**
		> 15,000	

Table 10-4. Essence Alternative 6 worst-case scenario - Impacts on Recruitment Foregone (Number of recruits) for Year 2040

		Mississippi River					Illinois Waterway		
	Species	**USA-3**	**4-8**	**9-15**	**16-27**	**Open River**	**Lower**	**Middle**	**Upper**
1	**goldeye**	131	0	0	0	0	0	0	0
2	**lake sturgeon**	0	1	2	4	1	0	0	0
3	**paddlefish**	1	1	3	8	3	1	0	0
4	**shovelnose sturgeon**	2	8	21	55	22	6	3	0
5	**flathead catfish**	19	2	39	158	8	21	11	6
6	**northern pike**	109	129	347	630	245	69	38	21
7	**white crappie**	277	408	2,382	1,220	103	274	148	82
8	**black crappie**	337	496	2,893	1,482	125	333	180	100
9	**largemouth bass**	61	29	318	1,733	607	242	131	72
10	**blue catfish**	0	0	777	2,070	47	0	0	0
11	**walleye**	679	91	732	2,122	155	177	94	50
12	**bigmouth buffalo**	38	182	897	2,572	1,433	170	92	45
13	**smallmouth bass**	115	55	601	3,277	1,149	458	248	137
14	**blue sucker**	145	287	9,675	4,086	1,132	0	0	0
15	**channel catfish**	377	21	925	4,972	125	328	181	101
16	**sauger**	1,877	251	2,024	5,872	429	488	260	138
17	**smallmouth buffalo**	103	495	2,435	6,978	3,889	971	250	135
18	**river carpsucker**	151	549	2,475	6,669	1,058	1,000	544	293
19	**white bass**	666	3,924	5,839	7,256	151	1,364	737	227
20	**spotted sucker**	2,488	2,766	93,340	39,412	10,917	13,238	7,194	0
21	**shorthead redhorse**	5,363	6,154	153,821	84,425	22,855	30,348	16,474	9,079
22	**freshwater drum**	3,338	3,307	47,448	114,228	2,810	7,805	4,231	2,361
23	**bluegill**	280	3,050	56,167	134,404	352	1,344	733	398
24	**mooneye**	3,275	5,997	81,387	139,335	31,659	8,681	0	0
	TOTAL	**19,833**	**28,200**	**464,546**	**562,967**	**79,274**	**67,318**	**31,549**	**13,246**
	Percent of River	1.72%	2.44%	40.23%	48.75%	6.86%	60.05%	28.14%	11.81%

Total Mississippi River = 1,154,824	Impact Index RF	Total IWW = 112,112
Total UMR-IWW = 1,266,936	1,000 to 5,000	
%UMR 91.2	5,000 to 15,000	**%IWW = 8.8**
	> 15,000	

Mitigation will be discussed as it relates to the following four items: (1) Physical Forces Impacts, (2) Spatial Scale of Impacts, (3) Temporal Scale of Impacts, and (4) Fish Species. The purpose of this section is to identify which actions, effects, locations, time frames, or species are significant and likely to require appropriate avoid/minimize measures, mitigation alternatives, or additional data/information. The significance of each component included under each of these four categories will be considered and rated in terms of significance. The significance rating used in this document was as follows:

LOW - little to no measurable impact or inconsequential loss
MODERATE - measurable impact with some losses
HIGH - relatively high measurable impact with relatively high losses

The determination of significance is ultimately the driving force behind the Adaptive Mitigation Process, identifying impacts or losses that will require an effort to avoid, minimize, compensate, or monitor.

1) Physical Forces Impact Significance

Pressure Changes - **LOW SIGNIFICANCE**

Hull Shear Forces - **LOW SIGNIFICANCE**

Drawdown - **LOW SIGNIFICANCE**

Larval Entrainment Mortality - **HIGH SIGNIFICANCE**

Adult Entrainment - **LOW SIGNIFICANCE**

Displacement - **LOW SIGNIFICANCE**

Overwintering Habitat - **LOW SIGNIFICANCE**

2) Spatial Significance

Upper Mississippi River
Pools 1-8 - **MODERATE SIGNIFICANCE**
Fisheries impacts in this reach suggest a need for some mitigation measures.
Pools 9-15 - **HIGH SIGNIFICANCE**
Fisheries impacts under Alternative 4 are 44.9 percent and under Alterative 6 are 40.23 percent; mitigation measures are prepared.
Pools 16-26 - **HIGH SIGNIFICANCE**
Fisheries impacts under Alternative 4 are 42.5 percent and under Alternative 6 are 48.75 percent.
Open River - **MODERATE SIGNIFICANCE**
Though this reach of the river is projected to experience some increase in tow traffic, the model used to project mitigation in driven by larval entrainment. Larval drift studies showed an uneven abundance of ichthyoplankton between the Open River reach and the impounded reaches. More inchtyoplankton were found per square meter in the impounded part of the river. Use of these data resulted in model outputs that indicated fewer ichthyoplankton would be entrained in the lower reaches when compared to impounded reaches.

Illinois Waterway
Lower (Alton) - **MODERATE SIGNIFICANCE**
Fisheries impacts in this reach suggest a need for some mitigation alternatives.
Middle (La Grange and Peoria) - **MODERATE SIGNIFICANCE**
Fisheries impacts in this reach suggest a need for some mitigation measures.
Upper (Starved Rock, Marseilles, Dresden, Brandon Road, Lockport) - **LOW SIGNIFICANCE**
Because of the small losses of fish in the Upper Illinois Waterway, few measures will be implemented under this mitigation strategy.

3) Temporal Considerations
Year of Project Initiation/Completion
The calculated fisheries impact and mitigation costs will be largely dependent on the proposed dates for project completion. Mitigation measures will be in place several years before projected traffic increases occur.

4) Species Significance
Forage Species - **LOW SIGNIFICANCE**
Loss of forage fish species is considered not significant due to their naturally high abundance. Therefore, emerald shiner and gizzard shad were dropped from consideration in the mitigation process.

Sport Species - **HIGH SIGNIFICANCE**
Resource managers and the general public have a high regard for the protection and enhancement of sport species. Therefore, substantial losses will be compensated for with appropriate mitigation measures. Although habitat based measures or alternatives may be designed for sport fish mitigation, the benefits will likely affect a wide range of species.

Commercial Species - **MODERATE SIGNIFICANCE**
Commercial species represent a source of revenue for a relatively small number of individuals, yet it is a use of the resource that should be protected. The species also represent an important component of a healthy ecosystem. Aside from catfish, sturgeon, and paddlefish, the majority of the commercial catch consists of rough fish (i.e., buffalo, suckers) and the exotic carp (common, bighead, silver, and grass).

Rough Species - **LOW SIGNIFICANCE**
Rough fish species are generally held in low regard by the public, resource managers, and commercial/sport fishermen. In that sense, their losses are considered to be of low significance. However, they represent a component of the fishery resource of the Upper Mississippi River System (UMRS) and cannot be dismissed entirely. Certain species such as the shortnose gar and bowfin will be dropped from consideration; however, the suckers will remain and will subsequently be factored into the mitigation package.

Exotic Species - **LOW SIGNIFICANCE**
Exotic fish species losses are generally considered beneficial and therefore are of low significance. They will be dropped from consideration in the mitigation process.

Species of Concern - **HIGH SIGNIFICANCE**
Impacts to endangered, threatened, or special concern species are highly significant. Considerable effort will focus on avoid and minimize measures to prevent any losses of such species. The pallid sturgeon, blue sucker, lake sturgeon, and paddlefish are four species that are protected in one or more of five UMR

States. Many of the measures and alternatives presented later in this document will serve to affect the distribution and abundance of such species.

10.5.1.1 Mitigation Measures – Fisheries

Fish that are vulnerable to propeller entrainment are likely to benefit from microhabitat sites that provide suitable shelter from current, such as woody debris structures, altered dikes, and improved backwaters. In addition to providing sheltered habitat for lotic fish, some of these riverbed habitat structures can also provide hard substrate for filter-feeding macroinvertebrates in an otherwise shifting sand area. A higher density of sheltered riverbed microhabitats would reduce the energy expenditure of fish seeking sheltered locations, leaving a greater energetic scope of activity for growth and reproduction. Increased habitat structure can result in increased abundance of lotic fish.

10.5.1.1.1 Structural Measures

Large woody debris structures, dike alterations, and backwater improvements were the mitigation measures identified as those that would meet the objective. A more detailed description of all but one of these measures can be found in Chapter 8. Large woody debris structures are described below.

Large Woody Debris Structures
Bundles of large woody debris increase habitat diversity in the main channel border. Habitat will be improved through the placement of the wood itself (many fish species are attracted to structure in the water as areas of cover, reproduction, or forage), through the creation of localized scour holes below the bundles, and through the collection of organic debris, like leaves and drifting wood, which in turn provide a fertile food bed for aquatic insects. Work on other rivers has found that increases in woody debris can be expected to increase both local diversity and abundance of fish. There are three approaches for constructing large woody debris habitat: woody debris anchoring, wood bundles, and modified pile dikes.

1) *Woody debris anchoring* – This measure involves the anchoring of existing naturally deposited woody debris in place using cables and anchors pounded into the riverbed. Trees are held in place by a cable that is connected to soil anchors that were pounded 4 meters into the riverbed with hydraulic jacks. Over time, these anchored debris piles grow in size as they collect floating debris. Advantages of debris anchors include cost; enhancement of habitat in areas where it naturally occurs; shoreline protection; requires little planning, engineering or design work; and requires no heavy construction equipment. Disadvantages include longevity (anchors may not withstand repeated flooding or ice movement), and the systemic benefits to fisheries are difficult to quantify. Woody debris anchors can be installed for as little as $1,000 per structure. This method was selected for use in the example under this adaptive mitigation plan in Table 10-2.

2) *Wood bundles* – This measure involves attaching bundles of 4 to 10 interlaced logs attached to two or three 1,400-pound concrete anchors on the riverbed. Log bundles would be placed in groups of three at each location. Placement is such that one large woodpile would be formed at each site. Global Positioning System (GPS) locations would be taken at each site to enable bioresponse monitoring using hydroacoustic equipment. Advantages of this technique include the ability to construct fish habitat in deep water. Disadvantages include increased planning, the need for using large equipment, and the difficulty of measuring bioresponse.

3) *Modified pile dike* – This measure entails logs being driven into a loosely structured line perpendicular to the bank, with logs staggered within the line. Like the wood bundles, the pile structure would be placed farther away from the bank and closer to the thalweg to increase scour and/or deposition. Advantages of this measure include durability, area of influence near the main channel, and low Operation and Maintenance O&M cost. The largest disadvantage is initial construction cost. On the basis of St. Louis District's estimates for the IWW, the cost for 200 feet of bull nose piling habitat would be approximately $85,000 per structure.

Fish Nursery Areas
Moist soil management units are usually manipulated to maximize benefits for migratory waterfowl; however, they can be managed for the production of larval and juvenile fish. Inundated soils release nutrients that stimulate phytoplankton production and result in increased food supply for zooplankton just as larval fish are beginning to feed on zooplankton. Water levels are manipulated with gated structures that fill, maintain, and drain the unit. Draining releases larval and juvenile fish into the river system. Timing of the unit filling and drawdown is critical to the success of larval fish production. Various management strategies can be employed, ranging from reliance on natural hydrologic events to artificially raising and lowering the water levels.

Benefits. Studies conducted by the Illinois Department of Natural Resources (IL DNR) at the Andalusia Habitat Rehabilitation and Enhancement Program (HREP) project during 1995 tested the viability of the unit for larval fish production. The unit naturally produced an estimated 13.5 million larval fish including 10.5 million panfish, 3.5 million larval shad, 18,000 larval crappie, 9,000 larval bass, 16,000 larval common carp, 10,000 fingerling black crappie, and 21,000 miscellaneous adult minnows.

Cost. The Andalusia HREP in Pool 16 created a 130-acre impoundment at a cost of approximately $2.6 million, or $20,000 per acre. Annual operating cost for Andalusia was estimated at $12,000.

Gravel Bar Creation
Gravel bars support a diverse array of fish, many of which are obligate riverine species, sensitive to habitat degradation, and are protected by State and Federal regulations. These include sturgeon, paddlefish, suckers, benthic minnows, madtoms, and darters. Many obligate riverine species use gravel substrates for spawning, feeding, or as permanent habitat. Conservation of imperiled species and the overall loss of gravel substrates from anthropogenic disturbances support creation of gravel bars.

Based on field assessments of gravel bars in the Lower Mississippi River basin, environmental guidelines of gravel bar creation are suggested. Design criteria include placement of gravel in relatively high velocity areas to prevent sedimentation such as below dike notches and the tip of dikes. Dikes can also impact availability of gravel to fish. Dikes placed at the head of islands, an area where gravel often accumulates, may result in long-term accretion of sand that covers the gravel. Dikes can be reoriented to mitigate sediment accretion and maintain scour at these locations.

To be functionally equivalent to natural bars, gravel should be of varying sizes (1/8 to 1 inch in diameter). Depth of gravel should be a minimum of 6 to 12 inches. Preferably, larger grade gravel should be placed first, followed by smaller grade gravel to ensure compactness and reduce loss during placement. Larger boulders and cobble can initially be scattered throughout the restoration site to enhance compactness, minimize loss of smaller gravel, and increase topographic variation of the substrate. Larger stones also collect organic debris that is used by madtoms, darters, and other benthic fish. Variation in gravel size will provide stable substrates for permanent residents that burrow or hide in fine gravel (e.g., darters, macroinvertebrates), species that spawn over a range of gravel sizes (e.g., paddlefish and sturgeon), and fish that use larger gravel for velocity refugia and feeding areas within interstitial spaces.

Cost. The Indian Slough HREP in Pool 4 created a riffle gravel bar at a cost of approximately $50,000 per acre. Annual operating cost for Indian Slough was estimated at $275 per acre.

Other measures - Fish rearing and stocking failed to achieve the criteria of environmental sustainability. Many of the fish species, such as the bigmouth buffalo, have not been raised in hatchery conditions, and replacing these species on a one-for-one basis is impractical. Water level management may affect fishes in potentially beneficial ways (Garvey et al. 2003).

10.5.1.2 Monitoring and Information Needs

Monitoring costs were developed for Alternative 4, Alternative 6, and Alternative 4 & 6 (Table 10-5). Note that these totals do not include the cost of long-term monitoring, which can be found in Table 10-18.

Table 10-5. Estimated cost of fisheries monitoring for Alternative 4, Alternative 6, and Alt 4 & 6.

Alternative 4

Study	Amount		Cost ($)
Nav effects -Fish trawling	$200k/site	$	600,000
Fish pre construction	$50k/site	$	100,000
Fish post construction	$50k/site	$	100,000
		Total	**800,000**

Alternative 6 and Alternative 4 & 6

Study	Amount		Cost ($)
Nav effects -Fish trawling	$200k/ site	$	600,000
Fish pre construction	$50k/site	$	500,000
Fish post construction	$50k/site	$	500,000
		Total	**1,6000,000**

Navigation effects validation studies - Several information needs were identified during the development of this study. The techniques to sample the direct effects of entrainment of adult fish improved from early studies (Gutreuter et al. 2003) to later studies (Kilgore et al. 2004, Env 56). Total entrainment mortality was measured directly by sampling all water moving through the tow's propellers. Further application of this new technique is needed to validate these study results. The effects of evaluation of towboat propeller-induced mortality of adult fish will continue using the Kevlar seine hauled behind a tow in narrow reaches of the UMR (Pool 14) and the IWW (Marseilles Pool). This methodology will also be used to assess the impacts of tows in the Open River.

Model validation studies - None.

Pre-construction studies - Pre- and post- project performance monitoring of structural measures would require evaluating habitat use and assessing the effectiveness of mitigation measures.

Post-construction studies - The effect of dike alterations and large woody debris on the fish population could be evaluated using multi-beam hydroacoustic techniques developed by the St. Louis District.

Long-term performance monitoring - Fisheries measures would be checked every 5 years to ensure that they continued to meet the mitigation objectives over time. These findings will be provided in a 5-year mitigation performance report.

10.5.2 Submersed Aquatic Vegetation (SAV)

The objective is to reduce the effects of wave action upon SAV populations in areas identified as at risk from commercial navigation. Aquatic plants can be affected by navigation traffic through several impact mechanisms. Vessel wake waves and changes in current velocity and direction produced by passing vessels can cause entanglement and fragmentation of plants. Sediment resuspended by passing vessels reduces underwater light and can reduce photosynthesis, growth, and reproduction by plants.

The assessment of submersed aquatic plant impacts was based upon a review of the scientific literature, completion of laboratory and field studies, development of mathematical models, and coordination with State and Federal resource managers. Targeted research studies generated five reports dealing specifically with assessment of plant impacts resulting from commercial navigation traffic under the Navigation Study. These studies are summarized in Chapter 8. A risk assessment and mitigation strategy based upon incremental effects of increased traffic on plants was accomplished by use of the NavSAV model (Appendix ENV-H).

Mitigation was based upon these model results for effects on American wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*), using the projected future traffic of the Tow Cost Model, most favorable economic scenario traffic for Alternative 4, and the E_{UB} model, most favorable traffic scenario for Alternative 6.

10.5.2.1 Species Assessed

Mitigation was based upon modeled effects of American wild celery and sago pondweed. These plants were selected because they are relatively common throughout the project area and normally found in areas susceptible to navigation-induced waves. These species represent two distinct submersed aquatic plant growth forms. These species selected for study occur in the UMR main channel border areas and are representative of many species in the UMR community of submersed aquatic plants, based on their physiognomy and life histories. The effects of vessel-induced wake waves and changes in current velocity were also assessed for Eurasian water milfoil (*Myriophyllum spicatum*) (Stewart et al. 1997, ENV-1), but this exotic species was not used for assessing mitigation at the recommendation of the NECC.

The robust emergent aquatic plants such as arrowhead, bulrush, and cattail (*Sagittaria* spp., *Scirpus* spp., *Typha* spp., respectively) grow in stands that resist wave action and water exchange, limiting their vulnerability to navigation traffic effects. They occur primarily in shallow backwater areas removed some distance from the navigation channels. Further, they grow above the water surface and thus are not affected by light limitation imposed by suspended solids in the water. Therefore, the small potential to affect these species was not considered within this mitigation plan.

10.5.2.2 Navigation Effects on SAV

Wave height and currents produced by passing vessels were simulated for 108 vessel configurations, using NAVEFF and a cell-based geographic information system (GIS) for Pools 4 through 19. The potential for physical damage to plants was assessed by comparing these results of current velocity and wave height calculated by the NAVEFF model (Maynord 1996) to screening criteria developed for SAVs. A cell failed if the screening criteria of 0.75 m/s for velocity or 0.2 m for wave height were exceeded. The screening calculations were performed for nine combinations of river water level and vessel sailing line. The cell identification numbers for potential physical damage to plants were retained for use in generating a GIS map of potential physical impact sites. These sites are included in the impact area's GIS and are used in planning measures to avoid and minimize the impacts of increased navigation traffic on aquatic plants.

The impacts of sediment resuspension by navigation traffic on plant growth and reproduction were assessed using the results of the NAVEFF model (Maynord 1996), the NAVSED model (Copeland 1999, ENV 37), a literature review, laboratory experiments (Doyle 2000, ENV 28), and numerical models of plant growth and vegetative reproduction (Bartell et al. 2000a, ENV 17; Best et al. 2004 ENV 51).

The greatest percent reduction impacts on wild celery total biomass are predicted to occur in Pools 13 and 19 (Table 10-6). The individual GIS cell identification numbers where >5 percent biomass reduction could occur have been identified for use in mapping potential effects and for planning measures to avoid, minimize, and mitigate the effects of increased navigation traffic. NavSAV model output identifies areas that may be affected by the incremental increase in navigation (Appendix ENV-H).

Table 10-6. Comparison of model-predicted affected areas by alternative for plant mitigation. Note: Unaffected river reaches are not shown.

Pool	Alternative 4	Alternative 6 and Alternative 4 & 6
5		Near Alma (752R)
9		Crooked Slough Cut Daymark (653L)
		Atchafalaya Bluff (658R)
		Indian Camp Daymark (665L)
		Lost Channel (670R)
11		Near Island 212 (590R)
		Island 201 (599L)
		Sweezy Island (604R)
		Island 189 (609L)
13	Smith Bay Lower Daymark (528.0L)	Same as Alternative 4
	Smith Bay Light (528.5L)	
	Near Smith Bay Cut Light (529.0R)	
	Smith Bay Lower Daymark (530.5L)	
	Mound Island (532.5L)	
	Hubbell Island (534.5)	
	Edick Lake (535.5L)	
	Sweeney Islands/Island 266 (538.5L)	
	Near Riprap Island (540.5L)	
	Island 259 (543.0L)	
	Savanna Depot (547.0L)	
19		Larry Creek (369L)
		Nauvoo Point (375L)
		Devil's Island (378R)
		Hass's Island (380L)
		Old Niota (382L)
		Lead Island (387R)
		Pontoosac (388L)
		Grape Island (393L)
		Upper Twin Island (396R)
		Kemps Landing (397R)
		Craigel Island (399L)
		Near Craigel Island (400R)
		Moore/Charcoal Island (405L)

Each cell in Pools 5, 9, and 19 requires a minimum of 1/3 mile of protectoion, where Pool 13 requires 1/6 mile of protection

Early study model results indicated that traffic resulting from increased navigation (Bartell et al. 1999) did not affect the vegetative reproduction of either wild celery or sago pondweed. This indicates that, despite some light limitation imposed by vessel-resuspended sediments, the plants would be able to allocate sufficient energy to reproductive propagules so as not to limit reproductive potential. Therefore, despite some potential for reduced standing biomass, increased navigation traffic should not impose interannual effects on submersed aquatic plants in the channel border areas of the UMR.

The NavSAV model was used to identify areas affected by commercial tows (Table 10-6). The model identified areas where tows create an acceleration of water velocity beyond 0.75 m/s, or a wave height greater than 0.2 m in an area with a depth of less than 1.5 m. This level of impact was considered the threshold level for mitigation.

10.5.2.3 Mitigation Measures – Submerged Aquatic Vegetation (SAV)

10.5.2.3.1 Nonstructural Measures

Pool water level management was considered but not included for mitigation because the effectiveness in offsetting impacts to submersed aquatic vegetation is not verified. Revegetation or planting SAV is a recommended mitigation measure, to be applied in potential plant growth zones where increased navigation traffic may prevent plant growth. Planting SAV is recommended in conjunction with measures to avoid and minimize effects of traffic (off-shore revetments and island construction). The cost of potential SAV plantings is estimated using the following assumptions: one-third of the channel border potential plant growth areas that could be affected by increased traffic (total of approximately 10 areas) would be good candidate areas for revegetation. Approximately one-third of the length of those areas is in need of protection and revegetation. The estimated area in need of revegetation at each site is one-third mile long 100 feet wide, or about 4 acres.

10.5.2.3.2 Structural Measures

Structural measures to avoid and minimize effects of navigation traffic on aquatic plants are feasible, would function with minimal operation and maintenance, and could be ecologically effective. These include offshore revetments and constructed islands to shelter plants from vessel generated waves, currents, and resuspended sediment. Linear islands would provide protection for SAV as well as providing other mitigation and habitat benefits. Offshore revetments are less costly than islands to construct in main channel border areas, and are the recommended structural avoid and minimize measure. Other structural measures were considered and eliminated from consideration for mitigation because of cost and area of influence. These include backwater/side channel habitat protection and restoration, dam point control, backwater water level management, and floodplain restoration.

10.5.2.4 Monitoring and Information Needs

Monitoring costs were developed for Alternative 4, Alternative 6, and Alternative 4 & 6 (Table 10-7). Note that these totals do not include the cost of long-term monitoring. This cost is captured in Table 10-18.

Navigation effects validation studies - None.

Model validation studies - Potential plant growth areas within the UMR main channel borders are areas with less than 1.5 meters of water depth. These areas tend to support SAV in years when growing conditions allow. SAV occurs in Pools 1 through 19 in most years. Surveys of the potential SAV impact areas will be conducted to determine the presence, community composition, and spatial extent of SAV.

Pre-construction studies - Potential plant impact areas will be inspected in mid-summer to survey riverbed geometry, substrate type distribution, and current velocity distribution, and to determine the pre-mitigation presence, community composition, and spatial extent of SAV.

Post-construction studies - The ecological effectiveness of the measures in reestablishing and protecting SAV growth in the target areas will be monitored using aerial photography, and on-water surveys to measure SAV spatial extent, community composition, and maximum biomass. Selected physical conditions (e.g., current velocity, suspended solids concentrations, Secchi transparency) will be measured at each site on the protected and riverward sides of protective structures. The success of revegetation efforts will be monitored by quadrat surveys to determine growth and reproduction of introduced plants. Specifically, protected plant beds would be evaluated to determine their similarity to surrounding plant communities that are unaffected by commercial navigation.

Long-term performance monitoring – SAV measures would be checked every 5 years to ensure that they continued to meet the mitigation objectives over time. Sites of interest may be checked annually to ensure that these measures perform annually. These findings will be provided in a 5-year mitigation performance report.

Table 10-7. Estimated cost of SAV monitoring for Alternative 4, Alternative 6, and Alternative 4 & 6.

Alternative 4

Study	Amount		Cost ($)
Plant model validation	$200k/3 years	$	200,000
Plant pre-construction	$50k/site	$	50,000
Plant post-construction	$50k/site	$	50,000
		Total	**300,000**

Alternative 6 and Alternative 4 & 6

Study	Amount		Cost ($)
Plant model validation	$200k/ 3 years	$	200,000
Plant pre-construction	$50k/site	$	250,000
Fish post construction	$50k/site	$	250,000
		Total	**700,000**

10.5.3 Backwater and Secondary Channel Sedimentation

The objective is to stop or slow the deposition and movement of re-suspended sediments into backwaters and secondary channels in areas identified as at risk from commercial navigation. These areas are important because they provide off-channel habitat that shelters fish and other animals from the harsh conditions of the main channel.

The assessment of backwater and secondary channel sedimentation was based on a review of scientific literature, extensive fieldwork, numerical modeling, physical modeling, completion of a GIS/hydrologic/bed material characterization, and coordination with State and Federal resource managers. Targeted research studies generated 10 reports dealing with sedimentation, and two reports dealing specifically with assessment of secondary channels and backwater sedimentation impacts resulting from commercial navigation. Results of these studies are summarized in Chapter 8.

Pokrefke et al. (2000, ENV 41) identified 9 backwaters and 3 secondary channels on the Mississippi River, and 6 backwaters and 14 secondary channels on the Illinois Waterway as having the potential for increased sediment delivery as a result of incremental increases in tow traffic. These backwaters and secondary channels are a subset of an earlier Waterways Experiment Station (WES) classification effort (Nickles and Pokrefke 2000, ENV 27). These 32 areas were determined, based on delivery rates and physical characteristics and sediment types at their openings, to be at medium or high risk of sediment delivery due to tow passage. Each medium and high potential site was evaluated based on existing mapping or other quantitative data, as well as site knowledge of Corps and NECC personnel. This evaluation resulted in the removal of two sites. These sites were eliminated because the potential for adverse barge related impacts were ameliorated by recently completed projects. A site in Pool 8 (BW4) was restored through an Environmental Management Program project and a site in Pool 11 (BW1) was fixed using a double closing structure in Ackerman's Cut. The remaining 30 sites became the focus of mitigation planning efforts (Table 10-8).

These studies were able to identify areas affected by increased navigation but were unable to discern incremental changes between Alternative 4, Alternative 6, and Alternative 4 & 6.

10.5.3.1 Mitigation Measures – Backwater and Secondary Channel Sedimentation

10.5.3.1.1 Non-structural Measures

Mitigation measures include dredging or modification of river regulation. Dredging is recommended at certain locations in combination with structural measures. A more complete description of these measures can be found in the site-by-site summary of mitigation measures below and in Chapter 8.

10.5.3.1.2 Structural Measures

Structural measures include diversion or barrier structures, placement of rock to contain fine sediments, and island construction. This strategy emphasizes structural measures either alone or in combination with dredging or channel restoration. Rock or gravel placement may have application in limited circumstances, but it is not recommended due to its "pushing out" in-place sediments, or being subject to continued sediment accumulation after placement. Suggested structural measures consist of revetments or diversion weirs. A combination of measures, such as diversion structures, dredging, barrier island placement and/or restoration could be used to maximize habitat benefits. These projects could potentially address nearby problems that have in some cases been identified by State resource agencies. Structural measures and locations are summarized in Table 10-8.

10.5.3.1.2.1 Mississippi River

Pool 5; BW2, BW4 – At BW2 (RM 752R) – Wave energy is considered the main impact mechanism; there is a large shallow area at the opening. The area appears to be relatively stable, and probably has considerable flow-through. BW4, located near Muench Island, is a considerable distance from the sailing line, but again a large shallow shelf (~ <1 meter deep) exists at the mouth. Existing flow data indicates that 22 percent of the flow is conveyed out of the main channel into this backwater. "L-head" structures were considered beneficial at both sites, and at BW4, it was suggested that a lower cost alternative might be rock "liners" at each of the two openings (RM 746L and 747L). These limit inflow, but are shorter than typical revetments.

Pool 6; BW1 (RM 727R and 728R) – The Minnesota Department of Natural Resources (MN DNR) has expressed concerns with sedimentation in this area, and some proposals have been put forth for a partial closure at the inlet and backwater dredging. It is unclear; however, that full support exists for a structure. Therefore, it is proposed to place a drop structure in the overflow section of the dam, allowing introduction of flow into Black Bird Slough. The project would also include dredging of the slough and the possibility of a closure structure at the downstream opening.

Table 10-8. Summary of backwater/secondary channel mitigation locations and measures.
Note: Mitigation for Alternative 4, Alternative 6, and Alternative 4 & 6 is the same.

Pool	Name - River Mile (Code)	Mitigation Measure
UMR		
5	near Alma - 752R (BW2)	off shore revetment
	Fisher Island - 747L (BW4)	off shore revetment
	Muench Island - 746L (BW4)	off shore revetment
6	Black Bird Slough - 728R (BW1)	drop structure
	Near Argo Bend - 727R (BW1)	closure structure
8	Broken Arrow Slough - 696R (BW2)	bank protection, closure structure
9	Battle Slough - 671L (SEC3)	closure structure
10	Frenchtown Lake - 620R (BW10)	Dredging
	Frenchtown Lake - 620R (BW10)	closure structure
11	Goetz Slough - 612R (BW3)	barrier island, bank protection
13	Soupbone/Indian Island area - 542R (SEC8)	closure structure, dredging
IWW		
Dresden	Treats Island - 280L (BW2)	closure structure
Marseilles	Sugar Island - 261R (SEC1)	closure structure, bank protection
	Barry Island - 256R (SEC-A)	barrier island, bank protection, dredging
Starved Rock	Hill Island - 239L (SEC1)	closure structure
	Sheehan Island - 236R (SEC2)	Dredging
Peoria	Swan Lake - 201R (BW10)	Dredging
	near Whitney Lake - 195R (SEC2)	dredging, closure structure
	Upper Twin Sisters Island - 204L (SEC-B)	dredging, closure structure
	Lower Twin Sisters Island - 203R (SEC-C)	dredging, closure structure
LaGrange	Bath Chute - 113L (BW4)	Dredging
	Wood Slough - 96L (BW5)	Dredging
	Wood Slough - 92L (BW5)	Dredging
	Sugar Creek - 95L (BW6)	closure structure, dredging
	Turkey Island - 148R (SEC1)	closure structure, dredging
	Coon Hollow - 141L (SEC3)	closure structure, dredging
Alton	Hurricane Island - 28R (BW2)	closure structures
	Buckhorn Island - 46R (SEC-B)	closure structure, dredging
	Fisher Island - 39L (SEC-D)	closure structure, dredging
	Twin Islands - 38R (SEC-E)	closure structure
	Willow Island - 31L (SEC-F)	closure structure

Pool 8; BW2 (RM 696R), BW4 – Significant flow enters the upper inlet here. The area has been studied in the past because of erosion at island heads (point at Broken Arrow light and daymark, entrance to Target Lake). Further study may be needed to pinpoint if a sedimentation problem exists; the current approach would be to armor the island tips, and install a closure structure at one or both of the channel inlets into Target Lake and Broken Arrow Slough. Potential mitigation measures for BW4 (RM 670R and 671R) were considered unnecessary at the present time. In evaluating this area, WES scientists were unaware of a recent Environmental Management Program (EMP) project that included partial closure structures at the upstream portion of the area.

Pool 9; SEC3 – Flow through SEC3 (RM 671L) is estimated at 20 percent of the main channel flow, and this may not be a problem area. Pending further information on the area, a closure structure at the head end of Battle Slough was recommended.

Pool 10; BW10 (620R) – The Frenchtown Lake area; it is recognized that some problems with recreational boat access exist. A structure at the upper end may not be practical, but a closure structure (a shallow, notched structure) at the lower end was considered beneficial. Dredging of the upper channel was also included as a mitigation measure.

Pool 11; BW1, BW3 – The upper inlet to BW1, at RM 614L, corresponds with Ackerman's Cut, an area of high flow and the site where a double closure structure was installed to prevent sediment movement into Cassville Slough. Modeling of this area did not take into account this structure and its effect on the backwater. No measures were proposed for BW1. Similarly, it is uncertain if a sedimentation problem exists at BW3 (612R), due to the proximity of the channel and the presence of a single outlet. The area likely needs more study. Suggested measures were two small barrier islands on either side of the existing island or expanding the existing island, and armoring the tip(s) and river side of the island(s) adjacent to Goetz Slough. The fill material for island creation or expansion was assumed to come from the Turkey River dredging project.

Pool 13; BW11, SEC8, SEC12 – Corps Operations Division personnel expressed concern with shallow water depths in the area of BW11 (RM 528L). Island construction was considered as one option; it is possible that sediment deposition is more a consequence of the natural river dynamics as it opens up into the wide impounded area. More information is needed on both ecological and possible recreation concerns because the Thompson Causeway Recreation Area is located in this backwater. A mitigation measure was not recommended at this time. SEC8 (RM 542R) was considered a good site for a multi-feature project, including dredging to improve access to Pinoak Lake and open up Running Slough, as well as a closure structure between Little Soupbone and Railroad Islands. The IA DNR has expressed interest in some of these improvement measures. It was felt that more sediment data is needed near SEC12 (RM 532R); the material may be coarser than first thought. No associated measures were proposed for Cook Slough.

10.5.3.1.2.2 Illinois River

Dresden Pool; BW2 (RM 280L) – There is a need for depth information at the opening and at the sailing line. The opening is in proximity to the sailing line (48 meters). The potential exists for a closure structure at the head end of Treats Island, and this measure was recommended for this site.

Marseilles Pool; SEC1, SEC-A - SEC1 (RM 261R) is the channel behind Sugar Island; erosion of the upstream end of the island, if occurring, would negate the benefits of a closure structure. It was assumed that some level of bank protection would be required along with a closure structure. The efficacy of dredging the channel was also considered doubtful. Field verification of conditions at SEC-A (256R) would be helpful; on the navigation chart, Barry Island appears to be very small, and any attempts at avoidance/mitigation measures may be fruitless. Depths are shallow here and wave impacts are probably severe. It was suggested that any action would require a combination of measures; namely, dredging, protecting or building up the existing island, and constructing a barrier island.

Starved Rock Pool; SEC1, SEC2 – A closure structure was recommended for SEC1 (RM 239L) at the head end of Hitt Island, but consideration should also be given to some sort of deflection dike. Flow data would be useful for both of these secondary channels; both appear to be fairly deep, and if flows are high, it would help to decrease the flows somewhat. Assuming that the upper part of SEC2 (RM 236R) is maintained by the three elevators located there, dredging is recommended in the lower portion from the tail end of Sheehan Island to Edwards Run.

Peoria Pool; BW10, SEC2, SEC-A, B, C – The opening to BW10, at RM 201R, is very narrow; information from the IL DNR indicates that this area (Swan/Senachwine Lake) is an important walleye/sauger fishery, and this opening is used for boat access. There is a problem with filling in at the inlet and outlet. Dredging is proposed at the RM 201 opening. SEC2 (RM 195R) was thought to present an opportunity for a habitat-type project, including a partial closure structure at the head end of Upper Henry Island and dredging behind Upper and Lower Henry Islands, to include some of the small chutes leading to Newhaven and Meridian Lakes. However, discharge and sediment data would be useful here. The initial assumption was that no measures would be implemented at SEC-A (RM 208L), in the absence of additional information on the area and in particular the Hennepin Boat Launch and nearby grain terminals. Follow-up with the IL DNR indicates that the ramp is experiencing problems with filling in; the site will need further evaluation. At SEC-B and C (RM 203R and 204L), dredging and closure structures at the Upper and Lower Twin Sister Islands are suggested; there remains a need for further information on natural resource value of these areas.

La Grange Pool; BW4, BW5, BW6, SEC1, SEC3 – BW4 (Bath Chute) at RM 113L is very long, and though the Corps is not aware of maintenance dredging in the area, the chute is used by large recreational boats. Costs were computed for dredging the first 1,500 feet of the chute. Three openings (RM 98L, 96L, and 92L) were identified for BW5; this area essentially comprises the Sangamon River floodplain, and more information is needed here. The IL DNR has indicated that although the area is generally shallow (~2 feet), fish do move in and out, but the depths present problems in hot or cold weather. Some dredging activity was recommended here for the two lower openings; the area is included under the Illinois Ecosystem Study, and coordination of management goals should be pursued. BW6 (RM 95L) is in the same general vicinity, and actually is the channel behind Sugar Creek Island. Measures suggested here include dredging throughout the channel, and a closure structure. These same measures are proposed for SEC1 (behind Turkey Island) and SEC3 (behind Coon Hollow Island), although dredging would not be as extensive.

Alton Pool; BW2, SEC-B, SEC-D, SEC-E, and SEC-F – The area of BW2 (Dark Chute) is managed by the IL DNR, and agency personnel confirmed that sedimentation and shallow water depths are a problem here. A particular problem with shoreline accretion is found at the lower end of Diamond Island, near an existing boat ramp. It is recommended that submerged closure structures be placed at the inlets adjacent to the upstream end of Hurricane and Diamond Islands (RM 28.4 and 25.5, respectively). SEC-B is the channel behind Buckhorn Island; a closure structure is recommended, along with dredging to address sediment input from Buckhorn Creek. A similar approach was assumed for SEC-D, the channel behind Fisher Island; Apple Creek empties into this channel. Closure structures are also recommended at the upstream end of secondary channels E (Twin Island) and F (Willow Island).

10.5.3.2 Monitoring and Information Needs

Monitoring costs were developed for Alternative 4 and Alternative 6 (Table 10-9). These costs were determined to be the same for either alternative. The cost of long-term monitoring is presented in Table 10-18.

Navigation effects validation studies – None.

Model validation – None.

Pre-construction studies – Site assessment to document and determine the extent and potential significance of deposition at the identified areas.

Post-construction studies – A site assessment and bathymetric study of the sites will be performed to assess the effectiveness of structural measures at slowing sedimentation rates and maintaining geomorphic diversity within backwaters and secondary channels.

Long-term performance monitoring – Backwater and secondary channel measures would be checked every 5 years to ensure that they continued to meet the mitigation objectives over time. These findings will be provided in a 5-year mitigation performance report.

Table 10-9. Estimated cost of backwater and secondary channel monitoring for either Alternative 4, Alternative 6, or Alternative 4 & 6.

Alternative 4, Alternative 6, or Alternative 4 & 6

Study	Amount		Cost ($)
BW/SC pre construction	25 sites @ 35k/site	$	875,000
BW/SC post construction	6 sites @ $35k/site	$	210,000
	Total		**1,085,000**

10.5.4 Bank Erosion (including Historic Properties)

The objective is to reduce the effects of wave action and stop or slow erosion in areas identified as at risk from an incremental increase in commercial navigation. These areas have been identified as important because they contain critical habitat for terrestrial animals or are areas known for their cultural resources.

The assessment of bank erosion was based on a review of scientific literature and GIS databases, a field survey, a numeric model, and coordination with State and Federal resource managers. Targeted research studies generated two reports dealing with bank erosion. Results of these studies are summarized in Chapter 8 of this report.

Field surveys were performed to identify those areas that were susceptible to erosion from commercial navigation (Bhowmik et al. 1999, ENV 8; Landwehr and Nakato 1999, ENV 9). These surveys were then compared with GIS databases containing information on land cover, historic properties, and threatened and endangered species. This information was then used to determine what significant resources were at medium and high risk from navigation induced bankline erosion (Landwehr and Nakato 1999, ENV9) (See Figure 10-3). In order to determine if a significant resource would be affected by bankline erosion, any significant resources falling within 50 meters of an identified medium or high risk area were identified.

These studies were able to identify areas affected by increased navigation but were unable to discern incremental changes between Alternative 4, Alternative 6, and Alternative 4 & 6; therefore, appropriate mitigation will address all sites identified as adversely affected regardless of which alternative is ultimately implemented. Table 10-10 displays the total mitigation cost spread by the affected area.

Table 10-10. Cost of mitigation for bank erosion for Alternative 4, Alternative 6, and Alternative 4 & 6.

Bank Erosion Mitigation (2003 dollars)			
Mississippi River	Area of Affect (ft)		Total
Upland Forest	8217	$	2,432,078
Mesic Forest	7360	$	2,178,422
Island	10552	$	3,123,194
Species of Concern	3000	$	887,944
Other Social	2000	$	591,963
		$	**9,213,600**
Illinois Waterway			
Upland Forest	233	$	75,914
Mesic Forest	4094	$	1,333,876
Island	18301	$	5,962,695
Species of Concern	3000	$	977,438
		$	**8,349,923**

		Total
Upland Forest	$	6,020,291
Mesic Forest	$	9,085,889
Island	$	1,865,381
Species of Concer	$	591,963
	$	**17,563,523**

The following resources are considered significant and will be evaluated further to mitigate for impacts, if found. They include significant species, floodplain forest, islands, other social resources, and historic properties.

10.5.4.1 Significant Species

This includes one eagle nest and two heron rookeries on the Mississippi River and two locations with threatened plant species on the Illinois River totaling approximately 5,000 feet of bankline. Resources of special concern such as eagle nests, heron rookeries, or other listed species will be protected 100 percent as will upland forest, due to their special status or scarcity. Land cover identified as upland forest is assumed to include species such as oaks or hickories, which are not abundant in the floodplain.

10.5.4.2 Floodplain Forest

Through a spatial analysis using land cover data and erosion coverage, those areas classified as upland forest at risk from navigation-induced bankline erosion were selected (Figure 10-3). Upland forest totals 8,217 feet on the Mississippi River and 233 feet on the Illinois River. There were 245,340 feet of mesic forest on the Mississippi River and 135,451 feet on the Illinois River. Mesic forest classification includes abundant species such as silver maple or cottonwood. Based on the comments at the NECC meeting, this resource is considered abundant in the region and, thus, protection would not be a high priority.

However, significant areas may be identified during verification, and it was assumed that there would be the need to protect up to 3 percent for mitigation. Protection of US Fish and Wildlife Service National Wildlife Refuge lands containing high quality forests was identified as a Trust resource included for protection.

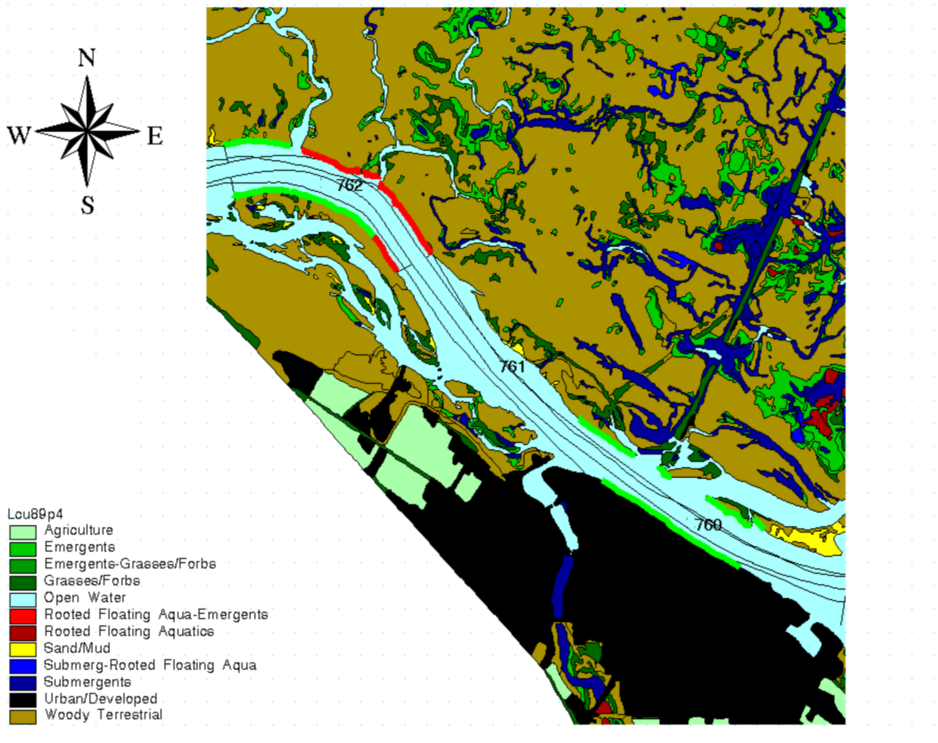

Figure 10-3. Example area of resources at potential risk for bank erosion.

10.5.4.3 Islands

The consideration of islands as a resource, regardless of land cover or other resources present, relates to the potential loss of habitat diversity provided by islands and the potential for the introduction of additional flow and sediment into backwater and secondary channel areas. Islands where a reasonable amount of erosion at the identified sites would result in the loss or dissection of an island were identified; examples include small islands in the impounded portion of the navigation pools; small, main channel islands; and islands with interior aquatic areas. In addition, the heads of islands on the outside of bends and crossovers, potentially subject to prop wash and other navigation effects were identified for protection. A total of 105,521 feet on the Upper Mississippi River and 18,301 feet on the Illinois River were identified. Because of the rarity of islands on the Illinois River, it was assumed that 100 percent of the bankline identified would be protected. In contrast, on the Mississippi River, it was assumed that placement of protection on 10 percent of the estimated total distance would be sufficient to provide erosion protection.

10.5.4.4 Social Resources

There may be isolated impacts to infrastructure or other developed areas adjacent to erosion areas. Protection of these areas will depend on identification and determination of the significance of the impact. It was estimated that up to 2,000 feet may require protection.

10.5.4.5 Historic Properties

Historic properties costs were determined based on assumptions derived from GIS archeological sites and geomorphological data and from historic properties management plans for each of the three Districts. Archeological survey needs were based on the assumptions that 10 percent of the erosion areas had been adequately surveyed and that 10 percent of the erosion areas were adequately protected. In addition, it has been assumed that anywhere from 25 percent (IWW) to 50 percent (UMR) of the remaining area subject to archeological survey would not require investigation due to low archeological potential.

The Programmatic Agreement (PA) between the St. Paul, Rock Island, and St. Louis Districts, U.S. Army Corps of Engineers, the State Historic Property Officers (SHPOs) from Wisconsin, Minnesota, Illinois, Iowa, and Missouri, and the Advisory Council on Historic Preservation (Appendix ENV-C) identified how the Corps would satisfy its responsibilities under Section 106 of the National Historic Preservation Act of 1966, as amended and its implementing regulations 36 CFR Part 800. Included in the PA are measures for determining effects to significant historic properties from both site-specific and systemic impacts from the proposed alternatives. Supporting investigations will be conducted in a phased-in approach consisting of Phase I survey, Phase II testing, and Phase III treatment. Phase III treatment of a historic property may include preservation, avoidance, or mitigation of the loss of the property through some form of data recovery such as, but not limited to, complete excavation of an archeological site or the detailed documentation of a standing structure.

Studies conducted for the Corps by Bear Creek Archeology (BCA) of Cresco, Iowa, and the Illinois State Museum (ISM) of Springfield, Illinois, prioritized each of the potential bank erosion areas according to the potential to affect significant historic properties. There are 37 previously recorded archeological sites on the UMR that are located within 50 meters of potential bank erosion areas. These sites are identified by UMR pool number and proposed cultural resource management action in Table 10-11.

The highest cultural resource management priority is given to those sites that are listed or eligible for listing to the NRHP that are threatened by bank erosion (n=9). All of these sites, regardless of existing bank protection, will need to be revisited in the field in order to verify their location and to establish a monitoring plan designed to evaluate existing bank protection and/or determine if bank erosion is taking place. In the event that bank erosion is determined to be adversely affecting any of these sites, the Corps will develop and implement protection and/or mitigation plans in consultation with the SHPO and in accordance with stipulations in the PA. The second highest management priority is given to those sites that are potentially eligible for listing to the NRHP that are threatened by bank erosion (n=21). Again, all sites will require field verification in order to establish the site location and to evaluate existing bank protection (n=9 sites) and/or determine if bank erosion is taking place. In addition, these sites will require archeological testing in order to determine NRHP eligibility. Those sites found eligible for the NRHP will be managed as described above and in consultation with the appropriate SHPOs and in accordance with stipulations of the PA. Those sites found to be ineligible for inclusion to the NRHP will be dropped from management concern.

There are 17 NRHP eligible archeological sites on the IWW that are threatened by bank erosion. Each site will require field verification to establish the site location and to develop a monitoring plan to determine if bank erosion is taking place (Table 10-12). If bank erosion is determined to be adversely affecting any of these sites, the Corps will develop and implement protection and/or mitigation plans in consultation with the SHPO and in accordance with stipulations in the PA. There are 46 archeological sites that are potentially eligible for the NRHP located within 50 meters of potential bank erosion areas. All of these sites will require field verification in order to establish the site location and to evaluate existing bank protection (n=5 sites) and/or determine if bank erosion is taking place. In addition, these sites will require archeological testing in order to determine NRHP eligibility.

Table 10-11. Archeological sites within 50 meters of potential bank erosion areas identified by UMR navigation pool and proposed cultural resource management action.

Cultural Resources Management Actions	UMR Navigation Pool 4	5	6	8	9	10	11	18	Total Sites by CRM Action
NRHP eligible; Monitor Condition and Mitigate or Protect as Necessary					1	3		2	6
NRHP Eligible; Monitor to Evaluate Existing Protection and Mitigate or Protect as Necessary				3					3
Monitor to Evaluate Existing Protection. Test and Mitigate or Protect as Necessary	3	1		1	2	1	1		9
Monitor, Test for NRHP Eligibility, and Mitigate or Protect as Necessary		1	1		1	7	2		12
Ineligible for NRHP. No CRM Action Proposed			2		1	1	2	1	7
Total Sites Subject to CRM Actions by Pool	3	2	3	4	5	12	5	3	37

Table 10-12. Archeological sites within 50 meters of potential bank erosion areas identified by IWW navigation pool and proposed cultural resource management action.

Cultural Resources Management Actions	IWW Navigation Pool Marseilles	Alton	Dresden	Lagrange	Peoria	Starved Rock	Total Sites by CRM Action
NRHP Eligible; Monitor Condition and Mitigate or Protect as Necessary	0	2	0	13	1	1	17
Monitor, Test for NRHP Eligibility, Mitigate or Protect as Necessary	3	4	6	22	6	0	41
Monitor to Evaluate Existing Protection. Test and Mitigate or Protect as Necessary	3	0	0	1	0	1	5
Ineligible for NRHP. No CRM Action Proposed	0	0	5	14	4	0	23
Total Sites Subject to CRM Actions by Pool	6	6	11	50	11	2	86

Those sites found eligible for the NRHP will be managed as described above and in consultation with the appropriate SHPOs and in accordance with stipulations of the PA. Those sites found to be ineligible for inclusion to the NRHP will be added to the list of ineligible sites and dropped from management concern.

In summary, there are 26 NRHP eligible archeological sites that will require field verification and bank erosion assessment. In addition, there are 67 archeological sites that are potentially eligible for inclusion to the NRHP that will require field verification, bank erosion assessment, and archeological testing to determine NRHP eligibility, when necessary. It is anticipated that archeological testing will be necessary only in those instances where bank erosion is documented. Bank erosion monitoring will require an initial site inspection and mapping followed by periodic inspection (every 5 years) designed to identify changed conditions. Archeological testing and/or mitigation will be employed only in those instances where bank erosion is documented over the period of inspection. The details of bank erosion monitoring and follow-on archeological testing and/or mitigation will be developed in consultation with the SHPOs and THPOs and in accordance with the PA.

In addition to previously recorded archeological sites, the BCA and ISMS analysis evaluated the likelihood that potential bank erosion areas would affect undocumented archeological sites. Critical to this analysis was the identification and evaluation of previously surveyed areas and the assessment of the archeological potential of those areas. Archeological potential was determined on the basis of HPMP data, geomorphic Landform Sediment Assemblages (LSA) data, and firsthand field experience of personnel from BCA and ISMS.

There are approximately 32,000 meters of potential bank erosion areas that have not been surveyed but are considered to have high potential for undocumented cultural resources. A combination of monitoring and field investigation will be required. There are approximately 87,000 meters of potential bank erosion areas that have not been surveyed that have medium potential for undocumented cultural resources. These areas will require some form of monitoring and, if necessary, field investigation. Finally, approximately 218,000 meters of unsurveyed potential bank erosion areas have been identified as having low or no potential to affect undocumented cultural resources. In addition, approximately 3,700 meters of the low potential bank erosion areas have some form of bank protection. Further cultural resource evaluation is not recommended for any of the low/no archeological potential locations.

10.5.4.6 Mitigation Measures – Bank Erosion

10.5.4.6.1 Non-structural Measures

Vegetative bank stabilization; this technique is becoming more common on small to medium-sized streams, but its application on a large river remains untested. For this study, use of this approach should be considered in conjunction with traditional bank protection methods, and if determined feasible, could lower overall costs for structural protection. Individual site assessment would be necessary to make this determination.

10.5.4.6.2 Structural Measures

Structural measures include bank protection and offshore revetments. A combination of measures, such as structural and vegetative bank protection, could be used to maximize habitat benefits.

10.5.4.7 Data Recovery

Where a site is at risk and information contained is appropriate for data recovery, archeological data recovery will be conducted.

10.5.4.8 Monitoring and Information Needs

Monitoring costs were developed for Alternative 4, Alternative 6, and Alternative 4 & 6. Bank erosion costs were the same for either alternative (Table 10-13), whereas historic properties mitigation and monitoring costs varied between Alternative 4, Alternative 6 and Alternative 4 & 6 (Table 10-14).

Table 10-13. Estimated cost of bank erosion monitoring for Alternative 4, Alternative 6, or Alternative 4 & 6.

Alternative 4, Alternative 6, or Alternative 4 & 6

Study	Amount		Cost ($)
Bank erosion pre construction	10 sites @ $5k/ site	$	50,000
	Total		**50,000**

Table 10-14. Estimated cost of historic properties mitigation and monitoring (including site-specific costs).

Alternative 4

Projected Measures	Projected Mitigation Cost			
	Amount*	Per Unit Cost		Total
Systemic Mitigation				
Archeological Site Monitoring	100 sites	$2K/site	$	200,000
Archeological Survey	2500 ac	$20K/100 ac	$	500,000
Archeological Testing	80 sites	$20K/site	$	1,600,000
Archeological Data Recovery	42 sites	$150K/site	$	6,300,000
			$	8,600,000
Site Specific Mitigation				
Film\Public Information	3 hr film	$5K/minute	$	900,000
		SubTotal	$	900,000
		Alt. 4 Total	$	9,500,000

Alternative 6 and Alternative 4 & 6

Projected Measures	Projected Mitigation Cost			
	Amount*	Per Unit Cost		Total
Systemic Mitigation				
Archeological Site Monitoring	100 sites	$2K/site	$	200,000
Archeological Survey	2500 ac	$20K/100 ac	$	500,000
Archeological Testing	80 sites	$20K/site	$	1,600,000
Archeological Data Recovery	42 sites	$150K/site	$	6,300,000
		SubTotal	$	8,600,000
Site Specific Mitigation				
Film\Public Information	3 hr film	$5K/minute	$	900,000
Architectural Recordation	12 locations	$50K/location	$	600,000
Archeological Survey	12 locations	$20K/location	$	240,000
Archeological Testing	5 sites	$20K/site	$	100,000
Archeological Data Recovery	1 site	$150K/site	$	150,000
		SubTotal	$	1,990,000
		Alt. 6 and Alt 4 & 6 Total	$	10,590,000

* Includes both known archeological sites and projected sites based on assumptions provided in the text.

Navigation effects validation studies – None.

Model validation – None.

Pre-construction studies – A follow-up site assessment would be performed to document and determine the extent and potential significance of erosion at the areas identified by Bhowmik et al. (1999, ENV 8) at 10 sites. The actual rate of erosion at the identified sites is dependent on the nature of the bank materials and subaqueous conditions, potential commercial navigation effects, and other erosion mechanisms affecting the site.

Post-construction studies – A site assessment will be performed to assess the effectiveness of structural measures at slowing erosion rates at five sites.

Long-term performance monitoring – Bank erosion measures would be checked every 5 years to ensure that they continued to meet the mitigation objectives over time. These findings will be provided in a 5-year mitigation performance report.

10.6 Mussels

The assessment of freshwater mussels was based on a review of scientific literature, a laboratory study, a numeric model, and coordination with State and Federal resource managers. Targeted research studies generated two reports dealing with freshwater mussels. Results of these studies are summarized in Chapter 8.

A laboratory study was conducted to determine the effects of navigation traffic-induced velocity and suspended solids on mussels (Payne et al. 2000, ENV 31). The study found that frequent exposure to high turbulence levels did not affect filtration rate, respiration rate, or tissue condition. Short-term experiments also investigated the additive effects of suspended solids. Physiological disruption was slightly greater when high suspended solids concentration accompanied intermittent turbulence. The tendency was toward downward shifts in nitrogen excretion. Although some statistically significant shifts were measured, major changes in metabolic conditions generally were not indicated. No changes in tissue condition occurred.

The investigation of the potential impacts of zebra mussels determined increased navigation traffic will not have a significant impact beyond existing traffic conditions. Although the magnitude of impacts was impossible to quantify, natural resource managers have noted that mussel beds are affected on occasion by such events as crushing of mussel shells by barges being fleeted in shallow areas, and habitat destruction by tow boats maneuvering in areas where water depth will not support navigation. However, these events are rare and would not significantly affect the mussel resources of the Upper Mississippi River. Finally, a modeling study looking at the effects of water velocity changes and suspended sediment on growth and reproduction found no significant impacts that would require mitigation. The largest adverse effects on growth and reproduction were observed on the Illinois River, but their magnitude was small. In total, these study efforts do not reveal any significant impacts to mussels associated with increasing traffic, and therefore, no mitigation is proposed for mussels.

10.6.1 Monitoring and Information Needs

Navigation effects validation studies – A mussel verification study would be performed on 12 known mussel beds over 2 years to validate the laboratory finding of no effect (Table 10-15).

Model validation – None.

Pre-construction studies – None (unless required under the Endangered Species Act).

Post-construction studies – None.

Long-term performance monitoring – None.

Table 10-15. Estimated cost of mussel verification monitoring for Alternative 4, Alternative 6, or Alternative 4 & 6.

Alternative 4, Alternative 6, or Alternative 4 & 6

Study	Amount	Cost ($)
Mussel verification	12 beds, $350/2 years	$ 350,000
	Total	**350,000**

10.7 Summary of Adaptive Mitigation Strategy

This mitigation plan used a science-based conservative approach to ensure all significant adverse effects would be mitigated to levels of insignificance. The net effect from both increased traffic and site-specific impacts would be no loss to fisheries, submersed aquatic plants, backwaters, secondary channels, and historic properties.

This strategy has presented an initial approach to application of avoid, minimize, and mitigation measures, based on predicted impacts and assessment of significance of those impacts to resources of concern (Table 10-16). The schedule for proposed implementation of these measures parallels that for the proposed navigation improvement alternatives. Generally, this means that further field verification would occur early in the planning period, followed by planning, design, and implementation of avoid and minimize measures. Following the adaptive framework of this document, performance of measures would be assessed and traffic levels and impacts monitored to determine further planning and implementation of avoid, minimize, and mitigation measures. CEQ guidance suggests that a reasonable worse case scenario be assessed when there are gaps in relevant information or scientific uncertainty; therefore, the model and scenario that forecast the largest incremental increase in traffic was selected as the base for mitigation. The total cost of mitigation for Alternative 4 is approximately $93,350,164; and $203,303,906 for Alternative 6 based upon Year 2003 dollar values (Table 10-17).

The CEQ NEPA Task Force (CEQ 2003) suggests that the effectiveness of adaptive management hinges upon an effective monitoring program to establish objectives, thresholds, and baseline conditions. This will be achieved through a stepwise process that includes 1) navigation effects validation studies, 2) model validation studies, 3) pre-construction studies, 4) post-construction studies, and 5) long-term performance modeling. These studies are scheduled early in the project timeline so that the adaptive mitigation plan can be modified based upon field results and future river conditions to ensure mitigation is effective. Table 10-18 shows the cost of monitoring for Alternatives 4 and 6. Performance monitoring will be conducted over a broad geographic range, keying in on those components that were identified by this plan as being affected by the incremental increase in commercial navigation traffic (Table 10-18).

Any mitigation actions will be adaptive in nature, and an authorized mitigation plan and costs will have leeway to modify mitigation features and measures based on monitoring results and future river conditions.

Table 10-16. Summary comparison of mitigation measures for the UMR-IWW under Alternative 4 and Alternative 6.

Upper Mississippi River	Bank Erosion		Backwater & Secondary Channel		Plants		Fish[1]		Historic Properties		Site Specific	
	Alt 4	Alt 6	Alt 4	Alt 6	Alt 4	Alt 6	Alt 4	Alt 6	Alt 4	Alt 6	Alt 4	Alt 6
1							X	X				
2							X	X				
3							X	X				
4	X	X					X	X	X	X		
5	X	X	X	X	X		X	X	X	X		
5a	X	X					X	X				
6	X	X	X	X			X	X	X	X		
7	X	X	X	X			X	X				
8	X	X	X	X			X	X	X	X		
9	X	X	X	X	X		X	X	X	X		
10	X	X	X	X			X	X	X	X		
11	X	X	X	X	X		X	X	X	X		
12	X	X					X	X			X	X
13	X	X	X	X	X	X	X	X				
14	X	X					X	X			X	X
15	X	X					X	X				X
16	X	X					X	X				X
17	X	X					X	X				X
18	X	X					X	X	X	X	X	X
19	X	X			X		X	X				
20	X	X					X	X			X	X
21							X	X				X
22	X	X					X	X			X	X
24	X	X					X	X			X	X
25							X	X				X
26	X	X					X	X				
Open river	X	X					X	X				
Illinois Waterway												
Dresden	X	X	X	X			X	X	X	X		
Marseilles	X	X	X	X			X	X	X	X		
Starved Rock	X	X	X	X			X	X	X	X		
Peoria	X	X	X	X			X	X	X	X		X
LaGrange	X	X					X	X	X	X	X	X
Alton	X	X					X	X	X	X	X	X

[1]Fisheries monitoring is not evenly distributed in all Pools.

Table 10-17. Comparison of mitigation cost between all navigation efficiency alternatives (2003 dollars).

Avoid, Minimize & Mitigation Measures	Mitigation Cost for Navigation Efficiency Alternative Plans: Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 4 & 6
B1. Bank Erosion	$ -	$ -	$ -	$ 17,563,523	$ 17,563,523	$ 17,563,523	$ 17,563,523
B2. Backwater & Secondary Channel	$ -	$ -	$ -	$ 29,390,769	$ 29,390,769	$ 29,390,769	$ 29,390,769
B3. Plants	$ -	$ -	$ -	$ 3,306,020	$ 12,021,890	$ 16,530,098	$ 16,530,098
B4. Fish	$ -	$ -	$ -	$ 13,167,619	$ 36,196,040	$ 59,156,934	$ 60,802,331
B5. Env. Monitoring	$ -	$ -	$ -	$ 7,171,441	$ 9,400,000	$ 14,292,780	$ 14,292,780
B6. Historic Properties	$ -	$ -	$ -	$ 9,500,000	$ 10,200,000	$ 10,590,000	$ 10,590,000
B7. Site Specific Mitigation	$ -	$ -	$ -	$ 4,764,413	$ 15,127,011	$ 37,297,628	$ 37,297,628
subtotal	$ -	$ -	$ -	$ 84,863,785	$ 129,899,233	$ 184,821,733	$ 186,467,129
B8. Administration				$ 8,486,379	$ 12,989,923	$ 18,482,173	$ 18,646,713
B9. Total Mitigation Cost	$ -	$ -	$ -	$ 93,350,164	$ 142,889,156	$ 203,303,906	$ 205,113,842

Table 10-18. Performance monitoring breakdown for Alternative 4, Alternative 6, and Alternative 4 & 6.

Alternative 4

	Amount	Cost ($)
Plant model validation	$200k/3 years	$ 200,000
Plant pre construction	50k/site	$ 50,000
Plant post construction	50k/site	$ 50,000
Nav effects -Fish trawling	$200k/ site	$ 600,000
Fish pre construction	2 @ $50k/site	$ 100,000
Fish post construction	2 @ $50k/site	$ 100,000
BW/SC pre construction	25 sites @ $35k/site	$ 875,000
BW/SC post construction	6 sites @ $35k/site	$ 210,000
Bank erosion pre construction	10 sites @ $5k/site	$ 50,000
Mussel verification	12 beds, $350/2 years	$ 350,000
Project performance monitoring[1]	Start in year 2016	$ 4,586,441
	Total	**7,171,441**

Alternative 6 and Alternative 4 & 6

	Amount	Cost ($)
Plant model validation	$200k/3 years	$ 200,000
Plant pre construction	5@$50k/site	$ 250,000
Plant post construction	5@$50k/site	$ 250,000
Nav effects -Fish trawling	$200k/ site	$ 600,000
Fish pre construction	10 @ $50k/site	$ 500,000
Fish post construction	10 @ $50k/site	$ 500,000
BW/SC pre construction	25 sites @ $35k/site	$ 875,000
BW/SC post construction	6 sites @ $35k/site	$ 210,000
Bank erosion pre construction	10 sites @ $5k/site	$ 50,000
Mussel verification	12 beds, $350/2 years	$ 350,000
Project performance monitoring[1]	Start in year 2016	$ 10,507,780
	Total	**14,292,780**

[1]10% of cost of Fish, Plant, and Backwater and Secondary Channel projects

11.0 STATUTORY AND OTHER APPLICABLE REQUIREMENTS

The U.S. Army Corps of Engineers has conducted site characterization activities in accordance with requirements of applicable laws and regulations and a range of permits and approvals that regulate the various aspects of the activities. Under the programmatic approach described in this PEIS, the Corps would successfully meet environmental protection standards for its site characterization activities by developing a comprehensive approach to environmental compliance that ensures adherence to Federal and State requirements. It has implemented specific environmental compliance programs for protection of cultural resources, unique resources, and protection of threatened or endangered species. Future actions involving the development of this plan will continue to comply with applicable Federal and State environmental requirements and with the conditions of the permits and approvals that might be required to conduct its activities in accordance with Executive Orders and laws.

This chapter identifies major requirements that could be applicable to the Proposed Action, which is to construct, operate and monitor the UMR-IWW System under the dual purposes of navigation efficiency improvement and ecosystem restoration. Table 11-1 lists the effects of the recommended action on natural resources and historic properties, as well as the associated regulatory authorities for construction, operation, and maintenance of the UMR-IWW Navigation Study.

11.1 Compliance with Environmental Statutes

11.1.1 National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347).

The National Environmental Policy Act (NEPA) is the basic national charter for protection of the environment. The Corps has prepared this EIS in accordance with the provisions of the National Environmental Policy Act as implemented by Council on Environmental Quality regulations (40 CFR Parts 1500 through 1508) and Corps National Environmental Policy Act regulations (ER 200-2-2), and in conformance with the PA. The compilation of this PEIS addresses utilization of the identified programmatic alternatives. Any site-specific project that would tier off of this PEIS would do so with a supplemental NEPA document.

11.1.2 Protection and Enhancement of Environmental Quality (Executive Order 11514).

Executive Order 11514 directs federal agencies to monitor, evaluate, and control their activities continually to protect and enhance the quality of the environment and also requires the development of procedures both to ensure the fullest practicable provision of timely public information and understanding of federal plans and programs with potential environmental impacts, obtain the views of interested parties, provide information regarding potential or existing environmental problems to other government agencies, and review their agencies statutory authority. The Corps has promulgated regulations (33 CFR Part 230, Procedures for Implementing the National Environmental Policy Act) to ensure compliance with this Executive Order.

11.1.3 Administrative Procedures Act (5 U.S.C. 511-599)

The Administrative Procedures Act (APA) is the law under which federal agencies create the rules and regulations necessary to implement and enforce major legislative acts. This Act describes the standards by which federal agencies provide public information, records about individuals, open meetings, adjudications, and ancillary matters so that information can be uniformly managed. The Corps has complied with the provisions of this act through public meetings, newsletters, coordination and the NEPA review process.

Table 11-1. Programmatic assessment of effects of the recommended action on natural resources and historic properties, as well as the associated regulatory authorities.

Types of Resources	Regulatory Authorities	Level of Effect
Water Quality	Clean Water Act Safe Drinking Water Act	Site specific significant effects assessed under tiered NEPA assessment
Control of Pollution	Clean Air Act Noise Control Act	Site specific significant effects assessed under tiered NEPA assessment
Cultural Resources	National Historic Preservation Act Archaeological Resources Protection Act Abandoned Shipwreck Act American Indian Religious Freedom Act Native American Graves Protection and Repatriation Act Antiquities Act Indian Sacred Sites *(*Executive Order 13007) Consultation and Coordination with Indian Tribal Governments (Executive Order 13175)	Effects assessed through implementation of programmatic agreement process
Ecology and Habitat	Fish and Wildlife Coordination Act Endangered Species Act Migratory Bird Treaty Act Bald and Golden Eagle Protection Act National Wildlife Refuge System Administration Act Wild and Scenic Rivers Act Coastal Zone Management Act Protection of Wetlands (Executive Order 11990) Invasive Species (Executive Order 13112) Responsibilities of Federal Agencies to Protect Migratory Birds (Executive Order 13186)	Significant effects assessed and mitigated (See Chapt 10, Adaptive Mitigation) Site specific significant effects assessed under tiered NEPA assessment Significant impacts to threatened and endangered species assessed in BA and BO Wild and Scenic Rivers not present in planning area Though Coastal Zone not present in planning area, ecosystem restoration may reduce Gulf hypoxia
Use of Land and Water Bodies	Rivers and Harbors Act Farmland Protection Policy Act Watershed Protection and Flood Prevention Act Flood Plain Management (Executive Order 11988) Federal Water Project Recreational Act	Site specific significant effects assessed under tiered NEPA assessment

11.2 Water Quality

11.2.1 Clean Water Act of 1977 (33 U.S.C. 1251 *et seq.*) (Sections 401 and 404), as amended.

The purpose of the Clean Water Act, which amended the Federal Water Pollution Control Act, is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." The States have been delegated the authority to implement and enforce most programs in the State under the Clean Water Act; exceptions include those addressed by Section 404, which is administered by the U.S. Army

Corps of Engineers, as described below in this section. The Clean Water Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 118 of the Act generally requires all departments and agencies of the federal government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with federal, state, interstate, and local requirements. Under the Clean Water Act, states generally set water quality standards, and the U.S. Environmental Protection Agency and states regulate and issue permits for point-source discharges as part of the National Pollutant Discharge Elimination System permitting program.

Section 404 of the Clean Water Act gives the U.S. Army Corps of Engineers permitting authority over activities that discharge dredge or fill material into waters of the United States. The Corps would need a permit for activities associated with this action if those activities would discharge dredge or fill into any such waters. Sections 401 and 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act. Section 402(p) requires the U.S. Environmental Protection Agency to establish regulations for the Agency or individual states to issue permits for stormwater discharges associated with industrial activity, including construction activities that could disturb 5 or more acres (40 CFR Part 122). The Corps would attain 401 water quality certification on a project by project basis from the affected State.

11.2.2 Safe Drinking Water Act (42 U.S.C. 300f et seq, 6939b; U.S.C. 1261 et seq)

The primary objective of the Safe Drinking Water Act is twofold: (1) to protect the nation's sources of drinking water, and (2) to protect public health to the maximum extent possible, using proper water treatment techniques. This law grants the U.S. Environmental Protection Agency the authority to protect the quality of public drinking water supplies by establishing national primary drinking water regulations. In accordance with the Safe Drinking Water Act, the U.S. Environmental Protection Agency has delegated authority for enforcement of drinking water standards to the states. Underground sources of drinking water are also protected through applying the same drinking water standards, identifying critical aquifer protection areas, and programs to protect wellhead areas from contaminants.

11.3 Control of Pollution

11.3.1 Clean Air Act (42 U.S.C. 7401-7671g)

The purpose of the Clean Air Act is to protect public health and welfare by the control of air pollution at its sources and to set forth primary and secondary, National Ambient Air Quality Standards (NAAQS) to establish criteria for States to attain, or maintain, these minimum standards. It also requires the establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 U.S.C. 7411) and the evaluation of specific emission increases to prevent a significant deterioration in air quality (42 U.S.C. 7470). Air emission standards are established at 40 CFR Parts 50 through 99. It is not anticipated that the programmatic alternatives, neither short-term nor long-term, would result in violations to air quality standards. The environment would not be exposed to contaminants/pollutants in such quantities and of such duration as may be or tend to be injurious to human, plant, or animal life, or property, or which unreasonably interferes with the comfortable enjoyment of life, or property, or the conduct of business.

11.3.2 Noise Control Act of 1972, as amended (42 U.S.C. 4901 et seq.)

Section 4 of the Noise Control Act directs federal agencies to carry out programs in their jurisdictions "to the fullest extent within their authority" and in a manner that furthers a national policy of promoting an environment free from noise that jeopardizes health and welfare. This law provides requirements related to noise that would be generated by construction, operation, or closure activities associated with the Proposed Action on the UMRS. The evaluation of noise impacts would be performed during site-specific NEPA analyses tiered from this PEIS.

11.4 Cultural Resources

11.4.1 National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 et seq.).

The National Historic Preservation Act of 1966, amended through 2000 (NHPA, Public Law 89-665; 16 U.S.C. 470 et seq.). NHPA and its implementing regulations 36 CFR Part 800: "Protection of Historic Properties," establishes the primary policy, authority for preservation activities, and compliance procedures. The NHPA ensures early consideration of historic properties preservation in federal undertakings and the integration of these values in to each agency's mission. The Act declares federal policy to protect historic sites and values in cooperation with other nations, states, and local governments. The head of any federal agency having direct or indirect jurisdiction over a proposed federal or federally assisted undertaking shall, prior to the approval of the expenditure of any federal funds on the undertaking, take into account the effect of the undertaking of any district, site building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. The head of any such federal agency shall afford the Advisory Council on Historic Preservation a reasonable opportunity to comment with regard to such undertaking.

To afford protection to known and unknown significant historic properties resulting from the implementation of the Navigation Study navigation improvements, the Corps proposes a *Programmatic Agreement Among the U.S. Army Corps of Engineers Mississippi Valley Division, St. Paul District, Rock Island District, and St. Louis District, Illinois, Iowa, Minnesota, Missouri, and Wisconsin State Historic Preservation Officers, and Advisory Council on Historic Preservation, Regarding Implementation of the Upper Mississippi River-Illinois Waterway System Navigation Study and Ecosystem Restoration for Ongoing Effects of Navigation From the Upper Mississippi River - Illinois Waterway System Navigation Study* (Draft PA). As regulated by in 36 CFR Part 800.8(c)(1), the Draft PA is made available within the Draft environmental document for review and comment by the State Historic Preservation Officers (SHPOs), the Advisory Council on Historic Preservation, Native American Indian Tribes and other interested parties. Reviews and comments were considered in the final PA (Appendix ENV-C). The final and fully executed PA has been sent to the signatories to this agreement.

Although the PA assures NHPA compliance, consultation concerning all historic property findings, and that any determination of effects have been identified and documented within the area of potential affect and the District has taken into account all historic properties relative to the planning process through consultation and coordination, if any undocumented historic properties are identified or encountered during the undertaking, the Corps will discontinue all construction and ancillary activities as soon as feasible and resume coordination with the appropriate SHPOs, Tribal Historic Preservation Officer (THPOs), Tribes, other consulting parties to identify the significance of the historic property and determine potential effects as executed by the PA.

If human remains, funerary objects, sacred objects, or objects of cultural patrimony are encountered or collected, the Corps will comply with all provisions outlined in the appropriate state acts, statutes, guidance, provisions, etc., and any decisions regarding the treatment of human remains will be made recognizing the rights of lineal descendants, Tribes, and other Native American Indians and under consultation with the SHPOs/THPOs and the other consulting parties, designated Tribal Coordinator, and/or other appropriate legal authority for future and expedient disposition or curation. When finds of human remains, funerary objects, sacred objects, or objects of cultural patrimony are encountered or collected from federal lands or federally recognized tribal lands, the Corps will coordinate with the appropriate federally recognized Native American Tribes, pursuant to the Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001 *et seq*.) and its implementing regulations (43 CFR Part 10).

11.4.2 Archaeological Resources Protection Act, as amended (16 U.S.C. 470aa et seq.)

The Archaeological Resources Protection Act requires a permit for excavation or removal of archaeological resources from publicly held or Native American lands. Excavations must further archaeological knowledge in the public interest, and the resources removed are to remain the property of the United States. If a resource is found on land owned by a Native American tribe, the tribe must give its consent before a permit is issued, and the permit must contain terms or conditions requested by the tribe. Requirements of the Archaeological Resources Protection Act would apply to any project excavation activities that resulted in identification of archaeological resources.

11.4.3 Abandoned Shipwreck Act of 1987 (43 U.S.C. 2101-2106)

The Abandoned Shipwreck Act asserts the ownership of the United States over any abandoned shipwreck in State waters and submerged lands. The act provides federal protection to any shipwreck that meets the criteria for eligibility for inclusion in the National Register for Historic Places, therefore disposal or dredged material or other material on or in the near vicinity of such wrecks is prohibited. The Corps conducted an archival search for historic properties following the "Policy and Procedures for the Conduct of Underwater Historic Resource Surveys for Maintenance Dredging and Disposal Activities" (DGL-89-01, 1989) to assist in avoidance of significant impacts to these types of resources.

11.4.4 American Indian Religious Freedom Act of 1978 (42 U.S.C. 1996)

The American Indian Religious Freedom Act reaffirms Native American religious freedom under the First Amendment and establishes policy to protect and preserve the inherent and constitutional right of Native Americans to believe, express, and exercise their traditional religions. This law ensures the protection of sacred locations and access of Native Americans to those sacred locations and traditional resources that are integral to the practice of their religions. Further, it establishes requirements that would apply to Native American sacred locations, traditional resources, or traditional religious practices potentially affected by the construction and operation of the proposed project.

11.4.5 Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001 et seq)

The Native American Graves Protection and Repatriation Act provides for the protection of Native American cultural items, and establishes a process for the authorized removal of human remains, funerary objects, sacred objects, and objects of cultural patrimony from sites located on lands owned or controlled by the federal government. Major actions to be taken under this law include: (1) the establishment of a review committee with monitoring and policymaking responsibilities, (2) the development of regulations for repatriation, including procedures for identifying lineal descent or cultural affiliation needed for claims, (3) the oversight of museum programs designed to meet the inventory requirements and deadlines of this law, and (4) the development of procedures to handle unexpected discoveries of graves or grave goods during activities on federal or tribal land. The provisions of the Act would be invoked if any excavations led to unexpected discoveries of Native American graves or grave artifacts. The Corps, the THPOs and the SHPOs have entered an agreement to address the potential applicability of the Native American Graves Protection and Repatriation Act to artifacts collected during site characterization activities.

11.4.6 Antiquities Act (16 U.S.C. 431 *et seq.*)

The Antiquities Act protects historic and prehistoric ruins, monuments, and objects of antiquity (including paleontological resources) on lands owned or controlled by the federal government. If historic or prehistoric ruins or objects were found during the construction or operation of facilities associated with this project, the Corps would have to determine if adverse effects to these ruins or objects would occur. If adverse effects would occur, the Secretary of the Interior would have to grant permission to proceed with the activity (36 CFR Part 296 and 43 CFR Parts 3 and 7).

11.4.7 Indian Sacred Sites (Executive Order 13007)

This Order directs federal agencies, to the extent permitted by law and not inconsistent with agency missions, to avoid adverse effects to sacred sites and to provide access to those sites to Native Americans for religious practices. The Order directs agencies to plan projects to provide protection of and access to sacred sites to the extent compatible with the project.

11.4.8 Consultation and Coordination with Indian Tribal Governments (Executive Order 13175)

This Order directs federal agencies to establish regular and meaningful consultation and collaboration with tribal governments in the development of federal policies that have tribal implications, to strengthen United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates on tribal governments.

11.5 Ecology and Habitat

11.5.1 Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, 48 Stat. 401)

The Fish and Wildlife Coordination Act promotes more effectual planning and cooperation between federal, state, public, and private agencies for the conservation and rehabilitation of the Nation's fish and wildlife and authorizes the Department of the Interior to provide assistance. This project has been coordinated with the U.S. Fish and Wildlife Service and the Wisconsin Department of Natural Resources (DNR), Minnesota DNR, Iowa DNR, Illinois DNR, and Missouri Department of Conservation through a series of NECC meetings as well as formal coordination. The USFWS developed a Coordination Act Report (CAR) for this study dated 1 August 2001 (also in Appendix ENV-K) that has been used to guide decisions as the study has been developed. The USFWS updated this CAR in April 2004 for the integrated plan. The following recommendations are from the April 2004 CAR:

1. The Service endorses Ecosystem Restoration Alternative E and Cost Sharing Option C for a full 50-year project life, since they offer the highest degree of certainty for achieving the study's UMRS habitat goals and objectives.

2. The Service supports a new dual purpose Nine-foot Channel Navigation Project authority that includes ecosystem restoration as a project purpose.

3. Initial implementation of any ecosystem restoration program should employ an adaptive management strategy.

4. The Corps, Service, states, and other partners should make every effort to integrate their programs and authorities to achieve ecosystem restoration.

5. In order to effectively integrate the multiple authorities, programs, and activities that occur on the UMRS, a new intuitional framework must be established.

6. Implementing cross-cut budgeting among the Corps, USDOI, USEPA, and USDA should be a high priority in order to achieve UMRS partner goals

7. Planning, engineering, design, and construction requirements for habitat restoration projects must be revised in order to implement adaptive management and improve cost efficiency.

8. Operation and maintenance of restoration projects that offset navigation impacts should be a Corps responsibility.

9. In order to avoid or minimize barge fleeting impacts to fish and wildlife resources, a system-wide fleeting plan should be prepared.

These recommendations were considered and discussed with the stakeholder agencies as the Corps developed the recommended plan.

11.5.2 Endangered Species Act of 1973 (16 U.S.C. 1531 et seq)

The Endangered Species Act provides a program for the conservation of threatened and endangered species and the ecosystems on which those species rely. A federal agency must assess the potential impacts and develop measures to minimize those impacts if a proposed action could affect threatened or endangered species or their habitat in a Biological Assessment (BA). The agency then must consult formally with the U.S. Fish and Wildlife Service, as required under Section 7 of the Act. Consultation could lead to a jeopardy opinion by the U.S. Fish and Wildlife Service if the proposed action would jeopardize the continued existence of the species under consideration. If there is a non-jeopardy opinion, but some individuals are killed incidentally as a result of the proposed action, the Service can determine that such losses are not prohibited as long as measures outlined by the Service are followed. Regulations implementing the Endangered Species Act are codified at 33 CFR Parts 320, 323, 325, and 330.

The St. Paul, Rock Island, and St. Louis districts concluded consultation on the Operation and Maintenance of the Upper Mississippi River Navigation Project in 2000. The Service's Biological Opinion (BO) determined that the continued operation and maintenance of the 9-foot Navigation Project would jeopardize (Jeopardy Opinion) the continued existence of the pallid sturgeon and Higgins eye pearlymussel. The BO also determined that the project would not jeopardize the least tern and winged mapleleaf mussel, but would result in incidental take (Incidental Take Statement). The Corps is in the process of implementing the Reasonable and Prudent Alternatives and Reasonable and Prudent Measures provided by the Service. The Service considered the operation and maintenance Biological Opinion to be the baseline for the Upper Mississippi-Illinois Waterway Navigation Study. The Service provided a BO for the Navigation Study on 27 August 2004. The BO determined that the project will not jeopardize the continued existence of the Indiana bat, decurrent false aster, pallid sturgeon, and Higgins eye pearlymussel, but will result in incidental take. If the project is approved, the Corps will comply with all provisions of the new BO, including implementation of the Reasonable and Prudent Measures and their implementing terms and conditions, as well as continued implementation of the Reasonable and Prudent Alternatives and Measures from 2000 BO. If the project were constructed, the Corps would work with the U.S. Fish and Wildlife Service to ensure compliance with the Endangered Species Act.

11.5.3 Migratory Bird Treaty Act, as amended (16 U.S.C. 703 et seq.)

The purpose of the Migratory Bird Treaty Act is to protect birds that have common migration patterns between the United States and Canada, Mexico, Japan, and Russia. It regulates the take and harvest of migratory birds. The U.S. Fish and Wildlife Service will review this PEIS and will work with the Corps as part of the compliance with the Migratory Bird Treaty Act.

11.5.4 Bald and Golden Eagle Protection Act, as amended (16 U.S.C. 668-668d)

The Bald and Golden Eagle Protection Act makes it unlawful to take, pursue, molest, or disturb bald and golden eagles, their nests, or their eggs anywhere in the United States (Section 668, 668c). The Department of the Interior regulates activities that might adversely affect bald eagles. The U.S. Fish and Wildlife Service will review this PEIS to determine whether the activities analyzed in this PEIS would comply with the Bald and Golden Eagle Protection Act. Bald eagles are common in the project area, normally migrating south to overwinter along the UMR-IWW. They forage for fish where they can find open water, such as the tailwaters below the lock and dam complexes, the warm water effluent of power plants and municipal and industrial discharges, or in power plant cooling ponds. The U.S. Fish and Wildlife Service will review this PEIS and will work with us as part of the compliance with the Act..

11.5.5 National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd)

The National Wildlife Refuge System Administration Act provides guidelines for the administration and management of lands in the system, including "wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas, or waterfowl production areas." The U.S. Fish and Wildlife Service will review this PEIS and will work with us as part of the compliance with the Act.

11.5.6 Wild and Scenic Rivers Act of 1968, as amended.

The UMR and IWW within the District are not listed in the National Rivers Inventory (NRI). The NRI is used to identify rivers that may be designated by Congress to be component rivers in the National Wild and Scenic Rivers Systems. Several rivers are listed to their confluence with the Mississippi. These include the Lower St. Croix (component river) and the Wisconsin River (inventory and study river). Any site-specific project with potential to affects these rivers would be evaluated with a supplemental NEPA document tiered from this PEIS.

11.5.7 Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464)

The purpose of the Coastal Zone Management Act is to preserve, protect, develop, restore, and enhance the resources of the Nation's coastal zone. Resources include wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat. This law provides for: (1) management to minimize the loss of life and property caused by improper development and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands, and (2) improvement, safeguarding, and restoration of the quality of coastal waters, and for protection of existing uses of those waters. Section 307 directs federal agencies proposing activities or development projects including Civil Works activities, whether within or outside of the coastal zone, that are reasonably likely to affect any land or water use or natural resource of the coastal zone, to assure that those activities or projects are consistent, to the maximum extent practicable with the approved state programs. Ecosystem restoration activities associated with this project may intercept part the nitrogen load released from the upper Midwest, having a positive effect in reducing Gulf hypoxia.

11.5.8 Protection of Wetlands (Executive Order 11990).

This order directs federal agencies to avoid new construction in wetlands unless there is no practicable alternative and unless the proposed action includes all practicable measures to minimize harm to wetlands that might result from such use. The alternatives presented here avoid, to the extent possible, placement of material in wetlands. Any wetland areas that may be affected by a future placement that would require disclosure within a tiered NEPA document. This includes possible farmed wetlands, which may exist within the agricultural land targeted for future placement.

11.5.9 Invasive Species (Executive Order 13112)

This order directs federal agencies to act to prevent the introduction of or to monitor and control invasive (non-native) species, to provide for restoration of native species, to conduct research, to promote educational activities, and to exercise care in taking actions that could promote the introduction or spread of invasive species. The implementation of fish passage measures at the dams could facilitate the spread of invasive fish species at a faster rate than the without-project alternative. Exotic fish consideration will be further coordinated with State and federal natural resource agencies as new information becomes available.

11.5.10 Responsibilities of Federal Agencies to Protect Migratory Birds (Executive Order 13186)

This executive order requires federal agencies to avoid or minimize the negative impacts of their actions on migratory birds, and to take active steps to protect birds and their habitats. The Order directs each federal agency taking actions having or likely to have a negative impact on migratory bird populations to work with the U.S. Fish and Wildlife Service to develop an agreement to conserve those birds. The order directs agencies to avoid or minimize impacts to migratory bird populations, take reasonable steps that include restoring and enhancing habitat, prevent or abate pollution affecting birds, and incorporate migratory bird conservation into agency planning processes whenever possible. The Corps would comply with provisions of this Executive Order as part of construction, operation and monitoring, and closure activities.

11.5.11 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Executive Order 12898)

This executive order requires the fair treatment and meaningful involvement of all people regardless of race color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations and policies. Fair treatment means that no group of people, including a racial, ethnic, or a socioeconomic group should bear a disproportionate share to the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Meaningful involvement means that: (1) potentially affected community residents have an appropriate opportunity to participate in decision about a proposed activity that will affect their environment and/or health; (2) the public’s contribution can influence the regulatory agency’s decision; (3) the concerns of all participants involved will be considered in the decision making process; and (4) the decision makers seek out and facilitate the involvement of those potentially affected. The Corps has complied with the provisions of this executive order through public meetings, newsletters, coordination and the NEPA review process.

11.6 Use of Land and Water Bodies

11.6.1 Rivers and Harbors Acts (33 U.S.C. 401, 403, 407)

The formal authorization for the U.S. Army Corps of Engineers to perform operation and maintenance activities on the UMR was given in the Rivers and Harbors Act of 1927; as modified by the Rivers and Harbors Acts of 1930, 1932, and 1935; and a Resolution of the House Committee on Flood Control of September 19, 1944. These Acts and Resolution authorize the construction, operation, and maintenance of the 2.75 m (9-foot) navigation channel on the Mississippi River between the mouth of the Missouri River and St. Paul, Minnesota and the Illinois Waterway. Under the dual purposes of navigation efficiency improvement and ecosystem restoration, this project would not place any obstruction across navigable water nor would it place obstructions to navigation outside established federal lines.

11.6.2 Farmland Protection Policy Act of 1981 (7 U.S.C. 4201 et seq)

The purpose of this act is to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of farmland to nonagricultural uses, and to assure that federal programs are administered in a manner that will be compatible with State, local government, and private programs and polices protecting farmland. The Corps recognizes that the transformation of agricultural land, particularly prime farmland, is undesirable but sometimes necessary to meet the Corps mandate of maintaining the navigation system. Any ecosystem restoration measures that affect agricultural fields have the potential to impact prime farmland. All future projects will consider alternative actions that could lessen adverse effects to farmland. These alternatives would be, to the extent practicable, compatible with state, unit of local government, and private programs and policies to protect farmland. Detailed evaluation of all agricultural sites was not performed during this process. Thus, for the use of all future agricultural sites, a complete review will be performed by federal, state, and local agencies using the appropriate, approved criteria. This would include the District and the appropriate County District Conservationist completing an AD-1006 Farmland Impact Conversion Rating for each site that may affect prime farmland.

11.6.3 Watershed Protection and Flood Prevention Act (16 U.S.C. 1001 et seq)

This Act authorizes the Secretary of Agriculture to cooperate with states and other public agencies in works for flood prevention and soil conservation, as well as the conservation, development, utilization, and disposal of water. This Act imposes no requirements on Corps Civil Works projects. The Natural Resource Conservation Service will review this PEIS to determine whether the activities analyzed in this project would compliment activities performed by their agency under the Watershed Protection and Flood Prevention Act.

11.6.4 Floodplain Management (Executive Order 11988)

This Order directs federal agencies to establish procedures to ensure that any federal action undertaken in a floodplain considers the potential effects of flood hazards and floodplain management and avoids floodplain impacts to the extent practicable. Implementation of the programmatic alternatives would avoid, to the extent possible, long- and short-term adverse impacts associated with the occupancy and modification of the base floodplain. They also would avoid direct and indirect support of development or growth (construction of structures and/or facilities, habitable or otherwise) in the base floodplain wherever there is a practicable alternative. However, for any future NEPA document, additional evaluations will be performed to identify any changes to the 100-year flood profile. The Corps would obtain and adhere to all stipulations of the Floodplain permit from the appropriate State agency prior to implementation of this proposed project.

11.6.5 Federal Water Project Recreational Act (16 U.S.C. 460l-12 to 22, 662)

The Federal Water Project Recreation Act establishes the policy that consideration be given to the opportunities for outdoor recreation and fish and wildlife enhancement in the investigating and planning of any federal navigation, flood control, reclamation, hydroelectric or multi-purpose water resource project, whenever any such project can reasonably serve either or both purposes consistently. Recreation opportunities were considered at the programmatic level but efforts were not made to identify specific opportunities for recreational development for individual projects. Should these be identified for future sites, they will be discussed within any supplemental NEPA document.

11.7 Compliance with Environmental Quality Statutes

A summation of compliance with environmental statutes and regulations can be found in Table 11-2.

Table 11-2. Applicability and compliance with environmental protection statutes and other environmental requirements affecting the proposed project.

Federal Environmental Protection Statutes and Requirements	Applicability/ Compliance
Abandoned Shipwreck Act, 43 U.S.C. 2101-2106	Full compliance
Administrative Procedures Act, 5 U.S.C. 511-599	Full Compliance
American Indian Religious Freedom Act, 42 U.S.C. 1996	Full compliance
Antiquities Act, 16 U.S.C. 431 et seq.	Full compliance
Archaeological and Historic Preservation Act, 16 U.S.C. 469, et seq.	Full compliance
Bald Eagle Protection Act, 16 U.S.C. 668-668d	Full compliance
Clean Air Act, as amended, 42 U.S.C. 1857h-7, et seq.	Full compliance
Clean Water Act, Sections 404 and 401	Full compliance
Coastal Zone Management Act of 1972, as amended	Full compliance
Consultation and Coordination with Indian Tribal Governments (Executive Order 13175)	Full compliance
Endangered Species Act of 1973, as amended, 16 U.S.C. 1531, et seq.	Full compliance
Environmental Effects Abroad of Major Federal Actions (Executive Order 12114)	Not applicable
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not applicable
Farmland Protection Policy Act. 7 U.S.C. 4201, et seq.	Full compliance
Federal Actions to Address Environmental Justice in Minority populations and Low-Income populations (Executive Order 12898)	Full compliance
Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), et seq.	Full compliance
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Full compliance
Flood Plain Management (Executive Order 11988)	Full compliance
Indian Sacred Sites (Executive Order 13007)	Full compliance
Invasive Species (Executive Order 13112)	Full compliance
Land and Water Conservation Fund Act, 16 U.S.C. 460/-460/-11, et seq.	Not applicable
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not applicable
Migratory Bird Treaty Act, 16 U.S.C. 703 et seq.	Full compliance
National Economic Development (NED) Plan	Full compliance
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Full compliance
National Historic Preservation Act, 16 U.S.C. 470a, et seq.	Full compliance
National Wildlife Refuge System Administration Act of 1966, 16 U.S.C. 668dd	Full compliance
Native American Graves Protection and Repatriation Act of 1990, 25 U.S.C. 3001 et seq.	Full compliance
Noise Control Act of 1972, 42 U.S.C. 4901 et seq.	Full compliance
Protection of Wetlands (Executive Order 11990)	Full compliance
Responsibilities of Federal Agencies to Protect Migratory Birds (Executive Order 13186)	Full compliance
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Full compliance
Safe Drinking Water Act, 42 U.S.C. 300f et seq., 6939b; U.S.C. 1261 et seq.	Full compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Not applicable
Wild and Scenic Rivers Act, 16 U.S.C. 1271, et seq.	Not applicable

Full compliance. Having met all requirements of the statute for the current stage of planning (either preauthorization or post authorization).

Not applicable. No requirements for the statute required; compliance for the current stage of planning.

12.0 COMPARISON OF ALTERNATIVE PLANS

12.1 Comparison of Navigation Efficiency Alternative Plans

12.1.1 Description of Comparison Process

The purpose of this step is to compare the results from the evaluations outlined in Chapter 7, for the purpose of developing a recommended plan that will address the Navigation Efficiency concerns. The primary comparison information will be the National Economic Development (NED) benefits as measured by robustness and risk. Robustness is the extent to which an alternative is justified across a broad range of economic conditions. Risk is a measurement of the potential economic costs of selecting or not selecting an alternative as measured in foregone benefits. Other evaluation information will be considered as appropriate. The Alternative Evaluation Scoresheet displays a summary of the quantitative and qualitative evaluation information for each alternative plan (Figure 12-1). It serves as a quick reference to the data and criteria that have been assembled for the comparison process. The comparison of alternative plans was an iterative process that generally followed the method below:

1. Compare results of the NED evaluations to the future without-project condition.

2. Identify the most robust plan and calculate the risks of plans. Screen out plans that have no positive benefits or have large degrees of negative benefits

3. Screen out plan(s) not meeting the other evaluation criteria and return to step 1. Ensure plan(s) meet minimum requirements of all other evaluation criteria.

4. Reformulate to identify plan variations, which become additional plans. Evaluate the additional plan(s).

5. Compare the risk and robustness of the plans from Steps 3 and 4. Also compare the other evaluation criteria.

6. Identify the best plan based on risk and robustness if possible. This is the selected plan or explain the rationale for any other plan selection based upon the of other evaluation criteria

12.1.2 Initial NED Comparison

The NED benefits for each of the six alternatives are displayed on Figure 12-2. The distribution of risk, measured as forgone benefits, for each alternative plan is displayed on Figure 12-3. The foregone benefits are computed as the difference in net benefits between a specific alternative and the alternative with the highest net benefits for that economic condition. It is important to emphasize that the relative differences in risk cost between and among alternatives, and not the absolute magnitudes of risk expressed for each alternative, are the meaningful measures. Table 12-1 displays the comparison of values for robustness, maximum and minimum net benefits. As seen in Table 12-1, Alternative 2 provides positive net benefits for all 15 economic conditions. Alternative 2 also contains the least amount of risk across these same conditions as displayed on Figure 12-1, because it contains the highest net benefits for 14 of 15 economic conditions. Therefore, Alternative 2 is initially the best plan based solely on the NED comparisons; however, it needs to be further analyzed against the other criteria. Other observations to note are that if future traffic is flat as represented in scenario 1, Alternatives 4, 5, and 6 would not be justified. Some increases in future demand will be required to economically support these alternatives. It also should be noted that the net benefits are very sensitive to the assumption of demand elasticity. If the demand elasticity is represented by the upper bound ESSENCE assumption, Alternatives 4, 5, and 6 would not be justified regardless of the scenario. In addition, Alternative 3 can be screened from further consideration since it does not produce positive benefits across any of the economic conditions.

NAVIGATION EFFICIENCY ALTERNATIVES *Alternative Evaluation Scoresheet*							
	ACCOUNTS	**ALTERNATIVE PLANS**					
		1	**2**	**3**	**4**	**5**	**6**
	A. National Economic Development (NED)	**RANK**					
	A1. Project Cost	NA	$0	$80,000,000	$84,000,000	$795,000,000	$2,268,000,000
	A2. Total Avg Annual Cost	NA	$2,500,000	$12,500,000	$47,600,000	$112,700,000	$191,200,000
*	A3. Net Economic Benefits ($ Millions)	NA	***See Table 12-1 & Fig. 12-2 for Net Benefits for each of the 15 Economic Conditions***				
*	A4. Risk	NA	***See Figure 12-3 depicting Risk across the 15 Economic Conditions***				
*	A5. Robustness	NA	***See Table 12-1 & Fig. 12-2 depicting Robustness across the 15 Economic Conditions***				
	B. Environmental Quality	**INCLUDED IN NED / CONSIDERATION**					
	B1. Islands and Shoreline Erosion	NA	NA	NA	$14,200,000	$14,200,000	$14,200,000
	B2. Backwaters/Side Channel Sedimentation	NA	NA	NA	$27,200,000	$27,200,000	$27,200,000
	B3. Aquatic Plants	NA	NA	NA	$1,600,000	$32,400,000	$51,900,000
	B4. Fisheries	NA	NA	NA	$12,400,000	$34,000,000	$42,700,000
	B5. Monitoring	NA	NA	NA	$7,500,000	$9,400,000	$11,300,000
	B6. Historic Properties	NA	NA	NA	$8,600,000	$9,600,000	$10,000,000
	B7. Other	NA	NA	NA	$7,900,000	$15,500,000	$19,400,000
	B8. Site Specific Mitigation	NA	NA	NA	$0	$8,700,000	$30,300,000
	B9. TOTAL MITIGATION	NA	NA	NA	$79,400,000	$151,000,000	$207,000,000
	C. Regional Economic Development	**CONSIDERATIONS**					
	C1. Avg Annual Income	NA	***See Table 7-4 for Avg. Annual Income by State/Region***				
	C2. Avg Annual Employment	NA	***See Table 7-4 for Avg. Annual Employment by State/Region***				
	D. Other Social Effects	**CONSIDERATIONS**					
	D1. Emissions	NA	***See detailed description of Emissions Comparison***				
	D2. Accidents	NA	***See Table 7-5 providing a differential financial cost of Accidents and Fatalities***				
	D3. Noise and Other Impacts	NA	***See Table 7-6 providing a differential for Traffic Noise and Other Community Impacts***				
	E. Contribution to Planning Objectives						
	E1. Provide for a safe, reliable, efficient, and sustainable UMR-IWW navigation system over the planning horizon.						
	E1a. Safety	Neutral	Neutral	Neutral	Neutral	Positive	Positive Plus
	E1b. Reliability	Neutral	Neutral	Neutral	Neutral	Positive for completed Project, Potential negative during construction	Positive for both completed and during construction
	E1c. Efficiency	Neutral	Positive	Negative	Positive	Positive	Positive
	E1d. Sustainability	Neutral	Negative	Negative	Depends on traffic Growth	Depends on traffic Growth	Positive for all Traffic Growth Scenarios
	E2. Address the cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.	NA	Neutral	Neutral	Neutral	Neutral	Neutral
	E3. measures are consistent with protecting the Nation's environment; avoiding, minimizing, or mitigating significant environmental, cultural, or social impacts.	NA	YES	YES	YES	YES	YES
	F. Acceptibility	**CONSIDERATIONS**					
	F1. Institutional	NA	***See detailed description of Institutional Acceptability***				
	F2. Social	NA	***See detailed description of Social Acceptability***				
	G. Adaptability	**IMPLEMENTATION**					
		NA	***See detailed description of Alternative Plan Adaptability***				

Figure 12-1. Alternative Evaluation Scoresheet for Navigation Efficiency Alternatives.

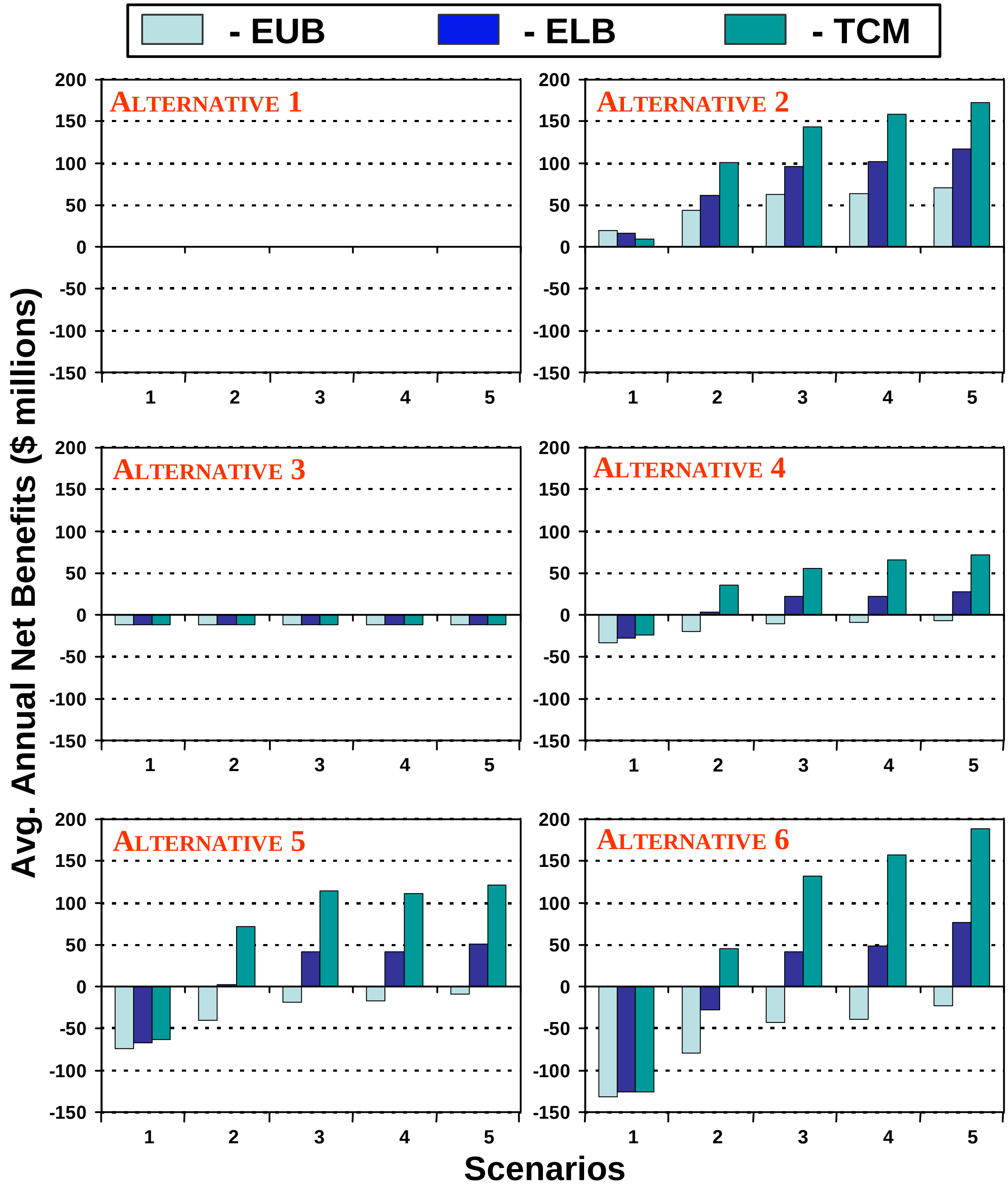

Figure 12-2. Average Annual Net Benefits ($ millions) for Navigation Efficiency Alternatives 1 through 6.

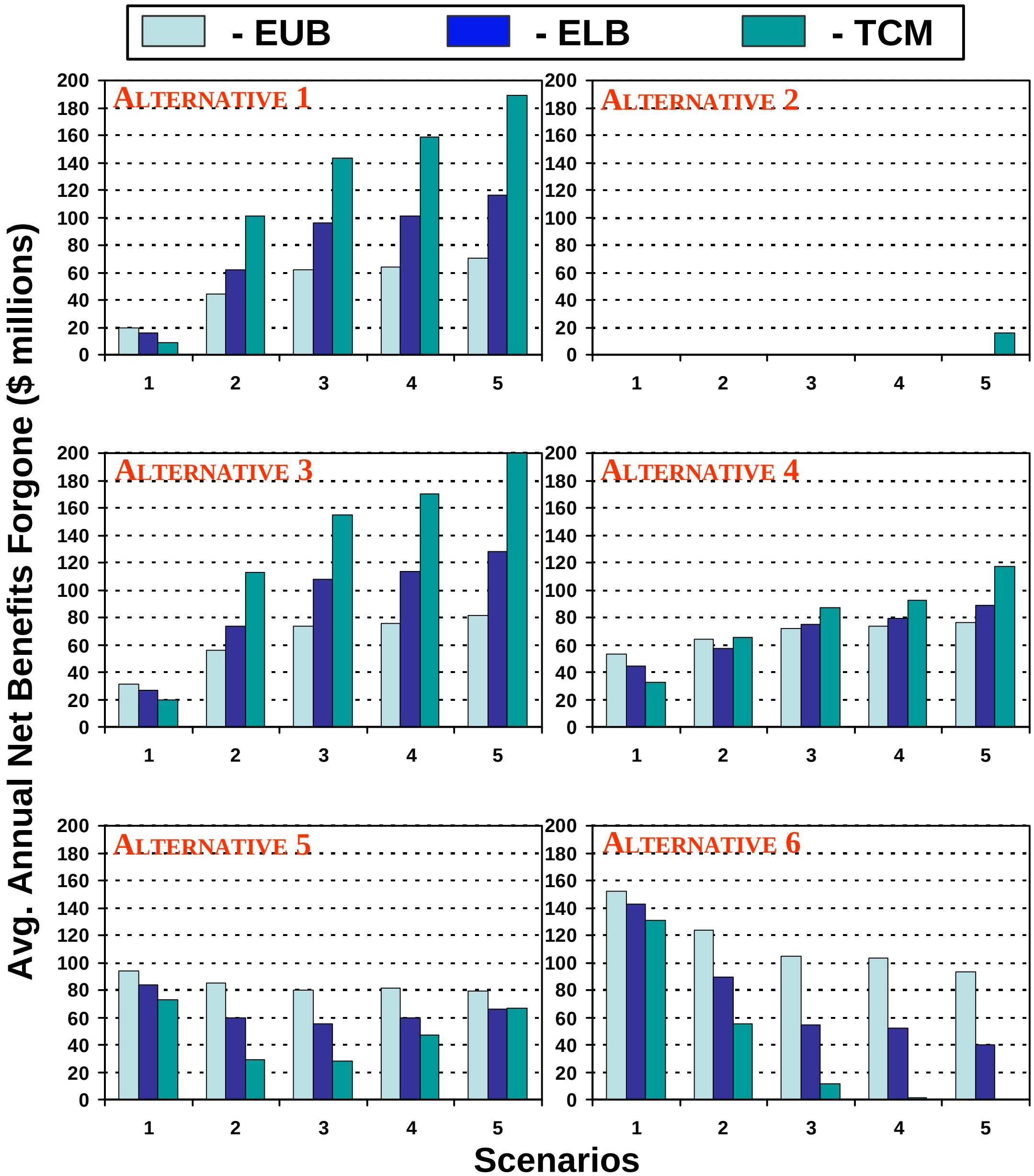

Figure 12-3. Risk Assessment for Navigation Efficiency Alternatives 1 through 6.

Table 12-1. Initial NED Comparison of Navigation Efficiency Alternatives 1 through 6.

Alternative	Robustness (Pos. Net Ben)	Greatest Net Benefits Per Economic Condition	Least Net Benefits Per Economic Condition
1	0/15	0/15	0/15
2	15/15	14/15	0/15
3	0/15	0/15	7/15
4	8/15	0/15	0/15
5	8/15	0/15	0/15
6	7/15	1/15	8/15

12.1.2.1 Application of Other Criteria

12.1.2.1.1 Environmental Quality

On the basis of best available information, none of the plans create serious negative environmental consequences that cannot be avoided, minimized, or mitigated to an acceptable level in the context of the adaptive mitigation strategy proposed. Refer to Tables 7-2 and 7-3 for description and cost of avoid, minimize, and mitigation measures for the navigation efficiency alternatives.

12.1.2.1.2 Regional Economic Development

Alternative 2 results in negative effects to income and employment benefits to the five-State regional economy. The Regional Economic Developments (REDs) do not factor into the Federal decision-making process; however, they will influence the acceptability of an alternative to the region. Refer to Table 7-4 for examples of RED benefits of the navigation efficiency alternatives.

12.1.2.1.3 Other Social Effects

Implementation of Alternative 2 may result in a cost to society in terms of additional accidents by moving traffic off the waterway and onto other transportation modes. While the effects described here are potentially NED in nature, the level of input detail and lack of standardized measurement techniques within the Corps preclude these impacts from being considered in the NED formulation process.

12.1.2.1.4 Planning Objectives

Alternative 2 reduces congestion by imposing a fee that drives marginal users off the system. This alternative is safety and reliability neutral. It does provide positive benefits across a broad range of economic conditions. The alternative fails to meet the planning objective of ensuring an economically sustainable navigation system, since it constrains the future growth on the system.

12.1.2.1.5 Acceptability

Current national policy to maximize the capacity and efficiency of existing modes of commodity transportation makes institutional acceptability of this alternative plan doubtful. The Department of Transportation, the Department of Agriculture, and the States have also expressed negative comments on this alternative plan. The navigation and agriculture non-governmental organizations have expressed negative comments, while the environmental interests have generally expressed the need to fully consider this alternative plan.

12.1.2.1.6 Adaptability

Alternative 2 is highly adaptable in that it could be implemented quickly and removed quickly as needed.

12.1.2.2 Conclusions of Initial NED Comparisons

Alternative 3 is screened from further consideration since it produces negative benefits across all economic conditions. Alternative 2 fails to fully meet the planning objectives. Current law prohibits Alternative 2, and current national policy makes institutional acceptability of this alternative doubtful; therefore, it is screened from further consideration. Since Alternative 2 is screened, a second iteration of NED comparisons must be done to determine the best plan.

12.1.3 Second Iteration of NED Comparisons

A second iteration was completed comparing Alternative plans 1, 4, 5 and 6. The NED benefits and robustness described above are unchanged; however, the risk charts have been modified due to the screening of Alternative 2. The new risk charts are displayed on Figure 12-4. Table 12-2 displays the new summary comparison of robustness, and maximum and minimum net benefits.

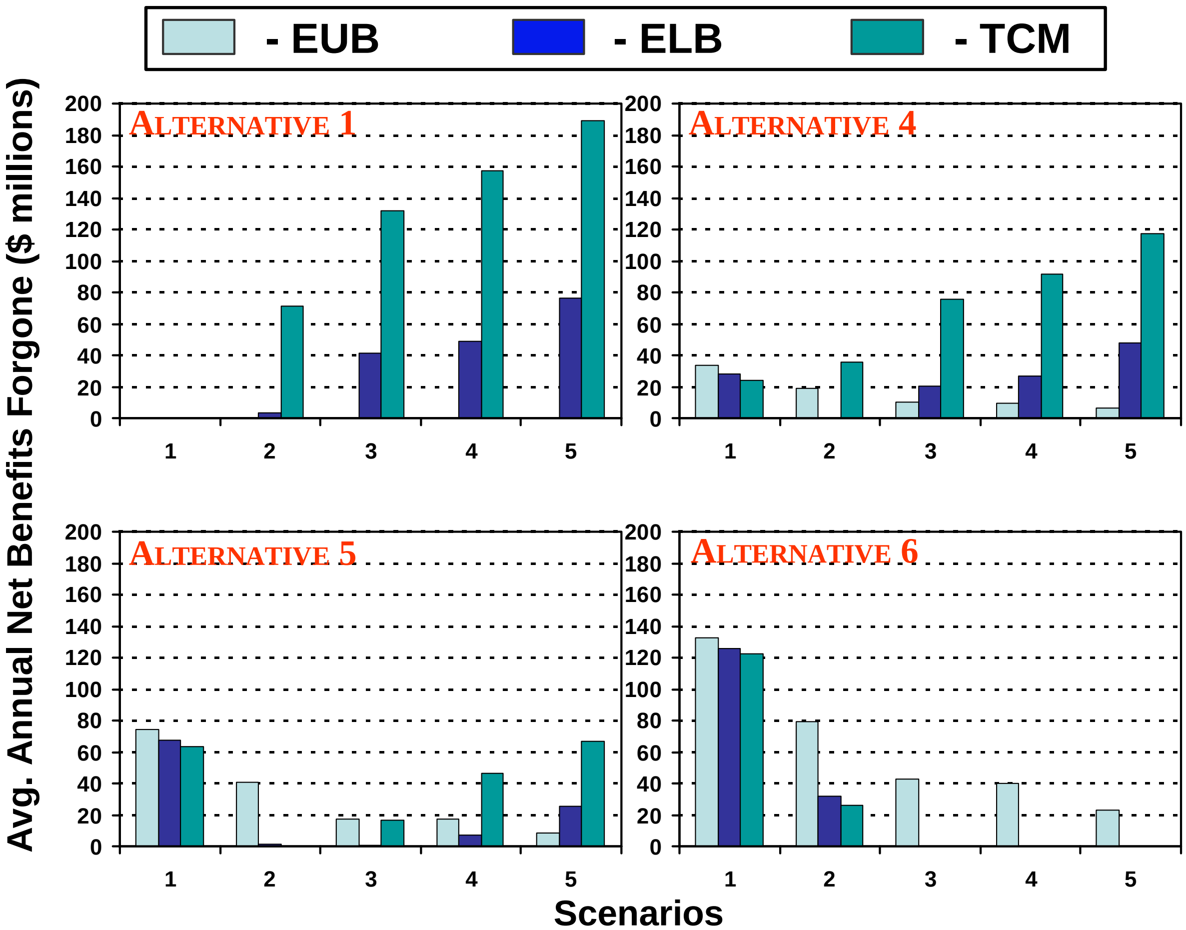

Figure 12-4. Average Annual Net Benefits ($ millions) for Navigation Efficiency Alternatives 1, 4, 5, and 6 (Alternatives 2 and 3 screened in initial NED comparison).

Table 12-2. Secondary NED Comparison of Navigation Efficiency Alternatives 1, 4, 5, and 6.

Alternative	Robustness (Pos. Net Ben)	Greatest Net Benefits Per Economic Condition	Least Net Benefits Per Economic Condition
1	0/15	7/15	7/15
4	8/15	1/15	0/15
5	8/15	1/15	0/15
6	7/15	6/15	8/15

The comparison of robustness shows that Alternatives 4, 5, and 6 exhibit essentially the same number of positive net benefits, with no indication of a clear winner. Alternative 1 contains 7 of 15 of the greatest net benefits and 7 of 15 of the least net benefits. Alternative 6 contains the maximum number of net benefits 6 out of 15 times. This variation in net benefits again supports no clear winner. The comparison of risk indicates that if traffic increases in the scenario 3 to 5 range there is a great amount of risk in selecting Alternative 4. If flat-lined traffic occurs as in scenario 1, there is a great amount of risk in selecting Alternative 6. Alternative 5 is risky at the upper and lower bounds of the traffic scenarios. The comparison of risk does not identify any additional information to make a clear selection. The other criteria need to be compared to determine if they can help select a best plan.

12.1.3.1 Application of Other Criteria

12.1.3.1.1 Environmental Quality

Environmental impacts on the waterway increase with increases in proposed construction and associated projected increases in navigation traffic. These impacts have been quantified and an acceptable adaptive mitigation strategy developed for each alternative.

12.1.3.1.2 Regional Economic Development

The income and employment benefits for each alternative are reported for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri, along with the Lower Mississippi River Region and the rest of the United States. These income and employment effects are derived from direct construction expenditures required to implement an alternative and from the transportation efficiencies generated by the alternative. The greater the investment, the greater the benefits; thus, Alternative 6 has higher REDs than Alterative 4. The REDs do not factor into the Federal decision-making process; however, they will influence the acceptability of an alternative to the region. The States have not yet endorsed an alternative.

12.1.3.1.3 Other Social Effects

The positive numbers indicated for Alternatives 4, 5, and 6 all indicate a benefit to society. Generally, the greater the investment in improvements, the greater the benefits. While the effects described here are potentially NED in nature, the level of input detail and lack of standardized measurement techniques within the Corps preclude these impacts from being considered in the NED formulation process.

12.1.3.1.4 Planning Objectives

Alternative 4
Safety:
Moorings – Neutral.
Switchboats – Neutral.

Reliability:
Moorings – Neutral.
Switchboats – Neutral.

Efficiency: Moorings and switchboats provide positive efficiency benefits to the system as measured by the NED benefits.

Sustainability: Moorings and switchboats will be sustainable for low growth scenarios; however, they will not be sustainable for high growth scenarios.

Alternative 5
Safety: Positive. Lock extensions at Locks 20 through 25 will eliminate double-cut lockages (approximately 75 percent of all lockages) and the associated personal-injury hazards at those sites. Alternative 5 is an improvement in safety over Alternative 4.

Reliability: Positive for completed project; potential negative during construction. Lock extensions reduce the number of operating cycles of machinery by eliminating the need for the double-cut lockage of tows. Reduced cycles affect the machinery life, related unscheduled lock closures, and intervals of major rehabilitation. Lock extensions would improve the reliability of the system once they are completed and in service. Alternative 5 has greater reliability than Alternative 4.

Performance would be greater than with Alternative 4.

There is substantial risk in experiencing a reduction in reliability during construction of the lock extensions. The lock extensions are technically feasible; however, there are inherent risks in the construction sequencing. In a situation where lock extensions were to experience construction delays, causing construction beyond the wintertime closure period, the consequences of navigation impacts would be large. Wintertime navigation closures were used to allow uninterrupted construction work. These were modeled as fixed durations of about 90 days each and then traffic would resume. If the construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. The chance of construction delay and the duration of delay were not considered in the economic model because both are uncertain. Alternative 5 will result in a potential for a less reliable system during the construction period.

Efficiency: Alternative 5 is more efficient than Alternative 4.

Sustainability: Alternative 5 is more sustainable for high levels of traffic than Alternative 4.

Alternative 6

Safety: Positive plus. New locks have the same benefits listed for lock extensions, along with other safety advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. The existing 600-foot lock can be used for recreation craft and other small vessels. This separates the small craft from the large commercial tows. Also, location 3 locks on the lower five locks on the Mississippi River would feature a riverside approach wall on the upstream end. This approach wall location with respect to the dam generally is considered safer than the present guidewall structure along the landside of the lock. Riverside approach walls are safer because they provide a physical barrier between the tow and the dam that would reduce the chance and consequences of tow mishaps that result in barges breaking loose from the tows and sometimes subsequently running into the dam. Alternative 6 is superior in safety considerations to Alternative 5B (see Section 12.1.4.4 for a detailed description of Alternative 5B).

Reliability: New locks have the same benefits listed for lock extensions, along with other advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. This reduces the number of operating cycles that either lock must perform. The cycles are reduced because there would normally be no double lockages for the small lock, no recreation craft for the long lock, and fewer small commercial craft (600 feet long or less) for the long lock. Also, a second lock at the existing projects offers the opportunity to temporarily remove a lock from service for repairs that could result in restored performance. Alternative 6 has superior normal operating reliability characteristics compared to Alternative 5B.

In a situation where lock extension construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. New locks reduce this risk to near zero and also allow normal wintertime traffic to transit the system on the lower part of the system by incorporating planned lock openings into the construction schedule. Alternative 6 contains fewer construction risks than Alternative 5B.

Efficiency: Alternative 6 is incrementally justified over Alternative 5B in 6 of 15 economic conditions.

Sustainability: Alternative 6 is more sustainable for the high growth scenarios.

12.1.3.1.5 Acceptability

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.3.1.6 Adaptability

Adaptive management concepts can be applied through a phased implementation approach for any of these alternative plans. Adaptability is an implementation concern and cannot be used to further define the selection.

12.1.3.2 Conclusions of Second NED Comparisons

The NED and other criteria comparison of Alternatives 4, 5, and 6 do not result in a clear winner. Additional alternative plans were subsequently formulated to fully understand the incremental benefits of the individual measures and sites under consideration and to determine if a clear winner can be identified.

12.1.4 Additional NED Comparisons

In order to better understand the incremental effects of the various measures, additional alternative plans were formulated and evaluated. The description of these new alternatives designated 5A, 5B, 6A, and 6B and the results of the net benefits evaluation are presented below. Environmental effects, REDs, and other social effects were not evaluated for these alternatives.

12.1.4.1 Alternative 5A

Alternative 5A substitutes 1,200-foot new locks for 1,200-foot lock extensions. All other improvement measures of Alternative 5 and Alternative 5A are identical. The evaluation of this plan addresses whether 1,200-foot new locks would be superior to 1,200-foot lock extensions from an NED perspective. Substitution of new locks adds $365 million of initial construction costs and $39.2 million of average annual costs (costs reflect 2001 price levels and a base year of 2023 for annual cost computations; Figure 12-5). The completion time frame for the two alternatives is unaffected.

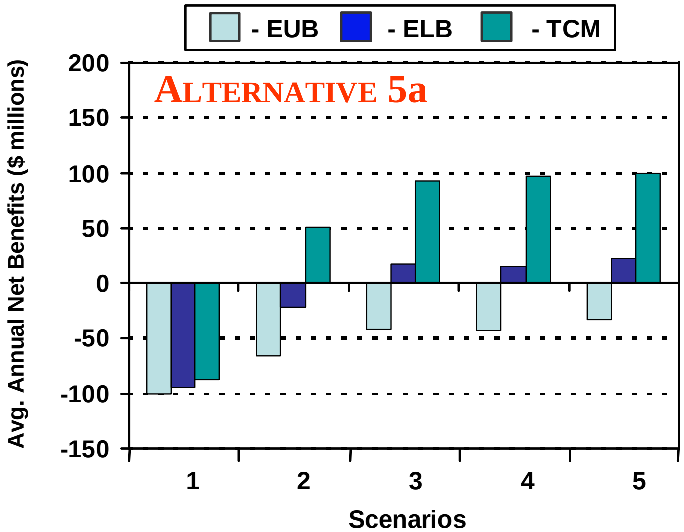

Figure 12-5. Average Annual Net Benefits ($ millions) for Incremental Alternative 5A (w/o mitigation costs).

Alternative 5A produces positive net benefits for 7 of 15 economic conditions, only one less economic condition than with Alternative 5. However, an incremental assessment of Alternative 5A reveals that while Alternative 5A adds $39 million to annual costs compared to Alternative 5, the range of increase in benefits over the 15 economic conditions is only approximately $1 million to $15 million. Therefore, for all 15 economic conditions, the substitution of 1,200-foot new locks for 1,200-foot lock extensions adds significantly more to annual costs than to annual benefits. Said differently, for each economic condition the average annual net benefits for Alternative 5A are lower than for Alternative 5. (Note that system mitigation costs were not specifically developed for Alternative 5A and that the average annual net benefit graph above does not include system mitigation costs. If average annual mitigation costs of $10.9 million, equal to the system mitigation costs of Alternative 5, were incorporated into the above graph, average annual net benefits would decline by $10.9 million. However, inclusion of this mitigation cost assumption would not change the number of positive net benefit cases. Also note that the incremental cost comparison assumes an equal level of average annual mitigation costs.)

12.1.4.2 Alternative 6A

Alternative 6A is identical to Alternative 6 with the exception that Alternative 6A does not include any improvements at the Peoria and La Grange Locks. Consideration of Alternative 6A addresses the question of incremental NED justification of 1,200-foot new locks at Peoria and La Grange. By comparing the change in average annual benefits between Alternative 6 and Alternative 6A, incremental justification of the new locks can be determined. Note that the incremental justification is with respect to the implementation time frame reflected in Alternative 6 (2021 start and 2034 finish for Peoria and La Grange).

Alternative 6A generates positive average annual net benefits for 7 of 15 economic conditions. (These results are exclusive of system mitigation costs. System mitigation costs are currently not disaggregated in sufficient detail so as to identify mitigation costs for this alternative.) However, as suggested above, it is the incremental performance of 1,200-foot new locks at Peoria and La Grange that is of specific interest. Moving from Alternative 6 to Alternative 6A results in a reduction in average annual net benefits for 10 of 15 economic conditions. Since Alternative 6A eliminates 1,200-foot new locks at Peoria and La Grange, a reduction in average annual net benefits means that new locks (with a 2021 start) are incrementally justified for 10 of 15 economic conditions. (Note again that these results are exclusive of mitigation costs.)

The first costs of the new locks at Peoria and La Grange total $393 million and average annual costs are $35.5 million (costs reflect 2001 price levels and a base year of 2023 for annual cost computations). The range of average annual benefits over the 15 economic conditions is $14.4 million to $65.6 million (Figure 12-6).

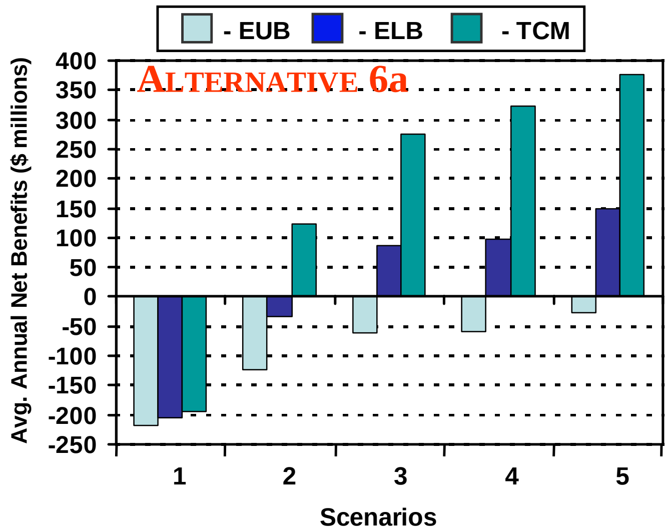

Figure 12-6. Average Annual Net Benefits ($ millions) for Incremental Alternative 6A (w/o mitigation costs).

12.1.4.3 Alternative 6B

Alternative 6B includes 1,200-foot new locks at Peoria and La Grange with no other improvements elsewhere on the system. Alternative 6B was developed to address the question of an immediate start (2005) for 1,200-foot new locks at Peoria and La Grange. Average annual net benefits are positive for 6 of 15 economic conditions exclusive of system mitigation costs. (Net benefits reflect 2001 price levels and a base year of 2023 for annual net benefit computations; Figure 12-7).

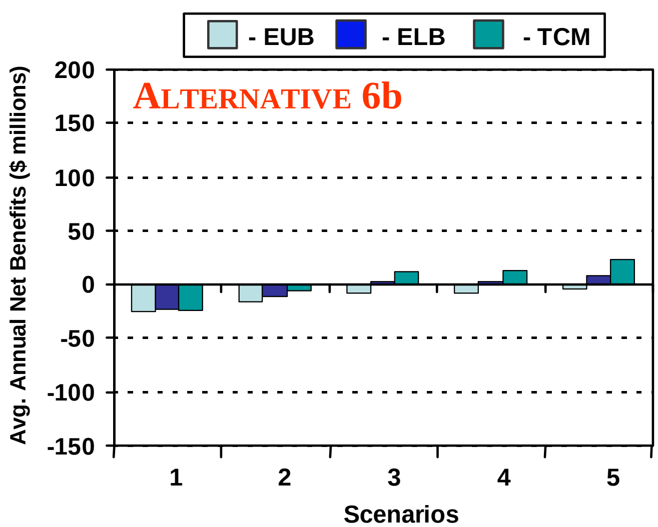

Figure 12-7. Average Annual Net Benefits ($ millions) for Incremental Alternative 6B (w/o mitigation costs).

12.1.4.4 Alternative 5B

Alternative 5B was developed to address stakeholder interest in a "seven-lock" alternative plan (Locks 20 through 25 on the Mississippi River and Peoria and La Grange Locks on the Illinois Waterway) that reflected a "reasonable" start for all seven locations (i.e., no delay due to budget or economic timing considerations). The performance of such an alternative plan was approximated by combining the net benefits of Alternative 5 and Alternative 6B. The results are approximate because elements of both benefits and costs are double counted when the net benefits of Alternative 5 and Alternative 6B are simply combined. Costs are double counted because the net benefits reflect costs for both switchboats and 1,200-foot new locks at Peoria and La Grange. Similarly, benefits for both switchboats and new locks are also include in the net benefits. In developing this "seven-lock" alternative, the lock extensions of Alternative 5 were incorporated into this new alternative instead of the new locks of Alternative 5A because of the superior incremental performance of Alternative 5 over Alternative 5A.

While it would be a relatively simple matter to adjust the cost for this combined alternative to properly reflect the desired measures, an accurate capture of benefits would not be possible without the expense of additional economic model computations. Because the annual cost of Peoria and La Grange switchboats is relatively modest in the context of the net benefits for this alternative and also because switchboat costs are offset to some degree by switchboat benefits, the combined net benefits described here represent a reasonable approximation of the true net benefits of this alternative plan.

Alternative 5B generates positive net benefits for 7 of 15 economic conditions (costs reflect 2001 price levels and a base year of 2023 for annual net benefit computations; Figure 12-8). Note that the net benefits include only partial system mitigation costs. Specifically, the system mitigation costs for 1,200-foot new locks at Peoria and La Grange over and above the system mitigation costs for switchboats at Peoria and La Grange are not captured.

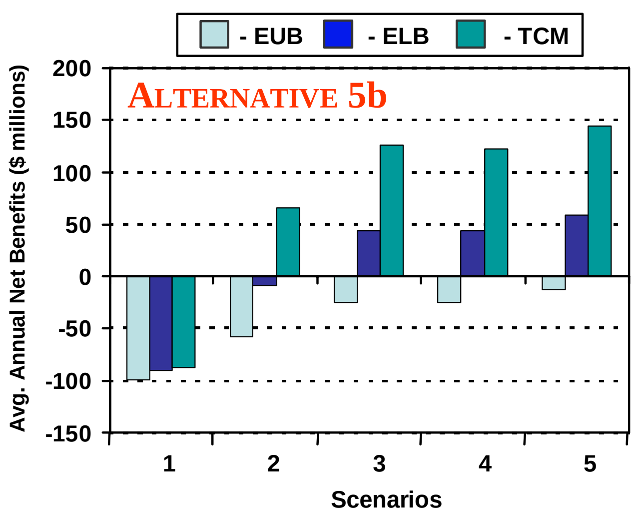

Figure 12-8. Average Annual Net Benefits ($ millions) for Incremental Alternative 5B (w/o mitigation costs).

12.1.4.5 Conclusions of Additional NED Comparisons

By comparing the results of Alternatives 5 and 5A, the conclusion was made that for all economic conditions, the substitution of new 1,200-foot locks in place of 1,200-foot lock extensions added more to annual costs than to annual benefits. From a system efficiency perspective, the additional processing capability of new locks would not be significantly realized without upstream improvements more expansive than switchboats (i.e., lock extension at Locks 14 through 18). Alternative 5A will not be carried forward for further consideration.

By comparing the results of Alternatives 6 and 6A, the incremental contribution of the new locks at Peoria and La Grange in Alternative 6 could be isolated. The comparison revealed mixed results across economic conditions. For 9 of the 15 economic conditions, exclusive of system mitigation costs, new locks at Peoria and La Grange contributed more to annual benefits than to annual costs. This determination applies to start and completion dates of 2021 and 2033, respectively (the time frame reflected in Alternative 6). Therefore, Alternative 6A will not be carried forward since Peoria and La Grange are incrementally justified. Alternative 6B will not be carried forward since an alternative plan that only considers lock construction at Peoria and La Grange is impractical.

For 6 of 15 economic conditions, Alternative 5B would generate higher net benefits than Alternative 5 (Figure 12-9).

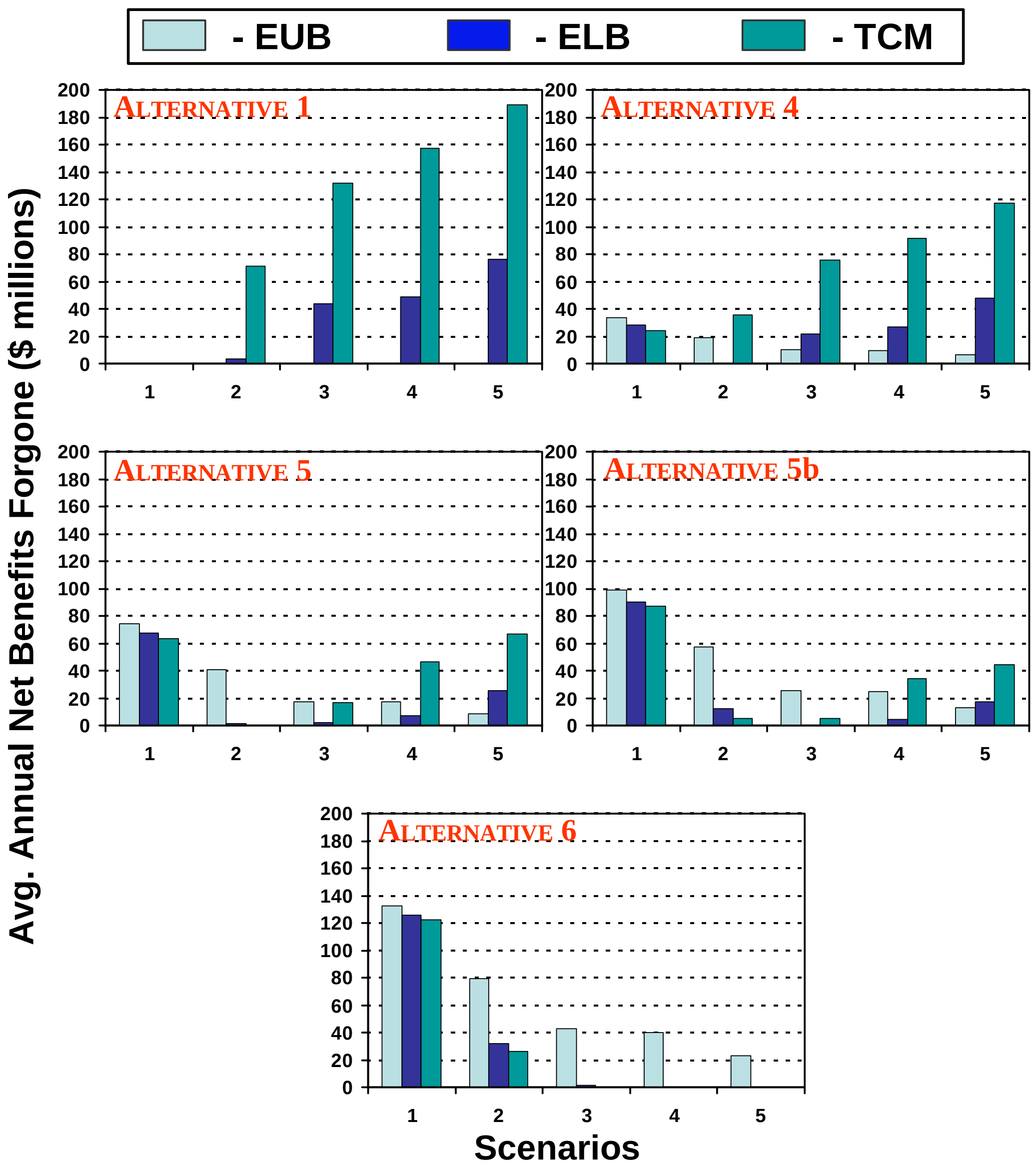

Figure 12-9. Risk Assessment for Navigation Efficiency Alternatives 1, 4, 5, 5B, and 6.

Table 12-3 displays the new summary comparison of robustness and maximum and minimum net benefits for the additional alternatives evaluated.

Table 12-3. Additional NED Comparison of Navigation Efficiency Alternatives 1, 4, 5, 5B, and 6.

Alternative	Robustness (Pos. Net Ben)	Maximum Net Benefits Per Economic Condition	Minimum Net Benefits Per Economic Condition
1	0/15	7/15	7/15
4	8/15	0/15	0/15
5	8/15	1/15	0/15
5B	7/15	0/15	0/15
6	7/15	7/15	8/15

Additional evaluations for Environmental Quality, RED, and other social effects were not performed for the additional alternatives.

Summation

- The substitution of new locks for lock extensions at Locks 20 through 25 (as with Alternative 5A) would not be desirable from an NED perspective (unless improvements are considered upstream as in Alternative 6).
- Incremental NED justification of new locks at Peoria and La Grange exists for a number of economic conditions in the context of Alternative 6 (a 2021 start), as well as for an early (2005) start.
- The robustness of Alternatives 4, 5, 5B, and 6 are essentially the same. The range of greatest net benefits is variable between Alternatives 1 and 6, and the distribution of risk is on the same order of magnitude.
- The information provided by these additional alternatives answers several important formulation questions; however, the information does not fundamentally change the basic conclusion reached with the initial set of alternatives regarding the absence of a clear winner.

12.1.5 Incremental Analysis Comparisons among Alternatives 4, 5, 5B, 6, and 6C

As additional information for the comparison of plans, an incremental analysis was performed to view the incremental justification of each alternative in terms of benefits and other criteria contained on the scoresheet. Table 12-4 contains the first cost, average annual costs, average annual benefits, and average annual net benefits for Alternatives 5, 5B, and 6. This comparison begins with a description of Alternative 4 and then moves on to a comparison with Alternatives 5, 5B, and 6.

12.1.5.1 Alternative 4
Moorings (12, 14, 18, 20, 22, 24, and La Grange); Switchboats at Locks 20 through 25.

National Economic Development (NED):

First cost of this alternative is $84 million. Average annual costs are $47.6 million. Alternative 4 produces positive net benefits in 8 of 15 economic conditions. Listed below are the average annual benefits in millions of dollars for each economic condition.

	Alt 4
TCM-S1	23
ELB-S1	20
EUB-S1	14
TCM-S2	83
ELB-S2	52
EUB-S2	28
TCM-S3	103
ELB-S3	69
EUB-S3	38
TCM-S4	113
ELB-S4	70
EUB-S4	38
TCM-S5	119
ELB-S5	76
EUB-S5	41

Environmental Quality:

The cost to avoid, minimize, and mitigate for this alternative is $79.4 million over the 50-year planning horizon.

Regional Economic Benefits (RED):

The REDs for scenario 3 for all economic modeling conditions are shown in Table 7-4.

Other Social Effects (OSE):

The OSE are listed in Chapter 7.

Contribution to Planning Objectives:

Safety:
Moorings – Neutral.
Switchboats – Neutral.

Reliability:
Moorings – Neutral.
Switchboats – Neutral.

Efficiency: Moorings and switchboats do provide positive efficiency benefits to the system as measured by the NED benefits.

Sustainability: Moorings and switchboats will be sustainable for low growth scenarios; however, they will not be sustainable for high growth scenarios.

Acceptability:

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.5.2 Alternative 5
Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 through 18, La Grange and Peoria

National Economic Development (NED):

First cost of this alternative is $652 million. Average annual costs are $113 million. Alternative 5 produces positive net benefits in 8 of 15 economic conditions. Listed below are the average annual benefits in millions for the 15 different economic conditions for both Alternatives 4 and 5, and the difference in benefits.

	Alt 4	Alt 5	Delta
TCM-S1	23	49	26
ELB-S1	20	45	25
EUB-S1	14	39	25
TCM-S2	**83**	**184**	**101**
ELB-S2	52	115	63
EUB-S2	28	72	44
TCM-S3	**103**	**228**	**125**
ELB-S3	**69**	**154**	**85**
EUB-S3	38	95	57
TCM-S4	**113**	**223**	**110**
ELB-S4	**70**	**154**	**84**
EUB-S4	38	95	57
TCM-S5	**119**	**235**	**116**
ELB-S5	**76**	**163**	**87**
EUB-S5	41	104	63

An incremental assessment of Alternative 5 reveals that Alternative 5 adds $65.4 million to annual costs compared to Alternative 4; the range of increase in benefits over the 15 economic conditions is approximately $25 million to $125 million. Seven of 15 economic conditions are incrementally justified (higher benefits) over Alternative 4, with two conditions being marginally close.

Environmental Quality:

The cost to avoid, minimize, and mitigate for this alternative is $151 million over the 50-year planning horizon. This is an increase in cost of $71.6 million over Alternative 4.

Regional Economic Benefits (RED):

The REDs for scenario 3 for all economic modeling conditions are shown in Table 12-4. The REDs are controlled by the magnitude of the construction alternative; thus, Alternative 5 produces more REDs than Alternative 4.

Table 12-4. First cost, average annual costs, average annual benefits, and average annual net benefits for Alternatives 5, 5B, and 6.

Costs, Benefits, and Net Benefits
Alternatives 5, 5A, and 6

Economic	First Cost ($mil)			Average Annual Costs ($mil)			Average Annual Benefits ($mil)			Average Annual Net Benefits ($mil)		
Condition	Alt 5	Alt 5B	Alt 6	Alt 5	Alt 5B	Alt 6	Alt 5	Alt 5B	Alt 6	Alt 5	Alt 5B	Alt 6
TCM - S1	652	1,044	2,015	113	157	191	49	69	69	-64	-88	-122
ELB - S1	652	1,044	2,015	113	157	191	45	67	65	-67	-90	-126
EUB - S1	652	1,044	2,015	113	157	191	39	58	59	-74	-99	-132
TCM - S2	652	1,044	2,015	113	157	191	184	223	236	71	66	45
ELB - S2	652	1,044	2,015	113	157	191	175	208	163	2	51	-28
EUB - S2	652	1,044	2,015	113	157	191	72	100	112	-41	-57	-79
TCM - S3	652	1,044	2,015	113	157	191	228	283	323	115	126	131
ELB - S3	652	1,044	2,015	113	157	191	154	200	233	41	44	42
EUB - S3	652	1,044	2,015	113	157	191	95	131	149	-18	-25	-43
TCM - S4	652	1,044	2,015	113	157	191	223	280	348	111	123	157
ELB - S4	652	1,044	2,015	113	157	191	154	201	240	42	45	49
EUB - S4	652	1,044	2,015	113	157	191	95	132	152	-17	-25	-40
TCM - S5	652	1,044	2,015	113	157	191	235	302	380	122	145	189
ELB - S5	652	1,044	2,015	113	157	191	163	216	268	51	59	77
EUB - S5	652	1,044	2,015	113	157	191	104	144	168	-9	-13	-23

Costs and benefits reflect 2001 price levels, and a discount rate of 5.875 percent and base year of 2023 for average annual computations.
First Costs do not include switchboat or system mitigation costs.

TCM = Tow Cost Model
ELB = ESSENCE Lower Bound
EUB = ESSENCE Upper Bound
S1 thru S5 = Trafffic Scenarios 1 thru 5

Other Social Effects (OSE):

The OSE are listed in Chapter 7. The OSE evaluate the impacts of waterway traffic versus rail. Generally, the more traffic that is put on the system by higher investment alternatives, the greater the benefits for the OSE. Alternative 5 has greater OSE benefits than Alternative 4.

Contribution to Planning Objectives:

Safety: Positive. Lock extensions at Locks 20 through 25 will eliminate double-cut lockages (approximately 75 percent of all lockages) and the associated personal-injury hazards at those sites. Alternative 5 is an improvement in safety over Alternative 4.

Reliability: Positive for completed project; potential negative during construction. Lock extensions reduce the number of operating cycles of machinery by eliminating the need for the double-cut lockage of tows. Reduced cycles affect the machinery life, related unscheduled lock closures, and intervals of major rehabilitation. Lock extensions would improve the reliability of the system once they are completed and in service. Alternative 5 has greater reliability than Alternative 4.

Performance would be greater than with Alternative 4.

There is substantial risk in experiencing a reduction in reliability during construction of the lock extensions. The lock extensions are technically feasible; however, there are inherent risks in the construction sequencing. In a situation where lock extensions were to experience construction delays, causing construction beyond the wintertime closure period, the consequences of navigation impacts would be large. Wintertime navigation closures were used to allow uninterrupted construction work. These were modeled as fixed durations of about 90 days each and then traffic would resume. If the construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. The chance of construction delay and the duration of delay were not considered in the economic model because both are uncertain. Alternative 5 will result in a potential for a less reliable system during the construction period.

Efficiency: Alternative 5 is more efficient than Alternative 4.

Sustainability: Alternative 5 is more sustainable for high levels of traffic than Alternative 4.

Acceptability:

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.5.3 Alternative 5B
Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 through 18 and new locks at La Grange and Peoria

National Economic Development (NED):

First cost of this alternative is $1,044 million. Average annual costs are $157 million, $44 million more than Alternative 5. Alternative 5B produces positive net benefits in 7 of 15 economic conditions. Listed below are the average annual benefits for the 15 different economic conditions for both Alternatives 5 and 5B, and the difference in benefits.

	Alt 5	Alt 5B	Delta
TCM-S1	49	69	20
ELB-S1	45	67	22
EUB-S1	39	58	19
TCM-S2	184	223	39
ELB-S2	115	148	33
EUB-S2	72	100	28
TCM-S3	**228**	**283**	**55**
ELB-S3	**154**	**200**	**46**
EUB-S3	95	131	36
TCM-S4	**223**	**280**	**57**
ELB-S4	**154**	**201**	**47**
EUB-S4	95	132	37
TCM-S5	**235**	**302**	**67**
ELB-S5	**163**	**216**	**53**
EUB-S5	104	144	40

An incremental assessment of Alternative 5B reveals that Alternative 5B adds $44 million to annual costs compared to Alternative 5; the range of increase in benefits over the 15 economic conditions is approximately $19 million to $67 million. Six of 15 economic conditions are incrementally justified (higher benefits) over Alternative 5. These economic conditions are the scenarios 3, 4, and 5 for TCM and ELB.

Environmental Quality:

Not developed.

Regional Economic Benefits (RED):

Not developed.

Other Social Effects (OSE):

Not developed.

Contribution to Planning Objectives:

Safety: Alternative 5B provides the same benefits in safety as Alternative 5.

Reliability: Alternative 5B provides the same level of reliability as Alternative 5.

Efficiency: Alternative 5B provides more efficiency to the system with the inclusion of new locks at Peoria and La Grange.

Sustainability: Alternatives 5 and 5B provide the same sustainability benefits.

Acceptability:

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.5.4 Alternative 6

Mooring (12, 14, 18, and 24); New Locks at 20 through 25, La Grange, and Peoria; Lock Extensions at 14 through 18; and Switchboats at Locks 11 through 13.

National Economic Development (NED):

First cost of this alternative is $2,015 million. Average annual costs are $191 million, $34 million more than Alternative 5B. Alternative 6 produces positive net benefits in 7 of 15 economic conditions, the same as Alternative 5B. Listed below are the average annual benefits for the 15 different economic conditions for both Alternatives 5B and 6, and the difference in benefits.

	Alt 5B	Alt 6	Delta
TCM-S1	69	69	0
ELB-S1	67	65	-2
EUB-S1	58	59	1
TCM-S2	223	236	13
ELB-S2	148	163	15
EUB-S2	100	112	12
TCM-S3	**283**	**323**	**40**
ELB-S3	**200**	**233**	**33**
EUB-S3	131	149	18
TCM-S4	**280**	**348**	**68**
ELB-S4	**201**	**240**	**39**
EUB-S4	132	152	20
TCM-S5	**302**	**380**	**78**
ELB-S5	**216**	**268**	**52**
EUB-S5	144	168	24

An incremental assessment of Alternative 6 reveals that it adds $34 million to annual costs compared to Alternative 5B, while the range of increase in benefits over the 15 economic conditions is approximately $0 million to $78 million. Six of 15 economic conditions are incrementally justified (higher benefits) over Alternative 5B. These economic conditions are scenarios 3, 4, and 5 for TCM and ELB, the same as for Alternative 5B.

Environmental Quality:

The cost to avoid, minimize, and mitigate for this alternative is $207 million over the 50-year planning horizon. This is an increase in cost of $56 million over Alternative 5.

Regional Economic Benefits (RED):

The REDs for scenario 3 for all economic modeling conditions are shown in Table 7-4. The REDs are controlled by the magnitude of the construction alternative; thus, Alternative 6 produces more REDs than Alternative 5.

Other Social Effects (OSE):

The OSE are listed in Chapter 7. The OSE evaluate the impacts of waterway traffic versus rail. Generally, the more traffic that is put on the system by higher investment alternatives, the greater the benefits for the OSE. Alternative 6 has greater OSE benefits than Alternative 5.

Contribution to Planning Objectives:

Safety: Positive plus. New locks have the same benefits listed for lock extensions, along with other safety advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. The existing 600-foot lock can be used for recreation craft and other small vessels. This separates the small craft from the large commercial tows. Also, location 3 locks on the lower five locks on the Mississippi River would feature a riverside approach wall on the upstream end. This approach wall location with respect to the dam generally is considered safer than the present guidewall structure along the landside of the lock. Riverside approach walls are safer because they provide a physical barrier between the tow and the dam that would reduce the chance and consequences of tow mishaps that result in barges breaking loose from the tows and sometimes subsequently running into the dam. Alternative 6 is superior in safety considerations to Alternative 5B.

Reliability: New locks have the same benefits listed for lock extensions along with other advantages. Locks 20 through 25 and Peoria and La Grange would retain use of the existing locks. This reduces the number of operating cycles that either lock must perform. The cycles are reduced because there would normally be no double lockages for the small lock, no recreation craft for the long lock, and fewer small commercial craft (600 feet long or less) for the long lock. Also, a second lock at the existing projects offers the opportunity to temporarily remove a lock from service for repairs that could result in restored performance. Alternative 6 has superior normal operating reliability characteristics compared to Alternative 5B.

In a situation where lock extension construction activities were delayed beyond the closure period, navigation traffic would be delayed until completion of the specific construction activities. New locks reduce this risk to near zero and also allow normal wintertime traffic to transit the system on the lower part of the system by incorporating planned lock openings into the construction schedule. Alternative 6 contains less construction risks than Alternative 5B.

Efficiency: Alternative 6 is incrementally justified over Alternative 5B in 6 of 15 economic conditions.

Sustainability: Alternative 6 is more sustainable for the high growth scenarios.

Acceptability:

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.5.5 Alternative 6C
Mooring (12, 14, 18, and 24); Lock Extensions at 14 through 18 and 20 through 25, New Locks at La Grange, and Peoria; and Switchboats at Locks 11 through 13.

Alternative 6C is introduced at this point in the analysis to determine the incremental net benefits of new locks at Locks 20 –25 compared to lock extensions at those same sites packaged with upstream improvements.

National Economic Development (NED):

First cost of this alternative is $1,650 million. Average annual costs are $151.7 million, $39.3 million less than Alternative 6. Listed below are the average annual benefits for 6 different economic conditions for Alternative 6C, which represent a reasonable means for comparison to Alternative 6, and the difference in benefits.

	Alt 6	Alt 6C	Delta
TCM-S1	69	64	5
ELB-S1	65	-	-
EUB-S1	59	-	-
TCM-S2	236	227	9
ELB-S2	163	-	-
EUB-S2	112	-	-
TCM-S3	323	312	11
ELB-S3	233	-	-
EUB-S3	149	-	-
TCM-S4	348	332	16
ELB-S4	240	-	-
EUB-S4	152	-	-
TCM-S5	380	368	12
ELB-S5	268	262	6
EUB-S5	168	-	-

An incremental assessment of Alternative 6C reveals that it reduces by $39.3 million the annual cost compared to Alternative 6, but has reduced benefits over the analyzed economic conditions ranging from approximately $5 million to $16 million. In all conditions, the annual cost reduction of Alternative 6C is greater than the additional annual benefits of Alternative 6 with the net value ranging from approximately $23 to $35 million. It would appear that Alternative 6C would be preferable but known conservatisms in the performance and cost estimates of Alternative 6 had to be revisited to ensure this result. The analysis revisited conservative assumptions in order to quantify additional Alternative 6 economic benefits connected with New locks at Locks 20 – 25. The additional economic benefits consist of the following:

a. more lock availability during construction of new locks compared to lock extensions
b. lock redundancy during the project life due to new locks
c. increased safety due to added features of new locks
d. cost savings from helper boat elimination due to new locks

The summation of these additional annual economic benefits was calculated to be approximately $16.8 million, which reduces the net economic advantage of Alternative 6C over Alternative 6 to approximately $6 to $18 million annually. The revisiting of the conservatism in the analysis revealed other shortcomings of Alternative 6C compared to Alternative 6 that couldn't be expressed in economic terms, but can be expressed in terms the other accounts and the contributions to planning objectives criteria.

Environmental Quality:

Not specifically evaluated, however it is anticipated that the traffic effects from Alternative 6C are essentially the same as Alternative 6.

Regional Economic Development (RED):

Not specifically evaluated, although since construction costs are less than Alternative 6, the regional economic benefits would also be less.

Other Social Effects (OSE):

Not specifically evaluated, however they would be essentially the same as Alternative 6.

Contribution to Planning Objectives:

Safety: Some aspects of added safety are the same between Alternative 6 and 6C; however, there is an economic benefit increment of added safety of the guardwall feature at Locks 20 thru 25 for Alternative 6 that was not computed. The guardwall feature will have overall accident reduction and enhanced lockage safety including less human risk-related to injuries. New locks also feature improved and safer channels at Locks 20 thru 25, which are an advantage over Alternative 6C. Also, the two-lock condition afforded by Alternative 6 separates recreation craft paths from commercial tows better than Alternative 6C resulting in increased public safety. Finally, during construction the consequences of tow impacts with features under construction will be significantly less for new locks compared to lock extensions.

Reliability: Alternative 6 with its new locks at Locks 20 through 25 would retain use of the existing locks. Some of this benefit was captured in the revisited analysis, but there are more advantages. They include 100% lock availability during performance restoration of degraded lock features and repair scheduling opportunities during the navigation season rather than in the winter enhancing quality and reducing costs. Also, unusually lengthy lock closures were not considered due to uncertainty in their application, but they have been observed to occur. The lock redundancy feature of Alternative 6 would be highly desirable to reduce the associated economic impacts.

Additionally, new lock construction allows normal wintertime traffic to transit the lower part of the system using planned lock openings into the construction schedule. The economic impact was estimated, but the impact of the shipping option on the base business was not. Finally, new locks in Alternative 6 would be constructed prior to the later package of lock extensions, which will provide valuable experience to use on the more risky venture of lock extensions; Alternative 6C would jump directly into lock extension construction.

Efficiency: Alternative 6C would be less efficient than Alternative 6 in many conditions.

Sustainability: n/a.

Acceptability:

The following information represents the position of stakeholders during the alternative comparison process. The U.S. Fish and Wildlife Service has taken a neutral stance on navigation efficiency alternatives. The Environmental Protection Agency has expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The Department of Transportation and the Department of Agriculture have supported a national policy that calls for efficient use of all transportation modes and for reducing congestion on the Nation's highways and railroads. None of the States has yet endorsed a specific navigation efficiency alternative, although Minnesota and Illinois have unofficially leaned toward Alternative 6. However, the States have collectively voiced general support for economically justified and environmentally acceptable navigation improvements. The navigation and agriculture non-governmental organizations have fully endorsed implementation of Alternative 6 in a phased-in approach. The environmental interests have expressed the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks. The most recent official position statements from Federal agencies, States, and NGOs are presented in Chapter 13.

12.1.5.6 Conclusions of Comparison Analysis

This comparison confirms that the higher investment alternatives are incrementally justified under certain economic conditions. It also uncovers that there are strong intangible advantages associated with new locks in Alternative 6 compared to the lock extensions in Alternative 6C, which makes Alternative 6 preferable to Alternative 6C.

12.1.6 Premise Sets Comparison

As outlined above, the NED analysis is very sensitive to the future traffic forecasts and assumptions of demand elasticity. The development of forecasts did not include selecting the most probable scenario or assigning probabilities to individual scenarios. Likewise, no probability distribution was defined for the range of demand elasticity values utilized. Premise Sets is a process whereby conditions are set by the decision-maker to help define an outcome. In layman's terms, it is described as, "If you believe X will occur, than the recommendation should be for Y". The results of this process are provided as a means to help decision-makers understand the sensitivity of any recommendation to the assumptions made on elasticity, and traffic growth in the analysis. Premise Sets will be established for assumptions on demand elasticity of grain and for scenarios.

12.1.6.1 Premise Set No. 1: Tow Cost Model

If you believe that the future demand for grain will be very inelastic as represented by the tow cost model results, the following table of net benefit numbers should serve as the basis for selection of a plan.

Alternative Plans	Net Benefits (millions) by Scenario				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
4	-24.09	35.55	55.56	65.47	71.62
5	-63.59	71.31	115.01	110.65	121.97
5B	-87.55	66.02	126.40	123.17	144.80
6	-126.15	45.13	131.44	157.01	188.98

The plan that maximizes net benefits is still very much dependent upon the traffic scenarios. Scenario 1 traffic levels result in no plan being justified, scenario 2 traffic levels result in an Alternative 5 selection, and scenarios 3, 4, and 5 result in Alternative 6 selection.

12.1.6.2 Premise Set No. 2: ESSENCE Upper Bound

If you believe that the future demand for grain will be very elastic as represented by the ESSENCE upper bound results, the following table of net benefit numbers should serve as the basis for selection of a plan.

Alternative Plans	Net Benefits (millions) by Scenario				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
4	-33.36	-19.12	-10.02	-9.02	-6.2
5	-74.08	-40.7	-17.75	-17.19	-8.96
5B	-99.21	-57.22	-25.40	-24.86	-12.93
6	-132.03	-79.07	-42.68	-39.67	-22.92

Under this premise set, no alternative plans are justified regardless of the traffic levels assumed.

12.1.6.3 Premise Set No. 3: ESSENCE Lower Bound

If you believe that the future demand for grain will be somewhat elastic as represented by the ESSENCE lower bound results, the following table of net benefit numbers should serve as the basis for selection of a plan.

Alternative Plans	Net Benefits (millions) by Scenario				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
4	-28.03	3.99	21.55	22.19	28.24
5	-67.31	2.32	41.35	41.74	50.73
5B	-90.10	-8.56	43.53	44.59	58.80
6	-126.15	-27.79	41.79	48.97	76.52

The plan that maximizes net benefits is still very much dependent upon the traffic scenarios. Scenario 1 traffic levels result in no justification, scenario 2 traffic levels result in Alternative 4 selection, and scenarios 3, 4, and 5 result in Alternative 6 selection.

12.1.6.4 Premise Set No. 4: Scenario 1

If you believe that scenario 1 traffic is the most likely condition to occur in the future, the following table of net benefit numbers should serve as the basis for selection.

Alternative Plan	Economic Model Condition	Net Benefits Scenario 1 ($ millions)
4	EUB	-33.36
	ELB	-28.03
	TCM	-24.09
5	EUB	-74.08
	ELB	-67.31
	TCM	-63.59
5B	EUB	-99.21
	ELB	-90.10
	TCM	-87.55
6	EUB	-132.03
	ELB	-126.15
	TCM	-126.15

The net benefit numbers are negative across all economic conditions, which means that none of the plans is economically justified under scenario 1 traffic levels.

12.1.6.5 Premise Set No. 5: Scenario 2

If you believe that scenario 2 traffic is the most likely condition to occur in the future, the following table of net benefit numbers should serve as the basis for selection.

Alternative Plans	Economic Model Condition	Net Benefits Scenario 2 ($ millions)
4	EUB	-19.12
	ELB	3.99
	TCM	35.55
5	EUB	-40.7
	ELB	2.32
	TCM	71.31
5B	EUB	-57.22
	ELB	-8.56
	TCM	66.02
6	EUB	-70.07
	ELB	-27.79
	TCM	45.13

The plan that maximizes net benefits is still very much dependent upon the assumption for demand elasticity. EUB assumptions result in no justification, ELB assumptions result in Alternative 4 selection, and TCM assumptions result in Alternative 5 selection.

12.1.6.6 Premise Set No. 6: Scenario 3

If you believe that scenario 3 traffic is the most likely condition to occur in the future, the following table of net benefit numbers should serve as the basis for selection.

Alternative	Economic Model Condition	Net Benefits Scenario 3 ($ millions)
4	EUB	-10.02
	ELB	21.55
	TCM	55.56
5	EUB	-17.75
	ELB	41.35
	TCM	115.01
5B	EUB	-25.40
	ELB	43.53
	TCM	126.40
6	EUB	-42.68
	ELB	41.79
	TCM	131.44

The plan that maximizes net benefits is still very much dependent upon the assumption for demand elasticity. EUB assumptions result in no justification; ELB and TCM assumptions result in Alternative 6 selection.

12.1.6.7 Premise Set No. 7: Scenario 4

If you believe that scenario 4 traffic is the most likely condition to occur in the future, the following table of net benefit numbers should serve as the basis for selection.

Alternative	Economic Model Condition	Net Benefits Scenario 4 ($ millions)
4	EUB	-9.24
	ELB	22.19
	TCM	65.47
5	EUB	-17.19
	ELB	41.74
	TCM	110.65
5B	EUB	-24.86
	ELB	44.59
	TCM	123.17
6	EUB	-39.67
	ELB	48.97
	TCM	157.01

The plan that maximizes net benefits is still very much dependent upon the assumption for demand elasticity. EUB assumptions result in no justification; ELB and TCM assumptions result in Alternative 6 selection.

12.1.6.8 Premise Set No. 8: Scenario 5

If you believe that scenario 5 traffic is the most likely condition to occur in the future, the following table of net benefit numbers should serve as the basis for selection.

Alternative	Economic Model Condition	Net Benefits Scenario 5 ($ millions)
4	EUB	-6.2
	ELB	28.24
	TCM	71.62
5	EUB	-8.96
	ELB	50.73
	TCM	121.97
5B	EUB	-12.93
	ELB	58.80
	TCM	144.80
6	EUB	-22.92
	ELB	76.52
	TCM	188.98

The plan that maximizes net benefits is still very much dependent upon the assumption for demand elasticity. EUB assumptions result in no justification; ELB and TCM assumptions result in Alternative 6 selection.

12.1.6.9 Premise Set No. 9: Scenario 3 and ESSENCE Lower Bound
If you believe that scenario 3 traffic and ESSENCE lower bound elasticity values represent the most likely future condition, the following table of net benefit numbers should serve as the basis for selection.

Alternative	Net Benefits Scenario 3, ELB ($ millions)
4	21.55
5	41.35
5B	43.53
6	41.79

The plan that maximizes net benefits is Alternative 5B.

12.1.6.10 Conclusions of Premise Set Comparisons
The summary of the premise set comparisons is displayed in Table 12-5.

Table 12-5. Alternative that maximizes net benefits for each economic condition based on premise set comparison.

Demand Elasticity Assumption	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TCM	Alternative 1	Alternative 5	Alternative 6	Alternative 6	Alternative 6
ELB	Alternative 1	Alternative 4	Alternative 5B	Alternative 6	Alternative 6
EUB	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1

*Scenario 3 ELB average annual net benefits are essentially equal for Alternative 5 ($41 million), Alternative 5B ($44 million), and Alternative 6 ($42 million).

- The need for navigation efficiency improvements is very much dependent on the assumptions of demand elasticity. The ESSENCE upper bound assumptions result in no justification for improvements. The ESSENCE lower bound and Tow Cost Model assumptions result in the same conclusion for two of the five traffic scenarios. Scenario 1 traffic levels result in no justification; scenario 2 traffic levels result in Alternative 4 selection for ELB and Alternative 5 selection for Tow Cost Model; scenario 3 traffic levels result in Alternative 5B selection for ELB; and scenario 4 and 5 traffic levels result in Alternative 6 selection for both.

- The need for future navigation efficiency improvements is very much dependent on the traffic forecasts. Scenario 1 traffic results in no justification for any of the alternatives under consideration. If the elasticity of grain is somewhat elastic as represented by ELB or completely inelastic as represented by Tow Cost, Alternative 5B maximizes net benefits for scenario 3 and Alternative 6 maximizes benefits for scenarios 4 and 5. Scenario 2 results in Alternatives 4 and 5 conclusion, respectively.

12.2 Comparison of Ecosystem Restoration Alternative Plans
A populated scoresheet (Figure 12-10) was used to assist in the ecosystem alternative comparison process. The Alternative Evaluation Scoresheet is merely a means to display the quantitative and qualitative evaluation information for each alternative plan. It serves as a quick reference to the data and criteria that have been assembled for the comparison process. The descriptions and definitions provided in Chapters 6 and 7 should be reviewed carefully by anyone attempting to interpret or use the information

provided in the scoresheet. A single scoresheet cannot fully represent the considerable supporting documentation used to develop and assess the alternatives. However, it is an important tool for facilitating dialogue within the study team and with varied stakeholders.

ECOSYSTEM RESTORATION ALTERNATIVES *Alternative Evaluation Score Sheet*						
	ACCOUNTS	ALTERNATIVE PLANS				
		A	B	C	D	E
	A. Environmental Benefits (NER)	**Rank**				
	A1. Project Cost					
	A1a. Total Cost	$0.0	$1,691,700,000	$2,816,600,000	$5,182,800,000	$8,416,700,000
	A1b. Cost (w/out Fish Passage or WLM)	$0.0	$1,561,900,000	$2,686,800,000	$4,262,700,000	$6,272,800,000
	A1c. Total Average Annual Cost (Base Year 2005)	$0.0	$35,080,000	$58,400,000	$106,290,000	$174,520,000
	A2. Env. Benefits (Acres of Influence) (w/out FP or WLM)	0	119,800	223,700	388,300	604,100
*	A3. Cost Effectiveness					
	A3a. Alternative Cost Effectiveness (A1b ÷ A2)	$0	$13,000	$12,000	$11,000	$10,400
	A3b. Water Level Management Cost Effectiveness	-	High	High	High	Moderate
	A3c. Fish Passage Cost Effectiveness	-	-	-	High	Moderate
	B. Environmental Quality	**Rank/Considerations**				
*	B1. Completeness					
	B1a. Relation to Existing Condition	Lose	Maintain	Restore	Restore	Restore
	B1b. Proportion of the Ecosystem Measures	0%	43%	56%	70%	83%
	B1c. UMRCC Env. Objectives (River that Works R.)	0/9	6/9	7/9	8/9	8/9
*	B2. Ecosystem Diversity					
	B2a. Maintain viable populations of native species in situ.	-	Low	Moderate	High	High
	B2b. Represent all native ecosystem types across their natural range of variation.	-	Low	Moderate	High	High
	B2c. Restore and maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrological processes, nutrient cycles, etc.).	-	Low	Low	Moderate	High
	B2d. Integrate human use and occupancy within these constraints.	-	-	-	-	-
	C. Regional Economic Development (2005-35)	**Considerations**				
	C1. Avg Annual Income to the Five States	$0	$28,000,000	$47,000,000	$78,200,000	$125,600,000
	C2. Avg Annual Employment for the Five States	0	470	760	1,180	2,080
	D. Other Social Effects	**Considerations**				
	D1. Ecosystem Goods and Services	***See detailed description of Ecosystem Goods and Services***				
	E. Contribution to Planning Objectives					
*	E1. Provide for a safe, reliable, efficient, and sustainable UMR-IWW navigation system over the planning horizon.	-	Neutral	Neutral	Neutral	Neutral
*	E2. Address cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.	-	Partial	Partial	Yes	Yes
*	E3. Measures are consistent with protecting the nations environment.	-	Yes	Yes	Yes	Yes
	F. Acceptability	**Considerations**				
	F1. Alternative Plan Acceptability					
	F1a. Institutional	***See detailed description of Institutional Acceptability***				
	F1b. Social	***See detailed description of Social Acceptability***				
	F2. Requirements of Partners					
	F2a. Cost Share ($)	$0	$209,400,000	$335,900,000	$1,051,200,000	$2,206,900,000
	F2b. Cost Share (%)	0%	12%	12%	20%	26%
	F2c. Operation & Maintenance (Non-Corps) ($)	$0	$46,400,000	$76,600,000	$138,700,000	$219,600,000
	G. Adaptability	**Implementation**				
		See detailed description of Alternative Plan Adaptability				

Figure 12-10. Ecosystem Alternative Evaluation Scoresheet.

12.2.1 Description of the Comparison Process

An evaluation process was developed and followed to compare the ecosystem restoration alternatives and ultimately select the best plan. It was structured to review and assess the criteria information within the alternative evaluation scoresheet, identify additional evaluation criteria and implementation considerations, and provide a final selection with supporting rationale. Specifically, a three-step process for comparing alternatives was developed and is described below:

Step 1: Compare and rank alternatives using key evaluation criteria (e.g., environmental benefits, efficiency, etc.) from the alternative evaluation scoresheet.
Step 2: Refine the alternative ranking with the remaining criteria (e.g., regional economic development and other social effects) in the evaluation scoresheet.
Step 3: Identify other criteria, implementation considerations, or technical information that were not included in the scoresheet. This step would include information provided by stakeholders and the general public.

By adhering to this assessment structure, the alternative comparison process ultimately led to the selection of the Recommended Ecosystem Restoration Plan.

12.2.2 Step 1: Alternative Comparison and Ranking with Key Criteria

After reviewing the comprehensive set of criteria included in the alternative scoresheet, three evaluation criteria were identified as being best suited to select the most appropriate ecosystem plan. These criteria included:

1) evaluating the contribution of the alternatives to the Navigation Study planning objectives,
2) assessing the environmental quality (i.e., completeness and diversity) of the alternatives in addressing the UMRS ecosystem needs, and
3) as part of the NER environmental benefits, evaluating the efficiency of the alternative in addressing ecosystem needs.

12.2.2.1 Contribution to Planning Objectives

The ecosystem alternatives were first assessed on how they contribute to the following planning objectives.

E1. Provide for a safe, reliable, efficient and sustainable UMR-IWW Navigation System over the planning horizon.
E2. Address cumulative impacts including ongoing effects of the operation and maintenance of the UMR-IWW Navigation System.
E3. Assure that any recommended measures are consistent with protecting the Nation's environment; avoiding, minimizing, or mitigating significant environmental, cultural, or social impacts.

Alternatives D and E received the highest rank for their effect on the study planning objectives (Table 12-6) because they were the only alternatives to provide full contribution to both E2 and E3.

Table 12-6. Contribution of Alternatives to Study Planning Objectives.

Alternative	E1	E2	E3	Rank
A	-	-	-	3
B	Neutral	Partial	Yes	2
C	Neutral	Partial	Yes	2
D	**Neutral**	**Yes**	**Yes**	**1**
E	**Neutral**	**Yes**	**Yes**	**1**

Alternatives B and C were given a rank of 2 because they had only partial contribution to E2. Alternative A does not meet the study planning objectives; therefore, it was given the lowest ranking in this assessment. All the alternatives were evaluated as neutral (i.e., little to no impact) in their effect on the navigation transportation system (E1).

12.2.2.2 Environmental Quality (Completeness and Diversity)

The environmental quality of the restoration alternatives was evaluated by examining how they contribute to UMRS ecosystem completeness and diversity. Three parameters of completeness were evaluated including:

1) Relation to the existing condition
2) Proportion of virtual reference ecosystem measures addressed
3) Number of UMRCC essential ecosystem objectives addressed

As described in the Cumulative Effects Study and Habitat Needs Assessment Reports, the condition exhibited by the UMRS ecosystem will continue to degrade over time. In assessing the relation of alternatives to the existing condition, it was determined that Alternative A would result in a loss of habitat and continued degradation of the ecosystem (Table 12-7). The management and restoration measures included in Alternative B would maintain habitat at current levels. The remaining alternatives would maintain and begin to restore habitat at increasing levels from Alternatives C to E. Due to the general nature of this assessment, the alternatives were not ranked. Rather, their general relation to the existing condition was identified and explained. See Section 6.2.7 for a detailed explanation of the Ecosystem Alternatives and their relation to the existing UMRS condition.

Table 12-7. Alternative Plan Completeness – Relation to Existing Condition.

Alternative	Relation to Existing Condition
A	Lose Habitat
B	Maintain Habitat
C	**Maintain/Restore Habitat**
D	**Maintain/Restore Habitat**
E	**Maintain/Restore Habitat**

The UMRS Environmental Objectives Database was used to identify the type and quantity of management and restoration measures needed to achieve the virtual reference (i.e., desired ecosystem condition). The proportion of virtual reference measures addressed by the ecosystem alternatives provides an estimate of the completeness of the ecosystem alternative plans (Table 12-8).

Table 12-8. Alternative Plan Completeness – Addressing UMRS Ecosystem Needs.

Alternative	Proportion of UMRS Ecosystem Measures	Rank
A	0%[a]	5
B	43%	4
C	56%	3
D	70%	2
E	**83%**	**1**

[a] Although Alternative A is noted as addressing 0% of the virtual reference needs, other UMRS programs will complete some of these restoration efforts. The Environmental Management Program will carry out approximately 100 restoration projects over the next 50 years. These activities will address a small proportion of the identified virtual reference measures.

Alternative E was given the highest rank because it addresses the highest proportion (i.e., 83%) of the virtual reference measures. The remaining alternatives were ranked 2 to 5 from D to A based on their declining proportion of measures addressed.

Assessing the number of essential UMRS ecosystem objectives (from the UMRCC *River that Works* report) addressed by each ecosystem alternative provided an additional estimate of their completeness in addressing the environmental needs of the system. Alternatives D and E received the highest ranking (Table 12-9) because they addressed eight of the nine UMRCC objectives. Alternatives C and B were given rankings of 2 and 3, respectively, and Alternative A received the lowest ranking.

Table 12-9. Alternative Plan Completeness – Addressing UMRCC Ecosystem Objectives.

Alternative	UMRCC Eco. Objectives	Rank
A	0/9	4
B	6/9	3
C	7/9	2
D	**8/9**	**1**
E	**8/9**	**1**

The one essential UMRCC ecosystem objective not directly addressed by the restoration alternatives relates to reducing the spread of exotic species into and within the UMRS. Though not directly addressed, exotic species will maintain a high priority as a component of the ecosystem alternative plan's rigorous adaptive management program. Future research will be conducted to further explore system management and restoration measures that could be employed to address the issue of exotic species.

The environmental quality of the ecosystem restoration alternatives was also evaluated by gauging how well alternatives contribute to ecosystem diversity. The following systemic ecosystem goals (Grumbine 1994) were used to assess the alternative influence (i.e., low-high) on UMRS ecosystem diversity.

B2a. Maintain viable populations of native species in situ.
B2b. Represent all native ecosystem types across their natural range of variation.
B2c. Restore and maintain evolutionary and ecological processes (i.e., disturbance regimes, hydrologic processes, nutrient cycles, etc.).
B2d. Integrate human use and occupancy within these constraints.

Alternatives E and D received the highest ranks (1 and 2, respectively) for their effect on diversity (Table 12-10) because they provided a moderately high positive influence on UMRS ecosystem diversity. The remaining alternatives were ranked 3 to 5 from C to A because of their decreasing influence on ecosystem diversity. Alternative E ranked slightly higher than D because it had a greater effect on restoring and maintaining evolutionary and ecological processes, primarily because it includes systemic fish passage and water level management.

Table 12-10. Alternative Effect on UMRS Ecosystem Diversity.

Alternative	B2a	B2b	B2c	B2d	Rank
A	-	-	-	-	5
B	Low	Low	Low	-	4
C	Moderate	Moderate	Low	-	3
D	High	High	Moderate	-	2
E	**High**	**High**	**High**	**-**	**1**

12.2.2.3 NER Environmental Benefits (Efficiency)

The NER environmental benefits of the ecosystem alternative plans were assessed by evaluating their efficiency in addressing the UMRS ecosystem needs. This assessment was accomplished by first examining the alternative plan cost effectiveness (without fish passage or water level management). Alternative plan water level management and fish passage measures were then examined to determine their efficiency in addressing the system needs.

Assessment of the ecosystem alternative cost effectiveness (without fish passage or water level management) was accomplished by dividing the alternative cost by potential area of influence to establish the alternative cost per acre (Table 12-11). Ecosystem alternative cost effectiveness was influenced primarily by the type and quantity of measures making up the alternative. Because Alternative E had the highest proportion of cost effective measures, it was determined to be the most cost efficient (having the cheapest per acre cost). Therefore, Alternative E was given the highest ranking followed by Alternatives D through A in descending order. Alternatives D and E were fairly close in their assessed cost efficiency, while the remaining alternatives exhibited larger declines in overall effectiveness.

Table 12-11. Ecosystem Alternative Plan Cost, Benefits, and Effectiveness.

Alternative	Cost (no FP/WLM)	Area of Influence (no FP/WLM)	Cost/Acre	Rank
A	$0	0	$0	5
B	$1,561,900,000	119,800	$13,000	4
C	$2,686,800,000	223,700	$12,000	3
D	$4,262,700,000	388,300	$11,000	2
E	**$6,272,800,000**	**604,100**	**$10,400**	**1**

The effectiveness of individual management and restoration measures was also evaluated to gauge the efficiency of alternatives in addressing the ecosystem objectives. By examining the cost and benefits of individual measures in each alternative, the most efficient level of investment could be determined. Because of the detailed level of information required, a large proportion of the measures could not be evaluated in this way. However, with the additional effort accomplished by work groups examining fish passage and water level management, a more detailed assessment of the efficiency of these measures could be performed.

Alternative D includes the most cost efficient fish passage measures (Table 12-12). This is due to the more efficient measure locations identified by the work groups being incorporated into this alternative. For example, at a similar level of investment, fish passage at Lock and Dam 26 provides for greater connectivity to the main channel and tributaries than other locations. Lock and Dam 26 was one of the 14 fish passage measure locations selected for Alternative D. Alternative E incorporated the remaining less efficient locations for fish passage and therefore received a lower ranking.

Table 12-12. Water Level Management and Fish Passage Cost Effectiveness.

Alternative	WLM Cost Effectiveness	Fish Passage Cost Eff.	Rank
A	-	-	4
B	High	-	3
C	High	-	3
D	**High**	**High**	**1**
E	Moderate	Moderate	2

Alternatives B through D include the most cost efficient water level management measures (Table 12-12). This was determined by assessing the cost, area affected, and likelihood of success of these measures.

Alternative D received the top ranking for measure cost effectiveness because fish passage and water level management measures in this alternative exhibited the highest efficiencies. Alternatives C through A received the lowest rankings because they were missing one or both of the measures being assessed. A smaller number of fish passage structures were not included in Alternative B or C because of an identified threshold of need. That is, the systemic improvement of fish passage connectivity was not minimally obtained until fish passage was restored at the 14 identified locations.

12.2.2.4 Step 1 Results

By using the key evaluation criteria of adherence to the planning objectives, environmental completeness and diversity, and alternative efficiency, this assessment was successful in providing the information needed to identify the ecosystem alternative that best addressed the UMRS environmental objectives. Using the information above, the following paragraphs document the selection process.

Evaluation of the ecosystem alternative contribution to the Navigation Study planning objectives determined that Alternatives D and E provide full contribution to the ecosystem related planning objectives while having little or no impact on the Navigation System. Therefore, they received the highest ranking.

Assessment of the ecosystem alternative completeness was accomplished by examining the alternative relation to the existing condition, proportion of the virtual reference achieved, and number of UMRCC essential ecosystem objectives addressed. Based on the results of this assessment, Alternatives D and E were ranked very closely, with Alternative E being preferred slightly over Alternative D.

Restoration alternative effects on systemic ecosystem goals (Grumbine 1994) were assessed to qualitatively identify the influence of alternatives on UMRS ecosystem diversity. Alternative E was determined to have the largest positive influence on the systemic ecosystem goals and therefore received the highest ranking for ecosystem diversity. Alternative D was very close to Alternative E in its affect on ecosystem diversity, but scored slightly lower because it did not include systemic fish passage and water level management. Upon further review, the actual diversity achieved by Alternatives D and E may be close to equal because of the lower likelihood of success of the water level management measures added to Alternative E. The first set of fish passage improvements described in Alternative D would be done at sites that present more complete barriers to upriver fish passage and would re-connect major areas of main channel and tributary habitats important to migratory fishes. The additional fish passage improvements in Alternative E would result in improved opportunity for long-distance migratory fishes like skipjack herring, American eel, paddlefish, and lake sturgeon to gain access to the upper river. Also, additional fish passage improvements would allow slower-swimming species that cannot normally swim upriver through open dam gates access to habitats upriver of additional dams. The additional fish passage improvements in Alternative E would provide less incremental benefit to migratory fish populations than the initial set identified in Alternative D because the dams at those sites are often out of control (dam gates raised out of the water) for a greater percentage of the time, already allowing the stronger-swimming species some passage opportunity.

Environmental efficiency was evaluated by examining the cost effectiveness of fish passage, water level management, and the combined efficiencies of the remaining alternative measures. Alternative E was slightly more efficient than Alternative D when comparing the combined efficiencies of their measures (without fish passage and water level management). However, with more detailed assessment of fish passage and water level management measures, Alternative D was determined to be more cost effective than Alternative E and to have a greater likelihood of success. Therefore, Alternative D was identified as the most efficient alternative in addressing the UMRS ecosystem needs.

Based on the assessment of these key evaluation criteria, it was determined that Alternative D outperforms Alternative E because it contains measures that are more effective and have a greater likelihood of success. Although Alternatives D and E were very close in there overall ranking, Alternative D was identified as the best alternative primarily because it is likely to achieve a high degree of completeness and diversity in the most efficient manner.

12.2.3 Step 2: Refinement of the Initial Ranking with Remaining Criteria

The second step of the evaluation process involved refining the ranking of the alternatives with the remaining scoresheet criteria. This step was conducted with two primary goals in mind:

1) assist in making a single selection if the initial evaluation (i.e., Step 1) resulted in two equally favored alternatives, and
2) further consider benefits offered by the ecosystem alternatives.

Because the initial evaluation identified Alternative D as the recommended alternative, this step in the evaluation process will concentrate on the second goal of further considering the benefits offered by the ecosystem alternatives. Benefits produced through regional economic development, other social effects, acceptability, and adaptability are explained in detail below.

12.2.3.1 Regional Economic Development

The income and employment benefits for each alternative are reported for the States of Minnesota, Wisconsin, Iowa, Illinois, and Missouri, along with the Lower Mississippi River Region and the rest of the United States (Table 12-13). These income and employment effects are derived from direct construction expenditures required to implement an alternative. The greater the investment, the greater the benefits; thus, Alternative E has the greatest RED benefits. The remaining alternatives exhibit declining benefits moving from Alternative D to Alternative A. The RED benefits do not factor into the Federal decision-making process; however, they will influence the acceptability of an alternative to the region.

Table 12-13. RED benefits produced by the environmental alternatives.

	Alt. A	Alt. B	Alt. C	Alt. D	Alt. E
C1. Average Annual Income to the Five States	$0	$28.0M	$47.0M	$78.2M	$125.6M
C2. Average Annual Employment for the Five States	0	470	760	1,180	2,080

12.2.3.2 Other Social Effects

Overall, the restoration alternatives contribute to maintaining and restoring a wide range of UMRS ecosystem goods and services. The fact that many of the goods and services provided by the UMRS are uniquely important to the Nation was validated when the U.S. Congress in the Water Resources Development Act of 1986 declared the area “a nationally significant ecosystem”.

The following is a sample of the many uses, species, and habitats that are of particular importance in the UMRS or are rarely found in other areas.

- The Mississippi River is the largest riverine ecosystem in North America and third largest in the world.
- Combined with the floodplains of the Illinois, Minnesota, St. Croix, Black, and Kaskaskia Rivers cover 2.6 million acres of land and water area.
- Commercial and recreational fishery.
- Today, some 297,000 acres of the floodplain are now within the Wildlife Refuge System.
- Home and habitat for 485 species of fish, mussels, birds, mammals, amphibians and reptiles
- For some bird species, nest success may be higher in (UMR) floodplain forests than in upland forests, and in these cases, floodplains are an important recruitment or "source" area for certain bird populations. (UMRCC 2002)
- About half of the 30 million residents of the watershed rely on the water from the UMR and its tributaries for municipal and industrial water supplies.
- It provides for over $6.6 billion in revenue annually from some 12 million visitor-days of use by people who hunt, fish, boat, sightsee or otherwise visit the river, its magnificent bluffs and communities (Black et al. 1999).
- Recreation and tourism employ 143,000 people in the corridor.
- It is a migratory flyway for 40 percent of all North American waterfowl.
- It is a globally important flyway for 300 bird species (60 percent of all species in North America).
- At least 260 fish species have been reported in the basin (25 percent of all fish species in North America).
- The river is habitat for 37 species of freshwater mussels.
- The river corridor is habitat for 45 amphibian and reptile species and 50 mammal species.
- It is important habitat for 286 State-listed or candidate species and 36 Federal-listed or candidate species of rare, threatened, or endangered plants and animals endemic to the UMR Basin.
- It provides the important, but intangible, benefit of over 1,300 river miles of diverse natural, rural, and urban open space for human exploration, experiential education, spiritual renewal, and aesthetic enjoyment.
- It is a 2.6-million-acre large river floodplain laboratory. It is a "system of systems" for us to use, understand, and appreciate. It is a place for this and future generations to learn how to restore and maintain a "living river" in the face of a global human population that will grow by 1 billion people in the next 12 years.

12.2.3.3 Acceptability

The current comments and positions statements provided by stakeholders (from public meetings, formal letters, etc.) can be used to obtain a general sense of stakeholder opinion on alternative acceptability. Based on current feedback, Ecosystem Alternative E and Cost Sharing Option C have carried the most support among stakeholders. Official position statements from the Federal agencies, States, and NGOs are presented in Chapter 13.

12.2.3.4 Adaptability

Implementing the recommended alternative through a process of adaptive management will minimize uncertainty and risk. By developing a sound organizational structure, evaluating measure outputs, and monitoring systemic trends, the ecosystem alternative will be more adaptable in testing and improving on the design, performance, and sequencing of management and restoration measures.

One of the primary benefits of an UMRS adaptive management program is the development of an iterative and flexible approach to management and decision-making. It also provides an open management process that seeks to include partners and stakeholders in the planning and implementation stages of the recommended ecosystem alternative plan (see Chapter 12).

12.2.4 Step 3: Identify other Criteria and Considerations

After the initial assessment, additional criteria and considerations were identified and discussed by the Navigation Study Team and stakeholders. After reviewing the initial assessment process, stakeholders determined that no additional evaluation criteria were necessary at this time. However, considerations for refining and modifying Alternative D led to an augmented version of the alternative, now referred to as Alternative D*. Based on stakeholder input and discussion, the existing Alternative D measures would be further refined to include embankment lowering at lock and dam sites to promote floodplain connectivity. Also, Alternative D* would include the addition of measures that reduce water level fluctuation on the Illinois River in an effort to improve aquatic habitat.

Embankment lowering was identified as a cost efficient means to promote system connectivity and naturalization of UMRS hydrologic processes. This restoration measure involves lowering portions of the earth embankments between navigation pools to low control pool levels and construction of an overflow spillway. Based on stakeholder input, embankment lowering at lock and dam sites will be included as a measure in Alternative D* to improve floodplain connectivity, shoreline stability, and fish passage. This measure will be incorporated into the existing measures of fish passage, floodplain restoration, and shoreline protection at no additional cost. It is anticipated that initial implementation will take place in conjunction with construction of fish passage structures.

Ecological advantages of embankment lowering include the following:

- Restoration of floodplain water and sediment flow
- Improved habitat diversity
- Increased fish passage during high water events
- Increased sediment scour in downstream waterways
- Restoration of the river to a more natural pattern of sediment movement and deposition
- Reduced risk of earth embankment and shoreline erosion during overtopping

Measures to reduce water level fluctuation on the Illinois River were also recommended by stakeholders due to their significant and spatially extensive benefits. These measures would attempt to produce a more natural hydrograph in parts of the system that see sudden changes in water level. They would potentially include more frequent adjustment and remote operation of dam gates, centralization of water control on the Illinois Waterway, and structural modifications to the wicket dams at Peoria and La Grange. Based on stakeholder input and conclusions from the Water Level Management Work Group, measures to reduce water level fluctuation on the Illinois River will be added to Alternative D* at an estimated cost of $140 million over 50 years.

Ecological advantages of reducing water level fluctuation include the following:

- Naturalization of the hydrologic cycle
- Expanded emergent aquatic plant distribution
- Improved habitat diversity
- Increased in-shore macroinvertebrate communities benefiting shorebirds and some fish
- Reduced impacts on nesting fish, increasing spawning success

13.0 COMMENTS AND VIEWS

13.1 Introduction

This chapter summarizes the process used for review of the Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement (draft report) that was released for agency and public review on May 14, 2004. The availability and comment protocols for the draft report were announced in the Federal Register, in a study newsletter mailed to over 9,600 individuals and agencies, on the study website, and at eight public hearings attended by over 1,200 people (June 7-17, 2004), and on the study website. Also during the review period, general questions on the draft report were answered through meetings, telephone calls, and emails involving many collaborative partners. Comments on the draft report were accepted until July 30, 2004.

Nearly 40,000 individual comments on the draft report were received from over 4,300 persons during the public comment period. A complete record of comments, responses, and letters can be found in the Response to Comments Appendix.

13.2 Coordination Efforts

Paragraph 13.2.1 discusses the wide distribution of the draft report. Many additional efforts were made to increase awareness of the draft report and to gather comments from agencies and the public. These coordination efforts are discussed in paragraphs 13.2.2 through 13.2.6 below.

13.2.1 Report Distribution

During the public and agency review period, paper copies and/or compact discs (CD's) of the draft report were mailed to Congressional representatives, numerous agencies, organizations, and libraries. The study newsletter, the Federal Register, the study website, and the public hearings provided information on how to request a copy of the draft report; as a result, many requests were received.

The breakdown of the report distribution is shown in Table 13-1.

Table 13-1. Number and format of draft reports initially distributed to organizations and individuals.

	Paper Copy	CD
Senators; Congressmen/women	70	0
Federal agencies	47	25
State agencies	42	3
Local governments	1	3
Non-governmental organizations	26	0
Misc. organizations, groups, businesses	39	42
Libraries	85	1
Members of the public	7	26
Total	317	100

Numerous CD's given to members of the public who requested them at the June 2004 public hearings are not included in the count. In addition, copies of the Executive Summary from the draft report were distributed by request at the public hearings.

13.2.2 Newsletter

The May 2004 newsletter announced the details and release of the draft report and provided the timeline for public review and comment on the report. The newsletter also announced the schedule and locations of the public hearings. There were over 9,600 persons on the mailing list, including Congressional representatives; Federal, State, county and city representatives; various interest groups and organizations, including waterway system users and environmental groups; businesses; drainage districts; media; and the unaffiliated general public.

13.2.3 Federal Register

The Notice of Availability of the draft report was published in the May 14, 2004, Federal Register Vol. 69, No. 94 (pgs 26811 and 26818). These postings included a summary of the study, the end date of the public and agency review comment period (July 30, 2004), and ways to submit comments. The public hearing dates, locations, and schedules also were provided.

13.2.4 Study Website

The draft report was posted on the study's website. Also on the website were links to two email mailboxes for the public to use: one to order a copy of the report, and the other to leave comments about the draft report.

13.2.5 Public Hearings

A series of eight public hearings was held in June 2004 to explain how the study team selected the Recommended Integrated Plan and to listen to public statements regarding the draft report. Two sessions were held – an informal afternoon open house and the formal evening public hearing. A total of 1,248 persons attended an open house and/or public hearing, as shown in Table 13-2.

Table 13-2. Location and attendance figures for the June 2004 public hearings.

Date	Location	Attendance		
		Open House	**Public Hearing**	**Total**
June 7	Davenport, IA	36	151	187
June 8	Dubuque, IA	32	96	128
June 9	La Crosse, WI	31	98	129
June 10	Bloomington, MN	22	75	97
June 14	Peoria, IL	26	203	229
June 15	Quincy, IL	42	208	250
June 16	St. Louis, MO	31	143	174
June 17	Washington, DC		54	54
Total		220	1,028	1,248

Note: In Washington, D.C., Open House and Public Hearing sessions were combined. Total attendance is included in the count for the Public Hearing.

13.2.6 Collaboration Meeting

In addition to multiple collaborative efforts, a combined Navigation Environmental Coordination Committee/Economic Coordinating Committee (NECC/ECC) meeting was held in Moline, Illinois, on July 13 and 14, 2004. In attendance were Corps representatives and many collaborative partners from Federal and State agencies and non-governmental organizations. The main focus of the meeting was to listen to the committee members' input on the Navigation Study's Recommended Integrated Plan and to discuss institutional arrangements. In addition, comment letters were received from the agencies and non-governmental organizations.

13.3 Comment Processing

During the public and agency review period, comments regarding the draft report were submitted via the public open houses and hearings, the study's web site, email, and regular mail. All statements of public hearing testimony, letters, emails, and comment forms received were analyzed using a "content analysis" process. In the content analysis process, each letter was given a unique identifying number that allowed analysts to link specific comments to original letters. All respondents' names, comments, and corresponding codes were entered into a project-specific database. All input was considered and reviewed by at least two analysts. Each comment was read, sorted into comments and common themes, and then entered verbatim into the database.

A coding structure was developed to help identify and group individual comments received into logical groups by main and sub-category themes. The following stepwise process was used to ensure that each comment was given consideration and response.

1) Collection of statements, concerns, and questions during the review period
2) Categorization and grouping of similar statements, concerns, and questions into topic statements
3) Identification of a common thematic statement based upon topic statements
4) Response to the thematic statement

Responses were developed for each of the thematic statements. These can be found in the Response to Comments Appendix. Every effort was made to capture the intent of the questions and issues presented in categorizing and consolidating comments.

13.3.1 Oral Comments

Oral comments from the eight public hearings were transcribed into written comments by three Corps of Engineers listeners. They took notes from each speaker's oral statement and compared these notes after each hearing to reach agreement on each of the speaker's comments. These agreed upon comments were then compared to the hearing transcript as a follow-up check. The oral comments were recorded in the database and processed in the same manner as the written comments. Oral statements provided by 367 speakers at the public hearings resulted in approximately 8,000 coded comments in the database.

13.3.2 Written Comments

Written comments were collected during the public and agency review period in four ways: comment sheets and prepared written statements submitted at the public hearings, emails, letters, and agency memoranda. As with oral comments, written statements were analyzed and individual comments were identified within each. These comments were coded, categorized, and sorted into themes. The nearly 4,000 written pieces of correspondence translated into approximately 32,000 coded comments in the database.

13.3.3 Response Processing

Comments were considered both individually and collectively. Many comments were grouped into categories of themes, and responses were developed for each thematic statement. Within each main category, sub-categories were created to best depict the wide variety of topics that relate to the main category. Individual comments developed from the coding process were placed within the sub-categories to allow for unique characterization. This unique characterization is the basis for the development of comment topic statements. The topic statements were used to write public concern thematic statements to which the Corps prepared responses. It should be noted that one response may reply, generically, to many comments.

For example, the main category of "Ecosystem Restoration" has 17 sub-categories that reflect the wide variety of theme statements related to Ecosystem Restoration. A comment such as "I support restoring the Upper Mississippi River ecosystem to a state that can sustain the wildlife that depend upon it" would be coded under the main category ER for ecosystem restoration and then into sub-category 17 for general ecosystem remarks. The unique category for this example is ER-17-c, with a topic statement of "I/we support ecosystem restoration."

These thematic statements were responded to in one of five ways, by: (1) modifying alternatives including the proposed action, (2) developing and evaluating alternatives not previously given serious consideration by the Corps, (3) supplementing, improving, or modifying the analyses, (4) making factual corrections, and (5) explaining why the comments do not warrant further agency response, citing the sources, authorities, or reasons that support the agency's position and, if appropriate, indicating those circumstances that would trigger agency reappraisal or further response. Some responses resulted in changes to the draft report; other responses are addressed solely in the Response to Comments Appendix. Some of these responses will incorporate specific sections of the draft report by reference.

13.4 Views of Federal and State Agencies, NGOs, and the General Public

This section provides a summary of the agency and organization views received during the draft report comment period. Some of the comments from these agencies were lengthy and detailed. An effort was made to summarize the information in these letters and position statements as accurately and concisely as possible. These letters and public statements can be found in their entirety in the Response to Comments Appendix. Agencies are ordered in this section by the date that their letter was postmarked.

13.4.1 Views of Federal Agencies

13.4.1.1 U.S. Environmental Protection Agency (letter dated July 29, 2004)

The Environmental Protection Agency (EPA) has worked with the Corps since 1993 and expressed their appreciation for the collaboration process in both the NECC and Federal Principals Groups. They support the adaptive management strategy to implement both the navigation improvements and ecosystem restoration. The EPA supports the Corps' proposal to adaptively implement project phasing of the recommended plan by including nonstructural and small-scale structural components and checkpoints for future decisions regarding lock expansion and construction. The EPA prefers ecosystem restoration Alternative E, which would provide a 50 year comprehensive restoration plan for the Upper Mississippi River System. However, they also recognize that Alternative D* is an acceptable choice that provides an adequate framework for the proposed first 15-year increment of the 50-year plan, as long as it is supported by a strong, integrated, adaptive management process. The EPA remains committed to the collaborative process with the Corps and other stakeholders of the Upper Mississippi River System as the Feasibility Study is completed and implementation decisions are made.

The EPA indicates that the Corps needs to provide greater detail on the adaptive management strategy, phasing, institutional arrangements, future use of economic models, and use of the Volpe report in selecting the recommended alternative, and to expand on the implementation timeline and decision criteria. They also recommend that the Corps consider total maximum daily load (TMDL) in future decision-making, consider other/additional mitigation measures not identified in the draft report, and better define Alternatives 4 and 6 in the Final Feasibility Report/PEIS. They indicate the need to investigate the merits of developing and implement this scheduling system with the use of state-of-the-art technology during the 15-year phase of the dual-purpose project. These issues should be outlined in detail and included in the Record of Decision (ROD). They recommend that the Corps include the draft ROD with the final report or submit it for stakeholder review and comment prior to signing.

13.4.1.2 U.S. Department of Agriculture (letter dated July 30, 2004)

The U.S. Department of Agriculture (USDA) applauds the Corps for the level of openness and collaboration and appreciates being included in the Federal Principals Group. The USDA advocates sound investments in the Nation's transportation structure, including the inland waterways, to help ensure its position as a global leader in agricultural production and trade. They state that exports are critical to the livelihood of U.S. farmers, accounting for about one quarter of farm cash receipts, and that their latest long-term Baseline Projections forecast corn production increasing 14 percent by 2013, but corn exports increasing by 53 percent over the coming decade. They indicate USDA research has shown that transportation costs can be as high as 50 percent of the final landed cost for grain reaching Asian markets. They state that in 1999 barge traffic of food and farm products on the Mississippi River System totaled nearly 86 million tons and that shippers would have required an additional 3.3 million additional trucks or 857,000 additional rail cars to move that same amount of products. They also state that the presence of barge transportation as an alternative to rail, particularly in locations where both are present, helps keep rail rates competitive. The USDA believes that Brazil could surpass the United States in soybean exports in the near future if recent trends continue.

13.4.1.3 U.S. Fish and Wildlife Service (letter dated August 6, 2004)

The U.S. Fish and Wildlife Service (USFWS) has been involved for more than a decade with studies and coordination concerning the UMR-IWW System Navigation Study and continues to be pleased with the direction of the Restructured Study. The USFWS strongly supports the creation of a dual-purpose authority for navigation and ecosystem restoration and believes that the UMR-IWW System can be managed to achieve both economic and fish and wildlife objectives. The USFWS has maintained its endorsement of Corps efforts to fully restore the UMR-IWW System ecosystem with a new authority. In its April 23, 2004, Draft Supplement to the April 2002 Draft Fish and Wildlife Coordination Act (FWCA) Report, the USFWS provided specific comments and recommendations regarding the Corps' proposed project and expressed the USFWS's preference for Ecosystem Restoration Alternative E. However, the USFWS also acknowledges that Alternative D* (if fully implemented) would likely reverse the overall decline in natural resources. The USFWS supports 100 percent Federal (Corps) cost sharing for ecosystem restoration actions that involve modification of navigation structures or operations, measures on Corps project lands or refuge lands, and measures in the main channel or directly connected backwaters below the ordinary high water mark. Although the USFWS supports the major elements of the proposed 15-year plan, they believe there will be a need for a UMR-IWW System ecosystem restoration authority for as long as the UMR-IWW System 9-foot Channel Navigation Project is operated and maintained, because it is those operation and maintenance measures that will continue to have a substantial adverse impact on Federal trust resources.

The USFWS finds the organization of the draft report confusing. They would like the Corps to provide greater detail on adaptive management, describing how this program would affect existing programs (the Environmental Management Program (EMP), the Illinois River Ecosystem Restoration Study, and the Comprehensive Floodplain Management Study), institutional arrangements, increased emphasis on the need for a dual-purpose authority, strengthened commitment to a 50-year plan, and more emphasis on the past effects of operation and maintenance on the degradation of the ecosystem in the Final Feasibility Report/PEIS. They would also like to see a description of a science-based objective strategy for adaptive management of the ecosystem, an assessment of present and future barge fleeting impacts followed by the preparation of a barge fleeting plan for the UMRS, broader assessment of ecosystem goods and services, more detail in the description of the affected environment, an increased description of the effects of floodplain agriculture on the ecosystem of the UMR-IWW System, plus an expanded discussion of the Middle Mississippi River reach and the Kaskaskia River in the Final Feasibility Report/PEIS.

13.4.1.4 U.S. Department of Transportation - Maritime Administration

The Maritime Administration commended the Corps on the collaborative process used in developing the feasibility report and programmatic EIS. They indicated that the result is a comprehensive study that addresses the issues from a national and local perspective with all parties aware of the issues and the findings. The Maritime Administration stated that it is working to develop a fully integrated national transportation system. To achieve this objective, they indicated that they are working with other Federal agencies, as appropriate, to solve national challenges to waterborne transportation and thanked the Corps for the opportunity to advocate for maintaining an efficient waterway system.

13.4.2 Views of State Agencies

13.4.2.1 Joint Governors' Statement (letter dated July 16, 2004)

The Governors of the five States that share stewardship of the project area (Illinois, Minnesota, Iowa, Wisconsin, and Missouri) jointly endorse the Corps' proposed plan as set forth in the draft report. In particular, they support (1) Navigation improvements, including mooring facilities, switchboats, seven new locks, and related mitigation, within the framework of a $2.4 billion plan, with an initial investment totaling $1.671 billion and further investments contingent upon an updated feasibility report, and (2) Ecosystem restoration actions, including island building, fish passage at dams, floodplain restoration, water level management, backwater and side channel restoration, wing dam and dike alterations, island and shoreline protection, improvements to topographic diversity, and switching to dam point control, within the framework of a $5.3 billion 50 year plan, with an initial investment increment of $1.462 billion. They support an integrated, balanced, adaptive, collaborative, and fairly funded plan.

13.4.2.2 Upper Mississippi River Basin Association (letter dated July 16, 2004)

The Upper Mississippi River Basin Association (UMRBA) is a regional interstate organization formed by the Governors of Illinois, Iowa, Minnesota, Missouri, and Wisconsin to help coordinate the States' river-related programs and policies and work with Federal agencies that have river responsibilities. The UMRBA expresses support for the preferred plan described in the draft report. They concur that ecosystem restoration should be added as a federally authorized project purpose on the Upper Mississippi River, thus providing dual authority and mandating integrated planning and management by the Corps. They also endorse the adaptive management approach, and the adaptive implementation approach for addressing navigation, ecosystem restoration, and mitigation. The UMRBA supports cost share Option C for ecosystem restoration and the specific cost share provisions recommended in the preferred plan. They believe it would be most appropriate to pursue institutional arrangements independent of the feasibility study.

13.4.2.3 State of Missouri (letter dated July 27, 2004)

In addition to the Joint Governors Statement and the UMRBA letter (Sections 13.4.2.1 and 13.4.2.2); the Corps received a letter from the Missouri Department of Conservation (DOC). The Missouri DOC offers several comments on the draft report. They believe that the floodplain restoration measures have more potential to positively affect habitat restoration efforts in the lower pools and the Middle Mississippi River, and they prefer ecosystem Alternative E over ecosystem Alternative D* because it addresses more floodplain restoration. They are concerned with the proposed adaptive implementation schedule and they support requesting full authorization of ecosystem restoration funding. The Missouri DOC states that institutional arrangements received insufficient attention within the report. They suggest that the Environmental Management Program Coordinating Committee (EMPCC), with appropriate additional State and Federal agency representation and expanded responsibilities, could become the River Management Council. They also suggest the chartering of a River Management Council, River Management Teams, and a Science Panel. The Missouri DOC believes that mitigation for impacts of the anticipated incremental increase in traffic is insufficient because of uncertainties present in the assessment of those impacts. They believe adaptive management and flexibility in funding and operations will be necessary to implement the integrated plan in the most effective manner. They state that a phased approach with a full complement (250,000 acres) of floodplain restoration acreage needs to be recommended for ecosystem restoration. They ask the Corps to provide greater detail on institutional arrangements and validate traffic growth rates, transportation cost savings, and tourism projections presented in the report.

13.4.2.4 State of Wisconsin (letter dated July 27, 2004)

In addition to the Joint Governors Statement and the UMRBA letter (Sections 13.4.2.1 and 13.4.2.2); the Corps received a letter from the Wisconsin Department of Natural Resources (DNR). The Wisconsin DNR has been part of a collaborative team for the UMR-IWW Navigation Study for over 12 years. With regard to the draft report, the Wisconsin DNR wants the Corps to reconcile information found in the Alternative Formulation Briefing with that presented in the draft report (including the annual rehabilitation costs and the name used to describe Alternative 3), add implementation options, correct the acreage used to describe the acres of floodplain, remove references to criticality of the river to national defense, update census information, and identify the source of the $6.6 billion annual revenue from recreation in the final report. They ask that the Corps consider the impact of international competition in the economic scenarios and acknowledge that most of the studies conducted during the Feasibility Study were defined during the Plan of Study for the Record of Decision for the Second Lock at Lock and Dam 26. The Wisconsin DNR requests additional responses from the Cumulative Effects report (WEST 2000) to comments on Definitions, Boundary Delineations, Measurements of Attributes and Analysis of the Hydraulic Classification of Aquatic Areas, Upper Mississippi River System.

The Wisconsin DNR requests more information on several items, including documentation for the health of the dams, projections of when the next major rehabilitation may be needed for existing infrastructure and new/extended locks, a comparison of commercial to recreational lockages, inclusion of the annual and the projected 50-year cost of major rehabilitation, a factoring of savings and slippage into total funding for all projects, an explanation of why the only studies on aquatic plants were done on submersed aquatic plants, the clear identification of threats to cultural resources from water level management, and the increase in benefits in recreation opportunity and tourism that will result from ecosystem restoration in the final report. They also identified discrepancies in air pollution comparisons between waterway, railroad, and truck transportation; the benefits of clean water to municipalities; the characterization of aquatic plant losses in the main channel border; the use of exotic species in plant experiments; the use of one aquatic plant category for discussion rather than the three plant categories; the assignment of percentage to ecosystem restoration alternatives; the discussion of global terror and national security; the reasoning for selection of Alternative D* over Alternative E; and the proposed management of the Science Panel.

The Wisconsin DNR states several things for the record. With regard to Figure 4-10, they have difficulty determining the legitimacy of predictions/assumptions for many of the scenario drivers and key variables and find it hard to believe that no predictions from the literature could be found as references for at least a few of the trade scenarios presented. They believe Table 4-11 misrepresents the true trend in production acreage. Rather than no decrease in production acreage, they state that future acreage may most likely decline due to urban sprawl and conversion of farmland from agriculture to rural home, urban sprawl, and recreation property use. They also comment that the amount of review time provided the NECC was very limited and state that Alternative E would be the only alternative that would provide an element of true restoration to the Upper Mississippi River System. The Wisconsin DNR supports the preferred plan because the 15-year implementation plan will allow a gradual increase in ecosystem restoration measures along the river in an adaptive management process. This work will allow scientists, biologists, and river managers to further define the best future course for ecosystem restoration and more than likely, through this process, conclusively document the need for higher restoration efforts as outlined in Alternative E. The State of Wisconsin also states for the record that small centrarchids do not cross the main channel of the river to get to preferred habitat; therefore, the study underestimates the amount of restoration actually needed. They also state that the floodplain restoration element should be adjusted up to 105,000 acres.

13.4.2.5 State of Minnesota (letter dated July 20, 2004)

The Corps received a letter from the Minnesota Department of Natural Resources (DNR) in addition to the Joint Governors Statement and the UMRBA letter (Sections 13.4.2.1 and 13.4.2.2). The Minnesota DNR supports improvements that would provide the most aid to Minnesota shippers in moving their waterway freight more efficiently and they also support measures to restore and protect the Mississippi River's ecosystem. They do not believe any of the alternatives considered in the Feasibility Study represent a fully restored ecosystem. Alternative E would go the farthest toward this goal. However, Alternative D* would also provide substantial benefits and opportunities toward a restored ecosystem. The Minnesota DNR supports Alternative D*, but also encourages the Corps to consider several approaches to implementing or modifying that alternative to make it more effective in restoring a sustainable ecosystem. Specifically, the restoration measures identified in the study should be prioritized, with floodplain restoration and water level management receiving the highest priority. The Minnesota DNR supports Cost Share Option C, and adaptive management of the plan over 50 years. The State of Minnesota is pleased that the Navigation Feasibility Study recognizes the multiple uses of the Mississippi River and includes both navigation and ecosystem restoration components.

The Minnesota DNR recommends that all UMR pools in Minnesota waters (Pools 1-9) be included in the water level management measures and that a long-term hydrologic plan be developed for the entire UMR-IWW System that includes funding for recreational and commercial access dredging to accomplish summer drawdowns. They state that they would like increased funding directed toward floodplain restoration and implementation of measures to prevent movement of Asian carp into Minnesota waters.

13.4.2.6 State of Iowa (letter dated July 30, 2004)

The Corps received a letter from the Iowa Department of Natural Resources (DNR) in addition to the Joint Governors Statement and the UMRBA letter (Sections 13.4.2.1 and 13.4.2.2). The Iowa DNR agrees that ecosystem restoration should be added as a federally authorized and funded project purpose on the Upper Mississippi River. They believe that with the restructuring of the project in 2001 the foundation was laid for truly integrating navigation and ecosystem restoration.

With regard to the draft report, the Iowa DNR believes more effort needs to given not only to describing the current conditions, but also to how these current conditions affect the functioning of the ecosystem. They state that the report does not adequately define a sustainable ecosystem, nor does it address the impact of the proposed restoration measures (e.g., island creation, fish passage) on the sustainability of the ecosystem, and that the study does little to address current and future cumulative effects on species of interest. They believe the study does a good job of assessing the regional economic impact of the construction of new locks and lock extensions. However, it does not address the regional economic impact of an improved ecosystem. The Iowa DNR has concerns about the modeling of larval fish mortality and that tow-induced mortality to larval fish may currently be affecting species such as walleye.

13.4.2.7 State of Illinois

Representatives from the State of Illinois confirmed at the Governors' Liaison Committee meeting on August 8, 2004, that Illinois would provide no additional comments on the draft report beyond those made in the Joint Governors Statement and the UMRBA letter (Sections 13.4.2.1 and 13.4.2.2.)

13.4.3 Views of Non-Governmental Organizations (NGOs)

13.4.3.1 Mississippi River Basin Alliance (letter dated July 13, 2004)

The Mississippi River Basin Alliance believes that adequate funds need to be devoted to the river restoration. They state that Alternative E should be the recommendation of this study and that emphasis should be on projects that restore natural river processes, such as water level management and floodplain restoration. They believe restoration activities are prioritized to ensure that the portions of the river that are in the worst condition receive appropriate attention. The Mississippi River Basin Alliance believes that restoration funding should be explicitly linked to annual funding for operations and maintenance to ensure balanced funding in the future. On the topic of navigation efficiency, they believe the most prudent course of action is to implement small-scale measures to reduce site-specific congestion. They think the Corps should not recommend new locks because of flat and declining traffic, recent rehabilitation of locks, and current lock life expectancy. They recommend implementing the small-scale measures, evaluating their effect, completing the equilibrium model, fairly assessing projected traffic demand, and then evaluating the need for new locks. They are not opposed to new locks, but rather support using common sense, and they believe a common sense justification for new locks has not been met.

With regard to the draft report, the Mississippi River Basin Alliance would like additional information included in the report pertaining to community cohesion and ecosystem restoration, and social resources impacts from acquisition of farmland. In both instances, they feel that the Corps focused on the negative impacts of such actions and did not thoroughly discuss the potential benefits. They are also concerned about the risks associated with taking or not taking an action. There is risk associated with taking no action when an action is warranted. However, this risk is not the same type of risk as taking an action when the action is not warranted. The risk of taking unwarranted action is greater because the action cannot be undone. In addition, they feel that the analysis regarding sustainability ignores that Alternatives 5 and 6 are not sustainable in low growth scenarios. They also disagree with the Corps' determination that fish passage and water level management locations in Alternative D have a greater likelihood of success than Alternative E. Finally, they feel that the discussion regarding the condition of the locks is biased towards new lock construction because it ignores the major rehabilitation activities at the lock and dam sites. They also feel that the national security issues mentioned are over-generalized and provide no quantitative argument as to why "positive national security benefits will not be realized without implementation of the plan."

13.4.3.2 Audubon (letter dated July 19, 2004)

The Audubon organization supports an integrated plan for management of the river system, including Federal/State/NGO cost sharing and an adaptive approach to decision-making. Audubon appreciates the collaborative approach the Corps of Engineers has used since 2001 – an approach that has provided Audubon and others with opportunities for a high level of involvement in the study process. With regard to the draft report ecosystem restoration program, they recommend that the Corps clearly establish ecosystem restoration as a project purpose in managing the Upper Mississippi River System, pursue Cost Sharing Option C, seek authorization for Ecosystem Restoration Alternative E, expand and improve the Environmental Management Program, establish a trust fund for restoration, and give priority to projects that restore or mimic natural river processes.

Audubon supports mooring facilities at Locks 12, 14, 18, 20, 22 and LaGrange, switch boats at Locks 20 through 25 in a phased approach, mitigation for the impacts of these measures, development of an appointment scheduling system, development of a new spatial model, collection of demand elasticity data, monitoring of traffic delays and patterns, monitoring of domestic and global grain market conditions, land use, crop yield technology, and developments in other countries, especially China, regarding import and export market trends. They believe that the Corps should include stakeholder groups and the general public at project checkpoints (with rationale and cost/benefit analysis), and that the cost of study, construction, mitigation, and monitoring should be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

13.4.3.3 Mississippi River Citizens Commission (letter dated July 25, 2004)

The Mississippi River Citizens Commission (MRCC) supports the recommendations of the study. Specifically, they support granting the Corps dual authority to manage simultaneously for navigation and the environment; 100 percent Federal cost sharing for projects that are located below the ordinary high water mark or in a connected backwater, that are needed to maintain commercial and recreational navigation when changes or modification to structures or operations are employed to improve the environment, or that are located on federally owned land; and provision for non-governmental organizations to contribute the non-Federal cost sharing requirements applicable to other projects. They believe adaptive management is crucial for implementation of recommendations for both the environment and navigation and that eligible habitat rehabilitation projects should include but not be limited to those specified in the draft report. They strongly urge that the report clarify and strengthen provisions to maintain and fund a strong monitoring and research base conducted through the U.S. Geological Survey and the current EMP partnership to insure unbiased analysis independent of management. The MRCC would like coordination, facilitation, and public involvement to originate from an agency along the Upper Mississippi River rather that near the Corps' Division Headquarters in Vicksburg, Mississippi, to maintain scientific integrity. They believe the process currently used to incorporate public improvement in both EMP projects and research and in navigation management has been successful and should be carried forward into recommendations for the future. Finally, the MRCC believes project selection should recognize the value of working with natural processes.

13.4.3.4 National Corn Growers Association (letter received June 25, 2004)

The National Corn Growers Association (NCGA) believes the preferred alterative will meet the needs of corn growers across the United States as well as the economic needs of the Midwest and the environmental needs of the UMR-IWW System. They support the Corps' phased-in approach to address congestion on the navigation system where it exists today. By segmenting the phases of the plan, the Corps will be able to continually update its studies and methodologies to better understand the system and meet congressional directives and public expectations.

The NCGA encourages the Corps to keep management and funding for the navigation system separate from the ecosystem restoration component. They believe neither should be directly tied to the other or allowed to negatively affect the other. They feel that navigation should be managed so as not to limit its future growth. They also state that the restoration program should be implemented in a thoughtful, carefully planned manner to ensure resources are not wasted but are targeted toward projects of the highest value, providing the greatest public benefit. Finally, they express their concerns regarding adaptive management. In theory, project management should adapt to changing conditions and needs. In practice, it could be a way around well-established rules and practices with the purpose of implementing top-down solutions. The NCGA does not expect the Corps will use adaptive management in this manner; however, the NCGA encourages the Corps to continue to work closely with stakeholders and to maintain its general policy and practice of openness.

13.4.3.5 The American Waterways Operators (letter dated June 29, 2004)

The American Waterways Operators (AWO) fully supports the long-term recommendation in the draft report to provide twelve 1,200-foot lock capacity chambers on the Upper Mississippi River and Illinois River. They also support phasing in this approach with immediate construction authorization for seven new 1,200-foot lock chambers at Locks 20, 21, 22, 24, and 25 on the Upper Mississippi River and at the Peoria and LaGrange locations on the Illinois River. The AWO stated that the lock and dam system on the UMR-IWW System is hindered by deterioration, unreliability, and inefficiency, and that delays at the lock facilities cost millions of dollars a year. The AWO is deeply committed to modernization of the inland waterways system.

13.4.3.6 The Nature Conservancy (letter dated July 29, 2004)

The Nature Conservancy (Conservancy) has been actively engaged with the U.S. Army Corps of Engineers and other stakeholders on the restructured feasibility study for two years. The Conservancy strongly supports a vigorous ecosystem restoration program for the UMR-IWW System; however, they take no position on the recommended measures to reduce navigation congestion. They support the proposal for cost-sharing contained in the Preferred Plan.

The Conservancy encourages the Corps to reconsider using Alternative E as the basis for its Preferred Plan, and they feel strongly that alternatives that are hybrids of Alternatives D and E should also be considered; they recommended that the Corps clearly acknowledge the need to phase in a 50-year restoration plan and provide some description of steps that may be taken once the 15-year program is complete. The Conservancy recommends linking funding for restoration to funding for the navigation system, including its ongoing operation and maintenance, and the continuance of integration as the plan was completed and implementation began. The Conservancy recommends that the preferred alternative for ecosystem restoration be presented in the context of goals and objectives achieved rather than as a list of restoration actions, with an emphasis that the goal of restoring natural river processes would guide the design and implementation of all projects. They also ask the Corps to clarify what the virtual reference represents and to define another reference point for the ecosystem if all of the goals and objectives were met.

13.4.3.7 American Rivers (letter dated July 30, 2004)

American Rivers states that they have worked for years to improve the process that has produced the draft report. They are strongly opposed to that portion of the Corps' preferred plan that recommends authorization of new and expanded locks on the Mississippi and Illinois Rivers. They also strongly support establishing a comprehensive restoration program for the Mississippi and Illinois Rivers that has a guaranteed source of adequate funding, that prioritizes efforts to restore natural river processes, and that is based on sound science and ecological principles. They urge the Corps to revise the recommended restoration plan to meet these criteria and to uncouple the restoration plan from any lock expansion proposal, which they believe will doom restoration efforts to failure. They state that the Corps should comply with the requirements of the National Environmental Policy Act and its written promises, and fully evaluate alternatives to its current operations and maintenance practices before finalizing the Feasibility Study. After conducting the needed analysis, the Corps should recommend – and implement as quickly as possible – changes to its current practices that would cause less harm to the environment and that would improve the ecological health of the system. While American Rivers fully supports a comprehensive restoration plan on the Upper Mississippi and Illinois Rivers, they believe that the Corps should not use the potential for authorization of such a plan to avoid using all existing authorities to protect and restore the health of these great rivers. They state that many, if not all, of the activities recommended by the Corps for new Congressional authorization in the guise of an ecosystem restoration plan could be implemented, at least in part, and should be implemented through the Corps' existing operations and maintenance authorities. They conclude that the Corps should reevaluate and improve its management of the existing navigation system before determining whether or how to expand that system.

American Rivers also supplied specific comments on the draft report. They believe this report overestimates future river traffic, underestimates growing domestic demand for grain, and ignores the benefits of less expensive congestion management measures such as traffic scheduling. They believe the Corps is required by law to prepare a supplemental environmental impact statement on its operations and maintenance of the 9-foot navigation channel for the UMR-IWW System. American Rivers also provided specific comments on ecosystem restoration that include the following four points: (1) the plan should be incorporated into the Environmental Management Program (EMP) to ensure adequate restoration funding; (2) funding to implement the restoration plan should be explicitly linked to annual funding for operations and maintenance to ensure guaranteed and balanced funding in the future; (3) the plan should explicitly require that priority be given to implementing projects that restore natural river processes to help guarantee the greatest restoration benefits; and (4) the plan should include the creation of an advisory committee of independent scientists with the expertise to review and comment upon habitat needs, pool plans, project criteria, project selection, and project sequencing. American Rivers commends the Corps for proposing a significant restoration plan in the Draft Feasibility Study; however, they believe that plan unfortunately falls far short of what is needed to restore these rivers.

13.4.3.8 Illinois Stewardship Alliance and Sierra Club, Midwest Region (combined letter dated July 30, 2004)

The Illinois Stewardship Alliance (ILSA) and the Sierra Club, Midwest Region state that the draft report reflects a continuation of the failures pointed out previously when the Interim Report was issued, and that the Corps and Congress continue to ignore ecosystem restoration. They state that the Corps' $2.3 billion lock expansion proposal grossly overestimates likely future river traffic, underestimates the growing domestic demand for grain, and ignores the benefits of less expensive congestion management measures such as traffic scheduling. They suggest that river traffic has been flat for more than two decades, and has actually fallen in recent years. They state that many of the locks the Corps would replace have been rehabilitated in recent years, extending their life for decades. They believe the Corps should only offer recommendations to implement small-scale congestion management measures like scheduling while the agency completes a credible assessment of longer locks. They also state that the Corps should move immediately to implement ecosystem restoration and protection measures as part of reissuing and implementing an updated EIS for operations and maintenance of the navigation system. They believe the Corps should also seek authorization for equal project purpose for ecosystem management and restoration and immediately implement an ongoing program with funding equivalent to that currently expended on navigation operations and maintenance.

They state that the primary causes of UMRS ecosystem decline are due to the following: (1) the imposition of the inland waterway system upon these rivers, and (2) the failure of the Corps to modify its operations and maintenance activities. They also believe that Federal law and Corps regulations lay out the responsibilities for 100 percent Federal response to the decline of the natural resources of the UMRS. The ILSA and Sierra Club, Midwest Chapter recommend modifying and expanding the EMP authority to an ongoing integrated river management program, modifying the cost-sharing requirement to reflect the primary Federal responsibility in this multi-jurisdictional project – thus extending the 100 percent Federal responsibility to all lands and waters affected by project operations and to significant areas of the floodplain important to sustainable operations of the river ecosystem. They believe that adaptive management requires implementation of the Corps' Mitigation Trust Fund authority and that the primary funding vehicle for this trust fund should fall upon the Federal navigation project, which has caused the impacts. They support the extended interpretation of Federal responsibilities for management of the impacts of the navigation system as outlined in the Draft EIS and believe the Corps already has existing authorities for such management responsibilities.

The ILSA and Sierra Club, Midwest Region offer criticisms of the draft report, as follows: barge traffic predictions were inaccurate, the traffic scenarios were grossly optimistic, the analyses ignored the continuing growth of value-added processing, traffic levels predicted by earlier Corps forecasts have not materialized for this and other projects, the National Academy of Sciences explicitly rejected "scenarios" as a substitute for forecasts, models overstated the economic benefits of lock expansion, the Tow Cost Model ignored alternative modes and destinations and the unfinished ESSENCE model employed arbitrary data and assumptions, the Corps failed to adequately assess small-scale measures (lock scheduling, helper boats, congestion fees, excess lock time charges), and the Corps failed to link congestion fees to actual traffic levels.

13.4.3.9 Midwest Area River Coalition 2000 (letter dated July 30, 2004)

The Midwest Area River Coalition (MARC) 2000 has been involved in this evaluation since inception of the feasibility phase in 1993. MARC 2000 supported the recommendation to build twelve 1,200-foot capacity locks on the UMR-IWW System, starting with seven new 1,200-foot locks as prescribed by the Corps' plan. They also believe that a case was made for initial ecosystem restoration with $1.46 billion in funding with an opportunity to return for the balance following a reevaluation report. MARC 2000 reiterates its rejection of a scheduling scheme on the inland waterways. They also feel that the funding of both navigation improvements and ecosystem restoration must have the flexibility to proceed each at its own pace in order to maximize a return on Federal investments in two very different kinds of activities. They state that ecosystem restoration within prescribed adaptive criteria, which did not adversely affect the market needs for the availability of a consistent and predictable inland waterway transportation system, was the key to success for achieving national benefits from this Federal investment. They believe that implementation should begin immediately and comment that the preferred plan is good for the Nation because it would provide alternate modes of transportation, create jobs, and increase global competitiveness. They identify several areas of particular concern that include scheduling, economic model development, funding implementation, and public acceptability. Additionally, they do not support integration of operation and maintenance (dual-purpose authority) for navigation and ecosystem restoration.

MARC 2000 offers several technical suggestions to the draft report. With regard to scenario development, they state the failure to assign unique numerical probabilities to each scenario created a situation where each scenario is assigned the same probability of occurrence. They feel that it was unreasonable to believe that a scenario in which nearly every identified factor, policy, or event that affects U.S. grain exports was either always negative (Scenario 1) or always positive (Scenario 5) would have the same likelihood of occurrence as scenarios that allow for some negative and some positive grain export oriented policies. With regard to alternate modes of transportation and economic modeling, they state that the assumption that alternate mode costs would not increase through the entire forecast horizon appears to be untenable. They believe that future alternate mode costs could increase as traffic was diverted from the waterway, and if this were to occur, then the benefit estimates for navigation enhancements likely were understated in the draft report. With regard to Alternative 2, they feel that the discussion of congestion fees should have identified the theoretical basis regarding justification and derivation of the annual cost of Alternative 2 in the report. They believe that the approach used to evaluate and compare Alternative 2 was flawed since no changes in lock infrastructure and lock processing times were contemplated. They also feel that the methodology used to calculate NED benefits for this alternative should be better documented in Chapter 7 (Evaluation of Alternative Plans).

They offer several addition observations about economic modeling. These include contradictions in the descriptions of the Tow Cost Model (TCM) provided in the draft and the Economics Appendix. They also suggest the addition of a discussion on the qualitative difference between ESSENCE and TCM and the inclusion of an explicit statement that ESSENCE is not a spatial model. They request more information on how the ESSENCE elasticity ranges were established, and they suggest that these ranges should fall between -0.20 and -1.0. They believe the use of ESSENCE in the feasibility study was inappropriate and that the model's shortcomings should be fully disclosed and the direction and potential magnitude of its biases with respect to measuring benefits also should be disclosed.

13.4.3.10 Public Employees for Environmental Responsibility (letter dated July 31, 2004)
The Public Employees for Environmental Responsibility (PEER) state that the draft report violates the National Environmental Policy Act, the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G), and the Corps' own Engineering Regulations (ER 1105-2-100); mischaracterizes, ignores, and contradicts the explicit recommendations of the National Research Council of the National Academy of Sciences; and constitutes a significant step backwards in Corps planning to the detriment of the true system stakeholders, the taxpayers.

PEER offers specific criticisms on the draft report including the following: it was impossible to review the document because information within it was incomplete, inconsistent, computationally inaccurate, and unreviewed; better alternatives were excluded; environmental restoration plans should not be held hostage to implementation of any of the navigation efficiency alternatives; the preferred alternative plan is internally inconsistent; Alternative 2 should not have been arbitrarily excluded; the NED evaluation of Alternative 3 is internally inconsistent and incorrect; selection of the preferred alternative should have factored in unquantified risks; the Corps failed to follow recommendations from the National Academy of Sciences dealing with scenarios; traffic forecasts should have been developed using truly independent forecasters; forecast scenarios are arbitrary; the need for navigation improvements should be based on markets, not models; and the models (Tow Cost and ESSENCE) are flawed. PEER also believes that Alternative 2 would return money that would offset the cost of improvements; existing operations and maintenance costs should have been compared to Alternative 1 (no project); Table 12-1 contains computational and logical errors; the most likely future without project condition was not identified; the hybrid preferred alternative (Alternatives 4 and 6) was not specifically evaluated; Regional Economic Development (RED) accounts were incomplete; and the "optimal" timing of the implementation of the various combinations of navigation alternatives was not fully investigated. PEER also questions the report’s recommendations because of command interference.

13.4.3.11 Izaak Walton League (Public Hearing testimony June 7, 2004)
The Izaak Walton League’s involvement with Mississippi River conservation dates back to 1924. The League believes that the Corps, along with a host of scientists and researchers over many years, has made the case that the Upper Mississippi River is in need of restoration to slow and, it is hoped, stop the damage navigation is doing to its ecosystem. They also indicate that the Corps has not yet made the case for expanding the UMR-IWW Navigation System. The Izaak Walton League believes that the new 1,200-foot locks at Locks and Dams 20 through 25, LaGrange, and Peoria are unnecessary. They feel that proposing to replace these recently rehabilitated locks, including the $88 million project presently under way at Lock and Dam 24, does not appear to be a wise use of financial resources in light of the future demands in ecosystem restoration and existing Federal budget deficits and the fact that the Corps has failed to complete promised restoration elsewhere across the country. The League believes there is a better, scientifically supported plan for the UMR-IWW System. This plan would include $170 million annually for the Environmental Management Program; guaranteed, balanced funding by linking restoration funding to annual funding for the operation and maintenance of the 9-foot channel project; prioritized funding for those projects that restore natural river processes; restoring floodplain habitat; reducing navigation impacts; creating an independent science advisory committee; and regularly updating pool plans.

13.4.3.12 Upper Mississippi, Illinois & Missouri Rivers Association (Public Hearing testimony June 16, 2004)
The Upper Mississippi, Illinois & Missouri Rivers Association (UMIMRA) supports navigation efficiency Alternative 6. They believe that new locks on the Mississippi River are essential if our farmers and producers are to compete on the global marketplace and that the waterways are the most fiscally, economically, and environmentally sound method for delivering products to the Gulf of Mexico. They

urge the Corps to complete this study and Congress to authorize and appropriate funds for the immediate start on work for new locks. UMIMRA is extremely concerned about environmental measures that remove farmland from production.

The UMIMRA offers suggestions for improvements to the plan, which include the following: (1) coordination with the Comprehensive Plan addressing systemic flood control for the river valley; (2) clarification of existing baseline conditions and environmental targets; (3) use of an "environmental measures" rating matrix to evaluate environmental projects as they relate to other river valley needs and activities; and (4) use of Federal and State grants to provide incentives to Levee and Drainage Districts and private property owners to reduce proposed Federal land acquisitions.

13.4.3.13 American Soybean Association (Public Hearing testimony June 17, 2004)

The American Soybean Association (ASA) wholeheartedly supports the draft plan to improve navigation on the Mississippi and Illinois Rivers. The ASA is concerned about global competition with South America and the effect that increased transportation costs would have on world trade. They believe the key to why American exports continue to grow is the system of locks and dams on the UMR-IWW System and that this deteriorating system jeopardizes the foreign markets that the ASA developed. The ASA states that there are environmental benefits from transporting commodities by towboats through reduction in pollutants and more efficient use of fuel, and that an improved navigation system would protect jobs.

13.4.4 Views of the General Public

Comments that did not represent a specific non-governmental organization were classified as other views. These views are not necessarily those of the general public, since they do not constitute a valid random or representative sample of the general public. Thus, although this information can provide insight into the perspectives and values of the respondents, it does not necessarily reveal the desires of society as a whole. The content analysis process treats all comments equally, makes no attempt to treat comments as votes, and does not attempt to sway decision-makers toward the will of any majority. Comments were not weighted by organizational affiliation or other status of respondents, and it did not matter if an idea was expressed by thousands of people or by a single person. Emphasis is on the content of a comment rather than on who wrote it or the number of people who agree with it.

The following list represents the entire thematic range of comments received during the comment period. Themes were developed to encompass the depth and breadth of comments; therefore, themes can encompass few or thousands of comments. Details of the thematic statements, including the sub-themes and the responses to all themes, are found in the Response to Comments Appendix.

Theme Statements

- How is the broad range of opinions on the preferred plan going to be incorporated into the recommended plan?
- Why were the recommended cost-sharing proposals selected and how can the Corps ensure that the Federal government and the cost-sharing entities fulfill their responsibilities to ensure the final integrated plan is completely implemented?
- How has the Corps addressed the National Research Council recommendations into this study?
- Economics do not appear to justify the project. How can the Corps move forward with a recommendation that is based on scrutinized economic models and uncertain traffic forecasts?
- How will this project be integrated with other Federal programs such as EMP and the Comprehensive Study?

- Waterborne transportation has both direct and indirect effects on the cost of imports and exports for the Region. Transportation costs affect the ability of the U.S. to remain internationally competitive. The Midwest especially needs efficient transportation to compete against coastal ports for international markets.
- Concern whether the environmental analysis accurately captures the site specific, system and cumulative effects of the preferred plan, and concern with implementation of the proposed mitigation plan.
- What is the relationship between maintenance, major rehabilitation and the navigation study?
- The benefits and costs (e.g. safety, congestion, competitive pricing, fuel usage) for each transportation mode (i.e. truck, train, barge) are dependent upon many factors. How were these differences compared and used in development of the preferred plan?
- What is the baseline for ecosystem restoration, and what goals and processes have been established to restore the ecosystem and return it to a more natural state?
- The UMR-IWW is a complex ecosystem that is influenced by many stressors throughout the watershed. Will this project address all problems throughout the watershed as well as problems related to the navigation project?
- Concern that restoration will impact private landowners and navigation.
- How will navigation improvements and ecosystem restoration affect the economy beyond the obvious benefit to barge companies, especially regarding recreation and tourism?
- Comments on the effectiveness of the collaboration process and its application to future study management.
- This study does not adhere to the Corps' "Principles and Guidelines".
- What types of tools will be used to ensure future ecological integrity of the system?
- What are the impacts of the recommended plan on flooding throughout the system?
- With the increasing problem of invasive species, are fish passage structures at the dams a good idea?
- Specific comments regarding the detailed location, design, cost, and schedule of navigation improvements.
- The project is expensive and out of sync with our national priorities.
- The study has gone on long enough and it is time to take action.
- Support for recent Congressional legislative actions relative to the Draft Feasibility Report.
- General comments on public meeting structure, including suggested improvements for future meetings and appreciation of Corps' efforts.
- Comments with responses designated as "Noted".

Content analysis of this body of comments identified approximately 40,000 public concerns that are represented in nine thematic categories. Table 13-3 presents the number of comments recorded by thematic category for which responses were prepared. Over 700 comments fell into the category of "so noted" and did not require a response.

Table 13-3. The number of comments for each of the thematic categories.

Thematic Category	Number of Comments
Recommended Plan	12,514
Economics	12,111
Ecosystem Restoration	9,766
Engineering	3,438
Environmental	553
Study Management	401
Public Involvement	147
Other – Related to Study	144
Other – Not Related to Study	35

For this study, our 1,248 respondents are interested in the recommended plan, economics, and ecosystem restoration. Over 86 percent of all comments received fall within these three top categories. This could be attributed to the nature of an EIS and that individuals are commenting on a proposed plan, and this particular plan has many economic and ecosystem features that are of high interest and concern. It was well documented that people are concerned about the health of the environment and about the overall health of the Nation's economy.

The comments addressing the preferred plan ranged from general support, to opposition for linking ecosystem funding to navigation improvements. Other high interest issues were as follows: small scale measures should be done first, support for environmental Alternative E, plus a sense of urgency expressed by the desire to stop studying and start moving toward implementation.

For remarks that touched on economic-related issues, comments ranged widely from barges are more efficient than trucks or rail and delays are costing $0.17 per bushel, to economics do not justify the project and barge traffic is decreasing, to Upper Mississippi River shippers have paid 40 percent to the IWW Trust Fund and projects will create many jobs.

The comments received pertaining to ecosystem restoration were also wide ranging. Statements ranged from support for restoration and keeping the river healthy, to concerns about landowners' rights and concerns that full funding for ecosystem restoration will not be realized, and to support drawdowns and the need for erosion control.

The remaining categories of comments account for less than 14 percent of the total comments received. These comments ranged from recreation and tourism are economically important to safety issues are very important. Concerning future efforts, comments recommended that collaborative efforts must continue, the plan should be integrated with other Federal and State programs to complement the efforts to improve the health of the Mississippi River, and achieving long-term sustainability of the UMR system will require adaptive management of the navigation and environmental restoration. As the study concludes its final public outreach effort, many respondents took the time to express their thanks and appreciation for the opportunities to express thoughts and participate in the study process, and for the time and dedication and willingness to open up the process to everybody.

One observation that can be made is that, without the bulk of comments expressed through organized campaigns (form letters via e-mail and postal service, and petitions), the remaining comments in the database tie closely in content with those expressed by the stakeholder groups.

Comments received from our stakeholder groups expressed overall support for the dual-purpose preferred plan, and appreciation of the collaborative framework and decision process. Endorsements received from the Governors of the 5-state study area supported the proposed plan, and requested that implementation be integrated, balanced, adaptive, collaborative, and fairly funded. The principal concerns of the USEPA centered on implementation and funding issues. The USFWS strongly supports creation of the dual-purpose authority and the adaptive management approach.

The global importance of this issue is reflected in the fact that email responses were received from each of the 50 States, in addition to Washington, D.C., and Canada.

14.0 RECOMMENDED PLAN

14.1 Dual Purpose Integrated Plan

The Upper Mississippi River (UMR) System is a multi-purpose river system that provides economic and environmental benefits to the Nation. The stakeholders of the UMR system have expressed their desire to seek a balance between the economic, ecological, and social conditions to ensure the waterway system continues to be a nationally treasured ecological resource as well as an efficient national transportation system. Currently, the Upper Mississippi River and Illinois Waterway (UMR-IWW) System projects have a single authorized purpose of inland navigation. Therefore, funds appropriated for operation and maintenance of the system are limited to supporting the navigation purpose. This operation and maintenance responsibility must comply with environmental laws and policies regulating all Federal activities and responsible environmental stewardship of the system's land and water resources. This enables the Corps of Engineers to minimize environmental impacts from operations and maintenance activities; however, ecosystem restoration is not an authorized purpose in the UMR-IWW projects. This has made management of the system to ensure environmental sustainability problematic. The addition of ecosystem restoration as a project purpose to the Upper Mississippi River and Illinois Waterway System, coupled with the formulation and authorization of projects and programs to implement the ecosystem restoration purpose, will allow for the modification of the system in the interest of ecosystem restoration and the operation and maintenance of the system for both inland navigation and ecosystem restoration.

It is proposed that an integrated dual purpose plan be approved as a framework for modifications and operational changes to the Upper Mississippi River and Illinois Waterway System to provide for navigation efficiency and environmental sustainability, and to add ecosystem restoration as an authorized project purpose. The integrated plan will provide better focus and flexibility to adaptively manage the operation and maintenance of the system for both navigation and the environment. This dual-purpose plan will provide a clear congressional intent on managing the river for dual purposes, in support of the 1986 Water Resources Development Act declaration. Examples of this integration include:

- Integration of channel maintenance activities with island building and backwater restoration will provide better synergy of management practices.
- Water level management activities that restore plant habitat and consolidate sediment, can be effectively implemented without little to no impacts to navigation.
- Placement of mooring facilities for waiting tows can also remove tow traffic from environmentally sensitive areas.
- Institutional arrangements will include representation from economic and environmental interest to insure sustainable operation and maintenance of the system.
- Potential for combined PED and construction activities related to new lock and fish passage at L&D 22.

The plan will include a long-term framework (Alternatives 4 and 6) for navigation efficiency improvements to include small-scale structural and nonstructural measures, new 1,200-foot locks and lock extensions, and appropriate measures to avoid, minimize, and mitigate for environmental impacts at a first cost of $2.4 billion plus annual switchboat operation costs of $18 million. It also includes a $5.3 billion long-term framework (Alternative D*) ecosystem restoration plan to be accomplished in cooperation with the U.S. Fish and Wildlife Service, the five States, and private non-profit groups to improve the natural resources of the river through projects for habitat creation, water level management, fish passage, and floodplain restoration.

The integrated plan will be implemented through an adaptive approach that will include checkpoints requiring future reporting to the Administration and Congress. The recommendation for implementation of this integrated plan is outlined below for navigation efficiency improvements and ecosystem restoration.

14.2 Recommended Navigation Efficiency Plan

As outlined in Chapter 4, the future uncertainty in demand for waterway transportation was represented by the development of five scenarios or future traffic forecasts. The variation in forecasts is primarily due to the uncertainty in export markets for corn and soybeans. Nonstructural and structural measures to improve navigation efficiency were formulated in Chapter 6 and combined into alternatives for detailed evaluation. The measures that were carried forward for further evaluation included switchboats, mooring facilities, lock extensions, and new locks. Master scheduling and tradable permits were determined not to be practical due to operational and market characteristics of the system, however an appointment scheduling system will be developed and tested. Chapter 7 provides a quantitative and qualitative analysis of the alternatives including National Economic Development (NED) benefits, environmental quality, regional economic benefits, other social effects, safety, reliability, efficiency, sustainability, acceptability, and adaptability. The NED benefits were calculated using the Tow Cost Model (TCM) and ESSENCE economic models with three assumptions for demand elasticity of grain. This allowed the recognition of uncertainty associated with the future demand for waterway transportation and the lack of definitive data on demand elasticity, particularly grain. Chapter 12 provides a comparison of the alternatives using the criteria described above. In a traditional Corps study, a single most probable future without condition is determined and the NED plan that maximizes net benefits is developed. The approach outlined in this study, with the five different traffic forecasts and three demand elasticity modeling assumptions, results in 15 economic conditions or without-project conditions that must be evaluated. Table 14-1 provides a summary of the alternative that produces the NED plan and maximizes net benefits to the Nation for each economic condition.

Table 14-1. Alternative that maximizes net benefits to the Nation for each of the 15 possible economic conditions.

Demand Elasticity Assumption	Scenario 1	Scenario 2	Scenario 3*	Scenario 4	Scenario 5
TCM	Alternative 1	Alternative 5	Alternative 6	Alternative 6	Alternative 6
ELB	Alternative 1	Alternative 4	Alternative 5B or 6	Alternative 6	Alternative 6
EUB	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1

* Scenario 3 ELB average annual net benefits are essentially equal for Alternative 5 ($41 million), Alternative 5B ($44 million), and Alternative 6 ($42 million).

Alternative Description*

Alternative 1: No Action.

Alternative 4: Moorings (12, 14, 18, 20, 22, 24, and La Grange); Switchboats at Locks 20 through 25. First Cost of Infrastructure Improvements: $84.0M; Annual Switchboat Operation Cost: $40.2M; Total Mitigation Cost: $93.4M; Total Average Annual Cost: $47.6M; Completion Date: 2009.

Alternative 5: Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 through 18, La Grange, and Peoria. First Cost of Infrastructure Improvements: $795M; Annual SWB Operation Cost: $33.8M; Total Mitigation Cost: $142.9M; Total Average Annual Cost: $112.7M; Completion Date: 2023.

Alternative 5B: Moorings (12, 14, 18, 24, and La Grange); Lock Extensions at Locks 20 through 25; Switchboats at Locks 14 through 18; and New Locks at La Grange and Peoria.

Alternative 6: Moorings (12, 14, 18, and 24); New Locks at 20 through 25, La Grange, and Peoria; Lock Extensions at 14 through 18; and Switchboats at Locks 11 through 13. First Cost of Infrastructure Improvements: $2.268B; Annual Switchboat Operation Cost: $7.8M; Total Mitigation Cost: $203.3M; Total Average Annual Cost: $191.2M; Completion Date: 2035.

* - Average annual costs reflect a base year of 2023 for discounting purposes.

The comparison of plans in Table 14-1 reveals that no single alternative is a clear best alternative across a broad range of economic conditions. It also concludes that the analysis is very sensitive to the traffic forecasts and to the assumptions of demand elasticity. Because of this uncertainty, any recommended plan must take into account the possibility of significant increases in system traffic as represented by scenario 5, as well as flat-lined traffic as represented by scenario 1. It must also take into account potential future advances in the modeling of economic conditions and specification of demand elasticity. The risks are high if no action is taken and high forecast scenarios occur. Risks are also high if a large investment is made and increases in traffic do not materialize. Any recommended plan will contain some risk in the face of an uncertain future. This risk can be managed only with an adaptive approach that includes checkpoints for reevaluation of any investment decision.

Sufficient analysis has been completed to support an initial investment decision that is implemented with an adaptive approach to minimize the risk of the investment. The recommended plan is to seek Congressional approval of a framework plan consisting of a blending of Alternatives 4 and 6 to include immediate implementation of some small-scale structural and nonstructural measures, a phased approach for implementation of Alternative 6, and continued study and monitoring of the system. The details of the recommended plan include the following:

1. **Authorization and immediate implementation of Alternative 4 small-scale structural and nonstructural measures to include:**
    - Mooring facilities at 12, 14, 18, 20, 22, 24, and La Grange
    - Switchboats at 20 through 25
    - Appropriate mitigation
    - Cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

2. **Approval of the Alternative 6 framework to include:**
    - New 1,200-foot locks at 20 through 25, La Grange, and Peoria
    - Lock extensions at 14 through 18
    - Switchboats at 11 through 13
    - Appropriate mitigation
    - Adaptive implementation to include decision points and congressional oversight
    - Cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

3. **Continued study and monitoring of the system to include:**
    - Development of an appointment scheduling system
    - Development of a new spatial model
    - Collection of demand elasticity data
    - Monitoring of traffic delays and patterns
    - Monitoring of domestic and global grain market conditions, land use, crop yield technology, and developments in China regarding import trends
    - Cost of the study and monitoring plan shall be paid 50 percent from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

14.2.1 Adaptive Implementation

The moorings are low-cost measures that will provide immediate benefits to the system. There is minimal risk in implementing the moorings since they are common to Alternatives 4, 5, 5B, and 6, and they also provide some site-specific environmental benefits. Installing switchboats immediately in a phased-in approach allows them to be tested at multiple sites to validate performance, cost, and operational acceptability, before they would be installed for broader use. The switchboats will also provide immediate benefits in reducing delays. The use of switchboats is very adaptable, and they can be implemented and removed in a short amount of time. If lock construction occurs in the future, the switchboats would be required to aid navigation around the construction activities. Several implementation options were considered for the timing of approval and sequencing of the initiation of construction of Alternative 6. A description of each option considered is outlined below. The options are also listed for comparison in a matrix (Table 14-2) and timeline (Figure 14-1).

Option 1. Authorization for construction of seven locks as the first increment of construction. Preconstruction, Engineering, and Design (PED) on the first increment of construction would begin immediately upon appropriation of funds. Upon completion of PED of the first increment, Congress would be notified of the latest information available as to traffic delays and updated forecasts, and the results of any improved models and analysis. Authorization and construction of the lock extensions at 14 through 18 would be conditioned on a future report (Option 1a). Option 1b would include a reevaluation report to the Administration and Congress that would be submitted upon the development of new and widely accepted models (5 to 7 years), and include a recommendation whether to continue, stop, or delay locks currently under construction.

Option 2. Authorization for construction of seven locks as the first increment of construction. Preconstruction, Engineering, and Design (PED) on the first increment of construction would begin immediately upon appropriation of funds. Approval for construction appropriation would be conditioned upon committee resolution based on a new report to be submitted either a) immediately after PED providing any information then available as to traffic delays, updated forecast, and modeling results, and include a recommendation whether to continue, stop, or delay lock construction decision; or b) at a future decision point when updated information on traffic delays, forecasts, and modeling results becomes available. Authorization and construction of the lock extensions at 14 through 18 would be conditioned on a future feasibility report.

Option 3. Authorization for construction of the complete package of Alternative 6. Preconstruction, Engineering, and Design (PED) for the first increment of construction would begin immediately. Approval for construction appropriation would be conditioned upon committee resolution based on a new report to be submitted either a) immediately after PED, providing any information then available as to traffic delays, updated forecasts, and modeling results, and include a recommendation whether to continue, stop, or delay lock construction decision; or b) at a future decision point when updated information on traffic delays, forecasts, and modeling results becomes available.

Option 4. Authorization of Preconstruction, Engineering, and Design (PED) for construction of seven locks. Authorization for construction would be based on a new report to be submitted either a) immediately after PED, providing any information then available as to traffic delays, updated forecast, and modeling results, and include a recommendation whether to continue, stop, or delay lock construction decision or b) at a future decision point when updated information on traffic delays, forecasts, and modeling results becomes available. Authorization and construction of the lock extensions at 14 through 18 would be conditioned on a future feasibility report.

Table 14-2. Matrix depicting each of the Implementation Options for Navigation Efficiency Alternative 6.

Option	Locks Auth.	Type Report	Timing of Report	Report Prepared for	Action Required Before Approp.	Additional Locks Contingent Upon
1a	7	Notification	Completion of PED	Authorization Committee	None	Future Report & Authorization
1b	7	Notification	Completion of PED	Authorization Committee	None	Future Report & Authorization
		Re-evaluation Report	5-7 Years	Authorization Committee	Committee Resolution	Future Report & Authorization
2a	7	New Report	Completion of PED	Authorization Committee	Committee Resolution	Future Report & Authorization
2b	7	New Report	When New* Data Available	Authorization Committee	Committee Resolution	Future Report & Authorization
3a	12	New Report	Completion of PED	Authorization Committee	Committee Resolution	N/A
3b	12	New Report	When New* Data Available	Authorization Committee	Committee Resolution	N/A
4a	PED for 7	New Report	Completion of PED	Full Congress	Construction Authorization	Future Report & Authorization
4b	PED for 7	New Report	When New* Data Available	Full Congress	Construction Authorization	Future Report & Authorization

* New Report would be made when new/improved models are available, when trends can be determined, when trade conditions warrant, or in 10 years, which ever comes first.

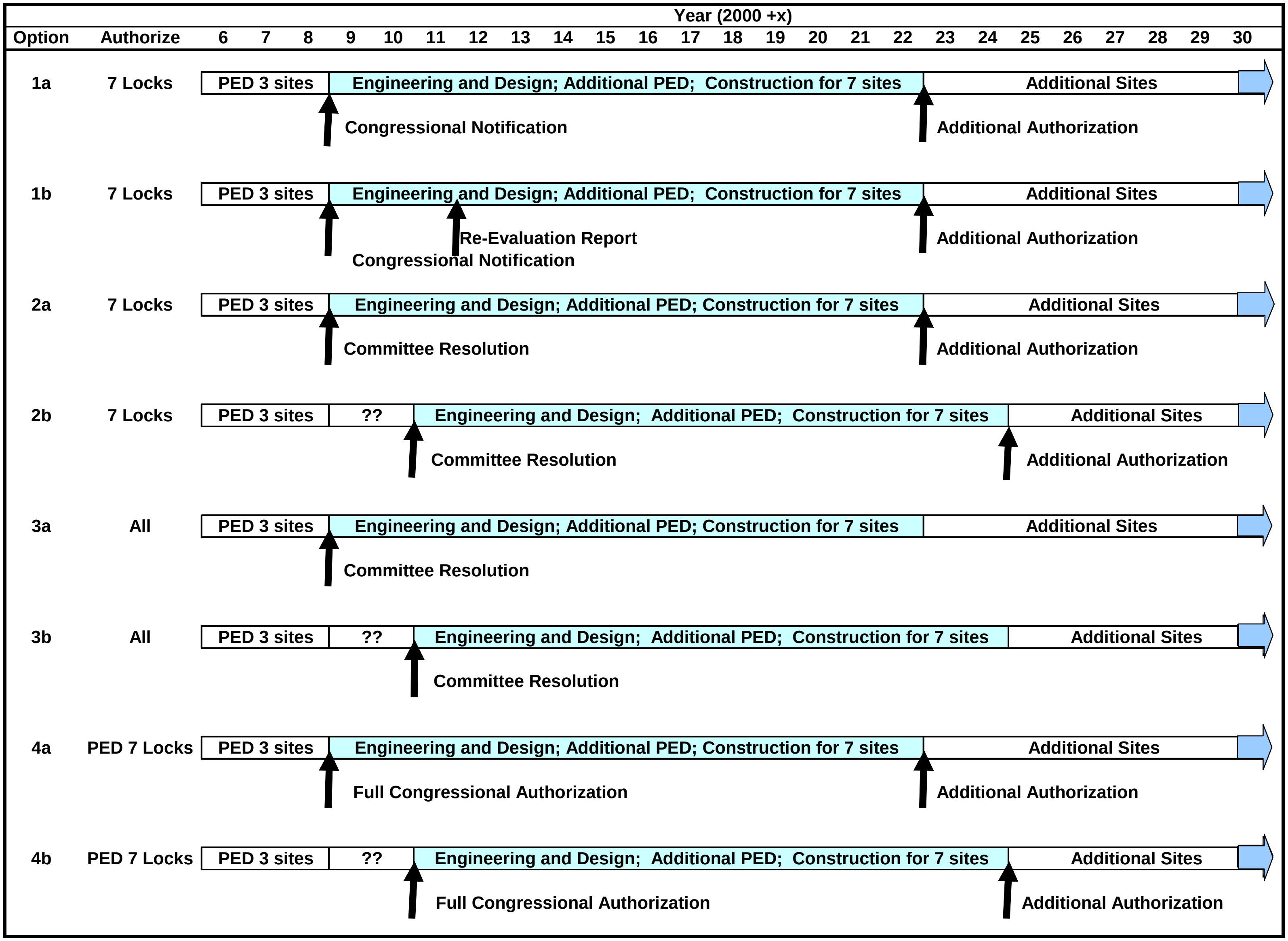

Figure 14-1. Timeline depicting each of the Implementation Options for Navigation Efficiency Alternative 6. (Black arrows represent decision points.)

14.2.2 Implementation Considerations

The implementation options are basically the same through the PED phase, including initiation of the plan for continued monitoring and study of the system. The main difference is the amount of oversight and approvals required to commence construction of new locks. Option 4 requires the most oversight since it mandates full Congressional authorization prior to initiating construction of new locks. Option 1 is the least restrictive since it only requires notification to the Congress, prior to the initiation of construction of new locks. The selection of an implementation option for the Alternative 6 framework in an adaptive phased-in approach must take into account the quantified and nonquantifiable considerations listed below.

14.2.2.1 Demand for Waterway Transportation

As indicated in the evaluation and comparison of plans, there is considerable uncertainty in the future demand for waterway transportation and the need for navigation improvements. The scenarios provide a plausible range of potential forecasts; however, there is still a great amount of uncertainty in what the demand will be 20, 30, or 40 years from now. The scenarios are based on various assumptions necessarily made to simplify a complex system of international trade policy and practices, national policy, crop yields and acreage, and consumption. In order to simplify the analysis, complex and unpredictable factors such as the impact of changes in direction of national policy, global weather patterns, fluctuations in the cost of oil, global war on terror, potential use of contained shipments, and increasing demand vs. limited supply of ocean transport were not evaluated. These factors, under certain conditions, could contribute to changes in waterway demand.

Historically, demand has been driven by events and trends that were largely unanticipated. The Soviet Union grain embargo, the collapse of the Soviet Union, the change in China economic and agricultural policies, and the rapid emergence of Brazil as a major soybean exporter are all events that have had a large negative impact on U.S. grain markets over the last two decades, and all were not fully anticipated. Likewise, the change in the U.S. farm program in eliminating mandatory supply controls (set-asides) and the sudden emergence of China as a major economic power may have a positive impact on U.S. grain exports in the future. It is almost a certainty that looking at past trends will not give us an accurate picture of the future and that events that we do not currently anticipate will drive future conditions.

14.2.2.2 Economic Modeling

The TCM and ESSENCE economic models were used to develop an array of NED benefits across the broad range of economic conditions. They provided valuable information on the range of plausible economic evaluation outcomes, even in recognition of their capabilities and weaknesses. The model development research currently under way may produce more sophisticated models and the ability to look at the problem from different angles, and might contribute to an increase in confidence levels; however, there is limited likelihood of producing new modeling capability in 3 to 5 years that would provide any better insights or bounding of the problem. In addition, the likelihood of new and more widely acceptable models producing more accurate results is unknown.

14.2.2.3 Risk of Implementation

The risks of implementation will be dependent upon what action is taken and what traffic scenario actually occurs. The risk of overbuilding can be measured by the expenditures that do not produce positive net benefits. The risk of underbuilding can be measured by the foregone benefits if no action is taken and the demand increases. The ultimate risks taken are dependent upon decisions that will be made in the future. While these risks are real, the adaptive management process incorporated into the recommended plan can minimize them. The ultimate amount of risk undertaken will be dependent upon the timing of a decision that will change the course of action.

14.2.2.4 Other Social Effects

The results presented in the other social effects evaluation confirmed positive benefits associated with removing traffic from landside modes. Any plan that delays implementation will delay these positive social benefits.

14.2.2.5 Condition of Locks

The locks have exceeded their 50-year design life, and the maintenance requirements are increasing significantly. Additionally, the frequency of unscheduled closures has also been increasing. The construction of new locks and lock extensions will reduce unscheduled closures by providing new locks or rehabilitated lock extensions in advance of scheduled lock rehabilitations under the without-project condition.

14.2.2.6 Safety

Providing an additional lock at an existing site will improve the safety conditions at the lock. The existing 600-foot lock can be used for recreation craft and other small vessels. This separates the small craft from the large commercial tows. Also, their interferences on approaching the lock would be reduced, thereby reducing the chance of conflict between vessels. New locks at Locks 20 through 25 would also include a riverside approach wall on the upstream end. Riverside approach walls are safer because they provide a physical barrier between the tow and the dam that would reduce the chance and consequences of tow mishaps that result in barges breaking loose from the tows and sometimes subsequently running into the dam. The approach wall also would allow downbound tows to better align themselves for lock entry, thus reducing impact damage to miter gates and lockwalls resulting from the present lock entry conditions. These positive safety benefits cannot be realized without implementation.

14.2.2.7 Reliability

The reliability of the system will be improved by reducing cycles of use, and providing a redundant system in the case of a problem. These positive reliability benefits will not be realized without implementation of the plan.

14.2.2.8 National Security

Inland waterways contribute to national security in two ways: the strength of the economy and the robustness of the transportation network. This robustness is vital for military uses, other security uses, and the movement of basic, essential commodities such as food and coal both for the Nation and provision of international aid. The ecosystem goods and services provided by a healthy and sustainable river also contribute significantly to the security and health of the Nation. These positive national security benefits will not be realized without implementation of the plan.

14.2.2.9 New Lock Construction Schedule Implications

Figure 14-2 displays the estimated timeline for completion of a new 1,200-foot lock at a typical site. The first step in this process is completion of a site-specific document (PED) containing sufficient engineering and design to initiate plans and specifications for a 2-stage construction process. The first stage would involve construction of a guidewall, and the second stage would be the new lock. The total estimated timeline for a typical lock is 13 years from start of PED. Three sites could be initiated, with the second grouping of four locks following up 3 years later depending on availability of resources and funding. This results in a 16-year minimum schedule to complete construction of all seven new locks given sufficient resources. This long period for construction has two implications. The first implication is that a major structural response to increasing traffic and attendant delays will take a considerable time to implement. The lower Upper Mississippi River locks have current utilizations of 70 to 80 percent. Under these conditions, traffic growth will result in increases in waiting times at locks, creating lock delays that will increase exponentially each year that new locks are not in place. Under traffic growth conditions, each year of delay in implementation of new locks will result in substantial economic costs to the Nation in increased transportation cost and decreased international competitiveness. The second implication of the long implementation period for the seven new locks is that there is time to adapt to emerging conditions. Under optimal conditions, construction of the first locks will not be initiated until about four years from authorization. If there is no indication of traffic growth during this 4-year period or if the switchboats and mooring cells prove to be very effective in decreasing delays, initiation of construction could be postponed or put off indefinitely. The pre-construction engineering and design funds at risk during this period are about $30 million assuming three sites are started. Even after construction is initiated, there is time for adaptation. The new locks will be constructed in groups of two or three, allowing for suspending construction short of construction of all seven locks if traffic and trade conditions dictate. The long implementation period increases the risk of delay in authorization but decreases the risk of a wrong decision by providing time for adaptive implementation.

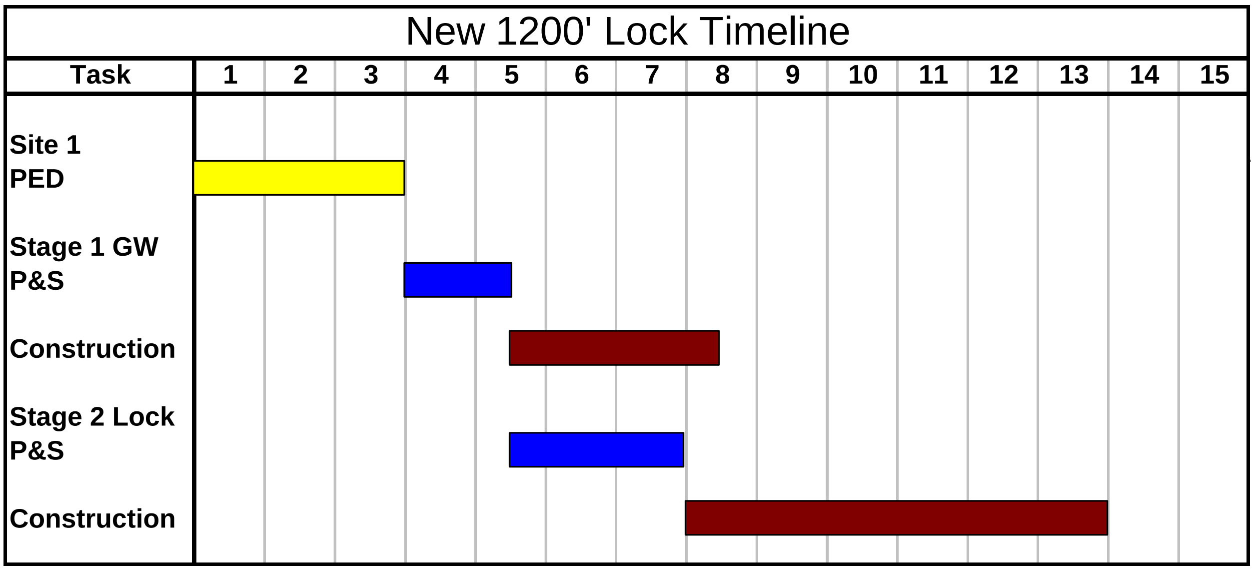

Figure 14-2. Typical 1,200-foot Lock Construction Timeline

14.2.3 Recommended Implementation Option

It is recommended that the framework of Alternative 4 and 6 be implemented in accordance with Option 1b and include Congressional and Administration oversight at three decision points as follows:

- A notification report at the end of design and before construction contract award that presents (1) all new information resulting from monitoring river traffic and markets, and (2) the results of any improved models and analysis.
- An evaluation report will be submitted in approximately 5-7 years to the Administration and Congress upon the reevaluation of regional, national and world market conditions and development and application of new peer-reviewed models, concluding with a recommendation on whether or not to stop or delay lock construction. These new models will be subjected to review by scientific peers and the model's acceptability will be based on validated theory, computational correctness, and model appropriateness for the study tasks.
- An updated feasibility report requiring additional authorization before proceeding with the five lock extensions at Locks 14-18.

This option will meet a range of strategic needs, and emphasize adaptive implementation to adjust as events occur and trends emerge. This option recognizes the uncertainty in future demand for waterway transportation, the uncertainty in demand elasticity, and the ongoing research effort in developing updated economic models, by providing for two checkpoints within the first 7 years of the plan that involves Administration and Congressional oversight. These two checkpoints would provide the opportunity to continue, stop, or delay locks currently under design and/or construction. Figure 14-3 displays the recommended implementation timeline with checkpoints. The plan provides an insurance policy against the potential increases in demand, while at the same time minimizing the risks of overbuilding. Option 1b supports a national transportation strategy of maximizing each mode's contribution to social welfare and national security and ensures competition for the shipment of bulk commodities. This option also provides an opportunity to modernize the locks with the highest level of use and increase their reliability and safety of use.

Recommended Implementation. The following activities, as outlined in Figure 14-3, will be initiated as part of the recommended plan.

Mooring Facilities. Mooring facilities will be placed at lock and dams 12, 14, 18, 20, 22, 24, and LaGrange. Year 1 of this plan will involve coordination with industry and agency representatives to select final location, and completion of final design. Year 2 would involve initiation of construction and take approximately 2-1/2 years to complete placement at all sites.

Switchboats. Switchboats (SWB) would be implemented at Locks 20 – 25 in two phases and would remain on station through lock construction to offset lock performance due to construction of lock features. The first phase would include 2 contracted SWBs for use at any of the lower 5 locks for efficiency testing and overall observation. If the boats prove efficient, three more contracted SWBs would be obtained placing one boat at each lock. The results of this testing will be included in the notification and evaluation report.

New Locks 20-25, Peoria and LaGrange. The new locks would be initiated in accordance with the general timeline contained in Section 14.2.2.9 (Figure 14-2) and require at least 2 construction contracts. Site specific planning, engineering and design (PED) would take approximately 3 years to complete. Initiation of plans and specifications for construction would begin after PED and be subject to no stoppage of work as a result of submission of the notification report. Initiation of construction for the first contract would begin in year 5 along with development of plans and specifications for the second contract. This contract would involve construction of guidewalls and hardpoints to aid navigation during the main lock contract. Construction of the second contract would begin in approximately year 8, and include the major lock expansion components. Initiation of construction on the second contract would be dependent upon the recommendation contained in the evaluation report.

Mitigation. Mitigation for construction site impacts will be conducted coincident with the construction. Impacts resulting from traffic increases associated with any new construction are expected to occur and grow throughout the planning horizon. Mitigation measures for navigation traffic effects will begin immediately and be implemented adaptively throughout the project life.

Notification Report. This effort would be initiated with first appropriation of funds and include a report out on the development and testing of an appointment scheduling system; update on the development of a new spatial model and collection of demand elasticity data; results of monitoring traffic delays and traffic patterns; results of monitoring of domestic and global grain market conditions, land use, crop yield technology and international conditions; and results of monitoring the effectiveness of the mooring cells and switchboats at the designated sites. This report would be completed in approximately 3 years and provided to the Administration and Congress. Implementation of the plan would continue unless action is taken by Congress. See Figure 14-3 for relation of notification report to other activities.

Evaluation Report. This report will be an extension of the notification report and include updates on all activities outlined above in addition to a complete economic analysis utilizing updated models (if available) and input data. The evaluation report will be accomplished in full coordination with the stakeholders of the system. The criteria for this updated analysis will be the same primary criteria used in the Feasibility Report and include national economic development benefits (NED's), environmental quality effects, other social effects, risk, robustness and macro level considerations including demand for waterway transportation, condition of locks, safety, and reliability. It is anticipated that the evaluation report may narrow the range of economic conditions developed in the original report, however, there will likely remain a large amount of uncertainty in forecasting the demand for waterway transportation. The scenario based approach will be updated and refined in the evaluation report, however, there will still be uncertainty involved in the decision process. The determination of NED's will incorporate the effectiveness of the nonstructural measures, small-scale measures, and an appointment scheduling system. The results of the economic evaluations will also be compared to the original environmental impact evaluation to insure that the adaptive mitigation plan developed as part of this feasibility report is sufficient. See Figure 14-3 for relation of evaluation report to other activities. This report would be completed in 5-7 years and provided to the administration and congress for action.

Lock Extensions (14-18) and Switch Boats (11-13). The need for these activities will be determined and presented in the updated Feasibility Report.

Updated Feasibility Report. This report will be similar in scope to this Feasibility Report. This report would not be initiated until a future date and completed in approximately 16 years.

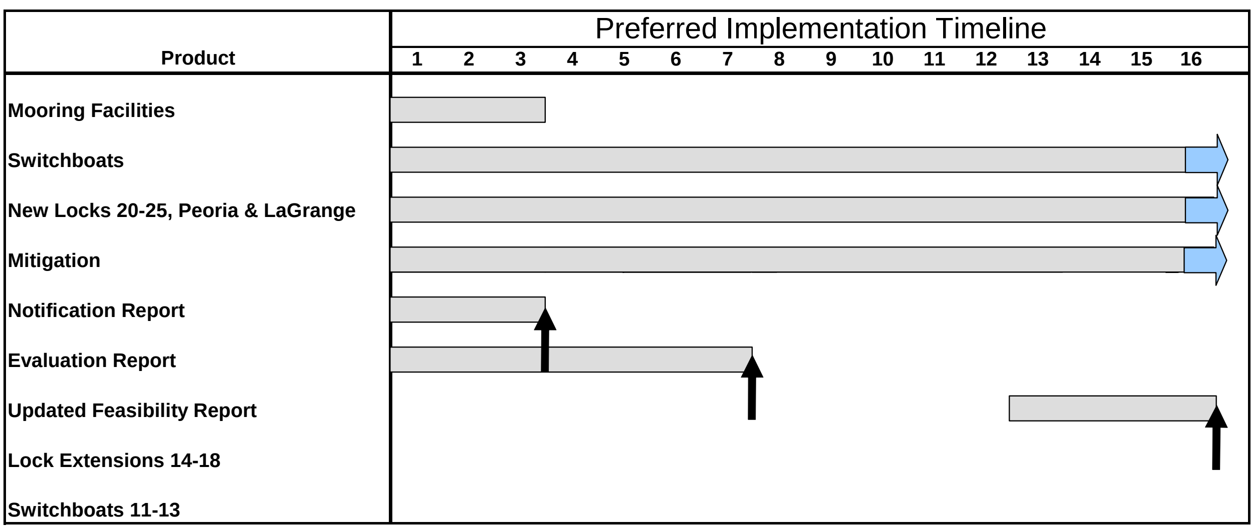

Figure 14-3. Recommended Implementation Timeline. Black arrows represent checkpoints.

14.2.4 NED Impacts of the Recommended Navigation Efficiency Alternative

The recommended alternative for navigation efficiency is a combination of Alternative 4 and Alternative 6, with altered timing of some individual measures and with several checkpoints built into the implementation schedule. Generally, the recommended alternative includes a subset of the switchboats associated with Alternative 4, along with the new 1200' locks and the1200' lock extensions associated with Alternative 6. The recommended alternative also includes the mooring facilities of Alternative 6. The most significant change in implementation timing when comparing the recommended alternative to Alternative 6 is the early implementation of new locks at Peoria and LaGrange.

In order to describe the NED consequences of the recommended alternative in a comprehensive manner over a typical planning horizon, it is necessary to assume a complete implementation schedule. Therefore, for purposes of describing the annual benefits and costs of the recommended alternative, no deviations from the initial course of action are assumed at the checkpoint reviews or at any other time during project implementation.

The NED assessment of the recommended alternative required simplifying assumptions, since the economic model results exactly describing all desired combinations and timing of measures have not been completed. Consequently, the results described in the following paragraphs are approximate, but reasonable estimates of the NED impacts. In defining the combinations and timing of measures, some concessions to the availability of previously evaluated model conditions have been made. An example of such a concession is treatment of new locks at Peoria and LaGrange. The evaluation presented below assumes a 2005 start for both Illinois Waterway sites. As indicated above, this assumption was driven by the availability of previously evaluated model conditions. Despite such differences, the impact to annual net benefits considered across the range of economic conditions is not expected to be significant.

14.2.4.1 Costs

Table 14-3 describes the assumed implementation schedule for the individual measures of the recommended alternative for purposes of this analysis.

Table 14-3. Implementation schedule for recommended navigation efficiency improvements.

Recommended Alternative - Navigation Efficiency
Navigation Improvements - Implementation Schedule

Measure	Start – Conclude
Moorings	
at Locks 12, 14, 18, 24	2005 – 2007
Switchboats	
at Locks 22, 25	2007 – 2016
at Locks 21, 24	2009 – 2020
at Lock 20	2009 – 2022
at Locks 11-13	2029 –
New 1200' Locks	
at Locks 22, 25	2005 – 2016
at Locks 21, 24	2010 – 2020
at Lock 20	2012 – 2022
at Peoria, LaGrange	2005 – 2017
1200' Lock Extensions	
at Locks 17, 18	2015 – 2024
at Lock 16	2017 – 2026
at Locks 14, 15	2019 – 2028

The timeframes and costs by year for moorings, Mississippi River new locks and lock extensions, and switchboats at Locks 11-13 are identical to those of Alternative 6. The assumed implementation timeframe and cost by year for new locks at Peoria and LaGrange are identical to that of Alternative 6B described in Section 12.1.4.3. Switchboat implementation at Locks 20-25 assumes one boat per site starting with the year indicated in the table and remaining in place until the completion of lock construction. Implementation costs for the recommended alternative also assume system mitigation costs identical to those of Alternative 6. (Note: The combined Alternative 4 and 6 mitigation is now estimated to cost $205 million (see chapter 10). This is a 2% increase over the Alternative 6 mitigation used for the following analysis. See Sensitivity discussion below at 14.2.4.4.)

Total first costs of the recommended alternative, including system mitigation costs, are $2.267 billion (2001 prices). The average annual costs (in 2001 prices and reflecting an interest rate of 5.625 percent and a base year of 2023 for discounting purposes) of the recommended alternative, $217.4 million, are higher than those of Alternative 6 due to the addition of early year switchboat costs and the earlier implementation of new locks at Peoria and LaGrange.

14.2.4.2 Benefits

As with all other alternatives, there are two categories of NED benefits associated with the recommended alternative, transportation savings and avoided major rehabilitation expenditures.

14.2.4.2.1 Transportation Savings

Economic model results from several other alternatives, with some modification, were used to construct the estimates of transportation savings by year for each of the 15 economic conditions. Specifically, Alternative 4, Alternative 6, and Alternative 6B results were used in this process.

The first step in the recommended alternative benefit construction process was to add the savings of Alternative 6B (new 1200’ locks at Peoria and LaGrange, start date of 2005) prior to 2035 to the savings of Alternative 6. Alternative 6 assumes new locks at Peoria and LaGrange will be online in 2035. Including Alternative 6B savings prior to 2035 allows for the capture of the earlier implementation of new locks at Peoria and LaGrange associated with the recommended alternative. A note regarding the system modeling is warranted at this point. In many instances, adding the benefits of different alternatives to reflect the combined effect of the individual measures included in those alternatives can be a problematic proposition. This is so because important system interaction may be ignored in the process. However, in the case of adding Mississippi River improvements (Alternative 6) to Illinois Waterway improvements (Alternative 6B prior to 2035), system interaction is limited to Locks 26 and Locks 27. Given the relatively large capacity of these two Mississippi River sites compared to the traffic passing through these sites, the system interaction consequences of adding the savings of the two alternatives is extremely small.

The next step in constructing the recommended alternative savings was to account for the savings associated with early year (2007-2019) switchboat implementation. This was accomplished by modifying the savings associated with Alternative 4. Alternative 4 assumes 10 switchboats (two each at Locks 20-25) in place by 2009. To approximate the savings associated with the recommended alternative, the savings of Alternative 4 were multiplied by the proportion of recommended alternative switchboats in place for a given year to the 10 switchboats in place with Alternative 4. (One additional adjustment was made to Alternative 4 savings. Before taking the appropriate proportion of Alternative 4 savings, Alternative 4 savings were reduced by an estimate of the contribution of Alternative 4 moorings. This was necessary because the savings estimates in these years includes the effects of both moorings and switchboats. Alternative 4 moorings savings were estimated by observing Alternative 6 savings during the 2007 to 2010 when only moorings are in place. By doing so, the effect of moorings could be isolated.)

Table 14-4 displays the transportation savings associated with the recommended alternative for the 15 economic conditions.

Table 14-4. Recommended alternative transportation savings.

Recommended Alternative - Navigation Efficiency
Annual Transportation Savings
(in thousands of 2001 dollars, 5.625 percent)

Model/Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TCM	59,100	244,400	345,500	369,500	410,000
ESSENCE lower	54,900	161,700	240,200	246,700	279,000
ESSENCE upper	46,900	105,500	147,700	149,000	170,100

Assumes base year of 2023 for discounting purposes.

14.2.4.2.2 Avoided Major Rehabilitation Expenditures

Rehabilitation expenditure savings represent costs that would be avoided with project implementation. Lock extensions or new lock construction would obviate the need for certain items of work that would otherwise be required. The magnitude of this benefit category is a function of not only the magnitude of the expenditures required, but also the timing of the outlays. Specifically, the measure of this benefit is the present value difference between the projected without-project rehabilitation expenditures and the projected with-project rehabilitation expenditures.

Rehabilitation expenditure savings associated with the recommended alternative are greater in magnitude than those of Alternative 6. While the magnitude and timing of rehabilitation expenditures at Mississippi River locations is the same between the recommended alternative and Alternative 6, the recommended alternative advances implementation of new locks at Peoria and LaGrange. As a consequence, a without project major rehabilitation event scheduled in 2015 for both Peoria and LaGrange would be avoided. In 2001 prices and reflecting an interest rate of 5.625 percent and a base year of 2023 for discounting purposes, the average annual avoided major rehabilitation expenditure is $51.5 million for the recommended alternative. This expenditure savings does not vary with economic condition.

14.2.4.3 Net Benefits

Annual net benefits, the difference between average annual benefits and average annual costs, associated with the recommended alternative for the 15 economic conditions are displayed in Table 14-5. Net benefits are positive for 7 of the 15 economic conditions, the same as with Alternative 6.

Table 14-5. Annual net benefits of the recommended Navigation Efficiency Alternative.

Recommended Alternative - Navigation Efficiency
Annual Net Benefits
(in thousands of 2001 dollars, 5.625 percent)

Model/Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TCM	-131,600	53,700	154,800	178,800	219,300
ESSENCE lower	-135,900	-29,000	49,500	56,000	88,300
ESSENCE upper	-143,800	-85,200	-43,000	-41,700	-20,600

Assumes base year of 2023 for discounting purposes.

14.2.4.4 Sensitivity

As mentioned earlier, the assumed implementation dates and combinations of individual measures was driven in part by the availability of completed economic model results. The assumed 2005 start date for Peoria and LaGrange is such an example. Consequently, there is interest in evaluating the sensitivity of the starting date assumption with respect to project net benefits. An alternate start date of 2008 was evaluated for this sensitivity analysis.

The necessary adjustments to project costs to reflect a 2008 start date are straightforward and require only a shift of the expenditure stream. However, adjustments to the benefits require approximation of transportation savings during the project implementation period. (These values have been approximated because no model results have been produced with a 2008 start date for these new locks.) Because these transportation impacts are generally small, the fact that the values are estimated without the benefit of economic model results is not a significant consideration. Delaying the start of new lock work at Peoria and LaGrange until 2008 with construction finishing in 2020 would have minimal impact on the annual net benefits of the recommended alternative. Net benefits are generally reduced by less than five percent.

Changes in timing of the Navigation improvements on the Illinois River and the inclusion of Alternative 4 switchboats early in the implementation of alternative 6 results in a minor advance in time of incremental traffic on the system. Mitigation for this minor advancement of traffic results in a $2 million increase in mitigation out of a total project cost of $2.269 billion. This minor increase in total cost will not meaningfully affect the cost benefits presented above for the recommended plan.

14.3 Recommended Ecosystem Restoration Plan

Chapter 4 defines the without project condition for the ecosystem, as continued degradation do to the ongoing effects of the 9 foot channel project and other stressors imposed by human activities. Chapter 6 identifies measures for maintaining and restoring the ecosystem in concert with operating and maintaining the Navigation system. These measures include island building, fish passage, floodplain restoration, water level management, backwater and side channel restoration, wing dike alteration, and island-shoreline protection. These measures were combined into alternatives that provide varying degrees of restoration to the system. Chapter 7 provides a quantitative and qualitative analysis of the alternatives including National Ecosystem Restoration benefits, environmental quality, regional economic benefits, other social effects, addresses cumulative impacts including ongoing effects of the operation and maintenance of the system, acceptability, and adaptability. Chapter 11 provides a comparison of alternatives A through E using the criteria described above. The Alternative B framework could seek to maintain current conditions and Alternative C would begin to restore aspects of the ecosystem, however they do not contain all the tools and measures necessary to address restoration of key ecological processes and ecological diversity. Alternative E contains the same tools and measures as Alternative D with increased attention to Fish passage modifications at all 33 Dams (versus 14 in Alternative D), water level management modifications in 26 pools (versus 12 in Alternative D) and floodplain restoration for 250,000 acres (versus 105,000 acres in Alternative D). The water level management and fish passage locations added to Alternative E are costly with less likelihood of success and less contribution to benefits than those contained in Alternative D. Most floodplain restoration will require non-federal cost-share partners. Based on cost effectiveness, likelihood of successful implementation, and reasonable estimate of potential cost shared floodplain restoration opportunities; Alternative D with slight changes recommended by stakeholders (D*) is identified as the recommended ecosystem restoration alternative.

As part of the formulation and evaluation process, considerations for refining and modifying Alternative D were discussed by the Navigation Study Team and stakeholders. This led to the augmented version of the alternative referred to as Alternative D*. Based on stakeholder input and discussion, the existing Alternative D measures would be further refined to include embankment lowering at lock and dam sites to promote floodplain connectivity. Also, Alternative D* would include the addition of measures that reduce water level fluctuation on the Illinois River in an effort to improve aquatic habitat.

Embankment lowering was identified as a cost efficient means to promote system connectivity and naturalization of UMRS hydrologic processes. This restoration measure involves lowering portions of the earth embankments between navigation pools to low control pool levels and construction of an overflow spillway. Based on stakeholder input, embankment lowering at lock and dam sites will be included as a measure in Alternative D* to improve floodplain connectivity, shoreline stability, and fish passage. This measure will be incorporated into the existing measures of fish passage, floodplain restoration, and shoreline protection at no additional cost. It is anticipated that initial implementation will take place in conjunction with construction of fish passage structures.

Ecological advantages of embankment lowering include the following:

- Restoration of floodplain water and sediment flow
- Improved habitat diversity
- Increased fish passage during high water events
- Increased sediment scour in downstream waterways
- Restoration of the river to a more natural pattern of sediment movement and deposition
- Reduced risk of earth embankment and shoreline erosion during overtopping

Measures to reduce water level fluctuation on the Illinois River were also recommended by stakeholders due to their significant and spatially extensive benefits. These measures would attempt to produce a more natural hydrograph in parts of the system that see sudden changes in water level. They would potentially include more frequent adjustment and remote operation of dam gates, centralization of water control on the Illinois Waterway, and structural modifications to the wicket dams at Peoria and La Grange. Based on stakeholder input and conclusions from the Water Level Management Work Group, measures to reduce water level fluctuation on the Illinois River will be added to Alternative D* at an estimated cost of $140 million over 50 years.

Ecological advantages of reducing water level fluctuation include the following:

- Naturalization of the hydrologic cycle
- Expanded emergent aquatic plant distribution
- Improved habitat diversity
- Increased in-shore macroinvertebrate communities benefiting shorebirds and some fish
- Reduced impacts on nesting fish, increasing spawning success

Sufficient analysis has been completed to support the restoration alternative D* fifty year framework which will restore to a level that includes management practices and cost effective actions affecting a broad array of habitat types. Implementation of the recommended plan will meet the UMRS ecosystem goals of:

1. Maintaining viable populations of native species in situ.
2. Representing all native ecosystem types across their natural range of variation.
3. Restoring and maintaining evolutionary and ecological processes.
4. Integrating human use and occupancy within these constraints.

The Framework will consist of the adaptive implementation of an estimated 1,010 projects with a combined first cost of about $5.3 billion.

14.3.1 Adaptive Implementation

Several implementation options were considered for the timing of approval and sequencing of the measures outlined in alternative D*. A description of each implementation option is outlined below. The options are also listed for comparison in a matrix (Table 14-6) and timeline (Figure 14-4).

Option 1. Authorization for the initial 15 years of the Alternative D* framework. Preconstruction, Engineering and Design (PED) on the first increment of construction would begin immediately upon appropriation of funds. At the end of 15 years, a new report would be provided to the full Congress for potential authorization of additional increments of the plan. Future additional authorizations beyond this point would be contingent upon a new report to the full Congress.

Option 2. Authorization for the entire Alternative D* framework. Preconstruction, Engineering and Design (PED) and construction for the first 15 years of the Alternative D* framework would begin immediately upon appropriation of funds. Approval for additional construction would be conditioned upon committee resolution based on a new report to be submitted at the end of 15 years

Option 3. Authorization for the entire Alternative D* framework. Preconstruction, Engineering and Design (PED) and construction for the first 15 years of the Alternative D* framework would begin immediately upon appropriation of funds. Congress would be notified of the status of the plan at 15 years.

Option 4. Authorization for the initial Preconstruction, Engineering and Design (PED) on the first 15 years of the Alternative D* framework. Authorization for construction would be based on a new report to be submitted to the full Congress, immediately after PED. Authorization and construction of additional increments would be conditioned on a future feasibility report.

Table 14-6. Matrix depicting each of the Implementation Options for Ecosystem Restoration Alternative D*.

Option	Authorization	Type Report	Timing of Report	Report Prepared for	Action Required Before Approp.	Next Increment of Construction Contingent Upon
1	Initial 15 yr of Alt. D* framework	New Report	End of 15 yrs	Full Congress	None	Future Report & Authorization
2	Entire Alt. D* Framework (50 yr)	New Report	End of 15 yrs	Authorization Committee	Committee Resolution	Future Report & Authorization
3	Entire Alt. D* Framework (50 yr)	Notification	End of 15 yrs	Authorizing Committee	None	NA
4	PED (15 yr. Increment)	New Report	Completion of PED	Full Congress	Construction Authorization	Future Report & Authorization

* New Report would be made when new/improved models are available, when trends can be determined, when ecological conditions warrant, or in 15 years, which ever comes first.

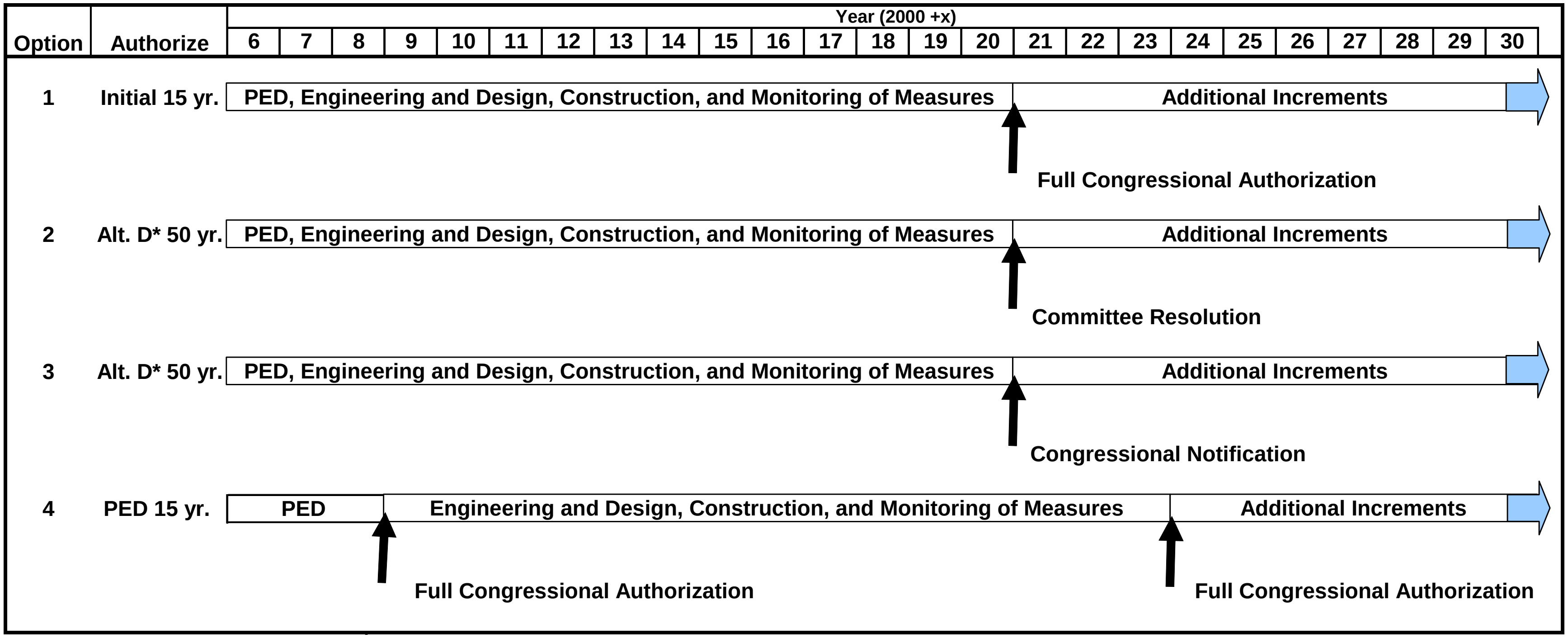

Figure 14-4. Timeline depicting each of the Implementation Options for Ecosystem Restoration Alternative D*. (Black arrows represent decision points.)

14.3.2 Implementation Considerations

The implementation options vary with the initial years authorized and oversight and approvals required to continue work on the Alternative D* framework. Option 3 is the least restrictive because it authorizes the entire Alternative D* and only requires notification to the authorizing committees at year 15 for continuation of the plan. Option 4 is the most restrictive since it only authorizes 3 years worth of PED and requires full Congressional Authorization prior to initiation of construction. The selection of an implementation option for the Alternative D* framework in an adaptive phased approach must take into account the quantified and non-quantifiable considerations listed below.

14.3.2.1 Uncertainty in Long-term Ecological Response

Due to uncertainty of future conditions and the exact outcome of the measures, there remains the risk of underestimating or overestimating the need for ecosystem restoration. If the need is underestimated, the result would be a lack of environmental sustainability and continued degradation of the UMRS ecosystem. Overestimating the need would lead to spending more funds than are necessary to maintain the ecosystem. An implementation strategy must take into account this uncertainty.

14.3.2.2 Best Return on Investment

An implementation strategy that provides the best return for the investment made should be considered for early implementation. This could include projects such as island building for example, where a 30-acre island building project positively influences about 1,000 acres of aquatic and terrestrial habitat. Fish passage sites that provide the greatest increased longitudinal connectivity (to mainstem river and tributaries) should also be considered for early implementation. Other measures that include a potential for great success over a wide area includes the water level management changes.

14.3.2.3 Best Gains in Diversity

An implementation strategy that provides the best gains in diversity to affected habitats and species should be considered for early implementation. The strategy should provide significant benefits across diverse geomorphic reaches and habitat types.

14.3.2.4 Additional Knowledge Required to Guide Future Investments

An implementation strategy must include an adaptive management approach that includes application of research to be conducted to better understand the outcome of measures and reduce their associated risk and uncertainties. This adaptive learning should range from pre and post project monitoring to pool and system-wide modeling to support the design and evaluation ecosystem restoration efforts. The ability to measure and communicate the programs accomplishments to diverse stakeholders is essential.

14.3.2.5 Sufficient Period to Begin Program

An implementation strategy needs to be developed that will allow sufficient time to plan, design, construct, and monitor the performance of a diverse group of measures. This is necessary to assure any modifications to the Alternative D* framework recommended for the second increment of investment is based on adaptive learning and sound science.

14.3.2.6 Other Social Effects

Other social effects in the form of ecosystem goods and services should be considered as part of the implementation strategy. These goods and services include municipal water supply, hydroelectric power, recreational activities, hunting and fishing activities and cycling of nutrients.

14.3.3 Recommended Implementation Option

It is proposed that the framework of alternative D* be implemented in accordance with Option 1 to include authorization for the first 15-year increment of the plan (Table 14-7).

This initial "15-year" implementation plan, was developed with the stakeholders to address critical ecosystem needs and to provide insight into the response of the environment to the various Navigation project modifications and measures. The 15-year plan will emphasize measures that provide:

1. The best return on investment,
2. Best gains in diversity,
3. Additional knowledge required to guide future investments.

This strategy recommends that future UMR-IWW management be conducted in an adaptive management framework that considers all the needs and opportunities for the system. Integrated management of the Corps' environmental and navigation, missions will improve cooperation and efficiency, resulting in cost savings and increased capabilities. An Adaptive Management Plan that includes a science panel, system level learning and monitoring, and restoration project bio-response monitoring is budgeted for $653 million over 50 years for Alternative D* and about 30% of that ($272 million) in this 15 year plan.

The ecosystem restoration measures include 13 broad categories of measures that can achieve most of the site-specific objectives. Actual site planning is quite complex and involves expertise from planning, engineering, environmental, construction, and many other disciplines, as well as the interagency and public coordination required for large Federal projects. Fish migrations are largely impeded by the lock and dam system, and there are desires for fish stocks to move more freely through the system at the appropriate times of year. Evaluations of fish passage problems and opportunities concluded that a subset of dams were a high priority to provide passage structures. This 15-year plan includes about 30% of the recommended measures, at Dams 4, 8, 22 and 26 plus initial planning for 19, at a total cost of about $209 million.

Large habitat blocks of floodplain forest, wetland, and prairie were a high priority in the Lower Impounded Reach south of Rock Island, Illinois to Alton, Illinois, the Middle Mississippi River, and the Lower Illinois River. Alternative D* includes restoration (including hydrologic connectivity during some times) of 105,000 acres of isolated habitat. This 15-year implementation plan proposes implementing 40% of those, or 35,000 acres at a total cost of $277 million. There are several immediate cost-share opportunities on the Illinois River, and prospects for other areas on the Mississippi River. Several environmental NGOs and the states could be instrumental in making these measures happen.

The remainder of the program is distributed among a range of restoration measures that target off-channel aquatic habitat and terrestrial measures. The priorities of stakeholders were considered in the allocation of effort among measures and sites. The measures making up the 15-year increment of the plan (Table 14-7) are based on the best available information. Specific actions may be modified and refined based on information gained through performance evaluation and the adaptive implementation of the plan.

An updated feasibility report will be prepared using knowledge gained from the initial 15-year investment. This report will make recommendations for any necessary modification to Alternative D* for the next increment of ecosystem restoration authorization.

Table 14-7. Description and cost of Management Measures included in the proposed 15-year implementation strategy.

Management Measures	Alternative D*		15-year Implementation Plan		
	Number of Projects	Area of Benefit (acres)	Number of Projects	Area of Benefit (acres)	Total by Measure ($millions)
Adaptive Management					**$136**
Cultural Res. Management & Mitigation					**$26**
Forest Management					**$38**
Real Estate (35,000 acres in MVR and MVS)					**$146**
Ecosystem Management and Restoration Measures	**1,010**	**388,281**	**225**	**104,986**	**$980**
Island Building	91	91,000	23	23,000	$151
Fish Passage	14		4		$209
Floodplain Restoration[1]	72	118,756	24	46,056	$177
Water Level Management[2]	15		15		$87
Backwater Restoration	215	124,800	38	24,800	$177
Side Channel Restoration	147	14,700	29	2,900	$82
Wing Dam/Dike Alteration	64	640	19	190	$29
Shoreline Protection[3]	392	38,385	73	8,040	$68
Restoration Response Monitroing and Evaluation					**$136**
Total Program Cost	**$5,323**		**$1,462**		

[1] - Includes large and small-scale floodplain restoration, dam embankment lowering, and topographic diversity
[2] - Includes pool-scale drawdowns, changing to dam point control at 2 sites, and reducing water level fluctuations on the Illinois River.
[3] - Included bankline and island protection.

14.3.4 Recommended Cost Sharing Plan

The proposed cost sharing arrangement is for a combination of 100 percent Federal and cost-shared 65 percent Federal and 35 percent non-Federal funding for implementation of the ecosystem restoration portion of the plan. The operation, maintenance, replacement, repair and rehabilitation costs are proposed to be assumed by the agency with management responsibility for the land on which the project is located or the operation and maintenance responsibility for the structure being modified. The plan also includes seeking authority to allow for Federal participation (100 percent Federal or cost shared as applicable) in major rehabilitation of projects damaged in major flood events.

14.3.4.1 Justification for 100 Percent Federal Funding

The 100 percent Federal funding is proposed for those ecosystem restoration measures that primarily address the ongoing impacts of the existing 9-foot navigation project. There are three primary reasons for recommending a large proportion of 100 percent Federal funding. The first is the extensive Federal resources within the waterway including almost 285,000 acres of National Wildlife and Fish Refuges. More than 40 percent of North America's migratory waterfowl and shorebirds depend on the food resources and other life requisites that the system provides. Further, the health of the project area upon the system as a whole extends system-wide, benefiting the five lower Mississippi Valley states, the Gulf of Mexico and tributaries within the Valley. Therefore, the benefits of the ecosystem restoration plan accrue to the nation and not just the state or region. The second factor is the large role that the operation of the existing 9-foot navigation project has played in the environmental degradation addressed by the ecosystem restoration plan. There is a convincing body of research and documentation of the direct and indirect impacts resulting from the creation and ongoing operation and maintenance of the Navigation System. Congress has declared the UMR-IWW to be nationally significant both as a navigation system and as an ecosystem. Therefore it is appropriate that the majority of the costs of sustaining the ecosystem as well as the navigation system be borne by the nation. The third reason is the interstate nature of the navigation system and the fact that is passes through five different states significantly complicating any cost sharing arrangements.

14.3.4.2 Criteria for 100 Percent Federal Funding

It was recognized that an approach of mitigating for the ongoing and cumulative impacts of the project would normally involve a process of identifying and quantifying such impacts and then formulating cost effective and justified measures to mitigate for the impacts. However, it was concluded that, in view of the complexity of the system and the long history of multiple human impacts to the ecosystem, such an approach would be very difficult and unlikely to yield creditable results. The formulation of the ecosystem restoration plan has involved identifying the stressors and impacts on the existing ecosystem but did not involve a detailed accounting of cause and effect relationships needed to isolate the impacts of the navigation project. Rather than attempt such an analysis, the proposal to share at 100 percent Federal costs measures involving the modification of the structures and operations of the existing projects, measures on project and lands included in the National Refuge System and measures in backwater areas connected to the main river channel within the Ordinary High Water line regardless of current ownership captures those measures which are primarily responding to existing project impacts. Measures on other public lands or requiring land acquisition would be cost shared.

14.3.4.3 Application of Proposed Cost Sharing

14.3.4.3.1 Framework Plan

The recommended ecosystem restoration framework plan consists of an estimated 1,010 projects with a combined first cost of about $5.3 billion. The total estimated operation and maintenance costs for these projects over a 50-year project life in 2003 dollars is estimated at $257 million. The first cost of the 100 percent Federal projects is estimated at about $4.25 billion. The total first cost of the cost shared floodplain restoration projects is estimated at about $1.05 billion with a Federal share of about $680 million and a non-Federal share of about $370 million. Since the majority of the land and water areas of the UMR-IWW are managed by either the U.S. Fish and Wildlife Service or the 5 states, the Corps operation and maintenance responsibility will be largely limited to fish passage facilities, operational costs of water level management, and operation and maintenance of dike and wing dam alterations. These cost are estimated at a total of $30 million over a 50-year period. The remaining 50-year total operation and maintenance cost of $227 will be borne by the U.S. Fish and Wildlife Service, the states and other cost share partners.

14.3.4.3.2 Initial 15-Year Plan

The initial ecosystem restoration plan proposed for immediate authorization consists of an estimated 225 projects with a combined first cost of about $1.462 billion (Table 14-7). The total estimated operation and maintenance costs for these projects over a 50-year project life in 2003 dollars is estimated at $76 million. The first cost of the 100 percent Federal projects is estimated at about $1.090 billion. The total first cost of the cost shared floodplain restoration projects is estimated at about $372 million with a Federal share of about $242 million and a non-Federal share of about $ 130 million. Since the majority of the land and water areas of the UMR-IWW are managed by either the U.S. Fish and Wildlife Service or the 5 states, the Federal operation and maintenance responsibility will be largely limited to fish passage facilities, operational costs of water level management, and operation and maintenance of dike and wing dam alterations. These cost are estimated at a total of $12 million over a 50-year period. The remaining 50-year total operation and maintenance cost of $64 will be borne by the U.S. Fish and Wildlife Service and the states.

14.3.4.4 Partners' Views

The primary partners in the implementation of the ecosystem restoration projects will be the U.S. Fish and Wildlife Service and the states in assuming the operation and maintenance responsibility for completed habitat projects and the states and nonprofit entities for cost sharing and operation and maintenance of floodplain restoration projects.

14.3.4.4.1 The States

The Governors of Minnesota, Iowa, Wisconsin, Illinois and Missouri supported the recommended plan including the recommended cost share option C in a letter dated July 16, 2004.

14.3.4.4.2 U.S. Fish and Wildlife Service (FWS)

The FWS supports the proposed cost sharing because it addresses the greatest breadth of measures at 100 percent Federal cost essential to mitigating the operation and maintenance impacts of the entire project. The FWS expresses reservations about assuming management of measures to address the impacts of the existing project but indicates a willingness to assume maintenance of projects on refuge or General Purpose lands that are consistent with their management objectives (letter dated December 19, 2003). The FWS restated support for the recommended cost share option by letter dated August 6, 2004.

14.3.4.4.3 The Nature Conservancy

The Nature Conservancy has indicated their willingness to work with the Corps in implementing ecosystem restoration projects and endorses the authority for nonprofit organizations to be cost sharing partners for aspects of the ecosystem restoration plan. The TNC has identified the Emiquon project as an early candidate for floodplain restoration under the navigation study authority. The TNC indicated a desire to participate as a cost share partner on floodplain restoration projects by letter dated July 29, 2004.

14.3.5 Adaptive Management

Implementation of any alternative needs to be done in the context of a comprehensive and integrated plan for river management because so many system components are intrinsically linked. Making decisions to address and resolve the complex assortment of ecological needs and objectives within the UMRS should be conducted in the context of a long-term commitment to a policy of adaptive management. Adaptive management is a process that seeks to aggressively use management intervention as a tool to strategically probe the functioning of an ecosystem. Management measures are designed to test key hypotheses about the structure and functioning of the ecosystem. Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management actions as tools to not only change the system, but as tools to learn about the system.

There are several elements both scientific and social that are vital components of adaptive management:

1. Management is linked to appropriate temporal and spatial scales
2. Management retains a focus on statistical power and controls
3. Use of computer models to achieve ecological consensus
4. Use embodied ecological consensus to evaluate strategic alternatives
5. Communicate alternatives to stakeholders for negotiation of a selection

Specific elements incorporated into the UMR-IWW adaptive management program would include:

1. Organization
    - River Management Council
    - Science Panel
    - River Management Teams
2. Systemic Studies
    - Ecosystem Modeling (numerical and conceptual)
    - Information Needs Assessment
    - Biological data collection (example Fish Stock Assessment)
    - Physical data collection (bathymetry)
    - Etc.
3. Restoration Measure Evaluation
    - Island Building
    - Fish Passage
    - Side Channel Restoration
    - Etc.

The success of an adaptive management approach will require an open management process that seeks to include partners and stakeholders during the planning and implementation stages. Consequently, adaptive management must be a social as well as scientific process. It must focus on the development of new institutions and institutional strategies just as much as it must focus upon scientific hypotheses and experimental frameworks. Adaptive management attempts to use a scientific approach, accompanied by collegial hypotheses testing to build understanding, but this process also aims to enhance institutional flexibility and encourage the formation of the new institutions that are required to use this understanding on a day-to-day basis.

One of the main benefits of adaptive management is the development of an iterative and flexible approach to management and decision-making. This iterative approach emphasizes the fact that management actions can be viewed as experimental manipulations of the system of interest. The results of the manipulations can be monitored and future management decisions can be informed by the outcomes of previous decisions. Another important benefit of adaptive management lies in the opportunity for scientists and managers to collaborate in the design of novel and imaginative solutions to the challenges of managing complex and incompletely understood ecological systems. Alternative management actions can be stated as hypotheses and addressed from the perspectives of rigorous experimental design and decision analysis. The probable (possible) outcomes of management alternatives and the values of such outcomes can be estimated in relation to management goals and objectives. The adaptive approach recognizes that uncertainty is unavoidable in managing large-scale ecological systems. Importantly, uncertainty can be analyzed and exploited to identify key gaps in information and understanding. The results of such analyses of uncertainty can be used to efficiently allocate limited management resources to new research or monitoring programs.

14.3.6 Integrated Management

The dual-purpose plan will strive to integrate Federal river management activities to achieve sustainability of the system. The Federal activities to be coordinated under the sustainability umbrella include operation and maintenance of the 9-Foot Channel Navigation Project, the Environmental Management Program, Environmental Continuing Authorities Programs (CAP; i.e., Sections 204, 206, and 1135), the WRDA 1999 (Public Law 106-53 §459) Comprehensive Plan for the floodplain, U.S. Fish and Wildlife Service Refuge management, and the Illinois River Basin Restoration initiatives (Illinois River Ecosystem Restoration Feasibility Study and WRDA 2000, Public Law 106-541 Section 519, Illinois River Basin Restoration), Department of Agriculture programs and other activities. A conceptual model of the floodplain and the areas of responsibility for these various ongoing Federal actions are presented in Figure 14-5.

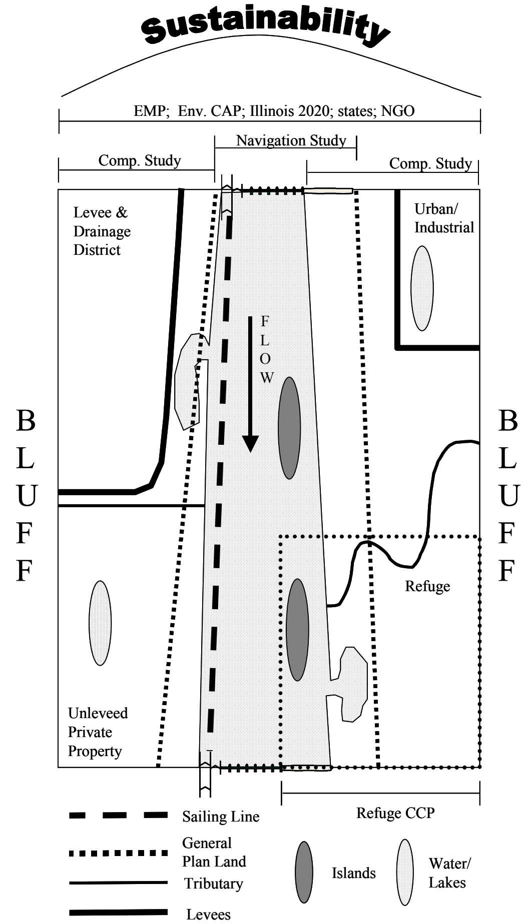

Figure 14-5. Schematic representation of a river reach illustrating the general types of land uses and ownership and the approximate extent of river management authorities including: the Environmental Management Program, Environmental CAP, states and NGOs, U.S. Fish and Wildlife Service Refuges, the floodplain Comprehensive Study, Illinois River Restoration (Illinois 2020), and the Navigation Study.

Each individual program will then determine implementation requirements within its area of responsibility as shown in Figure 14-6. The Navigation Feasibility Study will define management for sustainability within the limits of the navigation project. Likewise, the Comprehensive Study will define management for sustainability in the context of flood damage reduction for the Mississippi River floodplain. The Illinois River Basin Restoration initiatives will define management for sustainability throughout the entire Illinois River Basin. These three programs are all currently in the alternatives evaluation phase. It is anticipated that the recommended plans for each component will contain synergistic opportunities as well as some duplication and overlap. This can best be managed as part of an adaptive implementation with integrated management oversight.

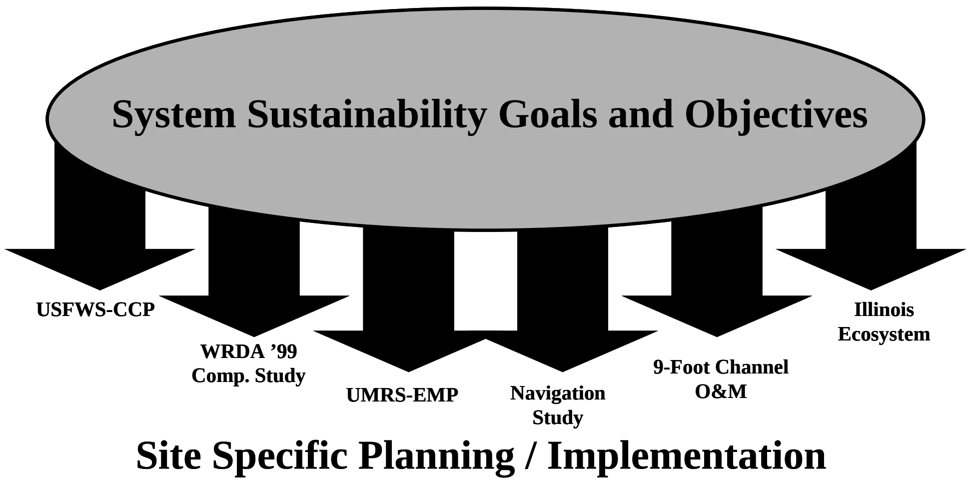

Figure 14-6. Goals and Objectives for the UMR-IWW have been established in a comprehensive fashion under the authority of the restructured navigation feasibility study. Detailed planning and implementation will be distributed among many applicable authorities.

14.3.7 Institutional Arrangements

The existing framework of institutional arrangements needs some modification to enable more integrated, science-driven, inclusive, efficient, and cost-effective management of the UMRS. At the system-wide scale, the present Environmental Management Program Coordinating Committee (EMPCC) attends to the UMRS Environmental Management Program (EMP), but not to other aspects of river management including navigation system O&M, refuge, fish and wildlife, water quality, floodplain, and recreation management. These other major categories of river management activities presently do not have a system-wide coordinating forum.

The implementation of an integrated plan will require a review and possible reevaluation of existing institutional arrangements. This reevaluation will not take place as part of the feasibility study, but instead it will be adaptively developed within the region once an implementation plan is developed. One possible consideration is to re-organize and expand the responsibilities of the EMPCC to become a River Management Council. The River Management Council could coordinate integrated management of the UMRS and provide input to the implementing agencies. The River Management Council would be comprised of regional leaders of the Army Corps of Engineers, U.S. EPA, U.S. Fish and Wildlife Service, U.S. Geological Survey, Maritime Administration, USDA Natural Resources Conservation Service, U.S. Coast Guard, state natural resources management agencies, and state transportation departments. Interested non-governmental agencies would be encouraged to participate voluntarily and exchange information with the Council. Integrated management of the UMRS would encompass the existing

UMRS-EMP as well as other river management activities of the member agencies. The Council would receive recommendations from a Science Panel, and give direction to the River Management Teams (see below).

14.3.7.1 River Management Teams

The existing District-level interagency river management teams could be expanded with additional responsibilities, and made more consistent in mission between Corps Districts. The size, membership composition, and attention to different aspects of river management will differ between Districts, as appropriate to the challenges of river management in the different river reaches. Four River Management Teams could be considered, one for each Mississippi River reach corresponding to Corps of Engineers District boundaries and one for the Illinois River. The River Management Teams would be comprised of engineers, scientists, and resource managers from the Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. EPA, the U.S. Coast Guard, the USDA NRCS, state natural resource management agencies, and state departments of transportation.

14.3.7.2 Science Panel

The Science Panel would be comprised of nationally recognized ecologists, engineers and planners that would be retained to further develop a set of working ecosystem models and provide scientific guidance for ecosystem management and restoration work on the UMRS. This diverse variety of highly competent scientists and engineers across a range of Federal and State agencies along with a number of private contractors will be required to meet the wide-ranging needs of the adaptive management approach. The Army Engineer Research and Development Center (ERDC) System-Wide Water Resources Research Program will contribute to UMRS Science Panel work. The Science Panel would also work closely with the River Management Teams to:

- Collaboratively develop a set of ecosystem models for the UMRS
- Refine and expand objectives for condition of the river ecosystem
- Set endpoints and metrics for monitoring and performance evaluation
- Simulate the ecological effectiveness of different combinations of ecosystem management and restoration actions
- Quantify the outputs of ecosystem management and restoration investments

In addition to ecosystem modeling, the Science Panel will:

- Develop a science-based process for sequencing ecosystem management and restoration work system-wide.
- Conduct an assessment of information needed for river management.
- Assist in integrating EMP Long Term Resource Monitoring Program research and monitoring activities.
- Provide technical direction to performance monitoring and evaluation, systemic studies, and major survey data acquisitions.
- Evaluate monitoring results, review and report on progress.
- Interact with the River Management Teams, and advise the River Management Council.

14.3.7.3 Process for Modifying Institutional Arrangements

The preceding paragraphs present one concept for institutional arrangements for integrated management and adaptive implementation of the recommended plan. Early in the next phase of product development an inter-organizational sub-committee of the NECC will be assembled for purposes of considering this and other concepts. The sub-committee will review current institutional arrangements, investigate alternatives, and formulate a plan for review by the NECC, the GLC, the Federal Principals Group and by impacted organizations. Once in place, the modified institutional arrangements will prepare charters and establish processes for both integrated and adaptive management as provided for in implementing guidance.

14.4 Compatibility of Plans

The ecosystem restoration measures under consideration will address the ongoing and cumulative impacts of the nine-foot channel project and other human activities and can be accomplished while still maintaining a nine-foot channel project. The primary ecosystem restoration measure that could impact navigation efficiency is the water level management strategies that could reduce pool levels below the current operation band of the authorized nine-foot channel project. Impacts to navigation traffic as well as recreational craft, water supply, and hydropower can be mitigated by advanced planning and dredging. The costs for these actions are included in the water level management estimates. Changes in water level management have been previously demonstrated on the system with little to no impacts to navigation traffic.

The navigation efficiency improvements under consideration can be accomplished without impact to the ecosystem restoration measures. Mitigation for site specific and system traffic effects will be fully incorporated into the adaptive management approach for ecosystem restoration. The dual-purpose authority would allow operation and maintenance activities to fully support ecosystem restoration objectives when appropriate. For instance, material disposal from channel maintenance dredging could be used for island building. In addition, backwater dredging could be included with channel maintenance dredging when it makes economic sense and hydrologic conditions can be managed for both navigation and the environment.

14.5 Acceptability of Recommended Plan

The Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement public review period extended from May 14 to July 30, 2004. Nearly 40,000 comments on the draft report were received from over 4,300 persons during the public comment period. The global importance of this issue is reflected in the fact that email responses were received from each of the 50 States, in addition to Washington, D.C., and Canada. The comments ranged from complete support of the recommended plan to support for returning the river to its natural state. These views are not necessarily those of the general public, since they do not constitute a valid random or representative sample of the general public. Thus, although this information can provide insight into the perspectives and values of the respondents, it does not necessarily reveal the desires of society as a whole.

The State and Federal agencies generally agreed with the adaptive implementation strategy central to the recommended plan. They felt this approach would provide the opportunity to re-evaluate investment decisions as more information is obtained. The navigation and agriculture non-governmental organizations generally endorsed the recommended plan with a heavy emphasis on supporting infrastructure improvements. The environmental non-governmental organizations generally support more ecosystem restoration than contained in the recommended plan and support the desire to have nonstructural and small-scale measures implemented prior to any consideration for large-scale improvements such as new locks.

Chapter 13 contains a summary of these comments and views and a complete record of comments, responses, and letters can be found in the Response to Comments Appendix.

14.6 Summary of Integrated Plan

It is recommended that an integrated plan be approved as a framework for modifications and operational changes to the Upper Mississippi River and Illinois Waterway System to provide for navigation efficiency and environmental sustainability, and to add ecosystem restoration as an authorized project purpose. The plan will be administered by the Corps of Engineers in full collaboration with the other Federal and state agencies involved in management of the UMR-IWW System. The integrated plan will seek authorization for the following:

1. Authorization and immediate implementation of Alternative 4 small scale structural and non-structural measures at a total cost of $218 million to include:
    - Mooring facilities at Lock and Dams 12, 14, 18, 20, 22, 24 and LaGrange ($11 million)
    - Switchboats at Lock and Dams 20-25 Phased Approach ($207 million for 15 years)
    - Appropriate Mitigation
    - Cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

2. Authorization and immediate implementation of the first increment of Alternative 6 at a total cost of $1.66 billion to include:
    - New 1200’ Locks at Lock and Dams 20-25, LaGrange and Peoria ($1.46 billion)
    - Appropriate Mitigation ($200 million for site specific system effects)
    - Adaptive implementation to include the following decision points and Congressional oversight:
        - A notification report at the end of design and before construction contract award that presents (1) all new information resulting from monitoring river traffic and markets, and (2) the results of any improved models and analysis.
        - An evaluation report will be submitted in approximately 5-7 years to the Administration and Congress upon the reevaluation of regional, national and world market conditions and development and application of new peer-reviewed models, concluding with a recommendation on whether or not to stop or delay lock construction. These new models will be subjected to review by scientific peers and the model’s acceptability will be based on validated theory, computational correctness, and model appropriateness for the study tasks.
        - An updated feasibility report requiring additional authorization before proceeding with the five lock extensions at Locks 14-18.
    - The cost of construction and mitigation shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

3. Authorization of continued study and monitoring of the system to include:
    - Development of an appointment scheduling system
    - Development of new spatial model
    - Collection of demand elasticity data
    - Monitoring of traffic delays and patterns
    - Monitoring of domestic and global grain market conditions, land use, crop yield technology, and developments in China regarding import trends
    - Cost of the study and monitoring plan shall be paid 50 percent each from the Inland Waterways Trust Fund and the general fund of the U.S. Treasury.

4. Authorization of the first 15 year increment of the Alternative D* framework at a total cost of $1.462 billion to include:

a. The following measures shall be specifically authorized for implementation at a total Federal cost of $250 million and require project implementation reports to be approved by the Secretary of the Army prior to appropriation of funds.

- Fish Passage at dams 4, 8, 22, 26 & initial E&D at 19 ($209 million total).
- Dam point control at dams 25 & 16 ($41 million total).

b. A programmatic authority to implement measures that will provide substantial restoration benefits and will include funds for adaptive management and monitoring at a total cost of $935 million. These measures will include:

- water level management (i.e., drawdowns) in 12 pools,
- 23 island building projects,
- backwater restoration at 33 sites,
- 29 side channel restoration efforts,
- wing dam/dike alteration at 19 locations,
- island/shoreline protection at 73 sites,
- improving topographic diversity at 9 locations,
- 13 dam embankment lowering projects, and
- reduction of water level fluctuation on the Illinois River.

The programmatic authority will include the following:

- Project implementation reports for these measures will be reviewed and approved by the Secretary of the Army (the Secretary).
- Total cost of each feature will not exceed $25 million and be appropriated from the general fund of the U.S. Treasury.
- The cost of operation, maintenance, repair, replacement, and rehabilitation for these features shall be the responsibility of the Federal or state agency administering and managing the public land on which the project is located.
- The costs for major rehabilitation of projects constructed and damaged in major flood events shall be 100% Federal within the project and aggregate limits specified above.
- The cost of a new report at the end of 15 years to be provided to Congress for potential authorization of additional increments of the plan.

c. Authorization for acquisition of 35,000 acres of land for purposes of floodplain connectivity, wetland and riparian habitat protection and restoration at a total cost of $277m. The acquisition shall be from willing sellers. The total Federal cost is estimated at $180m and the non-Federal cost $97m. The cost sharing requirements for this acquisition are as follows:

- The Federal share of the cost of land acquisition and restoration shall be 65%.
- The non-federal shall be responsible for all lands, easements, rights of way and relocations necessary to implement the land acquisition and restoration projects.
- Non-Federal sponsors may include nonprofit entities.
- Regardless of the date of acquisition, the value of lands or interest in lands for land acquired by a non-Federal sponsor in accordance with a project implementation report for any land acquisition and restoration project shall be included in the total cost of the project and credited towards the non-Federal share of the cost of the project. The value of

the lands or interest in the lands and incidental costs for lands acquired by a non-Federal sponsor that exceed the non-Federal share of the land acquisition and restoration project costs shall be reimbursed to the non-Federal sponsor.

- The non-Federal sponsor shall be responsible for the cost of operation, maintenance, repair replacement, and rehabilitation of projects under this section.
- The costs for major rehabilitation of projects in this section that are damaged by flood events shall be cost shared.
- The Secretary may provide credit, including in-kind credit, toward the non-Federal share (35%) of land acquisition and restoration projects under this section for the reasonable costs of any work performed in connection with a study, preconstruction engineering and design, or construction that is necessary for project implementation. The credit for the work shall be limited to the non-Federal share and shall not result in any reimbursement.
- Project implementation reports for these features will be reviewed and approved by the Secretary.

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B.A. Biology, University of Missouri-St. Louis; M.S. Biology, Southern Illinois University-Edwardsville; Ph.D. University of Illinois-Champaign/Urbana. Certified Fisheries Professional No. 2237. Co-author of ten scientific publications on navigation effects. Appointed by the Assistant Secretary of the Army (Civil Works) as the Principal U.S. Representative to the International Navigation Association (PIANC) Working Group 27 ("Guidelines for Environmental Impacts of Vessels"). Previously employed as an Adjunct Assistant Professor in the Environmental Sciences Program, Southern Illinois University-Edwardsville. Fishery Biologist, Ecologist, and currently Research Fishery Biologist, U.S. Army Corps of Engineers, St. Louis District, since 1980.
Technical manager for the assessment of the effects of navigation traffic on fish and freshwater mussels. Technical manager for endangered species compliance. Author of sections of the Feasibility Report and PEIS and co-author and editor of the Biological Assessment. St. Louis District representative to the NECC.

Nicole McVay, General Biologist, Rock Island, IL
B.A. Biology, Augustana College (1998). Previously employed as a Hydrologist, U.S. Army Corps of Engineers, Rock Island District (1996-2002). General Biologist, U.S. Army Corps of Engineers, Rock Island District, since 2002.
Responsible for coordination and execution of the environmental objectives workshops; creation and implementation of the Comment-Response database for the Draft Feasibility and PEIS public comments; and assisting with editing and consolidation of the Draft Feasibility and PEIS. Co-author of ENV Report 50, Environmental Objectives Planning Workshops.

James Ross, Archeologist, Rock Island, IL
B.A. Anthropology, North Texas State, Denton, TX (1985), M.A. Anthropology, Illinois State University-Carbondale (1991). Previously employed as an archeologist for the Institute of Applied Sciences at Denton, TX, field technician with the Center for Archeological Investigation SIU at Carbondale, IL, and as an archeologist for the American Resources Group at Carbondale, IL. Archeologist, U.S. Army Corps of Engineers, Rock Island District, since 1994.
Co-author of Cultural Resources sections of the Feasibility Report and PEIS.

Elliott Stefanik, Biologist, Saint Paul, MN
B.S. Biology, University of Wisconsin, Platteville (1995), M.S. Biology, University of Wisconsin, La Crosse (1997). Previously employed as a Fisheries Biologist with Surface Water Resources, Inc, Sacramento, California (1997 thru 1999). Biologist, U.S. Army Corps of Engineers, Rock Island and Saint Paul Districts, since 2000.
Support author and reviewer of Feasibility Report. Co-author of supporting Biological Assessment. Provided technical overview for select ecological fieldwork and impacts assessments. Participated in the fish passage work workgroup, public meetings, and NECC meetings. Coordination with the USFWS for compliance with the Endangered Species Act.

Charles Theiling, General Biologist, Rock Island, IL
M.S., Aquatic Ecology University of Michigan (1991); B.S. Zoology; B.S. Environmental Biology, Eastern Illinois University (1987). Previously employed by Lawler, Matusky & Skelly Engineers as a Site Manager, Illinois Natural History Survey as a Field Station Leader at Alton, IL; Ecological Specialists Inc as a Project Manager; and the USGS Aquatic Ecologist. General Biologist, U.S. Army Corps of Engineers, Rock Island District, since 2000
Author of sections of the Feasibility Report and PEIS, Member of the Navigation Study Science Panel and technical editor of Science Panel Report.

Daniel B. Wilcox, Fisheries Biologist. River Falls, Wisconsin.
B.S. Water Resources Science University of Wisconsin, Stevens Point.
29 years professional experience in water resources planning and aquatic ecology. 24 years with St. Paul District, U.S. Army Corps of Engineers.
Technical manager for assessment of the effects of navigation traffic on aquatic plants, and for assessment of the effects of recreational boating. Technical manager and lead author of fish passage workgroup report. Author of sections of the Feasibility Report and PEIS and the Cumulative Effects Study Report.

15.5 Public Involvement

Kevin W. Bluhm, Public Involvement Team Leader, Saint Paul, MN
Native of southern Minnesota. B.S. in agriculture, University of Wisconsin, River Falls. Employed by the U.S. Army Corps of Engineers St. Paul District since 1986. Public Involvement training instructor for Inland waterway planning and for CORE planning public involvement class since 2003. Worked as public involvement specialist for Devils Lake feasibility report and EIS. Have conducted over 50 public meetings and have facilitated 12 public workshops.

Sharryn A. Jackson, Social Science Analyst, Rock Island, IL
B.A. Sociology, Western Illinois University, Macomb, Illinois. Social Science Analyst, U.S. Army Corps of Engineers, Rock Island District, since 1972. Member Public Involvement Workgroup participating in Public Involvement efforts, scoping meetings and public meetings. Primary author of social impact assessment and demographic evaluation. Co-author of Public Involvement Appendix.

Suzanne R. Simmons, Public Involvement Specialist, Rock Island, IL.
Employed by U.S. Army Corps of Engineers, Rock Island District for 29 years. Currently serving as Public Involvement Specialist since 1988. Provided coordination of public involvement efforts, scoping meetings, public meetings, and committee meetings. Co-author of Public Involvement Appendix.

16.0 TECHNICAL REPORTS (with abstracts)

A diverse range of evaluative and investigative studies were undertaken to gain a comprehensive understanding of the social, economic, engineering and environmental issues, concerns and implications associated with accomplishing the study objectives. To accomplish such studies, the study team engaged a diverse array of technical expertise to conduct the necessary evaluations and investigations. In many cases the study team relied on the technical expertise of scientists, engineers, and economist from other state/federal governmental agencies, private sector consulting firms, and universities. Coordinating committees identified in Chapter 2 were involved in nearly all aspects of the planning, implementation and review of these interim products. The following provides a comprehensive listing of the interim products and reports generated by each of the respective technical study workgroups:

* - These reports are published on the website in multiple sections. The report link will take you to the table of contents. We are currently working on creating a better link for these documents, and hope to have this working soon.

** - These reports are not available for Public review due to the sensitive nature of the data contained therein.

*** - Gray boxes indicate the report is still in Draft and is currently unavailable.

Report #	Report Title	Abstract	Report
	Environmental Reports		
ENV 1	*Flume Study Investigation of the Direct Impacts of Navigation - Generated Waves on Submersed Aquatic Macrophytes in the Upper Mississippi River*	Abstract	Report
ENV 2	*Rates of Net Fine Sediment Accumulation in Selected Backwater Types of Pool 8, Upper Mississippi River*	Abstract	Report
ENV 3	*Physical Forces Study, Kampsville, Illinois Waterway*	Abstract	Report
ENV 4	*Prediction of Vessel-Generated Waves with Reference to Vessels Common to the Upper Mississippi River System*	Abstract	Report
ENV 5*	*Physical Forces Study, Clark's Ferry, Mississippi River*	Abstract	Report
ENV 6*	*Upper Mississippi River Navigation and Sedimentation Field Data Collection Summary Report*	Abstract	Report
ENV 7	*Site-Specific Habitat Assessment*	Abstract	Report
ENV 8*	*Bank Erosion Field Survey Report of the Upper Mississippi River and Illinois Waterway*	Abstract	Report
ENV 9*	*Identification of Potential Commercial Navigation Related Bank Erosion Sites*	Abstract	Report
ENV 10	*A Two-Dimensional Flow Model for Vessel-Generated Currents*	Abstract	Report
ENV 11	*Application of UNET Model to Vessel Drawdown in Backwaters of Navigation Channels*	Abstract	Report
ENV 12	*Effects of Waves on the Early Growth of Vallisneria americana*	Abstract	Report
ENV 13	*Methodologies Employed for Bathymetric Mapping and Sediment Characterization as Part of the Feasibility Study*	Abstract	Report

ENV 14	*Comparison of NAVEFF Model to Field Return Velocity and Drawdown Data*	**Abstract**	**Report**
ENV 15	*Wave height predictive techniques for commercial tows on the UMRS*	**Abstract**	**Report**
ENV 16*	*Ecological risk assessment of the effects of the incremental increases of commercial navigation traffic on larval fish entrainment*	**Abstract**	**Report**
ENV 17	*Ecological risk assessment of the effects of the incremental increase of commercial navigation traffic on submerged aquatic plants*	**Abstract**	**Report**
ENV 18	*Effects of Rec. Boating: Traffic Allocation and Forecasting Model*	**Abstract**	**Report**
ENV 19	*Physical Forces Near Commercial Tows*	**Abstract**	**Report**
ENV 20	*Wave-Induced Sediment Resuspension Near the Shorelines of Upper Mississippi River Study*	**Abstract**	**Report**
ENV 21	*Velocity patterns downstream of a Mississippi River Dike with and without tow traffic*	**Abstract**	**Report**
ENV 22	*Stranding potential of young fishes*	**Abstract**	**Report**
ENV 23	*Hull shear mortality of eggs and larval fish*	**Abstract**	**Report**
ENV 24	*Shear stress on the hull of shallow draft barges*	**Abstract**	**Report**
ENV 25	*Inflow zone and discharge through propeller jets*	**Abstract**	**Report**
ENV 26	*Computer Model for Transport of Larvae Between Barge Tows in Rivers*	**Abstract**	**Report**
ENV 27	*Definitions, Boundary Delineations, and Measurements of Attributes for the Hydraulic Classification of Aquatic Areas*	**Abstract**	**Report**
ENV 27 (appendix)	Hydraulic Classification Analysis	**Abstract**	**Report**
ENV 28	*Effects of Sediment Resuspension and Deposition on Plant Growth and Reproduction*	**Abstract**	**Report**
ENV 29	*Abundance of Fishes in the Navigation Channels of the Mississippi and Illinois Rivers and Entrainment Mortality of Adult Fish Caused by Towboats*	**Abstract**	**Report**
ENV 30	*Evaluation of Propeller-Induced Mortality on Selected Larval Fish Species*	**Abstract**	**Report**
ENV 31	*Physiological effects on freshwater mussels (Family: Unionidae) of intermittent exposure to physical effects of navigation traffic*	**Abstract**	**Report**
ENV 32	*Determination of the Fate of Fish Displaced from Low-Velocity Habitats at Low Temperatures*	**Abstract**	**Report**
EVN 33	*Determination of the Tolerance of Fish in Low-Velocity Habitats to Hydraulic Disturbance at Low Temperatures*	**Abstract**	**Report**
ENV 34	*Effects of pressure changes induced by commercial navigation traffic on mortality of fish early life stage*	**Abstract**	**Report**
ENV 35	*Mortality of fish early life stages resulting from hull shear associated with passage of commercial navigation traffic*	**Abstract**	**Report**

ENV 36	*Mortality of Animals Due to Highway and Railroad Conditions*	**Abstract**	**Report**
ENV 37	*Entrainment and Transport of Sediments by Towboats in the Upper Mississippi River and Illinois Waterway, Numerical Model Study*	**Abstract**	**Report**
ENV 38	*Ecological Models and Approach to Risk Assessment*	**Abstract**	**Report**
ENV 39	*Ecological Risk Assessment of the Effects of the Incremental Increase of Commercial Navigation Traffic on Freshwater Mussels in the Main Channel and Main Channel Borders*	**Abstract**	**Report**
ENV 40 Vol I	*Upper Mississippi River and Illinois Waterway Cumulative Effects Study. Volume I: Geomorphic Assessment and*	**Abstract**	**Report**
ENV 40 Vol II	*Upper Mississippi River and Illinois Waterway Cumulative Effects Study. Volume II: Ecological Assessment*	**Abstract**	**Report**
ENV 41	*Tow Induced Backwater and Secondary Channel Sedimentation, Upper Mississippi River System*	**Abstract**	**Report**
ENV 42	*UMRS-IWWS Navigation Study, Physical Effects System Model*	**Abstract**	**Report**
ENV 43	*Hydraulic Effects of Recreational Boat Traffic on the Upper Mississippi River System*	**Abstract**	**Report**
ENV 44	*Inventory of Hydrographic Survey and Cross-Section Data Available on the Upper Mississippi River and Illinois Waterway at the U.S. Army Engineer Districts, St. Paul, Rock Island, and St. Louis*	**Abstract**	**Report**
ENV 45	*Decay of Tow-induced Drawdown in Backwaters and Secondary Channels*	**Abstract**	**Report**
ENV 46	*Users Manual for NAVSED*	**Abstract**	**Report**
ENV 47	*Users Manual for SEDLOAD*	**Abstract**	**Report**
ENV 48	*Ecological Modeling*	**Abstract**	**Report**
ENV 49	*NAVSED Validation*	**Abstract**	**Report**
ENV 50	*Upper Mississippi River – Illinois Waterway System Environmental Objectives Planning Workshops*	**Abstract**	**Report**
ENV 51	*Aquatic Plant Growth Model Refinement for the Upper Mississippi River – Illinois Waterway System Navigation Study*	**Abstract**	**Report**
ENV 52	*Environmental Panel Science Report*	**Abstract**	**Report**
ENV 53	*Water Level Management Opportunities for Ecosystem Restoration on the Upper Mississippi River and Illinois Waterway*	**Abstract**	**Report**
ENV 54	*Improving Fish Passage Through Navigation Dams on the Upper Mississippi River System*	**Abstract**	**Report**
ENV 55	*Commercial Navigation Traffic Induced Shoreline Dewatering on the Upper Mississippi River: Implication for Larval Fish Stranding*	**Abstract**	**Report**
ENV 56	*Evaluation of Towboat Propeller-induced Mortality of Juvenile and Adult Fishes in the Upper Mississippi River System*	**Abstract**	**Report**

ENV 57	*Seasonal Fish Densities in the Lock Chamber at Lock and Dam 25, Upper Mississippi River*	**Abstract**	**Report**
ENV 58	*Adult Fish Mortality During Lockage of Commercial Navigation Traffic at Lock and Dam 25*	**Abstract**	**Report**
ENV 59	*Flow Through the Wheels of Towboats in 600ft Locks on the Upper Mississippi River – Illinois Waterway*	**Abstract**	**Report**
ENV 60	*Seasonal Abundance of Fishes in the Main Channel of the Illinois River*	**Abstract**	**Report**
ENV 61	*Hydroacoustic Survey of the Main Channel of the Illinois River to Detect Barge Avoidance Behavior by Fish*	**Abstract**	**Report**
	Historic Properties Reports		
HP 1	*Assessment of Archeological Site Potential at Commercial; Navigation Erosional Areas on Lands Within the Illinois Waterway System Between Brandon Road Lock and Dam and Grafton, Illinois Within the St. Louis and Rock Island Districts*	**Abstract**	**Report**
HP 2**	*The Historic Properties Management Plan for the Mississippi River, Pools 11 Through 22 Rock Island District, Corps of Engineers*	**Abstract**	**Report**
HP 3**	*Consolidation of the Archeological Sites Database for the Historic Properties Management Plan for the St. Louis District Corps of Engineers Lands Between Mississippi River Miles 0-300, Above the Ohio River*	**Abstract**	**Report**
HP 4**	*Historic Properties Potential & Geomorphological Assessment at Locks and Dams 11-22, 24, and 25, Upper Mississippi River System, Illinois, Iowa, Missouri, and Wisconsin*	**Abstract**	**Report**
HP 5**	*Consolidation of Extant Data for the UMR-IWWS Navigation Feasibility Study and the Development of Portions of the Historic Properties Management Plan for the Corps of Engineer Lands Between Mississippi River Miles 0-300 Above the Ohio Rivers in Illinois and Missouri*	**Abstract**	**Report**
HP 6	*Assessment of the Historic Properties Potential at Commercial Navigation Erosion Sites on the Mississippi River in the St. Louis, St. Paul, and Rock Island Districts*	**Abstract**	**Report**
HP 7	*Landform Sediment Assemblage (LSA) Units in the Upper Mississippi River Valley, United States Army Corps of Engineers, Rock Island District*	**Abstract**	**Report**
HP 8**	*An Investigation of Submerged Historic Properties in the Upper Mississippi River and Illinois Waterway*	**Abstract**	**Report**
HP 9	*Landform Sediment Assemblage (LSA) Units in the Illinois River Valley and the Lower Des Plaines River Valley*	**Abstract**	**Report**
HP 10**	*Cultural Resources Inventory of the Upper Mississippi River, St. Anthony Falls to Pool 10, Wisconsin, Iowa, and Minnesota*	**Abstract**	**Report**

HP 11**	*Gently Down the Stream: An Inquiry into the History of Transportation on the Northern Mississippi River and the Potential for Submerged Cultural Resources*	**Abstract**	**Report**
HP 12**	*Geomorphological Mapping and Archaeological Sites of the Upper Mississippi River Valley, Navigation Pools 1-10, Minneapolis, Minnesota to Guttenberg, Iowa*	**Abstract**	**Report**
HP 13	*Historic Properties Potential and Geomorphological Assessment Along the Illinois Waterway for the Rock Island District of the U.S. Army Corps of Engineers*	**Abstract**	**Report**
HP 14	*Gateways to Commerce*	**Abstract**	**Report**
HP 15	*Architectural and Engineering Resources of the Illinois Waterway between 130th Street in Chicago and La Grange: Volumes I and II*	**Abstract**	**Report**
HP 16	*National Register of Historic Places Nomination Registration Form for the Upper Mississippi River Federal Navigation Projects*	**Abstract**	**Report**
HP 17	*The Historic Properties Management Plan for the Illinois Waterway System, Rock Island District, Corps of Engineers: Volumes I and II*	**Abstract**	**Report**
HP 18**	*Historic Properties Management Plan*	**Abstract**	**Report**
HP 19**	*Unpublished Manuscript of St. Louis District Shipwrecks*	**Abstract**	**Report**
HP 20**	*Shoreline Erosion Monitoring at Twenty Archeological Sites, Rock Island District, Upper Mississippi River System* (1998)	**Abstract**	**Report**
HP 21**	*Shoreline Erosion Monitoring at Twenty Archeological Sites, Rock Island District, Upper Mississippi River System* (2000)	**Abstract**	**Report**
HP 22**	*Archeological Testing of Nine Sites in Support of Shoreline Erosion Monitoring, Rock Island District, Upper Mississippi River System*	**Abstract**	**Report**
HP 23**	*National Register of Historic Places Multiple Property Documentation Form with Associated Nomination Forms for Corps-Owned Historic Properties Along the Mississippi River in the States of Illinois, Iowa, Missouri, and Wisconsin* (2 Volumes)	**Abstract**	**Report**
HP 24**	*National Register of Historic Places Multiple Property Submission: Illinois Waterway Navigation Study Facilities*	**Abstract**	**Report**
HP 25**	*Historical Shipwrecks on the Middle Mississippi and Lower Illinois River*	**Abstract**	**Report**
	Economic Reports		
EC 1	*Transportation Rate Analysis: Upper Mississippi River Navigation Study*	**Abstract**	**Report**
EC 2	*Rail Rates and the Availability of Water Transportation: The Upper Mississippi Basin*	**Abstract**	**Report**
EC 3 * Vol. I	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Summary*	**Abstract**	**Report**
EC 3 Vol. II	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Grain*	**Abstract**	**Report**

EC 3 Vol. III	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Agricultural Chemicals*	**Abstract**	**Report**
EC 3 Vol. IV	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Prepared Animal Feeds*	**Abstract**	**Report**
EC 3 Vol. V	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Coal*	**Abstract**	**Report**
EC 3 Vol. VI	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Industrial Chemical*	**Abstract**	**Report**
EC 3 Vol. VII	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Petroleum Products*	**Abstract**	**Report**
EC 3 Vol. VIII	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Construction Materials*	**Abstract**	**Report**
EC 3 Vol. IX	*Waterway Traffic Forecasts for the Upper Mississippi River Basin: Steel and Steel Sector Raw Materials*	**Abstract**	**Report**
EC 3 Addendum	*Review of Historic and Projected Grain Traffic on the Upper Mississippi River and Illinois Waterway: An Addendum*	**Abstract**	**Report**
EC 4	*The Incremental Cost of Transportation Capacity in Freight Railroading*	**Abstract**	**Report**
EC 5	*A Spatial Price Equilibrium Based Navigation System NED Model for the Upper Mississippi River Illinois Waterway Navigation System Feasibility Study*	**Abstract**	**Report**
EC 6	*Calculating the Value of Upper Mississippi River Navigation: Methodological Review and Recommendations*	**Abstract**	**Report**
EC 7	*Commercial/Recreational Navigation Conflicts*	**Abstract**	**Report**
EC 8	*Regional Impacts of Nine Construction Options for Infrastructure Modernization on the Upper Mississippi River & Illinois Waterway*	**Abstract**	**Report**
EC 9	*Analysis of Energy, Emission, and Safety Impacts of Alternative Improvements to the Upper Mississippi River and Illinois Waterway*	**Abstract**	**Report**
EC 10	*Upper Mississippi River – Illinois Waterway (UMR-IWW) System Navigation Study Accidents and Hazardous Spills Task*	**Abstract**	**Report**
EC 11	*Emissions and Fuel Use Analysis for Upper Mississippi River Basin*	**Abstract**	**Report**
EC 12	*Accidents and Hazardous Spills Analysis for Upper Mississippi River Basin*	**Abstract**	**Report**
EC 13	*Fleeting Analysis*	**Abstract**	**Report**
EC 14	*Induced Development*	**Abstract**	**Report**
EC 15	*Upper Mississippi River and Illinois Waterway Navigation Study Economic Scenarios and Resulting Demand for Barge Transportation*	**Abstract**	**Report**
EC 16	*Regional Economic Impact Analysis of Construction Activities and Transportation Savings Due to Changes in Inland Waterway Systems – An Operational Guide for Using the Multiregional Variable Input-output Modeling System*	**Abstract**	**Report**

EC 17	*Upper Mississippi River 2003 Sample Rate Study*	**Abstract**	**Report**
EC 18	*Analysis of the Energy, Safety, and Traffic Effects of Proposed Upper Mississippi River – Illinois Waterway System Navigation Improvements*	**Abstract**	**Report**
EC 19	*Regional Impacts of Proposed Navigation, Ecosystem, and Flood Control Improvements on the Upper Mississippi River and Illinois Waterway*	**Abstract**	**Report**
	Engineering Reports		
EG 1	*Engineering Objective 1 Report, Baseline Operation and Maintenance*	**Abstract**	**Report**
EG 2	*System Significant Components, Engineering Reliability Models Report*	**Abstract**	**Report**
EG 3	*General Assessment of Small-Scale Measures*	**Abstract**	**Report**
EG 4	*Improved Tow Haulage Equipment*	**Abstract**	**Report**
EG 5	*Universal Couplers and Crew Training*	**Abstract**	**Report**
EG 6	*Detailed Assessment of Small-Scale Measures*	**Abstract**	**Report**
EG 7	*Summary of Small-Scale Measures Screening*	**Abstract**	**Report**
EG 8	*Large-Scale Measures of Reducing Traffic Congestion, Conceptual Lock Designs*	**Abstract**	**Report**
EG 9	*Large-Scale Measures of Reducing Traffic Congestion, Hydraulic Impacts of New Lock Construction*	**Abstract**	**Report**
EG 10	*Large-Scale Measures of Reducing Traffic Congestion, Location Screening*	**Abstract**	**Report**
EG 11	*Interim Revised Lock Extension Design Concepts*	**Abstract**	**Report**
EG 12	*Summary of Large-Scale Measures Screening*	**Abstract**	**Report**
EG 13	*Site Adaptation of Cost Estimates and Lockage Performance for Surviving Lock Extensions and Types*	**Abstract**	**Report**
EG 14	*Secondary Benefits Associated with Large Scale Improvements*	**Abstract**	**Report**
EG 15	*Analysis of Future Investment Needs on the Upper Mississippi River and Illinois Waterway (Objective 2A)*	**Abstract**	**Report**
EG 16	*Structural Small Scale Measures Mississippi River Locks 22 & 25: Extended Guidewalls, Powered Traveling Kevels, Approach Channel Improvements*	**Abstract**	**Report**
EG 17	*Navigation Conditions at Lock and Dam 25, Mississippi River*	**Abstract**	**Report**
EG 18	*Navigation Conditions at Lock and Dam 22, Mississippi Rive*	**Abstract**	**Report**
EG 19	*Independent Review of Concept Design Construction Costs*	**Abstract**	**Report**
	Public Involvement Reports		
PI 1	*October-November 1993 Public Meetings - Responses to Questions and Comments*	**Abstract**	**Report**
PI 2	*Responses to Issues Raised at the Public and NEPA Scoping Meetings of November 1994*	**Abstract**	**Report**

PI 3	*Content Analysis Report from the November 1994 Public Meetings*	**Abstract**	**Report**
PI 4	*Transcripts from the 1994 November Public Meetings*	**Abstract**	**Report**
PI 5	*Interim Report: Open House Meetings Held November and December 1995*	**Abstract**	**Report**
PI 6	*Content Analysis Report of July-August 1999 Public Workshops*	**Abstract**	**Report**
PI 7*	*Transcripts of July-August 1999 Public Workshops, 1999*	**Abstract**	**Report**
PI 8	*Content Analysis Report, Public Meetings, March 12-21, 2002*	**Abstract**	**Report**
PI 9	*Transcripts from the March 2002 Public Meetings*	**Abstract**	**Report**
PI 10	*Content Analysis Report, Public Meetings, October 20-30, 2003*	**Abstract**	**Report**
PI 11	*Transcripts from the October 2003 Public Meetings*	**Abstract**	**Report**

INTERIM REPORT ABSTRACTS

The products are organized by work group: Environmental, Historic Properties, Economics, Engineering, and Public Involvement. Numbering for work groups other than environmental was included in this document for the sole purpose of facilitating the summary of where these reports fall on the attached product tree list (the engineering product tree does not include report numbers, since nearly the entire titles are shown). A number of other reports are in the process of being finalized.

16.1 Environmental Reports

ENV Report 1 - *Flume Study Investigation of the Direct Impacts of Navigation - Generated Waves on Submersed Aquatic Macrophytes in the Upper Mississippi River* by Robert M. Stewart, Dwilette G. McFarland, Donald L. Ward, Sandra K. Martin, and John W. Barko

ABSTRACT

In an effort to evaluate the impacts of waves and currents generated by navigation traffic on direct damage to submersed rnacrophyte communities in the Upper Mississippi River (UMR) system, a study was conducted in a two-dimensional flume facility at the U.S. Army Engineer Waterways Experiment Station. The submersed species, *Vallisneria americana Michx*. and *Myriophyllum spicatum L*., were exposed to 18 treatment combinations of current velocity (0.00, 0.10, and 0.25 m/set), wave height (0.1,0.2, and 0.3 m), and wave period (3 and 5 set). Both 4-weekend g-week-old greenhouse-cultured plants were exposed to each treatment combination for 25 min. Main response variables were numbers of fragments and total fragment biomass. Results showed that the level of direct damage was affected by interactions between treatment conditions and the species and size of the plants. At current velocities of 0.25/sec, damage was more related to exposure time than to wave height, as this current velocity forced the shoots downward in the water column and prevented them from being exposed to maximum wave forces. At lower current velocities, plant damage increased with wave height and plant size, and *M. spicatum* was more heavily damaged than *V.americana*. Visual observations indicated that the increased damage was related to plant entanglement resulting from current reversals in the passing wave series. Though no treatments generated biomass losses greater than 30 percent of exposed plant biomass, repeated daily exposures to secondary waves from current levels of navigation traffic may be partially responsible for the paucity of submersed macrophytes along the main channel border area of the UMR system.

ENV Report 2 - *Rates of Net Fine Sediment Accumulation in Selected Backwater Types of Pool 8, Upper Mississippi River* by James T. Rogala, William F. James, and Harry L. Eakin

ABSTRACT

Estimates of accumulation rates provide valuable information needed for projecting future conditions of backwaters in the Upper Mississippi River (UMR), either with or without changes in the use of resources. Net fine sediment accumulation rates since impoundment were estimated from sediment cores collected in selected backwater types of Pool 8. Net fine sediment rates at 147 depositional sites were calculated from the depth of sediment overlying pre-impoundment sediment and ranged from 0.017 to 1.36 cm/year. Mean rates for the 33 backwaters sampled in Pool 8 ranged from 0 to 0.82 cm/year. Large backwaters had the highest accumulation rate (0.57 cm/year); small, low-connectivity backwaters had the lowest rate (0.29 cm/year); and small, low-connectivity backwaters had an intermediate rate (0.43 cm/year). The overall mean rate of net accumulation for Pool 8 backwaters was 0.46 cm/year. Deeper areas within backwater regions tended to have higher accumulation rates than shallower areas, suggesting sediment focusing. Relationships were weak between accumulation rates and other parameters such as surficial sediment characteristics, backwater characteristics, and sedimentation measured during bed elevation surveys between 1989 and 1996.

ENV Report 3 - *Physical Forces Study, Kampsville, Illinois Waterway* by Stephen T. Maynord and Sandra K. Martin (Knight)

ABSTRACT
A 1:25-scale model of the Illinois Waterway near Kampsville, IL, was used to determine tow-induced return velocity and drawdown. The model was adjusted to account for scale effects based on a comparison of physical model and prototype data from the Kampsville reach. Return velocity and drawdown were determined for various pool elevations, tow positions, vessel speeds, drafts, and direction relative to flow. The vertical profile of return velocity was shown to be uniform, except near the bed. Physical model and prototype data were compared to a numerical model.

ENV Report 4 - *Prediction of Vessel-Generated Waves with Reference to Vessels Common to the Upper Mississippi River System* by Robert M. Sorensen

ABSTRACT
The waves generated by a moving vessel can disturb other vessels in navigation channels and marinas, damage shoreline structures, and cause the erosion of unprotected riverbanks. The erosion of unprotected riverbanks is of particular importance on the Upper Mississippi River System (UMRS). In this connection, there is a need to be able to predict the characteristics of the free waves generated by a given class of vessel and mode of operation. These characteristics include the wave period and direction of propagation, but most importantly the wave height. The wave period and direction of propagation can be predicted analytically for a given speed and water depth of the vessel; however, the wave height depends on additional factors including the hull form and operating draft of the vessel, the distance from the sailing line, and possibly the cross-section geometry of the channel. Nine models, all having a strong empirical base for predicting the generated wave height, were identified and evaluated based on the vessels common to the UMRS. Most of the models are restricted in some way, such as being applicable only to certain vessel types or to limited channel conditions. The three models having possible application to the UMRS were evaluated for their specific applicability and available field measurements of vessel wave height. This model evaluation produced limited results that can be significantly improved by comparison with additional field data. The final section of this report includes an annotated bibliography on the available and pertinent literature on vessel-generated waves.

ENV Report 5 - *Physical Forces Study, Clark's Ferry, Mississippi River* by Stephen T. Maynord and Sandra K. Knight

ABSTRACT
A 1:30-scale model of the Mississippi River near Clark’s Ferry, Iowa, was used to determine tow-induced return velocity and drawdown. The model was adjusted to account for scale effects based on a comparison of physical model and prototype data from the Clark’s Ferry reach. Return velocity and drawdown were determined for various pool elevations, tow positions, vessel speeds, drafts, and direction relative to flow. The vertical profile of return velocity was shown to be uniform, except near the bed. Rake angle at the bow of the vessel of 26 deg and 45 deg was shown to produce similar return velocity. Velocity measurements near submerged dikes were documented during vessel passage. The Clark’s Ferry model was used with a large depth to simulate open river conditions below St. Louis.

ENV Report 6 - *Upper Mississippi River Navigation and Sedimentation Field Data Collection Summary Report* by Timothy L. Fagerburg and Thad C. Pratt

ABSTRACT
The overall field data collection program is to provide a hydrodynamic and hydrologic monitoring program with emphasis on obtaining information including bathymetry at monitoring stations, currents, water levels, suspended-sediment concentrations, wind velocity, and concurrent navigation data. These parameters will be used in the evaluation of controlling landscape features, ecosystem stability, river morphology, and sediment-transport characterization in three study areas located in the Upper Mississippi River and Illinois Waterway (UMR-IWW)

system. The areas of interest are located in Pool 26 and Pool 8 on the Mississippi River and La Grange Pool on the Illinois River. These data are then to be used in the hydrodynamic and sediment-transport modeling efforts to provide the necessary boundary conditions, initial conditions, and verification data for comprehensive numerical simulations.

ENV Report 7 - *Site-Specific Habitat Assessment* by Richard Fristik, Scott K. Estergard and Brian L. Johnson

ABSTRACT
The objective of the site-specific analyses was to evaluate potential impacts of the proposed construction measures at lock and dams (L/Ds) on the Upper Mississippi River and Illinois Waterway System. These are L/Ds 11-25 on the Mississippi River, and Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, Peoria, and La Grange on the Illinois Waterway. The primary purpose was to assist the study team in formulating a recommended plan by providing quantitative measure or qualitative evaluation of environmental impacts and estimated habitat replacement costs. These analyses will also identify possible alternatives that avoid and minimize impacts or provide opportunities for restoration. Detailed analysis of site-specific impacts, based on any recommended/-authorized measures, will not be possible until detailed design information for those measures is available. The quantitative evaluation (at those locks and dams lower on the system) was accomplished using the Habitat Evaluation Procedures (HEP), while a qualitative evaluation was made at the remaining locks and dams and through evaluation of potential endangered species impacts, socio-economic impacts, and mussel surveys.

ENV Report 8 - *Bank Erosion Field Survey Report of the Upper Mississippi River and Illinois Waterway* by Nani Bhowmik, David Soong, and Tatsuaki Nakato

ABSTRACT
This report summarizes findings from several phases of the Upper Mississippi River/Illinois Waterway (UMR/IWW) Bank Erosion Study. Tasks completed to date include a literature study of bank erosion, an aerial reconnaissance survey, and a field survey trip organized and conducted by the lead agency, the U.S. Army Corps of Engineers, Rock Island District. Major emphasis of this report is given to the findings from the field survey.

During the field survey, the team selected 72 erosion sites (29 sites on the Illinois Waterway and 43 sites on the Mississippi River) for further study. For the selected sites on the IWW (80 bank sections from 29 sites), the research team observed multiple erosion processes at most of the selected bank sections. The most frequently identified erosion mechanisms are seepage, stage fluctuations, flood flows, navigation traffic, wave activities, and eddies and disturbed flows.

Bank failure and erosion conditions on the Upper Mississippi River also showed significant flood impacts. Analyses of surficial soil samples showed the banks were mantled by primarily sand and gravel in the upper reach of the river, silt and sand in the middle reach, and clay and silt in the lower reach. Most of the bank failure and erosion sites showed flood damage as the dominating erosion cause. Surficial, wave-induced erosion and erosion associated with direct barge impact, propeller wash and cabling to trees was present at some fleeting and mooring and lock approach sites.

Approximately fifty-one sites out of seventy-five of the UMR study sites (including observation sites) were within the upper portion of the navigation pools. Many of these active erosion sites are also historically dredged material placement sites. Below St. Louis, historical flood flow reworking of the channel margins was also observed.

A measurement of the length of severely eroded reaches, as marked on the navigation charts (appendix J), shows that there are approximately 115 bank miles on the IWW and 240 bank miles on the UMR. This represents that approximately 20 percent of the total bank length of the IWW and 14 percent of the UMR are actively eroding.

ENV Report 9 - *Identification of Potential Commercial Navigation Related Bank Erosion Sites* by Kevin Landwehr and Tatsuaki Nakato

ABSTRACT
Contingency analyses using discrete field bank erosion site data were conducted for the Upper Mississippi River between St. Paul, Minnesota, and Cairo, Illinois, and the Illinois Waterway between Joliet, Illinois, and Grafton, Illinois, in order to assess the risk of bank erosion directly related to commercial navigation. The introduction of exponential weighting factors in risk analyses enabled evaluation of the significance of several important physical parameters that affect bank erosion processes. A model based on the field survey data was successfully applied to both the Upper Mississippi River and Illinois Waterway resulting in the identification of areas with high, medium, and low potential for commercial navigation induced bank erosion. The analysis cannot predict the occurrence or magnitude of damage at the identified erosion sites due to the interdependence of the geotechnical and hydraulic processes occurring along the banks of the Upper Mississippi River. The results of this analysis are presented on GIS-based color mapping of the bank-erosion risk categories.

ENV Report 10 - *A Two-Dimensional Flow Model for Vessel-Generated Currents* by Richard L. Stockstill and R.C. Berger

ABSTRACT
The movement of a barge train through a body of water produces a complex pattern of currents and waves. Quantification of these currents has relied on physical models and analytical descriptions. Although empirical methods are practical for many situations, detailed analyses of specific areas are desirable. These empirical relations do not provide time-varying solutions necessary for predicting the duration of vessel-induced events. Also, spatial variations in rivers having backwaters and side channels are not modeled by these expressions. A two-dimensional representation of the equations of motion provides temporal variation of the depth-averaged velocity distribution and the water-surface elevation. This report describes the development of a numerical model to quantify vessel-generated currents and summarizes a series of numerical experiments. Flow fields containing a moving vessel are modeled by specifying a pressure field, representing a vessel hull, which is spatially varying in time. The movement of the pressure field in time is specified to represent a vessel navigating along a channel.

ENV Report 11 - *Application of UNET Model to Vessel Drawdown in Backwaters of Navigation Channel*s by Stephen T. Maynord

ABSTRACT
Results of the one-dimensional unsteady flow model UNET were compared to measured water level and velocity changes in backwater connected to a navigation channel. These changes resulted from passage of shallow-draft navigation in the navigation channel. Measurements used in the comparison were from a 1:30-scale physical model generic backwater and from an actual backwater of the Illinois Waterway. The UNET model covered only the backwater with the vessel-induced time-history of drawdown being the input boundary condition at the downstream end of the UNET model backwater. Based on comparisons, the UNET model can predict the magnitude and shape of the initial wave that travels up the backwater but subsequent reflections compare less favorably with the observed data. Water level predictions were generally better than velocity predictions, particularly in the Illinois Waterway backwater.

ENV Report 12 - *Effects of Waves on the Early Growth of Vallisneria americana* by Robert Doyle

ABSTRACT
The impacts of 15-cm waves on the survival and short-term growth and development of *Vallisneria americana* plants growing from tubers was investigated in artificial raceways. Twelve recently sprouted tubers were planted at each of three depths (15, 20, and 25 cm) within both wave and control raceways. Wave events designed to simulate wave disturbances caused by traffic along a shoreline were created five or six times each day during the 10.5-week experimental growth period. A wave event consisted of five 15-cm waves generated within the raceway within a 3-min period. The waves generated a maximum velocity of about 140 cm sec-1 as they swept over the plants. All

plants survived at all depths in both treatments. However, individual plants exposed to the wave regime accumulated significantly less mass than controls. On average, the total mass accumulated was only 50 percent of that of undisturbed plants. In addition, the plants experiencing the waves had significantly shorter leaves and produced significantly fewer daughter plants. While plants under both wave and no-wave treatments had a net positive growth over the experimental period, those exposed to frequent wave energy developed more slowly and may be less resilient to recovery from other forms of disturbance.

ENV Report 13 - ***Methodologies Employed for Bathymetric Mapping and Sediment Characterization as Part of the Upper Mississippi River System Navigation Feasibility Study*** by James T. Rogala

ABSTRACT
Bathymetric mapping and sediment characterization were completed to meet the needs of various modeling components of the Upper Mississippi River-Illinois Waterway System Navigation Study. The methodologies used to meet the modeling needs at several spatial scales are documented as supporting information for the modeling activities. Methods reported include bathymetric map generation, bathymetric surveys along transects, laboratory analysis of sediment characteristics, and visual classification of sediments. The documentation of these methods is designed to meet only the general needs of data users. Details adequate for use as standard operating procedures are not included in this methods document.

ENV Report 14 - ***Comparison of NAVEFF Model to Field Return Velocity and Drawdown Data*** by Stephen T. Maynord

ABSTRACT
The NAVEFF model is a one-dimensional model using conservation of energy and mass to determine return velocity and drawdown resulting from passage of vessels in a navigable river or channel. The NAVEFF model incorporates empirical exponential decay relations to provide the distribution of the maximum return velocity and maximum drawdown between the vessel and the shoreline. The NAVEFF model is compared herein to data that were not used in the development of the model from sites on the Mississippi River, Illinois Waterway, and Gulf Intracoastal Waterway. The observed prototype data are shown to exhibit considerable scatter based on comparison of similar vessels. Based on the comparisons of observed and computed values, the NAVEFF model over predicts maximum return velocity and drawdown by an average of about 25 percent. Detailed return velocity measurements between vessel and shoreline at one site on the Mississippi River support the use of the exponential decay of return velocity between vessel and shoreline.

ENV Report 15 - ***Wave height predictive techniques for commercial tows on the UMRS*** by Sandra K. Martin

ABSTRACT
Physical model studies and prototype data have been collected and analyzed as part of the Upper Mississippi River-Illinois Waterway System (UMRS) Navigation Feasibility Study for the purpose of developing a vessel wave predictive tool for commercial tows. The approach used was to examine existing analytical techniques for predicting wave heights produced by vessels, determine their suitability and applicability to the vessels and waterways of the UMRS, and modify/validate them with physical model and available prototype data. Based on the literature reviewed and the analysis, both a method of predicting the maximum secondary wave height produced by a moving commercial tow and the time-history associated with it are presented in this report. The wave-height model was based on the development of coefficients related to the hull cross-sectional area and relates maximum wave height to distance from sailing line and the vessel speed. This equation is appropriate for predicting maximum secondary wave height for the purposes of estimating ecological impacts as well as designing bank protection.

ENV Report 16 - *Ecological risk assessment of the effects of the incremental increases of commercial navigation traffic on larval fish entrainment* by Steve Bartell and Kym Rouse-Campbell

ABSTRACT
This report describes the implementation of ecological models used to estimate larval fish mortality resulting from entrainment by commercial vessels operating on the Upper Mississippi River and Illinois Waterway (UMR-IW) System. The models were used to assess impacts of the average numbers of commercial vessels per day for each navigation pool based on 1992 data. Assessments were performed for alternative traffic scenarios that were developed as 25, 50, 75, and 100% increases over the 1992 data. Entrainment rates (m3/s) were estimated for 108 different configurations of commercial vessels. Each configuration included the size, speed, direction, load, and presence of Kort nozzle technology. The relative frequency of each configuration was determined from the 1992 lockage records for each pool and month. This information was used to estimate the volume of water entrained per pool during the spawning months for 30 species of fish on the UMR-IW System. Entrainment mortality for each species was modeled in relation to the amount of water entrained by commercial vessels during the months of spawning, the corresponding monthly larval densities, the relative distribution of larvae in relation to the navigation channel, and the sensitivity of larvae to entrainment. Estimates of entrainment mortality were extrapolated to (1) losses of future adult fishes, (2) the number of fish that would not recruit to the recreational and commercial fisheries, and (3) losses in the future production of fish biomass. These extrapolations were made using models previously applied in fisheries impact assessments and included the Equivalent Adults Lost model, the Recruitment Forgone model, and the Production Forgone model. Model parameter values were developed for each model and species addressed in the assessment. The larval entrainment mortality estimates were reported as the incremental impacts of each traffic scenario compared to the 1992 baseline impacts.

ENV Report 17 - *Ecological risk assessment of the effects of the incremental increase of commercial navigation traffic on submerged aquatic plants* by Steve Bartell and Kym Rouse-Campbell

ABSTRACT
This report describes the implementation of hydrodynamic forces screening models and plant growth models used to estimate the potential impacts on submerged aquatic vegetation associated with commercial vessels operating on the Upper Mississippi River and Illinois Waterway (UMR-IW) System. The assessments addressed potential navigation impacts on SAV in the main channel and channel border. The screening models were used to identify the combinations of vessel characteristics, pool stage height, and sailing line that might produce waves or changes in current velocities that could result in physical damage to aquatic plants. The plant growth models were used to assess impacts of the commercial vessels on sediment resuspension that might reduce light availability for photosynthesis. Plant growth models were developed for wild celery and Sago pondweed, two species selected as representative growth forms of SAV in the UMR. The models were used to estimate decreases in plant growth and energy allocated to vegetative reproduction in relation to passing commercial vessels. Potential impacts were assessed for UMR pools 4, 8, and 13 using 1992 commercial traffic data. Potential plant growth habitat was defined as any area with a depth of 1.5 m or less in the main channel or channel border, regardless of the presence of SAV. The assessment addressed all areas of potential plant growth in the selected pools. Additional assessments were performed for alternative traffic scenarios that were developed as 25, 50, 75, and 100% increases over the 1992 data.

The report summarizes the magnitude of potential impacts of commercial vessels on plant breakage and reduced growth and reproduction as incremental differences between the 1992 baseline traffic and the four traffic alternatives.

ENV Report 18 - *Effects of Rec. Boating: Traffic Allocation and Forecasting Model* by Bruce Carlson, Steven M. Bartell, and Kym Rouse-Campbel

ABSTRACT
The purposes of this report are to (1) quantitatively characterize in a detailed manner the present recreational boating use of the UMRS and IW by developing a recreational traffic allocation model; and (2) estimate future changes in recreational boating on the river system for the period 2000-2050 by using the allocation model to project or forecast

future recreational traffic. This report develops a set of assumptions based on available information from past studies of recreational boating on the UMRS, supplemented with professional judgment from resource professionals most familiar with these activities. Associated risk and uncertainty exercises have been undertaken to highlight the factors that have the most sensitivity on the results. Initial estimates of increases in recreational boating were based on the assumption of unconstrained growth population growth in the UMR-IW region. Alternate recreational boating projections were developed to account for other possible future scenarios of factors affecting growth in boating. The allocation model process is based on highly aggregated data that quantify the total number of trips per year across all pools and recreational vessel categories on the UMRS and IW. The model development process continued by successively disaggregating the annual, whole-system numbers to allocations by pool, by vessel category, to vessels per day, and finally, to within-pool daily use projections for each vessel class for the baseline condition (i.e., year 2000).

ENV Report 19 - *Physical Forces Near Commercial Tows* by Stephen T. Maynord

ABSTRACT

The Upper Mississippi River-Illinois Waterway System (UMR-IWWS) Navigation Study evaluates the justification of additional lockage capacity at sites on the UMR-IWWS while maintaining the social and environmental qualities of the river system. The system navigation study is implemented by the Initial Project Management Plan (IPMP) outlined in "Upper Mississippi River-Illinois Waterway System Navigation Study," (U.S. Army Corps of Engineers (USACE) 1994). The IPMP outlines Engineering, Economic, Environmental and Public Involvement Plans.

Physical forces in the region near and beneath commercial tows occur because of the propeller jet and the displacement of water by the hull of the vessel. Physical forces are quantified in terms of the changes in pressure, velocity, and shear stress and are used to determine substrate scour, sediment resuspension, and effects on aquatic organisms.

This study of forces near and beneath commercial tows is conducted in a physical model. The reason for this is that field measurements beneath a vessel are difficult to obtain because some of the primary tows of interest are operating in shallow water with as little as a 0.6-m clearance beneath the tow. In addition, propeller jet bottom velocities can exceed 4 m/sec. Operation of velocity meters or other measuring devices in such an environment is quite difficult. The difficulty of obtaining field data means that verification data for the physical model is lacking. The approach used herein is to use a large physical model to minimize scale effects. Propeller jets, a main emphasis of this study, are operated at speeds where the thrust coefficients are dependent of Reynold's number, suggesting similarity with the prototype.

The results presented herein for the physical forces near commercial tows focus on the design tow using the UMR-IWWS. The design tow is a three-wide by five-long barge tow, loaded to about 2.74 m in diameter. These data are from experiments in a 1:25 –scale model channel, barges, and towboat that has operating propellers, rudders, and open-wheel or Kort nozzle propellers. The following parameters were measured in the model:

a. Channel bottom pressure under moving tow.
b. Near-bed velocity and bed shear stress changes under the barges of a moving tow.
c. Near-bed velocity and bed shear stress changes in the stern region from the propeller jet for a stationary tow and from the combined effects of the propeller jet and the wake flow for a moving tow.

Analytical/empirical methods were developed to describe near-bed velocity and shear stress as a function of tow parameters.

ENV Report 20 - *Wave-Induced Sediment Resuspension Near the Shorelines of Upper Mississippi River Study* by Nani Parchure

ABSTRACT

Part of the Upper Mississippi River-Illinois Waterway System navigation Study deals with estimation of environmental impacts caused by an increase in navigation traffic. Resuspension and deposition of fine clayey sediment have a significant impact on aquatic plants and animals. The objective of the study described in this report was to estimate the sediment resuspension resulting from waves generated by towboats and recreational craft. The scope of this study was limited to (a) generalization of wave patterns for the event of vessel passage, (b) estimation

of maximum suspension concentration caused by individual events of vessel passage, (c) deposition of suspended sediment, and (d) interference effect on the suspended sediment concentration caused by the passage of another vessel.

The Costal and Hydraulics Laboratory, Vicksburg, MS, U.S. Army Engineer Research and Development Center, conducted field measurements for wave heights, current, and suspended sediment concentration at various sites during November 1995, July 1996, and September 1996. The wave heights were measured with a pressure sensor, currents with a current meter, and suspended sediment concentration with Optical Backscatter sensors (OBS). The following conclusions are drawn: (a) large vessels generate large drawdown and small wave heights but a high suspended sediment concentration, and (b) small vessels such as a yacht generate small drawdowns and large wave heights. At high speed, small vessels also cause a substantial increase in suspended sediment concentration.

ENV Report 21 – *Velocity patterns downstream of a Mississippi River Dike with and without tow traffic* by Steve Maynord

ABSTRACT
The Upper Mississippi River-Illinois Waterway System (UMR-IWWS) Navigation Feasibility Study will evaluate the justification of providing additional lockage capacity at sites on the UMR-IWWS while maintaining the social and environmental qualities of the river system. The system navigation feasibility study will be accomplished by executing the Initial Project Management Plan that outlines Engineering, Economic, Environmental, and Public Involvement Plans. The Environmental Plan identifies the significant environmental resources on the UMR-IWWS and probable impacts in terms of threatened and endangered species; water quality; recreational resources; fisheries; mussels and other macroinvertebrates; waterfowl; aquatic and terrestrial macrophytes; and historic properties. It considers system-wide impacts of navigation capacity increases, while also assessing in preliminary fashion potential construction effects of improvement projects. One element of the Environmental Plan addresses the impacts of navigation on larval and adult fish. Part of the fish study evaluates the impact of tow traffic on adult fish using the low-velocity habitat found during winter months down-stream of dikes on the Mississippi River. Velocities were measured downstream of a typical Middle Mississippi River dike before and during passage of a model tow for typical winter flow conditions. Upbound versus downbound tows and tows near the dike as well as far from the dike were evaluated in the experiments. A limited set of experiments measured ambient velocities downstream of the dike when the dike is being overtopped and the effect of adding an “L-head” to the dike on velocities before and during tow passage.

ENV Report 22 - *Stranding potential of young fishes* by Adams

ABSTRACT
Early life stages of fish in the Mississippi River system may become stranded during shoreline drawdown, induced by the passage of commercial vessels. We examined the stranding of larval shovelnose sturgeon (*Scaphirhynchus platorynchus*), paddlefish (*Polyodon spathula*), and bigmouth buffalo (*Ictiobus cyprinellus*), and of juvenile blue catfish (*Ictalurus furcatus*), largemouth bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*) in a laboratory flume. Stranding was measured at three vertical drawdown rafts (0.76,0.46, and 0.21 cm/s) and two bank slopes (1:5 and 1:10). Blue catfish, shovelnose sturgeon, and paddlefish were not tested at both bank slopes. Susceptibility to stranding varied among species and was independent of drawdown rate. At a slope of 1:5, shovelnose sturgeon had the highest stranding percentage (66.7 percent), followed by paddlefish (38.0 percent), bluegill (20.0 percent), bigmouth buffalo (2.2 percent), and largemouth bass (0.0 percent). At 1: 10, blue catfish had the highest stranding percentage (26.7 percent), followed by largemouth bass (15.3 percent), bluegill (5.3 percent), and bigmouth buffalo (0.0 percent). The likelihood of stranding was related to the behavioral response of fishes to receding water levels. Species that typically occur in littoral/backwater areas swam with the current or passively drifted, while the young of main channel fishes, such as sturgeon and paddlefish, exhibited positive rheotaxis and were more likely to become stranded.

ENV Report 23 - *Hull shear mortality of eggs and larval fish* by Steve Maynord

ABSTRACT
The Upper Mississippi River-Illinois Waterway System (UMR-IWWS) Navigation Feasibility Study evaluates the justification of providing additional lockage capacity at sites on the UMR-IWWS while maintaining the social and environmental qualities of the river system. The system navigation feasibility study is accomplished by executing the Initial Project Management Plan (IPMP). The IPMP outlines Engineering, Economic, Environmental, and Public Involvement Plans.

The Environmental Plan identifies the significant environmental resources on the UMR-IWWS and probable impacts in terms of threatened and endangered species; water quality; recreational resources; fisheries; mussels and other macroinvertebrates; waterfowl; aquatic and terrestrial macrophytes; and historic properties. It considers system-wide impacts of navigation capacity increases, while also assessing in preliminary fashion potential construction effects of improvement projects.

One element of the Environmental Plan addresses the impacts of navigation on larval and adult fish. One element of the fish study addressed in another part of the UMR-IWWS study is the mortality of early life stages of fish passing near the hull of the vessel where they could be exposed to shear stress that could lead to mortality. The various elements of the hull shear mortality study are the waterway zone passing adjacent to the hull, the distribution of larval fish in the hull passage zone, the quantity of water passing through the zone having lethal values of shear stress, and the mortality of larval fish subjected to shear stress.

The object of this study is to evaluate the experiments by Morgan et al. (1976) who used concentric cylinders to determine the mortality of larval fish subjected to shear stress. Results of this study show that mortality tests are representative of shear along the hull of a vessel, and the shear stress computed in that publication is validated by recent measurements. The computed shear along the hull of UMR-IWWS tows is below the levels required to produce mortality of 50 percent of the fish eggs and larval tested. For typical vessel speed (2.9 m/sec) and a representative shear (87 dynes/sq. cm) that is exceeded/not exceeded in 50 percent of the zone beneath the tow, the average mortality for the four species/life stages is 9 percent. These results do not provide information about the sensitivity of most species of fish in the UMR-IWWS. Some of these species may be more sensitive to shear than the striped bass and white bass that were tested.

ENV Report 24 - *Shear stress on the hull of shallow draft barges* by Steve Maynord.

ABSTRACT
The Upper Mississippi River-Illinois Waterway System (UMR-IWWS) Navigation Study evaluates the justification of additional lockage capacity at sites on the UMR-IWWS while maintaining the social and environmental qualities of the river system. The system navigation study is implemented by the Initial Project Management Plan (IPMP) outlined in the "Upper Mississippi River-Illinois Waterway System Navigation Study," (U.S. Army Corps of Engineers (USACE) 1994). The IPMP outlines Engineering, Economic, Environmental, and Public Involvement Plans.

Physical forces in the region near and beneath commercial tows occur because of the propeller jet and the displacement of water by the hull of the vessel. Physical forces are quantified in terms of the changes in pressure, velocity, and shear stress and are used to determine substrate scour, sediment resuspension, and effects on aquatic organisms.

This study of forces near and beneath commercial tows is conducted in a physical model. The reason for this is that field measurements beneath a vessel are difficult to obtain because some of the primary tows of interest are operating in shallow water with as little as a 0.6-m clearance beneath the tow. In addition, propeller jet bottom velocities can exceed 4 m/sec. Operation of velocity meters or other measuring devices in such an environment is quite difficult. The difficulty of obtaining field data means that verification data for the physical model is lacking. The approach used herein is to use a large physical model to minimize scale effects. Propeller jets, a main emphasis of this study, are operated at speeds where the thrust coefficients are independent of Reynold's number, suggesting similarity with the prototype.

The results presented herein for the physical forces near commercial tows focus on the design tow using the UMR-IWWS. The design tow is a three-wide by five-long barge tow, loaded to about 2.74 m and pushed by a twinscrew towboat with open-wheel or Kort nozzle propellers, typically about 2.74 m in diameter. These data are from experiments in a 1:25-scale model channel, barges, and towboat that has operating propellers, rudders, and openwheel or Kort nozzle propellers.

The following parameters were measured in the model:
a. Channel bottom pressure under moving tow.
b. Near-bed velocity and bed shear stress changes under the barges of a moving tow.
c. Near-bed velocity and bed shear stress changes in the stern region from the propeller jet for a stationary tow and from the combined effects of the propeller jet and the wake flow for a moving tow.
Analytical/empirical methods were developed to describe near-bed velocity and shear stress as a function of tow parameters.

ENV Report 25 - *Inflow zone and discharge through propeller jets* by Steve Maynord

ABSTRACT
The inflow zone and discharge through propeller jets are used in evaluating the environmental effects of navigation on the Upper Mississippi River and Illinois Waterway (UMR-IWW). Both physical and numerical models were used to define the zone of inflow to typical tows used on the UMR-IWW. Results showed that the inflow zone for underway vessels is about 25 m on either side of the centerline of the vessel for the typical three-barge-wide by five-barge-long push tow used on the UMR-IWW. Water in this zone can go through the propellers but not all water in this zone will go through the propellers. Discharge through propeller jets is defined using the momentum theory of propellers design. Equations for discharge are presented based on thrust coefficients and propeller speed and are the most accurate means of defining discharge. However, thrust coefficients are rarely provided by vessel operators and approximate methods for discharge are developed based on applied power. Equations are presented for discharge as a function of applied power, propeller diameter, propeller type, and vessel speed. Equations for discharge based on thrust coefficients are compared to measured velocities for two open-wheel systems and one ducted propeller system. The measured and calculated valves were in agreement.

ENV Report 26 – *Computer Model for Transport of Larvae Between Barge Tows in Rivers* by E. R. Holley

ABSTRACT
For two separate tows, each composed of one or more barges and a self-propelled vessel, or towboat, traveling in the same direction in a river, some percentage of the water and fish larvae that go through the propellers of the second towboat may have also gone through the propellers of the first or leading towboat. A computer program has been developed for calculating this percentage. For this calculation, the river is schematized as a rectangular channel with constant depth and constant velocity. Being located at a certain percentage of the total width of a rectangular channel is essentially equivalent to being at the same percentage of total flow rate in a natural channel.

The flows from the propellers of a towboat are analyzed as jets. The distances between tows are assumed to be large enough that the flow from the propellers of the leading towboat will become fully mixed over the river depth before the second towboat encounters this water. Thus, all of the analyses are done in terms of two-dimensional, depth-averaged conditions. The propeller jets are generated by a moving source, while the analysis was done in a stationary coordinate system. Thus, it was necessary to transform the momentum or through from the propeller jets in a moving coordinate system into an equivalent momentum in a stationary coordinate system.

For tows traveling upstream, the jets are treated as being in a co-flow, i.e., a flow which is going in the same direction as the jet. Since the jets can persist for large distances (on the order of a kilometer), an approximate analysis was done to account of the effects of boundary friction on the jets. The end of the jet region is determined based on a tolerance for the magnitude of the jet velocity relative to the river flow velocity. After the jet velocities decrease to being within this tolerance, ambient river diffusion is used to determine the mixing of the water form the propellers of the first towboat. Based on the jet velocities, the river flow velocity, the speed of the tows, and the

distance between the tows, the program determines whether the second towboat encounters the water from the first set of propellers in the jet region or in the ambient diffusion region and then calculates the makeup of the intake water for the second set of propellers. For these calculations, the river is divided into a number of vertical strips. The calculations are done for the center of the first tow, at the center of each of the vertical strips. For each location of the first tow, the second one can also be at the center of each of the vertical strips. The jet calculations for tows traveling upstream were verified by comparison with laboratory measurements of velocities downstream form a stationary towboat.

The calculations for tows traveling downstream are similar except that the propeller jets are now directed against the river flow sot he analysis is based on jets in counter flows. Since the jet and river flows are opposed to each other, the region of jet flow is small enough that the effects of boundary friction are not included in these calculations. The end of the jet region is taken to be when the water from the propellers returns to the cross section where the jet was generated.

ENV Report 27 - ***Definitions, Boundary Delineations, and Measurements of Attributes for the Hydraulic Classification of Aquatic Areas by*** Nickels.

And ***Hydraulic Classification Analysis*** (Appendix to Classification Definitions Report) by Thomas Pokrefke.

ABSTRACT

The study includes the development, integration, and application of hydrodynamic, hydrologic, sediment transport, and biological models to assess the impacts on the ecosystem. This modeling system will also aid in the design of required mitigation measures. The impacts include those potentially induced by new CE structures, rehabilitation, Operation and Maintenance practices, etc., that might occur due to the increased navigation traffic over the next 50 years. Both long- and short-term effects are of concern for the habitat in the main channel and channel borders, around islands, in backwater areas, sloughs, erosion of islands and banks, secondary channels, and sedimentation caused by navigation.

The analysis of the hydraulic classification should be considered as one method for linking the various types of backwaters and secondary channels in the UMR study trend pools where significant data exist to similar attributes in nontrend pools or river reaches where much less data are present. There are probably almost infinite ways to establish those linkages, and in fact, the methodology presented in this analysis was developed over several months and numerous reviews of the hydraulic classification and associated maps. What became evident in working through the hydraulic classification was that if one tries to provide linkages using numerous characteristics, a new classification tended to be developed. Therefore in this analysis, the linkage was based on a minimum number of characteristics or measured quantities within the hydraulic classification. Thus, the approach taken was that general characteristics and separation of attributes, such as contiguous backwaters with single inlets and outlets, was sufficient for delineation and linkage to other backwaters.

ENV Report 28 - ***Effects of Sediment Resuspension and Deposition on Plant Growth and Reproduction by*** Robert Doyle

ABSTRACT

This report summarizes a series of controlled experiments designed to investigate the impacts of suspended inorganic turbidity on the growth and reproductive potential of two submersed macrophytes of importance to the Upper Mississippi River System. Experiments were conducted on vallisneria (Vallisneria americana) and sago pondweed (Potamogeton pectinatus). Separate controlled experiments addressed the impacts of turbidity on mature plants, recently-sprouted tuberlings, and recently-germinated seedlings (vallisneria only).

Turbidity significantly depressed the continued vegetative growth of mature vallisneria. As turbidity increased, vallisneria plants produced fewer daughter plants and accumulated less biomass. In fact, the most turbid conditions (continuous exposure to 30 NTU) prevented the plants from producing new daughter plants, and decreased total plant mass. In addition, vallisneria tuber and flower production were reduced under turbid conditions.

Turbidity also impacted the vegetative growth and reproductive capacity of sago pondweed, although the magnitude of the effect was less than for vallisneria. Total mass produced declined as light levels dropped due to increasing turbidity. As turbidity increased, so did the shoot:root mass ratio of the plants. Apparently, under turbid conditions, the plants had to invest proportionally greater amounts of energy in light-acquiring tissues, and produced fewer roots. In terms of reproductive potential, turbidity negatively affected tuber production but did not impact flower production.

Turbidity had a much stronger effect on recently-sprouted tuberlings of vallisneria than of sago pondweed. Sago pondweed tubers showed 100% survival under all turbidity treatments, and produced similar numbers of stems under all treatments. Total mass per tank was also not significantly different among turbidity treatments. Turbidity did influence vallisneria tuber survival and growth, especially for the smaller tubers. Small tubers showed very low survival (<20%) under the highest turbidity but survival increased to > 60% with decreased turbidity. The number of rosettes produced by a single vallisneria tuber was negatively affected by turbidity.

Finally, vallisneria seedlings were profoundly negatively influenced by turbidity. Under turbid conditions, seedlings had higher mortality, produced fewer no daughter plants, and accumulated less biomass than seedlings in low turbidity conditions. In additions, the seedlings in the turbid tanks had to invest proportionally more energy into above-ground tissues in an effort to compensate for the lower light conditions.

ENV Report 29 - *Abundance of Fishes in the Navigation Channels of the Mississippi and Illinois Rivers and Entrainment Mortality of Adult Fish Caused by Towboats* by Steve Gutreuter, John M. Dettmers and David H. Wahl

ABSTRACT

This study quantified the abundance and composition of larval fishes in the navigation channel, as well as side channel and backwater areas, for the purpose of providing these data for input into models of losses of adult-fish equivalents, production foregone, and recruitment foregone. We also have developed methods to estimate abundance and entrainment mortality of juvenile and adult fishes in navigation channels of large rivers. Our estimates of the abundance of all life stages of fish suggest that substantial year-to-year variability in timing of appearance in the navigation channel and in density of fishes does occur, but the duration of the current study was not sufficient to determine to what extent this variability might affect entrainment mortality rates. Gizzard shad was the only species observed freshly killed in our specialized entrainment sampling behind towboats. We estimate that 9.5 adult gizzard shad are killed or seriously injured, on average, per km of travel by each towboat, with an 80% confidence interval of 3.8-22.8 fish/km. observed additional freshly killed adult gizzard shad, shovelnose sturgeon, and smallmouth buffalo in our ambient abundance samples. We developed a statistical method to estimate entrainment mortality rates of adult shovelnose sturgeon and smallmouth buffalo from the combined entrainment and ambient samples. These ancillary entrainment mortality estimates or shovelnose sturgeon and smallmouth buffalo are each 2.4 adult fish/km of tow travel, with 80% confidence intervals of O-6.0 fish/km of tow travel. Because the confidence intervals for shovelnose sturgeon and smallmouth buffalo include zero, we believe that it is reasonable to conclude only that entrainment mortality cannot be disregarded as an important component of their dynamics in the navigation channels of the Upper Mississippi River System. The freshly wounded fish from which all these estimates were obtained were all observed during fall and early winter, suggesting a substantial seasonal effect that cannot be confirmed because the study included only one fall-winter sampling period. This work has provided a much clearer picture of the fish assemblage that uses the navigation channel and has successfully generated the first estimates of entrainment mortality inflicted by towboats. However, substantial uncertainty remains, suggesting the need for additional refinement as river managers seek to determine the potential impacts of commercial navigation on fishes within the navigation

ENV Report 30 - *Evaluation of Propeller-Induced Mortality on Selected Larval Fish Species* by K. Jack Killgore, Steve T. Maynord, Matthew D. Chan, and Raymond P. Morgan II

ABSTRACT

Mortality of ichthyoplankton entrained through a scale model of a towboat propeller was evaluated in a large (>2 million L) circulating water channel. Five species of fish (larval shovelnose sturgeon S*caphjrhynchus platorynchus*,

larval lake sturgeon *Acipenser fulvescens*, larvae and eggs of paddlefish *Polyodon spathula*, larval blue sucker *Cycleptus elongatus*, and juvenile common carp *Cyprinus carpio*.) were subjected to one or more shear stress levels (634.1.613, 3.058. 4,743 dynes/cm^2). Mortality was a linear function of shear stress for all species and life stages. However, conditional mortalities (i.e., subtracting control from treatment mortality) were relatively low (<30 percent) for paddlefish eggs and common carp juveniles. Smaller larvae (lake sturgeon and blue sucker) experienced higher mortalities than larger larvae. However, conditional mortality of blue suckers was less than 50 percent due to high mortality of control groups. Delayed mortality was observed for all larval species, particularly at higher shear stress levels, but none for common carp juveniles and paddlefish eggs. Shear stress created from propeller jet velocities in navigable rivers can exceed 5,000 dynes/cm^2 and is probably the primary force contributing to mortality of ichthyoplankton entrained during vessel passage.

ENV Report 31 - *Physiological effects on freshwater mussels (Family: Unionidae) of intermittent exposure to physical effects of navigation traffic* by Barry Payne and Andrew Miller

ABSTRACT
Commercial navigation traffic in large inland waterways can cause brief episodes of increased turbulence and suspended solids - both of which are potentially deleterious to essentially sessile, filter-feeding mussels. Predicting the consequences of traffic to mussels is difficult due to the intermittent, brief nature of changed physical conditions. Previous laboratory studies by Aldridge et al. (1987) and Payne and Miller (1987) indicated that aspects of physiological energetics, including filtration rate, respiration rate, nitrogen excretion rate, O:N ratio, and tissue condition index, are sensitive indicators of potential deleterious consequences of traffic effects on mussels. Aldridge et al. (1987), using very high suspended solids concentrations and frequencies of disruption, showed an additive effect of increased suspended solids to turbulence and provided evidence that the frequency of intermittent disturbance was important. In their short-term experiments, upward shifts in O:N by mussels in the most severely stressed treatment groups proved to be the best indicators of shifts toward a negative bioenergetic balance. In longer term studies of turbulence effects (Payne and Miller (1987), mussels under the most severe stress (continuous high turbulence) showed reduced tissue-to-shell mass ratios.

In the present study, turbulence effects were investigated in an experiment long enough to elicit such tissue condition index changes, using an array of frequencies of exposure treatments that spanned the range likely to be encountered by mussels in the upper Mississippi River. Frequency of intermittent exposure to high turbulence levels had no relationship to deleterious condition changes in terms of filtration rate, respiration rate, nitrogen excretion rate, O:N, or tissue condition index. Additional short-term laboratory experiments were conducted to investigate additive effects of suspended solids to turbulence, using frequencies of exposure and levels of suspended solids much more realistic than those of Aldridge et al. (1987). Evidence of an additive effect of suspended solids was more equivocal than in the harsher experiments of Aldridge et al. (1987). Physiological disruption was slightly greater when high suspended solids concentration accompanied intermittent turbulence. The tendency was for downward shifts in nitrogen excretion and upward shifts in O:N. However, this tendency was not manifest in all species within an experiment nor among experiments for particular species. Although some statistically significant shifts were measured, major changes in metabolic condition generally were not indicated. No changes in tissue condition occurred. Studies of shell valve gape behavior indicated that mussels sometimes responded to navigation traffic effects by slightly closing their shell for a brief period. However, such behavior is varied substantially among mussels and for an individual over time.

In general, physical habitat disruption associated with routine navigation traffic tends to elicit minor shifts upward in O:N and measurable changes in shell gape behavior. These are relatively subtle physiological responses - consistent with the subtlety of brief, infrequent episodes of turbulence and elevated TSS. Although such responses can be elicited and measured, their biological significance appears to be slight. Results of all laboratory experiments have been summarized in a series of curves which relate potential level of stress to a mussel versus the four possible effects of commercial vessel passage: low and high turbulence without suspended solids, high turbulence plus high suspended solids, and high turbulence plus very high suspended solids.

ENV Report 34 - *Effects of pressure changes induced by commercial navigation traffic on mortality of fish early life stage,* by Thomas Keevin

ABSTRACT
Mortality of fish early life stages was measured in a pressure vessel to simulate pressure changes associated with entrainment in the propwash of the towboat and subsequent vertical displacement within the water column. Mortality was measured for three pressure regimes for five fish species: larval bigmouth buffalo *Ictiobus cyprinellus*, larval blue catfish *Ictalurus furcatus*, larval walleye *Stizostedion vitreum*, early juvenile bluegill *Lepomis macrochirus*, and early juvenile largemouth bass *Micropterus salmoides*. The maximum pressure change tested, 344.8 kPa, equivalent to a 35.2 m displacement of fish within the water column, did not cause significant mortality of larvae or juveniles. Since 35.2 m exceeds depths in the Upper Mississippi River navigation channel, the range of pressure changes that could be experienced by early life stages during towboat mixing of the water column will not result in significant mortality.

ENV Report 35 - *Mortality of fish early life stages resulting from hull shear associated with passage of commercial navigation traffic* by Thomas Keevin.

ABSTRACT
Mortality of fish early life stages was measured in a Couette cell to simulate fluid shear stress resulting from passage of a barge hull in the water column. Mortality was measured for three shear stress levels at three exposure times for five fish species: larval shovelnose sturgeon Scaphirhynchus platorynchux, larval bigmouth buffalo Ictiobus cyprinellus, larval blue catfish Ictalurus furcatus, juvenile bluegill Lepomis macrochirus, and juvenile largemouth bass Micropterus salmoides.

Mortality values were compared with calculated barge hull shear stress levels to determine the potential for mortality of fish early life stages in relation to commercial navigation traffic. There was no significant mortality of shovelnose sturgeon, blue catfish, bluegill, and largemouth bass at shear stress levels produced by barges in the upper Mississippi River. However, the hull of a high-speed tow (4.0m/sed) with a 1.22-depth/draft ration will produce a shear stress or 250 dynes/cm2 in 5 percent of the zone beneath the tow. This is the only area in the water column where hull shear stress values approach levels causing significant ($P<0.05$) mortality of bigmouth buffalo larvae. Therefore, it is unlikely that barge hull shear stress will result in substantial mortality of larval and juvenile fishes.

ENV Report 37 - *Entrainment and Transport of Sediments by Towboats in the Upper Mississippi River and Illinois Waterway, Numerical Model Study* by Ron Copeland

ABSTRACT
A numerical model study was conducted to determine the magnitude and duration of increased sediment concentration due to towboat passage. The quantity of bed material transport into backwater areas was also predicted. This was accomplished using two 2-dimensional numerical models for hydrodynamics (RMA2 and HIVEL), and a sediment transport model (SED2D). Ambient hydrodynamic bed shear stresses were calculated using RMA2. Bed shear stresses created by drawdown and return currents were calculated using HIVEL. Bed shear stresses induced by the bow pressure wave and the tow's propeller jet as a function of depth and ambient velocity were determined external to the numerical models using an algorithm developed from experimental techniques. The combined bed shear stresses from these three sources were imported into the SED2D sediment model to calculate entrainment and transport. The currently available SED2D model was modified to simulate towboat passage and to entrain bed sediments from rapidly changing bed shear stresses. The two-dimensional depth-averaged unsteady-flow sediment transport model was then used to simulate the advection and diffusion of suspended sediment. Portions of Pools 8 and 26 on the Mississippi River and the LaGrange Pool on the Illinois River were modeled. The study included collection of bed-material and suspended sediment data. Model results showed very little impact on ambient sediment concentrations on the Mississippi River where the predominate bed sediment was medium sand. Likewise the on the Illinois River where the predominant bed material in the center of the navigation channel was fine sand, sediment entrained by towboats was quickly re-deposited. However, cohesive sediment, which is located

in patches on the bed and all along the edge of the navigation channel, remained in suspension much longer than the sand.

ENV Report 38 – *Ecological Models and Approach to Risk Assessment* by Steven Bartell and Kym Rouse-Campbell

ABSTRACT

The Navigation Study environmental assessments were organized according to the framework recommended in the Guidelines for Ecological Risk Assessment (USEPA 1998). The ecological risk assessment process consists of three steps: problem formulation, analysis (characterization of exposure and characterization of ecological effects), and risk characterization. This report describes the overall approach adopted for performing the environmental assessments and presents several ecological models that were instrumental in their completion. The report also briefly outlines several hydraulic and hydrodynamic models necessary for the assessments and discusses their integration with the ecological models to estimate ecological impacts. The problem formulation component of each of the Navigation Study ecological risk assessments consists of developing a conceptual model of the entire assessment process. The overall conceptual model is presented in detail in this report. In each ecological risk assessment, the ecological stressors take the form of the physical forces produced directly by commercial vessels navigating the UMR-IWW System and indirect effects that result from these forces. The direct hydrodynamic forces imposed by operating commercial vessels include increases in river current velocity, return currents, or drawdown; pressure changes and shear stresses associated with the propeller jet; shear stresses on the bed sediments beneath the vessel; and bed shear stresses extending to the channel borders and backwaters. The analysis of exposure consisted of performing laboratory experiments on physical replicas of river segments; making direct measurements on selected pools; and developing mathematical models to quantify the frequency, magnitude, extent, and duration of the hydrodynamic forces. The ecological effects identified in the risk assessment included commercial traffic-induced increases in fish early life stage mortality, degradation or loss of fish spawning habitat, physical breakage of submerged aquatic vegetation, impacts on the growth and reproduction of submerged aquatic vegetation, and impacts on the growth and reproduction of freshwater mussels. The quantification of these ecological effects in relation to anticipated increases in commercial navigation traffic is the objective of each of the Navigation Study ecological risk assessments. Potential ecological risks posed by commercial traffic on the UMR-IWW System are characterized by integrating the ecological models with models that quantify the magnitude, extent, and duration of the physical forces produced by commercial vessels. Alternative traffic scenarios project the average number of vessels passing daily through each pool provide the initial conditions (e.g., vessels/day, vessel and barge configuration, direction, speed, draft) that drive the hydrodynamic forces models. Integration of the hydrodynamic forces models and the ecological models occurs by using the results of the hydrodynamic forces models as inputs to the ecological models. Completion of the Navigation Study ecological risk assessments will provide a set of integrated hydrodynamic and ecological models for the UMR-IWW System. This integrated "system model" will provide USACOE planning personnel, resource managers, and decision makers with additional capabilities to characterize ecological impacts, calculate risks, and answer questions.

ENV Report 39 – *Ecological Risk Assessment of the Effects of the Incremental Increase of Commercial Navigation Traffic on Freshwater Mussels in the Main Channel and Main Channel Borders* by Steven Bartell and Kym Rouse-Campbell

ABSTRACT

The Navigation Study Mussel Ecological Risk Assessment was organized according to the fundamental components of the ecological risk assessment process: problem formulation, analysis (characterization of exposure and characterization of ecological effects), and risk characterization (USEPA 1998). This report assesses the potential ecological risks posed by commercial traffic on freshwater mussels that live in the main channel and main channel borders of the Upper Mississippi River-Illinois Waterway (UMR-IWW) System. Backwaters were not included in this risk assessment. The assessment examines the possibility that commercial vessel-induced increases in suspended sediments might impair the growth and reproduction of freshwater mussels. Risks to mussels posed by commercial traffic resulting from two improvement scenarios were evaluated. Scenario 2 consists of guidewall extensions at UMR Locks 20-25 to be in place by 2008, while Scenario 3 consists of guidewall extensions at UMR Locks 14-18 and lock extensions at UMR Locks 20-25 to be in place by 2012. The scenarios are presented as

increases in the average daily number of vessels traversing each pool on the UMR-IWW System (i.e., tows/day). The threeridge mussel (*Amblema plicata*) was selected to represent the freshwater mussel community in the UMR-IWW System. It is one of the most common species and is widespread throughout the UMR-IWW System (USGS 1999). Additionally, it is one of the most important commercially-harvested species. A bioenergetics model for the threeridge mussel was developed and implemented for locations in the UMR-IWW System where mussel beds are known to occur. Freshwater mussel bed locations are included in a geographic information system (GIS) data base. For this risk assessment, selected locations included mussel beds in UMR Pools 13 and 26 and the IWW LaGrange Pool. Results of the model simulations indicated that increases in suspended sediment concentrations associated with traffic increases resulting from Scenarios 2 and 3 do not affect the growth and reproduction of threeridge mussels for five locations in Pool 13, three locations in Pool 26A, one location in Pool 26B, and fifteen locations in the LaGrange Pool.

ENV Report 40 – *Upper Mississippi River and Illinois Waterway Cumulative Effects Study. Volume I: Geomorphic Assessment and Volume II: Ecological Assessment* by WEST Consultants, Inc.

ABSTRACT (Vol I)
The methods and results of a detailed evaluation of the cumulative physical effects of the 9-foot Channel Project are presented. The evaluation includes a review of pertinent prior studies, identification of controlling geomorphic characteristics, description of significant human influences and characterization of historic changes along the UMR system. A wide range of existing literature and data are analyzed including historic discharge and sediment measurement records, existing 2-dimensional hydraulic models and information on river regulating structures and dredging activities. Historic changes are determined by identification, delineation, measurement and analysis of approximately 25,000 plan form features and 2,000 channel cross sections. Results of the analyses are used to predict future physical conditions along the UMR. An assessment of cumulative ecological effects is presented in Volume 2 of this report.

ABSTRACT (Vol II)
The methods and results of a detailed evaluation of the cumulative ecological effects resulting from select physical and biological changes that have occurred since construction of the 9-foot Channel Project are presented. Predictions of changes between the present and 2050, given current management protocols and planned or anticipated habitat enhancement projects, are also made. Physical habitat changes evaluated include plan form, current velocity, sediment types and water depths. Twenty-three guilds of aquatic organisms are identified and used in this analysis. The analyses are generally representative of summer low-flow habitat conditions and adult aged organisms. To evaluate changes in the guilds, their major habitat requirements are compared with the amount of increase or decrease in suitable habitat. The percent change in the area of available habitats is assumed to proportionally affect the abundance of individuals within each guild. Best professional judgment is used to account for changes due to contamination, sedimentation, harvest and other stressors. Lack of data precluded analysis of certain habitats, such as floodplains and a formal risk assessment is not made because of the limitations of both physical and ecological information.

ENV Report 44 – *Inventory of Hydrographic Survey and Cross-Section Data Available on the Upper Mississippi River and Illinois Waterway at the U.S. Army Engineer Districts, St. Paul, Rock Island, and St. Louis* by Rebecca Seal-Soileau.

ABSTRACT
An inventory of existing hydrographic survey and cross-section data on the Upper Mississippi River and Illinois Waterway was taken at the U.S. Army Engineer Districts of St. Paul, Rock island, and St. Louis. This data compilation was requested in support of the Cumulative Impact Assessment Group (CIAG) effort to assess existing information to make predictions regarding future river conditions. General descriptions of the data sets and where they are located as well as other references pertaining to sediments are included in the text of the report. The metadata for the data sets are found in the appendices arranged by district. An annotated bibliography of relevant references found at the districts is also included as an appendix.

ENV Report 50 – *Upper Mississippi River – Illinois Waterway System Environmental Objectives Planning Workshops* by Henry C. DeHaan, Nicole M. McVay, Charles H. Theiling and Rebecca Seal-Soileau.

ABSTRACT
The Upper Mississippi River – Illinois Waterway (UMR_IWW) System Navigation Feasibility Study has been restructured to give equal consideration of fish and wildlife resources along with navigation improvement planning. The objectives of this restructured feasibility study are to relieve lock congestion, achieve a sustainable ecosystem, and holistically address ecosystem and floodplain management needs related to navigation. The restructured navigation study will seek to ensure that the rivers and waterway system continues to be an effective transportation system and a nationally treasured ecological resource. The restructured study will: (1) further identify the long-term economic and ecological needs, and potential measures to meet those needs, through collaboration with interested agencies, stakeholders, and the public; (2) evaluate various alternative plans to address those needs; (3) present a plan consisting of a set of measures for implementation that will achieve the study objectives; and (4) identify and address issues related to the implementation of the recommended plan. Four two-day workshops were held during November 2002 to aid in e process of establishing measurable environmental objectives for the UMR-IWW system. Workshops were conducted in Peoria, Illinois; St. Louis, Missouri; La Crosse, Wisconsin; and Moline, Illinois.

ENV Report 52 – *Environmental Science Panel Report* by Ken Lubinski et.al.

ABSTRACT
This report summarizes the considerations and recommendations of an Environmental Science Panel that was convened in early 2003 to provide guidance to the U.S. Army Corps of Engineers and Upper Mississippi River (UMR) – Illinois Waterway (IWW) stakeholders regarding the restructured UMR – IWW System Navigation Feasibility Study. Between January and April of 2003, the Corps organized four Panel workshops to review and contribute to Navigation Study progress and to begin work on several specific tasks. Those tasks required considerations of not only procedural steps anticipated during the remainder of the Navigation Study, but also issues related to the future establishment of an adaptive management process on the UMR – IWW. At the conclusion of the workshops, the Panel made the following recommendations:

- Planning for a formal Adaptive Management approach on the UMR – IWW should be accelerated and expanded to include multiple organizations and programs.
- Ecosystem goals and objectives developed so far through stakeholder input should be clarified and integrated. A structured process for evaluation of the unavoidable trade-offs between the ecological and economic values of the system should be established.
- Conceptual and simulation modeling should be established as vital steps in the adaptive management process in order to:
    1) Record the current state of the system.
    2) Create a holistic "virtual" reference system.
    3) Predict system-level outcomes of alternative actions and policies.
- Management actions available for implementation on the UMR – IWW should focus on attaining goals and objectives at the system level—with appropriate attention to risk and uncertainty.
- A UMR – IWW report card system and appropriate monitoring system should be developed to evaluate system condition and attainment of objectives.
- Selected future management actions should be considered as experimental manipulations, which will achieve stated objectives, enhance ecosystem health, and provide knowledge in a predictable and structured way.

16.2 Historic Properties Reports

HP Report 1 – *Assessment of Archeological Site Potential at Commercial; Navigation Erosional Areas on Lands Within the Illinois Waterway System Between Brandon Road Lock and Dam and Grafton, Illinois Within the St. Louis and Rock Island Districts* by Ahler, Stephen of the Illinois State Museum Society Archaeological Services, Springfield, Illinois

ABSTRACT
The Illinois State Museum Society (ISMS) reviewed a total of 699 locations on the IWW that had been identified by the Corps as having high or medium potential to erode as result of commercial navigation-related activities (n=510), barge facilities (n=179), and barge waiting points (n=10). The review resulted in a prioritization of erosion areas by their potential to impact significant historic properties. ISMS identified 85 previously recorded archeological sites within 50 meters of 87 erosion areas. Twenty-four of the areas are adjacent to sites that are either listed on the NRHP or have been determined to be eligible for listing. ISM gave these areas the highest priority ranking. An additional 33 areas are adjacent to archeological sites that are in need of formal NRHP evaluation; these have second priority. Four areas require formal NRHP evaluation of known sites as well as archeological survey. Twenty-six areas are adjacent to archeological sites that are either ineligible for the NRHP or are presently protected and require no further evaluation. One hundred and thirty two areas have been fully surveyed for historic properties and require no further evaluation. Another 57 potential erosion areas have no associated archeological sites and include some form of bank protection. These areas are given the lowest priority for archeological survey by ISM. The remaining 423 erosion areas have not been formally surveyed and have no form of bank protection. These areas are further prioritized by their associated LSA and potential for near-surface and buried historic properties. Eighty-four of the 423 erosion areas are identified as having high potential to impact historic properties while the remaining 339 areas have moderate potential. In summary, ISM documented 61 potential erosion areas adjacent to archeological sites that would likely require some form of field evaluation. In addition they identified 84 potential erosion areas that have high potential for undocumented historic properties and would likely require some form of field evaluation/verification. The ISM report was coordinated with the Illinois SHPO and concurrence with the recommendations was received (IHPA Log #0001180024KRG).

HP Report 2 – *The Historic Properties Management Plan for the Mississippi River, Pools 11 Through 22 Rock Island District, Corps of Engineers* by Benn, David W., Robert C. Vogel, E.A. Bettis III and J.D. Anderson of Bear Creek Archeology, Inc., Cresco, Iowa

ABSTRACT
This document is an historic properties management plan (HPMP) for the treatment of recorded and potential cultural resources in the Upper Mississippi River (UMR) pools 11 through 22 under jurisdiction of the Rock Island District, Corps of Engineers, (RICOE). The UMR-HPMP is a comprehensive program for the identification, evaluation, and preservation of cultural resources on federal property and on other lands that might be affected by operation of the navigation system. The organizing principal of the UMR-HPMP is an approach termed "comprehensive planning in context," which means decisions about cultural resource management are formulated within the context of what is already known about the prehistory, history, and current uses of the UMR study area. The HPMP establishes a set of goals and policies as the core of the HPMP and employs a database to consolidate current in historic properties records for the navigation zone of the UMR. Combining the goals and policies of the plan with the database analysis, a series of prioritized recommendations are derived for managing historic properties in the UMR into the next century. Appended to the HPMP are chapters containing the supporting data and descriptive texts. Other materials relating to the UMR-HPMP are bound separately, including the initial database, the HPMP database, and compendium of SHPO compliance letters for archeological projects with the UMR-RICOE district.

HP Report 3 – *Consolidation of the Archeological Sites Database for the Historic Properties Management Plan for the St. Louis District Corps of Engineers Lands Between Mississippi River Miles 0-300, Above the Ohio River* by Benn, David W., Robert C. Vogel, E.A. Bettis III, and J.D. Anderson of Bear Creek Archeology, Inc., Cresco, Iowa

ABSTRACT
This report describes the methods of preparation and summarizes the archeological site data for portions of the Historic Properties Management Plan (HPMP) developed for lands under the jurisdiction of the St. Louis Corps of Engineers (COE) within Upper Mississippi River (UMR) Pools 24-26 and open Mississippi River channel and bankline between Lock and Dam 26 and the confluence of the Mississippi and Ohio rivers (miles 0-301.2). There are two archeological site databases in this report. The INITIAL database lists all the archeological sites, their locations, and ownership status for the entire USGS 7.5 minute quadrangle maps within the Upper Mississippi River Valley in the St. Louis District. The HPMP database lists all of the archeological sites within the navigation zone, and includes locational information, context, cultural age, management history, National Register status, and adverse effect for each historic property. The text that accompanies the databases presents background information for the project, constructs a geomorphological overview of the Mississippi River landforms, describes how the databases were prepared, and evaluates some of the information in the HPMP database for variables such as cultural context, ownership, site integrity, land use, and adverse impacts. Four recommendations are suggested: Mapping landform sediment assemblages, studying the effects of bank erosion, a survey for site contexts, and a study of historic fur trade patterns.

HP Report 4 – *Historic Properties Potential & Geomorphological Assessment at Locks and Dams 11-22, 24, and 25, Upper Mississippi River System, Illinois, Iowa, Missouri, and Wisconsin* by Benn, David W. and Jeffery D. Anderson of Bear Creek Archeology, Inc., Cresco, Iowa

ABSTRACT
The purpose of this report is to present the findings of a reconnaissance survey to determine to prehistoric and historic archeological property potential and geomorphological contexts for locks and dams 11-22 in the Rock Island District and locks and dams 24 and 25 in the St. Louis District, United States Army Corps of Engineers. A reconnaissance survey was conducted by David W. Benn (archeologist) and Jeffrey Anderson (geomorphologist) for the Rock Island District Corps of Engineers under terms of Contract No. DACW25-92-D-0008, Work Order No. 26 with Bear Creek Archeology, Inc. The principal products of this investigation are evaluations of the archeological potential, including buried surfaces, of federal properties and recommendations regarding the need for phase I surveys, the potential NRHP eligibility of recorded sites within the projects areas, and avoidance or data recovery plans for adversely affected sites. All of the lock and dam facility properties are judged to have very low or low archeological resource potential. All of the viable archeological sites and landforms with moderate to high potential for cultural resources are identified either on federal property around the fringes of these facilities or on private lands adjacent to COE land. Thus, the proposed construction of larger (1200 ft) locks within the current facilities is predicted to have no direct effects on archeological sites. It is the ancillary activities, such as channel improvement, disposal of dredge material, and opening of construction support areas, that are likely to affect known and potential archaeological deposits. Phase I archeological survey and archival research are recommended for the ancillary work zones at locks and dams 11, 12, 13, 15, 16, 17, 18, 20, 21, 22, 24, and 25. Avoidance of project effects is recommended for 13ST84 and the burial mounds (11A34, -35, -1353, -1354, -1355) in the town of Meyer, Illinois (Lock and Dam 20). Test excavations are recommended for 11MC124, 23LE339, and 23LE353.

HP Report 5 – *Consolidation of Extant Data for the UMR-IWWS Navigation Feasibility Study and the Development of Portions of the Historic Properties Management Plan for the Corps of Engineer Lands Between Mississippi River Miles 0-300 Above the Ohio Rivers in Illinois and Missouri* by Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
This report summarizes archeological site data for portions of the Historic Properties Management Plan (HPMP) developed for lands under the jurisdiction of the St. Louis Corps of Engineers (MVS) with Upper Mississippi River (UMR) Pools 24-26 and open Mississippi River channel river (miles 0-301.2). The report includes two archeological

site databases that identify all sites within the Upper Mississippi River Valley and within the navigation zone respectively. A total of 265 sites were identified within the navigation zone. The only current primary navigation effect observed in the HPMP sample are impacts due to levee construction and maintenance. Fourteen of 265 sites are affected by this impact. Seven of these sites are on Corps property, and the 14 sites are located either upriver from the Illinois River confluence or in the American Bottom locality around St. Louis. The only current secondary navigation effect (i.e., an impact indirectly caused by use of the river for commercial navigation) registered in the HPMP sample is bank erosion. According to the field reports of the 1997 bank erosion survey on the UMR, none of the 21 Corps-owned sites is affected by bank erosion. The twenty sites affected by erosion on non-Corps lands are scattered throughout the district with a small concentration in the American Bottom.

HP Report 6 – ***Assessment of the Historic Properties Potential at Commercial Navigation Erosion Sites on the Mississippi River in the St. Louis, St. Paul, and Rock Island Districts by*** Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
The BCA analysis of the UMR identified 33 areas with a high potential to impact significant historic properties. Twenty of the erosion areas are adjacent to 21 archeological sites, a discrepancy due to the fact that in some cases multiple archeological sites are found adjacent to one erosion area and, in other cases multiple erosion areas are adjacent to the same archeological site. Two of the sites are eligible for the NRHP while 19 have yet to have their NRHP eligibility determined. The remaining 13 erosion areas with high potential to impact historic properties were chosen on the basis of the associated LSA. All high potential areas are recommended for intensive Phase I archeological survey. A total of 121 areas were identified with moderate potential to impact historic properties. These areas are recommended for monitoring and if erosion is documented, intensive Phase I archeological survey. Of that total, 9 erosion areas are adjacent to historic properties that are potentially eligible for inclusion on the NRHP. The BCA analysis identified 807 areas with low potential for impacting historic properties that would require no archeological survey. Eight of these erosion areas are adjacent to previously recorded archeological sites; however, these sites (n=7) have either been determined ineligible for inclusion on the NRHP (n=1) or are potentially eligible but not threatened due to existing protection (n=6). The BCA report was coordinated with the state historical preservation offices (SHPO) in Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Concurrence with the recommendations was received from Illinois (IHPA Log #0002160009KRG), Missouri (HPP Log Number N409), Iowa (R&C#: 900500072), and Minnesota (No Log Number). No comments were received from the Wisconsin SHPO.

HP Report 7 – Landform ***Sediment Assemblage (LSA) Units in the Upper Mississippi River Valley, United States Army Corps of Engineers, Rock Island District*** by Bettis, E. Arthur III, Jeffrey D. Anderson, and James S. Oliver

ABSTRACT is not available at this time.

HP Report 8 – ***An Investigation of Submerged Historic Properties in the Upper Mississippi River and Illinois Waterway*** by Custer, Jack E. and Sandra M. Custer of Steamboat Masters & Associates, Louisville, Kentucky, as a Cultural Resources Subcontractor to American Resources Group, Ltd., Carbondale, Illinois

ABSTRACT
The objective of this project was to identify all possible submerged boats, structures, and significant navigational markers dating from the nineteenth century to as late as 1960. The area in which the investigation was conducted was the federally controlled waters of the Rock Island District, U.S. Army Corps of Engineers. The 2 rivers involved were: (1) the Upper Mississippi River, Miles 300-614, from Saverton, Missouri, to Guttenburg, Iowa; and (2) the Illinois Waterway, Miles 80-327, from La Grange, Illinois to the North Branch of the Chicago River. One hundred and thirty-one boat sites were documented within the project area. These sites may include the remains of steamboats or other motor vessels. In addition, 7 submerged structures and navigational markers were documented within the project area.

HP Report 9 – ***Landform Sediment Assemblage (LSA) Units in the Illinois River Valley and the Lower Des Plaines River Valley*** by Hajic, Edwin R. of Illinois State Museum Society Archaeological Services, Springfield, Illinois.

ABSTRACT
Landform sediment assemblage (LSA) units are interpreted from geomorphic maps constructed on USGS 7.5' topographic maps. Original data maps are digitized using the ARC/INFO geographic information system. LSA units are defined, described, and summarized in terms of distribution along the valley; relationships to other LSAs; sedimentology, stratigraphy, and depositional environments; and, relative and absolute ages. Based on these data, the potentials of LSA units for having associated prehistoric cultural deposits are summarized based on depositional environments, drainage conditions, and relative rates of depositional processes.

HP Report 10 – ***Cultural Resources Inventory of the Upper Mississippi River, St. Anthony Falls to Pool 10, Wisconsin, Iowa, and Minnesota*** by Jalbert, Andrew, David F. Overstreet, and John D. Richards of Great Lakes Archaeological Research Center, Inc., Milwaukee, Wisconsin.

ABSTRACT
This report includes a regional cultural and geomorphic context and includes an inventory of identified precontact and historic archaeological sites from an area one-quarter mile landward of the bluff line on either side of the Mississippi River between Upper St. Anthony Falls, Minneapolis, Minnesota to Lock and Dam 10 at Guttenberg, Iowa. A total of 1,525 archaeological sites were codified and incorporated into a *dBASE III plus* database. Recommendations include conducting fieldwork to 'field check' or resurvey sites in order to update site information and to initiate geomorphic investigations across representative Landform Sediment Assemblages to build on and refine existing geomorphic information. Finally, the report recognizes shortcomings with the database conceived for the study and provides recommendations for its restructure.

HP Report 11 – ***Gently Down the Stream: An Inquiry into the History of Transportation on the Northern Mississippi River and the Potential for Submerged Cultural Resources*** by Jensen, John O. of the State Underwater Archeology Program, Division of Historic Preservation, State Historical Society of Wisconsin, Madison, Wisconsin.

ABSTRACT
The investigation identified 64 possible shipwreck sites and one possible location of an old pontoon bridge on the Upper Mississippi River between Guttenberg, Iowa and Minneapolis, Minnesota (including portions of the Black River near La Crosse and the St. Croix River up to Stillwater, Minnesota).

HP Report 12 – ***Geomorphological Mapping and Archaeological Sites of the Upper Mississippi River Valley, Navigation Pools 1-10, Minneapolis, Minnesota to Guttenberg, Iowa*** by Madigan, Thomas, Ronald C. Shirmer, Clark A. Dobbs, Jeff Berry, and John Rogers of IMA Consulting, Inc., Minneapolis, Minnesota.

ABSTRACT
This investigation resulted in the mapping of landform sediment assemblages (LSAs) and archeological sites in the upper Mississippi River Valley and the prediction of potential for each LSA to contain surface exposed or buried archaeological sites. Both archeological sites and LSAs were digitized into GIS coverages.

HP Report 13 – *Historic Properties Potential and Geomorphological Assessment Along the Illinois Waterway for the Rock Island District of the U.S. Army Corps of Engineers* by Martin, Claire F., Edwin R. Hajic, and Michael D. Wiant of Illinois State Museum Society Archaeological Services, Springfield, Illinois.

ABSTRACT
The Illinois State Museum Society compiled a land-use history of Corps facilities, principally locks and dams, along the Illinois River. The evaluations included: 1) geomorphic assessment of the lock facility and its geomorphic context in the Illinois River valley; 2) examination of archaeological site records; 3) examination of historic documents pertaining to settlement and land use prior to lock construction and 4) examination of plans for lock construction and modification of lock infrastructure. Archaeological assessment is recommended for small selected areas at five of the facilities including Dresden Island, Starved Rock, Peoria, and LaGrange.

HP Report 14 – *Gateways to Commerce* by O'Brien, William Patrick, Mary Yeater Rathbun, and Patrick O'Bannon of the Rocky Mountain Region of the National Park Service, Denver, Colorado.

ABSTRACT
This is the second in a series of National Park Service monographs about cultural resources in the Rocky Mountain Region. This monograph documents the construction of the 9-Foot Channel Project and results from three Historic American Engineering Record (HAER) studies completed under the direction of the Rocky Mountain Regional Office.

HP Report 15 – *Architectural and Engineering Resources of the Illinois Waterway between 130th Street in Chicago and La Grange: Volumes I and II* by Rathbun, Mary Yeater of Rathbun Associates, Hollandale, Wisconsin, as a Subcontractor to American Resources Group, Ltd., Carbondale, Illinois.

ABSTRACT
Nine historic properties with a collective total of 73 contributing resources were documented as eligible for inclusion on the National Register of Historic Places. It was recommended that all nine properties be organized as a multiple property submission to the National Register starting with a Chicago to Grafton, Illinois, Navigable Water Link, 1836-1945, Multiple Property Documentation form.

HP Report 16 – *National Register of Historic Places Multiple Property Submission: Upper Mississippi River 9-Foot Navigation Project, 1931-1948* by Rathbun, Mary Yeater of Rathbun Associates, Hollandale, Wisconsin, as a Subcontractor to American Resources Group, Ltd., Carbondale, Illinois.

ABSTRACT
This document details the history, property types, evaluation methods, and significance of 14 National Register of Historic Pleases historic districts within the Upper Mississippi River 9-Foot Navigation System, which are found between Minneapolis, Minnesota, and Winfield, Missouri, and are located within the states of Illinois, Iowa, and Missouri, and Wisconsin. This document is the culmination of six similar surveys of the 9-Foot Project and includes Lock and Dam Nos. 11 (R.M. 583.8), 12 (R.M. 556.7), 13 (R.M. 522.5), 14 (R.M. 493.3), 14 (R.M. 493.3), 15 (R.M. 482.9), 16 R.M. 457.2), 17 (R.M. 437.1, 8 (R.M. (410.5), 19 (R.M. 364.2, 20 (R.M. 343.2), 21 (R.M. 324.9), 22 (R.M. 301.2), 23 (R. M. 283.7), and 25 (R.M. 241.5). The 14 forms delineates the 17 district boundaries, categorizes the 158 contributing and 409 noncontributing resources, and evaluates each District's contribution to patterns of transportation, maritime history, engineering, commerce, conservation, military, politics, economics, labor, and social history during the period from 1931 to 1958.

HP Report 17 – *The Historic Properties Management Plan for the Illinois Waterway System, Rock Island District, Corps of Engineers: Volumes I and II* by Roberts, Timothy E., Claire F. Martin, Edwin R. Hajic, Christy S. Rickers, Erich K. Schroeder, James S. Oliver and Michael D. Wiant of the Illinois State Museum Society Archaeological Services, Springfield, Illinois.

ABSTRACT
This document is an Historic Properties Management Plan (HPMP) for the Illinois Waterway System (IWWS) under the jurisdiction of the Rock Island District Corps of Engineers (RICOE). It is a cultural resource management tool for the treatment of previously recorded and potential historic properties located with the navigation zone for the IWWS. The HPMP includes two databases which contain current information on cultural resources within the IWWS. Database sites within the navigation zone were evaluated for types of current impacts, their relationships to landforms, integrity, and provisional National Register status. By combining site database analysis and the goals, policies, and cultural contexts presented within the HPMP, a series of general recommendations were derived for managing cultural resources within the IWWS and individual sites within the navigation zone were assigned specific management priority rankings. The HPMP-IWWS provides a comprehensive reference for the identification, evaluation, and preservation of cultural resources located within the waterway.

HP Report 18 – *Historic Properties Management Plan* by St. Paul District, Corps of Engineers

ABSTRACT is not available at this time.

HP Report 19 – *Unpublished Manuscript of St. Louis District Shipwrecks* by Swift, James

ABSTRACT
This manuscript contains information related to shipwrecks (primarily steamboats) on the Mississippi River between the confluence with the Ohio and Hannibal, Missouri, and on the lower 80 miles of the Illinois River. The information was obtained from contemporary sources including newspaper accounts, merchant marine records, insurance records, and the Bureau of Navigation. These cross-indexed sources list a total of 690 vessels reported sunk on the Mississippi River and 23 reported sunk on the Illinois River. These vessels were lost between 1819 and 1938. Vessel name, wreck location, wreck date, vessel size, and other remarks were provided, if such information was available.

HP Report 20 – *Shoreline Erosion Monitoring at Twenty Archeological Sites, Rock Island District, Upper Mississippi River System* (1998) by Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
The purpose of this report is to present the findings and digital maps for an initial study of shoreline erosion monitoring at twenty archeological sites in the Upper Mississippi River valley. The 20 archeological sites selected for erosion monitoring belong to a new RICOE archeological district which is in the process of being nominated to the National Register of Historic Places. These sites were chosen for the monitoring study from the 530+ known sites within the RICOE navigation zone based on the following criteria: Corps ownership; NRHP potential, not previously mapped: representative of the types of sites with on-going adverse effects due to the river navigation system. The project involved establishing permanent datums, mapping the bankline, and creating a contour map for each site. The datums, whose locations are recorded by a GPS, will be used to precisely relocate the sites in the future and to measure the rate of change in the location of the cutbanks. A contour map was obtained in the area behind the bankline for each site so that the shape of the landform can be visualized. The twenty mapped sites and five other sites that were visited but not mapped also were evaluated for bank erosion impacts. This information included observations about conditions along the cutbank and the types of artifacts eroding from each site. Maps of the twenty sites were compared to the 1929-30 Brown engineering charts to determine how much bank retreat has occurred in 60 years.

HP Report 21 – ***Shoreline Erosion Monitoring at Twenty Archeological Sites, Rock Island District, Upper Mississippi River System*** (2000) by Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
This report presents the findings and digital maps for an initial study of shoreline erosion monitoring at twenty-one archeological sites in the Upper Mississippi River valley. Twenty-one sites on RICOE property that are either potentially eligible for the NRHP or are unevaluated w ere visited for the purpose of placing permanent datums and mapping their erodable banklines. Most of these sites are situated on navigable waters and are subject to bankline deterioration due to passing boat traffic. The RICOE will be able to monitor these sites for the rate of bankline erosion during the next 50 years. Information recorded in this volume regarding the 21 sites are compared to the 1929-30 Brown engineering charts to determine how much bank retreat has occurred in 60 years since the locks and dams were emplaced. Recommendations for the mitigation of adverse effects on sites include: Preservation (47GT32 and 11JD113); monitoring (13CT211, 13CT222, 47GT413, 47GT416, 11JD130, 13JK138, 13CN55, and 13CN60); testing (47GT411, 47GT412, 47GT419, 11JD123, 11JD132, 11CA117, and 11CA118); mitigation of adverse impacts (11CA44); and destroyed (47GT410, 11CA114, and 13CN57).

HP Report 22 – ***Archeological Testing of Nine Sites in Support of Shoreline Erosion Monitoring, Rock Island District, Upper Mississippi River System*** by Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
This report presents the findings and digital maps for a site boundary definition and initial deep testing study at nine archeological sites in the UMR. The purpose of this study is to examine the contents and stratigraphy of a small, but representative, sample of prehistoric archeological sites that are currently threatened by bank erosion due in part to maintenance of the UMR for commercial and recreational navigation. The sites tested during this study were selected by the PI based on information in the HPMP for the Mississippi River and on the latest results of site mapping in Pools 11 and 12. Excavation results lead us to sort the nine sites into three recommendation categories. Three sites judged to be "not significant" (13CT210, 11JD129, and 11MC124) have been damaged or destroyed to a degree that their cultural deposits no longer possess sufficient research value. Two sites (11JD132 and 11CA13) retain the potential to be eligible for the NRHP but limited testing in this project did not determine their status. Site 11jD132 should be monitored for bank erosion and artifacts. Site 11CA13 should be subjected to intensive testing to make a final determination as to its significance. Four sites (47GT411, 47GT412, 11JD125, and 11CA10) are judged to be eligible for inclusion to the NRHP and measures should be undertaken by the RICOE to mitigate adverse impacts to the cultural deposits, most of which is bank erosion.

HP Report 23 – ***National Register of Historic Places Multiple Property Documentation Form with Associated Nomination Forms for Corps-Owned Historic Properties Along the Mississippi River in the States of Illinois, Iowa, Missouri, and Wisconsin*** (2 Volumes) by Benn, David W. of Bear Creek Archeology, Inc., Cresco, Iowa.

ABSTRACT
Each of the 38 nominated sites is relatively intact and has yielded cultural diagnostic materials, which can be related to the cultural sequence and research problems outlined in the nomination. The text identifies property types known to be present and expected to occur as more sites are intensively investigated by archeological techniques. The information and interpretations discussed here are not being represented as anything more than a perfunctory review of what is known about past human occupation in the Upper Mississippi Valley from regional research and the RICOE site database of 534 entries. Only a handful of the 38 nominated sites have been investigated beyond the survey level, but the few sites already subjected to testing have proven to hold enormous research potential by having stratified components, intact artifact associations, features, and preserved biological remains.

HP Report 24 – ***National Register of Historic Places Multiple Property Submission: Illinois Waterway Navigation Study Facilities*** by Henning, Barbara J. of the Illinois State Museum Society, Springfield, Illinois.

ABSTRACT
This document details the history, property types, evaluation methods, and significance of 7 National Register of Historic Pleases historic districts within the Illinois Waterway, which are found between Chicago, and La Grange, Illinois, and is located entirely within the State of Illinois. This includes the original facilities of the 9-Foot Project and includes Lock and Dam Nos. 2 Lockport Lock, Dam, and Power House (R.M. 191.0), 3 Brandon Road Lock and Dam (R.M. 286.0), 4, Dresden Lock and Dam (R.M. 271.4), 5 Marseilles (R.M. 244.4), 6 R.M, Starved Rock Lock and Dam (231.0), 7, Peoria Lock and Dam (R.M. 157.7) and 8, LaGrange Lock and Dam (R.M. 80.2) and the Illinois Waterway Project Office (R.M. 164.4). The NRHP form delineates the 8 district boundaries (1, T. J. O'Brien, R.M. 326.4 is not included due to it's construction in 1960), categorizes the 35 contributing and 18 noncontributing resources, and evaluates each District's contribution to patterns of transportation, maritime history, engineering, commerce, conservation, military, politics, economics, labor, and social history during the period from 1905 to 1952.

HP Report 25 – ***Historical Shipwrecks on the Middle Mississippi and Lower Illinois River*** by Norris, F. Terry of the St. Louis District of the U.S. Army Corps of Engineers, Curation and Archives Analysis Branch.

ABSTRACT
This report summarizes the results of archival analysis and on-site reconnaissance surveys and compiles tabular data on nearly 700 shipwrecks on the middle Mississippi and lower Illinois rivers. In addition, the shipwreck site locations are documented on composite maps generated from General Land Office Survey (GLO) entries and historical Corps river channel surveys.

16.3 Economics Reports

EC Report 1 - ***Transportation Rate Analysis: Upper Mississippi River Navigation Study*** - July 1996, Tennessee Valley Authority (TVA) (**Complete but only Volume I available - the other volumes contain propriety information on individual movements**.)

EC Report 2 - ***Rail Rates and the Availability of Water Transportation: The Upper Mississippi Basin*** - July 1996 (Revised), Tennessee Valley Authority (TVA).

EC Report 3 - ***Waterway Traffic Forecasts for the Upper Mississippi River Basin*****,** - April 7, 1997, by Jack Faucett Associates, for the Institute for Water Resources

Volume I: Summary
Volume II Grain
Volume III Agricultural Chemicals
Volume IV Prepared Animal Feeds
Volume V Coal
Volume VI Industrial Chemicals
Volume VII Petroleum Products
Volume VIII Construction Materials
Volume IX Steel and Steel Sector Raw Materials.
Review of Historic and Projected Grain Traffic on the Upper Mississippi River and Illinois Waterway: An Addendum – Draft Report September 20, 2000

EC Report 4 - ***The Incremental Cost of Transportation Capacity in Freight Railroading*** - July 1998, by Marshall University.

EC Report 5 - ***A Spatial Price Equilibrium Based Navigation System NED Model for the Upper Mississippi River Illinois Waterway Navigation System Feasibility Study*** - July 6, 1998, by St. Louis District US Army Corps of Engineers. **(Complete – not full interim report, documentation of conceptual approach and application)**

EC Report 6 - ***Calculating the Value of Upper Mississippi River Navigation: Methodological Review and Recommendations*** - February 1999, Marshall University.

EC Report 7 - ***Commercial/Recreational Navigation Conflicts*** – August 1999, by US Army Corps of Engineers Rock Island District.

EC Report 8 - ***Regional Impacts of Nine Construction Options for Infrastructure Modernization on the Upper Mississippi River & Illinois Waterway***, January 2000, TVA

EC Report 9 - ***Analysis of Energy, Emission, and Safety Impacts of Alternative Improvements to the Upper Mississippi River and Illinois Waterway***, March 2000, Earth Tech (and Denver Tolliver, North Dakota State University)

EC Report 10 - ***Upper Mississippi River-Illinois Waterway (UMR-IWW) System Navigation Study Accidents and Hazardous Spills Task*** by Transportation Research and Analysis Center, Inc., Delaplane, Virginia. Final Report, August 1996 (180 pages-including blank pages).

EC Report 11 – ***Emissions and Fuel Use Analysis for Upper Mississippi River Basin. Report*** by The University of Memphis Transportation Studies Institute, Memphis, Tennessee. April 1998 (35 pages).

EC Report 12 – ***Accidents and Hazardous Spills Analysis for Upper Mississippi River Basin*** by The University of Memphis Transportation Studies Institute, Memphis, Tennessee. September 1998 (49 pages).

EC Report 13 - ***Fleeting Analysis*** - April 2000, by US Army Corps of Engineers Rock Island District.

EC Report 14 – ***Induced Development*** –

EC Report 15 – ***Upper Mississippi River and Illinois Waterway Navigation Study Economic Scenarios and Resulting Demand for Barge Transportation*** by Sparks Companies, Inc.

EC Report 16 – ***Regional Economic Impact Analysis of Construction Activities and Transportation Savings Due to Changes in Inland Waterway Systems – An Operational Guide for Using the Multiregional Variable Input-output Modeling System*** by Dennis P. Robinson, Ph.D., Of Planning and Management Consultants, Ltd.

EC Report 17 – ***Upper Mississippi River 2003 Sample Rate Study*** by Tennessee Valley Authority

16.4 Engineering Reports

EG Report 1 - ***Engineering Objective 1 Report, Baseline Operation and Maintenance***, November 1995.

ABSTRACT
This report establishes the funding required to operate and maintain the existing system. The report establishes past policies, practices, and historical trends in the Operation and Maintenance (O&M) budget and provides a projection of future O&M investments to keep the existing system operational through the study period. The future O & M baseline condition was based on current O & M funding policies that reflected no significant increases beyond recent levels. The recent levels of O & M baseline funding dictated that the Upper Mississippi River and Illinois Waterway Navigation system would continue to deteriorate and degrade.

The primary goal of Objective 1 was collecting, analyzing, and projecting historical cost data for the Upper Mississippi River and Illinois Waterway systems. Objective 1 established the baseline for determination of the without-project condition for the Upper Mississippi River and Illinois Waterway Navigation system. The baseline condition excluded any future rehabilitation or replacement of locks and dams.

The baseline estimate was established by assuming current maintenance practices, policies, and funding limitations will continue through the study period. Additional factors that could cause increased maintenance and operational costs such as increased traffic, painting regulations, increased wear and aging of equipment and components, zebra mussels, and dredging costs were analyzed and investigated, but not included in the baseline cost. The baseline estimate for the system was $115,000,000 per year in year 2000 dollars. This figure was based on historical cost data from fiscal years 1981 through 1992.

The system's locks and dams were mainly constructed in the 1930's and are currently undergoing a major rehabilitation. Over the study period, without an influx of funding above the baseline condition, the lock and dam navigation system will degrade and deteriorate. Eventually, a Major Maintenance and Rehabilitation effort or replacement of locks and dams will become necessary.

EG Report 2 - ***System Significant Components, Engineering Reliability Models Report***, July 1997.

ABSTRACT
This is a stand-alone report compiling model information on the analytical reliability assessments developed by the Engineering Work Group. Reliability assessments were prepared from 1993 through 1995. The UMR&IWW System Navigation study included tasking the three-district Engineering Work Group to determine the expected investment costs to operate the overall navigation system at an acceptable performance level for the 2000-2050 planning period. The expected investment costs for the without-project condition were derived from three contributing sources. The first investment cost source is derived from a projection of the historical Baseline Operation and Maintenance costs. The second investment cost source is derived from the expected costs associated with the engineering/economic reliability assessment analyses of the Future Without-Project condition of the system significant components. The final investment cost source is derived from the expected costs associated with components not captured via the reliability assessments. The report provides a compilation of the Engineering Work Group's reliability models for the system significant components and serves as a backup information report

EG Report 3 - ***General Assessment of Small-Scale Measures***, June 1995.

ABSTRACT
This is a report identifying small-scale measures that seek to reduce delays or congestion for barge traffic when transiting locks on the UMR-IWW System. The assessment process included: a historical records review; visits to two locks (one on each waterway); meetings with industry, environmental, and regulatory agency representatives; identification of potential small-scale measures; and recommendations for further study of a screened list of small scale measures. Ninety-two measure were identified during the course of the assessment through document research, discussion, and an October 1994 multi-interest brainstorming session. The number of small–scale

measures was narrowed down to 16 which are recommended for further study based on a qualitative screening process that focused on identifying those measure with greatest potential for reducing lockage times. The screening process eliminated those measures which had no potential to reduce delays at locks, were not technically feasible, were not safe, were not environmentally acceptable, were economically inefficient, were not cost effective, should have been pursued through industry cooperation rather than Corps of Engineers requirements, or were addressed through the Corps of Engineers Operations and Maintenance Program. Measures recommended for further study in the report were the use of a scheduling program, the use of towboat power, use of tow haulage equipment, new mooring facilities, crew elements, tolls and scheduling of recreational vessels.

EG Report 4 - *Improved Tow Haulage Equipment*, September 1995.

ABSTRACT
This report reviewed the current practices regarding hardware, procedures, and personnel related to utilization of tow haulage equipments to extract unpowered cuts from the lock chamber. It assessed the impact that these practices have on the efficiency by which the unpowered cuts are removed form the lock chamber and tied off on the guidewalls. The report discusses the opportunities that exist for improving this process through changes in hardware and operations in current practice. With the assumption that guidewalls would be extended to 1200', alternative configurations and motive power solutions were developed and then evaluated using the following four criteria: completeness, effectiveness, efficiency, and acceptability. Two alternatives that required the tow haulage equipment to cross the miter gates were eliminated due to safety and operational concerns and the potential for system down time due to failure. The two remaining alternatives and motive power solutions were further evaluated for implementation in the study area. Time savings and system costs were also developed and presented.

EG Report 5 - *Universal Couplers and Crew Training*, September 1995.

ABSTRACT
This report reviews the current practice regarding hardware, procedures and personnel training related to the secure lashing of barges into a tow configuration as practiced on the UMR&IWW. It assesses the impact that these practices have on the efficiency of moving tows through locks on these two river systems and discusses the opportunities that exist for increasing the efficiency of the lockage process through changes in current practice.

EG Report 6 - *Detailed Assessment of Small-Scale Measures*, December 1998.

ABSTRACT
This report assesses in detail 16 small-scale measures carried forward from the screening in the initial General Assessment report, in addition to some other measures resulting from further analysis and information. The measures were divided into two broad categories – structural and non-structural – primarily to distinguish between the items requiring construction and those that could be implemented with little or no construction. However, combinations of measures, such as towboat power with guidewall extensions or remote moorings, reduce these distinctions to some extent. Based on the analysis of both the quantitative and qualitative information collected as part of this study effort, it appears that several small scale measures used separately or in combination have the potential to provide significant time savings at the locks.

EG Report 7 - *Summary of Small-Scale Measures Screening*, April 1999.

ABSTRACT
This report summarizes the entire process of identifying and screening the small-scale measures. These measures were obtained from previous studies, Corps staff recommendations, and coordination with member of private industry, State resource and transportation agencies, the U.S. Fish and Wildlife Service, the U.S. Coast Guard, and the U.S. Environmental Protection Agency.

EG Report 8 ***-Large-Scale Measures of Reducing Traffic Congestion, Conceptual Lock Designs***, February 1996.

ABSTRACT

This is a report establishing the engineeringly feasible conceptual lock designs and associated costs for adding new locks at several alternative locations at typical rock and pile founded locks and dams. These so-called "generic" design concepts would be adapted to specific sites under a separate effort of the Navigation Study. The report identified that a number of conceptual lock designs are feasible from an engineering perspective.

EG Report 9 **-** ***Large-Scale Measures of Reducing Traffic Congestion, Hydraulic Impacts of New Lock Construction***, July 1996.

ABSTRACT

This report investigates the hydraulic impacts of new lock construction at 16 lock and dam sites on the UMR-IWW System. Extrapolation of the results of physical and numerical modeling conducted at 5 selected sites, along with mapping and aerial photography, were used to assess navigation conditions at each site and provide recommendations to improve navigation conditions as necessary.

EG Report 10 **-** ***Large-Scale Measures of Reducing Traffic Congestion, Location Screening***, July 1999.

ABSTRACT

This report documents the first phase of evaluating site locations for potential new locks conducted during fiscal years 1994 and 1995. The report presents the results of a qualitative process to screen and eliminate locations for potential new lock construction (1,200 or 600 feet long) at the 16 existing lock and dam sites under study for large-scale navigation improvements. The 16 sites identified during the Reconnaissance Study as having potential economic justification for improvements during the above planning period include Locks and Dams 11 through 25 on the Mississippi River and Peoria and La Grange Locks on the Illinois Waterway.

EG Report 11 **-** ***Interim Revised Lock Extension Design Concepts***, June 2000.

ABSTRACT

This report outlines efforts to significantly reduce the costs of navigation impacts during construction for the lock extension alternative.

EG Report 12 **-** ***Summary of Large-Scale Measures Screening***, October 1999.

ABSTRACT

The principal navigation problem addressed by this study is the potential for significant traffic delays on the UMR&IWW Navigation System within the 50-year planning horizon. The goal of this report was to summarize the identification and screening of the large-scale measures.

EG Report 13 **-** ***Site Adaptation of Cost Estimates and Lockage Performance for Surviving Lock Extensions and Types***, June 2000. (This is a compilation of computations and not a stand-alone report).

EG Report 14 **-** ***Secondary Benefits Associated with Large Scale Improvements***, June 2000. (The majority of this report has been superceded and is now included in the Engineering Appendix)

EG Report 15 - *Analysis of Future Investment Needs on the Upper Mississippi River and Illinois Waterway (Objective 2A)*, April 1999.

ABSTRACT

This is a report on the economic evaluation of system reliability and anticipated future investment needs to maintain the system's existing level of performance (includes evaluation on future need for repair, rehabilitation, and enhanced maintenance of the existing system).

EG Report 16 – *Structural Small Scale Measures Mississippi River Locks 22 & 25: Extended Guidewalls, Powered Traveling Kevels, Approach Channel Improvements,* July 2000.

ABSTRACT

This report includes discussions and recommendations for structural small scale improvements at Locks 22 and 25 on the Mississippi River. The specific improvements covered are extended guidewalls, powered traveling kevels, and approach channel improvements. Lock 22 and 25 were chosen for two main reasons. The first is that one lock is rock founded (Lock 22) and the other is sand founded (Lock 25). All analysis and decisions concerning these foundations will be easily transferred to other similar locks. The other reason is that Lock 22 is within the Rock Island District and Lock 25 is within the St Louis District. Since both Districts are heavily involved in the study, it was beneficial to gather information and input at locks from each District. Also, both locks are located at the southern end of the Upper Mississippi and therefore received heavy industrial traffic.

EG Report 17 – *Navigation Conditions at Lock and Dam 25, Mississippi River; ERDC Technical Report CHL 97-28,* September 1997.

ABSTRACT

Several locations are being considered for a new lock. This report documents the results of 1:120 scale physical model testing of conditions at Lock 25 that are related to the various locations. The purpose of the model study is to evaluate navigation conditions for each location, identify improvements such as guardwall lengths, remedial structures and channels, and determine approach times for various lock alternatives.

EG Report 18 – ***Navigation Conditions at Lock and Dam 22, Mississippi River*, by Ronald T. Wooley, Technical Report CHL-97-27**, October 1997.

ABSTRACT

Several locations are being considered for a new lock. This report documents the results of 1:120 scale physical model testing of conditions at Lock 22 that are related to the various locations. The purpose of the model study is to evaluate navigation conditions for each location, identify improvements such as guardwall lengths, remedial structures and channels, and determine approach times for various lock alternatives.

EG Report 19 – ***Independent Review of Concept Design Construction Costs, by the Rock Island District***, June 2003.

ABSTRACT

The primary purpose of this report is to address concerns about the construction costs stated in the Water Science and Technology Board, Transportation Research Board, and the National Research Council review of the UMR&IWW System Feasibility Report. More specifically, the committee stated that there was value in an independent review, particularly for studies of this magnitude. This documentation report compares construction cost estimates developed by the Corps of Engineers to that of an independent Architect-Engineering firm. It serves to validate COE cost estimates for Large-Scale measures.

16.5 Public Involvement Reports

PI Report 1 – *October-November 1993 Public Meetings - Responses to Questions and Comments*

ABSTRACT
Document contains responses to all 69 questions and comments received at the October/November 1993 Public Meetings.

PI Report 2 – *Responses to Issues Raised at the Public and NEPA Scoping Meetings of November 1994*

ABSTRACT
A complete summary of the information presented at the November 1994 public an NEPA scoping meetings plus the questions and statements.

PI Report 3 – *Content Analysis Report from the November 1994 Public Meetings*

ABSTRACT
A complete summary of the information presented at the November 1994 public meetings plus the questions and statements.

PI Report 4 – *Transcripts from the 1994 November Public Meetings*

ABSTRACT
Transcripts of November 1994 Public Meetings.

PI Report 5 – *Interim Report: Open House Meetings Held November and December 1995*

ABSTRACT
A detailed list of general observations compiled from the comment sheets and a listing of all written comments submitted at the November and December 1995 public open houses.

PI Report 6 – *Content Analysis Report of July-August 1999 Public Workshops*

ABSTRACT
Report containing more that 2,000 comments that were recorded within the small group discussions at the July/August 1999 public workshops.

PI Report 7 – *Transcripts of July-August 1999 Public Workshops, 1999*

ABSTRACT
Transcripts of July – August 1999 Public Workshops

PI Report 8 – *Content Analysis Report, Public Meetings, March 12 – 21, 2002*

ABSTRACT
Report of the March 2002 Public Meeting proceedings and analysis of the comments, questions and statements submitted by the public.

PI Report 9 – ***Transcripts from the March 2002 Public Meetings***

ABSTRACT
Transcripts of the five public meetings held in March 2002

PI Report 11 – *Transcripts from the October 2003 Public Meetings*

ABSTRACT
Transcripts of the seven public meetings held in October 2003.

17.0 REFERENCES

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ACRONYMS

The following alphabetically arranged list of commonly used acronyms may be found throughout this document:

AAHU	Average Annualized Habitat Units
AFS	American Fisheries Society
A&M	Avoid and Minimize
AMS	Agricultural Marketing Service
ANS	Aquatic Nuisance Species
AWO	American Waterway Operators
BA	Biological Assessment
BACSED	Backwater Sedimentation
BCA	Bear Creek Archeology
BO	Biological Opinion
BW	Back Water
CAP	Continuing Authorities Program
CCP	Comprehensive Conservation Plan
CEA	Cumulative Effects Analysis
CEMVS	Corps of Engineers, St. Louis District
CEQ	Council on Environmental Quality
CMMP	Channel Maintenance Management Plan
CRP	Conservation Reserve Program
DEIS	Draft Environmental Impact Statement
DNR	Department of Natural Resources
DOC	Department of Conservation
DOT	Department of Transportation
EA	Environmental Assessment
EAL	Equivalent Adult Loss
EC	Engineer Circular
ECC	Economics Coordinating Committee
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EM	Essence Model
EMP	Environmental Management Program
EMPCC	Environmental Management Program Coordinating Committee
EMTC	Environmental Management Technical Center
EnCC	Engineering Coordinating Committee
ELB	Essence Lower Bound
EPA	Environmental Protection Agency
EPM	Environmental Pool Management
EQIP	Environmental Quality Incentives Program
ER	Engineering Regulation
ERDC	Engineering Research and Development Center
ERGO	Environmental Review Guidance for Operations
EUB	Essence Upper Bound
FAPRI	Food and Policy Research Institute
FERC	Federal Energy Regulatory Commission
FPMA	Floodplain Management Assessment
FPP	Farmland Protection Program
FWCA	Fish and Wildlife Coordination Act

FWIC	Fish and Wildlife Interagency Committee
FWWG	Fish and Wildlife Work Group
GIS	Geographic Information Systems
GLC	Governors' Liaison Committee
GMO	Genetically Modified Organism
GPS	Global Positioning System
GREAT	Great River Environmental Action Team
GRP	Gross Regional Product
HAT	Habitat Assessment Team
HEP	Habitat Evaluation Procedures
HNA	Habitat Needs Assessment
HQUSACE	U.S. Army Corps of Engineers, Headquarters
HREP	Habitat Rehabilitation and Enhancement Project
HSI	Habitat Suitability Team
HTRW	Hazardous Toxic and Radioactive Waste
HU	Habitat Unit
ILDNR	Illinois Department of Natural Resources
IIHR	Iowa Institute of Hydraulic Research
INSA	Inland Navigation Systems Analysis
IPMP	Initial Project Management Plan
ISM	Illinois State Museum
ITR	Internal Technical Review
IRCA	Illinois River Carriers Association
ISWS	Illinois State Water Survey
IWR	Institute for Water Resources
IWUB	Inland Waterway Users Board
IWW	Illinois Waterway
JFA	Jack Faucett and Associates
L/D	Lock and Dam
LSA	Landform Sediment Assemblages
LPMS	Lock Performance Monitoring System
LSA	Lower Saint Anthony
LTRMP	Long Term Resource Monitoring Program
MARC	Midwest Area River Coalition
MIS	Mitigation Implementation Strategy
MMR	Middle Mississippi River
MNDNR	Minnesota Department of Natural Resources
MR&T	Mississippi River & Tributaries
MVD	Mississippi Valley Division
MVP	St. Paul District
MVR	Rock Island District
MVS	St. Louis District
NAS	National Academy of Sciences
NAVEFF	Navigation Effects
NAVSED	Navigation Sedimentation
NCD	North Central Division
NECC	Navigation Environmental Coordinating Committee
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NGO	Non-Governmental Organization

NHPA	National Historic Preservation Act
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
O&M	Operations and Maintenance
OMNI	Operation and Maintenance of Navigation Installations
OSIT	On Site Inspection Team
P&G	Principles & Guidelines
PA	Programmatic Agreement
PDT	Project Delivery Team
PED	Preliminary Engineering and Design
PEIS	Programmatic Environmental Impact Statement
PCB	Polycarbonate biphenyl
PF	Production Forgone
PICC	Public Involvement Coordinating Committee
PMP	Project Management Plan
POS	Plan of Study
PSP	Project Study Plan
QCP	Quality Control Plan
RC&D	Resource Conservation and Development
RCP	Responsible Carrier Program
RED	Regional Economic Development
RF	Recruitment Forgone
RIAC	River Industry Action Committee
RM	River Mile
ROD	Record of Decision
RPA	Reasonable and Prudent Alternatives
RPM	Reasonable and Prudent Measures
RRAT	River Resources Action Team
RRC	Reconnaissance Review Conference
RRCT	River Resources Coordinating Team
RRF	River Resources Forum
SAV	Submerged Aquatic Vegetation
SEC	Secondary Channel
SEM	Spatial Equilibrium Model
SHPO	State Historic Preservation Office
T&E	Threatened and Endangered Species
TCM	Tow Cost Model
THPO	Tribal Historic Preservation Office
TIPR	Traffic Impact Prevention and Reduction
TMDL	Total Maximum Daily Load
TRB	Transportation Research Board
TS	Traffic Scenario
TSS	Total Suspended Solids
TVA	Tennessee Valley Authority
UMIMRA	Upper Mississippi - Illinois - Missouri Rivers Association
UMR	Upper Mississippi River
UMR-IWW	Upper Mississippi River-Illinois Waterway System
UMRBA	Upper Mississippi River Basin Association

UMRCC	Upper Mississippi River Conservation Committee
UMRS	Upper Mississippi River System
UMWA	Upper Mississippi Waterways Association
USA	Upper Saint Anthony
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAM	Waterway Analysis Model
WCSC	Waterborne Commerce Statistics Center
WES	Waterways Experiment Station
WHIP	Wildlife Habitat Incentives Program
WRDA	Water Resources Development Act
WRP	Wetland Reserve Program
WSTB	Water Science and Technology Board
WTO	World Trade Organization

GLOSSARY

Abiotic – Non-living; as applied to the physical and chemical components of the ecosystem.

Adaptive Management – An approach to natural resources management that acknowledges the risk and uncertainty of ecosystem restoration and allows for modification of restoration measures to optimize performance. The process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans. A mechanism for integrating scientific knowledge and experience for the purpose of understanding and managing natural systems.

Anthropogenic - Caused by humans.

Area of potential effect – The geographic area within which an undertaking or activity may directly or indirectly cause change.

Avoid and minimize – Measures developed to avoid and minimize impacts to the river environment.

Avoidance zone – Voluntary avoidance areas established by the USFWS to protect native plants and animals.

Backwater – A small, generally shallow body of water attached to the main channel, with little or no current of its own; shallow, slow-moving water associated with a river but outside the river's main channel.

Bathymetry – The measurement of water depth across a water body.

Bed load – Material that remains in contact with the bottom of a stream when moved by flowing water.

Benchmark – A point of reference by which something can be measured.

Benthic – Refers to the bottom layer of any body of water and the organisms therein.

Biodiversity – The variety of living organisms considered at all levels of organization, from genetics through species, to higher taxonomic levels, and including the variety of habitats and ecosystems, as well as the process occurring therein. Biodiversity occurs at four levels; genetic diversity, species richness, ecosystem diversity, and landscape diversity.

Biotic – Living; as applied to the components of an ecosystem.

Catchment – Watershed; the area drained by a stream, lake or other body of water. Frequently used to refer to areas that feed into dams; may also refer to areas served by a sewerage or stormwater system.

Channel Training Structure – A man-made flow obstruction (e.g., wing dam, closing dam or revetment) used to divert river flow to a desired location, usually toward the center of the main channel to increase flow and limit sedimentation or to protect the river bank from eroding.

Community – A grouping of populations of different species found living together in a particular environment.

Comprehensive Conservation Plan – A document that describes the desired future conditions of a USFWS refuge and provides long-range guidance and management direction for the refuge manager to accomplish the purposes of the refuge, contribute to the mission of the system, and to meet other relevant mandates.

Conceptual model – A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed.

Conservation – Active management to ensure the survival of the maximum diversity of species, and the maintenance of genetic diversity within species; implies the maintenance of ecosystem functions; embraces the concept of long-term sustainability. A careful preservation and protection of something; esp. planned management of a natural resource to prevent exploitation, destruction, or neglect.

Cofferdam – A temporary dam built to keep the riverbed dry to allow construction of a permanent dam or infrastructure.

Corridor – A relatively narrow strip of habitat that crosses an area of non-habitat land and serves to connect larger areas of habitat.

Cumulative effects – Effects on the environment that result from the incremental impact of any action when added to other past, present or future actions, regardless of which agency or person undertakes such actions.

Demand elasticity – In reference to the Navigation Study, a measure of the price responsiveness to waterway demand.

Desired future conditions – A description of management goals for an area to achieve optimal conditions; the descriptions should be constructed with the input of all interested parties in the region and should include clear goals for species, communities, and ecosystem composition, structure, and functions across the landscape. For this system study, the desired future condition was based on coordination with resource managers and became the system objectives.

Disturbance regime – The spatial and temporal characteristics of disturbances affecting a particular landscape over a particular time (e.g., fire, flood, drought). Any relatively discrete event in time that disrupts the ecosystem, community or population structure and changes resources or the physical environment.

Draft – Depth below the waterline that the vessel is submerged.

Drawdown – Lowering the level of the water in a selected portion of an aquatic system; conducted for habitat management purposes with dams or pumps.

Dredged material – The excavated material from dredging operations.

Dredging – The removal of underwater material (e.g., sediment) from the bottom of a harbor or waterway.

Ecological (or Biological) integrity – The ability of an ecosystem to retain its complexity and capacity for sustainability (i.e., its health).

Ecological processes – The dynamic biological, geological, and chemical interactions that occur among and between biotic and abiotic components in an ecosystem.

Ecological stressor – A substance or action that has the potential to cause an adverse effect on an ecosystem.

Ecosystem – Dynamic and interrelating complex of plant and animal communities and their associated nonliving environment; a biological community together with the physical and chemical environment with which it interacts.

Ecosystem function – Processes that drive the ecosystem; any performance attribute or rate function at some level of biological organization (e.g., energy flow, sedimentation, detritus processing, nutrient spiraling).

Ecosystem health – A condition when a system's inherent potential is realized, its capacity for self-repair, when disturbed, is preserved, and minimal external support for management is needed.

Ecosystem management – Protecting, conserving, or restoring the function, structure, and species composition of an ecosystem, recognizing that all components are interrelated.

Ecosystem processes – The aggregate of all interactions among the various biotic components of an ecosystem (e.g., migration, pollination, predation), between the abiotic and biotic components of an ecosystem (e.g., nutrient uptake, erosion, respiration) and natural events and cycles (e.g., fire regimes, hydrologic cycles).

Ecosystem (or environmental) restoration – Management actions that attempt to accomplish a return of natural areas or ecosystems to a close approximation of their conditions prior to human disturbance, or to less degraded, more natural conditions.

Ecosystem services – All of the goods and services provided to humanity by natural ecosystems; examples include wood products, fertile soils, genetic variation, clean water, and clean air.

Ecotype – Populations adapted to a particular set of environmental conditions; a collection of plants that evolved in response to the specific local environment of an area; a population adapted to a restricted habitat as a result of natural selection within a local environment.

Enhancement – In the context of restoration ecology, any improvement of a structural or functional attribute.

Environmental assessment – A document required to determine if there are significant impacts from the effects for proposed activities on the environment, in compliance with the National Environmental Policy Act (NEPA) of 1969. An EA should address unresolved environmental conflicts and have sufficient analysis to determine significant impacts.

Environmental impact statement – A detailed written statement following the format and procedures outlined in the National Environmental Policy Act (NEPA) of 1969. This document is prepared to determine and provide a detailed explanation of the significant environmental consequences of the proposed action. The EIS addresses public input.

Environmental sustainability – The ability of aquatic, wetland, and terrestrial complexes to maintain themselves as self-regulating, functioning systems.

Fish entrainment – Process by which fish are wounded or killed after being swept in and through a boat's propellers.

Fleeting area – A permanent facility within defined boundaries used to provide barge mooring service and ancillary harbor towing under the care of the fleeting operator.

Floodplain – Lowlands bordering a river that are subject to flooding. Floodplains are composed of sediments carried by rivers and deposited on land during flooding.

Funerary object – Of, relating to, or for a funeral or burial; an object discovered in close proximity to human remains and interred with the remains.

Guard wall - an extension or new construction of a wall to prevent tows or loose barges from colliding with a dam during entry or exit from a lock chamber. Guard walls are various lengths depending on lock and dam configuration.

General Plan Land – Lands that the USACE outgrants to the USFWS through a Cooperative Agreement for fish and wildlife management purposes.

Genetically Modified Organism – An organism that has been modified by gene technology.

Geographic Information Systems (GIS) – A set of computer hardware and software for analyzing and displaying spatially referenced features, such as points, lines or polygons, with non-geographic attributes, such as species, age, etc. utilized for mapping and analysis.

Geomorphology – The science that deals with land and submarine relief features (landforms) of the earth's surface; the physical structure of the river floodplain environment.

Guidewall – The extension of the inner lockwall on the upper and lower side of the lock chamber to assist navigators in guiding vessels or tows into the lock chamber. It is usually 600 feet in length, although some are now 1,200 feet long.

Harbinger – a forerunner of something; a person, event, or situation that announces or signals the approach of something else

Habitat – The living place of an organism or community, characterized by its physical or biotic properties; habitats can be described on many scales from microhabitat to ecosystems to biomes.

Habitat fragmentation – The process whereby a larger, continuous area is both reduced in area and divided into two or more pieces. The disruption of extensive habitats into isolated and small patches. Fragmentation has three negative components: loss of total habitat area and smaller, more isolated remaining habitat patches, increased potential for edge effects

Historic property – Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Resister of Historic Places; includes artifacts, records, and remains that are related to and located within such properties.

Hydrologic – (1) Rise and fall of river crest; (2) Pertaining to the water cycle; through precipitation, runoff, storage and evaporation, and transevaporation and quantitatively as to distribution concentration, and quality.

Hydrology – A science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Hypoxia – The condition in which dissolved oxygen concentrations are less than 2 parts per million of water.

Impoundment – In reference to rivers, the area of water that is captured and held back by a dam.

Index of Biotic Integrity (IBI) –Index of Biotic Integrity utilizes numerous metrics or measures (often between 10 and 15) to assess aquatic biological integrity using fish community or macroinvertebrate community sampling. There are three broad categories under which the metrics fall: species composition; trophic composition; and fish abundance, condition, and tolerance to stressors.

Indicator – A measurable surrogate for environmental end points, such as biodiversity, that is; sensitive to changes in the environment and can warn that environmental changes are taking place.

Invasive species – Any species that has the tendency to invade or enter a new location or niche; an introduced species that out competes native species for space and resources; whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Keystone species – A species whose presence is crucial in maintaining organization and diversity in their communities and who are much more important than the abundance of the species would suggest.

Landscape – A heterogeneous land area composed of interacting ecosystems that are repeated in similar form throughout; landscapes are variable in size; usually overlaps governmental jurisdictions, thus requiring collaboration from a broad range of participants.

Landscape ecology – The study of the structure, function, and change in a heterogeneous land area composed on interacting ecosystems.

Large-scale measure – A new 1200' foot lock or extending the existing lock to 1200'.

Lateral connectivity – The connection of a river and its floodplain, allowing access across aquatic and terrestrial habitats by organisms as well as flood waters.

Lentic – Of, or relating to, or living in still water, such as a pond or lake.

Levee – An embankment constructed to prevent flooding.

Levee district – Cooperative quasi-governmental organizations that protect areas from flood waters and serve as wildlife refuges.

Levee setback – The process of moving levees back a sufficient distance from the Ordinary High Water Mark to allow an escape valve for flood water, to replenish the floodplain and to allow restoration of the riparian corridor.

Life history – An organism's patterns of growth, reproduction, and longevity that are related to specific demands for survival.

Limiting factor – The ecologic influence that limits or controls the abundance and/or distribution of a species.

Litter – An accumulation of dead plant materials on the soil surface.

Littoral - area of a stream, river, wetland, lake or pond that can support rooted aquatic plant growth.

Longitudinal connectivity – Allows for the upstream and downstream movement and/or migration of aquatic organisms; increases opportunities for aquatic organisms to utilize and move between exiting stream environments, colonize new habitats, or recolonize aquatic habitats following local extinctions.

Lotic – Of, or relating to, or living in flowing water, such as a river or stream.

Macroinvertebrates – Small, but visible with the naked eye, animals without backbones (insects, worms, larvae, etc.). The species composition, species diversity and abundance in a given water body can provide valuable information on the relative health and water quality of a waterway.

Management action – Measures used to modify or adjust the condition of the river system.

Mitigation – Actions taken to avoid, reduce or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those that restore, enhance, create, or replace damaged ecosystems.

Moist soil unit – Areas where water levels are controlled to provide a desired mix of moist soil vegetation.

Monoculture – A simplified biotic community dominated by one species.

Mooring buoy – A buoy attached to the river bottom by permanent moorings with means for securing a vessel by use of its mooring lines.

Mooring cell – A riverfront structure generally comprised of steel piling or a cluster of wooden piles used for securing barges along the bank at loading facilities.

N-up/N-down – A lock operating policy in which up to N upbound vessels are serviced, followed by up to N downbound vessels, where N is positive integers.

Naturalization – Establishing a sustainable, varied, yet stable natural area or system that is capable of supporting a healthy, biologically diverse ecosystem within the context of the developed landscape. When abiotic and biotic barriers to survival are surmounted and when various barriers to reproduction are overcome.

Navigation improvement – Structural and nonstructural measures that can increase the efficiency or capacity of the navigation system.

Non-indigenous species – Species of plants and animals that are not native to an area.

Non-point source pollution – Water pollution produced by diffuse land-use activities.

Open river condition – The condition when all dam gates are out of the water and the pool water level is no longer controlled by the dam.

Operation and Maintenance – Activities and costs associated with operating and maintaining the navigation system including funding for lock and dam personnel, maintenance crews, dredging, utilities, and minor repairs.

Patch – A nonlinear surface area that differs in appearance from its surroundings; the term used for distinct areas, such as ecosystems, on a landscape.

Performance measures – Metrics or indicators that are related to an ecosystem process or function and which are measurable in a natural ecosystem that can be used to judge the performance of restoration actions.

Piping – Removal of fine particles from the soil structure, usually near the toe of an embankment. Piping occurs when the forces produced by water moving through the soil exceed the resistance of the soil particles to movement.

Planform – The shape or form of an object, as seen from above, as in a plan view.

Project Management Plan - a plan that outlines the scope, cost, and schedule for executing a study. Chapter 14 contains the Project Management Plan for this study.

Point source pollution – Pollution into bodies of water from specific discharge points such as sewer outfalls or industrial-waste pipes.

Pool – The area of water that is impounded and maintained at a higher level behind a navigation dam; generally refers to the entire length of river between sequential dams.

Pool aging – A term used to broadly describe degradation in the quantity and quality of non-channel aquatic habitats since impoundment.

Pool Plans – Maps and descriptions of desired future conditions of the Mississippi River.

Pool reach – A portion of a pool between navigation dams.

Population – A group of individuals of the same species occupying an area small enough to permit interbreeding among all members of the group.

Preservation – To keep safe from injury, harm, or destruction.

Pre-settlement – A condition or state prior to human intervention.

Project Management Plan – A plan that outlines the scope, cost, and schedule for executing a study.

Reach – A continuous stretch or expanse. In reference to rivers, it can be used to define portions of rivers at different scales (i.e., floodplain reach, pool reach, and reach between two river bends).

Reference condition – The range of factors (e.g., hydrology, sediment movement, vegetation, and channel geometry) that are representative of a river's recent historical values prior to significant alteration of its environment.

Region – A large geographical area that is distinguished by certain characteristics (e.g., biological, ecological, social, political, economic).

Rehabilitation – Used primarily to indicate improvements to a natural resource; putting back into good condition or working order.

Resilience – The ability of a system to maintain its structure and patterns of disturbance in the face of disturbance.

Restoration – The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition (ER 1105-2-100). As defined under Section 519, in its broadest usage, restoration encompasses the following concepts: conservation, enhancement, naturalization, preservation, protection, rehabilitation, restoration, and stabilization.

Riparian – Areas that are contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (e.g., rivers, streams, lakes, or drainage ways).

Riparian corridor – a corridor of habitat that is directly related to or situated along the banks of rivers or streams; a riparian corridor is in contact with the stream during annual floods.

River stage – The elevation of the water surface, usually above an arbitrary datum.

Secondary (side) channel – Aquatic channel connected to the main channel and separated from the main channel by an island; usually has flowing water.

Sediment resuspension – The movement of sediment from the river bed into the water column due to a disturbance (e.g., wave action).

Sediment transport – The movement of sediment (usually by water).

Sedimentation – The process of sediment being deposited in a given location.

Small-scale measures – any navigation improvement less costly than extending or constructing a new 1200' lock.

Spatial – Relating to the nature of space.

Species – One or more populations of individuals that can interbreed, but cannot successfully breed with other organisms.

Species diversity – The richness, abundance, and variability of plant and animal species and communities.

Species evenness – A measure of diversity that quantifies unequal species representation in a community against a hypothetical community in which all species are equally common; the degree of heterogeneity in the spatial distribution of species in a community or ecosystem.

Species richness – A simple count of the number of species in an area.

Stability – The propensity of a system to attain or retain an equilibrium condition of steady state or stable oscillation; having a resistance to departure from that equilibrium condition, and if perturbed, returning rapidly to that equilibrium condition.

Stabilization –Protect from further degradation; restore the original condition when disturbed from a condition of equilibrium or steady motion.

Stakeholder – Those organizations and/or individuals having a vested interest in the outcome of a decision making process.

Structure – The horizontal and vertical spatial arrangement, or configuration, of a habitat, community or ecosystem; includes biotic and abiotic diversity.

Subwatershed (sub-basin) – A subdivision of a watershed, based on hydrology, generally corresponding to the area drained by a small tributary or stream, as opposed to a major river. Nineteen major sub-basins have been delineated in the Illinois River Basin: Chicago, Des Plaines, Spoon, Upper Sangamon, South Fork Sangamon, Lower Sangamon, Salt Creek, LaMoine, Lower Illinois, Lower Illinois – Lake Chautauqua, Lower Illinois – Lake Senachwine, Macoupin, Upper Fox, Lower Fox, Upper Illinois, Kankakee, Iroquois, Vermilion and Mackinaw.

Succession – Sequential change in the vegetation at a particular location over time.

Sustainable/sustainability – A level and method of resource use that does not destroy the health and integrity of the systems that provide the resource; thus the long-term resource availability does not ever diminish due to such use.

Temporal – Of, relating to, or limited by time.

Thalweg – The line defining the lowest points along the length of a riverbed or valley.

Threat assessment – The identification, evaluation, and ranking of stresses and sources of stress to populations, species, ecological communities or ecosystems at a site or within a landscape.

Threatened and endangered species – Those species that are listed as threatened or endangered under the Federal Endangered Species Act (ESA) of 1973, and those species that are candidates or proposed as candidates for listing under the ESA; listing can occur at the Federal or state level or both.

Threshold – The level (duration or intensity) of a stimulus required to produce an effect.

Total Maximum Daily Load – A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Tractive Force Scour – Removal of bank materials by the shear forces produced by flowing water moving past the bank.

Tributary – A stream or river whose water flows into a larger stream or river.

Tributary, major – The larger rivers or streams flowing directly into a larger river. There are 10 major tributaries of the Illinois River Basin. They are the: Chicago, Des Plaines, Spoon, Sangamon, LaMoine, Fox, Kankakee, Vermilion, and Mackinaw Rivers and Macoupin Creek.

Trust Species – USFWS trust species include migratory birds, anadromous and interjurisdictional fish, and endangered species, certain marine mammals, and National Wildlife Refuge and Wilderness Areas.

Turbidity – Measure of the "lack of clearness" of water. Degree to which light is blocked because water is muddy or cloudy.

Turnback lockage – A lockage in which no vessels are served; a reversal of the water level in a lock chamber with no vessels in the chamber. A turnback includes closing one set of gates, filling or emptying the chamber, and opening the other set of gates. Also called a "swingaround" or an "empty lockage."

Upper Mississippi River – Illinois Waterway (UMR-IWW) – the narrow (300-500m) 1,200 miles of 9-foot navigation channel, 37 locks and dam sites (43 locks), and thousands of channel training structures of the Upper Mississippi River and Illinois Waterway.

Upper Mississippi River System (UMRS) – the entire floodplain area and associated physical, chemical, and biological components of the Upper Mississippi and Illinois Rivers.

Volitional – Voluntary or directed movements under direct control of the organism (swimming, running) as opposed to movements regulated unconsciously (breathing)

Watershed – The geographic area that naturally drains into a given watercourse such as a stream or river.

Wicket gate – A rectangular heavily constructed slab of wood and steel hinged in a counterbalanced way so as to be lying flat on the river bed when down, and when raised will be held upright by the pressure of the water. Wicket gates are placed in a parallel line across the river and when all are in raised position they form a wall or dam, thus backing up the water and raising it to the pool level.

INDEX

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Bishop Henry Whipple Federal Building
1 Federal Drive
Fort Snelling, MN 55111-4056

IN REPLY REFER TO: FWS/AES-HC

SEP 13 2004

Colonel Dwayne P. Gapinski
District Engineer
US Army Engineer District, Rock Island
Clock Tower Building, P.O. Box 2004
Rock Island, Illinois 61204-2004

Dear Colonel Gapinski:

This letter provides the U.S. Fish and Wildlife Service's (Service) Final Fish and Wildlife Coordination Act (FWCA) Report regarding the U.S. Army Corps of Engineers' (Corps) Upper Mississippi River and Illinois Waterway System Navigation Feasibility Study. The Service prepared two previous reports regarding this study. The first report, an April 2002 Draft FWCA Report, provided extensive information on affected resources and the potential impacts occurring from site-specific construction activities, increased navigation traffic, and operation and maintenance activities. With the subsequent addition of ecosystem restoration as a study purpose, the Service prepared an April 2004 Supplement to the Draft FWCA Report. The supplement is included in the Corps' April 2004 Draft Integrated Feasibility Report and Programmatic Environmental Impact Statement (PEIS).

The Service reviewed this draft feasibility report/PEIS and provided comments through the Department of Interior's Office of Environmental Policy and Compliance (see enclosed letter dated August 6, 2004). The DOI letter includes comments from the Service's Rock Island, Illinois, Field Office with respect to the Corps' recommended plan. In accordance with the FWCA and associated policies and procedures, the Service also generally provides a final FWCA report for inclusion in the final feasibility report/EIS, particularly if the recommended plan is modified from the one addressed in previous Service reports and comments. As of the date of this letter, it is our understanding that the recommended navigation improvements and ecosystem restoration plan that will be set forth in the forthcoming Final Feasibility Report and PEIS is essentially unchanged from the Preferred Plan described in the April 2004 Draft Feasibility Report and PEIS. As long as there are no substantial changes to the recommended plan, the enclosed DOI letter will serve as the Service's Final FWCA Report. Please inform Mr. Richard Nelson, Field Supervisor of the Service's Rock Island Field Office, as soon as possible if the Corps anticipates making any substantial modifications to the recommended plan prior to the release of the Final Feasibility Report and PEIS. Any such changes would not only require the Service to possibly revise its

FWCA report but might also require modification of the Service's biological opinion of August 27, 2004, prepared pursuant to section 7 of the Endangered Species Act of 1973, as amended.

After more than a decade of involvement on planning efforts associated with the Navigation Study, the Service looks forward to working with the Corps to implement the recommended ecosystem restoration plan. The plan is quite ambitious and will require a substantial commitment of human resources by the Service. In order to provide timely coordination, we request that you contact the Service as soon as possible regarding FWCA transfer fund assistance that might be needed in fiscal year 2005. This letter provides comments under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.); and the Endangered Species Act of 1973, as amended.

Questions should be directed to Mr. Rick Nelson, Field Supervisor, U.S. Fish and Wildlife Service, 4469 48th Avenue Court, Rock Island, Illinois 61201, telephone: (309) 793-5800, ext 201.

Sincerely,

Charlie Wooley

Charles M. Wooley
Acting Regional Director

Enclosure

cc: NECC Members
Minnesota DNR Region 5; Rochester, MN; Tim Schlagenhaft
Wisconsin DNR; LaCrosse, WI; Gretchen Benjamin
Iowa DNR; Des Moines, IA; Dianne Ford-Shivers
Illinois DNR; Greenville, IL; Butch Atwood
Missouri Dept. Conservation; Jefferson City, MO; Janet Sternburg
US Environmental Protection Agency; Chicago, IL; Al Fenedick
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FWS/AES-HC

APR 23 2004

Colonel Duane P. Gapinski
District Engineer
US Army Engineer District, Rock Island
Clock Tower Building, P.O. Box 2004
Rock Island, Illinois 61201-2004

Dear Colonel Gapinski:

This letter provides a Draft Supplement to the Draft Fish and Wildlife Coordination Act (FWCA) Report published in April 2002 by the U.S. Fish and Wildlife Service (Service) for the Upper Mississippi and Illinois River System (UMRS) Navigation Feasibility Study. The enclosed Draft Supplement provides the Service's preliminary comments and recommendations with respect to the draft tentatively selected plan identified in the February 9, 2004, Alternative Formulation Briefing Pre-conference Report for the Restructured Navigation Study. Because of the fluid planning situation, as well as the short timeframe between the time the Service received the Restructured Study's draft recommendations and the scheduled release of the feasibility report, there was insufficient time for the Service to provide a detailed analysis of the alternatives. We intend to deliver a final and more comprehensive report later this summer for inclusion with the Study's Final Environmental Impact Statement (EIS). Project effects on federally listed endangered and threatened species are being evaluated separately from this report, in accordance with Section 7 of the Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq.

There is an overwhelming Federal interest in the UMRS because of the large acreage of Federal lands, the major importance of the UMRS as an interstate and international flyway for migratory birds, its importance for federally listed threatened and endangered species, and the interstate nature of fish and wildlife management in the system. These Federal trust resources are being significantly impacted by ongoing Federal projects for navigation and flood protection. Although the Environmental Management Program (EMP) has been successful in restoring habitat on a local basis, its current structure and funding is insufficient to reverse the system-wide long-term decline in fish and wildlife habitats.

The Service has been involved for more than a decade with studies and coordination concerning the UMRS Navigation Study and is pleased with the direction of the Restructured Study. The Service strongly supports the recommendation of the U.S. Army Corps of Engineers (Corps) to create a dual purpose authority for navigation and ecosystem restoration. The draft tentatively selected plan, which combines "Navigation Efficiency Alternatives 4 and 6" with "Ecosystem

Restoration Alternative D Prime," illustrates that the UMRS can be managed to achieve both economic and fish and wildlife objectives. The Service maintains its endorsement of Ecosystem Alternative E because it provides a higher probability of full restoration of UMRS fish and wildlife resources. Because of the extensive Federal interest, we also support "Cost-sharing Option C" as the most appropriate funding arrangement. We wholeheartedly support the adaptive management strategy as the best approach to achieving both navigation and natural resources long-term goals. Although we support the major elements of the proposed "15-Year Plan," we believe there will be a need for a permanent UMRS ecosystem restoration authority for as long as the UMRS Nine-foot Channel Navigation Project is operated and maintained.

Implementing this adaptive management strategy will require some significant changes in the way UMRS agencies currently operate and coordinate with one another. The Service urges the Corps to convene a team of partner agencies to consider what new institutional framework will be needed to implement a new dual purpose authority. Critical to this discussion is the urgent need to consider how the overlapping objectives of other existing and potential UMRS authorities (the EMP, the Illinois River Ecosystem Restoration Study, and the Comprehensive Floodplain Management Study) should be integrated. Developing a consensus regarding how to integrate the EMP is especially important.

We look forward to working with the Corps and other partners in developing the management and institutional framework necessary to implement the vision described in the recommended plan. We believe this can only be achieved through a revised navigation project authority that mandates the river to be managed for both commercial navigation and its nationally significant fish and wildlife resources. In support of this, the Service intends to maintain projects on National Wildlife Refuge System lands that are determined to meet refuge goals and objectives on a project-by-project basis. To meet this future obligation, we request the Corps' collaboration in developing budget information that ensures future Service funding is sufficient to keep pace with the Corps' ecosystem restoration planning and construction activities.

The Corps' St. Louis District recently provided the Service with a report, dated March 2004, that assesses navigation traffic generated by the Second Lock at Melvin Price Lock and Dam at Alton, Illinois. Although the Record of Decision for the Final EIS for the Second Lock at Lock and Dam 26 (Melvin Price) was completed in 1988, the FWCA Report was never finalized. The enclosed Draft Supplement will also consider traffic effects specific to the Second Lock.

This letter and enclosed Draft Supplement provide comments under the authority of and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). The report has been reviewed by, and discussed with, the five State Representatives on the Navigation Environmental Coordinating Committee (NECC). The NECC Members generally agree with the conclusions and recommendations of this report but have yet to provide specific written comments.

Questions on the enclosed report should be directed to Mr. Rick Nelson, Field Supervisor, U.S. Fish and Wildlife Service, 4469 48th Avenue Court, Rock Island, Illinois 61201, telephone: (309) 793-5800, ext 201.

Sincerely,

Charlie Wooley

Charles M. Wooley
Acting Regional Director

Enclosure

cc: Minnesota DNR Region 5; Rochester, MN; Tim Schlagenhaft
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US Environmental Protection Agency; Kansas City, MO; Larry Shepard

DRAFT SUPPLEMENT TO THE APRIL 2002 DRAFT FISH AND WILDLIFE COORDINATION ACT REPORT

for the

UPPER MISSISSIPPI AND ILLINOIS RIVER SYSTEM NAVIGATION FEASIBILITY STUDY

Submitted to:
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U.S. FISH AND WILDLIFE SERVICE
GREAT LAKES – BIG RIVERS REGION
FORT SNELLING, MINNESOTA

April 2004

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INTRODUCTION

This is a Draft Supplement to the Draft Fish and Wildlife Coordination Act (FWCA) Report published in April 2002 by the U.S. Fish and Wildlife Service (Service) for the Upper Mississippi and Illinois River System (UMRS) Navigation Feasibility Study. This Draft Supplement has been prepared by the Service under the authority of and in accordance with the requirements of Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 USC 661-667e). It provides the Service's preliminary comments and recommendations with respect to the draft tentatively selected plan identified in the February 9, 2004, Alternative Formulation Briefing Pre-conference (AFB) Report for the Restructured Navigation Study. The Draft Supplement has been reviewed by, and discussed with, the representatives of the five UMRS states (Minnesota, Wisconsin, Iowa, Illinois, and Missouri) on the Navigation Environmental Coordinating Committee (NECC). The NECC Members generally agree with the conclusions and recommendations of this report but have yet to provide specific written comments.

BACKGROUND AND HISTORY

Recent efforts to modernize the Upper Mississippi and Illinois Rivers Nine-foot Channel Navigation Project, constructed in the 1930s, began with the authorization in the 1978 Inland Waterways Authorization Act to replace Lock and Dam 26 at Alton, Illinois. In 1986, Public Law 99-88 added a Second Lock at Alton. The impact analysis for the Second Lock was delayed until the completion of studies designed to investigate traffic effects caused by the Second Lock. These investigations were conducted as part of the U.S. Army Corps of Engineers' (Corps) current Upper Mississippi and Illinois River Navigation System Feasibility Study, which began in the early 1990s.

When the Corps' Navigation System Feasibility Study was initiated, the Study's sole purpose was to investigate navigation improvements on the Upper Mississippi River and Illinois Waterway (UMR-IWW). The position of the U.S. Fish and Wildlife Service (Service) and the natural resource agencies of the five UMRS states stated that the Navigation System Study should also assess and mitigate the ongoing and cumulative effects associated with the operation and maintenance (O&M) of the existing Nine-foot Channel Navigation Project. However, the Corps' position was, and continued to be, that the National Environmental Policy Act (NEPA) does not require the Corps to mitigate existing project O&M effects. The Service and the states also advocated adding fish and wildlife as a project purpose.

Although the Service and the states continued to express their opposition to the Navigation Study's direction, they continued to coordinate with the Corps through the NECC. During the period from 1992 to 2000, at the Corps' insistence, the NECC focused on investigations which analyzed the impacts of increased navigation traffic on fish and wildlife resources. Several field and laboratory studies assessed impacts to fish, mussels, aquatic plants, and other resources. These studies focused on tow-generated physical effects such as waves, sediment resuspension, shoreline erosion, and propeller entrainment of larval and adult fish. Effects identified in these investigations were then modeled over a 50-year future using traffic projections developed by Corps economists.

In February 2000, the Corps contracted with the National Research Council (NRC) to review the Corps' Navigation System Study. The NRC (2001) concluded that the Corps did not "…embrace the broader authority to recommend improvements to the quality of the environment…" and that the Corps "…should ensure that the environmental consequences of proposed construction and operating practices be analyzed along with the National Economic Development (NED). Environmental improvements, not just mitigation of incremental environmental damages, should also be examined."

In early 2001, the Service had essentially completed its Draft FWCA Report, which assessed the site-specific and incremental traffic impacts associated with the proposed navigation improvement alternatives. By that time, however, those alternatives were no longer valid due to concerns about re-scoping the study. Submission of the FWCA Report to the Corps was delayed because of the uncertainty regarding the outcome of the Corps' Study reevaluation and the potential for a different array of alternatives. In April 2002, the Service submitted its Draft FWCA Report (U.S. Fish and Wildlife Service 2002) based upon Navigation Study information available through August 2001.

The Draft FWCA Report described the natural resources of the UMRS, their present status, likely future without the proposed project (prior to the Restructured Navigation Study), and the likely impacts generated if the earlier alternatives were implemented. The Draft FWCA Report also addressed the *site-specific* impacts of constructing new 1,200-foot-long locks, extended guide walls, and mooring cells at multiple locations. The mitigation plan to address the site-specific impacts was based on the preliminary design information available at the time and would be reevaluated when advanced engineering was initiated. The impacts associated with predicted incremental increases in navigation traffic were also evaluated along with a proposed traffic-effects mitigation plan. Although the Draft FWCA Report included several recommendations concerning traffic effects, their resolution was not the Service's highest concern.

The Service is most concerned about the adverse cumulative effects associated with operating and maintaining the existing project. The Draft FWCA Report predicted that UMRS fish and wildlife resources would continue to decline regardless of whether or not additional traffic occurred. The Report stated that the long-term, cumulative effects of existing project O&M on fish and wildlife would be much more significant than incremental traffic effects. The Service advocated that O&M impacts be assessed and mitigated as part of the current Feasibility Study. The Draft FWCA Report urged that an updated Nine-foot Channel Navigation Project Environmental Impact Statement (EIS) should be prepared as part of the current Feasibility Study EIS.

In early 2001, the Corps suspended work on the Feasibility Study to consider possible changes in the study purpose. A group of senior Federal agency representatives was convened to assist the Corps in consideration of a new study direction. The Federal Principals Task Force is comprised of the U.S. Department of the Interior (USDOI), U.S. Department of Agriculture (USDA), U.S. Department of Transportation, and the U.S. Environmental Protection Agency (USEPA). Another group, the Regional Interagency Work Group, was assembled to provide support to the

Principals Task Force at the regional level. The Regional Work Group prepared a series of environmental and economic issue papers which were forwarded to the Principals Task Force in May 2001. After considering these issues, the Principals Task Force prepared a "Concept Paper" that described recommendations for restructuring the Navigation Study (USACOE 2002). A key recommendation of the Task Force was that "a comprehensive mitigation plan should be developed to address the effects of the operation and maintenance of the navigation system on the environment, as identified and quantified in the cumulative effects analysis."

In August 2001, the Corps Headquarters issued new guidance which resulted in a restructuring of the study purpose. Following this guidance, the Corps began preparing a new study plan. In the fall of 2002, after further coordination with state and Federal agencies and private organizations (including several public meetings in March 2002), the Corps issued an *Interim Report for the Restructured Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study*. The Interim Report described how the Corps proposed to revise its economic models to reassess commercial navigation traffic needs and how it would prepare a habitat restoration plan for the UMRS. The Service's Interim Report comment letter dated June 11, 2002, expressed its full support for the revised study purpose and objectives.

The restructured study resumed on two parallel tracks - one to reassess the need for navigation improvement measures and a second to develop a comprehensive plan for restoring the fish and wildlife resources of the UMRS. The Corps' intent was to eventually integrate these two purposes into one recommended alternative/plan. The Service did not participate in the economic reassessment other than to consider the predicted incremental traffic impacts generated by the proposed alternatives. In addition, the ecosystem restoration plan would consider how other habitat-related activities and programs (e.g., the Environmental Management Program [EMP] and Continuing Authorities [PL 99-662], the Illinois River Basin Restoration Study [PL 106-541], the Upper Mississippi River Comprehensive Plan [PL 106-53], USDA Programs, and Service authorities) could be integrated with a new dual purpose navigation authority. A dual purpose authority would also improve habitat management (and cost savings) by allowing the Corps' navigation channel maintenance authority to be used for habitat restoration.

In collaboration with the NECC and other stakeholders, the Corps sought to establish goals and objectives for restoring and maintaining the fish and wildlife resources of the UMRS over a 50-year time horizon. This was accomplished through several public workshops in the fall of 2002, review of draft pool plans prepared by interagency teams, review of the Habitat Needs Assessment Report (USACOE 2000c), and input from an independent Science Panel. From these four sources, over 2,500 spatially explicit objectives were recorded and have been subsequently condensed to 1,451 habitat restoration actions. This represents a scope of habitat improvement measures referred to by the Corps as a "Virtual Reference" against which ecosystem restoration alternatives were gauged.

The term "ecosystem restoration" has been applied variably throughout the restructured study period and generally refers to management interventions undertaken to achieve desired habitat conditions. Because ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration Science and Policy Working Group 2002), the Service considers the use of the term appropriate in this case to describe the collaborative efforts of the agencies and stakeholders to reverse the apparent downward trajectory of river resources. The Service recognizes that complete restoration of all fish and wildlife resources to a predevelopment historic condition is not possible or desired by stakeholders at this time.

Because the term "Virtual Reference" has been used in at least two contexts, we wish to clarify our support for development of a virtual reference condition as described in the Science Panel report versus simply aggregating the suite of spatially explicit objectives described in DeHaan et al. (2003) as a target condition for river habitats. However, because that suite represents all of the habitat management actions identified to date by the public, agency managers, or other documents, it provides a valuable snapshot of desired future conditions. The Science Panel concluded that modeling would provide a suitable virtual reference based on the goals and objectives articulated by managers and stakeholders. The Science Panel did not conclude that the total objective set constituted a virtual reference in and of itself.

The 1,451 actions or objectives have not been scientifically evaluated to establish either their actual ecological need or their implementation priority over the next 50 years. There is an immediate need to implement the Science Panel's (ER 52, 2003) modeling recommendations to test assumptions regarding implementation of stakeholders' objectives and their potential contribution to the Tier 2 system goals.

It was hoped that the independent Science Panel would be able to provide insight into the priority and need for implementation of these actions. However, insufficient study time prevented such a review. The general consensus of UMRS managers is that only by means of a rigorous adaptive management strategy will the scope of ecosystem restoration needs be revealed. This will only be achieved through a commitment to testing traditional and innovative habitat management techniques, evaluating their performance, and adjusting management intervention over time in response to ecological need and societal desires.

The 1,451 ecosystem objectives were categorized into 12 types of measures (See Table 1). Using criteria based on the Corps' Principles and Guidelines (ER-1105-2-100), these measures were assigned to alternatives that portray potential degrees of ecosystem restoration ranging from Alternative A (no new measures) to Alternative E (1,202 measures). An Ecosystem Restoration Alternatives Evaluation Scoresheet was developed in order to compare and rate the five alternatives. In combination with input from the NECC and results of the Scoresheet, the Corps selected Alternative D as the one that best meets the study objectives.

PROJECT DESCRIPTION

The proposed commercial navigation improvements that are summarized in the Service's April 2002 Draft FWCA Report are very similar to the alternatives presented in the Corps' current feasibility study. The notable exception is the addition of tow scheduling and congestion fees alternatives. The most significant change was the addition of ecosystem restoration as a study objective.

Draft Tentatively Selected Navigation Efficiency Plan – The following project description is taken from the Alternative Formulation Briefing Pre-Conference (AFB) Report dated February 9, 2004 (USACOE 2004a). The recommended plan is a combination of measures from Navigation Efficiency Alternatives 4 and 6 consisting of:

> 1. Authorization and immediate implementation of small scale structural and non-structural measures found in Alternative 4: (a) mooring facilities at Locks and Dams 12, 14, 18, 20, 22, 24, and LaGrange, (b) switch boats at Locks and Dams 20 to 25, (c) initiation of a mitigation plan for Alternative 4, and (d) continuation of development and testing of an appointment scheduling system. The estimated cost of this alternative is $84 million for improvements plus $79.4 million for site-specific and traffic mitigation costs.
>
> 2. Implementation of Alternative 6, which includes: (a) new 1,200-foot-long locks at LaGrange and Peoria and Locks and Dams 20, 21, 22, 24, and 25, (b) extending the existing lock to 1,200 feet at Locks and Dams 14, 15, 16, 17, and 18, and (c) utilizing switch boats at Locks and Dams 11, 12, and 13. The cost of Alternative 6 is $2.268 billion for improvements plus $207 million for mitigation.

Mitigation measures for Alternatives 4 and 6 consist of incremental traffic remedies such as: (1) measures to reduce shoreline and island erosion, (2) remediation of backwater and side-channel sedimentation, (3) protection of aquatic plant beds, (4) maintenance of fishery habitat, (5) monitoring of mitigation performance, (6) protection of historic properties, and (7) site-specific measures to protect or replace fish and wildlife resources impacted by actual construction. Mitigation costs would be funded in the same way as navigation improvements, which is 50 percent from the Corps' construction general funds and 50 percent from the Inland Waterways Trust Fund.

Several authorization options are proposed, but none have been recommended. Options range from the immediate authorization of all improvements to authorization of only pre-engineering and design, with full authorization delayed until submission of a future report and approval by the full Congress.

Draft Tentatively Selected Ecosystem Restoration Plan – The draft tentatively selected plan is a modified version of Ecosystem Alternative D (See Table 1 taken from the Corps' AFB Report). In addition to those measures identified in the accompanying figure, the Corps has added the following measures to the alternative (now called "Alternative D Prime"): (1) embankment lowering at lock and dam sites to improve floodplain connectivity, shoreline stability, and fish passage at no additional cost, and (2) measures to reduce water-level fluctuation on the UMRS, which would cost an additional $140 million dollars over 50 years.

Alternative D includes a total of 1,009 habitat improvement measures in 12 different categories, which would be implemented over a 50-year timeframe under an adaptive management framework. The AFB Report also recommends an initial 10-year authorization, which could be extended contingent upon another Congressional authorization. Similar to the navigation efficiency measures, several authorization options are being considered, but none have been recommended.

Table 1 - Alternative D – Number of ecosystem projects, costs, and benefits over 50 years. (Source: Corps of Engineers Alternative Formulation Briefing Pre-Conference Report dated February 9, 2004)

Ecosystem Measures	Project Footprint	Number of Projects	Project Costs (Millions) Measure	O&M	Benefits Acres of Influence
Island Building	30 Acres	91	$314.8	$22.5	91,000
Fish Passage[a]	1 Site	14	$329.0	$21.0	-
Floodplain Restoration (Pools 1-13)	500 Acres	21	$21.0	$7.9	10,500
Floodplain Restoration (Rest of UMR-IWW)	5,000 Acres	16	$400.0	$60.0	80,000
Water Level Management - Pool[a]	1 Site	12	$54.0	$0.0	-
Water Level Management - Backwater	1,000 Acres	7	$23.8	$7.0	7,000
Backwater Restoration (Dredging)	20 Acres	208	$483.8	$0.0	124,800
Side Channel Restoration	100 Acres	147	$213.2	$84.5	14,700
Wing Dam/Dike Alteration	5 Structures	64	$50.2	$4.4	640
Island Protection	3000 Feet	157	$83.0	$13.0	37,680
Shoreline Protection	3000 Feet	235	$124.2	$19.4	705
Topographic Diversity	5 Acres	32	$24.6	$1.9	256
Dam Point Control	1 Site	2	$23.2	$4.5	6,000
Floodplain Restoration-Immediate Opportunities	5,000 Acres	3	$75.0	$11.3	15,000
Additional Costs[b]			$2,963.0	$0.0	
	Total	1,009	$5,182.8	$257.3	388,281

a. Fish passage and pool-scale Water Level Management benefits were assessed separately.
b. Additonal costs are derived from categories of adaptive management, forestry management, systemic fleeting plan, cultural resources management/mitigation, Planning Engineering Design (PED), and adminstration.

The proposed ecosystem alternatives would be funded at either 100 percent Federal cost or cost-shared with a non-Federal partner. The Corps considered various cost-sharing arrangements for implementing the ecosystem restoration plan by means of existing authorities as well as a potential new authority. The tentatively recommended cost sharing "Option C" described in the AFB Report is:

Cost Sharing Option C. - Measures involving modification of structures and/or operations of existing projects, measures on Corps project lands and lands included in the National Wildlife Refuge System, and measures in the main channel or directly connected backwater areas below the Ordinary High Water Mark would be 100 percent Federal funded regardless of current ownership. Measures on other publicly or privately owned lands would be cost shared at 65 percent Federal and 35 percent non-Federal.

Using this methodology, ecosystem measures funded at 100 percent Federal cost would include:

- Fish Passage
- Pool-Scale Water Level Management (Drawdown)
- Wing Dam/Dike Alteration
- Dam Point Control
- Island Building
- Side Channel Restoration

The following non-structural measures would also be funded at 100 percent Federal cost:

- Forestry Management
- Systemic Fleeting Plan
- Cultural Resources Management/Mitigation

Measures that could be funded either at 100 percent Federal cost or 65/35 cost share (or a combination of both depending upon location and ownership) would include:

- Floodplain Restoration
- Topographic Diversity
- Backwater Water Level Management
- Backwater Restoration (Dredging)
- Island and Shoreline Protection

The adaptive management component of the alternative plans will also be partially cost shared. Specifically, performance evaluation on cost shared projects would be cost shared 65/35 by partnering agencies.

Operation and maintenance costs would be borne by the Corps for measures involving modification of structures or operations of existing Corps projects. These include Fish Passage, Pool-scale Water Level Management, Wing Dam/Dike Alteration, and Dam Point Control. The O&M costs for the remaining measures would be borne by the partnering agencies managing the land. As a component of the measures, real estate costs (e.g., land acquisitions or easements) would be borne by non-Federal interests that will receive cost sharing credit for the value of the land or easements.

Integration to Create a Dual Purpose Plan – Currently, the navigation project is a single purpose authority that does not include habitat restoration. Since the navigation feasibility study was restructured, the goal has been to develop a combination of alternatives that "...seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System." In pursuit of this goal, the AFB Report states:

> "It is recommended that these two tentatively selected plans be combined into a single plan to be executed under a dual-purpose authority that would allow balanced management of the river for both navigation and ecosystem restoration. The navigation efficiency improvements under consideration can be accomplished without impact to the ecosystem restoration measures. Mitigation for site specific and system traffic effects will be fully incorporated into the adaptive management approach for ecosystem restoration. The dual-purpose authority would allow operation and maintenance activities to fully support ecosystem restoration objectives when appropriate. "

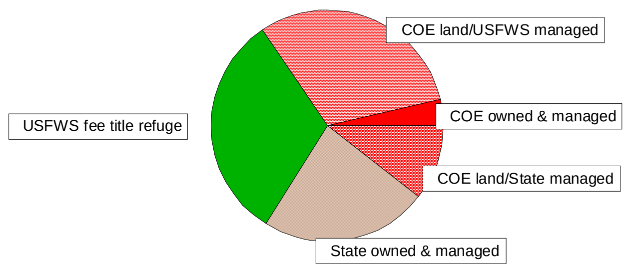
Implementing an integrated management plan where navigation and habitat restoration are equal project purposes would likely require a new institutional framework, changing how river management agencies and organizations coordinate with one another. Adopting an adaptive management strategy could significantly change the roles and responsibilities of many organizations. The AFB Report proposes that a new management structure be established, consisting of: (1) a River Management Council, (2) River Management Teams, and (3) a Science Panel. The River Management Council would expand the responsibilities of the existing EMP Coordinating Committee to include navigation-related habitat restoration authorities. It would serve as an agency level forum for coordinating implementation of a dual-purpose plan.

Each of the three UMRS Corps Districts now utilizes interdisciplinary teams of engineers, biologists, and other scientists to coordinate management actions under existing authorities. The River Management Teams would provide the field-level expertise required to design and plan local habitat projects. A Science Panel would be established to provide scientific guidance to the River Council and assistance to the River Management Teams.

AFFECTED RESOURCES AND THE FEDERAL INTEREST

A more complete description of the fish and wildlife resources of the UMRS study area can be found in the draft 2002 FWCA report. In addition, the Service prepared a computerized (Geographic Information System) inventory of significant resources located throughout the UMRS (U.S. Geological Survey 2000).

Figure 1 - Current Management Responsibilities for Public Lands on the UMRS



Of the approximately 2.6 million acres of floodplain on the UMRS, there are about 425,000 acres in public ownership (See Figure 1). Most of this acreage is Corps fee title land purchased for the Nine-foot Channel Navigation Project. Except for 17,000 acres of project-specific property, the Corps continues to manage the forest resources on most of these lands. However, it has turned over management for a large portion of these lands to the Service and the states. The Service owns about 134,000 acres of Congressionally authorized refuge fee title land but also manages an additional 131,000 acres of Corps navigation project lands as part of the National Wildlife Refuge System. (Note: See the Draft FWCA Report for a list of refuges included in the study area). In addition, the five UMRS states own about 101,000 acres and also manage 45,000 acres of Corps navigation project lands for fish and wildlife.

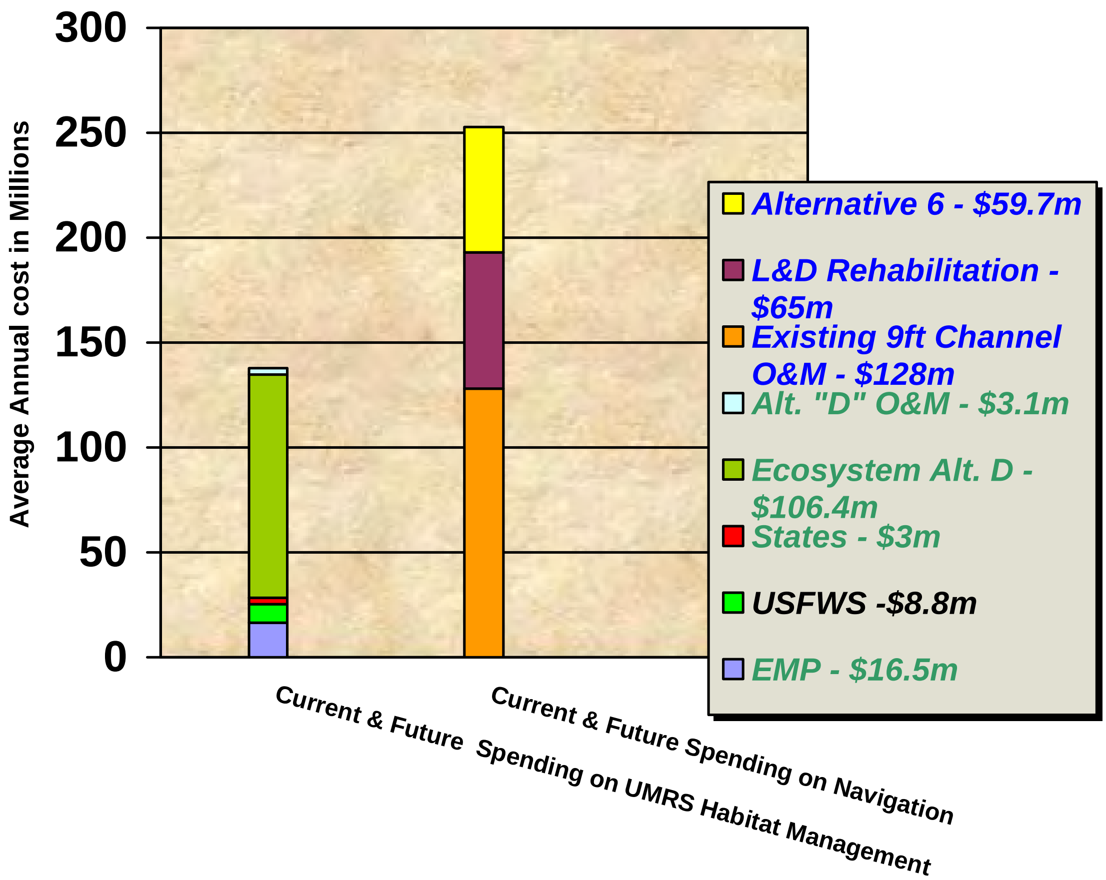
A 1992 recreation study (Carlson et al. 1995) calculated that recreation on the UMRS generates over $1.2 billion in benefits and supports about 12,600 jobs. A 1999 study (Industrial Economics 1999) estimated that tourism supports 140,000 jobs and generates $6.6 billion in goods and services for counties bordering the UMRS. On average there are over 11 million visits a year to the UMRS, including 3.5 million annual visits just to the Upper Mississippi River Wildlife and Fish Refuge. Most of these visitors use the river for boating (30.4 percent), fishing (31.2 percent), hiking and sightseeing (20.3 percent), and camping (7.9 percent).

The UMRS is extremely critical to migratory birds such as waterfowl, colonial nesting birds, songbirds, and raptors. It is the most significant natural feature of the Mississippi Flyway, which is one of four North American bird migration corridors. Bottomland hardwoods and floodplain wetlands provide nesting and migratory habitats for hundreds of bird species. There are approximately 132 species of fish and over 30 freshwater mussel species (Wiener et al. 1998).

Considering the economic importance of UMRS natural resources to the five-state region, the Federal investment in maintaining these resources is very low, especially when compared to the investment for commercial navigation. Figure 2 compares funding for navigation and natural resource management. The Corps predicts its average annual budget for maintaining the existing navigation project will be $128 million over the next 50 years. An additional $65 million per year will be spent to rehabilitate the navigation infrastructure. Implementing Navigation Alternative 6 will add another $59.7 million to the annual budget. Average annual spending on natural resource management by the Service, state natural resources agencies, and EMP projected over the next 50 years is less than $30 million annually. Even with the full implementation of Ecosystem Restoration Alternative D, natural resource management funding would still be roughly equal to the existing navigation project's average annual O&M funding.

Overlapping local, state, and Federal authorities create a very complex management framework. This frustrates efforts to holistically manage the fish and wildlife resources of the UMRS. Divided land management responsibilities (Corps, Service, states, and local law enforcement) create perennial problems throughout the system such as consistent enforcement with respect to litter, ATV use, unregulated camping sites, and timber cutting. The single authority that exerts the most control and consistency over the entire length of the system is navigation. Secondary controlling authorities are the Corps' Federal flood protection authority and the Service's refuge management authority.

Figure 2 - Average Annual Cost of Navigation Vs. Habitat Management (2005 base year) For 50 Years



Note: This chart compares the average annual cost of UMRS natural resource management against the cost of maintaining the Nine-foot Channel Navigation Project over a 50-year period. The annualized costs of the recommended Ecosystem Alternative D and Navigation Improvement Alternative 6 (calculated over 50 years also) are superimposed on top of these figures.

EFFECTS OF THE PROPOSED PROJECT AND THE SECOND LOCK AT MELVIN PRICE LOCK AND DAM

The navigation efficiency improvements proposed in Alternatives 4 and 6 include measures that will increase the number of commercial tows using the Upper Mississippi River and the Illinois River. This will directly impact fish and wildlife and their habitats. Site-specific impacts will also result from the construction of these measures at several locations. The continued operation and maintenance of the existing project (and future rehabilitation), which is needed to support this additional traffic, will also continue to cause adverse impacts to fish and wildlife resources. The Corps has identified a mitigation plan for incremental traffic effects and site-specific construction impacts but not for project O&M impacts. Instead, the Corps has proposed Ecosystem Restoration Alternative D Prime, which will restore terrestrial and aquatic floodplain habitats that have been impacted by navigation project O&M activities.

Second Lock Traffic Effects

When the EIS for the Second Lock at Melvin Price Lock and Dam (USACOE 1988) was prepared, navigation traffic was predicted to increase substantially. The UMRS Master Plan (UMR Basin Commission 1982) predicted an increase of four additional tows per day. Information in the Corps' March 2004 Report for Second Lock Traffic Projections (USACOE 2004b) shows that those predictions were overly optimistic. Using the Tow Cost Model (TCM), the Corps calculated the difference in traffic between a "with project condition" consisting of one 1,200-foot-long lock plus a 600-foot-long lock and a "without project condition" of only one 1,200-foot-long lock.

The TCM exercise utilized five different traffic prediction scenarios, which were used to model the current study's proposed navigation efficiency measures. The increment of traffic generated by the Second Lock was very small, less than 1 percent of the total system traffic. The Corps' Report concluded, "In summary, incremental traffic due to the Second Lock, as calculated in 2003, is extremely small and could be argued to be within the level of model precision." The Corps' Second Lock traffic analysis did not model the predicted traffic effects upon any fish and wildlife resources, nor did it propose any mitigation measures.

Based on a preliminary review of the Corps' Report, the increased traffic impacts associated with the Second Lock at Melvin Price appear negligible. In addition, mitigation actions proposed for the current feasibility study's recommended navigation efficiency measures would likely compensate for any adverse effects.

Site-specific and Incremental Traffic Impacts Associated With Navigation Efficiency Alternatives 4 and 6

The Corps' impact assessment has projected the *incremental traffic increase* (predicted traffic with the project, minus the projected traffic without the project [baseline]) over the next 50 years. This additional traffic will increase the rate of shoreline erosion, degrade submergent aquatic plant beds, increase sedimentation in side-channels and backwaters, and result in fish mortality from propeller entrainment. The April 2002 Draft FWCA Report assesses these impacts as well as the adequacy of the Corps' own impact analysis. Switch boats and lock scheduling, which are included in the recommended navigation efficiency measures, were not addressed in the Draft FWCA Report. Despite some uncertainty about the magnitude of larval fish entrainment effects, traffic impacts from the proposed navigation efficiency improvements should be adequately mitigated given the assurance that an ecosystem restoration program is also implemented. The Service also concurs with the preliminary site-specific impact analysis and mitigation plan, which is subject to further refinement during the advanced engineering and design phase.

Operation and Maintenance Impacts Associated with Navigation Efficiency Alternatives 4 and 6
The Corps' impact analysis of the proposed alternatives does not specifically address navigation project O&M impacts, although we understand that the Feasibility Report EIS will address them. Also, a mitigation plan was not specifically prepared for project O&M impacts. In the Service's opinion, this was a critical deficiency in the impact analysis performed prior to study restructuring. However, the Corps did prepare a report (USACOE 2000c) that calculated changes in habitat (surficial land forms) since river impoundment. It also predicted habitat changes for the next 50 years assuming there is no change in O&M. Although the models used in this prediction had severe limitations, the results still demonstrated the overall negative effects of the navigation project from sedimentation, erosion, dredged material placement, channel regulatory works, and impoundment. The 2002 Draft FWCA Report also identified related impacts of major concern such as the spread of exotic species, water level management, barge fleeting, and hindered fish passage through the navigation dams.

Since the O&M EIS was prepared in the 1970s, a substantial amount of new information regarding O&M impacts has been documented. The Service, therefore, concluded in its 2002 Draft FWCA Report that the Feasibility Study EIS should include an updated O&M impact analysis. Ideally, the update should identify and quantify the "cause and effect" relationships between O&M activities and associated impacts. This would be an extremely costly and lengthy exercise. It may even be impossible given the difficulty in eliminating the non-navigation stressors, which also contribute to river degradation (e.g., nutrient loading from the watershed and floodplain development), from the analysis.

Effects of Ecosystem Restoration Alternative D Prime
A total of 1,009 ecosystem management measures in 12 different categories are proposed (See Table 1). Although the categories of measures are considered separately below, managers intend to combine these measures, where possible, to achieve site-specific habitat objectives and decreased construction costs.

Island Building – A total of 91 island-building projects, averaging 30 acres in size, would be built. Although the total island "footprint" would be only 2,730 acres, up to 91,000 acres of shallow water would benefit from the islands' shadow effect. Using designs developed as part of the EMP, island design configurations would create conditions intended to promote the establishment of submergent and emergent aquatic plants. Increased aquatic plant growth would benefit fish and migratory birds as well as increase habitat diversity. The islands themselves would provide nesting habitat for migratory birds.

Most island project locations are upstream of navigation dams, where impoundment has created large reaches of wind-swept open water with soft bottom sediments, often devoid of vegetation. Although the building of islands would result in a decrease in the acreage of open water, the habitat quality of the remaining acreage should increase significantly, as demonstrated by monitoring of completed EMP habitat rehabilitation projects.

Fish Passage – 14 fish-passage projects are proposed. Excluding the Illinois River, there are 29 locks and dams that hinder fish passage to some degree. The degree of hindrance depends to a large degree upon the amount of time navigation dams are open to allow fish to pass upstream. Some dams, such as Lock and Dam 19, act as total barriers because of their extreme head differential and should be considered a priority location for improved fish passage. In recent years, however, the spread of Asian carp throughout the UMRS has caused managers to consider the ramifications of improving fish passage. Ideally, managers desire to encourage the passage of native fish such as paddlefish and sturgeon but deter the movement of exotic species such as Asian carp. Existing information on fish passage techniques does not offer a good solution to achieving both objectives.

Ambitiously implementing all 14 fish-passage projects could unnecessarily promote the spread of Asian carp and other exotics (e.g., round goby, European ruffe). Small-scale testing of multiple fish-passage techniques and methods should precede construction of any large-scale fish-passage projects (e.g., Lock and Dam 19). Such investigations, combined with a better knowledge about Asian carp life history, will help managers determine the optimal array of fish-passage projects throughout the UMRS. Such an approach is consistent with an adaptive management strategy proposed for implementing the ecosystem restoration measures.

Floodplain Restoration – A total of 37 floodplain restoration projects are proposed (21 projects in UMR Pools 1-13 and 16 projects in the remaining portions of the UMR and Illinois River). Floodplain restoration would utilize a variety of habitat methods dependent upon local habitat needs. These would include actions such as reconnecting backwaters to the main channel; restoring degraded tributary channels; and creating wetlands, forests, and wet prairies. Projects in the upper navigation pools would average approximately 500 acres each, while those in the rest of the system would average about 5,000 acres each. Floodplain habitat objectives would also benefit from pursuing cooperative projects with Federal and state agricultural programs. There is also an opportunity to achieve habitat benefits by integrating flood protection programs overseen by the Federal Emergency Management Agency (FEMA).

Over a third of the floodplain is in agriculture (See Figure 3). Successful floodplain restoration will hinge upon willing partnerships with private landowners. Landowners all have different perspectives/values concerning their land; some may wish to preserve agricultural productivity as much as possible, while others may be interested in restoring fish and wildlife habitats. Meeting landowners' individual objectives will require a variety of approaches from multiple sources. Some may prefer USDA programs such as the Conservation Reserve Program, while others might be more interested in the Service's Partners for Fish and Wildlife Program. Integrating these varied approaches through a revised institutional framework, coupled with a cross-cut budgeting strategy for Federal authorities, could greatly improve floodplain restoration efforts.

Water Level Management (WLM) – Prior to impoundment, the floodplain experienced wet and dry periods in response to the main channel's fluctuating water level. Because of the varied topography and bathymetry, a very diverse mosaic of habitats resulted. Since the timing and duration of water levels varied every year, the locations and extent of these habitats also varied. This created a diverse and constantly changing landscape that supported many fish and wildlife species. Impoundment and other floodplain development (e.g., levee construction) reduced or eliminated the conditions that sustained the floodplain's habitat diversity and productivity. Hence, many plant and animal species are no longer present or are significantly reduced in number. The decline of bottomland hardwood forest species such as oaks and other mast-bearing trees is particularly significant in this regard. A recent aquatic vegetation survey conducted between UMR Pools 15 and 26 showed that, except for Pool 19, aquatic vegetation was absent from the main channel border of the river.

Twelve pool-scale projects that would mimic the river's historic low-water periods are proposed. Another seven projects, averaging 1,000 acres each, would be implemented to simulate backwater habitat conditions that would occur from a natural river hydrograph. Successful implementation of these measures would provide significant habitat benefits by stimulating aquatic vegetation growth and reproduction, mast tree survival and reproduction, spawning and nursery habitat for fish, and migratory bird habitat. Pool-scale drawdowns will temporarily prevent boat access from local marinas to the main channel. Additional dredging may be required to maintain recreational boat access as well as for commercial boats transiting the main channel. Measures for WLM may be the most cost-effective ecosystem measure in terms of cost per acre. Successful WLM will also enhance the success of other habitat measures.

Backwater Restoration – A total of 208 backwater dredging projects are recommended at an average size of 20 acres. Based on research from the EMP, each acre dredged could potentially benefit up to 30 adjacent acres. Sedimentation has significantly reduced the habitat value of backwater lakes and ponds. Recreational access has also been severely affected. Backwater habitats are particularly important to many fish species. Fish over-wintering habitats must have water temperatures higher than is typically found in the main channel. Dissolved oxygen levels must also be higher than 4-6 mg/l. These locations also must exhibit little or no current. Backwaters degraded by sedimentation often go anoxic in the winter and in northern reaches may even freeze to the bottom. Poor quality over-wintering habitat translates directly into reduced fish populations the following spring. Isolated backwaters of sufficient depth are also needed to sustain reptile and amphibian populations and provide brood cover for waterfowl such as wood ducks.

Side-Channel Restoration – A total of 147 side-channel restoration projects are proposed, averaging 100 acres each. Sedimentation, exacerbated by the system of navigation channel regulating works, has reduced the value of many side-channel locations. Channel regulating structures have resulted in reduced flow and connectivity in side channels. These structures have led to aggradation in side channels and degradation in the main channel, thus reducing water depth and quality in the side channels. In addition, channel regulating structures have altered the geomorphological processes (e.g., channel meandering) that create and maintain diverse side channel/island complexes. Most of these are degraded due to sedimentation. Restoration of side-channel habitat in the middle river reach is particularly critical to restoring habitat for the federally endangered pallid sturgeon.

Wing Dam/Dike Alteration – Literally thousands of rock dikes have been constructed along the length of the UMR (there are few or none on the Illinois River) for one purpose - to constrict the river's flow and deepen the navigation channel. This reduces the need for costly channel dredging. These structures can provide localized benefits by providing substrates for invertebrates consumed by fish and shelter from river currents. Cumulatively, however, this system of regulating works has degraded aquatic habitat diversity. New designs and dike field configurations need to be developed that can increase habitat diversity and still reduce the need for channel maintenance dredging.

Island Protection – Geomorphologists tell us that many of the UMR's islands have been present for hundreds, if not thousands, of years. The complex mosaic of island/backwater/side-channel configurations along the UMR creates numerous micro-habitat conditions important to many species. Although shoreline erosion is a natural process, these island complexes have been eroding at an accelerated rate since impoundment. Forest trees that normally stabilize shorelines die prematurely because their shallow root systems (caused by elevated water levels) cause them to topple during high winds. It is not uncommon to see shorelines littered with mature trees following high winds. The EMP Long Term Resource Monitoring Program (LTRMP) documented the severity of island erosion for lower Pool 8 near La Crosse, Wisconsin. Alternative D Prime recommends 157 island protection projects, averaging 3,000 feet in length. These measures are needed to protect the remaining islands from certain loss.

Shoreline Protection – Some 235 shoreline protection projects, averaging 3,000 feet each, are proposed. Shoreline protection is needed for the same reasons mentioned above.

Topographic Diversity – Historical records and observations show that prior to navigation and other floodplain development, the river had numerous sand bars, snags, and rapids (e.g., at Rock Island, Illinois; Keokuk, Iowa). These features created a topographically and bathymetrically diverse aquatic and terrestrial landscape supporting a multitude of aquatic and terrestrial organisms. Particularly since impoundment, these habitats have become much more homogeneous. This condition is most noticeable immediately above the navigation dams. Impoundment/sedimentation effects have transformed large wetland and riverine expanses into thousands of acres of open water, often only a couple of feet deep and devoid of vegetation. A total of 32 projects, averaging 5 acres each, are proposed to help restore topographic diversity. Such restoration would benefit a wide range of aquatic plants and animals.

Dam Point Control – Some navigation dams manage pool water levels according to a procedure known as "hinge point control." Changing to a "dam point control" procedure will increase the area benefited by WLM projects. However, this will require the purchase of additional flood easements since it will increase the period of time some locations will be inundated.

Alternative D Prime also calls for increased lockmaster attention regarding dam gate operation at some navigation dams. In particular, the LaGrange and Peoria navigation dams on the Illinois River are different from those on the UMR. Their design (wicket gate) and method of operation often results in rapid and dramatic water level fluctuations. Such fluctuations can cause significant adverse impacts on fish spawning success by stranding eggs and/or larvae. This type of fluctuation is also detrimental to aquatic and wetland vegetation.

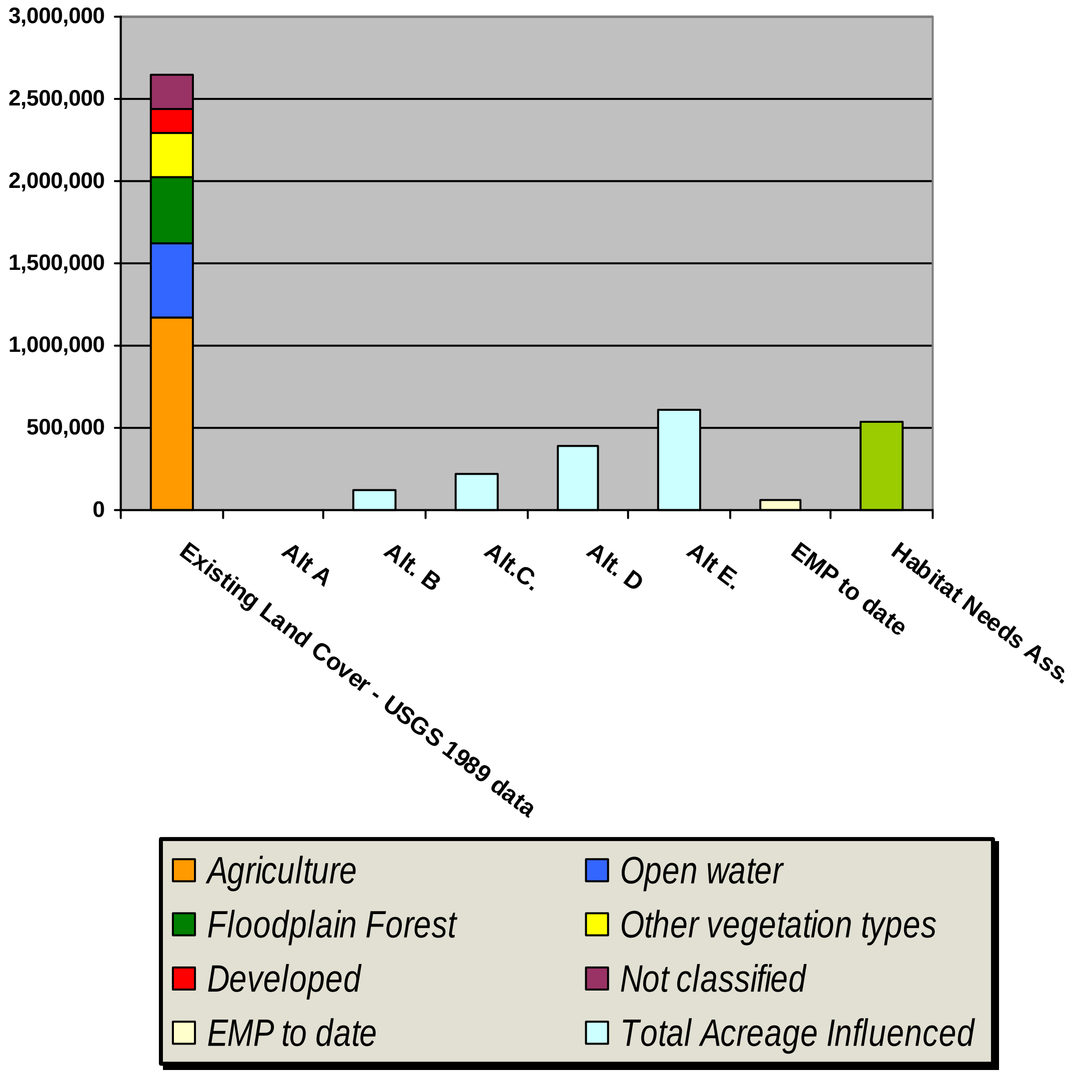
Summary of Project Effects

Figure 3 illustrates the acres of existing land cover types in the UMRS floodplain, how much acreage would be affected by each of the proposed restoration alternatives, the EMP projects acreage to date, and the Habitat Needs Assessment (HNA) Report (USACOE 2000c) recommendations. To date, the EMP has benefited less than 3 percent of the total floodplain habitat. At its current restoration rate, only 11 percent will be restored in the next 50 years. The HNA Report, which was a collaborative effort of Service, state, and Corps biologists, identified a need to restore slightly more than 500,000 acres. Restoration Alternative E most closely approximates meeting the habitat needs identified in that report.

Given our understanding of UMRS ecology, implementation of Alternative D Prime should reverse the ongoing decline of natural resources in much of the UMRS. However, the degree to which this decline is reversed and to which environmental sustainability is achieved can only be determined by long-term monitoring and full implementation of the adaptive management framework.

Compared to Alternative E, there is a higher risk under Alternative D Prime that some fish and wildlife habitats and species may not be restored or sustained for the foreseeable future. This presumes that the entire array of measures will be implemented over the 50-year period. Cessation of the ecosystem restoration program will cause the UMRS's fish and wildlife resources to resume their decline since the river will likely continue to be maintained for commercial navigation regardless of whether or not the proposed navigation efficiency movements are implemented.

Figure 3 - Acreage of Proposed Restoration Alternatives



Note: Data source for Alternatives acreage is the Corps' AFB Report dated February 2004. The area-of-influence figures do not include fish passage or pool-wide WLM. For EMP, the acreage to date includes both the project footprint and area of influence. The HNA acreage is the recommended habitat restoration need identified by UMR biologists in the HNA Report (USCOE 2000) and is not equivalent to the "area of influence" calculated for the ecosystem restoration alternatives.

CONCLUSIONS

1. The UMRS is a globally significant ecosystem with extensive Federal interest in the study area, involving 425,000 acres of public land, including nine national wildlife refuges. It is internationally significant for migratory birds and provides habitat for several federally listed threatened or endangered species and interjurisdictional fish species. There is a need for continued Federal leadership because of the interstate and interjurisdictional nature of fish and wildlife management. The ongoing and cumulative impacts of flood control and navigation upon these national resources have never been sufficiently evaluated.

2. The continued operation and maintenance of the UMRS navigation project will continue to degrade UMRS fish and wildlife resources unless it is managed under a dual purpose authority that includes ecosystem restoration as a project purpose. Artificially regulated water levels, sedimentation exacerbated by impoundment, shoreline erosion, and other O&M activities will result in an ongoing, cumulative degradation of habitat diversity and productivity (U.S. Geological Survey 1999). This situation will continue as long as habitat restoration actions must be implemented within the authority constraints of the existing Nine-foot Channel authority. Biologists have documented (USGS 1999, Wiener et al. 1998) that there is little uncertainty that UMRS fish and wildlife resources are experiencing a long-term decline. The only uncertainty is the scope of measures needed to restore and maintain them. An effective adaptive management strategy will provide the necessary feedback loops to inform managers how successfully they are meeting this goal.

It is reasonable to expect that the Nine-foot Channel Navigation System will be maintained and operated for the next 50 years and beyond. Therefore, the negative effects generated by the existing project will continue to accumulate as well. As long as the river is to be maintained for the Nation's benefit there will be a need to remediate those effects. Mitigation measures will be necessary to offset those effects, otherwise fish and wildlife resources will continue their decline. Thus, the Service believes there is sufficient justification and scientific documentation to support a full 50-year ecosystem restoration authorization.

3. Cost Sharing Option C is most appropriate for restoration. Federal trust resources are being impacted by Federal projects and should receive full Federal funding. Since the 1800s, the UMRS has been continually modified by Federal activities to increase its navigability and improve flood protection. Federal navigation and flood control authorities continue to exert a detrimental influence on the floodplain ecosystem by manipulating the frequency, stage, quantity, location, etc., of stream discharge through the system. The navigation project directly impacts approximately 285,000 acres of National Wildlife Refuge System lands, including habitat for federally listed threatened and endangered species. By law, these refuges are managed primarily for the benefit of Federal trust species. Objectives for navigation and flood protection frequently conflict with fish and wildlife objectives. In striving to achieve refuge objectives, managers incur additional expense and fall short of achieving optimum habitat management because of these constraints. The adverse effects generated by the navigation and flood control authorities deter adjacent states from participating in many cost-sharing opportunities. State management agencies are reluctant to cost-share in projects where the effects of navigation and flood control projects counteract resource management objectives and lead to higher habitat maintenance costs. For example, navigation impoundments created by the locks and dams increase pumping and levee maintenance costs for both national wildlife refuges and state-managed migratory bird refuges. A strong Federal presence is needed to coordinate among the multitude of management agencies. The majority of proposed restoration measures will occur on Federal lands or waters that are directly or indirectly subject to the adverse effects of operation of the existing Nine-foot Channel Navigation Project. For this reason, it is unreasonable to expect these measures to be cost-shared.

4. The Service considers ecosystem restoration as a long-term (50 years and beyond) Federal obligation to address the ongoing and cumulative effects of the Nine-foot Channel Navigation Project. The Corps has argued that existing project O&M impacts are not relative to the current study purpose and a full NEPA assessment is not required. The Service has argued that the Corps should assess Nine-foot Channel O&M impacts in the EIS for the System Navigation Study.

Since the study was restructured, the Corps has agreed to assess O&M effects in the EIS but not to "mitigate" them. Ideally, such an assessment should quantify the effects of the existing project so that an appropriate mitigation plan can be developed. However, the Service agreed with the Corps that quantifying such impacts would be very costly, time consuming, and provide uncertain results in assigning the Project's appropriate level of culpability. Thus, the Service has agreed that assessment of O&M effects in the Draft EIS for the Restructured Navigation Study will be qualitative. A qualitative assessment will guide the identification of mitigation measures but not determine their appropriate scope. Full implementation of Ecosystem Alternative D or E will likely reverse many of the adverse impacts that continue to accumulate from operation and maintenance of the existing Nine-foot Channel Navigation Project. The Service's position is that ecosystem restoration is, in fact, mitigation for O&M impacts.

5. Implementation of Navigation Efficiency Alternatives 4 and 6 will not significantly impact the fish and wildlife resources of the UMRS if the proposed mitigation plan and ecosystem restoration plan are implemented. Although there remains a high degree of uncertainty about predicted traffic impacts, the mitigation proposed to compensate for incremental traffic effects appears adequate based on the impact modeling performed to date. In light of this proposed mitigation, the Service did not identify any traffic-related effects that would prevent construction of the proposed efficiency measures. Mitigation needs could change during detailed engineering and design. The site-specific impacts of construction and the resulting incremental increase in navigation traffic will be adequately mitigated by the proposed mitigation plan. Implementation of Ecosystem Alternative D Prime will also improve the health of fish and wildlife resources sufficiently to counter the negative effects of increased traffic.

6. Without additional funds to operate and maintain UMRS lands managed under the National Wildlife Refuge System, the Service may not be able to accept project O&M responsibilities for all potential Service sponsored projects identified in "Ecosystem Restoration Alternative D Prime." The Service will have a major role in ecosystem restoration due to the extensive Service presence and the considerations reflected in "Cost Sharing Option C" recommended by the Corps. The estimated non-Corps share of operation and maintenance costs for Alternative D Prime is estimated to be $138 million. The Service's share is estimated to range from $200 thousand to $1 million a year. This will be a significant obligation since the Service's annual budget for refuges on the Upper Mississippi and Illinois Rivers is about $7 million. The Service cannot commit in advance to maintaining the full list of measures identified in Alternative D Prime. These projects (measures) are yet to be designed and cost estimated and could change significantly in scope, location, and cost depending upon lessons learned through adaptive management. However, the Service will seek funding to meet future O&M obligations for habitat measures on refuge lands that are consistent with refuge purposes, goals, and objectives. Funding for additional Refuge O&M obligations should be included in any cross-cut budget documents that might be prepared in the future.

7. Because of the uncertainty in managing the UMRS for both navigation and habitat purposes, UMRS restoration requires an adaptive management framework that is "science based" and has a clearly defined decision-making component. There is still much to learn about habitat restoration on the UMRS, hence the need for an adaptive management approach for ecosystem restoration. The flexibility for such an approach does not exist in the current EMP, although the LTRMP of the EMP could potentially support such an approach. A Science Panel, co-chaired by the Service and the Corps, should be established to provide good scientific information about project performance to a decision-making forum such as a River Council. The Corps should immediately set about establishing a permanent Science Panel to guide the restoration initiative upon project approval.

Successful adaptive management requires a formalized approach that learns from assessing the outcomes of management actions and can make program changes in response to these lessons learned. The framework for adaptive management is a subset of an overall institutional framework. Although the EMP has provided very valuable lessons in the design and construction of habitat projects on the UMRS, it has yet to provide sufficient information regarding the effectiveness of habitat measures for achieving habitat restoration on a system scale. The Science Panel should be available to assist, as needed, the Federal and state managers with design, monitoring, and evaluation tasks for habitat projects. The Panel could also provide recommendations for improving the effectiveness of the habitat projects in meeting system goals and objectives.

8. Given its current/historical funding and program constraints, the Environmental Management Program (EMP) is inadequate to offset the negative impacts caused by the continued operation and maintenance of the navigation project. The EMP has demonstrated its effectiveness in restoring fish and wildlife habitat at a local level. In addition to funding, there are several constraints (e.g., Corps policy and regulations, cost-sharing rules, O&M responsibility, land acquisition limitations, and subservience to the Nine-foot Channel Navigation Project authority) that prevent the EMP from implementing actions of the scope necessary to achieve fish and wildlife habitat goals on a systemic scale.

RECOMMENDATIONS

1. The Service endorses Ecosystem Restoration Alternative E and Cost Sharing Option C for a full 50-year project life, since they offer the highest degree of certainty for achieving

the study's UMRS habitat goals and objectives. If Alternative E was fully implemented, up to 1.2 million acres (46 percent of the study area) could potentially benefit (604,121 acres or 23 percent of the study area if fish passage and navigation pool acreage benefited by WLM are not counted). All of these acres do not benefit to the same degree, however, since much of the habitat acreage is at the fringes or margin of habitat-measure effect. The tentatively recommended plan, Alternative D Prime, would only benefit up to 27 percent of the UMRS study area (703,717 acres) or 15 percent of the study area (388,281 acres) if fish passage and WLM acreage are discounted. The range of measures proposed under Alternative E provides the best opportunity for success, and more flexibility, in achieving ecosystem restoration. Alternative D Prime may be sufficient to mitigate the impacts associated with the operation and maintenance of the existing and proposed project, but there is a substantially greater risk that habitats needed by some species will not be restored. This would likely result in a lower level of UMRS ecosystem species diversity or productivity. Cost Sharing Option C would provide the broadest level of ecosystem restoration for Federal and non-Federal trust resources that continue to be adversely affected by the Federal navigation project.

2. The Service supports a new dual purpose Nine-foot Channel Navigation Project authority that includes ecosystem restoration as a project purpose. To reverse the ongoing decline of fish and wildlife resources, the Nine-foot Channel Navigation Project authority must be expanded to include fish and wildlife objectives as a project purpose. The existing navigation authority prevents the implementation of necessary habitat management actions on a scale sufficient to accomplish habitat improvement on a systemic scale. A "dual authority" would increase the Corps' efficiency and flexibility and permit it to utilize resources currently exclusive to navigation O&M for habitat restoration as well. For example, the three Corps Districts on the URMS have a considerable capacity (e.g., dredges, barges, cranes) that could be utilized for habitat restoration measures. The Corps is preparing a "15-Year Plan" that describes the initial activities to be conducted under a new UMRS adaptive management strategy. The details of this plan have not been finalized. The Service supports development of such a plan and believes that it will set the stage for the ensuing decades of dual purpose management needed to sustain navigation and fish and wildlife resources. However, completion of a 15-Year Plan would be only the beginning of true dual purpose management.

3. Initial implementation of any ecosystem restoration program should employ an adaptive management strategy. Initial implementation of ecosystem restoration under the adaptive management philosophy must focus the selection of projects on those which fulfill experimental design or contribute to the learning process through rigorous performance evaluation. The EMP has successfully restored UMRS aquatic and terrestrial habitats but has had limited success in documenting cause-and-effect relationships that clearly establish project success or design efficiency. A refocused effort could lead to improved project designs or the discovery of new and more efficient management tools. The first 10 to 15 years of any new restoration program should focus on system-wide management questions, monitoring, and performance evaluation to establish future management priorities. As stated in the conclusions above, the existing LTRMP structure is not flexible enough to meet the science needs of an adaptive management strategy. The EMP partnership should undertake an evaluation of the program's capabilities to support the adaptive management learning process.

4. The Corps, Service, states, and other partners should make every effort to integrate their programs and authorities to achieve ecosystem restoration. The UMRS floodplain is a very complex "landscape" in terms of agency roles and responsibilities. The Corps has multiple authorities, including navigation, flood control, EMP, Section 1135, and Section 206. The Service manages several national wildlife refuges. The USDA manages farm programs on floodplain lands. The five UMRS states manage several areas for recreation and wildlife. Other agencies such as USEPA, FEMA, and the U.S. Coast Guard also have a presence.

Many authorities within this complex jurisdictional landscape have similar fish and wildlife restoration goals and objectives. In addition to the Navigation Study ecosystem restoration plan, there are other studies (e.g., Illinois River Ecosystem Restoration and the UMR Comprehensive Plan) with similar objectives. This situation is potentially very inefficient and wasteful of human and capital resources. The AFB Report's discussion concerning how these efforts should be integrated is very inadequate.

Developing an integrated approach for these multiple habitat management authorities will require considerable coordination to establish the organizational roles and responsibilities inherent in an integrated habitat restoration plan. Incorporating an adaptive management strategy further adds to the complexity. The Corps and other partner agencies must immediately begin discussions on how to accomplish this integration.

5. In order to effectively integrate the multiple authorities, programs, and activities that occur on the UMRS, a new institutional framework must be established. In 1994, the Interagency Floodplain Management Review Committee (Galloway 1994) found that:

> "Currently no single entity has federal or federal-state oversight responsibility for the range of activities within the upper Mississippi River basin, or for ensuring that funding and performance among programs are commensurate with national goals. The Review Committee found no single hydraulic or hydrologic model, and no system-wide flood reduction strategy or ecosystem management strategy within the basin. Linkage exists among system components, but separate federal agencies deal with component problems independently."

In the ensuing decade, the Corps completed updating a system hydraulic model through the Flow Frequency Study, Congress authorized the Upper Mississippi River Comprehensive Plan, and the Corps has assembled the results of several interagency ecosystem planning efforts into one data set of desired future conditions for river habitats on the UMRS. However, cross-program linkage remains elusive and integrated river management has not been achieved through the existing interagency coordination groups.

The partners recognize that an adaptive management approach is necessary to move forward and have suggested three levels of organization: 1) a policy and administrative level group with the appropriate rank to make decisions and program course adjustments as necessary; 2) an advisory science level to guide the monitoring and evaluation portion of the adaptive management process; and 3) an action level to drive the problem identification, project design, and implementation of management actions. To meet the conceptual scope of adaptive management, these groups must be responsive, accountable, and sufficiently representative of stakeholders and the organizations or entities with jurisdiction or responsibility for management of river resources.

6. Implementing cross-cut budgeting among the Corps, USDOI, USEPA, and USDA should be a high priority in order to achieve UMRS partner goals. Implementing the recommended array of habitat measures will require effective and timely coordination among the multiple Federal agencies involved. Agency cooperation will be critical for achieving effective adaptive management. Integrated financial planning by Federal agencies (e.g., Service, Corps, USDA, USEPA, and FEMA) would foster such cooperation and focus respective agency programs on priority actions. The Everglades Restoration Program is a good template for such a recommendation.

A dual purpose authority for the Corps of Engineers will not achieve all stakeholder ecosystem goals and objectives alone. Watershed (nutrient runoff) and floodplain development impacts will reduce the effectiveness of the ecosystem measures identified in the recommended plan. Coordinating current programs of USDOI and the Natural Resources Conservation Service with the new proposed Corps authority will significantly advance the goal of a sustainable ecosystem. The Service's Partners for Fish and Wildlife Program should be expanded to meet watershed and floodplain landowners' needs. There should be an expansion of agriculture programs such as the Conservation Reserve Program and Wetland Reserve Program specifically dedicated to floodplain locations.

7. Planning, engineering, design, and construction requirements for habitat restoration projects must be revised in order to implement adaptive management and improve cost efficiency. Engineering and design criteria used for designing and constructing past Habitat Rehabilitation and Enhancement Projects (HREP) projects are sometimes too restrictive and frustrate efforts to develop new habitat management techniques. A number of HREP projects were designed and constructed to meet human health and safety standards rather than recreate or restore natural habitat conditions. Many habitat projects could be built to a lower standard, at a substantial savings in construction and O&M costs, yet still achieve habitat objectives. Because of the rivers' dynamic nature, project performance can sometimes be significantly different from expectations. The Science Panel should assist, when requested, in reviewing project design.

Partners are also unwilling to sign project O&M agreements for untested designs. Less stringent O&M agreements are needed in order to implement those measures of unproven design. In order to develop a full array of cost-effective habitat restoration/management measures and assess their biological performance, the requirements for project design, construction, and maintenance must allow for a higher level of risk.

8. Operation and maintenance of restoration projects that offset navigation impacts should be a Corps responsibility. Currently, the Service and state natural resource agencies incur significant expenses due to the existing Nine-foot Project. Many of the Nine-foot Project's adverse effects (e.g., shoreline erosion, forest decline, sedimentation, artificial water levels, hindered fish movement, and exotic species introduction) fall upon Service and state refuge lands or Corps' general project lands managed as a refuge. For example, some refuge lands are managed to simulate a natural hydrograph, to benefit migratory birds, by protecting wetland habitat from the influence of the navigation dams. Levees and pumping systems are frequently used as tools to artificially create needed wetland habitats. The costs of operating and maintaining such systems needed to counter the adverse effects of the Nine-foot Project are presently borne by the resource agencies.

9. In order to avoid or minimize barge fleeting impacts to fish and wildlife resources, a system-wide fleeting plan should be prepared. Corps traffic forecasts predict an increase in barge traffic on the UMRS. This will likely lead to an increased need for barge fleeting areas and, consequently, increased development pressure on National Wildlife Refuge System lands and other natural resources (e.g., mussel beds). A system-wide fleeting plan would benefit both developers and natural resources. Responsibility for preparing the plan should be shared by the US Coast Guard, the Service, and the Corps. The plan should not only seek to identify critical habitats that are unsuitable fleeting areas, but also identify river locations where fish and wildlife issues would not preclude development. The proposed budget of $300,000 is inadequate to prepare such a plan.

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