Estimate of Habitat Restoration Costs for the Upper Mississippi River System

Prepared by:
Jeff Janvrin
Mississippi River Habitat Specialist
Wisconsin DNR
June 2002

Table of Contents

Table of Contents **2**

Introduction **3**

Background **3**

Justification and Explanation of Cost Calculation for Each Technique **6**

Main Channel Habitat Restoration 6
Secondary/Side Channel Restoration 6
Backwater Restoration 7
Oxbow Lake/Isolated Wetland Restoration 7
Island Restoration 7
Forest, Prairie and Marsh Restoration 7
Forest Restoration 7
Prairie Restoration 8
Marsh Restoration 8
Maintain Existing Quality Habitat 8
Maintenance of Existing Forest Resources 8
Maintenance of Existing Prairie Resources 9
Maintenance of All other Habitat Types 9
Shoreline Stabilization 9
Wing Dam/Dike Field Modifications 10
Channel Maintenance Implementation of Environmentally Preferred Option 10
Modifications of Lock and Dam Operation 11
Water Level Management 11
More Frequent Operation of Gates on Dams 11
Restoring Floodplain Connectivity 12
Fish Passage 12
Spillway/Lock and Dam Dike Modifications 12
Connectivity Modification Structures 12
Levee Modifications 13
Land Use Change 13
Voluntary 13
Incentive Programs 14
Environmental Easements 14
Acquisition from Willing Sellers 14
Restoration of Aquatic Micro-Habitat for Fish, Mussels and Waterbirds 14
Fish Habitat Structures 14
Mussel Habitat Restoration 14
Moist Soil Management 15
Monitoring and Applied Research 15

Explanation of Column Headings in Tables 2 and 3 ..... **15**
Table 2. HNA geomorphic and land cover classifications affected by different UMRS habitat restoration techniques. **18**

Table 3. Cost calculation for techniques needed for UMRS habitat restoration. **20**

Literature Cited **22**

Estimate of Habitat Restoration Costs for the UMRS

Introduction

This analysis was prepared to fulfill a request made by the Upper Mississippi River Conservation Committee (UMRCC) Executive Board. The request was to develop a cost estimate for reaching a state of ecosystem sustainability on the Upper Mississippi River System (UMRS), which includes the Mississippi River from Minneapolis, Minnesota to its confluence with the Ohio River at Cairo, Illinois, the Illinois River, and the commercially navigable portions of the Minnesota and St. Croix Rivers. This is the same geographic area being investigated by the Corps of Engineers for an evaluation of navigation improvements to the UMRS.

Guidance provided by the UMRCC Executive Board was:

- Utilize published data if available.
- Use a 50 year timeline for accomplishment to match planning timeline of COE navigation study.
- The locks and dams will continue operating for the purpose of commercial navigation.
- The Environmental Management Program Habitat Needs Assessment will be used as the base estimate for quantification of restoration needs.
- Focus on measures or techniques which can be implemented within the UMRS floodplain to achieve a more sustainable ecosystem.

Background

This is the first attempt to develop a cost estimate for restoring the UMRS floodplain habitat to a more sustainable ecosystem. Developing this estimate required identification of a desired condition which would represent a more sustainable ecosystem. The most comprehensive estimate of restoration needs is presently found in a report entitled, "Upper Mississippi River System Habitat Needs Assessment," often referred to as the HNA (U.S. Corps of Engineers, 2000, Theiling et. al. 2000). At about the same time as publication of the HNA, the UMRCC published, "A River that Works and a Working River: A Strategy for the Natural Resources of the Upper Mississippi River System." (UMRCC, 2000). Since completion of the HNA and the UMRCC's strategy, state and federal river manager's have initiated Environmental Pool Plans for the Mississippi River. All of these planning efforts have built upon the experience and knowledge gained over even a relatively short time frame in what is often referred to as an adaptive management approach.

The Habitat Needs Assessment (HNA) was the first systemic attempt at quantifying habitat goals to address the cumulative ecological impact of human actions in the UMRS floodplain and watershed. This quantification was at a coarse scale, but serves as the basis upon which to develop more refined estimates of need in subsequent planning efforts (i.e. Environmental Pool Plans). The HNA provided a quantification of habitat restoration needs for a variety of habitat types (Table 1).

An important assumption used in the HNA is that the quantification of need, "presumes existing desirable habitat is maintained." Existing habitat amounts to 1,121,608 acres, not including agricultural areas, developed areas or areas of no photo coverage. The HNA further adds that, "Estimates of needs are expected to nearly double by 2050 if no action is taken." Unfortunately, the HNA did not provide a specific quantification of Maintaining Existing Quality Habitat beyond emphasizing that existing habitat must be maintained. Nor did it include a quantification of existing habitats in need of enhancement to reach a better quality for a variety of species.

Table 1. Habitat Needs Assessment Habitat Need and acres quantified for restoration (COE, 2000 and Theiling et. al. 2000).

HNA Habitat Type		Acres of Habitat Need
Main Channel		1,700
Secondary Channel		27,000
Contiguous/Impounded Backwaters		55,500
Oxbow Lakes/Isolated Backwaters		24,000
Islands		24,000
Forest		100,000
Prairie		100,000
Marsh		100,000
Maintain Existing Quality Habitat	Forest Resources	443,315
	Prairie Resources	54,454
	Other Habitats Combined	623,831

Maintaining existing habitat and restoring the habitats identified above is just one step toward a more sustainable UMRS ecosystem. Several other actions are also needed to achieve a more sustainable ecosystem.

The HNA included documentation on a variety of other needs, but did not provide a quantification. These needs were often presented with a discussion on the affect they have on habitat quality for a variety of species. Many of these needs are actually human induced "ecological disturbances" to the river for which management measures have been identified to reduce the ecological impacts of these disturbances. Table 2 provides a list of some of the human disturbances to the ecological sustainability of the UMRS identified in the HNA and proposes actions to reduce the impact of the disturbances. The proposed actions have been presented and discussed in numerous forums and have either been constructed or implemented at locations on the UMRS, or are planned for implementation.

Table 2. Human induced ecological disturbances (from COE, 2000) and proposed actions to reduce impact of disturbance.

Human Induced Ecological Disturbance	Proposed Action(s)
Water Level Regulation (Locks and Dams)	• Water Level Management • More Frequent Operation of Gates on the Dam
Dredging and Dredged Material Disposal	• Channel Maintenance Implementation of Most Environmental Disposal Option Versus Most Cost Effective
Channel Training Structures	• Training Structure Modifications
Boat Generated Waves	• Shoreline Stabilization
Levee Construction	• Levee Modifications
Agriculture	• Land Use Change
Logging	• Maintenance of Existing Forests
Changes in Floodplain Connectivity	• Optimize Connectivity • Spillway/Lock and Dam Dike Modifications • Fish Passage

The human induced ecological disturbances not included in Table 2 were beyond the scope of this analysis. The disturbances were: Urban Development, Nutrient Enrichment and Contaminants. While restoration of the UMRS floodplain will play a small role in addressing nutrient enrichment and contaminants, the only effective approach at addressing these disturbances is at the watershed scale. Alternatives for addressing urban development within the floodplain of the Mississippi have been presented in a report on the Flood of 1993 (Interagency Floodplain Management Review Committee, 1994)

A final need identified in the HNA was that of more information. The HNA was limited to using available information from which to develop a quantification of habitat needs. During the analysis, information needs to arrive at more precise estimates of habitat need and quality were recorded. All of this data need is dependent on having a monitoring and focused research component to any program for ecosystem restoration.

One of the closing remarks in the HNA is:

"*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."*

The HNA did not identify specific project locations, or tools for implementation, to address the habitat needs identified. Since completion of the HNA, Environmental Pool Plans (EPPs) have been initiated in the St. Paul, Rock Island and St. Louis Districts of the Corps of Engineers. EPPs rely on the information in the HNA and the UMRCC publication, "A River that Works and Working River" as the foundation for more detailed planning of a desired future. EPPs include a description of "tools" which need to be implemented in each pool to improve habitat conditions and quality. The EPPs also propose locations these tools could be implemented. Collectively, these EPPs depict a more detailed desired future for the UMRS than the broad overview presented in the HNA. This more detailed analysis at a pool scale also identified some additional techniques for restoring habitat on the UMRS. Additional techniques in the EPPs include:

- Fisheries Habitat Strucutures
- Freshwater Mussel Habitat Structures
- Moist Soil Units

Several EMP HREPs have used specific structures or features to restore critical habitat necessary for meeting the life requirements of different fish and mussel species. As more monitoring and research on species needs is completed, the micro habitats necessary for the survival of rare and endangered species will be better understood. Endangered and rare species are often those which have very specific habitat requirements. Many of these unique habitat types have been destroyed or altered through human actions for the purpose of commercial navigation. Replacing the habitats lost will be critical to maintain viable populations of many rare and endangered species.

Moist soil units are a management tool which allows for manipulation of water levels in backwater areas independent of main stem flows. Resource managers manipulate water levels to promote the growth of annual and perennial vegetation and invertebrates as food resources for migratory waterbirds. The use of moist soil management units assures reliable and dependable food resources are available. Moist soil management is a necessity due to the loss of wetland habitat throughout the UMRS watershed and floodplain, changes in the UMRS hydrograph due to locks and dams and other human actions.

The above references can be used collectively as sources for estimating the cost of restoring the UMRS ecosystem. These costs can be developed by reviewing actual and estimated costs for similar techniques from various Environmental Management Program Habitat Rehabilitation and

Enhancement Projects, Corps of Engineer projects and projects implemented by other state and federal agencies.

Description and Explanation of Cost Calculation for Each Technique

The following techniques for restoration of the Mississippi River represent what must be done to accomplish the habitat needs identified in the HNA, to reduce the impacts of human actions within the floodplain identified in the HNA and address additional needs identified in planning efforts completed or begun since the HNA was published. The analysis takes a straight forward approach to minimize confusion. While some of the techniques are specific to the habitat it will restore, the fact is that many habitat types will also benefit to some degree from implementing a restoration technique (Table 3). The multiple habitat benefits of a technique cannot be interpreted to mean one technique will serve all restoration needs or can be used in lieu of another. In practice, the various techniques will need to be implemented in various combinations and for a variety of specific purposes. For example, some of the island restoration can be accomplished with material dredged to meet backwater restoration needs. Evaluating the potential for combining different techniques was beyond the scope of this study. This cumulative affect emphasizes the need to have all of these tools available and adequately funded to begin and then accomplish ecosystem restoration.

The ecological and geomorphic roles many of these restoration measures will address are described in the HNA Executive Summary and/or HNA Appendix. In those cases, the ecological and geomorphic purposes are not repeated here. However, clarification or additional information is provided for some of the techniques. The unit cost estimates provided below are for construction of the feature and does not include estimates of planning/design or contingencies. Table 4 provides a summary of the costs for each of the following techniques and applies planning/design and contingencies to each of the methods to arrive at a total estimated cost for implementation.

Main Channel Habitat Restoration --- The HNA identified 1,700 acres of main channel and main channel border habitat for restoration. Improvement of these habitat types will be accomplished through implementation of several techniques (Wing dam/Dike Field Modifications, Changes in dredge disposal, and structure for fish and mussel habitat improvement), therefore, no specific cost is assigned to this habitat. The costs for each of the techniques which will benefit main channel and main channel habitat are provided individually below.

Side Channel Restoration ---

The HNA estimate of need is for 27,000 acres of side channel restoration. The costs for implementation of side channel restoration are based on the cost of project features proposed for St. Paul District's Pool 8 Islands Phase III and Harper's Slough HREPs which will improve the quality of side channel habitat impacted by construction of the locks and dams. The island features for these two projects are primarily designed to reduce wave action, however the position of the islands will also benefit secondary channel habitat. Another example for cost estimation is from construction for Shenimann Chute restoration in the St. Louis District of the COE. The per acre cost of improving or restoring side channel habitat is $32,000 for Pool 8 Phase III, $31,000 for Harpers Slough, and $10,000 for Shenimann Chute. The average cost for these 3 projects is approximately $24,000 per acre. However, this cost estimate may be low since side channel restoration in the open river reach of the Mississippi River will require the acquisition of lands to implement and restore to the desired level of quality.

Backwater Restoration ---

Acreage to be dredged is derived from the HNA, 55,500 acres. This represents increasing the depth of approximately 10% of the aquatic area within the floodplain of the UMRS. Cost were calculated based on removal of 6 feet of material, or 9680 cubic yards per acre. The cost per acre is the average of hydraulic and mechanical dredging rates of fine excavation from HREP bids (range $1.55/yard to $38/yard, ave. = $9 per yard). All per acre costs include a fixed rate of $10,000 per acre for mob/demob and a fixed rate of $5,000 per dredged acre for disposal site prep.

Oxbow Lake/Isolated Wetland Restoration ---

The HNA identified the restoration of isolated wetlands and oxbow lakes as a systemic need. The quantity provided in the HNA was 24,000 acres. Cost of restoring these areas is considered to be approximately the same as Backwater Restoration with some allowance for additional features. Restoration of isolated wetlands and oxbow lakes will most likely require dredging, construction of site specific structures to allow "flooding" of the restored areas at ecologically based stage events, and in some cases may require the use of pumping structures. The use of pump structures may be needed in some locations on the open river section of the UMRS due to a "lowering" of water surface elevations due to human actions in the watershed and floodplain (Wlosinski 1999).

Island Restoration ---

The acreage is derived from the HNA UMRS total of 24,000 acres. The costs used were based on constructed and planned HREP island construction projects in the St. Paul and Rock Island Districts (Average cost/acre = Approx. $120,000, range $90,000 – 208,000). These are costs for sand/fine islands and include any stabilization techniques necessary plus the planting of the islands to trees, prairie or a mixture of habitats. However, the cost of island construction varies greatly based on location on the UMRS. The average cost used for this analysis most likely underestimates the future average cost of island construction. This is because of the higher cost of construction further downstream (greater need for stabilization due to physical forces), island design changes based on increased knowledge regarding sediment transport and deposition, desires to make islands designs more aesthetic, etc.

Forest, Prairie and Marsh Restoration ---

Forest, prairie and marsh habitats have been impacted due to conversion of land to agriculture, inundation of the floodplain due to the locks and dams, and the introduction of exotic species. Restoration of these resources includes acquisition from willing sellers to increase their acreage. This acquisition will consist of some areas which are already in these habitat types, but the majority of additional forest, prairie and marsh restoration will need to be accomplished through conversion of floodplain lands currently in agriculture.

- **Forest Restoration**

  (Sources for estimates: Randy Urich, St. Paul District COE and John Kabrick, Research Forest Ecologist, Missouri DOC) The acreage is obtained from the HNA summary report plus the assumption that land use change through a variety of methods in the UMR and IW floodplains will result in increased acreage of forested land (Environmental Pool Plans). Costs consider acquisition of lands from willing seller at $2,500 per acre and use of a variety of planting and site prep techniques from a low of no site prep ($726 per acre to plant trees with no tree mats) to preparing a site for planting where topsoil must be brought in, dozer work to shape site, and bare root stock with tree mats to improve survival ($7,850 per acre). A standardized cost of $7,000 per acre ($2,500 per acre acquisition and $4,500 for site prep and planting) was chosen based on discussions with Randy Urich, St. Paul District COE and

John Kabrick, Research Forest Ecologist, Missouri DOC. This cost includes methods to increase survival by reducing competition through weed control using weed mats and/or herbicides. Maintenance includes a variety of techniques to improve survival and manage the forest over the years. This includes inventory, development of management plans, etc. An average yearly maintenance cost of $35 per acre was calculated based on information provided by Randy Urich, COE, St. Paul District

- **Prairie Restoration**

  Costs are estimates based on bids submitted for establishment of prairie habitat on constructed EMP HREP islands. Maintenance costs are estimates to maintain prairies through the use of a variety of common techniques (grazing, burning, herbicides, etc.). The 100,000 acres in need of restoration was obtained from the HNA

- **Marsh Restoration**

  The HNA identified 100,000 acres in need of marsh restoration. The cost estimate for restoration includes the assumption that restoration of marsh habitat will require acquisition from willing sellers at a cost of $2,500 per acre. Wisconsin Department of Transportation wetland restoration cost range from $16 (placement of ditch plugs) to $6,600 per acre (for full site restoration (Bob Swartz, Wisconsin DOT, La Crosse). The cost of marsh restoration will vary considerably throughout the UMRS due to local factors and site specific needs. A figure of $4,000 per acre was chosen as a realistic estimate for UMRS marsh restoration given the high variability in implementation costs. Operation and maintenance costs were estimated at $250 per acre based on review of HREP costs with marsh features, and discussion with Bob Swartz.

Maintenance of Existing Quality Habitat ---

An important assumption used in the HNA is that the quantification of need, "presumes existing desirable habitat is maintained." Existing habitat amounts to 1,121,608 acres, not including agricultural areas, developed areas or areas of no photo coverage. The HNA further adds that, "Estimates of needs are expected to nearly double by 2050 if no action is taken." Unfortunately, the HNA did not provide a specific quantification of Maintaining Existing Quality Habitat beyond emphasizing that existing habitat must be maintained.

A U.S. Fish and Wildlife Service estimate of maintenance needs for refuges located along the UMRS was recently made. The USFWS manages over 265,000 acres on the Upper Mississippi and Illinois Rivers. Their analysis indicated a financial need of $32.2 million to meet current maintenance needs ($25,437,000 more than their FY 2002 allocation). This same analysis also included identification of an additional $8.75 million for acquisition of lands where a willing seller has indicated intent to sell, $12.2 for meeting federal fishery obligations, and $2.3 million for Ecological Services. The Corps of Engineers and UMR states have not completed a similar analysis for comparison purposes, but the need for increased resources for maintenance of existing habitat they manage is most likely proportional to those of the USFWS.

An estimate for Maintenance of Existing quality habitat has been made through breaking out the two habitat types which have enough information from which more accurate estimates can be provided, forests and prairies. An estimate for other habitat types can be indirectly calculated based on the predicted operation and maintenance costs of features for EMP HREPs which are designed to restore and protect habitats.

- **Management of Existing Forest Resources**

  The HNA provides a quantification of 440,000 acres of forest resources in the UMRS floodplain. Maintenance of these forest resources will require the following activities:

inventory (once every 10 years), develop compartment plans, implement harvest contracts, site prep, and replanting. The average annual maintenance cost of $35 per acre (range $20 to $50) was based on information provided by Randy Urich, St. Paul District COE. Also included in the estimate is funding to convert a proportion of land use change to forest resources at a cost of $525/acre.

- **Management of Existing Prairie Resources**

  Maintenance costs are estimates to maintain prairies through the use of a variety of common techniques (grazing, burning, herbicides, etc.) with an estimate of approximately $20 per acre. The acreage, 54,454, is obtained from the HNA technical appendix and represents the total of existing prairie lands in the UMRS floodplain. The cost estimate also includes funding to convert an unknown portion of land use change acreage to prairie at a cost of $525 per acre.

- **Maintenance of Existing Quality Habitat**

  A critical component of meeting restoration needs is to maintain existing habitat. Costs are based on the unit cost estimated for operation and maintenance of a variety of habitats restored under the EMP. The HNA identified 623,831 acres of existing habitat in need of maintenance (this does not include the acreage of forest and prairie habitat within the UMRS floodplain). An estimate of approximately $50 per year per acre was obtained from a review of operation and maintenance costs of features for EMP HREPs which are designed to restore and protect habitats. The cost estimate also includes a modest level of funding ($250 per acre) to enhance existing quality habitat since the HNA did not include consideration of enhancement of existing habitat.

  For comparison purposes, an estimate of maintenance costs can also be calculated using recent estimates of maintenance needs prepared by the USFWS for lands they manage on the Upper Mississippi and Illinois Rivers. They estimate the financial resources needed to manage 265,000 acres at $32.2 million, for a per acre cost of approximately $120 per acre.

Shoreline Stabilization ---

Bhowmik et al. (1999) identified 355 linear miles of eroding shoreline adjacent to the main channel as unprotected high and medium erosion risk related to commercial navigation. (page 2 of the Bank Erosion Field Survey Report of the UMR and IW.) For sake of estimation, an additional amount equal to this was assumed to be related to recreational traffic, plus two times this distance was assumed to be the stabilization needs in areas not surveyed for the Navigation study erosion estimates (i.e. backwater locations). This provides for a total length of shoreline stabilization of 1420 miles. A variety of methods would be used to stabilize shorelines: bioengineering, groins, Iowa vanes, earthen or rock breakwaters, off-shore mounds, adjustment of the sailing line, slow-no-wake zones, mooring cells, rock protection, etc. Arriving at a cost estimate for each of these methods was beyond the scope of this analysis, so the following were used as a basis to arrive at an estimate using rock protection as a standardized technique:

- Average water depth at toe of slope = 9 feet
- Slope of existing shoreline average = 1V:2H
- Average thickness of material used for stabilization (no fabric used) = 3 feet
- The above yields a standard of 10560 cubic yards/mile
- Cost/yard of rip-rap in place is $45 without consideration of access dredging needs, or site preparation.
- Note: Bank stabilization costs and techniques are highly variable dependent on site conditions.

The average annual maintenance for the St. Paul District's Bank Stabilization HREP was $1,656 per linear mile of protection. Most of the erosion sites for this project were in high energy areas which may not represent a true "average" maintenance cost for stabilization. Also considered, was the potential reduction in maintenance costs if alternatives other than rock were chosen. Therefore, a maintenance cost of $1,000 per year per mile was selected for this analysis.

Wing Dam/Dike Field Modification ---

Over 3000 training structures (wing dams, closing dams, dikes, bank revetment, etc.) have been constructed for the purpose of improving conditions for commercial navigation. Many of the structures are still needed for maintenance of the present 9-foot navigation channel. These structures reduce the amount of dredging necessary to maintain a 9-foot deep channel. However, several of the training structures which were built as part of the 4, 4.5 and 6 foot navigation projects are no longer functional or necessary for the 9-foot channel project because they are completely covered with sediment, their function replaced by more recently constructed structures, or located in the lower sections of a pool. It is estimated approximately 500 of these structures could be modified to improve aquatic habitat conditions over the next 50 years. Work has already been initiated to inventory structures which could be modified in the St. Paul District to improve habitat conditions. Some of the structures have already been modified in recent years. Modifications include notching, repositioning, replacement with new structures and removal. The costs for modification are variable depending on each structure is altered. Actual and estimated implementation costs for training structure modifications in the St. Paul, Rock Island and St. Louis Districts range from $4,000 to $471,000 a structure, with an average cost per structure of approximately $130,000. This wide range is due to differences in complexity of the modifications, from simple notching of a structure to total removal and replacement. Maintenance cost ($250/year/strucuture) was estimated based on the assumption that wing dam and dike maintenance would be approximately 25% of maintaining bank protection.

Channel Maintenance Implementation of Most Environmental Disposal Option Versus Most Cost Effective ---

Funding and authority constraints have severely limited the Corps' ability to restore and manage UMRS navigation project fee title lands and water. The three UMRS Corps Districts remove millions of cubic yards of clean sand from the navigation channel each year and deposit it at various locations coordinated with other state and federal agencies. Some of the material is disposed of in a method referred to as thalweg disposal. Thalweg disposal may cause environmental impacts in some locations and as more knowledge regarding unique habitat types of the UMRS is gained, options to replace thalweg disposal may be needed. In the last 20 years, the Corps of Engineers has made significant improvements in the disposal of dredged material. Much of this material could be used to restore terrestrial and aquatic habitats if the navigation operation and maintenance authority would permit it. The navigation project's authority and physical plant limitations severely limit the Corps ability to use this material for environmental enhancement or restoration purposes. Authority revisions which would allow the Corps to use O&M capability to construct environmental management actions would be a significant cost savings, especially if such actions could be implemented at the time channel dredging is conducted. Along with authority revisions, additional funding would be needed. An estimated 80 dredging events occur annually on the UMRS. The estimate for implementation ($125,000) and O&M ($2,500) is based on a per event cost of implementation increase over present preferred option in lieu of most environmental option. No documentation was found to arrive at these estimates, therefore, the actual cost of implementation per event will need to be analyzed prior to any funding requests and implementation.

Modification of Lock and Dam Operations ---

Emulating more natural river flows/stages by modifying navigation dam operations is a measure which is just beginning to be conducted at various locations on the UMRS for the purpose of restoring emergent vegetation. Recent demonstrations in the St. Paul and St. Louis Districts have documented the environmental benefits from navigation pool regulation actions and shown that water levels of the pool can be manipulated without impacting commercial navigation. Additional study is needed to determine: (1) which river reaches would benefit most from pool drawdown, (2) what additional costs (e.g. navigation channel dredging) would result, (3) how frequently drawdowns are needed, and (4) the impacts to a particular locale, (5) impacts on sediment transport and deposition.

- **Pool Wide Water Level Management Cost Calculation***:*

  Several different options for pool wide water level management have been described in the Problem Appraisal Report for Water Level Management (WLM) in the St. Paul District (COE, 1999). Water level reduction within the operating band for the pool is a low cost alternative for most of the pools. However, the response of vegetation and area influenced is directly related to the amount of reduction done for a WLM event. Therefore, the cost estimate is for WLM outside of the operating band. Costs are based on estimates from the St. District report, recent analysis of costs for Pool 5 ($650,000-3,000,000) and the actual cost of doing 1.5 foot reduction for WLM in pool 8 during 2001 ($750,000), for an average cost of $1.48 million per event. These costs do not include any potential savings to channel maintenance which may result due to residual benefits from over-depth dredging to maintain channel depths for commercial navigation during a drawdown. The cost includes consideration of providing adequate access for recreational craft.

  River manager's believe, based on water level management experiences throughout the country, that the water level for each pool will need to be reduced on a 4-7 year cycle. To accomplish this cycle, a long term water level management plan would have to plan on reducing water levels on an average of 9 pools per year since river flows and stages will occasionally preclude management efforts in some pools each year. For example, Pool 8 was planned for a drawdown in 2000, however, the flow forecast for the coming months indicated a drawdown would not meet the criteria establish to promote the germination and growth of perennial aquatic vegetation. The drawdown was postponed 2000 and implemented in 2001.

- **More Frequent Gate Adjustments at the Dams Cost Calculation:**

  The purpose of this measure is to decrease/eliminate wide variation in daily fluctuations of water levels in the pools. The Water Level Management Problem Appraisal Report for the St. Paul District proposed that at least one additional individual would need to be hired at each dam to implement. It was unclear if this meant one person/day, or one person/ shift. The estimate is based on one additional person/8 hour shift. To do this throughout the UMRS it is proposed that each of the Districts would also need an additional person/shift to calculate new settings at more frequent occurrences. (3 people/dam X $75,000) + ((3 Districts * 3 people*$75,000)/36 dams) = $ 231,250/year/dam. This cost may be grossly under estimated based on a figure provided in the draft Interim Report for the Upper Mississippi River and Illinois Waterway Restructured System Navigation Feasibility Study. This document estimates $518,000 for 2 additional personnel/ year for 24hours for 270 days a year. Since more cost effective alternatives may exist for more frequently making gate adjustments (i.e. computerizing gate settings and adjustments), the cost of $231,250/year/dam was deemed acceptable for this analysis.

Restoration of Floodplain Connectivity ---

The HNA contains documentation on the need to optimize the connectivity of habitats within the floodplain but did not include quantification of features needed to address this issue of habitat quality. Some sections of the UMRS have seen a great reduction in connectivity through the construction of levees which eliminated access to habitat for a variety of aquatic species. The upper sections of the UMRS are experiencing habitat loss and change due to the "increase" in connectivity due to the construction and operation of locks and dams plus the erosion and dissection of islands. The following techniques will address the impacts of connectivity throughout the UMRS for a variety of species.

- **Fish Passage**

  Biologists have long sought to assist UMR fishes in their efforts to pass through the navigation dams on their way to spawning or overwintering areas. Biological evidence (Wlosinski and Surprenant 2001) confirms that the mainstream navigation dams (and on some tributaries) do impede fish passage. The relative significance of this impact is yet to be determined, but biologists believe some corrective actions are necessary.

  Locks and Dams 3 and 19 have recent estimates prepared by the COE for what it would cost to implement fish passage at the dams, $4.5 million and $40 million, respectively. These were the estimates used for this technique with the average cost estimated per dam estimated at $23 million. The number of dams assumes that at least one dam will not be feasible for implementation of fish passage measures. Maintenance was estimated to be $5,000 dollars.

- **Spillway/Dike Modifications**

  The St. Paul District River Resources Forum Fish and Wildlife Work Group has submitted a series of fact sheets to modify existing spillways and dikes for the Lock and Dams to improve habitat in the upper part of the pool. Options identified include: lowering of the dike height, replacement of the spillways with roller gates to allow for greater range of flows into large channels in the upper sections of the pools, notching spillways to increase base flow, the construction of additional spillway, and construction of culverts to provide flow to areas in the upper section of the pools. Cost estimates for implementation ($5,000,000 per dam) and O&M ($500) were made based projected costs for implementation of a variety of measures at each dike. Construction and O&M costs should be verified by the COE. The number of sites equals the number of dams on the URMS. This would be another measure to address connectivity as described in the HNA.

- **Connectivity Modification Structures**

  This technique would be used to optimize connectivity based on the needs for habitat improvement in specific areas. The features may include: re-establishment of channels, placement of culverts, construction of partial or complete closures, etc. Optimizing connectivity will also employ other features to improve the connectivity of terrestrial floodplain features (forests, prairies, etc). Costs ($250,000 implementation, $250 O&M) are based on measures which have already been implemented in past HREPs to address the issue of connectivity (i.e. Spring Lake Peninsula, Pool 5; Bank Stabilization HREP, Pools 3-10; Peterson Lake, Pool 4; East Channel HREP, Pool 7; etc.). The number of sites was determined based on preliminary estimates provided in Environmental Pool Plans from the St. Paul District and an estimate of the need for the rest of the UMRS. This estimate does not include features for levee modification, which are presented below.

- **Levee Modifications**

  The wide floodplains of the UMRS prior to construction of dams and levees provided for a mosaic of habitat conditions. At high flow conditions, areas normally isolated from the main channel flows would be reconnected, allowing for nutrient exchange and fish movement to areas conducive for the spawning and rearing of many fish species. This category includes the costs needed for modifying levees to allow for more frequent inundation of portions of the floodplain on public land and, with approval or easements, on private lands. For example, the dike at Lake Odessa, Iowa, Pools 17 and 18, is proposed to have two sections of it modified to allow inundation (10-year flood events) of the wetlands protected by an exterior levee at a cost of $1,000,000 and $1,500,000 each. A spillway was also a feature of the Princeton HREP in the COE Rock Island District. The cost of this modification was $85,000/ Levee modifications of this type will address the issue of connectivity presented in the HNA and also will reduce flood stages in leveed portions of the UMRS (Interagency Floodplain Management Review Committee, 1994). Number of locations are based on preliminary estimates from discussions during Environmental Pool Plan meetings. A cost of $1,000,000 per structure was chosen for cost estimation, with an annual O7M cost of $1,000.

Land-use Change ---

One of the five guiding principles for river management advocated at the 1994 Large River Floodplain Conference spoke specifically to the floodplain: "*The degree of connectivity between the main channel and its floodplain is a primary structural attribute of river ecological integrity*." The effect of floodplain development upon habitat was noted in the Report: *"Alteration of Mississippi, Illinois, and Missouri Rivers and floodplains has resulted in significant changes or losses of habitat. The disruption of natural ecosystems has caused the destruction of many native species populations and has caused an increasing number to listed as threatened or endangered."*

In 1994, the Interagency Floodplain Management Review Committee published a report on the factors contributing to widespread record flooding the UMRS in 1993. One of their proposed goals was, "To take full advantage of existing federal programs which enhance the floodplain environment and provide for natural storage in bottomlands and uplands, the Administration should:…Better coordinate the environmentally-related land interest acquisition of needed lands form willing sellers…" They also presented a variety of existing and new programs which could be used to achieve this goal.

River managers acknowledge that land use changes in the floodplain to restore connectivity will be necessary to achieve long-term habitat goals, but an estimate of this need is almost impossible to calculate. For this reason, and its political sensitivity, the HNA is very vague. Table 4 lists an estimated goal of 700,000 acres of land use change based upon goals described in various resource agency planning documents and the Environmental Pool Plans now in preparation. For example, the Environmental Pool Plans for Pools 3-10 identify at least 15,000 acres of land use change from willing participants and 270,000 acres of land use change have been identified in preliminary analysis of needs in the open river (Jenny Frazier, American Land Conservancy). It is essential that a variety of tools and authorities be used to accomplish land use change in the floodplain of the UMRS. These tools include: voluntary measures, incentive programs, conservation easements and acquisition from willing sellers. The costs for converting these areas to quality habitat, if conversion is necessary, have been included in the implementation costs for forest, prairie and habitat maintenance above.

- **Voluntary:** Estimates of cost are based on establishing a program with personnel to actively encourage people to restore habitat in the floodplain using their own money or using funds from existing programs. The cost proposes a program which would have one person per

UMRS states actively contacting floodplain landowners along the UMRS at $75,000/person/year plus $30,000/person/year for office and travel.

- **Incentives:** The cost assumes a tax credit or payment similar to CRP or WRP and an array of other options presented in the Report of the Interagency Management Review Committee. Administration costs are included in the per acre amount.

- **Environmental Easements:** The cost assumes payment of easements proportional to value of the land. For this analysis, easements costs were calculated based on a value of 50% of acquisition Administration costs are assessed are assessed as 5% of the purchase cost and are included in the per acre amount.

- **Acquisition From Willing Sellers:** Total acreage of 250,000 is based on acquiring from willing sellers approximately 20% of the land identified in the HNA as agriculture. (This figure does not represent the acreage identified for restoration of forest, prairie and marsh habitat). However, this is misleading since acquisition from willing sellers will also include a proportion of floodplain forest and wetlands identified for potential acquisition from willing sellers in order to protect existing resources. The cost for acquisition varies highly based on present land use and location along the UMRS. An estimate of $2,500 was used for the purposes of this analysis and is based on discussions with Jenny Frazier, American Land Conservancy, although she cautioned this may be a low per acre estimate.

Fish , Mussels and Waterbird Habitat Structures ---

As more monitoring and research on species needs is completed, the micro habitats necessary for the survival of rare and endangered species will be better understood. Endangered and rare species are often those which have very specific habitat requirements. Many of these unique habitat types have been destroyed or altered through human actions for the purpose of commercial navigation. Replacing the habitats lost will be critical to maintain viable populations of many rare and endangered species.

- **Fish Habitat Structures**

  Many species of fish require specific micro habitats to meet different life needs. Creation of these micro habitats for spawning, over-wintering and juvenile habitat are needed to restore habitat which has been loss due to human actions within the river floodplain. Examples of structures include the habitat channel at Bertom and McCartney HREP, fish cribs, spawning reefs, over-wintering structure for catfish, etc. The estimate of restoring 200 miles of is an initial proposal to improve micro-habitat conditions for fish. The assumption is that as we learn more about fishery needs the estimate may increase. Cost is based on the cost of the Bertom and McCartney Lakes HREP habitat channel which was 1,500 feet long and cost $508,347 for a cost per mile of $1,789,381. Annual operation and maintenance costs were estimated to be $4,800 per year, or $16,896 per mile. For the purposes of this analysis, these figures were rounded to the nearest $1,000 and used to calculate the systemic cost of implementing this measure.

- **Mussel Habitat improvement**

  Dredging, wingdam construction and locks and dams have caused the destruction of several 100 miles of mussel habitat on the UMRS. The 200 miles of habitat improvement for mussels is an initial proposal to begin restoration of beds throughout the UMRS. The cost is based on an estimate for mussel habitat restoration proposed as part of the Pool 8 Islands Phase III HREP. Approximately 0.25 miles of mussel habitat was estimated to cost $500,000 for a total of $2,000,000 per mile with an O&M cost estimated to be $2,750 per mile.

- **Moist Soil Management**

  This is to account for modifications to existing moist soil units to improve management capabilities and to allow for a rotational management regime which would allow for at least one cell per management area to be managed optimally for backwater spawning habitat for riverine species of fish. This also accounts for the potential to develop additional moist soil units to more efficiently restore wetland habitat within the floodplain in areas purchased in the future from willing sellers. The estimated number of additional units which will be created over the next 50 years. Cost were based on the unit cost of levee construction for moist soil projects constructed under authorization of EMP. These average approximately $3,000,000 per unit with an average O&M of 7,500/unit/year.

Monitoring (LTRMP, Post-Project, Applied Research)

There is unanimous consensus among the Corps of Engineers, US Fish and Wildlife Service, State Natural Resource Agencies, and resource organizations that an adaptive management philosophy is needed to conduct any long-term habitat restoration program for the UMRS. The ability to monitor and research the effectiveness of management actions is absolutely critical to assessing their effectiveness and planning future actions. To conduct an effective management program, managers need to answer such questions as how long and frequently should navigation pools be lowered to achieve habitat benefits? What are the economic costs to commercial and recreation traffic? What kinds of fish passage measures are needed and how effective are they? How can channel regulating structures be modified to benefit both the navigation channel and habitat? The likely organization to conduct the biological monitoring and research aspect of adaptive management approach on the UMRS is the current Long Term Resource Monitoring Program (LTRMP). However, current funding prohibits it from assuming additional research and monitoring tasks. The LTRMP should be given the funding and specific task of assessing navigation related management actions.

This is an estimated yearly cost for this feature. Cost is based on a multiplier of 4 applied to the present authorized appropriation limit for LTRMP. The purpose of increased funding is to accommodate increase the number of components monitored, implementation of out-pool sampling, doubling of the number of trend pools, post project monitoring of selected HREPs and expansion of focused research projects.

Explanation of Column Headings in Tables 2 and 3

HNA Geomorphic Classification(s) Affected -- These are the geomorphic areas from the Habitat Needs Assessment. A single technique has the potential to affect numerous geomorphic areas depending on its design and specific features.

HNA Land Cover Classifications Affected – These are the Land Cover Classifications from the Habitat Needs Assessment. A single technique has the potential to affect numerous Land Cover Classifications depending on its design and specific features.

Unit of Implementation -- These are the units of implementation for cost estimation using terminology commonly used for UMR management. The following units are used:

- **Acre –** The cost is based on a per acre unit.
- **Mile –** The cost is based on a per mile unit.
- **Acre/Year –** Represents implementing the technique for each acre on a yearly basis. If applicable, the cost for implementation is pro-rated on a yearly cost per acre even

though the activity may only occur once every 10 years. This unit applies to maintenance of forest and prairie resources.

- **Acre (Program)** -- The cost for implementation is based on the continuation of a program to affect a given acreage. For calculation purposes, the unit of implementation is 1 even though 200,000 acres are identified to be affected.

- **Site or Structure –** The technique is site or structure based (i.e. a fish passage structure at a dam or modification of a channel maintenance structure). This is used when the technique is not spatially explicit, but dependent on a structure for implementation.

- **Unit --** This refers to a moist soil unit. Moist soil units vary in size of area impacted and features for water level control (levees, pump structures, etc.).

- **Jobs/Year --** Number of dredging jobs which will be impacted by the technique each year. The costs for implementation is based on a yearly cost per job.

- **Year --** The unit of accomplishment is not spatially explicit. The term is used to identify the length of time a program for monitoring and research would be implemented.

- **Pools/Year --** The technique referenced will have a pool wide impact (i.e. pool wide water level management). Area of impact is highly variable from pool to pool and year to year.

HNA Estimated Need -- The quantification of need from the habitat assessment. The numbers are derived from the technical appendix of the HNA which provides a more detailed assessment of need by pool and geomorphic reach than the HNA summary. N/A (not applicable) is used to identify techniques for which no quantification of need is expressly provided in the HNA.

Combined Sources Estimated Need -- Numerous studies are ongoing or have been completed since the HNA (Navigation Study, Environmental Pool Planning, etc.). This column is used to provide an updated quantification based on needs from other sources. If there is a difference between "HNA Estimated Need" and "Combined Sources Estimated Need", the reference for increasing the need in this column is provided in the explanation for the technique.

Annual Maintenance Cost: These are the average maintenance costs for each of the techniques. The costs for maintenance are for the specific unit identified under "Unit of Implementation." The costs have been annualized. For example, if a feature will need maintenance once every 10 years, the maintenance cost for the technique unit has been divided by 10 to arrive at an annual cost per unit.

"Construction" Cost/Unit of Implementation: These costs were determined from a variety of sources which are documented in the technique description. These are the actual costs of implementation and do not include any costs for planning or contingencies.

Total Cost Over 50 years (2002 Dollars): This is the 50 year cost for construction and maintenance given in "Unit of Implementation" and includes the costs of planning and contingencies.

Planning Costs: Planning costs were considered to be independent of implementation and maintenance cost for most techniques. Planning costs were transformed into a percentage of construction costs for the purpose of this analysis. The average Corps of Engineers incurred cost of planning Environmental Management Program Habitat Rehabilitation and Enhancement Projects is 35% (range 2 to 116%, based on COE data). This does not include the costs incurred

by partner state and federal agencies. Techniques for which planning costs were not applied are: Monitoring, More Frequent Gate Adjustments, Land Use Change—Voluntary, Water Level Management, Channel Maintenance Implementation of Most Env. Disposal Options.

Contingencies: Given the uncertainty and variability in unit costs, a contingency was calculated for many of the techniques. Contingencies rates applied to COE projects have a wide range. Therefore, a fixed rate of 35% was used for these calculations and represents a median of values reviewed for this analysis. Techniques for which contingency costs were not applied are: More Frequent Gate Operations, Monitoring and Land Use Change—Voluntary.

The formula for arriving at the Total 50 Year Cost for most of the techniques was:

$$(((A*50\text{ years}) + B)*C) + (B*(\text{Planning Cost \%})) +$$

$$[(((A*50\text{ years}) + B)*C) + (B*(\text{Planning Cost \%}))]*\text{Contingency \%}$$

Where:

A = Annual Maintenance Cost
B = Construction Cost/Unit of Implementation
C = Combined Sources Need

The Total 50 Year Cost for Water Level Management and Channel Maintenance Implementation of Most Environmentally Preferred Disposal Options was:

$$((B * 50\text{ years})*C) + [((B * 50\text{ years})*C)]*\text{Contingency \%}$$

The formula for arriving at the Total 50 Year Cost for More Frequent Gate Operations, Monitoring and Land Use Change—Voluntary was:

$$(B * 50\text{ years})$$

Estimated Yearly Cost (2002 Dollars): This is the estimated yearly cost in 2002 dollars which would be needed to fully implement the technique systemically. The formula for calculation of the estimated yearly cost is:

Total Cost over 50 Years in 2002 Dollars/50 Years

Table 3. HNA geomorphic and land cover classifications affected by different UMRS habitat restoration techniques.

Technique	HNA Geomorphic Classification(s) Affected	HNA Land Cover Classification(s) Affected
Island Restoration	Island	Wet Meadow, Scrub/Shrub, Grassland, Salix Community, Populus Community, Wet Floodplain Forest, Mesic Bottomland Hardwood Forest, Sand/Mud
Backwater Restoration	Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area, Contiguous Impounded Area, Isolated Wetland	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed
Side Channel Restoration	Secondary Channel, Tertiary Channel, Tributary Channel, Excavated Channel,	Open Water
Oxbow Lake/Isolated Wetland Restoration	Isolated Backwater	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Marsh Restoration	Contiguous Floodplain Shallow Aquatic Area, Isolated Wetland	Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Forest Restoration	Island, Contiguous Terrestrial Floodplain, Isolated Terrestrial Floodplain	Scrub/Shrub, Salix Community, Populus Community, Wet Floodplain Forest, Mesic Bottomland Hardwood Forest, Sand/Mud
Prairie Restoration	Island, Contiguous Terrestrial Floodplain, Isolated Terrestrial Floodplain	Wet Meadow, Grassland,
Fish Habitat Structures	Secondary Channel, Tertiary Channel, Tributary Channel, Excavated Channel, Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area, Contiguous Impounded Area	Open Water
Mussel Habitat	Secondary Channel, Tertiary Channel, Tributary Channel, Excavated Channel,	Open Water
Optimize Connectivity (Flow Introduction/Reduction)	Secondary Channel, Tertiary Channel, Tributary Channel, Excavated Channel, Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area, Contiguous Impounded Area	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Fish Passage	N/A	Open Water
Shoreline Stabilization	Island, Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area	All
Spillway/Dike Modifications	All	All
Training Structure Modifications	Main Channel, Main Channel Border, Tailwater	Open Water

Table 3. Continued.

Technique	HNA Geomorphic Classification(s) Affected	HNA Land Cover Classification(s) Affected
Pool Wide Water Level Management	Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area, Contiguous Impounded Area	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
More Frequent Gate Adjustments	Contiguous Floodplain Lake, Contiguous Floodplain Shallow Aquatic Area, Contiguous Impounded Area	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Channel Maintenance Implementation of Most Environmental Disposal Option Versus Most Cost Effective	All	All
Levee Modifications	Isolated Wetland	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Land Use Change -- Voluntary	Wetland, Forest, Pairie, Side Channel, Marsh, Contiguous Backwater	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Land Use Change -- Incentive Program	Wetland, Forest, Pairie, Side Channel, Marsh, Contiguous Backwater	All
Land Use Change -- Easements	Wetland, Forest, Pairie, Side Channel, Marsh, Contiguous Backwater	All
Land Use Change -- Acquisition From Willing Sellers	Wetland, Forest, Pairie, Side Channel, Marsh, Contiguous Backwater	All
Moist Soil Management	Isolated Backwater, Contiguous Floodplain Shallow Aquatic Area	Open Water, Submersed Aquatic Bed, Floating-Leaved Aquatic Bed, Semi-permanently Flooded Emergent Perennial, Semi-permanently Flooded Emergent Annual, Seasonally Flooded Emergent Perennial, Wet Meadow
Maintenance of Existing Quality Habitat	All	All
Management of Existing Forest Resources	Island, Contiguous Terrestrial Floodplain, Isolated Terrestrial Floodplain	Scrub/Shrub, Grassland, Salix Community, Populus Community, Wet Floodplain Forest, Mesic Bottomland Hardwood Forest, Sand/Mud
Management of Existing Prairie Resources	Island, Contiguous Terrestrial Floodplain, Isolated Terrestrial Floodplain	Scrub/Shrub, Grassland, Salix Community, Populus Community, Wet Floodplain Forest, Mesic Bottomland Hardwood Forest, Sand/Mud
Monitoring (LTRMP, Post-Project, Applied Research)	N/A	N/A

Table 4. Cost calculation for techniques needed for UMRS habitat restoration.

Technique	Unit of Implementation	HNA Estimated Need	Combined Sources Estimated Need (N)	Annual Maintenance Cost	"Construction" Cost/Unit of Implementation	Total Cost Over 50 Years (2002 Dollars)	Estimated Yearly Cost Based on (2002 Dollars)
Island Restoration	Acre	24,000	24,000	250	120,000	5,653,800,000	113,076,000
Backwater Restoration	Acre	55,500	55,500	50	102,120	10,516,622,850	210,332,457
Side Channel Restoration	Acre	27,000	27,000	500	24,000	2,092,230,000	41,844,600
Oxbow Lake/Isolated Wetland Restoration	Acre	24,000	24,000	500	120,000	6,058,800,000	121,176,000
Wetland Restoration	Acre	100,000	100,000	250	4,000	2,416,500,000	48,330,000
Forest Restoration	Acre	100,000	200,000	35	7,000	3,780,000,000	75,600,000
Prairie Restoration	Acre	100,000	100,000	20	3,500	772,875,000	15,457,500
Fish Habitat Structures	Mile	N/A	200	17,000	1,789,000	881,590,500	17,631,810
Mussel Habitat	Mile	N/A	200	2,750	2,000,000	766,125,000	15,322,500
Optimize Connectivity (Flow Introduction/Reduction)	Site	N/A	500	250	250,000	236,250,000	4,725,000
Fish Passage	Site	N/A	36	5,000	23,000,000	1,521,180,000	30,423,600
Shoreline Stabilization	Mile	N/A	1,420	1,000	475,200	1,325,643,840	26,512,877
Spillway/Dike Modifications	Site	N/A	37	500	5,000,000	338,411,250	6,768,225
Training Structure Modifications	Structure	N/A	500	250	130,000	126,900,000	2,538,000
Pool Wide Water Level Management	Pools/Year	N/A	9	0	1,250,000	759,375,000	15,187,500
More Frequent Gate Adjustments	Site/year	N/A	37	0	231,250	427,812,500	8,556,250
Channel Maintenance Implementation of Most Environmental Disposal Option Versus Most Cost Effective	Jobs/year	N/A	80	2,500	125,000	675,000,000	13,500,000
Levee Modifications	Site	N/A	100	1,000	1,000,000	182,250,000	3,645,000

Table 4. Continued.

Technique	Unit of Implementation	HNA Estimated Need	Combined Sources Estimated Need (N)	Annual Maintenance Cost	"Construction" Cost/Unit of Implementation	Total Cost Over 50 Years (2002 Dollars)	Estimated Yearly Cost Based on (2002 Dollars)
Land Use Change -- Voluntary	Acre (Program)	N/A	100,000	0	525,000	26,250,000	525,000
Land Use Change -- Incentive Program	Acre	N/A	100,000	0	225	41,006,250	820,125
Land Use Change -- Easements	Acre	N/A	250,000	0	1,400	637,875,000	12,757,500
Land Use Change -- Acquisition From Willing Sellers	Acre	N/A	250,000	0	2,500	1,139,062,500	22,781,250
Moist Soil Management	Units	N/A	22	7,500	3,000,000	131,422,500	2,628,450
Maintenance of Existing Quality Habitat	Acre	500,000	500,000	50	250	1,915,312,500	38,306,250
Management of Existing Forest Resources	Acre/year	440,000	440,000	35	525	1,460,497,500	29,209,950
Management of Existing Prairie Resources	Acre/year	54,500	54,500	20	525	125,721,281	2,514,426
Monitoring (LTRMP, Post-Project, Applied Research)	N/A	1	1	0	44,000,000	2,200,000,000	44,000,000
Totals						45,452,513,471	909,050,269

Literature Cited

Bhowmik, N., D. Soong, T. Nakato, M. Spoor, J. Anderson, D. Johnson, 1999. Bank Erosion Field Survey Report of the Upper Mississippi and Illinois Waterway. Prepared for US Army Corps of Engineers, Rock Island District. Rock Island, Illinois 461 pp.

Environmental Pool Plans, COE St. Paul District River Resources Forum Fish and Wildlife Work Group, COE Rock Island District River Resources Coordination Team Fish and Wildlife Interagency Committee, COE St. Louis District River Resources Action Team. In preparation.

Interagency Floodplain Management Review Committee. 1994. Sharing the Challenge: floodplaini management into the 21st century. Scientific Assessment and Strategy Team, Interagency Floodplain Management Review Committee, Washington, D.D. 191 pp. + appendices

Theiling, C.H., C. Korchgen, H. De Haan, T. Fox, J. Rohweder, and L. Robinson. 2000. Habitat Needs Assessment for the Upper Mississippi River System: Technical Report. U.S. Geological Survey, Upper Midwest Environmental Science Center, La Crosse, Wisconsin. Contract Report prepared for the U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. 248 pp. + Appendices A to AA.

Upper Mississippi River Conservation Committee. 2000. A river that works and a working river: a strategy for the natural resources of the Upper Mississippi River System. Dan McGuiness editor. Upper Mississippi River Conservation Committee, Rock Island , Illinois. 40 pp.

U.S. Army Corps of Engineers. 2000. Upper Mississippi River System Habitat Needs Assessment: Summary Report 2000. U.S. Army Corps of Engineers, St. Louis District, St. Louis, Missouri. 53 pp.

Wlosinski, Joe W., and Chuck Surprenant. 2001. Fish Passage Through Dams on the Upper Mississippi River. Prepared for the U.S. Fish and Wildlife Service. Rock Island, Illinois.