**PROJECT IMPLEMENTATION REPORT**
**WITH INTEGRATED ENVIRONMENTAL ASSESSMENT**

**NAVIGATION AND ECOSYSTEM SUSTAINABILITY PROGRAM**
**HERCULANEUM SIDE CHANNEL RESTORATION**

## EXECUTIVE SUMMARY

The Herculaneum Side Channel Restoration Project is located on the Middle Mississippi River between river miles 156.5 and 149.5 in Jefferson County, Missouri and Monroe County, Illinois near the town of Herculaneum, Missouri (Figure 1). The Middle Mississippi River is defined as the lower 195 miles of the Upper Mississippi River, or that portion of the Upper Mississippi River that lies between the mouth of the Missouri River and the mouth of the Ohio River.

Existing stone dikes in the Herculaneum Reach and throughout the Middle Mississippi River, constructed to maintain a safe and dependable navigation channel, have resulted in homogenous flow, scour, and sedimentation patterns (Figure 2). The structures limit the quality and quantity of aquatic fish and wildlife habitat in the area. No biologically important side channel habitat exists within the reach. The nearest side channels are located upstream at river mile 160.8 and downstream at river mile 148.2. These and other existing side channels throughout the Middle Mississippi River are gradually being lost due to sedimentation (Simons et al. 1974). Furthermore, natural river processes which historically created new side channel habitat are precluded by river training structures. An opportunity exists in the Herculaneum Reach to modify existing river training structures and/or place new structures to create new side channel habitat. Previous dike notching efforts by the St. Louis District, in conjunction with the Illinois Department of Natural Resources and the Missouri Department of Conservation, have demonstrated that dike modifications can create more diverse flow, scour, and sedimentation patterns without affecting navigation. This diversity of habitat is more biologically desirable and should result in a more diverse biological community and should contribute to the long-term ecological integrity of the Herculaneum Reach and the Upper Mississippi River System in general.

In order to evaluate the efficacy of different dike modification scenarios in the Herculaneum Reach, a Hydraulic Sediment Response Study (formerly “micro-model”) was conducted (Rodgers et al. 2003). This study looked at various dike modification scenarios and the resultant scour and depositional patterns. The most effective combinations of dike modifications resulting from this study were then evaluated for ecosystem benefits using the Aquatic Habitat Appraisal Guide (AHAG) and Missouri Fisheries Habitat Appraisal Guide (MOFISH) methodologies. Ecosystem benefits and project costs were then put through Cost Effectiveness and Incremental Cost Analysis. This incremental analysis identifies which combinations of enhancement features and

their associated environmental outputs (Habitat Units) would be both cost efficient and cost effective. This analysis also shows the changes in cost for increasing levels of environmental output.

The tentatively selected plan for the Herculaneum Project consists of the creation of three side channel complexes throughout the Herculaneum Reach (Figures 3 and 4) by implementation of the following project measures:

Measure A: Creation of a side channel complex on the left descending bank from river mile 155.4 to 154.5. Measure A involves the following dike modifications/placements:

- Placement of four blunt-nosed chevrons
- Shortening of one existing dike
- Notching of one existing dike

Measure B: Creation of a side channel complex on the right descending bank from river mile 154.4 to 153.7. Measure B involves the following dike modifications/placements:

- Placement of three blunt-nosed chevrons
- Shortening of one existing dike

Measure C: Creation of a side channel complex on the left descending bank from river mile 153.2 to 151.0. Measure C involves the following dike modifications/placements:

- Placement of five blunt-nosed chevrons
- Notching of four existing dikes
- Unrooting of one existing dike (i.e. removing the portion of the dike nearest the bankline)

Implementation of the project features would result in the restoration of 4.1 miles of side channel habitat and enhancement of 1,647 acres of Middle Mississippi River fish and wildlife habitat. Ecosystem benefits analysis showed that the tentatively selected plan would generate 291.2 Average Annual Habitat Units for the analyzed species. Cost sharing will be 100% Federal in accordance with the project authority in the Water Resources Development Act (WRDA) of 2007. Implementation costs of the tentatively selected plan are estimated at 6.0 million dollars. In addition, all construction will be accomplished from the river and all work will be performed below ordinary high water thus eliminating the need for real estate acquisition.


Figure 1. Herculaneum Reach location within the St. Louis District.

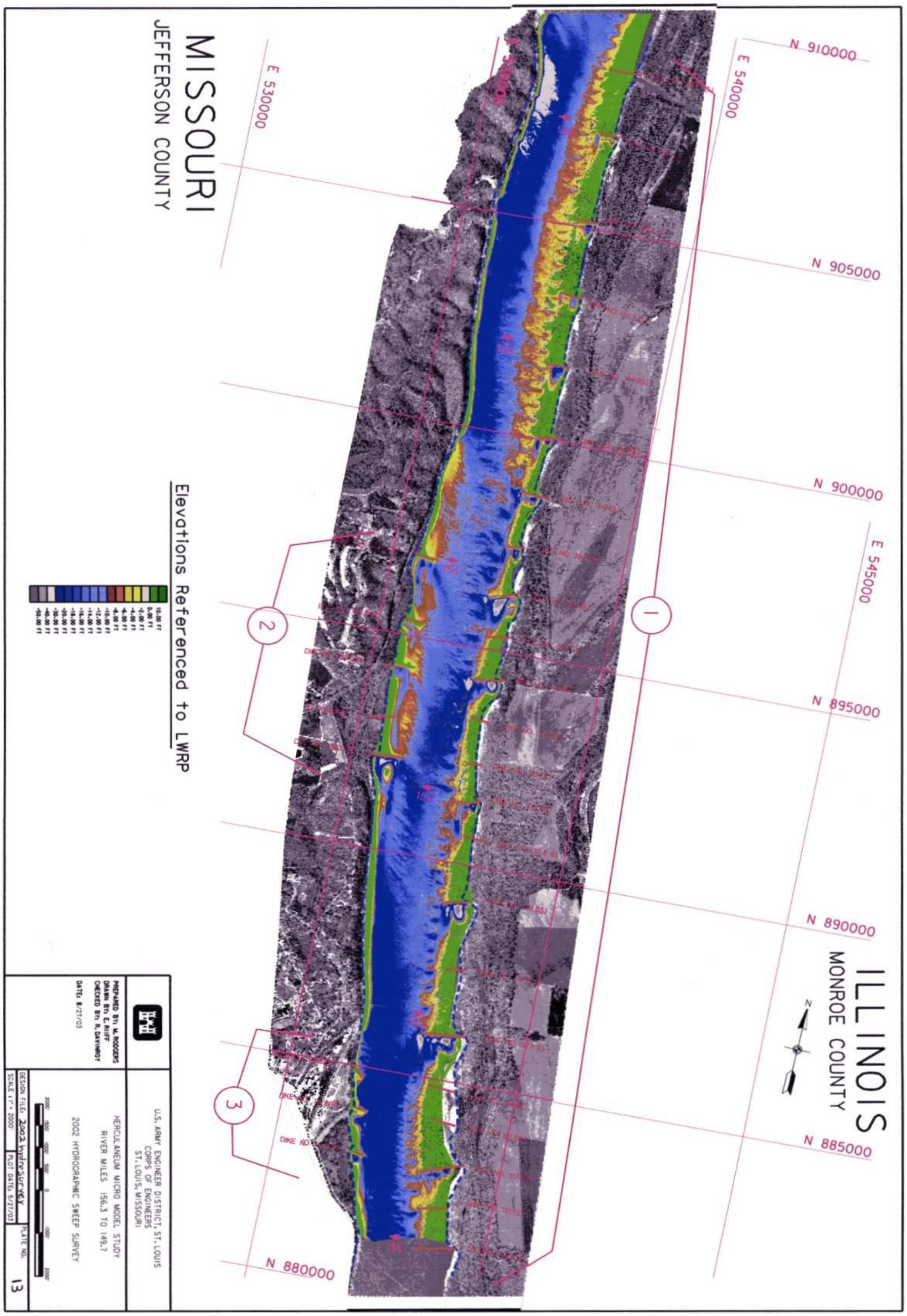


Figure 2. Bathymetric survey (2002) representing existing conditions in the Herculaneum Reach.

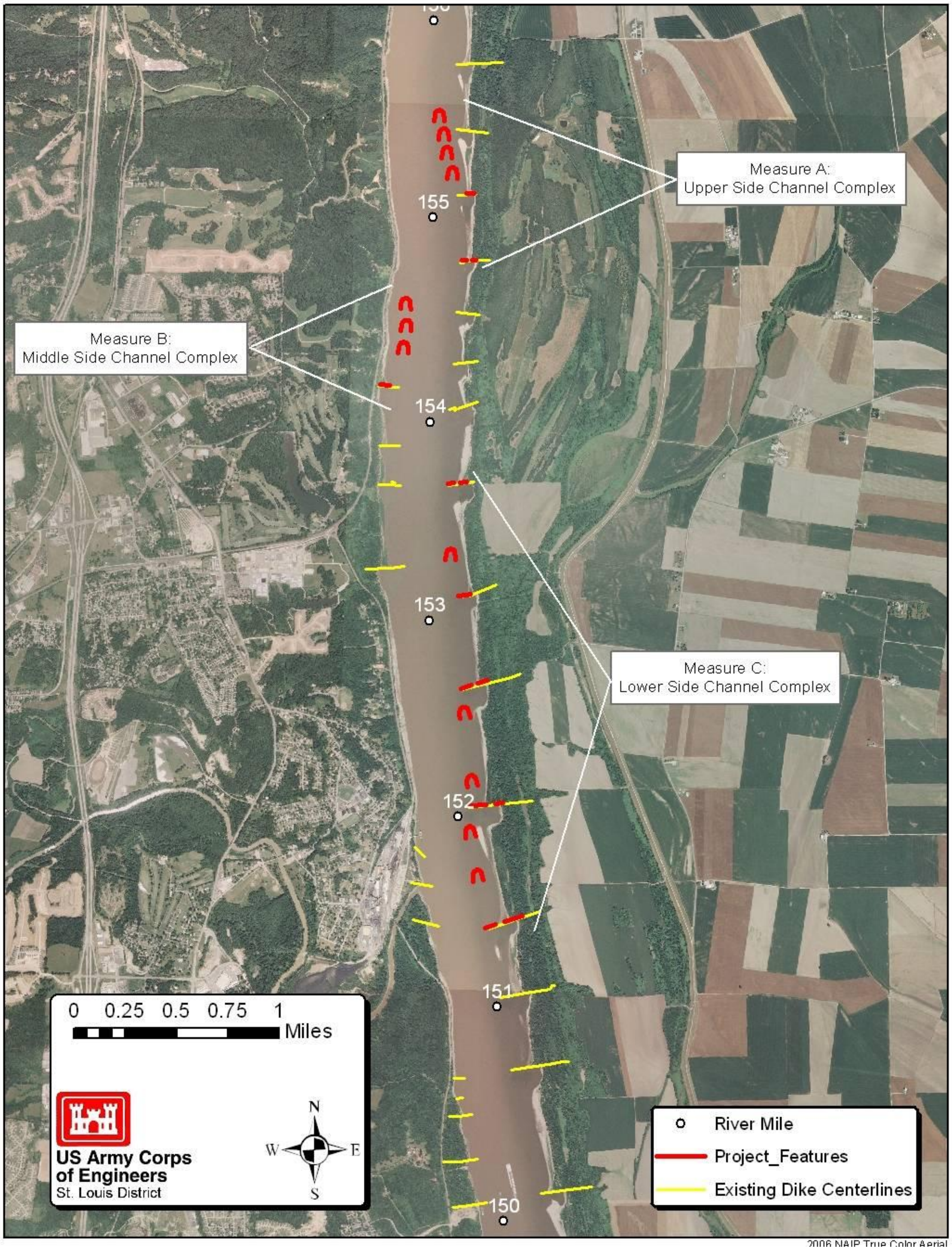


Figure 3. Proposed project features.

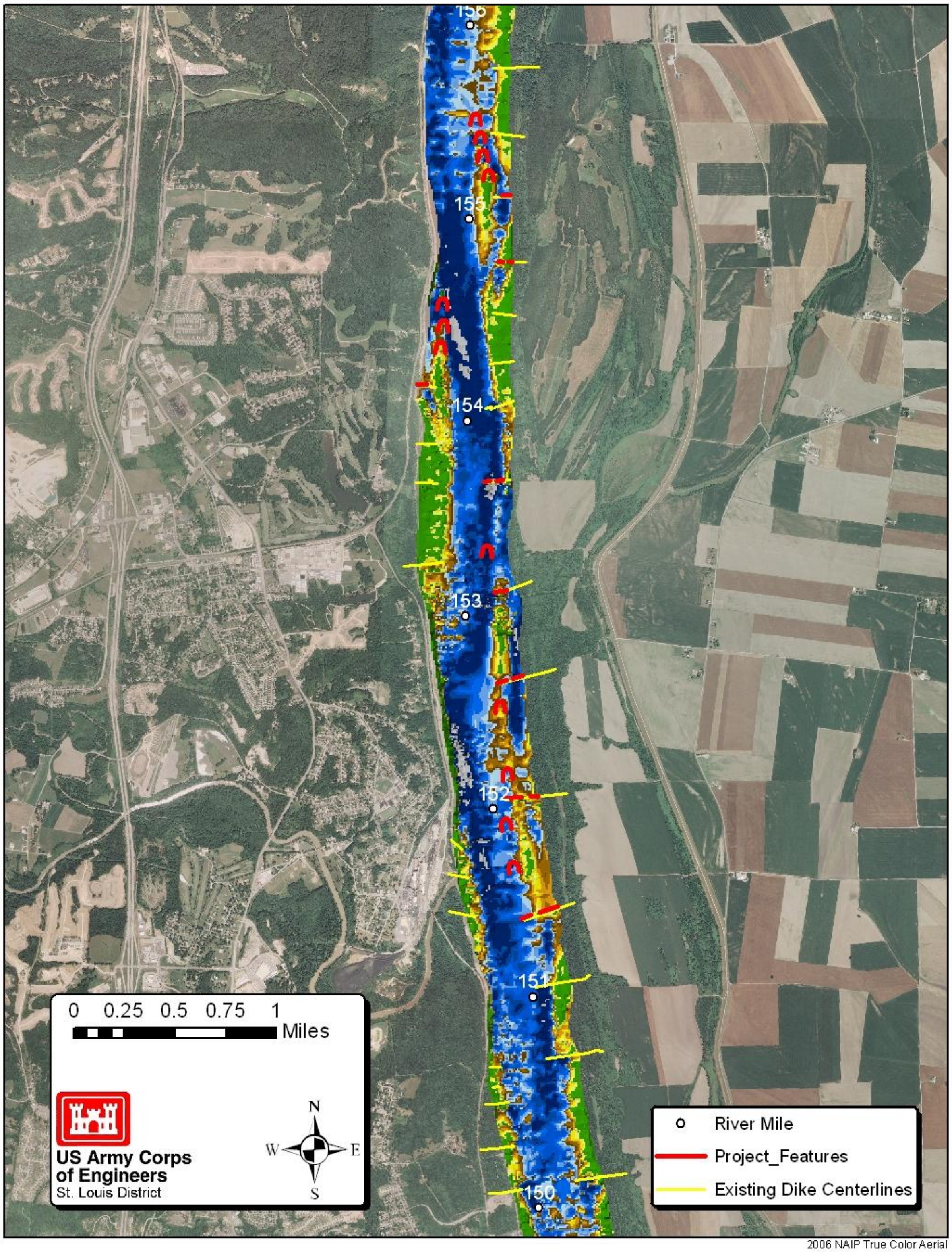


Figure 4. Hydraulic sediment response model representation of the proposed features and resultant bathymetry.

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# 1. INTRODUCTION

**1.1 Purpose of Report and Scope.** This Project Implementation Report (PIR) presents a detailed proposal for the restoration of the Herculaneum Reach. The report is organized to follow a general problem-solving format following the Corps six-step planning process (Engineering Regulation 1105-2-100). This iterative planning process of Identifying Problems and Opportunities, Inventorying and Forecasting Conditions, Formulating Alternative Plans, Evaluating Alternative Plans, Comparing Alternative Plans, and Selecting a Plan is designed to result in the formulation of complete, effective, efficient, acceptable plans. This report details the six-step planning process as it was utilized to generate a complete, effective, efficient, and acceptable tentatively selected plan for the Herculaneum Project. Existing conditions and anticipated future conditions are reviewed. Project goals and objectives are identified. Restoration measures and alternatives are formulated to address the goals and objectives. Costs and benefits of the restoration alternatives are identified and the alternative plans are compared on this basis. It also provides planning, engineering, and limited construction details for the tentatively selected restoration plan. This report is a feasibility level decision document, and approval of the report will allow the project to proceed to implementation.

Specifically the report provides: (1) a clear description of the tentatively selected plan; (2) demonstration of project justification based on reasonably maximizing net National Ecosystem Restoration (NER) benefits and demonstrating the selected plan is a cost effective project that is justified to achieve the desired level of outputs; (3) documentation of compliance with appropriate federal, state, and local environmental and regulatory requirements; (4) a completed Real Estate Plan; (5) identification of the anticipated operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) activities, including estimated costs; (6) a description of non-federal OMRR&R responsibilities, as appropriate; (7) the feasibility level ITR certification; and (8) District Counsel statement of legal sufficiency for the decision documentation and NEPA process.

In addition, the PIR establishes ecosystem restoration goals and specific performance indicators; the without-project condition or baseline for each performance indicator; and for each separable element of the ecosystem restoration, identifies specific target goals for each performance indicator. Performance indicators and units of measure shall include specific measurable environmental outcomes, such as changes in hydrology or the population and distribution of indicator species which are representative of the abundance and diversity of ecosystem-dependent aquatic and terrestrial species. The PIR includes a monitoring plan for the performance indicators including timeline to achieve the identified target goals and a timeline for the demonstration of project completion. The PIR includes documentation that the project and monitoring plan have been developed in consultation with the Department of the Interior and the involved states.

**1.2 Project Authority.** The site-specific evaluation was initiated as a follow on component of the Upper Mississippi River and Illinois Waterway System Navigation Feasibility Study ("Nav Study"; USACE 2004), which was a General Investigation study authorized by Section 216 of the Flood Control Act of 1970. Subsequent authorization was received in the Water Resources Development Act (WRDA) of 2007, Title VIII. Section 8004 of Title VIII authorizes implementation of Ecosystem Restoration projects to attain and maintain the sustainability of the ecosystem of the Upper Mississippi River and Illinois River. An excerpt from the authority states:

SEC. 8004. ECOSYSTEM RESTORATION AUTHORIZATION.

(a) OPERATION.—To ensure the environmental sustainability of the existing Upper Mississippi River and Illinois Waterway System, the Secretary shall modify, consistent with requirements to avoid adverse effects on navigation, the operation of the Upper Mississippi River and Illinois Waterway System to address the cumulative environmental impacts of operation of the system and improve the ecological integrity of the Upper Mississippi River and Illinois River.

(b) ECOSYSTEM RESTORATION PROJECTS.—

(1) IN GENERAL.—The Secretary shall carry out, consistent with requirements to avoid adverse effects on navigation, ecosystem restoration projects to attain and maintain the sustainability of the ecosystem of the Upper Mississippi River and Illinois River in accordance with the general framework outlined in the Plan.

(2) PROJECTS INCLUDED.—Ecosystem restoration projects may include—

(A) island building;
(B) construction of fish passages;
(C) floodplain restoration;
(D) water level management (including water drawdown);
(E) backwater restoration;
(F) side channel restoration;
(G) wing dam and dike restoration and modification;
(H) island and shoreline protection;
(I) topographical diversity;
(J) dam point control;
(K) use of dredged material for environmental purposes;
(L) tributary confluence restoration;
(M) spillway, dam, and levee modification to benefit the environment; and
(N) land and easement acquisition.

(3) COST SHARING.—

(A) IN GENERAL.—Except as provided in subparagraphs (B) and (C), the Federal share of the cost of carrying out an ecosystem restoration project under this subsection shall be 65 percent.

(B) EXCEPTION FOR CERTAIN RESTORATION PROJECTS.—In the case of a project under this section for ecosystem restoration, the Federal share of the cost of carrying out the project shall be 100 percent if the project—

(i) is located below the ordinary high water mark or in a connected backwater;
(ii) modifies the operation of structures for navigation; or

(iii) is located on federally owned land.

(C) SAVINGS CLAUSE.—Nothing in this subsection affects the applicability of section 906(e) of the Water Resources Development Act of 1986 (33 U.S.C. 2283(e)).

(D) NONGOVERNMENTAL ORGANIZATIONS.—In accordance with section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962d– 5b), for any project carried out under this title, a non-Federal sponsor may include a nonprofit entity, with the consent of the affected local government.

(4) LAND ACQUISITION.—The Secretary may acquire land or an interest in land for an ecosystem restoration project from a willing seller through conveyance of—

(A) fee title to the land; or

(B) a flood plain conservation easement.

(c) MONITORING.—The Secretary shall carry out a long term resource monitoring, computerized data inventory and analysis, and applied research program for the Upper Mississippi River and Illinois River to determine trends in ecosystem health, to understand systemic changes, and to help identify restoration needs. The program shall consider and adopt the monitoring program established under section 1103(e)(1)(A)(ii) of the Water Resources Development Act of 1986 (33 U.S.C. 652(e)(1)(A)(ii)).

(d) ECOSYSTEM RESTORATION PRECONSTRUCTION ENGINEERING AND DESIGN.—

(1) RESTORATION DESIGN.—Before initiating the construction of any individual ecosystem restoration project, the Secretary shall—

(A) establish ecosystem restoration goals and identify specific performance measures designed to demonstrate ecosystem restoration;

(B) establish the without-project condition or baseline for each performance indicator; and

(C) for each separable element of the ecosystem restoration, identify specific target goals for each performance indicator.

(2) OUTCOMES.—Performance measures identified under paragraph (1)(A) shall include specific measurable environmental outcomes, such as changes in water quality, hydrology, or the well being of indicator species the population and distribution of which are representative of the abundance and diversity of ecosystem-dependent aquatic and terrestrial species.

(3) RESTORATION DESIGN.—Restoration design carried out as part of ecosystem restoration shall include a monitoring plan for the performance measures identified under paragraph (1)(A), including—

(A) a timeline to achieve the identified target goals; and

(B) a timeline for the demonstration of project completion.

(f) SPECIFIC PROJECTS AUTHORIZATION.—

(3) INDIVIDUAL PROJECT LIMIT.—Other than for projects described in subparagraphs (B) and (J) of subsection (b)(2), the total cost of any single project carried out under this subsection shall not exceed $25,000,000.

(h) RANKING SYSTEM.—

(1) IN GENERAL.—The Secretary, in consultation with the Advisory Panel, shall develop a system to rank proposed projects.
(2) PRIORITY.—The ranking system shall give greater weight to projects that restore natural river processes, including those projects listed in subsection (b)(2).

**1.3 Summary of Location, Habitat Problems, and Opportunities.** The Herculaneum Side Channel Restoration Project is located on the Middle Mississippi River between river miles 156.5 and 149.5 in Jefferson County, Missouri and Monroe County, Illinois near the town of Herculaneum, Missouri. The Middle Mississippi River, or the open river as it is also known, is defined as the lower 195 miles of the Upper Mississippi River, or that portion of the Upper Mississippi River that lies between the mouth of the Missouri River and the mouth of the Ohio River.

Existing stone dikes in the Herculaneum Reach and throughout the Middle Mississippi River, constructed to maintain a safe and dependable navigation channel, have resulted in homogenous flow, scour, and sedimentation patterns. The structures limit the quality and quantity of aquatic fish and wildlife habitat in the area. No biologically important side channel habitat exists within the reach. The nearest side channels are located upstream at river mile 160.8 and downstream at river mile 148.2. These and other existing side channels throughout the Middle Mississippi River are gradually being lost due to sedimentation (WEST 2000). Furthermore, natural river processes which historically created new side channel habitat are precluded by river training structures. An opportunity exists in the Herculaneum Reach to modify existing river training structures and/or place new structures to create new side channel habitat and to restore natural river processes. Previous dike notching efforts by the St. Louis District, in conjunction with the Illinois Department of Natural Resources and the Missouri Department of Conservation, have demonstrated that dike modifications can create more diverse flow, scour, and sedimentation patterns without affecting navigation. This diversity of habitat is more biologically desirable and should result in a more diverse biological community and should contribute to the long-term ecological integrity of the Herculaneum Reach and the Upper Mississippi River System in general.

**1.4 Project Selection – Prioritization Process.** The authorizing legislation, Sec 8004(b)(2)of the Water Resources Development Act of 2007, identified a large number of potential ecosystem restoration project types. These project types include: island building; construction of fish passages; floodplain restoration; water level management (including water drawdown); backwater restoration; side channel restoration; wing dam and dike restoration and modification; island and shoreline protection; topographical diversity; dam point control; use of dredged material for environmental purposes; tributary confluence restoration; spillway, dam, and levee modification to benefit the environment; and land and easement acquisition.

It was further identified in Sec 8004(h) that a ranking system be developed by the Secretary in consultation with an identified Advisory Panel to rank proposed projects. The ranking system is to give greater weight to projects that restore natural river processes.

Following completion of the System Navigation Feasibility Study in September of 2004 and prior to the passage of WRDA 07, the Corps of Engineers, working with interagency partners, identified sixteen projects for initial planning efforts. These projects were identified based on their ability to address system restoration needs, represent a range of project types, provide restoration actions throughout various parts of the system, and contribute to system learning (i.e. refine understanding of the most cost-effective restoration methods and best techniques to restore natural river processes).

For these initial projects, project eligibility in terms of addressing system need was judged based on whether the restoration project addressed the ecosystem restoration goals, which include:

1. Manage for a more natural hydrologic regime (hydrology and hydraulics)
2. Manage for processes that shape a physically diverse and dynamic river-floodplain system (geomorphology)
3. Manage for processes that input, transport, assimilate, and output material within UMR basin river-floodplains: e.g. water quality, sediments, and nutrients (biogeochemistry)
4. Manage for a diverse and dynamic pattern of habitats to support native biota (habitat)
5. Manage for viable populations of native species within diverse plant and animal communities (biota)

The proposed Herculaneum Side Channel Restoration Project is a wing dam and dike restoration and modification project consistent with the ecosystem restoration goals of geomorphology, habitat, and biota.

A ranking system and associated eligibility requirements and project selection criteria will be further developed as part of the Upper Mississippi River and Illinois Waterway System and will be described in subsequent documentation and utilized in the selection of future projects.

## 1.5 Resource Significance

When determining Federal interest, it is important to clearly identify the significance of the resources being studied for restoration. The Corps of Engineers' *Principles and Guidelines* defines significance in terms of institutional, public, and technical recognition of the resources. For years, the Upper Mississippi River States (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), non-governmental organizations, and other agencies have been engaged in activities that clearly demonstrate the institutional, public, and technical recognition of the resources of the Upper Mississippi River Basin.

***1.5.1 Institutional Recognition.*** The formal recognition of the Upper Mississippi River Basin in laws, adopted plans, and other policy statements of public agencies and private groups illustrates the significance of the basin to a variety of institutions. The U.S. Congress recognized the Upper Mississippi River System (UMRS), as a unique, "…nationally significant ecosystem and a nationally significant commercial navigation system…" in Section 1103 of the Water Resources Development Act of 1986 (WRDA 86). This Federal recognition of the UMRS was not its first.

On the mainstem river there is a long and storied history of river development. The first Federal legislation in 1824 authorized clearing snags and other obstructions in the river. Opening individual rapids or other obstructions and dredging was conducted under many authorities, but the River and Harbor Act of 1878 authorized the Corps to establish a 4.5-ft channel from St. Louis to Minneapolis. That was followed by authority for a 6-ft channel in the 1907 Act. The existing 9-ft channel project was authorized in the 1927 River and Harbor Act. The Illinois River was developed by the State of Illinois until the development of the 9-ft. channel project when the Federal government assumed responsibility for the waterway. The Upper Mississippi River-Illinois Waterway Navigation System was operational by 1940 and worked efficiently until the 1960's when system capacity was being strained. The need for a new and expanded Lock and Dam 26 was identified in the 1960s, planned and approved by 1978. A second lock was added to the Melvin Price Locks and Dam (formerly Lock 26) in 1990.

Because the UMRS is so large and so prominent in the social development and structure of the Upper Midwest, there are many agencies and institutional arrangements supporting river and water-related activities in the region. For example, strong Federal, state, and local institutional support has resulted in the USDA Natural Resources Conservation Service (NRCS) being able to implement the highly successful Conservation Reserve Enhancement Program (CREP) in the Illinois and Minnesota River Basins which has resulted in hundreds of thousands of acres of floodplain and highly erodible lands being put into conservation. NRCS has also been active in the restoration of wetlands, through its Wetland Reserve Program (WRP) with the notable enrollment and restoration of approximately 8,000 acres of Illinois River Floodplain as part of its joint restoration efforts with The Nature Conservancy at its Emiquon and Spunky Bottoms Preserves.

Environmental conservation awareness was active and competing with economic interests by the turn of the 20th Century (Carlander 1954; Anfinson 2003). The U.S. Bureau of Fisheries was concerned with the viability of commercial fish stocks because river fish were an important food source, with fish shipped to fine restaurants in the East. The Izaak Walton League was instrumental in generating Congressional support for the Upper Mississippi River Fish and Wildlife Refuge. The refuge was established in 1924 specifically for the protection of fishes. Legislation establishing the 9-ft channel project included the prospect that fishways might be added to the navigation dams if adverse effects of impeded fish movement were demonstrated. Conservation awareness has been prominent throughout the development of the UMRS and has become increasingly coordinated over time. Biologists on the Upper Mississippi River established the Upper Mississippi River Conservation Committee (UMRCC) in 1943 composed of state and Federal biologists to proactively work on Upper Mississippi River issues. The Great River Environmental Action Team (GREAT) Studies during the 1970s were the first regional assessment and planning process on channel management (GREAT I, II & III 1980). The GREAT helped stop environmentally damaging practices and recommended changes for better environmental management of the navigation system. The Comprehensive Master Plan for the Management of the Upper Mississippi River System prepared by the Upper Mississippi River Basin Commission (UMRBC 1982) included many recommendations that expanded assessments to other cumulative effects and made recommendations for future programs.

The Upper Mississippi River System - Environmental Management Program (UMRS-EMP) was authorized in 1986 to conduct monitoring and habitat restoration activities along portions of the main stem of the Mississippi and Illinois Rivers. The EMP is one of the nation's first large-scale restoration efforts and brings together the expertise of the U.S. Army Corps of Engineers, the U. S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey, and the U.S. Environmental Protection Agency (EPA) and numerous state agencies. Congress reaffirmed the significance of the Upper Mississippi River System and the success of the program by reauthorizing the UMRS-EMP in 1999. The program has completed almost 50 ecosystem restoration projects and refined techniques for large river restoration (USACE 2004). The EMP's Long Term Resource Monitoring Program is one of the largest and longest-lasting ecosystem monitoring programs in the nation.

The Upper Mississippi River and Illinois Waterway System Navigation Study effort was the latest evaluation of large scale navigation capacity and ecosystem restoration needs. As described previously, it was a massive institutional effort involving many standing committees and significant coordination; as an example, one of the interagency committees associated with the study met more than 50 times. The tentatively selected plan is an ambitious one that seeks to improve the navigation and environmental problems addressed, but it also seeks to make system management more efficient and effective. The plan's authorization that included $2.2 billion in navigation improvement and $1.7 billion in ecosystem restoration features in the WRDA of 2007 further demonstrates the strong institutional support and significance of the UMRS to the nation.

***1.5.2 Public Recognition.*** 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. The Mississippi and Illinois Rivers are significant in their role in the development of the nation.

The region hosts a very sizable population, serving as home to more than 30 million people. Nearly 80 percent of the population lives in urban areas along the rivers such as Minneapolis-St. Paul, La Crosse, Dubuque, Davenport-Bettendorf-Rock Island-Moline (Quad Cities), Muscatine, Quincy, St. Louis, Hannibal, Cape Girardeau, Chicago, and Peoria. These communities developed because of the transportation provided by the river; and they are sustained by the water supply and waste assimilation capabilities of the river. Many industries depend on the System's commerce route and water supply.

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, materials (sand, gravel, iron ore, steel, and scrap), and manufactured goods. The existing navigation 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 (USACE 2004).

Recreation is important in the modern economy, and it is another important economic force in the UMRS. Over $6.6 billion dollars in revenue are generated annually from some 12,000,000 visitor-days of use by people that hunt, fish, boat, sightsee or otherwise visit the river (Black et al. 1999). That recreation supports almost 150,000 jobs in the river corridor.

An example of the broad range of national and local non-government organizations interested in UMR issues was observed during the development of the Navigation and Ecosystem Sustainability Program. Some of the members involved were American Land Conservancy, American Rivers, American Waterway Operators, Audubon Society, Illinois Stewardship Alliance, Midwest Area River Coalition 2000, Mississippi River Basin Alliance, National Corn Growers Association, The Izaak Walton League of America, The Nature Conservancy, The Sierra Club, Upper Mississippi, Illinois and Missouri River Association, and the Upper Mississippi River Conservation Committee. Many others were less formally involved, yet active.

Public involvement in river related issues, programs, and studies has been very positive. The public has helped identify and prioritize important resources. In public opinion surveys and focus panels the public has supported the multiple use nature of the river and emphasized water quality, sedimentation, and habitat degradation as continuing problems.

***1.5.3 Technical Recognition.*** Numerous scientific analyses and long-term evaluations of the Upper Mississippi River Basin have documented its significant ecological resources. Since the early $20^{th}$ century, researchers, government agencies, and private groups have studied the large river floodplain system and proposed ecosystem restoration in the Upper Mississippi River Basin. A few examples of the efforts to identify, quantify, and understand the ecological significance of the basin are described below.

In a 1995 report, the U.S. Department of the Interior (DOI) listed large streams and rivers as endangered ecosystems in the United States. The DOI documented an 85 to 98 percent decline in this ecosystem type since European settlement. In particular, large floodplain-river ecosystems have become increasingly rare worldwide. Two of the world's large floodplain-river ecosystems lie within the UMRS, namely, the Upper Mississippi and Illinois Rivers. These two ecosystems still retain seasonal flood pulses, and more than half of their original floodplains remain unleveed and open to the rivers (Sparks et al. 1998). The UMRS is one of the few areas in the developed world where ecosystem restoration can be implemented on large floodplain-river ecosystems (Sparks 1995).

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. The following is a sample of characteristics 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.
- 300,000 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.
- The system includes a variety of scarce habitats identified in the UMRS Habitat Needs Assessment of 2000 and UMR-IWW System Navigation Feasibility Report, 2004.
- The river system and its potential restoration would contribute significantly to the lateral and longitudinal connectivity of habitats for feeding, reproduction, migration, growth, and overwintering for fish,

waterbirds, reptiles, amphibians, and mammals (e.g. sturgeon, paddlefish, canvasback ducks, swans, etc.). Proposed projects will be able to make critical direct physical connections between existing habitat areas within migration corridors and larger landscapes, reducing population isolation, expanding home ranges, and providing access to areas supporting life requisites.

- The system 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. The project will directly and indirectly improve habitat conditions and fulfill life cycle requisites for 5 federally endangered species including the Higgins' eye pearlymussel, least tern, pallid sturgeon, Indiana bat, and decurrent false aster, as stated in the 2004 USFWS Biological Opinion.

In addition to the numerous biological functions the river provides, it also offers many ecosystem services to the nation and region (Lubinski et al. 2007). Ecosystem services are a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide (such as clean water, food, forest products, flood control, and natural resources) and the options to restore, conserve or enhance the sustainable use of these ecosystems. The objective of identifying ecosystem services is to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being. The UMR Science Panel, along with national experts in the emerging field of ecosystem valuation and economics, reviewed various approaches to summarizing these services (Farber et al. 2006) and adopted the classification of ecosystem services proposed by the UN Millennium Assessment (Millennium Ecosystem Assessment 2006). Some of the services the Mississippi River provides include aesthetics, recreation, science, education, spiritual, historic, food, genetic resources, raw materials, water supply, biological regulation, flood regulation, nutrient regulation, soil retention, and waste regulations. In general, the services identified show the wide range of uses from the river, which extend beyond just the ecological health of the UMR, and they directly relate to public welfare and long term economic health of the region. Currently, only limited tools are available to quantify these benefits, but even rough assessments point to the tremendous value from these aspects of the system.

The UMR is an amazingly productive and significant international and national resource. Existing habitat quality is degraded throughout the system. In order to maintain and improve this essential resource, action is necessary. Stakeholders have identified over 2,600 restoration objectives on more than 1,000 separate potential restoration sites. This gives an indication of the overall level of awareness and need for ecosystem restoration on the UMRS.

***1.5.4 Significance of the Herculaneum Project.*** In the Middle Mississippi River, the number and condition of side channels are in decline. Simons et al. (1974)

identified bank lines for the open river from river mile 170 to the confluence with the Ohio River for the years 1880 and 1968. Analysis of these plots (WEST 2000) shows the number of existing side channels for 1880 and 1968 as 35 and 27, respectively. Analysis of 1989 GIS coverages (WEST 2000) showed 25 side channels existing on the open river. These numbers show a steady rate of loss of side channel habitat on the open river due to sedimentation. The number of existing side channels on the open river is expected to drop to 19 by the year 2050 (WEST 2000). The proposed Herculaneum Side Channel Restoration Project would restore natural river processes and would provide valuable new side channel complex habitat to the Middle Mississippi River. Side channel habitat is a significant component of the Middle Mississippi River ecosystem in that it provides habitat heterogeneity to fish and wildlife populations that are adapted to habitat very different from the current predominately main channel, main channel border, and wing dike habitat. Side channels and associated islands provide current velocities, substrate composition, and bathymetry that differ from the main river channel, and can provide important fish overwintering habitat. The Environmental Management Program's Habitat Needs Assessment (Theiling et al. 2000) recognized the significance of side channel habitat in prescribing the creation or restoration of 25,000 acres of side channel and backwater habitat on the Middle Mississippi River. The Herculaneum project is expected to benefit numerous native fish species including the federally endangered pallid sturgeon. The Final Biological Opinion for the Operation and Maintenance of the 9-Foot Navigation Channel on the Upper Mississippi River System (USFWS 2000) recognized the significance of side channel habitat in calling for restoration of side channel and sandbar habitat to benefit all life stages of the pallid sturgeon. The ecosystem benefits analysis conducted for the Herculaneum Project (see Appendix C) predicted that the project would generate 272.2 Average Annual Habitat Units for the shovelnose sturgeon, a species thought to have habitat requirements similar to those of the pallid sturgeon.

**1.6 Discussion of Prior Studies, Reports, and Existing Water Projects.** There has been a considerable increase in information available about the Middle Mississippi River (MMR) over the past 10 to 15 years. The Middle Mississippi River, or the open river as it is also known, is defined as the lower 195 miles of the Upper Mississippi River, or that portion of the Upper Mississippi River that lies between the mouth of the Missouri River and the mouth of the Ohio River. Historic data and new tools have been combined to better understand historic, current, and projected future conditions of the MMR. The following studies or programs have applicability to the MMR and/or the Herculaneum Project:

***1.6.1 Avoid and Minimize (A&M) Program.*** The A&M Program was established to reduce possible environmental impacts from increased navigation traffic due to the construction of a second lock at Melvin Price Locks and Dam. Full scale implementation of the A&M Program began in 1996. The direction of the program is coordinated through an A&M Program study team which consists of state, federal, and private partners in both natural resource management and industry. Each year a progress report detailing program activities during the past year is released.  Funded activities include such things as the placement of woody habitat structures on the MMR, and the MMR Side Channels Report.

Middle Mississippi River Side Channels Report.  In 1999, the St. Louis District A&M Program completed a vision document for MMR side channel restoration (USACE 1999).  The document was prepared by A&M Program team members.  Long-term goals established by the team included providing over-wintering habitat every 5-7 miles, providing off channel habitat every 5-7 miles, maintaining connectivity of and small craft access to side channel areas, and providing improved public access to river resources.  The condition and physical attributes of all side channels in the MMR were outlined, as were the initial proposed actions required for rehabilitation and enhancement.

***1.6.2 Environmental Management Program (EMP).***  In 1986, PL 99-662, Section 1103, provided a comprehensive program for the planning, construction, and evaluation of measures for fish and wildlife habitat rehabilitation and enhancement on the Upper Mississippi River.  Key types of restoration projects within the realm of the Corps of Engineers' EMP implementation authority, and applicable to the MMR, are: backwater dredging, side channel openings/closures, wing dam and closing dam modifications, and local watershed sediment control structures.

Status and Trends Report.  In 1998, EMP produced a report on the status and trends of the ecology of the UMRS (USGS 1999).  This was the first report following the inception of the Environmental Management Program and beginning of data collection under the Long Term Resource Monitoring Program (LTRMP) in which the monitoring data are summarized into one report, alongside historical observation and other scientific findings. This report also serves as background material for the U.S. Army Corps of Engineers' Report to Congress that provided recommendations for future environmental management of the UMRS.  The Status and Trends Report provided a timely assessment of river conditions and also prescribed six criteria for a healthy ecosystem:  1) The ecosystem supports habitats and viable native animal and plant populations similar to those present prior to any disturbance; 2) The ecosystem is able to return to its pre-existing condition after a disturbance, whether natural or human-induced; 3) The ecosystem is able to sustain itself; 4) The river can function as part of a healthy basin; 5) The annual flood pulse "connects" the main channel to its floodplain; and 6) Infrequent natural events – floods and droughts – are able to maintain ecological structure and processes within the reach.

Habitat Needs Assessment (HNA).  In 2000, EMP produced a Habitat Needs Assessment (Theiling et al. 2000) which identified historical, existing, forecast, and desired future conditions of habitats within the Upper Mississippi River System.  For the open river area, the HNA identified:  a need for creation or restoration of 25,000 acres of backwater and secondary channel habitat; an increase in the amount of prairie, marsh, and forest habitat by approximately 100,000 acres; and restoration of geomorphic processes that create and maintain sand bars and shoals.

Stone Dike Alterations Project Report. The Stone Dike Alterations Project was initiated under the authority of the Environmental Management Program, and a draft report was generated with EMP funding (Gordon 2002). The report investigates the potential for existing MMR dikes to be modified to create more diverse scour and depositional patterns. The MMR was divided up into 22 separate reaches. Each reach was then rated based upon its need for habitat restoration and the likelihood of success of restoration. The Herculaneum Reach and two others received the highest rating.

2004 EMP Report to Congress. This Report to Congress (USACE 2004) is the second formal evaluation of the Environmental Management Program. This report evaluates EMP; describes its accomplishments, including development of a systemic habitat needs assessment; and identifies certain program adjustments.

No other EMP projects exist or are proposed in the Herculaneum Reach area. The EMP projects nearest the Herculaneum Reach are the Jefferson Barracks side channel project at river mile 169 and the Salt Lake/Fort Chartres side channel project at river mile 139. Both projects are in the fact sheet stage.

***1.6.3 Applied River Engineering Center Herculaneum Hydraulic Sediment Response Investigation.*** The USACE St. Louis District Applied River Engineering Center (AREC) conducted a hydraulic sediment response (HSR-formerly micro-model) study of the Herculaneum Reach (Rodgers et al. 2003) to develop possible dike modification/placement scenarios for the project. Hydraulic sediment response studies represent the next step in restoration project development beyond that of the general concepts laid out in the Stone Dike Alterations Project Report. HSR models are tabletop moveable bed physical hydraulic models used to optimize restoration goals while minimizing impacts to navigation on restoration alternatives. HSR models have been used for many years to design and plan new and innovative river structures. These models have been utilized in development of new structure types and configurations and for development of notching plans for existing structures with great success. The models have been used successfully in creating innovative habitat types, including secondary channels, and/or alleviating dredging problems. To date more than 10 modeled designs have gone on to be constructed with successful results with many additional modeled designs waiting for funding to be constructed. The Herculaneum HSR model was used to develop the best combinations of potential measures for meeting project objectives. These measures were then put through habitat analysis and incremental cost analysis.

***1.6.4 Upper Mississippi River Comprehensive Plan.*** The authority for the Upper Mississippi River Comprehensive Plan is contained in Section 459 of the Water

Resources Development Act (WRDA) of 1999. The legislation calls for the development of a plan to address water resource and related land resource problems and opportunities in the Upper Mississippi and Illinois River basins from Cairo, Illinois to the headwaters of the Mississippi River. The plan addresses systemic flood damage reduction by means of structural and non-structural flood control and floodplain management strategies; continued maintenance of the navigation project; management of bank caving and erosion; watershed nutrient and sediment management; habitat management; recreation needs; and other related purposes. The report (USACE in press) provides useful information for each Drainage and Levee District regarding: GIS habitat acres, levee over-topping elevations, start of damages, average annual damages, design flood elevation, critical infra-structure, tributary feeders, number of landowners, percent floodplain below the 2-year flood elevation, the cross-sectional area of floodplain below the 2-yr flood elevation, and a measure of topographic variation. The Upper Mississippi River Comprehensive Plan also assesses the environmental restoration opportunities afforded by various Flood Damage Reduction plans ranging from the purely structural to the purely non-structural. The plan determined that significant systemic ecosystem restoration opportunities exist within the Upper Mississippi River floodplain, but no cost-justified flood damage reduction projects were identified that would support inclusion of an ecosystem restoration component.

***1.6.5 Middle Mississippi River Partnership Coordination Plan.*** The Middle Mississippi River Partnership Coordination Plan was published in 2005 (MMRP 2005). The plan was generated by a partnership of 16 federal and state agencies and NGOs that have a common goal of restoring and enhancing the natural resources of the MMR corridor. The plan highlights the historical natural resource trends, identifies priority resource issues along the corridor, and outlines goals and strategies for addressing those resource needs. One of the strategies prescribed by the plan is to rehabilitate or create side channels using priorities established in the Middle Mississippi River Side Channels Report.

***1.6.6 U.S. Fish and Wildlife Service (FWS) Mark Twain National Wildlife Refuge Complex Comprehensive Conservation Plan and Environmental Assessment.*** The Comprehensive Conservation Plan and Environmental Assessment (CCP; USFWS 2004) for the Mark Twain National Wildlife Refuge Complex outlines how the FWS plans to meet its habitat, wildlife, and public use goals for the Complex through the year 2016. The report outlines the current and desired future status of habitat and fish and wildlife resources on each of the National Wildlife Refuges within the Complex (Port Louisa, Great River, Two Rivers, and Middle Mississippi River) and strategies for meeting objectives for each. Included in this discussion is a plan for potential acquisition of 27,659 acres of land within the complex. The selection and prioritization of land parcels included consideration of CCP goals/objectives, interagency input, site wetlands and forest restoration potential, levee district flood histories, habitat needs, opportunity to remove erosion/flood prone agricultural lands, and recreational access. The potential for nutrients reduction, increased flood storage benefits, and reduced disaster relief payments by the government on such lands were also considerations. The CCP identified approximately 4,900 acres of land in the immediate vicinity of the Herculaneum Reach that is of high acquisition priority.

***1.6.7 Geomorphology Study of the Middle Mississippi River.*** A geomorphology study of the Middle Mississippi River (Brauer et al. 2005) from St. Louis, Missouri to Cairo, Illinois was conducted between 2000 and 2005 by the St. Louis District's Applied River Engineering Center. The study was originally initiated as an investigative study for the Mississippi River Channel Improvement Project and later supported by funding pursuant to the Final Biological Opinion for the Operation and Maintenance of the 9-foot Navigation Channel on the Upper Mississippi River System (USFWS 2000). The primary goals of the report were to qualitatively and quantitatively chronologize the historical planform changes of the MMR and to develop conclusions and formulate ideas for future environmental initiatives. The report concludes that great potential for restoration of off-channel habitat exists within the floodplain of the river between the existing river banks and existing agricultural levees.

***1.6.8 Channel Improvement Master Plan.*** The St. Louis District's Channel Improvement Master Plan (USACE 2010) consists of a series of plates depicting existing and planned river regulating structures (i.e. dikes, revetment, chevrons, and bendway weirs). It also shows the locations of dredge cuts and dredge material placement during the past decade. Woody habitat structure locations, interior least tern nesting sites, and recapture locations for radio-tagged pallid sturgeon (*Scaphirhynchus albus*) are also depicted in these plates. The plan does not identify any new structures or modifications to existing structures for the Herculaneum Reach, with the exception of structures and modifications related to the Herculaneum Project itself.

***1.6.9 A River That Works and a Working River: A Strategy for the Natural Resources of the Upper Mississippi River System.*** This report (UMRCC 2000) describes the critical elements of a strategy for the operation and maintenance of the natural resources of the UMRS and its tributaries including the setting of restoration goals and objectives. The report suggests nine objectives for successful resource management of the UMRS: 1) Improve water quality; 2) Reduce erosion, sediment, and nutrient impacts; 3) Return natural floodplain; 4) Restore seasonal flood pulse and periodic low flow conditions; 5) Restore backwater connectivity; 6) Manage sediment transport and deposition in floodplain and side channels; 7) Manage dredging and channel maintenance; 8) Sever pathways for exotic species; and 9) Provide for fish passage at dams.

***1.6.10 Conservation Priorities for Freshwater Biodiversity in the Upper Mississippi River Basin.*** This study (Weitzell et al. 2003) evaluates the components and patterns for the freshwater biodiversity of the UMRB and identifies the most significant places to focus conservation opportunities to maintain it. The Upper

Mississippi River Unimpounded Reach is identified as a priority area and aquatic and terrestrial areas of biodiversity significance are identified for the reach.

***1.6.11 Upper Mississippi River-Illinois Waterway System Navigation Feasibility Study, Feasibility Report 2004.*** The feasibility study (USACE 2004) examines multiple navigation and environmental restoration alternatives, and contains the preferred integrated plan 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.

***1.6.12 Environmental Science Panel Report: Establishing System-wide Goals and Objectives for the Upper Mississippi River System.*** The report (Galat et al. 2007) presents suggested refinements to system-wide ecosystem goals and objectives and proposes steps to take in the further development of objectives for the system.

## 2. ASSESSMENT OF EXISTING AND FUTURE WITHOUT CONDITIONS

**2.1 General Upper Mississippi River Ecosystem Condition.** Prior to widespread European settlement of the region, the UMRS ecosystem supported a diverse 2.6 million-acre landscape of tallgrass prairie, wetlands, savannas, and forests (Kuchler 1964 *in* Gowda 1999). Logging, agriculture, and urban development over the past 150 years have resulted in the present basin-wide landscape that is more than 80 percent developed (Gowda 1999). 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 (Demissie and Kahn 1993). A draft of the Fish and Wildlife Coordination Act Report for the Upper Mississippi River and Illinois Waterway System Navigation Study reported that modern hydrology is highly altered, with increased frequency and amplitude of changes in river discharge in some river reaches (USFWS 2002). Dams and reservoirs in the basin and river regulation in the mainstem also modify river flows. The modern basin landscape delivers large amounts of sediment (WEST 2000; Bhowmik and Demissie 1989), nutrients (Interagency Hypoxia Committee 2000), and contaminants (Meade 1995) to the river. Since impoundment, sediment accumulation and littoral (i.e., wind and wave) processes in the navigation pools have greatly altered aquatic habitats (Rogala et al. 2003).

The historic UMRS ecosystem exhibited natural gradients in habitat among river reaches. Northern river reaches were more forested and were composed of mixed bottomland 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 river channels. The rivers provided efficient transportation and were the focal point of commerce and colonization. As the Midwest economy and population grew, so did the demand for water transportation. 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. Some of the more important development actions and impacts following that were: channelization (4-ft and 6-ft Channel Projects), impoundment and river regulation (9-ft Channel Project), commercial navigation effects, resource exploitation (e.g. logging, market hunting, commercial fishing and clamming), agricultural and urban development (including levees), water quality degradation and improvement, and more recently exotic species introductions.

**2.2 Resource History.** A historical look at the Herculaneum reach of the Middle Mississippi River revealed that the channel contained a different alignment 120 years ago. According to an 1880 topographic and hydrographic map, the channel was wider and contained several bars, including a large bar (Lucas Bar) from mile 152.3 to 151.0. The bars mainly consisted of fine sands and silts. Pile dike structures were placed along the left descending bank (LDB) from mile 156 to 153 to contract the river and direct the channel around Lucas Bar. Additional pile structures were put in place, primarily along the LDB of the Herculaneum Reach, from 1880 until 1889. This stabilized the LDB and resulted in the formation of the "modern day" channel for the Herculaneum Reach. Lucas Bar and several other bars eventually became part of the floodplain. In 1969 the Herculaneum Reach became part of the "Prototype Reach". The prototype reach is a part of the Middle Mississippi River where the channel was contracted to maintain a nine-foot navigation channel during low flow periods. This was accomplished by converting seventeen pile dikes to stone-fill dikes, extending nineteen existing stone-fill dikes, and constructing fifteen new stone-fill dikes to form a 1,200-foot contraction width. The contraction of the channel along the prototype reach has been successful in eliminating the need for dredging along this portion of the river, but also created a homogeneous pattern of flow, scour, and deposition. Analysis of aerial photographs and hydrographic surveys since establishment of the prototype reach shows that the channel in the Herculaneum Reach has been fairly stable since conversion of pile dikes to stone dikes during this period. An aerial photograph showing current channel morphology and dike locations can be found in Figure 5.

**2.3 Land Use and Infrastructure.** The main river channel in the Herculaneum Reach is used predominately as a commercial navigation corridor. The area also sees some limited commercial and recreational fishing. Commercial fishermen typically target common carp, bigmouth and smallmouth buffalo, channel and flathead catfish, and

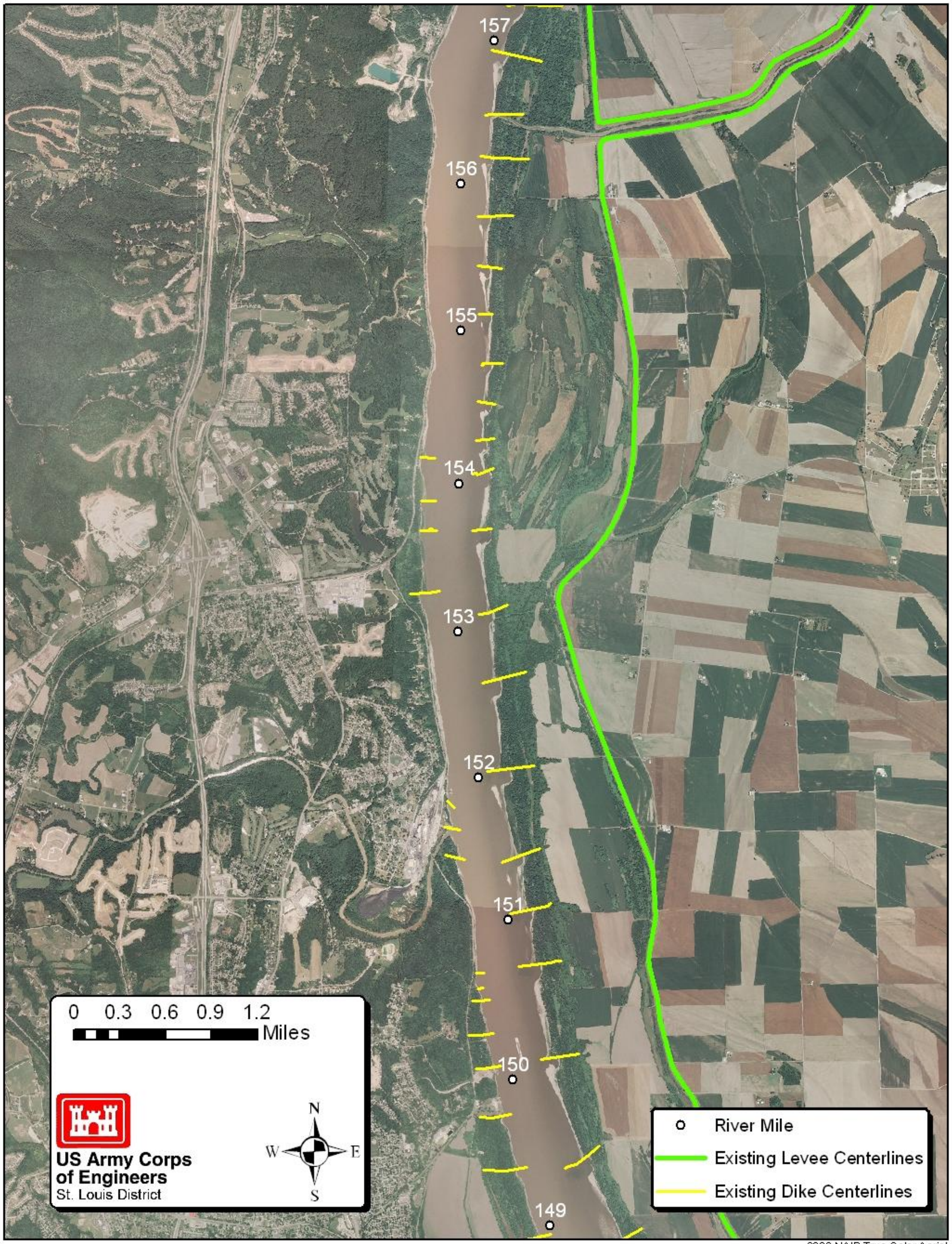


Figure 5. Herculaneum Reach dike and levee locations.

freshwater drum. Recreational fishermen typically target catfish. Land cover classification for the project area (Figure 6) is almost entirely open water, with some isolated areas of sand bars at low river levels. The floodplain surrounding the Herculaneum Reach is largely dominated by leveed agricultural fields (Figures 5 and 6) with some areas of willow, cottonwood, and silver maple floodplain forest immediately adjacent to the main channel.

**2.4 Aquatic Resources.** The aquatic resources within the project area of the Herculaneum Reach are main channel and main channel border open water habitat. These habitats are used by a variety of fish, mussels, birds, reptiles, amphibians, and mammals. The existing dike configurations within the project area create a very homogenous flow, scour, and depositional pattern, resulting in limited habitat diversity. The aquatic habitat of the Mississippi River historically consisted of more shifting sandbar and island complexes from natural erosional/depositional processes resulting in a more diverse habitat assemblage. The fish and wildlife species in the project area would benefit from an increase in the diversity of habitat available. Currently the nearest side channel upstream from the project site is Atwood Chute, located on the left descending bank from river mile 161.7 to 160.8. The nearest side channel downstream is Calico Island Chute, located on the left descending bank from river mile 148.2 to 147.2. Both side channel complexes have closing structures/wing dikes at the upper and lower ends which impact connectivity of aquatic habitats, particularly at low river levels.

**2.5 Floodplain Resources.** The floodplain in the area is dominated by agriculture. Floodplain areas protected by levees are almost entirely in agriculture. Areas outside of the levees are approximately 40 percent agriculture, with the balance being predominately willow, cottonwood, and silver maple forest.

**2.6 Fishery Resources.** The U.S. Fish and Wildlife Service, under contract with the Corps of Engineers, has been conducting pre-project fish sampling in the Herculaneum Reach and in a pseudo-control reach at Trail of Tears (Caswell and Richards 2007). Sampling at Herculaneum from year 1 yielded 3,331 fish from 54 species. The most abundant species were emerald shiner (*Notropis atherinoides*; N=835), freshwater drum (*Aplodinotus grunniens*; N=431), channel shiner (*N. wickliffi*; N=482), and common carp (*Cyprinus carpio*; N=218). Year 2 sampling at Herculaneum yielded 6,348 fish from 53 species. The most abundant species were emerald shiner (N=2844), gizzard shad (*Dorosoma cepedianum*; N=401), channel shiner (N=1164), and freshwater drum (N=555). Additional sampling will be conducted post construction. Analysis of pre-project and post-project samples from the Herculaneum and Trail of Tears Reaches should demonstrate the impacts of the project on the Herculaneum Reach fish community. Results will be applicable to future similar restoration projects throughout the Middle Mississippi River.

Asian Carp are common in this stretch of the Middle Mississippi River. It is not expected that this project will impact Asian Carp populations either positively or negatively. Improving habitat conditions for native fish species is expected to help them better compete against the Asian Carp.

The federally endangered pallid sturgeon also exists in the Middle Mississippi River, although no specific capture records exist for the Herculaneum reach.

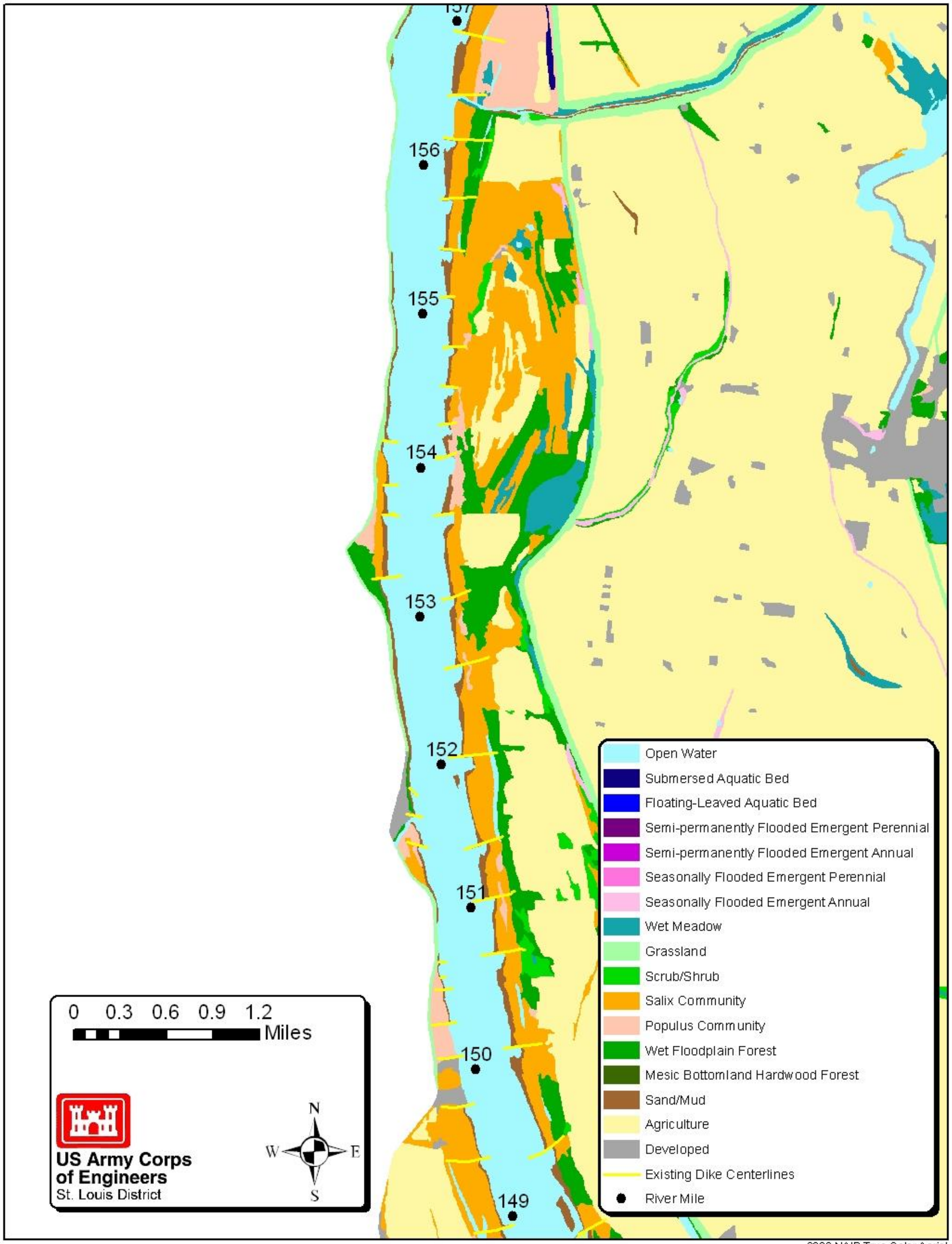


Figure 6. Herculaneum Reach land cover classification.

**2.7 Endangered Species.** In compliance with Section 7(c) of the Endangered Species Act of 1973, as amended, the U.S. Fish and Wildlife Service provided a listing of federally threatened, endangered, or candidate species that may occur in the vicinity of the Herculaneum Project (see letter dated 17 May 2007 in Appendix A). Table 1 provides a summary of threatened, endangered, and candidate species potentially occurring in the project area. No critical habitat exists in the project area.

Table 1. Threatened, Endangered, and Candidate species potentially occurring in the Herculaneum Project area.

| Species | Federal Status |
|---|---|
| Indiana bat (*Myotis sodalis*) | Endangered |
| Gray bat (*Myotis grisescens*) | Endangered |
| Pallid sturgeon (*Scaphirhynchus albus*) | Endangered |
| Least tern (*Sterna antillarum*) | Endangered |
| Illinois cave amphipod (*Gammarus acherondytes*) | Endangered |
| Pink mucket pearly mussel (*Lampsilis abrupta*) | Endangered |
| Scaleshell mussel (*Leptodea leptodon*) | Endangered |
| Sheepnose mussel (*Plethobasus cyphyus*) | Candidate |
| Spectaclecase mussel (*Cumberlandia monodonta*) | Candidate |

**2.8 Historic and Cultural Resources.** No potentially significant archaeological sites or historic shipwrecks are known to exist within the project boundaries. Missouri and Illinois State Historic Preservation Offices were consulted during the planning process (see Appendix A).

**2.9 Sedimentation.** Sedimentation within the Herculaneum Reach has been a fairly static process since the inception of the “Prototype Reach” in the 1960’s. Since that time the rock dikes put in place have resulted in a very stable channel. Although there is transport of sediment into and out of the reach and scour and depositional patterns do change to a degree with varying water levels, the overall pattern of flow and associated scour and deposition within the site remain fairly constant.

**2.10 Hazardous, Toxic, and Radioactive Waste (HTRW).** Due to concerns about possible contaminants in sediments from a lead smelting plant located along the right descending bank toward the lower end of the Herculaneum Reach and the possibility of project features mobilizing those contaminants, a sediment screening investigation was conducted within the lower portion of the Herculaneum reach.

Pesticide and Polychlorinated Biphenyl (PCB) analysis performed on sediment cores and soil samples did not indicate the presence of pesticide/PCB compounds except for dieldrin at 18.1 ppb (parts per billion) in one sample. The pesticide/PCB analysis provides evidence that dieldrin is present at a low level in the sediment and would have potential to be transported downstream. The concentration found is very low, in the parts per billion range, and is not considered to present a significant threat to downstream environments from a human health perspective. The Missouri Risk-Based Corrective

Action (MRBCA) lowest default limit for any exposure pathway for dieldrin is 93.6 ppb. The detected level of dieldrin in the sediment sample is well below the MRBCA guidance limit (93.6 ppb) as well as the Illinois Environmental Protection Agency (IEPA) Tiered Approach to Corrective Action Objectives (TACO) Tier 1 acceptable detection limit (603 ppb). This level is above the TACO Tier 1 residential objective for the ingestion exposure route (40 ppb), however this is not believed to pose a significant risk given the remote location and ingestion does not represent a realistic exposure pathway scenario. Further, using the lowest default values represents an ultra conservative approach; it is unlikely that the levels would yield concentrations adverse to humans in a realistic risk assessment with a more accurate exposure scenario. For potential ecological risk, it should be noted that this level (18.1 ppb) does not exceed the proposed EPA criterion of 11 ppm (parts per million) published in the National Oceanic and Atmospheric Administration's (NOAA) Screening Quick Reference Tables (SQRT) for ecological receptors in freshwater sediment, and is well below the Upper Effects Level (UEL) threshold for infaunal community impacts (300 ppb). The NOAA SQRT is used as a general ecological screening tool for potential impacts. In the absence of finalized EPA criteria, the ranges detected are well below existing screening levels. As with the human health risk implications, the concentration found is very low, in the parts per billion range, and is not considered to present a significant threat to downstream environments from an ecological health perspective.

Total metals analysis performed on sediment cores and soil samples revealed the presence of arsenic, barium, boron, cadmium, chromium, iron, lead, manganese, nickel and zinc. The levels of total metals ranged from "None Detected" (ND) to 24,500 ppm. The levels of arsenic ranged from ND to 7 ppm; barium, 29 ppm to 218 ppm; boron, ND to 25 ppm; cadmium, ND to 0.5 ppm; chromium, 2.8 ppm to 31.5 ppm; copper, ND to 19 ppm; iron, 3,580 ppm to 24,500 ppm; lead, 2 ppm to 42 ppm; manganese, 49.9 ppm to 1,260 ppm; nickel, 5 ppm to 24 ppm; and zinc, 11 ppm to 107 ppm. All mercury, selenium and silver concentrations were below the detection limit. Background concentrations of total metals were not determined under the scope of this project. No data was readily available for concentrations of inorganic chemicals in background soils for Missouri. Therefore, the levels detected for total metals were compared to the background levels in soils outside metropolitan statistical areas for Illinois. All metals concentrations were within the same order of magnitude as background levels (no background given for boron). Total chromium exhibited the greatest deviation from background levels (about 2.4 times higher in two samples). Other metals that exceeded background concentrations (from about 1.5 to 2 times) included barium, copper, iron, manganese, nickel and zinc. All mercury, selenium, and silver concentrations were below the detection limit; however, the detection limit in most cases exceeded the background concentration. Detected levels for total metals were below the Missouri Risk-Based Corrective Action (MRBCA) lowest default target levels for human health risk except for arsenic (3,890 ppb) and lead (3,740 ppb). These higher arsenic and lead levels are believed to be attributable to natural background levels as they are consistent with or below concentrations found in reference sediment samples from outside the potentially-impacted area as presented in the July 2005 Doe Run Company Characterization Investigation Report (Arsenic range 3,200-6,700 ppb; Lead range 8,700-59,300 ppb).

For potential ecological risk, seven metals are typically of "most concern" with regards to fish and wildlife (arsenic, copper, zinc, cadmium, selenium, mercury, and lead). Of these, all were detected at levels below the SQRT Threshold Effects Level (TEL) and below the Probable Effects Level (PEL) published. The TEL represents a highly conservative threshold value of posing little to no ecological risk, while the PEL is intended to provide an indication of levels with a higher probability of toxicity to ecological resources. Given that the levels are below the TEL and the PEL, inorganic metals are not considered to present a significant threat to downstream environments from an ecological health perspective.

In summary, the HTRW sediment screening investigation did not identify contaminant levels present that would adversely impact downstream environments (human and ecological receptors).

**2.11 Future Without Condition.** The future without project condition for the Herculaneum Reach is predicted to be very similar to its existing condition. Analysis of aerial photographs and hydrographic surveys since establishment of the prototype reach in 1969 shows that the channel in the Herculaneum Reach has been fairly stable. There is some speculation by resource managers that there will be some filling between wing dams in the Herculaneum Reach in the future (Theiling et al. 2000), but due to the lack of evidence of filling over the past 40 years, the project team assumed no future filling would occur. Outside of the Herculaneum Reach, loss of side channel habitat is expected to continue. Six of the 25 remaining side channels are predicted to fill in by 2050 (WEST 2000), and, specifically, Jefferson Barracks Chute at river mile 167 and Calico Island Chute at river mile 148 are predicted to be lost (Theiling et al. 2000). Immediately adjacent to the project study area along the left descending bank, the U.S. Fish and Wildlife Service has identified 4900 acres of floodplain habitat for acquisition (USFWS 2004). Availability of funding and willingness of landowners to sell will determine whether or not these lands are brought into public ownership at some point in the future. General predictions for future conditions of floodplain habitat in the Middle Mississippi River indicate that open water, wet floodplain forest, and sand/mud habitat acreage will decrease and mesic bottomland hardwood forest habitat acreage will increase in the future (Theiling et al. 2000). More detailed information on reports pertaining to the future without condition of the Middle Mississippi River and/or the Herculaneum Reach follows.

***2.11.1 Cumulative Effects Study.*** Cumulative effects are defined 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. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR Section 1508.7). A Cumulative Effects Study (WEST 2000) was undertaken as part of the Corps of Engineers' Upper Mississippi River/Illinois Waterway (UMR-IWW) System Navigation Feasibility Study. The Cumulative Effects Study was undertaken to assess the cumulative impacts of past, present, and reasonably foreseeable future actions associated with the continued operation of the 9-ft navigation channel on both the channel morphology and ecological characteristics of the river system. By analyzing past changes in the channel morphology and ecology of the river system and causative factors for those changes, predictions were developed for the geomorphic and ecological conditions of the basin through the year 2050.

Geomorphic Assessment. The study predicted that the geomorphic conditions of the Middle Mississippi River through the year 2050 should remain largely unchanged with the exception that a significant percentage of side channels would fill with sediment. By extrapolating the rate of loss of side channels from historic data out to the year 2050, the study estimated that 6 of the remaining 25 side channels on the Middle Mississippi River would fill in with sediment and eventually become indistinguishable from the rest of the floodplain. This prediction, however, is highly dependent on future river management decisions.

Ecological Assessment. The study considered a wide range of human actions and their impacts on various habitat classifications, vegetation, fish, macroinvertebrates, reptiles and amphibians, birds, and mammals when determining the predicted future condition of the UMR-IWW System. However, the analyses focused on the stretch of river from Pool 4 to Pool 26. Therefore, no conclusions about predicted future ecological conditions of the Herculaneum Reach can be drawn from the study.

***2.11.2 Habitat Needs Assessment.*** As part of the Upper Mississippi River System Environmental Management Program (EMP), a study was undertaken in 2000 to identify historical, existing, forecast, and desired future conditions of habitats within the Upper Mississippi River system. The Habitat Needs Assessment (HNA; Theiling et al. 2000) used the UMR-IWW Navigation Feasibility Study's Cumulative Effects Study, workshops with natural resource managers, and a floodplain vegetation successional model to forecast future conditions of Mississippi River habitat out to the year 2050. The Cumulative Effects Study was covered in the previous section and will not be covered further here.

The workshops with natural resource managers looked at 15 different geomorphic processes responsible for change:

- Delta formation
- Filling between wing dams
- Island dissection
- Island formation
- Loss of isolated backwaters
- Loss of secondary channels
- Tributary delta formation
- Wind-wave erosion of islands
- Channel formation

- Island migration
- Loss of contiguous impounded area
- Loss of bathymetric diversity
- Loss of contiguous/isolated backwaters
- Loss of tertiary channels
- Shoreline erosion

The workshops looked at potential changes in the river system due to these processes at a much finer scale than the Cumulative Effects Study due to the resource managers' intimate knowledge of specific areas of the river. For the Middle Mississippi River in general, the geomorphic processes cited by resource managers as responsible for change were filling between wing dams and loss of secondary channels. Within the Herculaneum Reach specifically, filling between wing dams was the only geomorphic process cited as likely to occur through the year 2050. Resource managers felt that some of the wing dams along the left descending bank would fill in with sediment. Also in the immediate vicinity of the Herculaneum Reach, the secondary channels at river mile 167 (Jefferson Barracks Chute) and 148 (Calico Island Chute) were predicted to be lost.

The terrestrial vegetation successional model was used to predict acreage changes in vegetation communities by the year 2050. The model was developed utilizing an expert panel of botanists and foresters to analyze current land cover, predicted geomorphic changes, land use, resource management, disturbance regimes, controlling factors, and successional theory. Certain assumptions were included in the development of the model:

- land presently in agricultural use will remain in agricultural use
- developed land will remain developed
- existing plans for floodplain vegetation management will be implemented
- the climate and hydrologic regime will not change
- the present set of floodplain vegetation natural disturbances (wind, fire, flood, ice, diseases, etc.) will continue

These assumptions appear to be appropriate for consideration of predicted changes in the terrestrial vegetation community in the Herculaneum Reach.

Predictions coming out of the vegetation model were made on fairly broad scales (system, reach, and pool) such that drawing any conclusions about smaller areas (e.g. the Herculaneum Reach) is difficult. However, in general, areas in the Middle Mississippi River floodplain are predicted to lose open water, wet floodplain forest, and sand/mud habitat and gain mesic bottomland hardwood forest habitat by the year 2050.

***2.11.3 United States Fish and Wildlife Service Comprehensive Conservation Plan.*** The CCP covering the Mississippi River at the Herculaneum Reach is the Mark Twain National Wildlife Refuge CCP. The 78-acre Meissner Island Division of the Middle Mississippi River National Wildlife Refuge (within the broader Mark Twain National Wildlife Refuge Complex) is located between river miles 154 and 153. This CCP does not specifically predict what future habitat conditions will be but does address land acquisition priorities of the Fish and Wildlife Service. Included in these land acquisition priorities are parcels of land within and around the Herculaneum Reach. Between river miles 157 and 144, the FWS has identified approximately 4900 acres of land as either being pre-approved for acquisition or of a high priority for acquisition. All of this property lies along the left descending bank of the river immediately adjacent to the main channel and is located outside or riverward of the existing agriculture levees. Depending on various factors influencing FWS land purchases, funding and willing sellers being foremost among them, some or all of these properties could be brought into public ownership within the next 50 years. Management of the properties would follow the FWS objectives for the Middle Mississippi River of restoring forest and aquatic river corridor habitat for fish and wildlife. Exact management and restoration scenarios could be influenced by many factors, the details of which will not be known until after the properties are purchased.

#### *2.11.4 Site-Specific Information.*

2010 Master Plan for Channel Improvement. The 2010 Master Plan for Channel Improvement (USACE 2010) is used to identify all known plans for new channel improvement structures or modifications to existing structures within the St. Louis District through the year 2014 or at any other yet-to-be-determined time. The plan does not identify any new structures or modifications to existing structures for the Herculaneum Reach, with the exception of structures and modifications related to the Herculaneum Project itself.

## 3. PROJECT GOALS AND OBJECTIVES

**3.1 Problems and Opportunities.** The stone dikes that were constructed in the Herculaneum Reach and throughout the Middle Mississippi River help maintain a safe, stable, and dependable navigation channel. However they have also resulted in a homogenous pattern of flow and sedimentation, lack of natural cut and fill channel meanderings, and a resultant lack of habitat diversity. Most of the 195 miles of the Middle Mississippi River consists of similar unchanging main channel and main channel border habitat. The remaining 25 side channels and little off channel habitat existing on the open river are gradually filling in with sediment. The hydraulic constraints put on the river system (dikes, weirs, revetment, etc.) preclude the natural creation of new side channel and off channel habitats to replace those being lost to sedimentation. This lack of habitat diversity limits certain fish and wildlife populations which are more adapted to the historic river condition. Dike notching and innovative dike configuration efforts by the St. Louis District, in conjunction with the Illinois Department of Natural Resources and the Missouri Department of Conservation, have demonstrated that dike modifications can create a more diverse flow, scour, and depositional pattern, creating valuable habitat diversity without affecting navigation. The opportunity exists in the Herculaneum Reach to modify existing channel training structures and place new structures to create several side channel habitat complexes, thereby contributing to habitat diversity and ecosystem integrity.

**3.2 Constraints.** The following constraints have been identified for the system and individual projects:

- Navigation - Avoid significant adverse effects on Navigation of the Upper Mississippi River and Illinois Waterway.
- Flood Elevations - Avoid increases in flood elevations that would require mitigation of adverse effects. Due to the potential high cost associated with mitigation actions, efforts will be made to avoid this threshold.
- Legal Compliance - All efforts conducted in the implementation of the Comprehensive Plan shall comply with all federal regulations pertaining to the activities undertaken by the Corps of Engineers.

**3.3 Project Goals and Objectives.** This site specific restoration project was identified and evaluated with the primary purpose of contributing to the restoration of the Upper Mississippi River and Illinois Waterway. The program has developed a vision statement and overarching and system-wide ecosystem goals for the restoration of habitat in the Upper Mississippi River System. The site specific goals and objectives are nested within the context of the system goals and objectives as described below.

**Vision Statement:** To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System.

**Overarching System-Wide Ecosystem Goal:** To conserve, restore, and maintain the ecological structure and function of the Upper Mississippi River System to achieve the vision.

**System-Wide Ecosystem Goals:**

1. Manage for a more natural hydrologic regime <u>(hydrology and hydraulics)</u>
2. Manage for processes that shape a physically diverse and dynamic river-floodplain system <u>(geomorphology)</u>
3. Manage for processes that input, transport, assimilate, and output material within UMR basin river-floodplains: e.g. water quality, sediments, and nutrients <u>(biogeochemistry)</u>
4. Manage for a diverse and dynamic pattern of habitats to support native biota <u>(habitat)</u>
5. Manage for viable populations of native species within diverse plant and animal communities <u>(biota)</u>

**Site-Specific Objectives:**

The project addresses system-wide goals 2, 4, and 5. In addition, the following site specific objectives, performance indicators, and measures have been identified:

Table 2. Summary of Site-Specific Objectives, Performance Indicators, and Potential Measures.

| System-Wide Goal | Site-Specific Objective | Performance Indicators | Potential Measures |
|---|---|---|---|
| ○ Restore geomorphology | ○ Enhance channel geomorphic diversity | ○ Number of side channel complexes existing within reach<br>○ Bathymetric diversity within reach | The measures considered to address the site-specific objectives consist of creation of side channel complexes throughout the Herculaneum Reach by:<br>○ chevron dike placement<br>○ dike notching<br>○ dike shortening<br>○ dike unrooting.<br><br>For further information on formulation of alternatives, see Section 4 – Potential Measures. |
| ○ Restore habitats | ○ Modify channels to provide suitable habitat for fishes | ○ Acreage of deep slack water within reach<br>○ Linear feet of wetted perimeter habitat in reach | |
| ○ Restore biota | ○ Maintain the diversity and extent of native communities | ○ Relative abundance of juvenile native fishes<br>○ Lentic/lotic ratio of native fishes | |

**3.4 Potential Performance Indicators.** As discussed in Section 3.1, Problems and Opportunities, the Herculaneum Reach and most of the Middle Mississippi River are characterized by an overabundance of homogeneous wing dike and associated main channel border habitat. The existing habitat does not resemble the diversity of habitat that existed in the historic Middle Mississippi River or that to which fish populations in the river adapted. The tentatively selected plan is designed specifically to modify existing homogeneous main channel habitat into a more geomorphically diverse pattern of habitats to benefit the fish community of the Middle Mississippi River. It follows that the performance indicators for gauging success or failure of the project should focus on geomorphic diversity, fish habitat, and resultant changes in fish populations in the area. Geomorphic diversity and habitat measurements will utilize standard geomorphic/bathymetric survey techniques used regularly on the Middle Mississippi River. Measurement of changes in fish populations will utilize pre- and post-project monitoring data collected by USFWS under contract with St. Louis District. For further information on development of performance indicators and monitoring, see Appendix K.

## 4. POTENTIAL MEASURES

**4.1 General.** Preliminary screening of potential measures took place early on in the planning process to eliminate potential features that were unfeasible or impractical. An array of measures that involved side channel restoration within the leveed and unleveed portions of the floodplain on the Illinois side of the river were considered. Measures considered included excavating a new side channel in various locations in the adjacent floodplain, reconnecting the main channel with remnant swales in the unleveed section of the adjacent floodplain, and reconnecting the main channel with remnant swales in the leveed section of the adjacent floodplain. For a variety of reasons including cost, acceptability to adjacent landowners and levee districts, and engineering feasibility, these measures were eliminated from further consideration (see Table 3). The remaining measures involving work within the existing river channel were considered the only viable potential measures.

Table 3. Criteria used in preliminary screening of potential measures.

| Potential Measure | Acceptability | Completeness | Effectiveness | Efficiency |
|---|---|---|---|---|
| Excavate new side channel* | L | H | M | M |
| Reconnect remnant swales in unleveed floodplain* | L | H | M | M |
| Reconnect remnant swales in leveed floodplain** | L | M | L | L |
| Modify existing structures | H | H | H | H |
| Place new structures | H | H | H | H |

* Eliminated from further consideration due to lack of acceptability to local landowners and levee and drainage districts.

** Eliminated from further consideration due to lack of acceptability to local landowners and levee and drainage districts, engineering feasibility, and cost inefficiency.

The measures remaining after preliminary screening were evaluated using St. Louis District's Applied River Engineering Center's hydraulic sediment response model (formerly micro-model) methodology. A hydraulic sediment response model is a tabletop moveable bed physical hydraulic model used to analyze restoration alternatives. Potential dike placement/modification options can be explored by moving structures within the model and visualizing flow, scour, and depositional response. The study was performed to address two separate sediment transport objectives. The first was to create side channel aquatic habitat within the dike fields. The second was to maintain current depths in the navigation channel to assure the need for dredging would not arise. A separate issue existed with potential HTRW concerns from a lead smelting plant along the right descending bank toward the lower end of the Herculaneum Reach. The Doe Run Lead Plant is located near river mile 152. There is potential for fallout from airborne lead particles in the dike field adjacent to this location and subsequent deposition in sediments. Therefore no modifications to this dike field were considered in the hydraulic sediment response study so as to eliminate the possibility of mobilizing deposited contaminants (see Section 2.10 and Appendix E for further HTRW information).

The hydraulic sediment response model was used to determine the best combinations of dike modifications/placements to generate side channel complexes and to ensure navigation channel impacts were minimized. Dike placement/modification features that were considered by the team included:

- Placement of blunt-nosed chevron dikes
- Placement of wing dikes
- Notching of existing dikes
- Shortening of existing dikes
- Unrooting of existing dikes (i.e. removing the portion of the dike nearest the bankline)
- Lengthening of existing dikes
- Increasing dike height
- Decreasing dike height

Many different combinations and arrangements of these features were experimented with in the model by the river engineers, river managers, and others on the PDT, with the goal of finding the best combination for creating side channel habitat without affecting navigation. The combinations of features that showed the most promise for meeting these goals were put through detailed modeling analysis. Detailed modeling analysis involved subjecting the model to various simulated hydrographs followed by analysis of bathymetric changes. The results of this detailed analysis yielded an optimized dike modification/placement scenario for each section of the project area (upper project area, left descending bank; middle project area, right descending bank; and lower project area, left descending bank; see Figures 3 and 4). Each of these optimized combinations of dike modifications and placements was then considered a measure. The existing dike configurations and the requirement of not conducting any work in the potentially contaminated area limited the areas that could be considered for side channel restoration, thereby yielding three potential measures. See Section 4.2 for a detailed description of each measure. A detailed report on the hydraulic sediment response study can be found in Appendix G.

**4.2 Potential Measures and Increments.** The following three measures resulted from the hydraulic sediment response study (see Figure 7). All elevations are referenced to the low water reference plane (LWRP). The LWRP represents a theoretical water surface elevation profile based upon a low flow of 54,000 cubic feet per second. The reference elevation of 0 feet LWRP is based upon the probability that this stage and discharge will be exceeded 97% of the time annually.

***4.2.1 Measure A***: Creation of a side channel complex on the left descending bank from river mile 155.4 to 154.5. Involves the following dike modifications/placements:

- Mile 155.4: 150-foot by 150-foot blunt nosed chevron centered at 800 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.3: 150-foot by 150-foot blunt nosed chevron centered at 875 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.15: 150-foot by 150-foot blunt nosed chevron centered at 600 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.05: 150-foot by 150-foot blunt nosed chevron centered at 450 feet from the LDB, placed at +15 feet LWRP.
- Dike 154.9 L: shortened to 250 feet in length.
- Dike 154.6 L: 650 feet in length, 200-foot notch located 300 feet from the bank line.

***4.2.2 Measure B***: Creation of a side channel complex on the right descending bank from river mile 154.4 to 153.7. Involves the following dike modifications/placements:

- Mile 154.4: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the RDB, placed at +15 feet LWRP.
- Mile 155.35: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the RDB, placed at +15 feet LWRP.
- Mile 154.2: 150-foot by 150-foot blunt nosed chevron centered at 350 feet from the RDB, placed at +15 feet LWRP.
- Dike 154.0 R: shortened to 250 feet in length.

***4.2.3 Measure C***: Creation of a side channel complex on the left descending bank from river mile 153.2 to 151.0. Involves the following dike modifications/placements:

- Mile 153.2: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.4: 150-foot by 150-foot blunt nosed chevron centered at 550 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.15: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.0: 150-foot by 150-foot blunt nosed chevron centered at 800 feet from the LDB, placed at +15 feet LWRP.
- Mile 151.3: 150-foot by 150-foot blunt nosed chevron centered at 600 feet from the LDB, placed at +15 feet LWRP.

- Dike 153.6 L: 570 feet in length, 200-foot notch located 200-feet from the bank line.
- Dike 153.0 L: 350 feet in length, made rootless from 0 to 250 feet from the bank line.
- Dike 152.5 L: 600 feet in length, 200-foot notch located 200 feet from the bank line.
- Dike 152.1 L: 780 feet in length, 200-foot notch located 250 feet from the bank line.
- Dike 151.3 L: 840 feet in length, 200-foot notch located 400 feet from the bank line.

## 5. ALTERNATIVE PLANS

**5.1 Formulation of Alternative Plans.** Given that a hydraulic sediment response study was utilized to formulate only viable project measures and given that all measures are combinable, formulation of alternative plans was simply an exercise in generating all possible combinations of the three viable measures. The three measures are summarized as follows (See Section 4.2 for a detailed description of the features included in each measure):

Measure A: Create side channel complex at upper end of reach along left descending bank
Measure B: Create side channel complex in middle of reach along right descending bank
Measure C: Create side channel complex at lower end of reach along left descending bank

The possible combinations of measures are listed below (Table 3). All of these possible combinations were then analyzed for environmental benefits and costs (see Section 6).

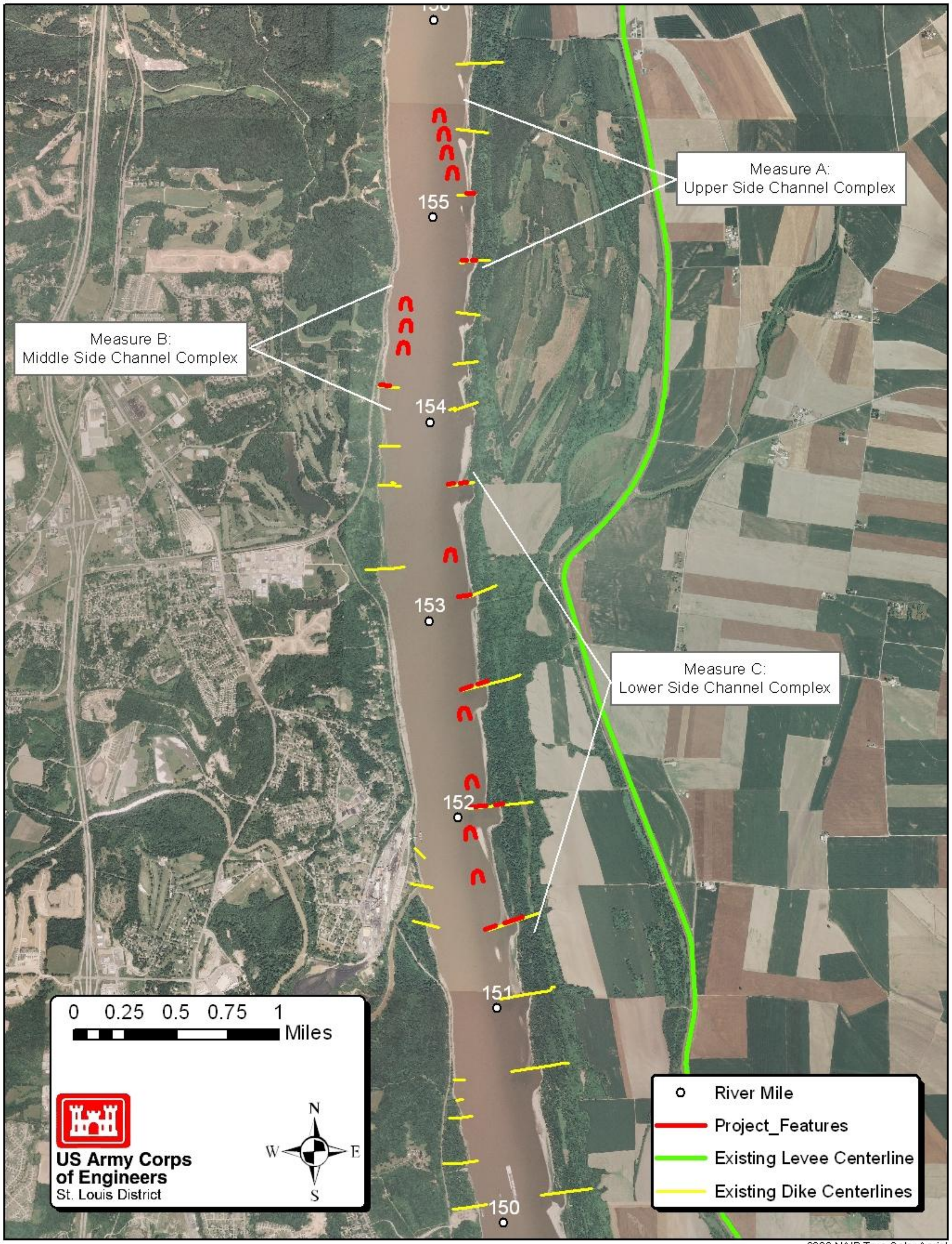


Figure 7. Measures A, B, and C and their associated features.

Table 3. Alternatives – all possible combinations of measures A, B, and C.

| Alternative | | Measures Included in Alternative | Symbol* |
|---|---|---|---|
| 1 | No Action | No measures | A0 B0 C0 |
| 2 | Upper side channel complex only | Measure A | A1 B0 C0 |
| 3 | Middle side channel complex only | Measure B | A0 B1 C0 |
| 4 | Lower side channel complex only | Measure C | A0 B0 C1 |
| 5 | Upper and Middle side channel complexes only | Measures A and B | A1 B1 C0 |
| 6 | Upper and Lower side channel complexes only | Measures A and C | A1 B0 C1 |
| 7 | Middle and Lower side channel complexes only | Measures B and C | A0 B1 C1 |
| 8 | Upper, Middle, and Lower side channel complexes | Measures A, B, and C | A1 B1 C1 |

* A "0" next to the measure indicates that it was not included in the Alternative; a "1" indicates that it was included in the Alternative.

## 6. EVALUATION AND COMPARISON OF ALTERNATIVE PLANS

**6.1 General.** Each of the alternatives described in the previous section was put through an ecosystem benefit analysis to determine the magnitude of ecosystem benefits to be expected if implemented. These benefits were combined with cost estimates in an incremental cost analysis in order to determine the cost effectiveness of each alternative plan.

**6.2 Ecosystem Benefit Analysis.** The ecosystem benefit analysis for the Herculaneum Project utilized a multi-agency team approach with representatives from U.S. Fish and Wildlife Service, Illinois Department of Natural Resources, Missouri Department of Conservation, and U.S. Army Corps of Engineers.

An analysis of existing conditions, future-without-project conditions, and future-with-project conditions was conducted using a combination of the Aquatic Habitat Appraisal Guide (AHAG) and the Missouri Fisheries Habitat Appraisal Guide (MOFISH). The AHAG approach was developed by the Corps of Engineers' Waterways Experiment Station and Rock Island District (Mathias et al. 1996). The MOFISH methodology was developed by the Missouri Department of Conservation (1991). Both approaches follow the format of the Wildlife Habitat Appraisal Guide (WHAG), developed by the Missouri Department of Conservation and the Natural Resources Conservation Service (1990). The WHAG is, in turn, based on the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (1980).

The combination AHAG/MOFISH methodology utilized for the Herculaneum Project evaluates the benefits of each alternative plan by looking at the quality and quantity of habitat for the animal species selected for evaluation by team members. The qualitative component of the analysis is known as the Habitat Suitability Index (HSI) and is rated on a 0.1 to 1.0 scale, with higher values indicating better habitat. The HSI for a particular habitat type is calculated by considering various biotic and abiotic characteristics of the habitat given different project alternatives and the resultant ability of the habitat to support the species under consideration. The quantitative component of the analysis is the number of acres of habitat that are available for the selected evaluation species. From the qualitative and quantitative determinations, the standard unit of measure, the Habitat Unit (HU), is calculated using the formula HSI x Acres = HUs. Changes in the quality and/or quantity of habitat, and therefore habitat units, can occur over time. In order to capture these changes, habitat conditions are estimated at selected target years for both with- and without-project conditions. Target years for the Herculaneum Project were established at 0 (existing conditions), 3, 25, and 50 years. The period of analysis for the project is 50 years. These changes over the period of analysis influence the cumulative HUs derived over the period of analysis. Cumulative HUs are annualized and averaged to determine what is known as Average Annual Habitat Units (AAHUs). AAHUs are used as an output measurement to compare all the measures and project as a whole and to evaluate the difference between the environmental outcomes of with- and without-project conditions. This difference results in the net AAHUs for the project or project feature.

Consistent with guidance from the USACE Ecosystem Planning Center of Expertise, the Agency Technical Review Team for the Herculaneum Project conducted an assessment of the models used for the project. This process did not result in certification, but did result in the determination that the technical quality and appropriateness of the models utilized were satisfactory.

***6.2.1 Site Specific.*** Species selected for analysis and the habitat metrics used can be found in Tables 4 and 5. The resultant Net Average Annual Habitat Units for all alternatives analyzed for the Herculaneum Project can be found in Tables 6 and 7. For all of the alternatives considered, gains in HSI values and therefore AAHUs were realized due to increases in three of the thirteen metrics used in the analysis: Metric 8) Distance to nearest side channel with permanent water greater than 2 meters deep and year-round connectivity; Metric 10) Connectivity of side channel to main channel; and Metric 13) Depth diversity. All of the other metrics were identical for future-with and future-without project conditions for all alternatives. Distance to and connectivity of side channel habitat are important habitat characteristics for the evaluated species due to their use of this type of habitat for reproduction, foraging, rearing, resting, and/or predator avoidance. Side channels provide heterogeneity of habitat in the current breaks, depth diversity, and substrate diversity they exhibit. Depth diversity is important in that it provides varying current velocities, substrate diversity, and habitat heterogeneity at varying river stages. These three metrics combined measure the degree to which the project features change the current homogeneous nature of the Herculaneum Reach to more closely resemble the historic condition of the Middle Mississippi River. The Herculaneum Reach currently has no side channel habitat and exhibits very little depth diversity.

Within the three aforementioned metrics, as the complexity and footprint of the alternatives increased, resultant HSIs increased and more AAHUs were realized. This results in the steadily increasing progression of AAHUs from 72.6 for Alternative 2 (upper side channel complex only) to 291.2 for Alternative 8 (upper, middle, and lower side channel complexes). This difference can also be seen when comparing alternatives with single, smaller side channel complexes (Alternatives 2 and 3; 155 acres and 120 acres, respectively) against an alternative with a single, larger side channel complex (Alternative 4; 340 acres). Alternative 4 involves a longer stretch of the river and more chevrons and dike modifications than the upper side channel complexes, and, therefore, results in higher HSIs and yields higher net AAHUs. Note, however, that Alternatives 2 and 3, despite their slightly different footprints, yield identical Net AAHUs (72.6). This is due to the fact that the entire project area (1647 acres) was treated as one management unit. The slightly larger size of the side channel created by Alternative 2 was not enough to increase the HSI for the entire project site, so it yielded the same AAHUs as Alternative 3. Appendix C, Habitat Evaluation and Quantification, provides a detailed description of the habitat analysis process.

Impacts Beyond Project Area. In the formula used for calculation of habitat units for the Herculaneum Project (HSI x acres), the acreage used (1647) was the footprint of the Herculaneum Reach. This reach stretches from river mile 156.3 to 149.7. This method of habitat unit calculation implies that beneficial impacts of the project will only be realized by fish within that stretch of river. This assumption is necessary due to the fact that quantification of impacts beyond this footprint is a difficult and inexact proposition. An exact determination of how far benefits might extend upstream and downstream for various species of fish would be nearly impossible. However, given the mobile nature of fish and the paucity of important side channel habitat in the Middle Mississippi River, a convincing argument can be made that project benefits extend considerably beyond just the footprint of the Herculaneum Reach. One logical methodology for estimating the degree to which project benefits extend beyond the project footprint is to consider the scarcity of, and distance to, similar habitat in the area. With respect to side channel habitat in the vicinity of the Herculaneum Project, the nearest side channel habitat in the upstream direction is Atwood Chute at river mile 160.8, and the nearest side channel habitat in the downstream direction is Calico Island Chute at river mile 148.2. Neither of these side channels provides year-round habitat due to the fact that both lose connectivity to the main channel at low river levels. The case could certainly be made that the benefits of the Herculaneum Project should extend further upstream and downstream than these two small, low quality side channels. However, even if they are used as the upper and lower limits of project benefits, the area of impact increases from 1647 to 3145 acres, which would effectively double the habitat units generated by the project and halve the cost per habitat unit. While it is difficult to discern exactly what the areal extent of benefits of the project should be, some consideration of this factor needs to be taken into account when looking at project costs and worthiness.

Table 4. Species selected for ecosystem benefit analysis.

| Species | Scientific Name | Habitat Guild | Reproductive Guild |
|---|---|---|---|
| Sauger | *Sander canadensis* | Lotic (moving water) | Lithophil (rock/gravel) |
| Shovelnose sturgeon | *Scaphirhynchus platorhynchus* | Lotic | Lithophil |
| Smallmouth buffalo | *Ictiobus bubalus* | Lentic (slack water) | Phytophil (plants) |
| Paddlefish | *Polyodon spathula* | Lentic | Lithophil |
| Flathead catfish | *Pylodictis olivaris* | Lentic | Speleophil (cavities) |

Table 5. Habitat metrics utilized for ecosystem benefit analysis.

| Habitat Metrics |
|---|
| 1. Average Water Temp $^{o}$C |
| 2. Average Turbidity (NTU) |
| 3. Minimum Daily Dissolved Oxygen (mg/l) |
| 4. Dominant Substrate Type |
| 5. Percent Surface Area w/ Visible logs, Inundated Timber and/or Brush |
| 6. Distance to Gravel Bar, Miles |
| 7. Average Water Velocity, cm/sec |
| 8. Distance to Nearest Side Channel with Permanent Water >2m and Year Round Connectivity |
| 9. Percent of Backwater/Sidechannel Area Suitable as Overwintering habitat from Nov.-Feb. |
| 10. Connectivity of Side Channel to Main Channel |
| 11. Flow Continuity |
| 12. % Shoreline Rip Rapped |
| 13. Depth Diversity |

Table 6. Average Annual Habitat Units by alternative and species and Net AAHUs as compared to the No Action Alternative (Alt 1).

| | Large Lotic Guild | | | Large Lentic Guild | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sauger | Shovelnose Sturgeon | Guild Avg | Smallmouth Buffalo | Paddlefish | Flathead Catfish | Guild Avg | Avg of Guild AAHUs | **Net AAHUs** |
| Alt 1 | 877.9 | 1167.3 | 1022.6 | 958.3 | 1125.0 | 955.6 | 1013.0 | 1017.8 | **0.0** |
| Alt 2 | 918.6 | 1256.7 | 1087.6 | 1042.7 | 1210.8 | 1026.0 | 1093.2 | 1090.4 | **72.6** |
| Alt 3 | 918.6 | 1256.7 | 1087.6 | 1042.7 | 1210.8 | 1026.0 | 1093.2 | 1090.4 | **72.6** |
| Alt 4 | 1017.4 | 1341.4 | 1179.4 | 1130.4 | 1298.5 | 1097.8 | 1175.6 | 1177.5 | **159.7** |
| Alt 5 | 1055.4 | 1341.4 | 1198.4 | 1157.3 | 1310.6 | 1108.9 | 1192.3 | 1195.3 | **177.5** |
| Alt 6 | 1067.5 | 1341.4 | 1204.4 | 1157.3 | 1310.6 | 1108.9 | 1192.3 | 1198.4 | **180.6** |
| Alt 7 | 1067.5 | 1341.4 | 1204.4 | 1157.3 | 1310.6 | 1108.9 | 1192.3 | 1198.4 | **180.6** |
| Alt 8 | 1211.8 | 1439.5 | 1325.6 | 1255.2 | 1418.2 | 1203.8 | 1292.4 | 1309.0 | **291.2** |

Table 7. Net Average Annual Habitat Units for all alternatives.

| **Alternative*** | | **Net AAHUs** |
|---|---|---|
| 1 | No Action (A0B0C0) | 0.0 |
| 2 | Upper side channel complex only (A1B0C0) | 72.6 |
| 3 | Middle side channel complex only (A0B1C0) | 72.6 |
| 4 | Lower side channel complex only (A0B0C1) | 159.7 |
| 5 | Upper and Middle side channel complexes only (A1B1C0) | 177.5 |
| 6 | Upper and Lower side channel complexes only (A1B0C1) | 180.6 |
| 7 | Middle and Lower side channel complexes only (A0B1C1) | 180.6 |
| 8 | Upper, Middle, and Lower side channel complexes (A1B1C1) | 291.2 |

* See Sections 4.2 and 5.1 for detailed descriptions of Measures and Alternatives.

**6.3 Cost Analysis.** Total project costs, using FY08 price levels (Specifically December 2007), are determined for all project alternatives. Average annual cost is calculated via cost stream analysis for all alternatives, assuming a 50-year project period of evaluation and a project discount rate of 4.875%. Both total project costs and average annual costs for all alternatives are presented in Table 8.

Table 8. Total project costs and average annual costs for all alternatives.

| Alternative | Total Project Costs | Average Annual Cost |
|---|---|---|
| 1-No Action (A0B0C0) | $0 | $0 |
| 2 (A1B0C0) | $1,892,000 | $101,643 |
| 3 (A0B1C0) | $1,521,000 | $81,712 |
| 4 (A0B0C1) | $2,171,000 | $116,631 |
| 5 (A1B1C0) | $3,207,000 | $172,287 |
| 6 (A1B0C1) | $3,856,000 | $207,153 |
| 7 (A0B1C1) | $3,485,000 | $187,222 |
| 8 (A1B1C1) | $5,171,000 | $277,798 |

### 6.4 Alternative Plan Evaluation and Comparison.

***6.4.1 Completeness, Effectiveness, Efficiency, Acceptability.*** Per Engineering Regulation 1105-2-100, the plan formulation process for the Herculaneum Project has addressed four overarching criteria: completeness, effectiveness, efficiency, and acceptability. Definitions of these four criteria follow:

**Acceptability** is the workability and viability of the alternative plan with respect to acceptance by federal and non-federal entities and the public and compatibility with existing laws, regulations, and public policies. Two primary dimensions to acceptability are implementability and satisfaction. Implementability means that the alternative is feasible from technical, environmental, economic, financial, political, legal, institutional, and social perspectives. If it is not feasible due to any of these factors, then it cannot be implemented, and therefore is not acceptable. An infeasible plan should not be carried forward for further consideration. However, just because a plan is not the preferred plan of a non-federal sponsor does not make it infeasible or unacceptable *ipso facto*. The second dimension to acceptability is the satisfaction that a particular plan brings to government entities and the public. Obviously, the extent to which a plan is welcome or satisfactory is a qualitative judgment. Nevertheless, discussions as to the degree of support (or lack thereof) enjoyed by particular alternatives from a community, state Department of Natural Resources, Ducks Unlimited, or other national or regional organizations, for example, are additional pieces of information that can help planners evaluate whether to carry forward or screen out alternative plans.

**Completeness** is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planning objectives. To establish the completeness of a plan, it is helpful to list those factors beyond the control of the planning team that are required to make the plan’s effects (benefits) a reality.

**Effectiveness** is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities. An effective plan is responsive to the identified needs and makes a significant contribution to the solution of some problem or to the realization of some opportunity. It also contributes to the attainment of planning objectives. The most effective alternatives make significant contributions to all the planning objectives. Alternatives that make little or no contribution to the planning objectives can be rejected because they are relatively ineffective. Another factor that can impact the effectiveness of an alternative is whether there is substantial risk and uncertainty associated with the alternative. If the functioning or success of an alternative is uncertain, or less certain than another alternative, its effectiveness may be compromised and should be discussed.

**Efficiency** is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment (P&G Section VI.1.6.2(c)(3)).

The Corps of Engineers' iterative six-step planning process of Identifying Problems and Opportunities, Inventorying and Forecasting Conditions, Formulating Alternative Plans, Evaluating Alternative Plans, Comparing Alternative Plans, and Selecting a Plan is designed to result in the formulation of complete, effective, efficient, and acceptable plans. The Herculaneum Project feasibility study followed this process in order to meet these four criteria. Information on selection of the tentatively selected plan based on these four criteria can be found in Section 6.6 below.

***6.4.2 National Ecosystem Restoration (NER) Plan.*** Engineering Regulation 1105-2-100 directs that Corps of Engineers ecosystem restoration projects should contribute to national ecosystem restoration. Contributions to national ecosystem restoration are defined as increases in the net quantity and/or quality of desired ecosystem resources. These NER outputs are to be expressed quantitatively in non-monetary units based on habitat quality and/or quantity. The average annual habitat units utilized in the Herculaneum Project plan formulation process quantify this contribution to the NER Plan. Refer to Appendix C, Habitat Evaluation and Quantification, for a detailed description of the habitat analysis process.

***6.4.3 Navigation Impacts.*** The Herculaneum hydraulic sediment response model was specifically utilized to determine the best regulating works configurations for optimizing ecosystem benefits while maintaining adequate depths in the navigation channel. Modeled dike configurations which resulted in excessive sedimentation in the navigation channel, and would consequently likely lead to dredging problems, were dropped from consideration.

***6.4.4 Cost Effectiveness/Incremental Cost Analysis.***

As covered in Section 6.4.1, the Corps of Engineers' planning process must address four criteria: completeness, effectiveness, efficiency, and acceptability. For traditional projects (flood damage reduction, navigation), the National Economic Development (NED) Plan objective (maximization of net benefits) ensures that the efficiency criterion has been met. The alternative which maximizes the net benefits of the project (total benefits less total cost) is the alternative which meets this criterion. However, such a selection criterion falls short for environmental restoration projects because of the difficulties in quantifying project benefits in traditional monetary terms. Without a reliable monetary estimate of project benefits with which to compare monetary costs, it is not possible to determine the alternative plan that maximizes net monetary benefits. However, this does not mean the economic efficiency of environmental plans cannot be properly evaluated in accordance with the decision criteria outlined in Engineering Regulation 1105-2-100.

The tool of cost effectiveness analysis enables planners to impose economic efficiency on the cost (production) side of the equation by assuring a range of cost effective plans are identified. This economic tool can ensure that either a set level of environmental output is produced in the least cost possible, or that for a set level of expenditures environmental output production is maximized. Although the cost analyses do not provide a discrete decision criterion (such as the maximization of net benefits in NED analysis), incremental cost analysis (ICA) provides for the explicit comparison of the relevant changes in cost and output on which such decisions may be based.

Cost effectiveness analysis and ICA are rooted in economic production theory and utilize such economic principles as scarcity and choice and opportunity cost. The cost analysis examines changes in cost and output that result from decisions to implement alternative plans and plan components. Cost effectiveness analysis can be used to identify the least-cost plan for producing every attainable level of environmental output, as well as identifying those plans where more output could be produced for the same or less cost. Environmental scale selection choices based on average, instead of incremental cost information can lead to misinformed and improper decision making. The rationale behind incremental cost analysis is to reveal the variation in cost from one plan to another, whereas average cost tends to obscure the variation in cost across plans. ICA is invaluable in assisting in determining the appropriate scale of restoration by revealing variations in cost across alternatives, explicitly asking for each attainable increment of output, "Is it worth it?"

The Cost Effectiveness and ICA process for the Herculaneum Project involved 4 steps:

**Cost Effectiveness**

1. Eliminate alternatives that are Inefficient in Production
2. Eliminate alternatives that are Ineffective in Production

**Incremental Cost Analysis**

3. Calculate Incremental Cost, Incremental Output, and Incremental Cost per Unit of Output
4. Calculate Incremental Change in Cost and Incremental Change in Output

**1. Eliminate Alternatives that are Inefficient in Production.**

An alternative which is Inefficient in Production is defined as any alternative where the same output level can be generated at a lesser cost by another alternative. This step identifies the least-cost alternative for every level of output under consideration. Alternative 2 and Alternative 6 were eliminated in this process due to the fact that Alternative 3 has the same output as Alternative 2 for a lower average annual cost, and Alternative 7 has the same output as Alternative 6 for a lower average annual cost. Results can be found in Table 9 and Figure 8.

Table 9. Results of production efficiency analysis.

| Alternatives | Net AAHUs | Average Annual Cost | Non-Cost Effective Alternatives |
|---|---|---|---|
| 1-No Action (A0B0C0) | 0.0 | $0 | |
| 2 (A1B0C0) | 72.6 | $101,643 | ***Inefficient in Production*** |
| 3 (A0B1C0) | 72.6 | $81,712 | |
| 4 (A0B0C1) | 159.7 | $116,631 | |
| 5 (A1B1C0) | 177.5 | $172,287 | |
| 7 (A0B1C1) | 180.6 | $187,222 | |
| 6 (A1B0C1) | 180.6 | $207,153 | ***Inefficient in Production*** |
| 8 (A1B1C1) | 291.2 | $277,798 | |

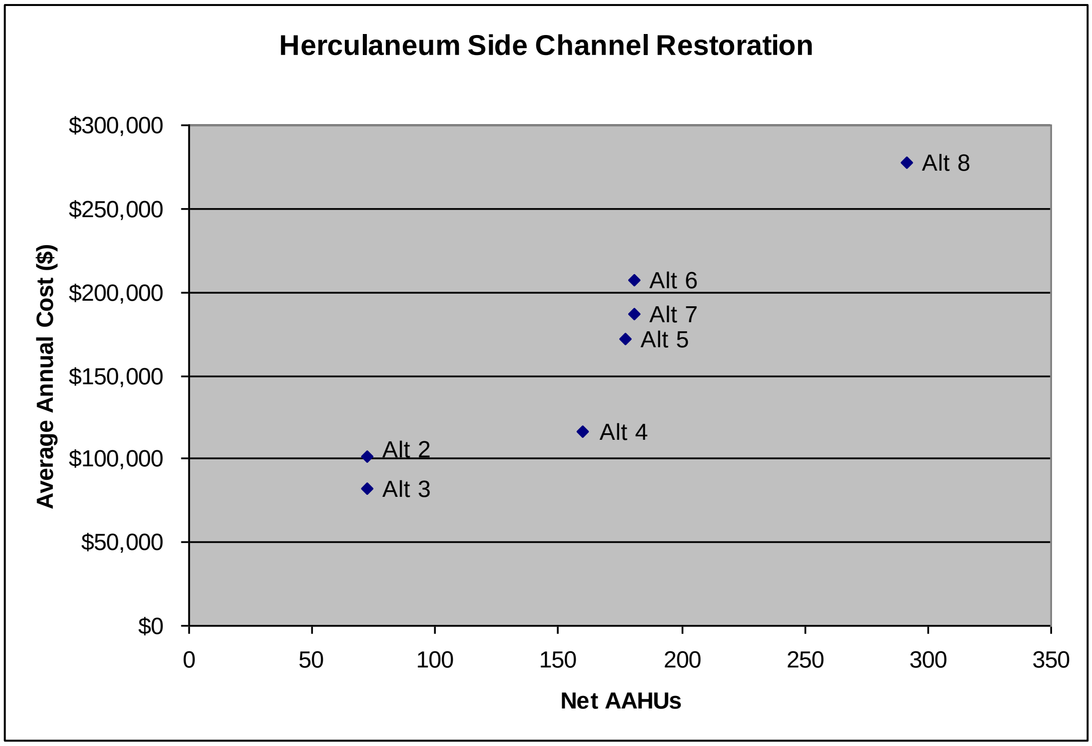


Figure 8. Average Annual outputs and costs.

**2. Eliminate Alternatives that are Ineffective in Production.**

An alternative Ineffective in Production is defined as any alternative where a greater output level can be generated at a lesser or equal cost by another alternative. In this step, the alternatives remaining after the first step are evaluated and any alternative generating less output at an equal or greater cost is eliminated. None of the remaining alternatives was determined to be Ineffective in Production.

**3. Calculate Incremental Cost, Incremental Output, and Incremental Cost per Unit of Output.**

Incremental cost is the additional cost incurred by selecting one alternative instead of another, and is computed by subtracting the cost of the last alternative under consideration from the cost of the current alternative under consideration. Similarly, incremental output is the additional output generated by selecting one alternative instead of another, and is computed by subtracting the output of the last alternative under consideration from the output of the current alternative under consideration. Incremental cost per incremental output is the additional cost per unit of advancing to each successive cost effective output level, and is computed by dividing the incremental cost between successive alternatives under consideration by the incremental output between those same alternatives. Table 10 depicts the results of these calculations.

Table 10. Results of Incremental Cost per Unit of Output calculations.

| Remaining Alternatives | Average Annual Output (Net AAHUs) | Average Annual Cost | Incremental Output (Net AAHUs) | Incremental Cost | Incremental Cost per Unit |
|---|---|---|---|---|---|
| 1 (No Action A0B0C0) | 0.0 | $0 | N/A | N/A | N/A |
| 3 (A0B1C0) | 72.6 | $81,712 | 72.6 | $81,712 | $1,125.3 |
| 4 (A0B0C1) | 159.7 | $116,631 | 87.1 | $34,919 | $401.0 |
| 5 (A1B1C0) | 177.5 | $172,287 | 17.8 | $55,656 | $3,118.7 |
| 7 (A0B1C1) | 180.6 | $187,222 | 3.0 | $14,935 | $4,935.9 |
| 8 (A1B1C1) | 291.2 | $277,798 | 110.7 | $90,576 | $818.4 |

Ideally, Table 10 would result in continuously increasing incremental costs per unit as successive larger output levels are considered. Continuously increasing incremental costs per unit facilitate answering the "Is it worth it?" question as successive larger project scale alternatives are compared. Since each successive alternative provides more output than previous plans, and additional output costs more per unit than preceding alternatives (i.e., increasing incremental costs per unit), it is intuitive to evaluate whether the additional output is worth its higher unit cost.

However, the more realistic case results in an incremental cost curve with irregularly increasing and decreasing incremental costs per unit, as clearly displayed in Table 10. As a result, this fluctuating incremental cost data makes the selection of the appropriate project scale alternative unclear. Additional steps are required to "smooth out" fluctuating incremental costs per unit and help clarify information about the incremental cost curve by identifying production efficiencies along segments of the cost curve.

**4. Calculate Incremental Change in Cost and Incremental Change in Output.**

Step 4 involves calculating incremental change in cost and incremental change in output from implementing each remaining alternative over the No Action alternative (Table 11). As can be seen from the table, alternative 4 yields the lowest incremental cost ($730.4). In other words, alternative 4 is the most cost effective remaining alternative for production of AAHUs over the No Action alternative, producing additional AAHUs at an additional cost of $730.4 per habitat unit. All alternatives with lower output levels than Alternative 4 are then eliminated from consideration, thus eliminating Alternative 3 from further consideration.

Table 11. Incremental Cost per Unit of Output as compared to the No Action Alternative.

| Remaining Alternatives | Incremental Output (Net AAHUs; compared to Alt 1) | Incremental Cost (compared to Alt. 1) | Incremental Cost per Unit (compared to Alt 1) |
|---|---|---|---|
| 1 (No Action A0B0C0) | N / A | N / A | N / A |
| 3 (A0B1C0) | 72.6 | $81,712 | $1,125.3 |
| 4 (A0B0C1) | 159.7 | $116,631 | $730.4 |
| 5 (A1B1C0) | 177.5 | $172,287 | $970.4 |
| 7 (A0B1C1) | 180.6 | $187,222 | $1,036.9 |
| 8 (A1B1C1) | 291.2 | $277,798 | $953.9 |

Next the incremental change in cost and incremental change in output from implementing each remaining Alternative over the Last Selected Alternative (Alternative 4) is computed, where the Last Selected Alternative is considered the *new* baseline condition against which each remaining Alternative is compared. The incremental cost per unit of each remaining Alternative over the Last Selected Alternative (Alternative 4) is presented in Table 12.

Table 12. Incremental Cost per Unit of Output as compared to Alternative 4.

| Remaining Alternatives | Incremental Output (Net AAHUs; compared to Alt 4) | Incremental Cost (compared to Alt. 4) | Incremental Cost per Unit (compared to Alt 4) |
|---|---|---|---|
| 1 (No Action A0B0C0) | N / A | N / A | N / A |
| 4 (A0B0C1) | N / A | N / A | N / A |
| 5 (A1B1C0) | 17.8 | $55,656 | $3,118.7 |
| 7 (A0B1C1) | 20.9 | $70,591 | $3,382.1 |
| 8 (A1B1C1) | 131.5 | $161,167 | $1,225.2 |

Examining the Incremental Cost per Unit column in Table 12 reveals Alternative 8 yields the lowest incremental cost per unit over the Last Selected Alternative, at $1,225.2. In other words, Alternative 8 is the most cost effective remaining Alternative for production of AAHUs over the Last Selected Alternative, producing additional AAHUs at an additional cost of $1,225.2 per habitat unit. Alternatives 5 and 7 are, therefore, eliminated from further consideration since they have lower output levels than Alternative 8. Also, since Alternative 8 is the last Alternative, there is no need for further incremental cost analysis; the ICA process is complete. The final remaining Alternatives (Table 13), also known as “Best Buy” Alternatives, can be used to determine the desired project scale. Characteristic of “Best Buy” Alternatives, the incremental cost per unit increases for successively larger levels of Net AAHU output, as evident in Table 13 and Figure 9.

Table 13. Best Buy Alternatives.

| "Best Buy" Alternatives | Average Annual Output (Net AAHUs) | Average Annual Cost | Incremental Output (Net AAHUs) | Incremental Cost | Incremental Cost per Unit |
|---|---|---|---|---|---|
| 1 (No Action A0B0C0) | 0.0 | $0 | N / A | N / A | N / A |
| 4 (A0B0C1) | 159.7 | $116,631 | 159.7 | $116,631 | $730.4 |
| 8 (A1B1C1) | 291.2 | $277,798 | 131.5 | $161,167 | $1,225.2 |

The Alternatives presented in Table 13 provide the information necessary to make well-informed decisions regarding desired project scale. For example, progressively proceeding through the increasing levels of output for the Alternatives in Table 13 help determine whether the habitat value of the additional output in the next level of output is worth its additional cost. If decision makers determine Alternative 4, generating 159.7 habitat units at an incremental cost per unit of $730.4, is preferred to the No Action Alternative then they would proceed to the next level of output to determine if it is worth its additional cost. Alternative 8 generates an increase in habitat units of 131.5, which is an increase of 80 percent over Alternative 4. The incremental cost per habitat unit under Alternative 8 is $1,225.2, which is an increase of almost 70 percent over Alternative 4. Therefore, dependent on the desired project objectives, both Alternative 4 and Alternative 8 are recommended as viable Alternatives.

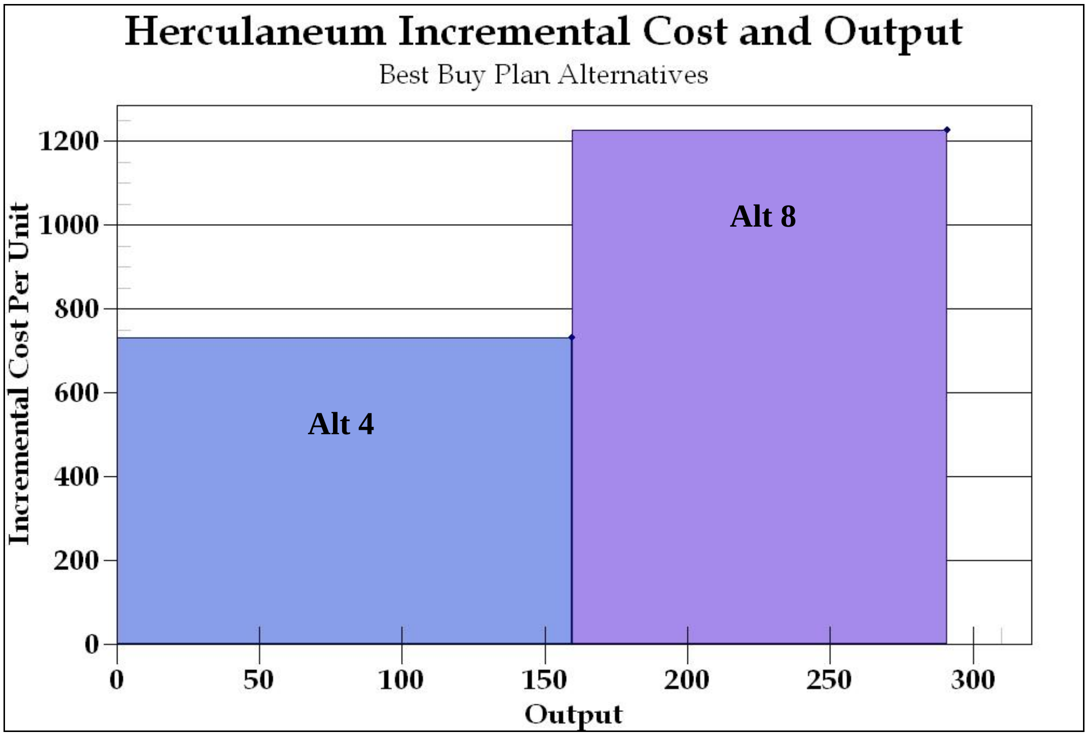


Figure 9. Output (AAHUs) and incremental costs of Best Buy plans.

***6.4.5 Risk and Uncertainty.*** Risk is the chance that something negative could occur as the result of project implementation. Uncertainty is defined as the degree to which we are not sure that the expected results will actually occur. The following paragraphs describe the risk and uncertainty associated with the Herculaneum Project.

**Risk**. There is a relatively low level of risk associated with the implementation of this project. There is some risk that the features of the project could negatively impact the navigation channel in the area by causing increased sedimentation and associated impediments to navigation. However, one of the goals of the hydraulic sediment response model utilized in development of restoration measures for the Herculaneum Project was "to maintain current depths in the navigation channel to assure the need for dredging would not arise" (Rodgers et al. 2003). Therefore, to the extent that the utilized model can accurately predict real-world results, risk to navigation was accounted for and minimized.

**Uncertainty**. A degree of uncertainty is inherently associated with the models used to generate estimates of benefits (habitat units) for the Herculaneum Project. These models involve estimates of environmental conditions for the project site over the next 50 years. Given the dynamic nature of riverine ecosystems and biological populations in general, predictions fifty years into the future will always involve some degree of uncertainty. The best scientific judgment of biologists with extensive experience on the Middle Mississippi River was utilized in the development of restoration benefits for the Herculaneum Project in order to minimize uncertainty as much as can reasonably be expected.

Some uncertainty also exists in the development of cost estimates for the various alternatives considered for the Herculaneum Project. Costs associated with the rock needed for construction of the chevron dikes proposed in the Project have been particularly volatile recently due to increased demand for hurricane recovery efforts. Up-to-date cost estimates were generated for the Cost Effectiveness and Incremental Cost Analysis; however, these costs could change considerably prior to construction. This problem is mitigated from a plan formulation perspective, however, by the fact that all of the alternatives considered utilize rock to a large degree and would, therefore, be affected relatively equally by a change in rock prices. Changes in rock costs would change the magnitude of the costs for all alternatives, but should not change which projects are best buys.

**6.5 Selection of Tentatively Selected Plan.** The Herculaneum incremental cost analysis "best buy alternatives" were each evaluated by the PDT against the four Planning and Guidance evaluation criteria identified in ER 1105-2-100. As covered in Section 6.4.1 above, the four evaluation criteria specified in the P&G are acceptability, completeness, effectiveness, and efficiency. Definitions of each were provided to the PDT prior to evaluation.

During the evaluation, the PDT referenced the best buy alternatives to the three project objectives identified for the Herculaneum Project. Those project objectives were:

1) Enhance channel geomorphic diversity
2) Modify channels to provide suitable habitat for fishes
3) Maintain the diversity and extent of native communities throughout their range in the UMRS

To allow for easier comparison, the PDT prepared a matrix for ranking each of the best buy alternatives according to how well they addressed the four evaluation criteria (Table 14). The result of the PDT evaluation was the identification of Alternative 8 as the alternative that best addressed the four P&G evaluation criteria. In addition, the regional scarcity of the habitat created (only 25 side channels remain in the MMR), the downward trend in suitable side channel habitat within the MMR (WEST 2000), the lack of similar habitat close to the project site (13 miles between side channels), the opportunity to nearly double (80% more) the number of AAHUs of a rare habitat for only a 70% increase in cost, the recognized significance of, and need for, the creation or restoration of 25,000 acres of side channel and backwater habitat on the Middle Mississippi River (Theiling et al. 2000), and the opportunity to create a significantly larger functional habitat complex in an area where that habitat does not exist, were all factors in the PDT selection of Alternative 8 as the most acceptable alternative.

Alternative 8 was also identified as the National Ecosystem Restoration (NER) plan. The NER is a plan for ecosystem restoration projects that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with Federal objectives. Alternative 8 was shown to be cost-effective and justified to achieve the desired level of output.

Table 14. Best Buy Evaluation Matrix.

| P&G Evaluation Criteria | Best Buy Alternatives | | |
|---|---|---|---|
| | **Alternative 1** (no action) | **Alternative 4** (lower side channel only) | **Alternative 8** (all side channels) |
| **Acceptability** | L | M | H |
| **Completeness** | L (A) | M (B) | H (C) |
| **Effectiveness** | L (A) | M (B) | H (C) |
| **Efficiency** | L | H ICA most cost-effective Alt. | M |
| **PDT Tentatively Selected Plan** | | | **X** |

L Low
M Medium
H High
(A) Meets none of the project objectives
(B) Partially meets objectives 1, 2, and 3
(C) Meets objectives 1 and 2. Partially meets objective 3.

## 7. DESCRIPTION OF TENTATIVELY SELECTED PLAN

**7.1 Plan Components.** The tentatively selected plan consists of the following three measures:

> ***Measure A***: Creation of a side channel complex on the left descending bank from river mile 155.4 to 154.5. Measure A involves the following dike modifications/placements:

- Mile 155.4: 150-foot by 150-foot blunt nosed chevron centered at 800 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.3: 150-foot by 150-foot blunt nosed chevron centered at 875 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.15: 150-foot by 150-foot blunt nosed chevron centered at 600 feet from the LDB, placed at +15 feet LWRP.
- Mile 155.05: 150-foot by 150-foot blunt nosed chevron centered at 450 feet from the LDB, placed at +15 feet LWRP.
- Dike 154.9 L: shortened to 250 feet in length.
- Dike 154.6 L: 650 feet in length, 200-foot notch located 300 feet from the bank line.

***Measure B***: Creation of a side channel complex on the right descending bank from river mile 154.4 to 153.7. Measure B involves the following dike modifications/placements:

- Mile 154.4: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the RDB, placed at +15 feet LWRP.
- Mile 155.35: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the RDB, placed at +15 feet LWRP.
- Mile 154.2: 150-foot by 150-foot blunt nosed chevron centered at 350 feet from the RDB, placed at +15 feet LWRP.
- Dike 154.0 R: shortened to 250 feet in length.

***Measure C***: Creation of a side channel complex on the left descending bank from river mile 153.2 to 151.0. Measure C involves the following dike modifications/placements:

- Mile 153.2: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.4: 150-foot by 150-foot blunt nosed chevron centered at 550 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.15: 150-foot by 150-foot blunt nosed chevron centered at 400 feet from the LDB, placed at +15 feet LWRP.
- Mile 152.0: 150-foot by 150-foot blunt nosed chevron centered at 800 feet from the LDB, placed at +15 feet LWRP.
- Mile 151.3: 150-foot by 150-foot blunt nosed chevron centered at 600 feet from the LDB, placed at +15 feet LWRP.
- Dike 153.6 L: 570 feet in length, 200-foot notch located 200-feet from the bank line.
- Dike 153.0 L: 350 feet in length, made rootless from 0 to 250 feet from the bank line.
- Dike 152.5 L: 600 feet in length, 200-foot notch located 200 feet from the bank line.

- Dike 152.1 L: 780 feet in length, 200-foot notch located 250 feet from the bank line.
- Dike 151.3 L: 840 feet in length, 200-foot notch located 400 feet from the bank line.

**7.2 Design Considerations.** The hydraulic sediment response model for the Herculaneum Project took into account two main sediment transport considerations as project features were developed: 1) side channel complex habitat within the reach was to be created, and 2) current depths in the navigation channel were to be maintained to assure the need for dredging would not arise. These considerations were the driving factors for all model scenarios that were developed and tested and ultimately for which features were selected.

**7.3 Project Implementation Timeline.**

The following is an estimated project implementation timeline (Table 15). However, the actual schedule will be influenced by available funding and resolution of project specific issues.

Table 15. Project implementation schedule.

| **Requirement** | **Scheduled Date** |
|---|---|
| Distribute Draft PIR | April 2009 |
| Complete Internal Technical Review of Draft PIR | May 2009 |
| Submit PIR for Public and Agency Review | June 2010 |
| Submit Final PIR to Mississippi Valley Division | Aug 2010 |
| Initiate Plans and Specifications | Dec 2010 |
| Complete Plans And Specifications | Mar 2011 |
| Advertise Contract | Nov 2011 |
| Award Contract | Jan 2012 |
| Construction Complete | Sep 2013 |

**7.4 Land, Easements, Rights-of-Way, Relocation, and Disposal Site (LERRDS) Considerations.** There is no fee title, permanent easement, or temporary easement required to implement the proposed project. The project area lies below the ordinary high water line within the main Mississippi River channel and is therefore within navigational servitude limits.

**7.5 Operational and Maintenance Considerations.** Any Operation and Maintenance responsibility for the structures put in place for this project will be a 100% Federal cost. Based on the type of work, the estimated Operation and Maintenance costs for the tentatively selected plan were minimal.

**7.6 Adaptive Management and Monitoring Plan.** The need for monitoring and adaptive management has been identified and recommended for the efficient management of the UMRS (Lubinski and Barko 2003; USACE 2004; Barko et al. 2006). The NESP Science Panel recommended an adaptive management framework including six functional areas: (1) refining and clarifying ecosystem objectives; (2) developing evaluation criteria outcomes including ecosystem services; (3) evaluating and sequencing proposed ecosystem restoration projects; (4) monitoring, including selection of response variables appropriate to different scales; (5) evaluating relevant ecological indicators, metrics and outcomes for a UMRS ecosystem condition report card; and (6) integrating ecological models and using information technology to facilitate the adaptive management process (Barko et al. 2006). More specifically for this project, the key areas to be addressed with adaptive management include risk and uncertainty related to potential impacts to the navigation channel from this type of project. In addition, adaptive management and monitoring provide the opportunity for learning about project impacts to geomorphic diversity and fish habitat and resultant changes in the fish community that could lead to further cost savings and more efficient implementation of future projects.

Initial efforts to implement this framework will begin with the establishment of monitoring plans for each of the ecosystem restoration project elements of the program. Per Sec 8004, before initiating the construction of any individual ecosystem restoration project, the following steps will be completed:

(A) establish ecosystem restoration goals and identify specific performance measures [indicators] designed to demonstrate ecosystem restoration;
(B) establish the without-project condition or baseline for each performance indicator; and
(C) for each separable element of the ecosystem restoration, identify specific target goals for each performance indicator.

Performance measures [indicators] shall include specific measurable environmental outcomes, such as changes in water quality or the well being of indicator species the population and distribution of which are representative of the abundance and diversity of ecosystem-dependent aquatic and terrestrial species. The monitoring plan (see Appendix K) includes the performance indicators, timeline to achieve the identified target goals/objectives, and a timeline for the demonstration of project completion. The monitoring plan was developed in consultation with the Department of the Interior and the involved states.

**7.7 Cost Estimates.** Table 16 and Appendix F provided the detailed cost estimates of the proposed project features for the tentatively selected plan. However, due to the sensitivity of providing this detailed information in advance of awarded construction contract, this material has been omitted for this public review. The June 2009 detailed cost estimate for the tentatively selected plan yielded a total project cost of approximately $6 million.

Table 16. Detailed project costs for the major features of the tentatively selected plan. All costs include a 20% contingency.

OMITTED

## 8. ENVIRONMENTAL EFFECTS

**8.1 Summary of Effects.** The proposed project would result in positive long-term benefits to fish and wildlife species within and around the Herculaneum Reach. The project would increase the flow, scour, and depositional diversity in the reach, adding valuable side channel complex habitat to the Middle Mississippi River. Side channel complex habitat is an important but dwindling resource on the open river. Existing side channel habitat is diminishing in quality and quantity due to sedimentation. There are currently no side channels on the open river between river miles 160.8 and 148.2. This project would greatly enhance the fish and wildlife habitat within that 12.6-mile homogeneous stretch of open river. No federally protected species are expected to be negatively affected. The project would likely result in minor short-term displacement of fish and wildlife species in the immediate vicinity of construction activities due to localized increases in noise and turbidity. No significant social or economic impacts are expected to result. No impacts to historic properties are anticipated.

**8.2 Natural Resources.** Impacts of the project on natural resources were evaluated using the Aquatic Habitat Appraisal Guide (AHAG) and Missouri Fish Habitat Appraisal Guide (MOFISH). See Section 6.2 and Appendix C for details regarding this process. These procedures were used during the plan formulation process to evaluate the effects of various combinations of measures on the habitat of the project area. The process is used to optimize project benefits (expressed as Habitat Units or HUs) in relation to project costs. Assessment of project impacts was based on sound management practices and the experience of USFWS, IDNR, MDOC, and USACE natural resource professionals.

***8.2.1 Terrestrial Habitat.*** The proposed project would not negatively impact any of the existing terrestrial habitat in the Herculaneum reach. All project features would be constructed from the river with no land access needed and all structures would be placed in the main river channel below the ordinary high water line. There would be no long-term impacts from the project on terrestrial habitat.

***8.2.2 Aquatic Habitat.*** The proposed project is designed to improve aquatic habitat and restore natural river processes by diversifying the homogeneous flow, scour, and depositional patterns within the project area. The increase in habitat diversity should result in an increase in fish and wildlife population diversity. The project would likely result in some minor short-term decreases in water quality in the immediate vicinity of construction activities.

***8.2.3 Wildlife.*** Improved habitat diversity within the Herculaneum Reach would have some minor positive impacts on wildlife populations and diversity. Although habitat improvements on this project are focused on fish habitat improvement, other wildlife would see some benefit from the increase in flow, scour, and depositional diversity provided by this project. Reptiles, amphibians, invertebrates, shorebirds, waterfowl, mammals, and other wildlife utilizing side channel and slackwater habitat would benefit. The long-term impacts of the project would be positive. The project would likely result in some short-term displacement of wildlife in the immediate vicinity of construction activities due to temporary decreases in water quality and disturbance by construction equipment.

***8.2.4 Fish.*** The proposed enhancement measures of the project are designed to positively impact river fish populations. The increase in flow, scour, and depositional diversity in the project area would add much-needed habitat diversity to the site and would restore natural river processes. The ecosystem benefit analysis (Appendix C) concluded that the tentatively selected plan would positively affect fish populations. Specifically, for the fish species included in the analysis (sauger, shovelnose sturgeon, smallmouth buffalo, paddlefish, and flathead catfish), the project would result in an increase of 291.2 average annual habitat units. The project would likely result in some short-term displacement of fish in the immediate vicinity of construction activities due to temporary decreases in water quality and disturbance by construction equipment. In terms of invasive fish species (e.g. Asian carp), project features are not designed to impact these species positively or negatively.

***8.2.5 Hazardous, Toxic, and Radioactive Waste.*** The HTRW sediment screening investigation concluded that contaminant levels present would not adversely impact downstream environments (human or ecological receptors).

***8.2.6 Prime and Unique Farmland.*** No prime and unique farmland would be impacted by the proposed project.

***8.2.7 Mineral Resources.*** No mineral resources would be impacted by the proposed project.

**8.3 Endangered Species – Biological Assessment.** In compliance with Section 7(c) of the Endangered Species Act of 1973, as amended, the U.S. Fish and Wildlife Service provided a listing of federally threatened, endangered, or candidate species or designated critical habitat that may occur in the vicinity of the Herculaneum Project (see letter dated 17 May 2007 in Appendix A). Table 17 provides a summary of threatened, endangered, and candidate species potentially occurring in the project area. No critical habitat exists in the project area.

Table 17. Federally endangered and threatened species potentially occurring in the vicinity of the Herculaneum Project.

| Species | Federal Status |
|---|---|
| Indiana bat (*Myotis sodalis*) | Endangered |
| Gray bat (*Myotis grisescens*) | Endangered |
| Pallid sturgeon (*Scaphirhynchus albus*) | Endangered |
| Least tern (*Sterna antillarum*) | Endangered |
| Illinois cave amphipod (*Gammarus acherondytes*) | Endangered |
| Pink mucket pearly mussel (*Lampsilis abrupta*) | Endangered |
| Scaleshell mussel (*Leptodea leptodon*) | Endangered |
| Sheepnose mussel (*Plethobasus cyphyus*) | Candidate |

| | |
|---|---|
| Spectaclecase mussel (*Cumberlandia monodonta*) | Candidate |
| Bald eagle (*Haliaeetus leucocephalus*) | De-listed August 8, 2007 |

***8.3.1 Indiana bat – Endangered.*** Indiana bats winter in caves or mines which satisfy their highly specific needs for cold temperatures during hibernation. No caves or mines would be impacted by the proposed project. During summer, female Indiana bats use trees in floodplains and upland areas as nursery roosts and forage for insects in the tree canopy. Males also roost in trees. No terrestrial habitat would be impacted by the project. The project is not expected to impact Indiana bats.

***8.3.2 Gray bat – Endangered.*** Gray bats utilize caves for both winter hibernation and summer roosting locations. Foraging occurs in riparian forest canopy and over water along river and lake edges. No caves would be impacted by the proposed project. Construction activities would take place along the river edge, but the localized nature of this activity is not expected to impact the gray bat. The project is not expected to impact gray bats.

***8.3.3 Pallid sturgeon – Endangered.*** Pallid sturgeon are large-river fish found in the Missouri River and the Mississippi River below the Missouri River confluence. Pallid sturgeon are adapted to braided channels, irregular flow patterns, flooding of terrestrial habitat, extensive microhabitat diversity, and turbid waters (Mayden and Kahajda 1997). The Herculaneum Project is designed to modify the homogeneous flow, scour, and depositional patterns currently existing within the project area to more closely resemble the habitat to which pallid sturgeon are adapted. The ecosystem benefit analysis (Appendix C) concluded that the tentatively selected plan would result in 272.2 average annual habitat units for the shovelnose sturgeon, a closely related species. The pallid sturgeon likely occurs within the project area, but no catch records exist. The project is expected to benefit the pallid sturgeon.

***8.3.4 Least tern – Endangered.*** Least terns nest on sparsely vegetated sand and gravel bars or islands in or adjacent to rivers, lakes, gravel pits, and cooling ponds. It forages in shallow water along river banks and backwater areas. There are no recent records of least terns nesting in the Herculaneum Project vicinity. Since there are no sand or gravel bars within the project site, with the exception of main channel border sand bars which don’t appear to provide adequate habitat, the project is not expected to negatively impact least terns. There is the possibility that sediment deposition associated with project chevron placements and dike modifications could result in sand bar formation. During low water events, these sand bars cold be utilized as nesting sites by least terns.

***8.3.5 Illinois cave amphipod – Endangered.*** The Illinois cave amphipod occurs only in underground streams in Monroe and St. Clair Counties, Illinois. No underground streams would be impacted by the project. The project is not expected to impact Illinois cave amphipods.

***8.3.6 Pink mucket pearly mussel – Endangered.*** The pink mucket pearly mussel typically inhabits medium to large rivers with strong currents. However, no records exist for the presence of this mussel in the Mississippi River in the Herculaneum Project vicinity, and the species is believed to be extirpated altogether from the main stem Upper Mississippi River. Records for Jefferson County, Missouri exist due to the mussel's presence in the Meramec and other smaller Missouri rivers. The project is not expected to impact pink mucket pearly mussels.

***8.3.7 Scaleshell mussel – Endangered.*** Scaleshell mussels prefer stable channels and good water quality in medium to large rivers. No records exist for the presence of this mussel in the Mississippi River in the Herculaneum Project vicinity, and the species is believed to be extirpated altogether from the main stem Upper Mississippi River. Records for Jefferson County, Missouri exist due to the mussel's presence in the Meramec River basin. The project is not expected to impact scaleshell mussels.

***8.3.8 Sheepnose mussel – Candidate.*** The sheepnose mussel prefers medium to large rivers with gravel or mixed sand/gravel substrate. No records exist for the presence of this mussel in the Middle Mississippi River. Records for Jefferson County, Missouri exist due to the mussel's presence in the Meramec and other smaller Missouri rivers. The project is not expected to impact sheepnose mussels.

***8.3.9 Spectaclecase mussel – Candidate.*** The spectaclecase mussel prefers large rivers with swiftly flowing water and a stable bottom of large rocks or boulders. No records exist for the presence of this mussel in the Middle Mississippi River. Records for Jefferson County, Missouri exist due to the mussel's presence in the Meramec and other smaller Missouri rivers. The project is not expected to impact spectaclecase mussels.

**8.4 Wetland Resources.** No wetland resources would be impacted by the proposed project.

**8.5 Cumulative Impacts.** Cumulative impacts are defined 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. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (40 CFR Section 1508.7). The cumulative impacts analysis for past, present, and reasonably foreseeable future actions on the UMR-IWW System was presented in the Programmatic Environmental Impact Statement for the UMR-IWW System Navigation Feasibility Study (USACE 2004) and is hereby incorporated by reference. As such, cumulative effects are only briefly discussed here. Generally, the analysis identified that river regulation, sedimentation, and floodplain development have contributed to a gradual decline in ecosystem health and quality and continue to be primary stressors on the system. Environmental management and restoration efforts have not prevented system-wide habitat degradation in the past and increased efforts to improve aquatic habitats, vegetation succession, and forest health are required to sustain ecosystem values. The analysis identified that true sustainability can only be met through the integration of upland and mainstem resource objectives and management actions, with integrated planning being a prerequisite to optimizing national benefits through efficient and effective adaptive river management. Implementation of ecosystem restoration features will contribute to offsetting adverse cumulative impacts.

**8.6 Socioeconomic Resources and Human Use.** The tentatively selected plan is not anticipated to adversely affect any local socioeconomic resources, including public facilities or services, or nearby communities or businesses. Some short-term increases in employment could be realized during construction of the project. Some increases could also be realized in commercial and recreational fishing due to the project's anticipated benefits to fish populations.

**8.7 Historic Properties and Cultural Resources.** No potentially significant archaeological sites or historic shipwrecks are known to exist within the project boundaries. The proposed notching of existing dikes will occur within areas previously disturbed by construction of the original dike structures, thereby reducing the likelihood of encountering potentially significant remains within these contexts. Chevron placement in the river channel will occur within areas previously disturbed by channel dredging activities. No impacts to historic properties or cultural resources are anticipated. However, should any human remains or other culturally sensitive items be discovered during project construction activities, work will be halted immediately and consultation with appropriate officials will be initiated. Missouri and Illinois State Historic Preservation Offices were consulted during the planning process (see Appendix A).

**8.8 Probable Adverse Environmental Impacts Which Cannot Be Avoided.** Temporary impacts during construction such as noise, aesthetic impacts, and increased turbidity may be experienced. Also, an increase in the footprint of dikes in the area would be experienced due to the chevron dikes being constructed as part of the tentatively selected plan. These adverse environmental impacts are considered minor as compared to the gains in fish and wildlife habitat that are anticipated with the project.

**8.9 Compliance with Environmental Quality Statutes.** Table 18 summarizes the Project's compliance status with respect to applicable statutes.

Table 18. Compliance Status.

| **Federal Policy** | **Compliance Status** |
|---|---|
| Bald Eagle Protection Act, 42 USC 4151-4157 | Full |
| Clean Air Act, 42 USC 7401-7542 | Full |
| Clean Water Act, 33 USC 1251-1375 | Partial 1* |
| Comprehensive Environmental Response, Compensation, and Liability Act, 42 USC 9601-9675 | Full |
| Endangered Species Act, 16 USC 1531-1543 | Full |

| | |
|---|---|
| Farmland Protection Policy Act, 7 USC 4201-4208 | Full |
| Fish and Wildlife Coordination Act, 16 USC 661-666c | Full |
| Food Security Act of 1985, 7 USC varies | N/A |
| Land and Water Conservation Fund Act, 16 USC 460d-461 | Full |
| Migratory Bird Treaty Act of 1918, 16 USC 703-712 | Full |
| National Environmental Policy Act, 42 USC 4321-4347 | Partial 2* |
| National Historic Preservation Act, 16 USC 470 et seq. | Partial 3* |
| Noise Control Act, 42 USC 7591-7642 | Full |
| Resource Conservation and Recovery Act, 42 USC 6901-6987 | Full |
| Rivers and Harbors Act, 33 USC 401-413 | Partial 1* |
| Water Resources Development Acts of 1986 and 1990 | Full |
| Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (EO 12898) | Full |
| Floodplain Management (EO 11988 as amended by EO 12148) | Full |
| Prevention, Control, and Abatement of Air and Water Pollution at Federal Facilities (EO 11282 as amended by EO's 11288 and 11507) | Full |
| Protection and Enhancement of Environmental Quality (EO 11991) | Full |
| Protection and Enhancement of the Cultural Environment (EO 11593) | Full |
| Protection of Wetlands (EO 11990 as amended by EO 12608) | Full |
| Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186) | Full |

1* Required permits will be sought during document review
2* Full compliance after submission for public comment and signing of FONSI
3* Full compliance to be achieved with SHPO's concurrence with conclusions

**8.10 Short-Term Versus Long-Term Productivity.** Some construction activities may temporarily disrupt fish, wildlife, and human use of the immediate vicinity. However, the long-term health and productivity of the fish and wildlife resources of the area are anticipated to increase with the project. Short-term human use impacts would be offset by long-term fish and wildlife habitat gains and their associated benefits to human use.

**8.11 Irreversible Resource Commitments.** The purchase of materials and the commitment of labor, fuel, and machinery to construct the project are considered irretrievable. Other than the aforementioned, none of the proposed actions is considered irreversible.

**8.12 Relationship of the Proposed Project to Other Planning Efforts.** The proposed project is not in conflict with any other planning efforts currently covering the project area (See Section 1.4 for a detailed discussion of other planning efforts covering the project area.).

## 9. IMPLEMENTATION RESPONSIBILITIES

**9.1 Federal (U.S. Army Corps of Engineers).** U.S. Army Corps of Engineers, St. Louis District, is responsible for project management and coordination with the USFWS, MDOC, IDNR, and other affected agencies. The U.S. Army Corps of Engineers will submit the subject Project Implementation Report (PIR); administer program funds; finalize plans and specifications; complete all NEPA requirements; advertise and award a construction contract; and perform construction contract supervision and administration.

WRDA 2007, Title VIII, Section 8004(b)(3)(B) states that ecosystem restoration project features shall be 100 percent Federal cost if the project features are located below the ordinary high water line or in a connected backwater, modified the operation of structures for navigation, or are located on Federally-owned land. The Herculaneum Project tentatively selected plan features are all located within the Mississippi River below the ordinary high water line. As a result, the Federal share of the cost of carrying out the project shall be 100 percent. No project sponsor is required and operation and maintenance including monitoring, data collection, and adaptive management as outlined in the monitoring plan will be a U.S. Army Corps of Engineers responsibility. Major rehabilitation of the project required as a result of specific storm, flooding, or other events will be performed by the U.S. Army Corps of Engineers.

**9.2 Real Estate Requirements.** The project area lies within the main Mississippi River Channel within navigational servitude. Navigational servitude does apply for this project, as the proposed ecosystem restoration measures are related to navigation. No real estate acquisition is anticipated for the recommended project.

## 10. COORDINATION AND VIEWS

**10.1 Public Involvement.** A draft version of this PIR with integrated Environmental Assessment and draft FONSI will be distributed to federal, state, and regional agencies, elected officials, and the general public as part of the 30-day public review process. District responses to public and agency comments on the draft PIR will be included as part of the final PIR. Correspondences are located in Appendix A.

The District's 404(b)(1) Evaluation was signed on ___________. A Section 401 water quality certification was issued by the Missouri Department of Natural Resources on ____________, and authorization under Section 404 of the Clean Water Act was granted by the St. Louis District on __________. The project's Finding of No Significant Impact (FONSI) was signed on ___________ .

**10.2 Federal Agencies.** The U.S. Fish and Wildlife Service has been involved throughout the planning and design process for the Herculaneum Project. The Service has provided written support for the construction of the Herculaneum Project (Appendix A). The Service also prepared the Fish and Wildlife Coordination Act Report for the Herculaneum Project.

## 10.3 State Agencies

> ***10.3.1 State Resources Agencies.*** The Illinois Department of Natural Resources and the Missouri Department of Conservation have been involved throughout the planning and design process for the Herculaneum Project. These agencies have provided written support for the construction of the Herculaneum Project (Appendix A).

**10.4 Native American Tribes.** Coordination with affiliated Native American Tribes will be conducted during the public review process. Should any human remains or other culturally sensitive items be discovered during project construction activities, work will be halted immediately and consultation with appropriate officials will be initiated.

## 11. RECOMMENDATIONS

Existing fish and wildlife habitat in the Herculaneum Reach of the Middle Mississippi River lacks diversity and is devoid of side channel complex habitat. The stone dikes in the reach, constructed to maintain a safe and dependable navigation channel, have resulted in homogenous flow, scour, and sedimentation patterns. The structures limit the quality and quantity of aquatic fish and wildlife habitat in the area. The nearest side channel habitat is located 4.3 miles upstream (Atwood Chute) and 1.3 miles downstream (Calico Chute) from the Herculaneum Reach. More habitat diversity is needed in the stretch of river between these two existing side channels to benefit fish and wildlife species.

The PDTs recommendation is approval of the tentatively selected plan (Alternative 8 at a total cost of $6.0 mil) - placement of twelve chevron dikes, shortening two existing dikes, notching five existing dikes, and unrooting one existing dike – which would result in the restoration of 4.1 miles of side channel habitat and enhancement of 1,647 acres of fish and wildlife habitat on the Middle Mississippi River. The tentatively selected plan is designed to meet the project's objectives which are:

- Enhance channel geomorphic diversity
- Modify channels to provide suitable habitat for fishes
- Maintain the diversity and extent of native communities

Analysis of future-without-project and future-with-project conditions quantified the benefits of the tentatively selected plan to fisheries habitat. The tentatively selected plan would generate 291.2 Average Annual Habitat Units for the analyzed species over the 50-year period of analysis.

The project is consistent with and fully supports the overall goals and objectives of the Navigation and Ecosystem Sustainability Program.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They reflect neither the program and budgeting priorities inherent in the formulation of the national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before transmittal to Congress as proposals for authorization and implementation funding.

## 12. DRAFT FINDING OF NO SIGNIFICANT IMPACT (FONSI)

1. I have reviewed and evaluated the documents concerning the proposed Herculaneum Side Channel Restoration Project. The Herculaneum Reach of the Middle Mississippi River is located between river miles 156.5 and 149.5 in Jefferson County, Missouri and Monroe County, Illinois near the town of Herculaneum, Missouri. Existing stone dikes in the reach, constructed to maintain a safe and dependable navigation channel, have resulted in homogenous flow, scour, and sedimentation patterns, limiting the quality and quantity of desirable fish and wildlife habitat. The proposed project is designed to restore natural river processes by creating more diverse flow, scour, and sedimentation patterns thereby increasing the quality and quantity of desirable fish and wildlife habitat in the Herculaneum Reach without affecting navigation. The Project proposes to create three side channel complexes by notching, shortening, or unrooting existing stone dikes and by placement of new chevron dikes.

2. I have also evaluated other pertinent data and information on the dike alteration project. As part of this evaluation, I have considered the following project alternatives:

a. No Federal Action ("No Action" Alternative).

b. Conducting dike placement/alteration. All feasible combinations of side channel complex locations (7 alternatives) were analyzed for environmental benefits and cost. The proposed project provided the most environmental benefits and best met the four plan formulation criteria of acceptability, completeness, effectiveness, and efficiency.

3. The possible consequences of these alternatives have been studied for environmental, cultural, social, and economic effects, and engineering feasibility. Significant factors evaluated as part of my review include:

a. No federally endangered, threatened, or proposed species will be negatively impacted by the proposed project.

b. The aesthetic quality of the area will not be changed.

c. The proposed project will have no effect upon significant historic properties or archaeological resources.

d. No adverse socioeconomic impacts from the proposed project were identified.

4.  Based on my analysis and evaluation of the alternative courses of action presented in the Environmental Assessment, I have determined that the implementation of the tentatively selected plan will not have significant effects on the quality of the environment.  Therefore, an Environmental Impact Statement will not be prepared prior to proceeding with this action.

| | |
|---|---|
| ____________________ | __________________________ |
| Date | Thomas E. O'Hara, Jr.<br>Colonel, U.S. Army<br>District Engineer |

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