Mississippi Valley Division,
Regional Planning and Environment Division South

Mississippi River Hatchie/Loosahatchie, Mississippi River Mile 775-736, TN and AR

Final Integrated Feasibility Report and Environmental Assessment

February 2024

Executive Summary

This Final Integrated Feasibility Report (FIFR) and Final Environmental Assessment (FEA) for the Hatchie-Loosahatchie Mississippi River Ecosystem Restoration Study investigates the feasibility of alternatives to address problems and opportunities associated with ecosystem degradation within the Mississippi river miles 775-736. The effort is in response to the Water Resources Development Act (WRDA) of 2018 study authority to investigate habitat restoration for eight reaches identified as priorities in the 2015 “Lower Mississippi River Resource Assessment.” The Hatchie-Loosahatchie Ecosystem Restoration study investigated the first of the eight priority reaches identified. The study’s non-Federal sponsor (NFS) is the Lower Mississippi River Conservation Committee (LMRCC), a non-profit organization comprised of six states along the Lower Mississippi River (LMR). The LMRCC is dedicated to conserving the natural resources of the LMR and its floodplain.

The 39-mile stretch of the Mississippi River that is included in the study area begins at approximately river mile 775, at the confluence of the Hatchie River, to approximately river mile 736, at the confluence of the Wolf River near downtown Memphis, Tennessee. The study area intersects several counties in both Tennessee and Arkansas, including Lauderdale, Tipton, and Shelby counties in Tennessee, and Mississippi and Crittenden counties in Arkansas. The study area was delineated into 11 ecological geographic complexes based on the geomorphology and hydrology of the floodplain.

The Mississippi River levee system disconnected much of the former Mississippi River floodplain from the river, and flood risk reduction projects have altered river channels. These changes disrupted the ecosystem in several ways, contributing to habitat related problems and physical problems, along with other challenges such as invasive species as described in this FIFR-FEA. A critical need to restore the habitat and ecosystem exists with opportunities to restore floodplain connectivity, enhance, and restore aquatic channels and waterbodies, and enhance and restore natural vegetation. The study purpose is to evaluate the causes and effects of significant environmental degradation in the study area; to formulate and evaluate potential solutions to these identified problems; and upon consideration of the various alternatives formulated, to recommend a justified plan that is effective, efficient, complete, and acceptable for Federal investment.

The plan was formulated following a six-step process. Step 1 focused on identifying problems and opportunities within the study area. Step 2 focused on inventorying and forecasting study area conditions. Step 3 developed a range of potential actions to solve the problems identified in Step 1. Step 4 evaluated actions, measures, and alternative plans. Step 5 compared alternative plans. Step 6 tentatively selected a plan.

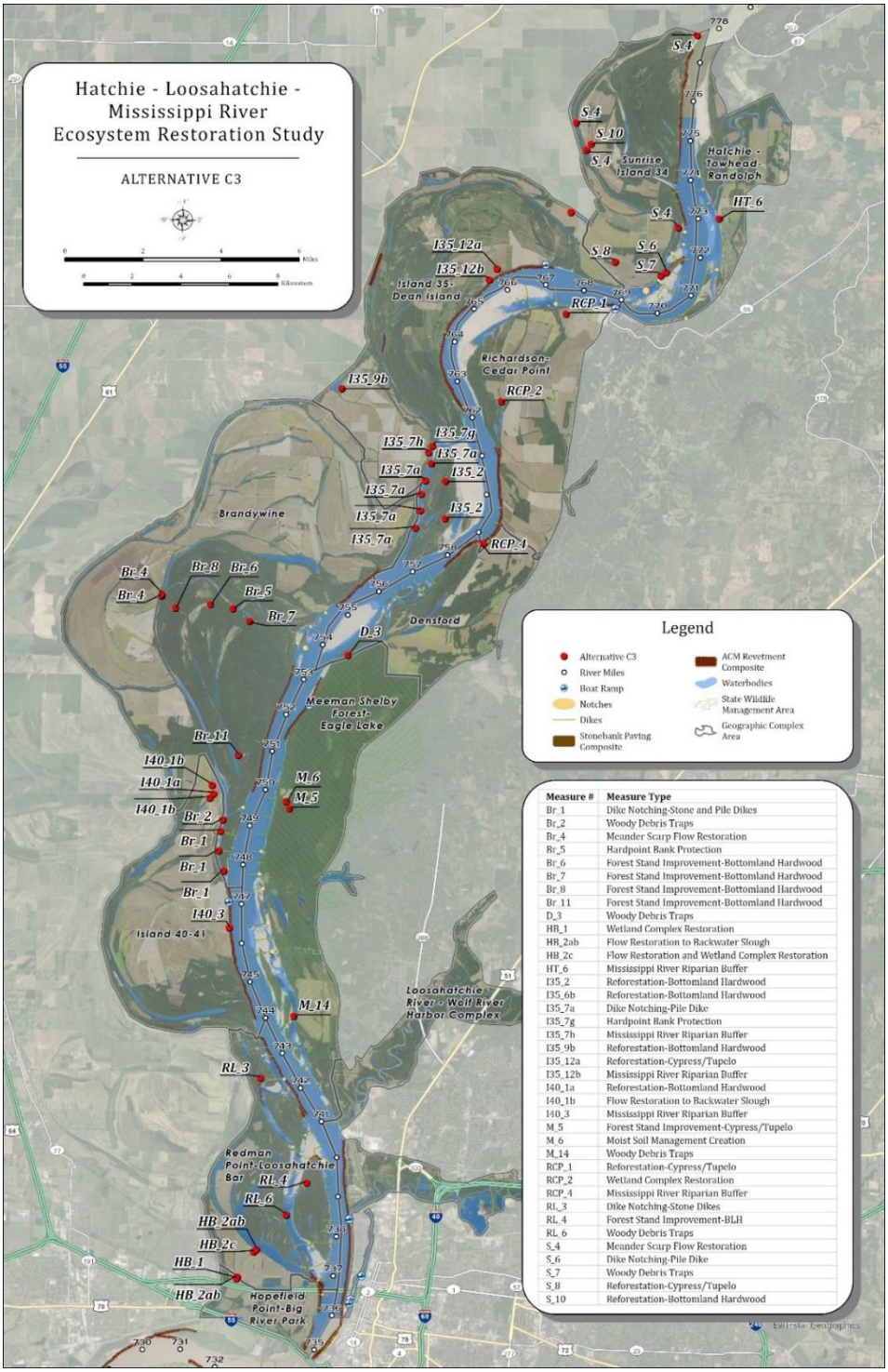
The study team identified a variety of measures that could be taken to achieve planning objectives, including earth work, dredging, and other geomorphic modifications, bank protection, bridge replacement, water level management structures, forest and wetland restoration strategies, structures to improve aquatic habitat, and measures to increase recreational opportunities. The measures were combined in various logical combinations and created using the Institute for Water Resources (IWR) Planning Suite Cost

Effectiveness Incremental Cost Analysis (CEICA) tool to form ten alternative project plans for consideration as the final array.

The National Environmental Policy Act (NEPA) analysis, CEICA, technical significance of the habitats, comprehensive benefits to national economic development (NED), regional economic development (RED), environmental quality (EQ) and other social effects (OSE) were considered in the decision-making process. Alternative C3 best met the study objectives and reasonably maximized benefits across the various categories of effects. Alternative C3 was identified as the national ecosystem restoration (NER) plan and is supported by the NFS. For those reasons, Alternative C3 was identified as the recommended plan (RP).

The RP is a comprehensive plan that collectively addresses significant and historically important habitats in Arkansas and Tennessee. Alternative C3 includes 38 restoration measures and two recreational measures that would improve connectivity, enhance the aquatic channel, restore, and enhance natural vegetation, improve water management, and recreational access. The RP would provide 4,673 average annual habitat units (AAHUs) to eight unique habitats, including bottomland hardwood (BLH), cypress-tupelo, meander scarp, moist soil, riverfront, seasonally herbaceous wetland, secondary channels, and slough, benefitting 6,282 acres. These habitats support federally listed endangered aquatic species, and critical vegetative habitats that host numerous species of conservation concern. This RP selection contributes to the protection of meander scarps (rare geological features that no longer occur naturally due to engineering controls along the Mississippi River). Additionally, this supports the restoration of other technically significant habitat, including cypress-tupelo swamps, moist soil, and seasonally herbaceous rivercane habitat. These habitat types provide valuable aquatic and vegetative habitats for a variety of species, such as the federally endangered pallid sturgeon, federally endangered fat pocketbook mussel, and rare species of conservation concern, such as the alligator gar, a native predator of invasive carp. Feedback on the FIFR-FEA was received through internal technical review and policy and legal review processes at USACE. Direct stakeholder engagement with environmental agencies occurred throughout the planning process. Public comments were collected during five public scoping meetings held between October 2021 and October 2022. Species of tribal importance were received through ongoing Tribal consultation.

The estimated cost for the RP is approximately $62 million with the Government’s share of such costs projected to be $40 million and the NFS’s share of such costs projected to be $22 million. This includes the cost of acquiring lands, construction costs, pre-construction engineering and design (PED), construction management, and contingencies. Real estate costs are projected to be $17.6 million. The estimated annualized operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) cost is $133,000. Monitoring and adaptive management costs are estimated at $5.3 million. Construction is currently estimated to begin in 2028 and continue for one calendar year. Commencement of construction is dependent on project authorization, appropriation, and availability of funding.



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Section 1
Introduction

The LMR is one of the largest floodplains in the world, comprised of approximately three million acres and interspersed with secondary channels, meander scarps, and large expanses of forested wetlands. Although the levee system has reduced the footprint of the historic floodplain, the remaining lands and waters between the levees (batture) is high in ecological value reflecting a complex mosaic of diverse aquatic and vegetative habitats. The preservation of natural aquatic habitats in conjunction with new, intentional river engineering activities contribute to the conservation of one of the most important and rare wilderness areas (Hartfield 2014) in the United States, providing habitat for approximately 136 freshwater fish species and several federally listed threatened or endangered species. Recurring aquatic connectivity among a diverse mosaic of floodplain waterbodies in the LMR sustains the necessary habitat complexity to preserve native and migratory species. Scarce and important aquatic habitat types to note include emergent sand/gravel bars, meander scarps, and oxbows. Often grouped with secondary channels, meander scars, scrolls, and scarps (hereinafter referred to as, scarps) in the LMR are rare geological remnants of the meandering Mississippi River channel. These channels no longer form due to river regulation; thus, hydrologic restoration of these remaining meander scarps is technically significant and critically important to sustain ecological functions and biological processes in the LMR. Oxbows are crescent or u-shaped waterbodies created after a meander in the river was abandoned for a shorter course. These habitat types provide valuable aquatic and vegetative habitats for a variety of species, such as the federally endangered pallid sturgeon and fat pocketbook mussel, as well as species of conservation concern such as alligator gar, a native predator of invasive carp, and American eel, a species of tribal importance. Within the LMR specifically and likely within the entire Mississippi River, there are only 14 meander scarps remaining.

Ecological restoration research and advocacy have been ongoing since the formation of the LMRCC in 1994. In 2000, the LMRCC published the Aquatic Resources Management Plan, in partnership with USACE. This information was compiled with state-level project identification to create the Restoring America's Greatest River Plan in 2004, revised in 2015, which serves as the LMRCC's habitat restoration guide. Section 402 of the WRDA of 2000 authorized the assessment of information needed for river related management, natural resource habitat needs, and river related recreation and access in the LMR, along the main channel and adjacent floodplains. The Lower Mississippi River Resource Assessment (LMRRA) included recommendations for: (1) the collection, availability, and use of data needed for river management; (2) the implementation of measures to restore, protect, and enhance habitat; and (3) potential projects for river recreation and access. LMRRA recommended eight priority conservation reach habitat restoration studies on the LMR to examine the Mississippi River batture for ecosystem restoration features. More information regarding the LMRRA is included in Section 1.5.

Section 1202(a) of WRDA 2018, Public Law 115-270 authorized the study to determine feasibility of habitat restoration for each of the eight identified priority reaches reported in the LMRRA. These reaches were identified as priorities because they may provide valuable habitat for rare species; they each contain a channel crossing; the batture is wide in the reaches; and there is a concentration of previously identified potential projects. One of the eight priority reaches comprises Hatchie/Loosahatchie Mississippi River Mile 775-736 for which this FIFR and FEA has been prepared. This study is the first large-scale ecosystem restoration feasibility study to be completed for the eight identified priority reaches. Study emphasis was placed on restoring ecological structure and function to the mosaic of habitats along the LMR and its floodplain, which is comprised of secondary channels, floodplain aquatic habitats, floodplain forests, and several scarce vegetative communities such as wetlands, rivercane, riverfront forests, and BLH forests. This study not only identifies solutions for USACE participation within the respective priority reach, but will further advance interconnection for ecosystem restoration initiatives through participation and collaboration with other conservation-focused organizations both within this reach and the remaining priority reaches. USACE CEMVM, prepared this FIFR-FEA for Hatchie/Loosahatchie Mississippi River Mile 775-736.

1.1 NON-FEDERAL SPONSOR

The study's NFS is the LMRCC. The LMRCC formed in 1994 and is a nonprofit coalition of the six states along the LMR: Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee. Each state has a representative from its natural resource conservation (e.g., game and fish) agency and its EQ agency that comprises a 12-member governing Executive Committee. There are also Federal partners and non-profit partners: the USACE, the Natural Resources Conservation Service (NRCS), the EPA, the USFWS, and the U.S. Geological Survey (USGS), the Nature Conservancy (TNC), and the Mississippi River Trust (MRT). The USFWS provides a coordinator and additional staff to assist the LMRCC in attaining its mission: "Promote the protection, restoration, enhancement, understanding, awareness and wise use of the natural resources of the LMR, through coordinated and cooperative efforts involving research, planning, management, information sharing, public education and advocacy." The LMRCC provides the only regional forum dedicated to conserving the natural resources of the LMR and its floodplain.

The study includes input from both the NFS, as well as input from other relevant regulatory agencies, natural resource agencies, and the public.

1.2 USACE PLANNING PROCESS

USACE incorporates SMART (specific, measurable, attainable, risk-informed, and timely) elements into feasibility studies to ensure an efficient feasibility study and to install accountability across all functional working groups.

Throughout the feasibility study, the study team followed USACE's six step planning process in accordance with USACE Engineering Regulation (ER) 1105-2-100. This process is a structured, systematic, and repeatable planning approach for quantitatively and qualitatively assessing water resource-related problems and opportunities and resulting in recommendations to address those problems and opportunities. The planning steps occur

iteratively and occasionally concurrently. Iterations of steps are necessary to formulate and evaluate an efficient, effective, and reasonable array of alternative plans. As more information is acquired and is revealed, it may be necessary to reiterate previous steps. The plan formulation for this study is further described in Section 2.0.

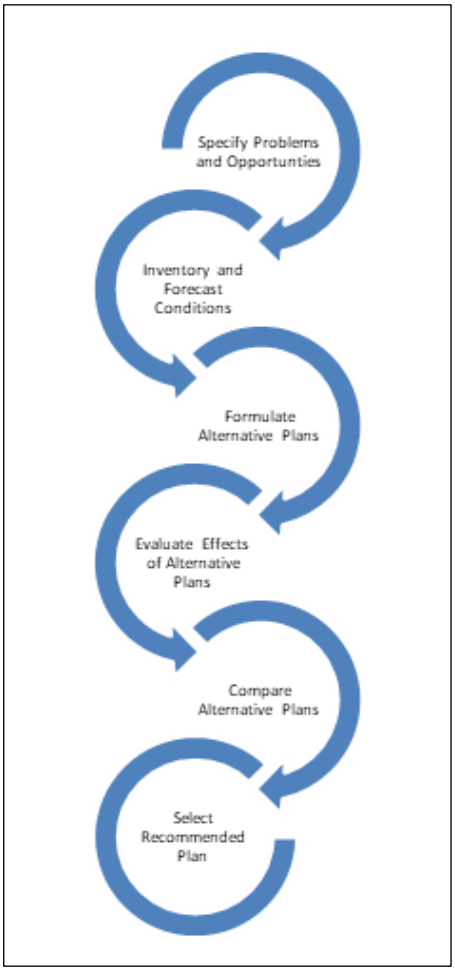


Figure 1-1. USACE Planning Process

1.3 STUDY AUTHORITY

Section 1202(a) of WRDA of 2018, Public Law 115-270 authorized the study to determine feasibility of habitat restoration for the eight identified priority reaches recommended in the LMRRA. One of the eight priority reaches comprises Hatchie/Loosahatchie Mississippi River Mile 775-736 for which this FIFR-FEA has been prepared. This study is the first large-scale ecosystem restoration feasibility study to be completed for the eight identified priority reaches. This study not only identifies solutions for USACE participation within the respective priority reach but will further advance interconnection for ecosystem restoration initiatives through participation and collaboration with other conservation-focused

organizations both within this reach and the remaining priority reaches. WRDA 2018 language is as follows:

Water Resources Development Act (WRDA) of 2018, Public Law 115-270, Section 1202

ADDITIONAL STUDIES. (a) LOWER MISSISSIPPI RIVER; MISSOURI, KENTUCKY, TENNESSEE, ARKANSAS, MISSISSIPPI, AND LOUISIANA.— (1) IN GENERAL.—The Secretary is authorized to carry out studies to determine the feasibility of habitat restoration for each of the eight reaches identified as priorities in the report prepared by the Secretary pursuant to section 402 of the Water Resources Development Act of 2000, titled "Lower Mississippi River Resource Assessment; Final Assessment In Response to Section 402 of WRDA 2000" and dated July 2015. (2) CONSULTATION. —The Secretary shall consult with the Lower Mississippi River Conservation Committee during each feasibility study carried out under paragraph (1).

1.4 STUDY AREA

The study area comprises a 39-mile reach, approximately 146,000 acres, of the Mississippi River and the surrounding batture, the riverside area between the levee and main channel within the Arkansas boundary and the riverside area between the natural ridge and main channel within the Tennessee boundary. The study area begins at the mouth of the Hatchie River at approximately river mile 775 and extends south to the mouth of the Wolf River Harbor (at approximately river mile 736). The study area intersects several counties in both Tennessee and Arkansas. In Tennessee, the study area encompasses parts of Lauderdale, Tipton, and Shelby Counties. In Arkansas, the study area encompasses parts of Mississippi and Crittenden Counties. The study area contains crossings, pools, side channels, old bendways, and wide overbank areas between the west levee and east bluff (varying 2-9 miles in width). As mentioned above, there are three tributary mouths located within the study area: Hatchie, Loosahatchie, and Wolf Rivers. State parks and refuges that border the study area include Meeman Shelby State Park, Fort Pillow State Park, and the Lower Hatchie National Wildlife Refuge (NWR). See Figure 1-2 for a descriptive overview of the study area.

The study area was further delineated into 11 separate ecological geographic complexes based on the geomorphic and/or hydrologic evolution of the floodplain using historical maps and existing elevation data. Land ownership and/or management considerations were also factored into the delineation of the complexes (e.g., Meeman Shelby Forest State Park – Eagle Lake State Wildlife Management Area (WMA)). The names of the ecological geographic complexes listed from north to south include (1) Sunrise Island 34 (S), (2) Hatchie Towhead Randolph (HT), (3) Island 35 – Deans Island (I35), (4) Richardson Cedar Point (RCP), (5) Densford (D), (6) Brandywine (Br), (7) Meeman Shelby Forest-Eagle Lake (M), (8) Island 40/41 (I40), (9) Loosahatchie River – Wolf River (LW), (10) Redman Point – Loosahatchie Bar (RL), and (11) Hopefield Point – Big River Park (HB). See Figure 1-3 for the ecological complexes.

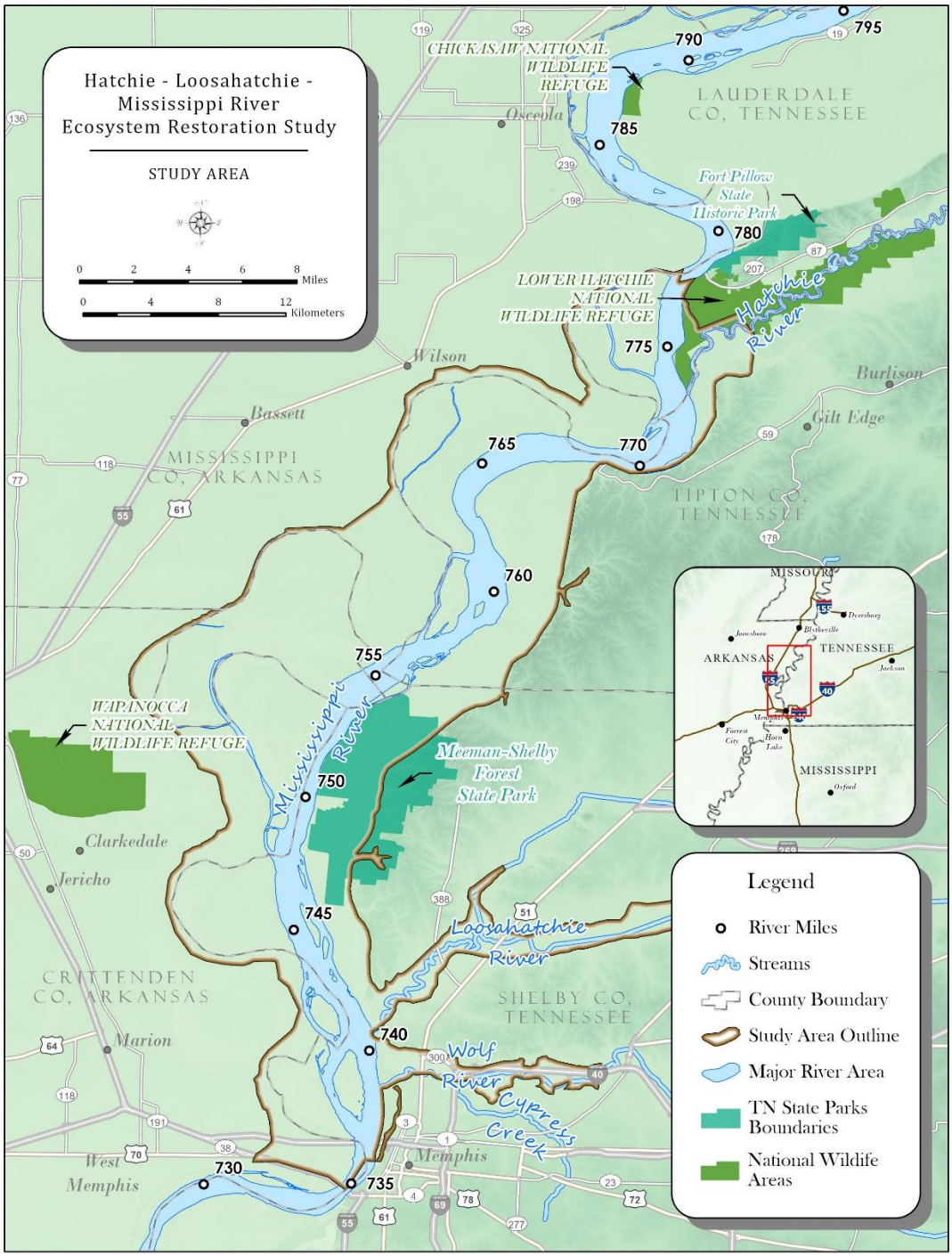


Figure 1-2. Hatchie/Loosahatchie Mississippi River Mile 775-736, TN And AR Feasibility Study Area

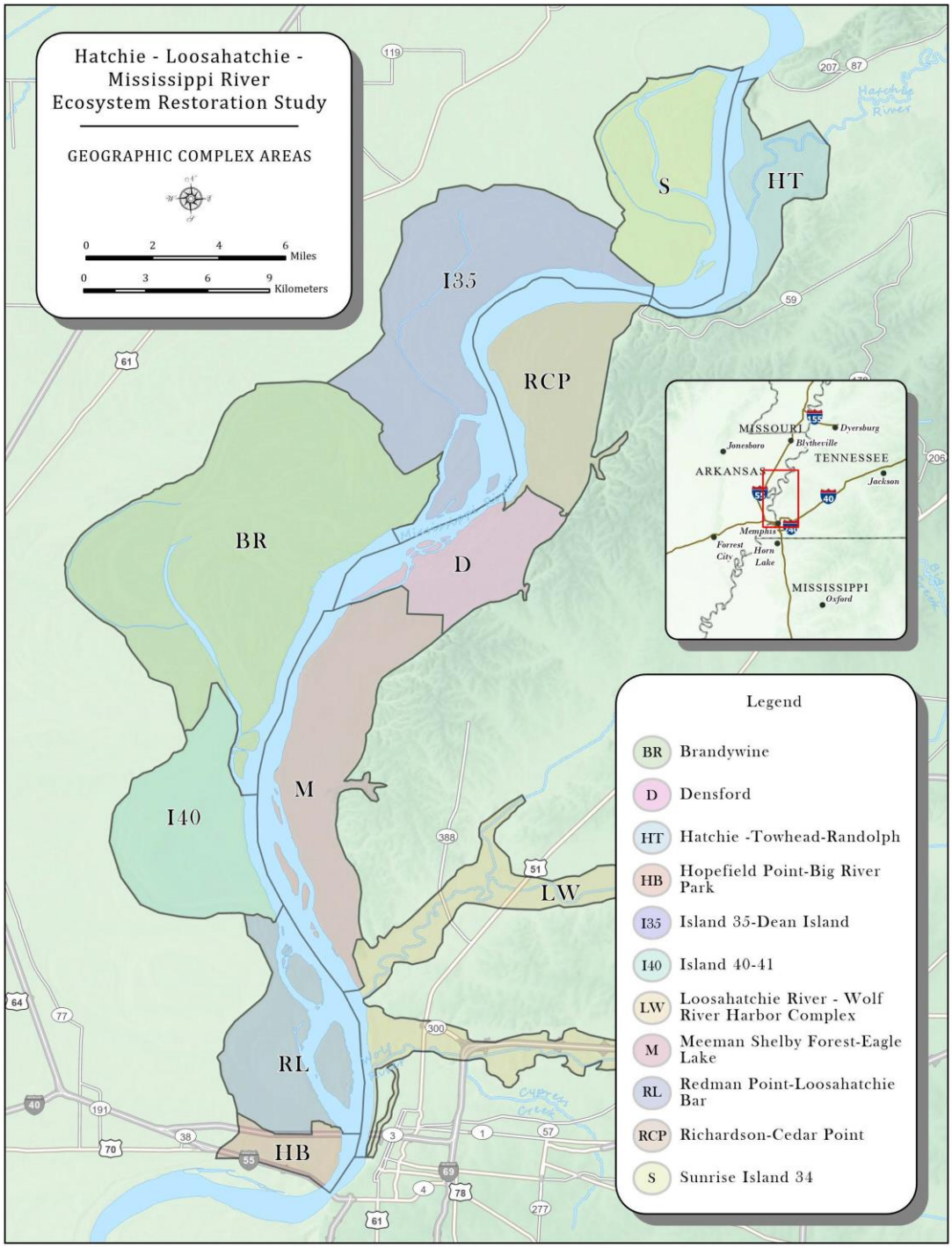


Figure 1-3. Study Area and Delineation of the Separate Ecological Complexes within the Study Area

1.5 BACKGROUND AND HISTORY

The Mississippi River levee system disconnected much of the floodplain from the main channel. Modifications to the natural flow regime for flood control in the LMR began in the early 1700s. Individual landowners would build levees to protect their property, which only transferred the flooding to their neighbors. The individual landowner levees were poorly constructed and often failed.

In the early 1800s, the Federal government began managing the flows in the LMR for navigational purposes. The General Survey Act of 1824 provided the establishment of the Rivers and Harbors Act to authorize work in the LMR and portions of the Ohio River. In response to disastrous flooding in the mid-1800s, the Federal government passed the Swamp and Overland Act of 1849-1850, authorizing the transfer of federally owned, unproductive swamp land to states. States would then drain the lands and convert them for agricultural purposes. The states would then sell the lands and use the proceeds for the construction of levees for flood control purposes. This also proved to be ineffective mainly because of levee design and coordination between levee boards (Rogers; Anfinson, 2003).

In 1928, the Flood Control Act was passed, authorizing USACE to construct projects within the LMR for the purposes of flood control from its tributaries to Cape Girardeau, Missouri and to the Head of Passes in Louisiana. As part of the Flood Control Act of 1928, as amended, the Mississippi River and Tributaries (MR&T) project authorized flood risk management and a navigation channel with the following four main features: levees and floodwalls; channel improvement & stabilization; tributary basin improvements; and floodways. Channel improvement and stabilization features serve to protect flood control features and to ensure the desired alignment of the main channel. Features such as cutoffs historically have been constructed to shorten the river and reduce flood heights; revetments have been constructed to stop the river's meandering; dikes have been constructed to direct the flow and deepen the main channel; and improvements such as dredging activities have been completed to realign the main channel.

An unintended effect from the MR&T program is the reduction of hydrologic connection between the main channel and the surrounding floodplain. Lateral connections to backwater areas were reduced between 80-90 percent, contributing to the loss of wetlands and causing impacts to the aquatic, semi-aquatic, terrestrial, and avian species. Figure 1-4 provides an overview of historical meandering channels from the main stem of the Mississippi River.

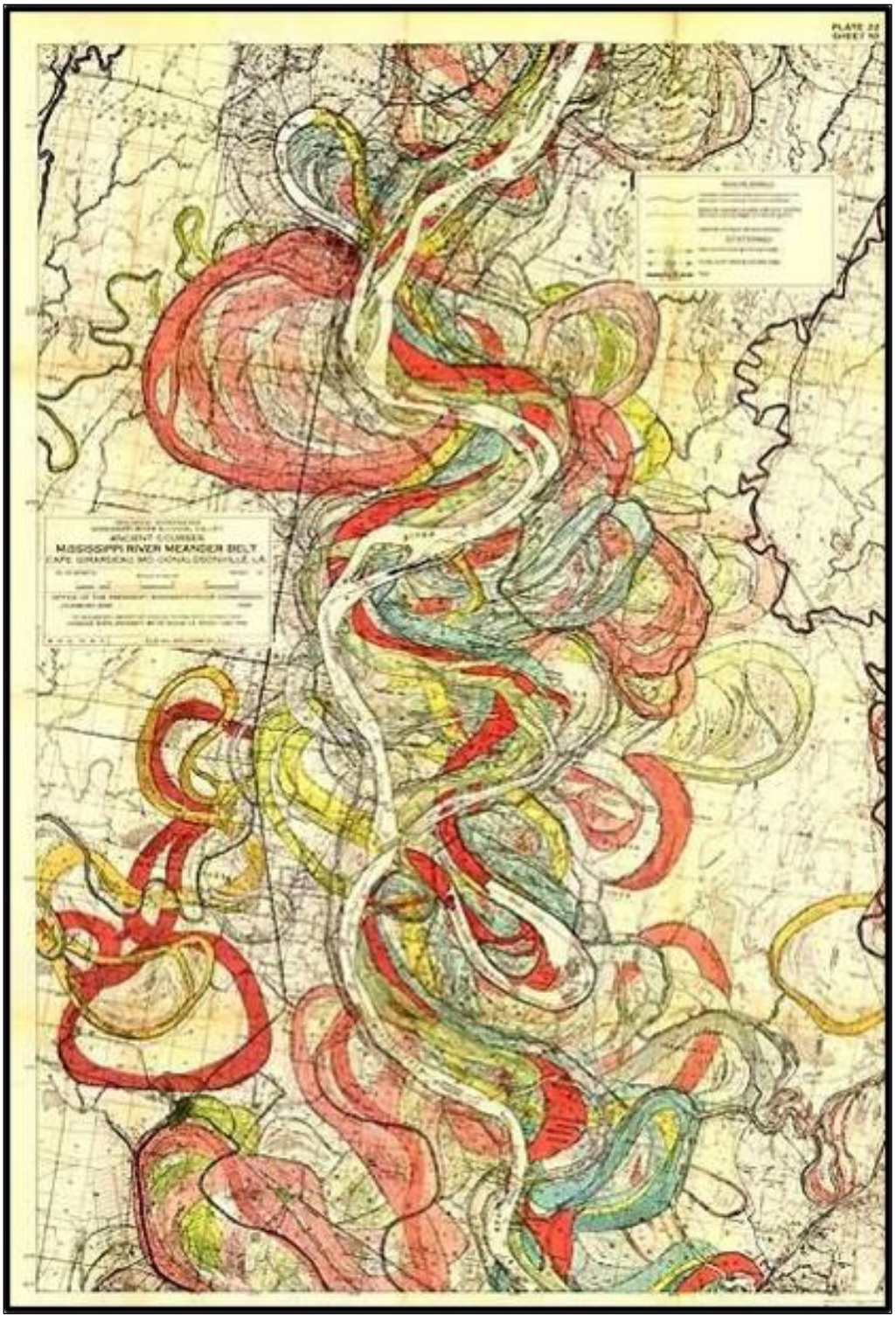


Figure 1-4. Historical Meandering Channels of the Mississippi River

Section 402 of the WRDA of 2000 authorized the assessment for management, information, habitat, and recreational access in the LMR, along the main channel and adjacent floodplains. Historically, the navigation and flood risk management systems received most of the recognition in studies on the LMR. LMRCC published the Restoring America's Greatest River Plan, in partnership with USACE, with a goal to maintain or improve aquatic habitat quantity, quality, and diversity in the LMR ecosystem. Congress requested for the LMRRA to be presented for review.

The LMRRA was presented in 2015 and included a proposal to fulfill the objectives identified in Section 402 of WRDA 2000. The LMRRA recommended for the creation of three programs to address needs in the LMR: (1) A Data Information, Science, and Communication Program; (2) A Habitat Restoration and Management Program (HRMP); and (3) A Recreation Program. Each of these program areas incorporate multiple studies and projects with public and private investments in the study areas. Recommendations made by LMRRA were compatible with navigation and flood risk management objectives. The HRMP is a collaboration between USACE, the USFWS, and the LMRCC along with cooperating agencies, partners across the states of Kentucky, Missouri, Tennessee, Arkansas, Mississippi, and Louisiana. The HRMP is designed to benefit a variety of habitats and species that rely on them, recreational users, local economies, and other LMR resources. The HRMP included eight priority conservation reach habitat restoration studies on the LMR to examine the Mississippi River and associated batture for ecosystem restoration features. Study emphasis includes project planning, engineering and design within the main channel, secondary channels, floodplain lakes, and other backwater areas within the LMR batture building from the work defined in LMRCC's Restoring America's Greatest River Plan and the LMRRA.

Section 1202(a) of WRDA 2018, Public Law 115-270 authorized the study to determine feasibility of habitat restoration for the eight identified priority reaches reported in the LMRRA HRMP. This study is the first large-scale ecosystem restoration feasibility study to be completed for the eight identified priority reaches.

See Table 1-1 for a list reports project and programs that were considered and incorporated into the FIFR-FEA.

Table 1-1. List of Prior Reports, Existing and Ongoing Programs

Year	Study/Report/Environmental Document Title	Document Type
2000	LMRCC Aquatic Resources Management Plan	Regional Management Plan
2014	ESA - LMR Conservation Plan, North	Conservation Plan
2015	LMRRA; Final Assessment in Response to Section 402 of WRDA 2000	Watershed Study
2015	LMRCC Restoring America's Greatest River: A Habitat Restoration Plan for the Lower Mississippi River	Restoration Plan
2015	State Wildlife Action Plans	Action Plan
2018	North American Waterfowl Management Plan	Action Plan
2019	LMR Basin Asian Carp Control Strategy Framework	Invasive Species Plan
2022	Exceptional Tennessee Waters and Outstanding National Resource Waters	Data Resource

1.6 PURPOSE AND NEED

The purpose and need for the proposed action are to restore habitat and ecosystem function along an approximate 39-mile reach of the LMR and its floodplain without conflicting with the existing USACE mission areas of ensuring navigation and flood risk reduction.

The study area within the LMR supports approximately 136 freshwater fish species, 325 migratory bird species, and approximately 50 mammal species, including eight federally

threatened or endangered species, one proposed endangered species, one proposed threatened species, and one candidate species. Because of this diversity, hunting, fishing, and wildlife watching are popular recreational activities in this region.

Implementation of various ecosystem restoration measures are necessary to maintain the complexity and diversity of rare habitats that occur within this reach, such as river cane brakes, meander scarps, and alligator gar spawning grounds. Without intervention the ecosystem services of clean air and water, flood control, pollination, and recreation provided by these habitats will only continue to diminish through time.

1.6.1 Resource Significance

Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Water Resources Council 1983) and USACE Planning Guidance Notebook ER 1105-2-100 determines the criteria for the significance of resources (USACE 2000). Resource significance is used to determine problems, opportunities, objectives, constraints, and Federal interest. Ultimately, it reflects an effort to measure the value to ecological functions of a specific project and study area to the Nation.

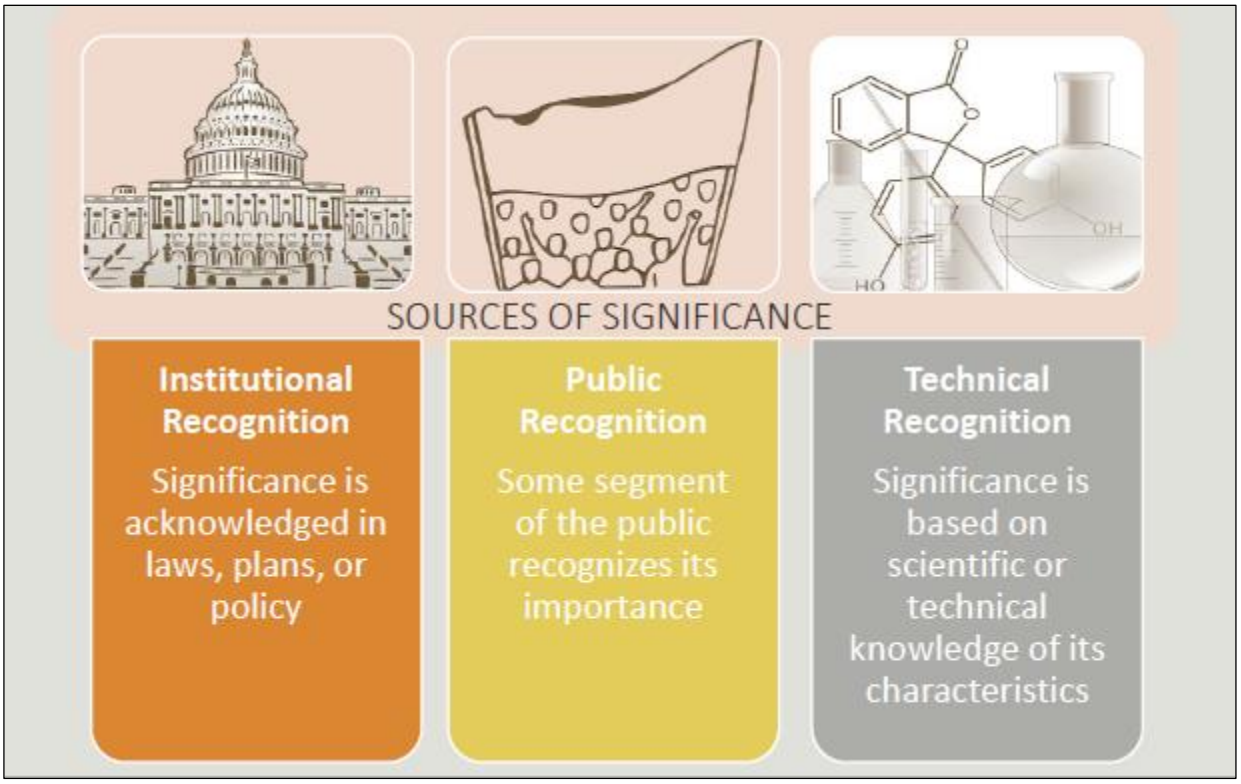


Figure 1-5. Sources of Significance

Protecting and restoring significant resources is in the national interest because of the scarcity of these resources (Figure 1-5). For ecosystem restoration projects, monetary and non-monetary values also quantify and qualify the resource significance. The resource's contribution to the Nation's economy determines monetary value (e.g., a lake with waterfowl encourages bird-watching tour businesses) whereas technical, institutional, or public recognition of the ecological, cultural, and aesthetic attributes determines non-monetary value (e.g., a lake serves as a historic site with cultural significance). ER 1105-2-100 Appendix E Civil Works Mission and Evaluation Procedures illustrates these three forms of significance determining non-monetary value. Documentation of the significance of outputs plays an important role in an ecosystem restoration evaluation by providing criteria for evaluating and justifying ecosystem restoration projects. Documentation of significance assists decision makers in determining Federal interest, and prioritizing ecosystem restoration efforts nationally. Guidance from the IWR's resource document, "Significance in Environmental Project Planning" is as follows:

> Significance of resources and effects will be derived from institutional, public, or technical recognition. Institutional recognition of a resource or effect means its importance is recognized and acknowledged in the laws, plans and policies of government and private groups. Technical recognition of a resource or an effect is based upon scientific or other technical criteria that establishes its significance. Public recognition means some segment of the general public considers the resource or

effect to be important. Public recognition may be manifested in controversy, support or opposition expressed in any number of formal or informal ways. The scientific community and natural resources management agencies recognize the technical significance of resources (IWR Report 94-R-7).

The LMR floodplain is a dynamic freshwater ecosystem that changes with the LMR's annual hydrologic regime with interactions among the terrestrial and aquatic systems, main channel and side channel areas, mudflats, backwaters, tributaries, islands, and large expanses of forested wetlands. These areas provide a diverse array of aquatic habitat types and are connected to the river at high water. The LMR supports approximately 136 freshwater fish species and several federally listed threatened or endangered species. (LMRRA, July 2015). Building from the work defined in LMRCC's Restoring America's Greatest River Initiative and the LMRRA, numerous opportunities exist for enhancing aquatic and terrestrial habitats with the LMR and its associated batture.

Federal interest for the study area is also demonstrated by the following factors:

- Institutional Recognition: The following laws, adopted plans, or other policy statements of public agencies, tribes or private groups acknowledge the importance of an environmental resources in the study area.
    - LMRCC Restoring America's Greatest River Initiative, ESA - LMR Conservation Plan, North American Waterfowl Management Plan, State Wildlife Action Plans, Traditional Indigenous Ecological Knowledge, Exceptional/Outstanding Resource Waters, LMR Basin Asian Carp Control Strategy Framework, etc.
- Public Recognition:
    - Ducks Unlimited, TNC, Audubon, Rivergator, LMR Foundation, Living Lands and Waters, Rivercane Restoration Workshop-USACE Tribal Nations Technical Center of Expertise, etc.
- Technical Recognition: The importance of environmental resources listed below are based on scientific or technical knowledge of the critical resource characteristics. The environmental resources are significant based on technical recognition when those resources are either scarce; are representative of their respective ecosystems; will improve connectivity or reduce fragmentation of habitat; represent limiting habitat for important species; will improve or increase biodiversity; or trends indicate that the health of the resource is imperiled and declining but can be recovered through human intervention.
    - Scarcity (relative abundance)
        - Less meandering due to Channel Improvement Program (CIP)-reduced connectivity, reduction in secondary channels and large woody debris, localized erosion to sensitive areas; meander scarps are no longer created

- Scarce vegetative communities- 80 percent reduction of forested floodplain in Mississippi Alluvial Valley (MAV), lack of hard mast species in existing forest, lack of cypress-tupelo, seasonal herbaceous wetlands, and rivercane (98 percent reduction)
- Missing large river riparian buffer habitat with associated erosion
- Floodplain waterbodies – reduced connectivity, reduced habitat complexity

- Representativeness (ability to exemplify the natural habitat or ecosystem)
  - Study area is defined by MR&T levee/CIP (two of the main ecological drivers)
  - Aquatic and floodplain habitats are remnants of historic uncontrolled Mississippi River
  - Habitat impairments representative of entire LMR
  - Secondary channel and meander scarp conditions are critical to endangered species, other species of conservation concern, and species of tribal importance. From 2013 USFWS Programmatic Biological Opinion for the CIP in the LMR..."there is a direct and strong link between LMR secondary channels and the recruitment and survival of interior least tern, pallid sturgeon, and Fat Pocketbook Mussel. A decline in the availability of these habitats to the species as a result of CIP modification of functional secondary channels would detrimentally affect their survival and recruitment and would result in take of the species.... Therefore, the Service will utilize secondary channel abundance and condition in the LMR as a surrogate for take of all three species."
- Status and Trends (declining trends, imperiled status)
  - Stressors to all LMR Habitats will persist
  - Meander scarps subjected to flow will continue to be lost and not replaced due to maintenance of navigation channel
  - Floodplain waterbodies continue to fill in with a reduction in habitat complexity
  - Rivercane has shown 98 percent reduction
  - Fewer secondary channels as documented in LMR Conservation Plan, Species of Conservation Concern
- Connectivity
  - Flood risk management and navigation projects have removed approximately 152 miles of bends and diverted flow from secondary channels
  - Reduced secondary channel connectivity
  - Reduced meander scarp connectivity
  - Reduced connectivity to floodplain waterbodies
  - Forest fragmentation in the MAV
- Limiting Habitat

- The study area defines the remaining Mississippi River floodplain habitats, lack of aquatic spawning habitat, few gravel bars, lack of oak species, etc.
- Refugia for large river aquatic species limited due to navigation channel
- Meander cutoffs no longer occur due to maintenance of navigation channel (flowing meander scarps may be lost forever)
- Lack of mast producers in BLH floodplain community due to past forestry practices
- Few floodplain waterbodies with sufficient permanent depth (most are < 3 feet)
- Limited forest habitat in MAV due to agricultural conversion (80 percent reduction)

- Biodiversity (e.g., species richness and evenness)
  - Lack of aquatic and terrestrial diversity often correlates with decreased connectivity
  - Aquatic species endemic to the area are threatened by systemic degradation of highly altered waterbodies in the MAV
  - Invasive species threaten aquatic fish communities and vegetative communities
  - BLH loss within the Mississippi flyway

See Figure A9-2 in Appendix 9, Monitoring and Adaptive Management, which displays the conceptual ecological model (CEM) for the LMRRA. The CEM identifies the major stressors and drivers affecting ecosystem restoration identified as part of the LMRRA.

1.6.1.1 Importance of Meander Scarps

Meander scarps in the LMR are geographic features that are remnants of an old meandering river channel mostly created during the cutoff program during 1930s-40s (Figure 1-6). In the LMR, there are few meander scarps that receive unidirectional flow throughout most of the year. Meander scarps are a rare habitat that are no longer formed because of the navigation and maintenance programs on the Mississippi River. There are only 14 remaining flowing meander scarps left in the entire LMR and only three within the study area. See Figure 1-7 for an example of a meander scarp within the study area.

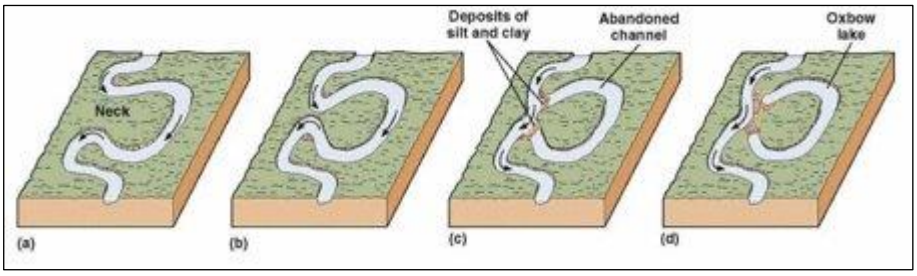


Figure 1-6. Development of a Meander Scarp (Geocache 2023)

The technical significance of meander scarps receiving unidirectional flow is understated because meander scarps are typically grouped together with other secondary channels (USACE 2015, Guntren et al. 2016); however, there are unique differences. LMR secondary channels (which typically include the remaining flowing meander scarps) are typically defined as a channel bordering either vegetated or non-vegetated islands and maintaining hydrological connectivity with the main channel at elevations between +5 and +10 LWRP (Low Water Reference Plane-where zero is defined as the river surface elevation that is exceeded 98 percent of the time) (Cobb and Clark 1981; USFWS 2013; Killgore et al. 2014; Guntren et al. 2016). Unlike typical secondary channels, scarps meander through wide swaths of the floodplain. Secondary channels are shorter, wider, less sinuous and flow generally parallel to the main channel. The meandering feature of scarps tend to connect extensive networks of floodplain waterbodies and wetlands including sloughs, oxbow lakes, and borrow areas along the levee.

Figure 1-7. Meander Scarps in Sunrise Island 34

Secondary channels (including flowing meander scarps) are critically important habitats in the LMR supporting the federally endangered fat pocketbook mussel and pallid sturgeon. The USFWS has recognized the "...direct and strong link between LMR secondary channels and recruitment and survival of interior least tern, pallid sturgeon, and Fat Pocketbook Mussel" and uses the abundance and conditions of secondary channels in ESA consultations, emphasizing the ecological importance of these riverine habitats (USFWS 2013). While some secondary channels can be created by artificial means like dike notching, meander cutoffs no longer occur on the LMR due to river regulation (Guntren et al. 2016). The LMR now responds to channel forming flows by attempting to build mid-channel bars (Smith and Winkley 1996) potentially affecting species that use the LMR (Guntren et al. 2016). Flowing meander scarps are important for many reasons: their primarily flowing channel habitat with natural forested banks are used by aquatic invertebrates; they are never dredged since they are outside the navigation channel, thus providing stable habitat for mussels; many meander scarps may provide refugia for native fishes impacted by the growing populations of invasive carp; and all are minimally impacted by barge traffic, thereby

reducing impacts to aquatic species caused by entrainment, wave wash caused by barge traffic, turbidity and other water quality impacts due to prop mixing. These flowing aquatic habitats, with the abundant and diverse aquatic invertebrates and other forage species they support, provide quality habitat for the catadromous American eel, a species of tribal importance and Federal trust species of importance to the USFWS (see Final Fish and Wildlife Coordination Act Report in Appendix 8 – Public Involvement and Coordination).

Meander scarps differ in their geomorphology and bathymetric diversity compared to typical secondary channels. Scarps are relatively scarce in the LMR with an initial estimate of 14 chutes compared to over 100 typical secondary channels. Scarps meander through wide swaths of the floodplain, whereas typical secondary channels are usually confined to island bordering the main channel. The meandering feature of scarps tend to connect other waterbodies, including sloughs, oxbow lakes, and borrow areas along the levee. Scarps are usually entrenched at low water, whereas point bars and eroding outside banks create habitat diversity and different functional process zones for riverine species.

Because meander scarps are no longer formed through natural riverine dynamics, the only option to preserve their benefits is to protect and restore those remaining. Restoring flow and maintaining connectivity to these habitats would become more difficult and costly to implement the longer they remain disconnected. (See Figure 1-8). There is a great risk of species endangerment if these habitats disappear.

Flowing meander scarps that maintain hydrologic connectivity with the main channel provide ideal habitat for the fat pocketbook mussel (a federally endangered species) due to the unaltered natural banks, stable sand/silt/clay substrates, refugia from high flows and other navigation impacts (e.g., wave wash, etc.) and because scarps are high quality environments for the mussel's fish host (freshwater drum). Thus, meander scarps should provide ideal habitat for sources of recruitment in the LMR, and an important habitat for resiliency and recovery of the species. Although fat pocketbook mussels can migrate horizontally and vertically in river channels to avoid becoming desiccated during low water and periods of drought, there are limitations to this length of time. With expected increases in intensity of drought in the LMR because of climate change, these ecosystem restoration measures of increasing connectivity are of great importance to fat pocketbook mussels and other freshwater mussel species, as well as aquatic macroinvertebrates.

In addition to freshwater mussel species and aquatic macroinvertebrates, pallid sturgeon also access meander scarps and secondary channels as young-of-year (less than one year of age) based on trawling data, using these areas for refugia from the navigation channel and for foraging.

Figure 1-8. Example Blockage of Flow in Meander Scarps

Hydrologic restoration of meander scarps is essential to organic carbon processing, cycling and food chain support. Re-coupling environmental flows (eflows) between the main stem of the Mississippi River and forested floodplains within the batture increases the capacity to retain and transform inorganic materials needed for biological processes into organic forms and to oxidize these organic molecules back into elemental forms through decomposition. Consequently, hydrologic restoration of scarps is paramount in maintenance of biologic functions, structure and processes through all trophic levels and food chain support: nutrient cycling, decomposers (e.g., fungi, bacteria, protozoa, aquatic insects), producers (plants), and consumers (animals). Restoration of eflows in scarps and side channels:

- Increases delayed flow, thus augments flow, and maintains baseflow.
- Improves hydroperiod, thus contact time between soil minerals, carbon chain functional groups and nutrients, heavy metals, and synthetic organics.
- Enhances nutrient cycling, oxygen dynamics, and carbon export (particulate and dissolved).
- Promotes native species competition to combat invasive species.
- Enhances ecotones (i.e., areas where biological communities meet and integrate along an environmental gradient like between land and water).
- Improves bedforms and bed material composition, thus aquatic habitat diversity.
- Fortifies and bolsters habitat for fish, invertebrates and amphibians for feeding, breeding and refugia.

1.6.1.2 Importance of Alligator Gar Habitat

The alligator gar (*Atractosteus spatula)* is a large, long-lived, opportunistic predatory fish usually dependent on inundated floodplains or wetland vegetation for spawning and nursery habitats when springtime water temperatures become warm. Historically, alligator gar were distributed throughout the central USA, but with recent declines in abundance, the species is now considered vulnerable to localized extirpation. Alligator gar has therefore been identified by the American Fisheries Society, the USFWS, and many state agencies as a species of concern in the lower MAV. Habitat alteration and overexploitation appear to be the most important factors in the widespread decline in abundance.

Alligator gar have few natural predators due to their large size and long life. An adult alligator gar can grow up to eight feet long and weigh more than 300 pounds. Alligator gar are one of the few natural predators that grow quick enough and large enough to feed on adult invasive carp, one of the more recent threats to aquatic resources in the LMR. The Lower Mississippi River Basin Invasive Carp Control Strategy Framework (Framework) includes seven goals and associated potential restoration strategies to collectively prevent further expansion, reduce populations, and better understand the impacts of invasive carps (Rodgers 2019). Recommended strategies include promotion of native fish species, particularly native predators, such as alligator gar. The Framework includes the entirety of the LMR basin, and also includes the following major tributaries and their watersheds: Arkansas River, Red River, White River, St. Francis River, Yazoo River, Obion River, Big Black River, and Hatchie River. The area encompasses the USGS Hydrologic Units for Region 08 (Lower Mississippi Region) and Region 11 (Arkansas-White-Red Region). For the six states in the LMR, the LMRCC provides a coordinating body for invasive carp control. The LMRCC understands the magnitude of the invasive carp threat and the need for coordinated efforts to prevent the continued spread, explore strategies to reduce the abundance of established populations, and better understand the impacts of established populations. LMRCC's overlap between the invasive carp control and this study provides an important connection to ensure that feasibility study recommendations complement the work of the Framework.

Implementation of the strategies documented in the Framework is the responsibility of basin states, is voluntary, and is intended to minimize the social, ecological, and economic impacts of these invasive fishes. Goal 3 directly aligns with the study goals, which indicates the need to improve native fishes' abundance and improve habitat through restoration of native fishes' habitat.

Objectives 3.6 and 3.7 directly relate to the goals and objectives of the feasibility study.

- *3.6 Implement management strategies to enhance populations of native piscivores that could prey upon both juvenile and adult Asian carps. (National Goal 3).*
    - *Implementation of management strategies would benefit from research to determine if select native fish feed on Asian carp juveniles and adults, especially those that select for Bighead Carp, Silver Carp, and Black Carp over other prey species. Alligator Gar, Flathead Catfish, Blue Catfish, and Bowfin may feed on all life stages. Other predators (e.g., black basses, White Bass, crappies) may only be able to feed on juveniles for a short period because of the prolific growth of Asian carps.*

- *3.7 Conduct habitat restoration projects that benefit native species and emphasize limiting factors for Asian carps (e.g., flow velocity, lack of plankton-rich water). (National Goal 4).*
    - *Higher flow velocity and other habitat criteria can adversely affect the habitat distribution of Asian carps. (See 4.2.).*

Objective 3.6 indicates improving conditions for native fish species will increase the diversity and abundance of desirable species and based on native fishes' life history, timing should increase predation of ichthyoplankton and juvenile invasive carps, such as the native predator alligator gar. This should cause natural suppression of invasive carps. Objective 3.7 indicates habitat improvements that increase velocity in off channel areas (reconnecting off channel areas) would adversely affect the feeding habits of invasive carp. Both objectives would be addressed in many of the measures outlined in the feasibility study.

Hydrologic alterations have disconnected much of the LMR from floodplain and backwater spawning areas affecting alligator gar reproductive success. Additionally, floodplain inundation alone in the LMR does not allow for successful alligator gar spawning. Alligator gar spawning success requires floodplain inundation long enough for water temperatures to become sufficiently warm, as well as low-canopy vegetation for attachment of the eggs. Forest vegetation is not ideal for spawning. Low-canopy vegetation, such as seasonally herbaceous wetlands and moist soil management areas in the LMR, provide high quality spawning areas when present at locations with the appropriate hydrology. An alligator gar habitat suitability index (HSI) was developed by USFWS to provide landscape-level spatial data to determine the extent and quality of floodplain habitat that may be available for alligator gar spawning (Allen et al. 2020). Multi-temporal analysis of remote sensing imagery was used to develop spatial data products that defined floodplain inundation extent, inundation frequency, and temperature. These products were combined with existing layers of physical habitat structure to define and quantify spawning habitat suitability throughout the entire area subject to direct inundation by the LMR. Habitat suitability categories were defined based on meeting unique combinations of inundation, temperature, and physical structure so that the most suitable conservation measures can be applied to improve local conditions. USFWS provided the alligator gar HSI data layer for the Hatchie/Loosahatchie conservation reach and their experts assisted in siting measures during plan formulation for this important species of concern. This information was used as a planning tool by natural resource managers to evaluate priority measures for hydrologic/hydraulic restoration to be included in the various ecological models. Alternative selection also included review of the alligator gar HSI tool, as well as other considerations of species and habitat significance, to determine the optimum priority for the tentatively selected plan (TSP) and eventual implementation in this conservation reach.

1.7 PROBLEMS AND OPPORTUNITIES

The Mississippi River levee system has disconnected much of the floodplain from the river. Flood risk management and navigation projects have altered bends and diverted flow from side channels. Extensive structural changes on the river's mainstem have disrupted the once dynamic ecosystem. These hydrogeomorphic changes caused what was once a frequently changing hydrogeomorphic landscape of channel shifting, creation and abandonment of islands, side channels and back channels, floodplain inundation, and vegetative responses to a far more static and uniform landscape. Modification and changes in the LMR have resulted in a number of extensive habitat changes, including reductions in both vegetative diversity and forested habitat; extensive loss of connection between the river, its associated floodplain, and critical floodplain habitat; loss and disconnection of side channels, backwaters, and oxbows; decreased main channel and main channel border

habitat diversity; loss of gravel bars, sandbars and islands; and a substantial increase in presence of invasive species. There is less available habitat for federally listed threatened and endangered species, including pallid sturgeon and fat pocketbook mussels, and other rare species of conservation concern including alligator gar.

The specific problems in the LMR are:

- Habitat Related Problems
    - An increase in sedimentation results in blocked secondary channels; this in turn leads to forest transitions and fragmentation of habitats.
    - An overall habitat diversity reduction in the main channel of the Mississippi River.
    - A loss or degradation of gravel bars and sandbars, which negatively impact spawning and nesting opportunities for threatened and endangered species.
    - An overall loss of feeding, spawning, rearing, and refugia habitats; lack of stop over and nesting habitat for migratory birds on the Mississippi River flyway.
    - A lack of woody debris, resulting in loss of aquatic habitat diversity and food sources in large river habitats.
    - A loss of terrestrial habitat connectivity.
    - A reduction in quantity and quality of floodplain waterbody habitats; fewer new waterbodies being created.
    - A reduction in vegetative diversity.
    - The size of the floodplain and the associated native vegetative and forested habitats is significantly reduced.
    - The water quality has degraded in isolated water bodies in the LMR which has contributed to decreased biodiversity.

- Physical Process Problems
    - Many secondary channels, backwaters, and oxbows are more frequently disconnected from the main channel due to flood risk reduction projects and navigation infrastructure.
    - The Mississippi River islands are a unique and limited habitat type, but their ecological importance is not fully understood.
    - A reduction in dynamic riverine processes.

- Invasive Species Problems
    - Invasive species threaten native species and native habitats, including species of concern as native flora and fauna do not compete well against some invasive species.

Opportunities in the LMR include restoring vegetative diversity and forest habitats in the active floodplain; improving floodplain connectivity with the river; reconnection of side channels, backwaters, and floodplain lakes; restoration of sandbars and gravel bars; development and enhancement of islands; and increasing habitat diversity in the main channel and along the shoreline and improve native fishes' abundance and improve habitat

through restoration of native fishes' habitat. There is also an increasing opportunity for public and private collaboration to restore habitat, increase recreation access, and promote information sharing. Opportunities vary throughout the different reaches within the LMR, depending on conditions.

Specific opportunities in the Hatchie/Loosahatchie Mississippi River Mile 775-736 include the following:

- Habitat opportunities:
    - Expand range and quality of gravel bars and sandbars.
    - Focus on connections between high elevation forests used by terrestrial wildlife during high water stages.
    - Inventory islands to understand their ecological value and develop management plans: manage and monitor flora and fauna.
    - Promote native species restoration to increase BLH, emergent, floating, and submersed aquatic vegetation, rivercane, riverfront forest, and main channel border habitats.

- Physical Process opportunities:
    - Compile river-related information and make it accessible.
    - Focus on formation of mid-channel MS River islands and point bar habitats.
    - Identify the information river managers need to make strategic decisions.
    - Improve water quality monitoring and management would benefit fish and wildlife, fishermen, paddlers, municipal water supplies, industries, and others who rely on the Mississippi River for clean water.
    - Increase aquatic connectivity of MS River mainstem to backwater side channel, and floodplain waterbody areas during low-mid river stages.

- Invasive species control opportunities:
    - Increase native species competition.

- Recreational opportunities:
    - Create an informational and marketing organization the public can use to learn about and plan recreational activities.
    - Develop more, and better, interpretative services and facilities.
    - Improve heritage tourism.
    - Improve publicly accessible riverfront areas.
    - Increase outdoor recreational opportunities such as boating, fishing, hunting, bird watching, hiking, photography, etc.
    - Increase recreational access to the public.
    - Provide more canoeing and kayaking access and more designated bicycling trails.

1.8 OBJECTIVES AND CONSTRAINTS

1.8.1 Objectives

Per ER 1105-2-100, the overarching objective of all USACE ecosystem restoration planning studies is to contribute to NER. Contributions to NER outputs are increases in the net quantity and/or quality of desired ecosystem resources. This project's specific NER planning focuses on restoration of ecological structure and function along the Mississippi River, including secondary channels and other aquatic habitat; floodplain forests; and several scarce vegetative communities such as wetlands, canebrakes, riverfront forests, and BLH forests. The goal of restoration in this reach of the LMR is to restore ecological structure and function to the mosaic of habitats along the Mississippi River, including secondary channels and other aquatic habitat; floodplain forests; and several scarce and significant vegetative communities such as wetlands, rivercane, riverfront forests, and BLH forests.

Objectives are specified below for the Hatchie/Loosahatchie Mississippi River Mile 775-736 during the 50-year period of analysis from 2028 to 2078. Performance metrics were created for each objective to measure an alternative's performance against the planning objectives.

Objective #1: Increase quantity and/or quality of vegetative habitats and maintain a diverse vegetative mosaic in the floodplain to benefit native fish and wildlife resources (e.g., migratory birds and species of conservation concern) focusing on habitat, such as emergent, floating, and submersed aquatic vegetation; rivercane; BLH.

The following metrics were established to measure performance of vegetative habitats:

- Maintenance of a minimum survival of 70 percent of planted living native canopy species per acre in mast production of BLH, cypress-tupelo, and seasonal herbaceous wetland species type;
- Demonstration of success with USACE hydrophytic vegetative criteria whereby more than 50 percent of all dominant species are FAC, FAC wet and/or obligate.
- Increase in canopy tree stem density of native species to approximately 150 stems per acre in riparian buffer areas.

Objective #2: Improve quantity and/or quality of diverse large river habitats (sandbars, gravel bars, secondary channels, etc.) to support critical life history requirements of priority species.

The following metrics were used to measure performance of large river habitats:

- Percent increase in frequency of hydrologic connectivity above baseline conditions by 25 percent by year 7 measured from bathymetric and light detection and ranging (LiDAR) surveys;
- Increase in large woody debris in secondary channels to include 25 percent of the estimated trap capacity by year 5.

Objective #3: Increase quality of the diverse mosaic of floodplain waterbodies (including but not limited to meander scarps, sloughs, crevasses, and borrow pits) and optimize their aquatic connectivity with the Mississippi River to support critical life history requirements of priority species.

The following metrics were established to measure performance of floodplain waterbody habitats:

- Percent increase in frequency of hydrologic connectivity above baseline conditions by 25 percent by year 7 measured from bathymetric and light detection and ranging (LiDAR) surveys;
- Increase in riparian buffer of native trees to 75% of the periphery;
- Increase in deep water conditions (> 5 feet with a 1:3 slope) to cover 75% of the waterbody;
- Increase in shallow water conditions (< 5 feet with a 1:10 slope) to cover 25% of the waterbody.

Objective #4: Improve recreational opportunities and access to public spaces in study area.

The following metric was used to measure performance:

- Increase in recreational usage and interest evaluated by NFS.

1.8.2 Constraints and Considerations

Planning constraints are temporary or permanent limits imposed on the scope of the planning process and the choice of solutions. These limits can be related to the ecological, economic, engineering, legal, and administrative aspects of a project. Some constraints are states of nature, whereas others are based on the design of built structures and other engineering considerations. Legislation and decision makers can impose other constraints and such human-imposed constraints may change. The institutional planning constraints identified for the study were as follows:

- Avoid and minimize impacts to established flood risk reduction, such as the MR&T features. Specifically, restoration measures cannot increase flood heights, adversely affect private property or infrastructure, or the continued operation of significant levee and navigation infrastructure.
- Avoid/minimize impacts to navigation operations on the Mississippi River.
- Avoid/minimize impacts to existing infrastructure.

Other factors that were considered by the team in the planning process included:

- Environmental considerations: Measures should be consistent with applicable Federal, state, and local laws. Compliance and coordination with applicable laws, such as the CWA, ESA, and NHPA, among others, requires environmental impacts to be minimized and avoided, as much as possible. Therefore, the following constraints are considered when analyzing alternatives:
    - Avoid/minimize impacts to existing gravel bars;
    - Avoid/minimize activities that lead to increased invasive species;
    - Avoid/minimize/compensate impacts to threatened and endangered species;
    - Avoid/minimize/compensate impacts to cultural resources.

1.8.3 Future Without Project Summary

Future without project (FWOP) conditions for the Hatchie/Loosahatchie Mississippi River Mile 775-736 study area over the period of analysis between 2028 and 2078 would continue to show a lack of hydrologic connectivity, the lack of a meandering river system, and adverse ecological impacts to fish and wildlife communities.

It is anticipated that floodplain waterbodies that were historically connected to the Mississippi River main channel would remain disconnected and continue to experience increased sedimentation loading. Using data collected in borrow areas, depth decreases at an annual rate of 0.004474 feet. See Appendix 5 for additional information.

The study area reach of the Mississippi River will continue to show a decreasing trend in the specific gage records, indicating a state of degradation (i.e., the lowering of the channel bed), further contributing to the disconnection of secondary channels and floodplain waterbodies from the main channel at moderate and low river stages. Analysis has shown that the rate of change in feet per year (ft/year) ranges between 0.15 ft/year at low discharges and 0.06 ft/year at moderate discharges at the Memphis gage as cited in Appendix 5 (Biedenharn et al. 2017). There is some uncertainty on expected hydrologic conditions in the study area due to a lack of consensus in literature regarding future precipitation projections.

FWOP vegetative conditions would continue to remain degraded with fewer mast producing species, cypress-tupelo swamp habitats, and rivercane. Fish and wildlife communities would be impacted due to the lack of connectivity and invasive species would continue to impact these communities. These conditions are explained in detail in Section 3.

Other conservation efforts from agencies or groups, such as the LMRCC, Lower Mississippi Valley Joint Venture (LMVJV), NRCS, Ducks Unlimited, and other conservation organizations, are ongoing in the study area. These efforts contribute to on-going conservation protection of wetland habitats in the MAV, help to reduce habitat fragmentation, increase wetland community compositions, and provide long-term benefits to those wildlife and migratory birds using these wetland habitats at critical times in their life cycles. Additional details on actions undertaken by these organizations are included in Cumulative Effects Section 3.9.

Section 2
Plan Formulation

2.1 PLANNING FRAMEWORK

Plan formulation was conducted in accordance with the six-step planning process described in Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983) and the Planning Guidance Notebook (ER 1105-

2-100) (Figure 1-1). This process is a structured, systematic, and repeatable planning approach for problem solving water resource issues. The six planning steps, though presented and discussed in a sequential manner in this FIFR-FEA for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate and evaluate an efficient, effective, and reasonable array of measures and alternative plans, including when an action is not taken, for the identified period of analysis. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. Plan formulation was conducted to be consistent with protecting the Nation's environment, pursuant to national environmental statues, applicable Executive orders (EOs), and other Federal planning requirements. Plan formulation also considers all effects, beneficial or adverse, to each of the four evaluation accounts identified in the principles and guidelines (P&G) (1983), which are NED, EQ, RED, and OSE. Plan formulation was a data driven process, building upon previous data and work, and developing more detail and including more refinement of alternatives and measures as the study team moved toward identifying the TSP. Each iteration identified additional information necessary to inform and make decisions. In the early phases of the study, the study team used existing information and professional judgment. As the study progressed, additional data and analyses were deemed necessary to identify the differences between alternatives and measures. Throughout the study, the study team incorporated risk-informed decision making to balance the level of study detail necessary to make decisions at that phase, along with uncertainty in accordance with USACE policy, such as ER 1105-2-101 "Risk Assessment for Flood Risk Management Studies."

When the study team lacked information about a critical aspect of a measure, it was determined how much analysis was needed to make an informed decision. Where possible, any additional analyses (and costs) were delayed until later in the study, after the TSP selection. Using these principles, the study team was able to manage risk by balancing the level of uncertainty with the tolerance for risk. Appendix 1 - Plan Formulation provides additional information to supplement the following description of the plan formulation process for this study.

- Step 1 focuses on identifying problems and opportunities within the study area. Objectives, potential project achievements, and constraints are also formulated as part of Step 1. The study team identified problems within the study area and root causes driving the issues based on the study team's knowledge of the project area, authorization, and previous reports. In September 2021, the USACE conducted a large interagency planning charette to formulate problems, opportunities, goals, and objectives for the study. The results are presented above in Section 1.
- Step 2 focuses on inventorying and forecasting conditions of the study area. In Step 2, the study team documented the existing conditions in the study area relevant to the data collected in Step 1. Existing conditions are those at the time the study is conducted. The forecast of the FWOP condition reflects the conditions expected during the period of analysis. This was completed by looking at historic trends and potential changes to the existing conditions and forecasting of the likely future outcome if no USACE actions were taken. The data from the inventory and forecasting was used to define the FWOP condition. The future

without project condition is the consequence of taking No Action to resolve the problems identified in Step 1. The inventory and forecasting of future conditions are presented in Section 3 of this final report.

- Step 3 focuses on developing a wide range of potential actions, referred to as restoration strategies (also known as site-specific management measures), to solve the problems identified in Step 1 while also meeting the planning objectives and avoiding planning constraints. Before measure identification, the team identified general types of restoration (bankline reforestation, dike notching etc.), referred to as restoration strategies, based on the identified problems, opportunities, objectives, constraints, and inventory and forecasting of critical resources. Thirty-one restoration strategies were formulated to inform the development of management measures. These strategies were informed by previous studies that occurred in the study area and any available existing data from the NFS and other subject matter experts. Five of these restoration strategies were screened, and 27 restoration strategies were retained. The 11 established geographic complexes were then investigated to determine which and where restoration strategies could be applied. In using the 27 restoration strategies retained, a total of 207 site-specific management measures were identified across the study area. Feedback on these measures was solicited during general scoping meetings held in October 2021.

- Step 4 focuses on evaluating management measures and developing alternative plans. This step uses information from initial and later iterations and ecological and economic models to measure how well individual measures and or alternatives performed. In early iterations, the study team reviewed each potential measure in consideration of planning constraints. The initial 207 site-specific measures were evaluated, screened, grouped, and refined resulting in 85 (83 ecological and two recreation-related) remaining site-specific management measures for further consideration.

- Eight ecological models were developed to quantify benefits for the habitats and functions represented in the 83 ecological measures. The remaining 83 ecological measures were classified by habitat and function and assigned to one of 8 ecological models. Cost estimates were concurrently developed for each measure. The 83 ecological measures were then evaluated and screened based on efficiency (based on CEICA results), and their ability to restore important habitats based on scarcity, and special species status. This analysis resulted in the screening of 19 measures and 64 ecological measures moving forward for further consideration. These 64 measures were then grouped into 27 measure combinations based on synergy and efficiency and rerun through the CEICA to inform selection of the final array of alternatives. The final array of alternatives included 10 alternatives comprised of 58 ecological measures. The two recreational opportunities were added into the final array of alternatives, bringing the total to 60 measures. The final array evaluation was informed by CEICA output, P&G criteria, environmental, cultural, and social resources impacts,

recreational opportunity, and the technical significance of habitat. Recreational measures were not modeled as they do not carry ecological benefits.

- Step 5 focuses on comparing alternative plans and is further described in Section 4. The study team compared the alternatives, including the “No Action” alternative. Based on the comparisons, the study team determined which alternative best met the goals, objectives, and evaluation criteria of the project.
- Step 6 is the TSP selection. This is the final step where the study team, in concurrence with vertical leadership, selected the TSP. Section 4.2 describes plan selection and Section 5 provides further detail on the TSP.

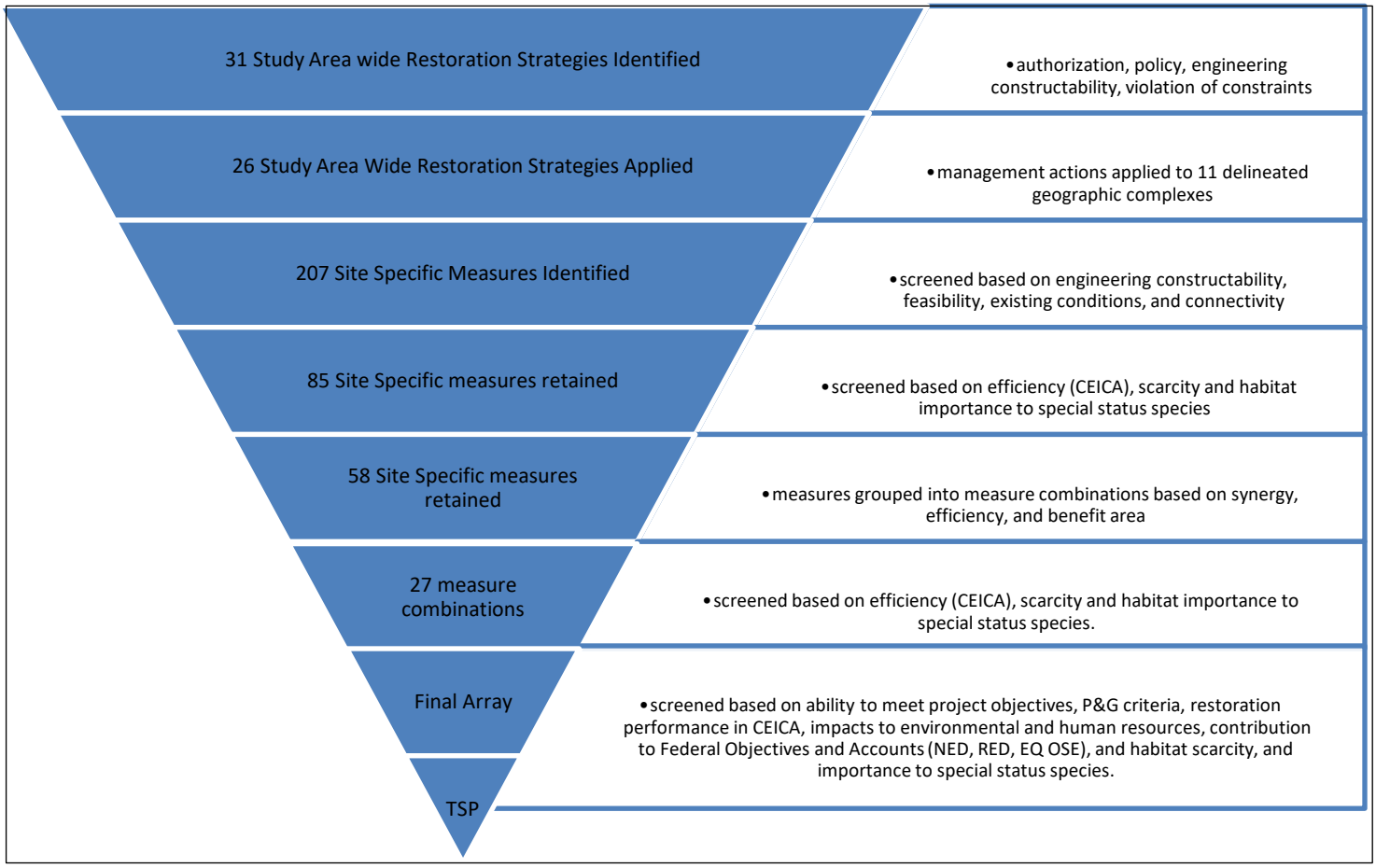


Figure 2-1. Summary of Alternative Development Assumptions

2.1.1 Assumptions

The following assumptions were made during the plan formulation process:

- The feasibility study assesses the study area's problems, opportunities, and FWOP conditions for a 50-year period of analysis from 2028-2078. This assumption included time for the completion of the feasibility study, PED period of two years and construction authorization and funding occurring around 2027. Assuming multiple construction contracts, construction could be completed in 1 year and benefits would start to be seen in the year of implementation, 2028.
- Features recommended in the TSP will be developed to a 35 percent design level for the final feasibility report, using existing data (such as topography and subsurface conditions) as much as possible. During the PED phase and in the Plans and Specifications Stage, USACE would use detailed data and final design calculations to complete a 100 percent design.
- Screening of a specific measure does not preclude resurrecting a measure at a future date if it becomes apparent that a measure was screened out based on incomplete data or an invalid assumption. Additionally, management measures

screened during this study, may be suitable for consideration under other authorizations or programs.

- Parametric costs and fee were used to develop Real Estate estimates based on the land type for the measures and final array. Most of the active floodplain of the LMR is privately owned. Thus, measures are proposed on private land. Ability of NFS to provide required lands was considered equal for all measures during plan formulation. Purchase of private lands in fee is the proposed Real Estate mechanism. If the non-Federal sponsor does not obtain sufficient lands, easements, rights of way, relocation, and disposal (LERRDs) for a particular measure, benefits would still accrue from the remaining constructable measures as benefits for each measure are independent. A only alternative will be evaluated in the final array (Section 5.7). Use of separate ecological models (as opposed to one landscape level model) were used to estimate benefits for use in CEICA to inform the TSP selection. A comprehensive landscape level model measuring the mosaic of diverse habitats in the LMR for use in CEICA would take extensive time and data to develop. The diversity of restoration measures required multiple habitat models that target floodplain communities or different groups or guilds of aquatic species in the river-floodplain environment and generally follows the habitat classification by Baker et al. (1991). For the aquatic evaluations, statistical models were developed from long-term databases at USACE Engineer, Research, and Development Center (ERDC) to predict eco-lift resulting from the various measures. A one-model-fits-all approach was not feasible since the measures influenced both channel and floodplain habitats with different plant and animal species. Thus, models were identified or developed for the guild or other functional groups that are most representative of the particular habitat and are important ecological indicators. Models were developed from several decades of field data that quantifies both species abundance and habitat use parameters from various LMR studies. The advantage of using this data is it can be analyzed by any third party for transparency, and it predicts a biological endpoint that can be monitored in the future. While the use of separate ecological models adds more confidence in the model results, incorporating different model outputs through the CEICA could underestimate the benefit outputs and/or cause measures to be screened early in the evaluation. It is assumed that any additional benefits are limited and would not impact plan selection at the alternative scale.
- Measures near the authorized navigation channel and MR&T flood-risk management features were reviewed by operations division and engineering experts to evaluate if there were potentially negative effects on the MR&T system. Measures that were expected to have negative effects to these areas were screened as infeasible in the plan formulation process.

2.2 MANAGEMENT MEASURES

Management measures are the building blocks of alternative plans. Potential activities to address the identified problems, opportunities, and objectives were identified through a multi-step, iterative process in which the sponsors and stakeholders were closely involved. The planning process was based on the multidisciplinary and multiagency study team knowledge of the study area, NFS extensive knowledge of the LMR, NEPA scoping process,

study authorization and previous reports. This process led to the identification of 31 categories of actions (restoration strategies) that could be applied for the study area to address identified problems. Environmental Operating Principles (EOPs) were considered during the plan formulation process. Potential restoration strategies with opportunities that could not be addressed through USACE's ecosystem restoration mission, within the study authority or USACE policy or that violated project constraints were removed from consideration for further analysis. Potential strategies were also removed from consideration where there were known technical constructability concerns. The evaluation and screening of restoration strategies resulted in 27 retained potential actions that were determined to best address project problems opportunities and objectives. Table 2-1 lists the restoration strategies identified along with whether they were screened or retained. It was noted that although a strategy was screened out under this particular study, it may be suitable for consideration under other authorizations or programs. EOPs are further discussed in Section 5.1.2.

Table 2-1. Summary of Restoration Strategies Grouped by Objective

Retained/Screened	Activity
Floodplain Vegetative Species (Objective 1)	
Major habitat targets: cypress-tupelo establishment, BLH promotion of Oak/Hard Mast species, Seasonal herbaceous wetlands, Riparian buffers, Rivercane	
Retained	Riparian buffer strip. (Agriculture ditch)
Retained	Riparian buffer strip. (MS River)
Retained	Increase quality and quantity of existing stands of rivercane
Retained	Establishment of rivercane on spoil piles
Retained	Reduction of ponding in forested communities
Retained	Creation of canopy gaps
Retained	Restore/create forest in high elevation areas for wildlife corridor and refugia
Screened -Constraint-Navigation	Changes to the MS River mainline levee
Retained	Private levee setbacks within the batture
Retained	River training structure at meander scarp entrances to divert flow in low water
Retained	Water control structure on existing drainages adjacent to non-forested areas for moist soil management
Large River Aquatic Species (Objective 2)	
Priority species: pallid sturgeon, Blue Sucker, Lake Sturgeon, Sicklefin Chub, Stonecat, American eel (secondary channels, gravel bars, point bars); Interior Least Tern (sandbars).	
Retained	Rock structure to maintain and/or scour buried gravel bars
Retained	Grade control structures to minimize head cutting in tributaries

Retained/Screened	Activity
Retained	Dike notching (existing dike fields)
Screened-ongoing dredge issues	Dike removal in Secondary Channels
Retained	Large woody debris traps in chutes/secondary channels
Retained	Bank protection within secondary channels to reduce scour
Retained	Pilot channel/plug removal in notched dike field
Retained	Multiple dike notches at different elevations for different guilds of fish and recreation access
Floodplain Aquatic Species (Objective 3)	
Priority species: Alligator Gar, Paddlefish, Alligator Snapping Turtles (floodplain waterbodies, floodplain spawning habitat, etc.)	
Retained	Meander scarp plug removal.
Retained	Restore channels connecting floodplain waterbodies to MS River main channel
Retained	Optimize/maintain isolation of rarely connected floodplain waterbodies
Retained	Optimize depth and diversity of floodplain waterbodies
Retained	Bridge modification to increase connectivity in meander scarps
Retained	Weir/control structures at slough overflows to hold warmer water in spring
Retained	Riparian Buffer Strip (Agricultural ditch)
Retained	Riparian buffer strip. (MS River)
Recreation (Objective 4)	
Screened – better accomplished through other programs	Biking trail across MS River levee
Screened – recommended for implementation by others	Change hunting regulations at Wappanocca NWR to be a refuge/protect wildlife during times when entire study area is inundated
Retained	Interpretive signage and education
Retained – couple with creating high elevation wildlife corridor	Primitive access ramps and hiking trails

2.2.1 Site-Specific Management Measures

Each of the retained restoration strategies identified in Table 2-1 were then applied to the geographic complexes (geographic complexes were identified previously in Section 1.4) through a series of expert elicitation and complex specific planning meetings with the study team, which includes the NFS and cooperating agencies. This approach supported the intent to develop a mosaic of habitats across the study area. The study team identified site-

appropriate measures, scales, and combinations of feature and activity types at each potential restoration site to improve the native habitats within the site.

A total of 207 site-specific management measures were identified. See Appendix 1 for a description of each site-specific management measure and a map of all management measures identified within each geographic complex.

The management measures were classified based on the restoration activity needed at that site to provide benefits to the habitat and species. The 207 management measures can be categorized by one or more of the following restoration activities: altering connectivity, waterbody enhancement, aquatic channel enhancement, water management, floodplain forest enhancement, bank line reforestation, sediment control and recreation. A summary of the restoration activity, measure descriptions and associated construction activities is included below and in Table 2-3. Additional details on the restoration activities can be found in Ecological Modeling Appendix 5 and additional information on the construction activities required is included in Engineering Appendix 3.

2.2.1.1 Altering connectivity

As documented in Section 1, improving floodplain connectivity with the river, including altering the flow to side channels, backwaters, and floodplain lakes, is critical to restore habitat and ecosystem function in the LMR. The connectivity needed to maintain the historic mosaic of habitats has been altered due to the continued operation of levee and navigation infrastructure. The identified measures include flow alteration and restoration to ecologically sensitive areas, backwater sloughs, wetlands, secondary channels, and meander scarps. Construction activities to achieve this restoration includes earthwork, including dredging, weirs and stoplog structures, culverts, bridge replacement, river training structures, riprap bank protection, and dike notching.

All waterbodies within the active floodplain experience a variety of flow regimes. For this study, regimes were characterized by the primary direction of flow: upstream to downstream flow (unidirectional), bidirectional (backwater) flow where river water flows into and out of the same channel, and minimal flow (isolation). Secondary channels and meander scarps flow from upstream to downstream at most river stages. As the river level drops, these channels can experience bidirectional flow as obstructions (sand, bedrock, clay deposits, rock, pile, and road crossings) become exposed and block unidirectional flow. When this occurs, groundwater and connected lakes can feed water into the channel. This water can then flow out the upstream and/or downstream ends to the main channel. Alternatively, river water can flow in and back up to the obstruction creating connected backwaters. If there are multiple obstructions, isolated pools may occur.

It is likely that secondary channels and meander scarps experienced all of these conditions with fluctuating river levels prior to European colonization. Maintaining channels in a variety of conditions will likely lead to greater system biodiversity. It is also likely that manmade obstructions (rock dikes, pile dikes, and road crossings) have skewed the system-wide connectivity of primarily unidirectional waterbodies toward a less connected system. Additionally, increasing the time-period, quantity, and velocity of unidirectional flow can increase sediment removal. In other words, sediment deposition increases in secondary

channels and meander scarps as flow decreases. With enough time, this sediment may vegetate, leading to these habitats transitioning to isolated floodplain sloughs and eventually vegetative habitats. In addition to improving waterbody longevity, increasing unidirectional flow ensures aquatic species access to these channels and the habitats that connect to them, and promotes persistence of species that require flowing water away from navigation disturbances. Native habitats experiencing unidirectional flow, like flowing meander scarps, are not created anymore due to maintenance of the navigation channel; thus, restoring ecological functions to these few remaining opportunities is important to preserving these scarce habitats.

Floodplain borrow areas, crevasses, sloughs, scour holes, and oxbow lakes predominantly connect to the river through bidirectional flow. During moderate stages, typically from late winter to early summer, the main channel rises enough for river water to flow up small natural and manmade floodplain channels and into floodplain waterbodies. When the river drops, the direction of flow reverses and water flows from the waterbodies back into the river. During these backwater events, sedimentation is negligible. The low velocity water from the top of the water column carries minimal sediment. During larger, more infrequent floods, the Mississippi River flows across the floodplain resulting in floodplain waterbodies experiencing unidirectional flows, which can scour/deposit sediment and flush organisms, organic matter, and nutrients into the main channel. In some instances, large floods can create new floodplain waterbodies or completely fill existing waterbodies. Improving bidirectional connectivity allows aquatic organisms to access waterbodies through lower velocity backwater flows.

Low unidirectional and bidirectional connectivity creates isolated aquatic habitats, which promote unique wetland fish assemblages that have declined in the LMR (Hoover and Killgore 1998). Prior to levee construction, isolated waterbodies were likely widespread on the far edges of the LMR floodplain. During infrequent large floods, these waterbodies were connected to the river. When connected, the rare fish community was picked up in flood waters and spread. These fish sometimes perished but sometimes settled in new suitable habitats, preserving, and increasing system species diversity.

Today, with the levee system in place restricting the areal extent of the floodplain, every year or every other year, floodwaters spread across the great majority of the active floodplain because it is constrained by the levees. This connects all but the most elevated waterbodies. With this connection, competitive riverine fish move in and dominate most communities until water quality or predation diminish their numbers. This decreases the prevalence of wetland fishes including flier, taillight shiner, pirate perch, banded pygmy sunfish, bantam sunfish, several species of darters and other wetland fish assemblages that have declined in the LMR (Appendix 5, Hoover and Killgore 1998). Isolated waterbodies may also have lower turbidity as bottom sediments are less frequently mobilized with inflowing water. Lower turbidity and compacted bed sediment promotes aquatic and wetland plant species, further increasing habitat value. Focusing on opportunities to these isolated waterbodies assists in maintaining a diversity of disturbance/connectivity regimes to the remaining floodplain waterbodies in the LMR batture maximizing the total biodiversity of the floodplain (Ward et al. 1999).

2.2.1.2 Waterbody enhancement

Waterbody enhancement involved increasing bathymetric complexity by deepening and creating bed elevation/shoreline diversity in sloughs and borrow areas. This was based off of the environmental guidelines developed from the extensive biological studies completed by the USACE on borrow areas along the LMR. Biologists have studied the use of borrow areas by fish, birds, turtles, frogs, and other wildlife and how wildlife use changes with the shape, depth, water quality, and degree of river flooding. Incorporating environmental design features in borrow areas can greatly enhance the diversity of fish and other wildlife that inhabit them. Environmental design features include making them mostly bowl-shaped, with deeper areas of up to 10 feet and shallower areas of less than five feet; creating sinuous, or curved, shorelines; planting native trees along shorelines; and creating islands.

Floodplain waterbodies form from the scour and migration of river channels (Winkley 1977) and when material is excavated to elevate surrounding ground (borrow areas). After initial formation, these waterbodies may be maintained for many decades to over a century by periodic scouring floods. However, the predominant trend is for waterbodies to slowly fill with sediment and transition to wetlands and eventually forest. As sedimentation occurs, the waterbodies also become shorter, narrower, and develop gently sloping beds of fine sediment. Agriculture can increase sedimentation and speed up this transition. Alternatively tiling and drainage canals can drain floodplain waterbodies. If temporary, this drying process can be both harmful and beneficial to aquatic organisms. This can be harmful because organisms must leave or die as the waterbody dries and beneficial because, as the waterbody dries, the bed sediment compacts, consolidates, and may grow wetland plants. When the waterbody refills, it will be deeper, less turbid and may have plants that aquatic organisms can use for shelter and food. With the managed river and privately owned and managed floodplain, fewer floodplain waterbodies form.

2.2.1.3 Aquatic channel enhancement

Aquatic channel enhancement includes measures that modify or build rock structures or install wood debris traps. Unlike unidirectional and bidirectional measures, the primary purpose of these measures does not involve connectivity.

Rock structures are proposed to alter the flow of water creating diverse flow patterns, which in turn alter sediment distribution and create a riverbed with varying substrate and elevation. Measures propose to enlarge or add to existing dike notches, which would divert more water into the downstream secondary channel but not alter connectivity. Hard points are proposed along bank lines to create bathymetric diversity and protect adjacent floodplain. Eddies form around hard points, which benefit numerous species that feed on the small-bodied organisms trapped in the swirling currents. The final type of rock structure proposed in this study are chevrons. Chevrons look like a horseshoe pointed upstream and have scouring flows along the legs that can clear fine sediment off of gravel, and/or protect valuable floodplain habitat and recreational infrastructure.

Wood debris traps are proposed to add additional woody debris to the LMR. Bank stabilization and floodplain forest management has likely led to a decrease in the amount of woody debris within the river affecting the species that use woody habitat. Secondary

channels are an ideal location to add woody debris. Secondary channel velocities are generally lower so the wood will not be washed away, the habitat is accessible to main channel species, and the wood will not impact navigation.

2.2.1.4 Water management

The pre-European LMR floodplain was likely a matrix of aquatic, herbaceous and forested habitat. Today, there is minimal herbaceous habitat and species populations that rely on this habitat, like alligator gar, are in decline. Management agencies maintain open moist soil management areas to address this need. To prevent invasive species colonization and woody encroachment, these areas are typically maintained as food plots, planted with row crops to feed resident and migratory wildlife. Determining moist soil management unit location based upon soils and hydrology would result in an ideal scenario. However, unit location is often based upon societal factors: access, land use, and farmer proximity. Thus, the hydrology may be sub-optimal for target species. In addition, the hydrology of the floodplain has been extensively altered by roads, agriculture, hunting camps, and other uses. Providing water management on existing moist soil management units allows managers to control the hydrology to benefit the widest range of species and/or those species most in need.

2.2.1.5 Enhance and restore natural vegetation

This group includes floodplain measures that enhance or restore natural vegetation by changing inundation, managing undesirable species, planting, or controlling sediment.

For the Hatchie to Loosahatchie reach, these measures generally included:

- Floodplain reforestation
- Bankline reforestation
- Forest management
- Forest inundation management
- Herbaceous wetland planting
- Sediment control.

Reforestation is proposed through replanting or natural succession in the floodplain and along banklines. Bankline reforestation always involves converting agriculture or relatively bare ground adjacent to waterbodies and channels to forest. Floodplain reforestation always involves planting either cypress-tupelo or BLH to reintroduce these rare forest types. Bankline reforestation can be through natural succession, allowing trees to fill in with time or through planting.

Floodplain reforestation targeted areas of migratory bird priority to address goals of the LMVJV for reforestation to benefit breeding birds (https://www.lmvjv.org/), areas on public land, and frequently inundated agriculture. Floodplain reforestation introduces rare forest types back into the local ecosystem. These trees provide unique habitat and benefit the species that use the surrounding forest. Enlarging contiguous tracts of forest (to create forest core areas with > 1 km of forest in all directions) will benefit declining populations of

birds that rely on forest interior (Twedt et al. 2006). Finally, the seeds produced could result in further increases of these forest types.

Reforesting bankline results in numerous additional benefits, including the increase in bank stability. The forest creates a wind break reducing sediment mobilization and wind fetch on the adjacent water body improving waterbody clarity and longevity. The trees provide shade reducing the adjacent water temperature and daily dissolved oxygen fluctuation. Leaves and branches that fall from the trees increase invertebrate abundance and diversity leading to larger and more numerous fish populations.

Forest management involves improving existing areas of forest. These areas were generally identified by study team members with local site knowledge. Tree girdling with trees left in place was the primary method chosen to improve forest stands. During plans and specifications, property or personal safety concerns may modify this approach. Tree girdling creates standing dead trees which are eaten by insects that then feed birds, and other wildlife. Additionally, many birds, including the prothonotary warbler, and mammals create and use nest cavities in dead trees. Eventually when the trees fall, they provide a source of floodplain and aquatic dead wood benefiting numerous additional insect and fungus species.

Forest inundation management proposed to change how water moved from the river onto and off of the floodplain. The natural levees along the Mississippi River can be 10 – 15 feet higher than interior floodplain lowlands. Overtopping floods, natural levees, and historic channel paths created complex lowland floodplain hydrology. Extensive alteration of the LMR floodplain channels has occurred, changing hydrology for access and use (agriculture, hunting, fishing, forestry, and others). River water frequently backs up the deep channels cut to drain overtopping floods. As the water drops, these channels quickly drain low areas that would have historically held water. Roads that cut across the floodplain can also cause water to pond on floodplain forests. Because of the complex hydrology, forest inundation management measures were designed to address the site-specific hydrology issues as determined by elevation data and information from site managers.

Herbaceous wetland planting: The distribution of emergent, floating, and submersed aquatic vegetation is dependent on flow regime and elevation relative to the river. River flows scour many aquatic habitats, preventing aquatic vegetation establishment. With increased disconnection from the Mississippi River's turbid and scouring flows and protection from agricultural runoff, floodplain waterbodies (borrow areas, sloughs, crevasses) can develop a variety of vegetation types. As water clarity improves, the most protected lakes can support submersed aquatics. Due to extensive floodplain agriculture, floodplain channelization, and invasive species, aquatic vegetation has become rare.

Sediment control measures were discussed where geomorphic channel adjustment was occurring due to channelization. Many LMR waterways including large tributaries have been straightened, increasing channel slope and thus stream power. In an alluvial system like the LMR, this leads to a period of increased erosion and bank caving until the channel readjusts. Often this adjustment is prevented by manmade features due to societal concerns. Sediment control measures were proposed in areas where continued erosion endangers high quality unique habitat and recreation infrastructure.

Recreation: There were two recreational opportunities identified from the application of the recreation related restoration strategies in Table 2-1. These two recreation measures were site specific opportunities identified during the scoping process. The recreation measure LW-1 includes interpretive media and potential demonstration for large woody debris traps. The recreation measure M_2 includes trail access improvements and large woody debris traps signage. They are compatible features identified in the checklist of recreation facilities, which may be cost shared in EP 1165-2-502 and were carried through to the final array of alternatives to be added into any of the alternatives in the final array.

Table 2-2. Summary of Developed Management Measures for the Mississippi River Hatchie/Loosahatchie Feasibility Study

Restoration Activity Type (Main)	Measure Description	Construction Activity Type	Habitat Addressed	Brandywine (BR)	Densford (D)	Hatchie Towhead Randolph (HT)	Hopefield Big Point River (HB)	Island 40-41 (I40)	Island 35-Deans Island (I35)	Meeman Shelby (M)	Redman Point (RL)	Richardson CP (RCP)	Sunrise Island 34 (S)	Loosahatchie Wolf River (LW)	Total # measures identified
Altering Connectivity	Flow Alteration to Ecologically Sensitive Area	Earthwork	Slough (Lentic Aquatic)	0	0	1	0	0	0	0	0	0	0	0	1
Altering Connectivity	Flow Restoration to Backwater Slough	Weirs and Stoplog Structures, Culverts, Riprap Bank Protection, Earthwork	Slough (Lentic Aquatic), Borrow Areas (Lentic Aquatic)	8	0	20	2	14	29	0	6	0	10	0	89
Altering Connectivity	Flow Restoration to Wetland	Earthwork	Slough (Lentic Aquatic), Borrow Areas (Lentic Aquatic)	0	0	2	0	0	5	0	0	0	0	0	7
Altering Connectivity	Secondary Channel Low Flow Pilot Channel	Earthwork	Secondary Channels (Lotic Aquatic)	0	0	1	0	0	0	0	0	0	0	0	1
Altering Connectivity	Flow Restoration and Habitat Complexity to Backwater Slough	Grade Control Structures, Earthwork, Riprap Bank Protection	Slough (Lentic Aquatic)	0	3	0	0	0	0	0	0	0	0	0	3
Altering Connectivity	Isolation of Floodplain Waterbody	Culverts, Riprap Bank Protection, Earthwork	Slough (Lentic Aquatic), Borrow Areas (Lentic Aquatic)	0	0	0	1	1	2	0	0	0	0	0	4
Altering Connectivity	Meander Scarp Flow Restoration	Bridge Replacement, Weirs and Stoplog Structures, River Training Structures, Earthwork, Dike Notching	Meander Scarps/Tertiary Channels (Lotic Aquatic), Slough (Lentic Aquatic), Borrow Areas (Lentic Aquatic)	2	0	0	0	0	7	0	0	0	4	0	13
Altering Connectivity	Dike Notching-Stone and/or Pile dikes	Dike Notching	Secondary Channels (Lotic Aquatic)	5	0	0	0	0	5	5	2	0	1	0	18
Waterbody Enhancement	Restoring Habitat Complexity in Borrow Area	Earthwork	Borrow Areas (lentic aquatic)	2	0	0	6	1	3	0	0	0	0	0	12
Waterbody Enhancement	Restoring Habitat Complexity in Crevasse	Earthwork	Borrow Areas (lentic aquatic)	0	0	0	0	0	1	0	0	0	0	0	1
Waterbody Enhancement	Restoring Habitat Complexity in Floodplain Waterbody	Earthwork	Borrow Areas (lentic aquatic)	0	0	0	1	0	3	0	0	0	0	0	4
Aquatic Channel Enhancement	River Training Structure-Chevron or Spur Dike	River Training Structure	MC/Main Channel Border (lotic aquatic)	0	0	2	0	0	1	0	0	0	0	0	3

Restoration Activity Type (Main)	Measure Description	Construction Activity Type	Habitat Addressed	Brandywine (BR)	Densford (D)	Hatchie Towhead Randolph (HT)	Hopefield Big Point River (HB)	Island 40-41 (I40)	Island 35-Deans Island (I35)	Meeman Shelby (M)	Redman Point (RL)	Richardson CP (RCP)	Sunrise Island 34 (S)	Loosahatchie Wolf River (LW)	Total # measures identified
Aquatic Channel Enhancement	Hardpoint Bank Protection	Riprap Bank Protection	Riverfront Forest - Riparian buffers (floodplain)	1	0	0	0	0	1	1	0	0	0	0	3
Aquatic Channel Enhancement	Woody Debris Traps	Woody Debris Traps	Secondary Channels (Lotic Aquatic)	1	1	0	0	0	0	1	1	0	1	0	5
Water Management	Moist Soil Management Creation	Weirs and Stoplog Structures; Earthwork	Moist Soil (aquatic & floodplain)	0	0	0	0	0	0	2	0	0	0	0	2
Water Management	Moist Soil Management Improvements	Groundwater Well	Moist Soil (aquatic & floodplain)	0	0	0	0	0	0	2	0	0	0	0	2
Enhance and Restore Natural Vegetation	Forest Stand Improvement – Cypress-tupelo	Weirs and Stoplog Structures; Earthwork	Cypress-tupelo (floodplain)	0	0	0	0	0	0	1	0	0	0	0	1
Enhance and Restore Natural Vegetation	MS River Riparian Buffer	Floodplain Vegetative	Riverfront Forest - Riparian buffers (floodplain)	0	0	1	0	1	2	0	0	1	0	0	5
Enhance and Restore Natural Vegetation	Reforestation-BLH	Floodplain Vegetative	BLH (floodplain), Riverfront Forest - Riparian buffers (floodplain)	0	0	0	0	3	5	0	0	1	2	0	11
Enhance and Restore Natural Vegetation	Reforestation – Cypress-tupelo	Floodplain Vegetative	Cypress-tupelo (floodplain)	0	0	0	0	0	1	0	0	1	2	0	4
Enhance and Restore Natural Vegetation	Forest Stand Improvement-Rivercane	Floodplain Vegetative	Seasonally herbaceous wetlands	0	0	1	0	0	0	0	0	0	0	0	1
Enhance and Restore Natural Vegetation	Forest Stand Improvement-BLH	Floodplain Vegetative	BLH (floodplain)	6	0	0	0	0	0	1	1	0	0	0	8
Enhance and Restore Natural Vegetation	Flow Restoration and Wetland Complex Restoration	Earthwork	Seasonally herbaceous wetland (aquatic & floodplain)	0	0	0	1	0	0	0	0	0	0	0	1
Enhance and Restore Natural Vegetation	Wetland Complex Restoration	Floodplain Vegetative, Culverts	Seasonally herbaceous wetland (aquatic & floodplain)	1	0	0	1	0	0	0	0	1	0	0	3
Enhance and Restore Natural Vegetation	Grade Control Structure	Culverts; Riprap Bank Protection; Earthwork	Riverfront Forest - Riparian buffers (floodplain)	0	0	3	0	0	0	0	0	0	0	0	3

Restoration Activity Type (Main)	Measure Description	Construction Activity Type	Habitat Addressed	Brandywine (BR)	Densford (D)	Hatchie Towhead Randolph (HT)	Hopefield Big Point River (HB)	Island 40-41 (I40)	Island 35-Deans Island (I35)	Meeman Shelby (M)	Redman Point (RL)	Richardson CP (RCP)	Sunrise Island 34 (S)	Loosahatchie Wolf River (LW)	Total # measures identified
NA	Recreation	Recreation	NA	0	0	0	0	0	0	1	0	0	0	1	2
													Total Measures		207

Figure 2-2. Example: Dike Notching Measure to Alter Connectivity (proposed notch shown in red)

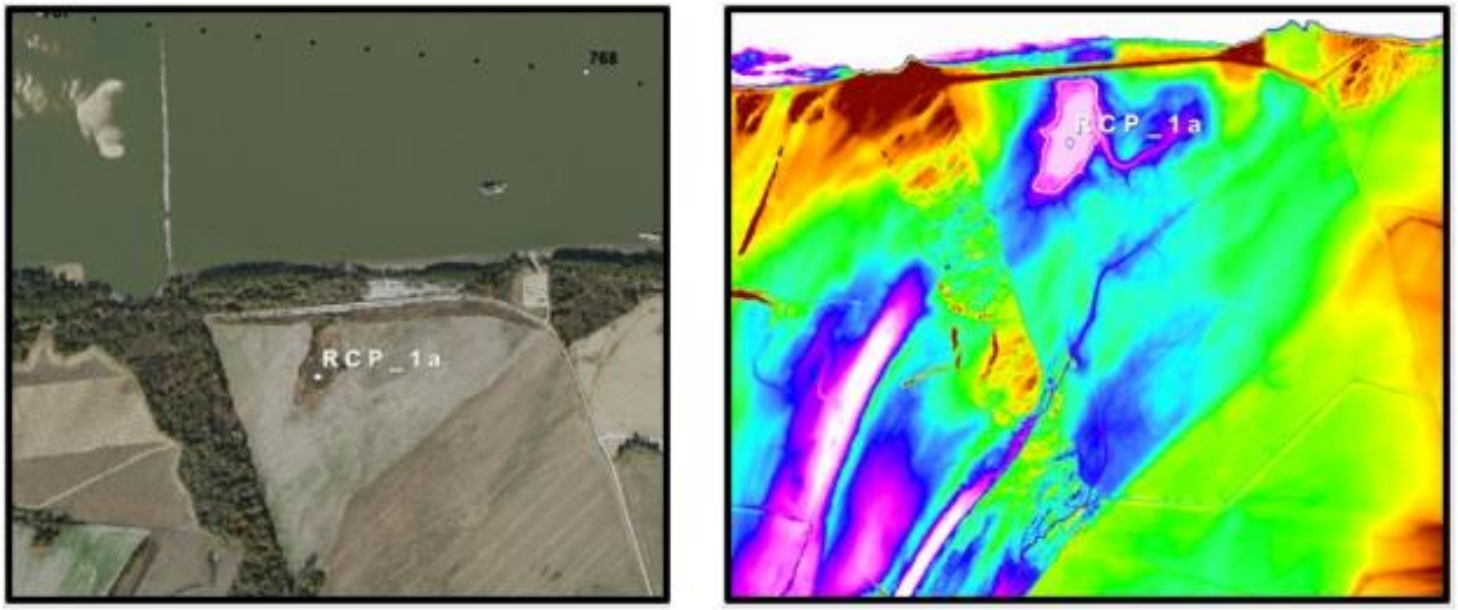


Figure 2-3. Example: Wet area targeted for Cypress Plantings (see low area designated as RCP_1a)

Screening of measures is a process whereby specific management measures are evaluated against pre-determined criteria to assess the likelihood that a given measure can achieve project objectives. The purpose of this screening is to remove measures that will not achieve the established restoration goals and objectives and efficient delivery of ecosystem restoration benefits. Screening does not preclude resurrecting a measure at a future date if it becomes apparent that a measure was screened out based on incomplete data or an invalid assumption or prohibit the measure from being investigated or implemented under another project or program.

The 207 site-specific measures were evaluated and screened based on the following criteria: existing conditions related to hydrologic connectivity, engineering constructability and feasibility in effecting connectivity, and long-term success and sustainability.

To evaluate existing conditions at the location and determine the engineering constructability and feasibility for the measures, the connection frequency, permanent waterbodies, and the channels that connect the waterbodies to the LMR were identified. Part of planning objective 3 is to optimize the aquatic connectivity of floodplain waterbodies. To address this component of the objective, the path that permanent waterbodies connected to the Mississippi River and any obstruction in this path were digitized into a line and point ArcGIS file, respectively.

Each measure was compared to the information developed regarding site elevation, existing obstructions, waterbodies, and channels to determine if the measure met project objectives and was technically feasible. Measures that could not meet objectives based on site analysis were removed from consideration. See Appendix 5 for further information on the analysis

and Appendix 1 for details regarding which measures were screened or retained based on this analysis.

When several measures (actions) were interconnected (e.g., multiple floodplain waterbodies tied to the same flow path), these restoration activities were grouped together into single measures to obtain the full range of benefits in a given area. For example, 15 management measures included removing blockages on a backwater channel and connecting five different sloughs or ponds at various points along this channel. This group became management measure I35-11 with items 11a-11K that were evaluated as one measure to reestablish flow and connectivity along the channel. Figures 2-2 and 2-3 above provide an example of management measures that were screened at various stages in the planning process.

The screening and grouping of the 207 measures led to 85 site-specific management measures being retained (83 ecological measures and 2 recreational measures) across all 11 geographic complexes.

An ecological model was then identified for each of the 83 ecological measures based on the benefits created for aquatic and floodplain organisms. See Section 2.2.3 for a list of the models identified for the measures and the habitat benefit analysis. The details of the ecological modeling and benefit analysis can be found in Ecological Modeling Appendix 5.

Rough order of magnitude cost estimates were also developed for each measure (See Section 2.2.4).

There were two recreational opportunities identified from the application of the recreation related restoration strategies in Table 2-1. Costs were developed for these recreational measures but since these measures do not provide ecosystem restoration benefits, they were not included in the ecological modeling.

2.2.2 Technical Significance of Study Area Habitats

To document the technical significance of the habitat in the study area, two significance criteria were used: scarcity and the importance of the habitat to special status species. To inform the determination of technical significance, the study team evaluated and weighted the habitats in the study area based on their importance to populations of Federal and state endangered species, as documented in the Arkansas and Tennessee State Wildlife Action Plans, along with the scarcity of the habitat documented by subject matter experts on the LMR (see Tables A2b-4 and A2b-5 in Appendix 2b1). For each of the special status species, those habitats that provide significant contributions to a key life requisite (e.g., food, reproduction, etc.) were identified (Table A2b-5), and the scores from the State Wildlife Action Plans (Table A2b-4) were re-scaled from 0-1 and used as the special status species index. For the scarcity index, each habitat was provided a scarcity ranking developed by the interagency team with 1 = rare habitats, 0.75 = moderate, 0.5 = moderate-common, and 0.25 = common (Table A2b-5). The values of the special status species index and habitat scarcity index were then averaged and normalized rankings were calculated for technical significance (Table 2-3 and Table A2b-5).

Table 2-3 provides the resulting ranking of habitats based on technical significance factors of scarcity, representativeness, status, trends, and limiting habitat. The technical significance of these habitats in the study area was used to inform the evaluation and comparison of measures and alternatives (Section 2.4).

Table 2-3. Technical Significance of Habitat Types within the Study Area

Habitat	Normalized Rank
Emergent Sand/ gravel bar (aquatic and floodplain)	1.00
Meander Scarp/ tertiary channels (lotic aquatic)	0.94
Oxbow (lentic aquatic)	0.94
Secondary Channels (lotic aquatic)	0.77
Cypress-tupelo (floodplain)	0.77
Moist Soil (aquatic & floodplain)	0.77
Seasonally herbaceous wetland (aquatic & floodplain)	0.76
BLH (floodplain)	0.56
MC/Main Channel Border (lotic aquatic)	0.41
Slough (lentic aquatic)	0.38
Borrow Areas (lentic aquatic)	0.38
Riverfront Forest - Riparian buffers (floodplain)	0.38

2.2.3 Habitat Benefit Analysis

Multiple ecological models were needed to evaluate the wide range of measures identified to restore the mosaic of habits in the study area (See Table 2-4). Models required different inputs reflecting the different effects of the various management measures based on FWOP conditions. Inputs and outputs were determined for a set of target years because measure effects may change with time (e.g., planted seedlings mature into full sized trees). Indices or units were then multiplied by acreage and divided by the 50-year project life to generate AAHU or Average Annual Functional Capacity Units (AAFCU). The difference between with project and without project AAHU/AAFCUs represents the ecosystem benefit of the measure. Two existing regionally certified and six new habitat benefit models were used to model the benefits of the measures. The models created under this study were coordinated with the USACE Ecosystem Restoration Planning Center of Expertise (PCX) and are

approved for regional use. Benefits of the 83 study measures varied from 0.02 net AAHU to 1,614 net average functional capacity units as displayed in Table 2-4 through Table 2-11. Please see Ecological Model Appendix 5 for more information.

Table 2-4 Ecological Models

Restoration Type	Model	Habitat Addressed	Associated Objective
Aquatic measures that alter connectivity	LMR Floodplain Waterbody Bidirectional Connectivity Model- increase bidirectional flow frequency of waterbodies	Floodplain waterbodies with frequent backwater connections (slackwater fish guild)	3-Floodplain Waterbodies
Aquatic measures that alter connectivity	LMR Floodplain Waterbody Wetland Isolation model- decrease flow frequency to floodplain waterbodies	Floodplain waterbodies with less frequent backwater connections (wetland fish guild)	3-Floodplain Waterbodies
Aquatic measures that alter connectivity	LMR Unidirectional Channel Connectivity Model- increase unidirectional flow frequency in secondary channels and meander scarps	Flow-thru-like secondary channels and meander scarps (benthic aquatic invertebrates and rheophilic fish guild)	2-Large River
Aquatic measures that enhance waterbodies or channels	Borrow Area HSI Fish Diversity Model -waterbody changes in depth or turbidity	Borrow areas and small floodplain lakes	3-Floodplain Waterbodies
Aquatic measures that enhance waterbodies or channels	LMR River Training Structure Riverine Eddy Model- aquatic measures that create eddies, scour holes, or bank scallops	Large river eddy, scour hole, and bank scallop habitats around river training structures	2-Large River
Aquatic measures that enhance waterbodies or channels	LMR Aquatic Invertebrate Substrate model-aquatic measures that change substrate	Large river substrates	2-Large River
Aquatic measures that enhance channels	LMR Wood Traps Model – add wood traps to existing channels	Secondary Channels	2-Large River
Floodplain measures that enhance or restore natural vegetation by changing inundation, managing undesirable species, or planting, and control sediment	Hydrogeomorphic Model (HGM) - regional guidebook for the MS Alluvial Valley	Vegetated wetlands	1-Vegetative Mosaic

2.2.3.1 LMR Floodplain Waterbody Bidirectional Connectivity Model (Bidirectional)

The bidirectional model was used to evaluate 22 measures that increased the connection frequency of sloughs, a borrow area, and secondary channels in eight complexes. Connection frequency ranged from 1 to 58 percent without project and 2 to 100 percent with project with an average increase of 8 percent. Net AAHU ranged from 0.02 to 46 with low values due to the minor increases in connectivity (< 10 percent) and/or the small acreage of many sloughs.

Table 2-5. Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Bidirectional Model

Short Description	Measure Code	Acres	Net AAHU
Slough connectivity	Br_10	2	0.06
Slough connectivity	Br_12	25	3.01
Slough connectivity	Br_13	80	4.83
Thweatt Chute connectivity	D_1	84	3.89
Slough connectivity	HT_1	9	0.47
Slough connectivity to Ballard Slough	HT_4	54	4.75
Ag field connectivity	HT_7	21	0.27
Food plot connectivity	HT_10	16	0.17
Swale connectivity to slough	HB_2ab	8	0.56
Borrow pit connection	I35_6c	22	0.11
I35 Towhead Chute connectivity	I35_8_a	70	7.73
Slough connectivity	I35_10a	4	0.02
Slough connectivity	I35_11	17	0.77
Danner Lake upstream connectivity	I40_1b	161	2.47
I40/41 Chute upstream connectivity	I40_2b	5	0.90
Slough connectivity	I40_4	5	0.22
Slough connectivity	I40_5	17	1.19
Redman Point Bar 2nd channel downstream connectivity	RL_3	4	0.42
Mound City Chute connectivity	RL_7	100	4.72
Slough connectivity	S_1	21	0.93
Slough connectivity	S_2	2	0.12
Lookout Bar downstream connectivity	S_6	127	46.38

2.2.3.2 LMR Floodplain Waterbody Wetland Isolation (Isolation)

Four measures were evaluated with the isolation model. Elevated ground around these three borrow areas and a crevasse would have led to infrequent connection if manmade channels had not been created. Reduced connectivity would benefit the wetland fish guild and aid in the overall diversity of waterbody types. Connectivity ranged from 6 to 21 percent and project measures proposed to reduce this connectivity to 3 to 10 percent. The relatively small acreage of the waterbodies and the less than 15 percent reduction in connectivity led to low AAHUs (Table 2-6).

Table 2-6. Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Isolation Model

Short Description	Measure Code	Acres	Net AAHU
Isolate borrow area	HB_10	12	0.61
Isolate borrow area	I35_4b	5	0.11
Isolate Golden Lake Crevasse	I35_5c	41	0.33
Isolate borrow area	I40_6	29	1.50

2.2.3.3 LMR Unidirectional Channel Connectivity Model (Unidirectional)

Five measures were evaluated with the unidirectional model. Dikes, road bridges, and vegetated sediment deposits increased the bed elevation of these secondary channels and meander scarps. This higher ground floods less often. The 2007 LWRP stage that channels began to flow currently ranges from 3 feet to 16 feet and project measures propose to decrease the stage to -5 feet to 10 feet. The large acreage of these measures combined with modest improvements in HSI resulted in AAHUs ranging from 23 to 275 (Table 2-7).

Table 2-7. Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Unidirectional Model

Short Description	Measure Code	Acres	Net AAHU
Notch Poker Point pile dikes	Br_1	106	24
Flow thru Brandywine Chute	Br_4	499	122
Flow thru I35 Chute	I35_3	240	4[8]
Notch Dean 2nd channel dikes	I35_7a	341	64
Flow thru Island 34 & Sunrise Towhead Chute	S_4	705	300

2.2.3.4 Borrow Area HSI Fish Diversity Model (Borrow)

The borrow area model was used to evaluate 11 measures that proposed to increase depth in borrow areas and one slough. The moderate acreage changes in HSI between without and with project produced moderate net AAHUs (Table 2-8).

Table 2-8. Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Borrow Model

Short Description	Measure code	Acres	Net AAHU
Deepen borrow area	Br_14	47	4.41
Deepen borrow areas	Br_16	54	3.76
Deepen Thweatt Chute	D_2	84	5.27
Deepen borrow area	HB_3	6	1.41
Deepen borrow area	HB_4	7	1.63
Deepen borrow area	HB_5	6	1.41
Deepen borrow area	HB_6	13	2.75
Deepen borrow area	HB_7	8	1.83
Deepen borrow area	HB_8	16	3.22
Deepen borrow area	HB_9	12	2.58
Deepen borrow areas	I40_7a	29	4.52

2.2.3.5 LMR River Training Structure Riverine Eddy Model (Eddy)

Three measures, each in a different complex, were evaluated with the eddy model. These measures created large benefits as captured by the difference between without and with project HSI and AAHUs varied depending on the acreage effected by the measure (Table 2-9).

Table 2-9 Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Eddy Model

Short Description	Measure code	Acres	Without	With	Net AAHU
			HSI		
Brandywine Chute hardpoints	Br_5	499	0.10	1.00	445
Dean 2nd Channel hardpoints	I35_7g	3	0.10	1.00	2.67
Main channel bank hardpoints	M_1	6	0.10	1.00	5.35

2.2.3.6 LMR Aquatic Invertebrate Substrate Model (substrate) and LMR Wood Traps Model

A structure to prevent fine sediment deposition on gravel was evaluated by the substrate model. The addition of wood traps was evaluated by the wood trap model. These six measures affected larger acreages with large differences between without and with HSI, resulting in high Net AAHUs (Table 2-10).

Table 2-10. Net Average Annual Habitat Units (Net AAHU) for Measures Evaluated with the Wood Trap or Substrate Model

Short Description	Measure Code	Acres	Net AAHU
Wood traps Poker Point	Br_2	106	70
Wood traps Densford	D_3	125	83
River structure clean gravel	HT_2	45	2[2]
Wood traps Hickman Bar 2nd channel	M_14	740	491
Wood traps Loosahatchie	RL_6	790	52[4]
Wood traps Lookout Bar 2nd channel	S_7	127	84

2.2.3.7 Hydrogeomorphic Model (HGM) - Regional Guidebook for the MAV

HGM was applied to 32 restoration measures across nine complexes totaling over 4,600 acres (Table 2-11). The HGM evaluation provided a particularly compelling opportunity to visualize the temporal response for each complex. In general, the following conclusions can be made:

- Approximately 10 years are required before most functions are expressed. Afterward, functional capacity increases substantially over time.
- Functions that are driven by hydrologic restoration and connectivity (detain floodwater, detain precipitation, cycle nutrients, and export organic matter) respond rapidly as compared to functions relying predominantly on plant maturation (maintain plant communities and provide habitat for fish and wildlife).
- Restoration of slough systems and existing agricultural lands results in the most benefit in net AFCUs.

Table 2-11. Application of HGM to Island Complexes

Short Description	Measure Code	Acres	Net AAFCU
Deans island reforestation	I35_2	42	65
Riparian buffer	I35_6b	11	25
Reforest bankline	I35_7h	8	18
Forested buffer	I35_9b	12	27
Cypress-tupelo swamp	I35_12a	14	32
Slough reforestation	I35_12b	55	126
Canopy gaps	Br_6	78	66
Canopy gaps	Br_7	196	48
Increase flow/reduce ponding	Br_8	207	133
Increase flow/reduce ponding	Br_9	15	31
Reduce inundation frequency	Br_11	600	627
Restore Willow Lake	Br_15	583	203
Reforest LMR high bank	HT_6	52	26
Prevent gully head cut, install grade control structure	HT_8	18	3
Reestablish flow, plant emergents	HB_2c	22	39
Reforestation	I40_1a	37	46
Reforestation	I40_2a	29	36
Reforest high bank	I40_3	59	102
Reforest wet agricultural land	I40_7b	44	116
Weir for cypress	M_5	6	8
Emergents for waterfowl	M_6	30	14
Emergents for waterfowl	M_11	52	24
BLH enhancement	M_13	54	29
BLH enhance forest	RL_4	1049	676
Reforest cypress-tupelo	RCP_1	8	19
Connectivity, emergent veg.	RCP_2	110	177
Bear Creek	RCP_3	87	177
Bear Creek	RCP_4	11	69
Reforest cypress-tupelo	S_8	19	30
Restore I34	S_9	1167	1,614
Buffer I34 riparian	S_10	21	36

2.2.4 Cost Estimates

Preliminary first cost estimates were developed for each of the 85 remaining measures (83 ecological; two recreational opportunities). These preliminary cost estimates included planning engineering and design costs, real estate costs, construction costs, construction management costs, monitoring and adaptive management costs, OMRR&R and contingencies. These costs were used to calculate average annual costs over the 50-year period of analysis.

- PED costs were estimated as a percentage of the construction costs developed for each site, consisting of costs for all activities associated with the PED effort, including costs related to regulatory compliance, field data collection, and the preparation of design plans, documentation, and specifications.
- Real estate costs developed for each site assumed that fee title and temporary easements would be acquired per ER 1105-2-100 Sec. 3- 5(b)(9) and ER 405-1-12. For initial screening, parametric cost estimates were applied to each measure based on the benefits acres identified in Section 2.2.3 and land type (open water, woodlands, agricultural land). A full real estate plan (REP) and revised cost estimates were developed for the TSP.
- Construction management costs were estimated as a percentage of the construction costs or adjusted upward to ensure appropriate funding was available for construction oversight for lower cost measures.
- Project contingencies were developed for each site using an Abbreviated Risk Analysis (ARA) provided by the Cost Engineer and ranged from 9 percent to 88 percent, depending on construction activity.

Costs for OMRR&R of measures were also estimated, for use in the calculation of the measures' average annual costs. Costs are shown at the FY24 price level and were annualized using the current FY24 Federal discount rate of 2.75 percent over a 50-year period of analysis.

See Appendix 4 (Cost Engineering) for the developed cost estimates and ARA. Appendix 7 (Economics) shows how cost estimates were annualized. It should be noted that only costs were developed for the recreational measures associated with objective 4 and those recreational measures were added to the final array. Please note that the preliminary costs estimates for the final array were updated for the selected TSP. The estimates presented in this section and Appendix 7 were updated and refined for the selected TSP presented in Section 5.

2.2.5 Use of CEICA as a Tool for Screening of Measures and Development of Alternatives

CEICA are analytical tools for assessing the relative outputs and costs of ecosystem restoration actions and informing decisions. Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. CEICA can be applied multiple ways when examining a multi-site restoration project. For this study, CEICA was used iteratively to evaluate and screen measures based on efficiency and to later develop efficient measure combinations, which were used to identify an array of alternative plans.

The CEICA related to measure evaluation and screening is presented in this section and CEICA results for the final array of alternative plans is presented in Section 2.4.2.

To perform the CEICA, the IWR Planning Suite Decision Support Software developed by USACE was used. IWR Planning Suite has been developed to assist with plan comparison by conducting CEICA. The software, available online, identifies the plans that are the best financial investments (best buys) and displays the effects of each on a range of decision variables. The latest version (2.0.9.1) has been certified for use by USACE Headquarters, meaning that it has been reviewed and certified by the appropriate PCX and represents a corporate approval that the model is sound and functional.

In general, for any given level of investment, the agency wants to identify the plan with the greatest return-on-investment (i.e., the most environmental outputs for a given level of cost or the least cost for a given level of environmental output). An "efficiency frontier" identifies all plans that efficiently provide outputs on a per cost basis. Incremental cost analysis (ICA) sequentially compares each cost-effective plan to all larger cost-effective plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide outputs on an incremental unit cost basis. ICA is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing outputs (i.e., each unit becomes more expensive). Plans emerging from ICA efficiently accomplish objectives relative to unit costs and area typically referred to as best buys. For each plan, net outputs were computed over the FWOP condition to reflect the change in ecological condition associated with the restoration costs.

The developed costs and outputs for the 83 remaining ecological management measures were used as inputs to the IWR Planning Decision Support Software CEICA (See Section 2.2.3, 2.2.4 and Appendix 7 Economics). The two remaining recreation measures were not run through IWR Planning Suite since they would not provide ecological restoration benefits.

Three rounds or iterations of CEICA and a total of 12 separate CEICA runs were used to inform measure evaluation and screening leading to the final array. A summary of this analysis is provided below; see Appendix 7 Economics for an in-depth discussion. Since this was early in the screening of measure the teams used both the information obtained from CEICA regarding the efficient of the measure in providing ecological outputs along with consideration of technically significant habitat as previously defined in Section 2.2.2. The project delivery team (PDT) did not want to prematurely screen out measures that included significant resources and important habitats before they were given full consideration.

The first round of CEICA evaluated 83 ecological measures to determine the most efficient measures for restoration of each habitat function. CEICA was performed separately for six ecological models identified in Section 2.2 and with one run for wood trap and substrate models. Each measure was only included under one model and one CEICA run. Additionally, due to the CEICA tool model computational limits regarding the number of inputs and the large number of measures to enhance and restore natural floodplain evaluated by the HGM model, two separate initial runs (measures with plantings and measure with no plantings) were performed. Splitting of the initial run did not impact screening of measures to enhance and restore natural floodplain vegetation. Thus, eight separate CEICAs were performed for this round. Measures that were not included in best

buy or cost-effective plans were removed from further consideration (non- efficient measures). Next, the frequency in which measures were included in the identified best buy plans were examined. Measures identified in more than 50 percent of the best buy plans were automatically moved forward for further evaluation. Measures identified in less than 50 percent of the resulting best buy plans were examined for potential screening. The measures that showed up with less frequency were further evaluated before screening to determine if the measure restored a technically significant habitat (Section 2.2.2). In cases where a technically significant habitat would be screened out during this early plan formulation iteration technically significant measures were reevaluated and combined and/or scaled where possible. In subsequent rounds of CEICA, if they still were underperforming, the measure was screened. There were 68 total measures retained. These 68 measures were next grouped by objective to determine the best performing measures per objective (vegetative species, large river species and floodplain water bodies).

A second round of CEICA was run on the remaining ecological measures to determine the best measures under each objective. The 68 retained measures were run together in three CEICA analyses for objectives 1, 2, and 3, respectively. This was due to the large number of management measures with varying features. The fourth objective, recreation, was not evaluated using CEICA. See Appendix 7 for results from CEICA. All measures included in best buy plans were retained. Fifty-eight ecological measures were retained, which were then grouped into 27 alternative measure groups based on the geographic locations of the benefit areas.

The third and final round of CEICA was conducted to determine the final array of alternatives. The study team identified two standalone alternatives (Alternatives A and B) by manually combining measures. Alternative A incorporated measures characterized as best buys for habitat diversity from all objectives and all model runs. Alternative B incorporated measures within public lands where real estate acquisition was minimal. Alternative A and B were not combinable with other alternatives or measures. To develop additional alternatives in the final array, the CEICA tool was used to create efficient combinations of the identified 27 measure groups. The CEICA resulted in 501 efficient plans and 27 best buys.

2.3 THE FINAL ARRAY OF ALTERNATIVES

The following section describes the final array of 10 alternatives. The final array of alternatives was identified based on the CEICA results by looking at the alternatives identified on the efficiency frontier breakpoints in the scatter plot of average annual costs and outputs, and the bar chart of the resulting best buys. Study objectives and the technical significance of the habitat were also considered in the identification of the final array. The recreational opportunities were added to the final array. All alternatives in the final array incorporated LW_1, and alternatives that included measures on land within Meeman-Shelby Forest State Park also incorporated measure M_2.

The specific measures and activities associated with each alternative are listed in its associated subsection. See Table 2-12 for measures included in the final array of alternatives. Please see Appendix 1 for more specific details of each identified measure and individual maps depicting the locations of the alternatives in the final array.

The final array of alternatives include the following:

- No Action Alternative-Baseline for comparison
- Alternative A-study team Developed
- Alternative B-study team Developed
- Alternative C1-CEICA Developed
- Alternative C2-CEICA Developed
- Alternative C3-CEICA Developed
- Alternative C4-CEICA Developed
- Alternative C5-CEICA Developed
- Alternative C6-CEICA Developed
- Alternative C7-CEICA Developed

Table 2-12. Measures Included in the Final Array of Alternatives

	Measures
No Action	None
A	Br_1, BR_2, Br_5, BR_6, D_1, D_2, D_3, HB_10, HT_4, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7h, I35_9b, I40_1a, I40_3, I40_6, I40_7b, M_14, M_5, RCP_1, RCP_2, RCP_4, RL_6, RL_7, S_10, S_4, S_6, S_7, S_8, LW_1, M_2
B	BR_1, BR_2, BR_5, D_3, HB_1, HB_3, HB_4, HB_5, HB_6, HB_7, HB_8, HB_9, I35_7a, M1, M5, M6, M11, M14, RL_3, RL_6, S_4, S_6, S_7, LW_1, M_2
C1	BR_1, BR_11, BR_2, BR_5, BR_6, BR_7, BR_8, D_3, HT_6, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_1a, I40_1b, I40_3, M_14, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_10, S_6, S_7, S_8, LW_1
C2	BR_1, BR_11, BR_2, BR_5, BR_6, BR_7, BR_8, D_3, HT_6, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_1a, I40_1b, I40_3, M_14, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_10, S_4, S_6, S_7, S_8, LW_1
C3	BR_1, BR_11, BR_2, BR_4, BR_5, BR_6, BR_7, BR_8, D_3, HB_1, HB_2ab, HB_2c, HT_6, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_1a, I40_1b, I40_3, M_14, M_5, M_6, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_10, S_4, S_6, S_7, S_8, LW_1, M_2
C4	BR_1, BR_11, BR_12, BR_13, BR_2, BR_4, BR_5, BR_6, BR_7, BR_8, D_1, D_2, D_3, HB_1, HB_10, HB_2ab, HB_2c, HB_3, HB_4, HB_5, HB_6, HB_7, HB_8, HB_9, HT_4, HT_6, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_1a, I40_1b, I40_3, I40_6, I40_7a, M_14, M_5, M_6, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, RL_7, S_1, S_10, S_4, S_6, S_7, S_8, LW_1, M_2
C5	BR_1, BR_11, BR_2, BR_5, BR_6, BR_7, BR_8, D_3, HB_1, HB_2ab, HB_2c, HT_6, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_1a, I40_1b, I40_3, M_14, M_5, M_6, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_10, S_4, S_6, S_7, S_8, LW_1, M_2
C6	BR_1, BR_2, BR_5, D_3, I35_12a, I35_12b, I35_2, I35_6b, I35_7a, I35_7g, I35_7h, I35_9b, I40_3, M_14, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_10, S_6, S_7, S_8, LW_1
C7	BR_1, BR_11, BR_2, BR_5, BR_6, BR_7, BR_8, D_3, I35_12a, I35_12b, I35_2, I35_7a, I35_7g, I35_7h, I35_9b, I40_3, M_14, RCP_1, RCP_2, RCP_4, RL_3, RL_4, RL_6, S_4, S_6, S_7, S_8, LW_1

Cost estimates were developed for each measure and compiled per alterative. See Table 2-13 for a summary of costs for alternatives in the final array.

Table 2-13. Summary of Costs for the Final Array of Alternatives ($1,000)

	Construction, PED, and Construction Management (S&A)	Real Estate (Lands and Damages)	Adaptive Management & Monitoring, including monitoring program costs	Project First Costs	Average Annual OMRR&R Costs	Total Average Annual Costs for the Alternative
No Action	$0	$0	$0	$0	$0	$0
A	$20,425	$4,289	$3,455	$24,803	$43	$952
B	$22,718	$938	$3,293	$23,758	$69	$936
C1	$6,901	$10,954	$3,743	$17,989	$26	$700
C2	$18,440	$10,954	$3,790	$29,536	$45	$1,132
C3	$29,442	$11,639	$3,944	$41,244	$61	$1,571
C4	$44,831	$13,884	$4,394	$58,970	$73	$2,226
C5	$20,982	$11,621	$3,893	$32,757	$61	$1,266
C6	$5,198	$5,948	$3,397	$11,233	$24	$448
C7	$18,072	$9,648	$3,673	$27,853	$44	$1,068

*Project first costs and total annual costs presented in the table reflect the parametric costs used for CEICA runs with added recreation costs and AM&M programmatic costs. C3 costs were later refined after TSP selection.

2.3.1 No Action Alternative

The outcome of the No Action Alternative is the FWOP condition. The forecast of the FWOP reflects the conditions expected during the period of analysis (2028-2078). Under the No Action Alternative, no ecosystem restoration would occur and the resources in the study area would continue to decline in all 11 of the geographic complexes. See section 1.8.30 for a more detailed description of the FWOP condition.

2.3.2 Alternative A

Alternative A includes measures for altered connectivity, aquatic channel enhancement, enhanced and restored natural vegetation, water body management and recreation. Alternative A consists of 32 ecological measures and two recreational measures. Alternative A would include restoration to eight habitat types, including BLH, borrow area, cypress-tupelo, meander scarp, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in alternative are spread across 10 geographic complexes and include a benefit area of 4,256 acres. This alternative includes restoration in the following

complexes: Brandywine Island (Br), Densford (D), Hatchie Towhead Randolph (HT), Hopefield Point Big River Park (HB), Island 35 Deans Island (I35), Island 40/41 (I40), Meeman Shelby (M), Redman Point Loosahatchie Bar (RL), Richardson Cedar Point (RCP), Sunrise Island 34 (S), and Loosahatchie River/Wolf River (LW). Potential construction activities include dike notching, woody debris traps, riprap bank protection, earthwork, grade control structures, culverts, vegetative improvements, weirs and stop log structures, bridge replacement, and river training structures. The ecological models used to determine benefits of measures included Bidirectional, Borrow, Eddy, HGM, Wood Trap, Isolation, and Unidirectional. This alternative would provide a total of 3,110 AAHUs.

2.3.3 Alternative B

Alternative B includes measures for altered connectivity, aquatic channel enhancement, enhance and restore natural vegetation, water management, water body enhancement and recreation. Alternative B consists of 23 ecological measures and two recreational measures. Alternative B encompasses measures on public lands encompassing seven habitat types, including BLH, borrow areas, cypress-tupelo, meander scarp, moist soil, seasonally herbaceous wetland, and secondary channels. The measures in Alternative B are spread across seven geographic complexes and include a benefit area of 3,564 acres. Restoration would be implemented in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Island 35 Deans Island, Island 40/41, Redman Point Loosahatchie Bar, Sunrise Island 34, Loosahatchie River Wolf River. Ecological models used for measures in B included Bidirectional, Borrow, Eddy, HGM, Wood Trap, and Unidirectional. Potential required construction activities include dike notching, installation of woody debris traps, river training structures, bridge replacement, earthwork, riprap bank protection, vegetative improvement, hardpoints and stoplog structures, and a groundwater well. This alternative would provide a total of 2,205 AAHUs.

2.3.4 Alternative C

Alternative C consisted of seven sub-alternatives formulated from 27 potentially combinable groupings of 58 measures. These are broken out by sub-alternative in further detail below.

2.3.4.1 Alternative C1

Alternative C1 includes measures for altered connectivity, aquatic channel enhancement, and enhance, restore natural vegetation and recreation. Alternative C1 consists of 31 ecological measures and one recreational measure. Alternative C1 measures encompass six habitat types, including BLH, cypress-tupelo, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in Alternative C1 are spread across nine complexes and include a benefit area of 5,494 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Island 35 Deans Island, Island 40/41, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C1 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. Potential construction activities include dike notching, installation of woody debris traps, riprap bank protection, vegetative improvement activities, culverts, and earthwork. This alternative would provide a total of 4,180 AAHUs.

2.3.4.2 Alternative C2

Alternative C2 includes measures for altered connectivity, aquatic channel enhancement, enhance, and restore natural vegetation and recreation. Alternative C2 consists of 32 ecological measures and one recreational measure. Alternative C2 encompasses seven habitat types, including BLH, cypress-tupelo, meander scarp, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in Alternative C2 are spread across nine complexes and include a benefit area of 6,199 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Island 35 Deans Island, Island 40/41, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C2 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. Potential construction activities include dike notching, installation of woody debris traps, riprap bank protection, vegetative improvement activities, culverts, earthwork, river training structures, and bridge replacement. This alternative would provide a total of 4,481 AAHUs.

2.3.4.3 Alternative C3

Alternative C3 includes measures for altered connectivity, aquatic channel enhancement, enhance, restore natural vegetation, water management and recreation. Alternative C3 consists of 38 ecological measures and two recreational measures. Alternative C3 encompasses eight habitat types, including BLH, cypress-tupelo, meander scarp, moist soil, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in Alternative C3 are spread across 11 geographic complexes and include a benefit area of 6,282 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Hopefield Point Big River Park, Island 35 Deans Island, Island 40/41, Meeman Shelby, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C3 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. Construction activities include dike notching, installation of woody debris traps, bridge replacement, weirs and stoplog structures, riprap bank protection, vegetative improvement measures, culverts, earthwork, and river training structures. This alternative would provide a total of 4,673 AAHUs.

2.3.4.4 Alternative C4

Alternative C4 includes measures for altered connectivity, aquatic channel enhancement, enhance, and restore natural vegetation, water body enhancement, water management and recreation. Alternative C4 consists of 55 ecological measures and two recreational measures. Alternative C4 encompasses nine habitat types, including BLH, borrow, cypress-tupelo, meander scarp, moil soil, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in Alternative C4 are spread across all 11 geographic complexes and include a benefit area of 6,735 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Hopefield Point Big River Park, Island 35 Deans Island, Island 40/41, Meeman Shelby, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C4 included Bidirectional, Borrow, Eddy, HGM, Wood Trap, Isolation, and Unidirectional. Construction activities include dike notching, installation of

wood debris traps, bridge replacements, weirs and stoplog structures, riprap bank protection, vegetative improvement activities, culverts, earthwork, grade control structures, dewatering, and river training structures. This alternative would provide a total of 4,722 AAHUs.

2.3.4.5 Alternative C5

Alternative C5 includes measures for altered connectivity, aquatic channel enhancement, enhance, and restore natural vegetation, water management and recreation. Alternative C5 consists of 37 ecological measures and two recreational measures. Alternative C5 encompasses eight habitat types, including BLH, cypress-tupelo, meander scarp, moist soil (alligator gar habitat), riverfront, seasonally herbaceous wetland, secondary channels, and slough. The measures in Alternative C5 are spread across 10 geographic complexes and include a benefit area of 6,274 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Hatchie Towhead Randolph, Hopefield Point Big River Park, Island 35 Deans Island, Island 40, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C5 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. Potential construction includes dike notching, installation of wood debris traps, riprap bank protection, vegetation improvement measures, culverts, weirs and stoplog structures, earthwork, river training structures, and bridge replacement. This alternative would provide a total of 4,551 AAHUs.

2.3.4.6 Alternative C6

Alternative C6 includes measures for altered connectivity, aquatic channel enhancement, enhance and restore natural vegetation and recreation, Alternative C6 consists of 24 ecological measures and one recreational measure. Alternative C6 encompasses five habitat types, including BLH, cypress-tupelo, riverfront, seasonally herbaceous wetland, and secondary channels. The measures in Alternative C6 are spread across eight complexes and include a benefit area of 4,163 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Island 35 Deans Island, Island 40/41, Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Models for measures in C6 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. Modeling efforts represented eight of the relevant geographic complexes. Potential construction activities include dike notching, installation of woody debris traps, riprap bank protection vegetative improvement, and culverts. This alternative would provide a total of 3,232 AAHUs.

2.3.4.7 Alternative C7

Alternative C7 includes measures for altered connectivity, aquatic channel enhancement, enhance and restore natural vegetation and recreation. Alternative C7 consisted of 27 ecological measures and one recreational measure. Alternative C7 encompasses six habitat types, including BLH, cypress-tupelo, meander scarp, riverfront, seasonally herbaceous wetland, and secondary channels. Models for measures in C7 included Bidirectional, Eddy, HGM, Wood Trap, and Unidirectional. The measures in Alternative C7 are spread across eight complexes and include a benefit area of 5,917 acres. Restoration would occur in the following complexes: Brandywine Island, Densford, Island 35 Deans Island, Island 40/41,

Redman Point Loosahatchie Bar, Richardson Cedar Point, Sunrise Island 34, and Loosahatchie River Wolf River. Construction activities include dike notching, installation of woody debris traps, riprap bank protection, vegetative improvement measures, culverts, river training structures, bridge replacement, and earthwork. This alternative would provide a total of 4,346 AAHUs.

2.4 PLAN EVALUATION

To determine the TSP, the final array of alternatives were evaluated and compared based on the following criteria:

- Performance - forecasting of environmental benefits of restoration actions through ecological modeling (AAHUs) (described in Section 2.2.3)
- Ability to meet project objectives (described in Section 2.4.1)
- CEICA (described in Section 2.4.2)
- Evaluation against P&G criteria (described in Section 2.4.3)
- Impact to environmental and human resources (described in Section0)
- Risk and uncertainty (2.4.4)
- Comprehensive benefits-contributions to Federal objectives and the four planning accounts (NED, RED, EQ, and OSE) (described in Section 2.5.22.4.5)
- Technical significance-established habitat ranking based on scarcity and importance of habitat to special status species (described in Section 2.2.2).

2.4.1 Ability to Meet Project Objectives

The study team evaluated how well the various alternatives met the project objectives. The team developed measures to meet project objectives therefore, most of the alternatives at least minimally met the identified objectives. However, the extent to which they met the objective differs. Alternatives A, B, C2, C3, C4, C5 and C7 met all of the study objectives to varying extents. The No Action Alternative did not meet any of the study objectives. Alternative C6 does not meet objective 3. Table 2-14 summarizes the alternative's ability to meet the planning objectives. Each alternative was evaluated and the number of times the alternative included a measure to address a specific habitat type was counted to determine the rank of the alternatives. The technical significance of habitats was considered separately. Specifically, it identifies how each respective alternative addresses the habitats under the objectives using the following abbreviations:

- CT- Cypress-tupelo swamp
- SHW - Seasonal herbaceous wetlands
- BLH - Bottomland hardwood forest
- RF- Riverfront Forest
- Moist soil
- MC - Main channel
- SC - Secondary channels
- MS - Meander scarp
- B - Borrow
- S – Slough
- RM - Recreation Measure

Table 2-14. Evaluation of Final Array Against Study Objectives

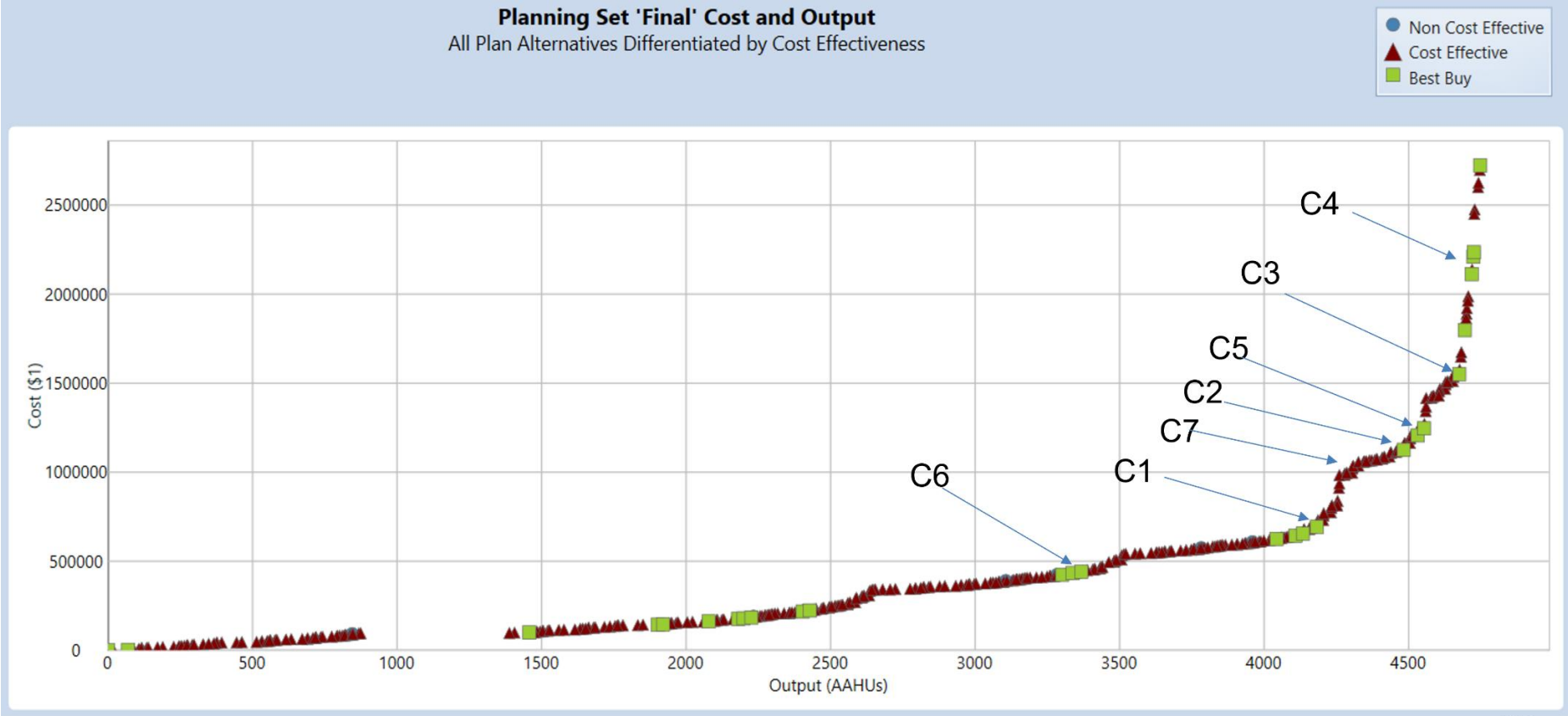
Objective	Habitat Addressed	No Action	A1 34 Measures	B1 25 Measures	C1 32 Measures	C2 33 Measures	C3 40 Measures	C4 57 Measures	C5 39 Measures	C6 25 Measures	C7 28 Measures
1-Vegetative Mosaic	Cypress-tupelo swamp (CT) seasonal herbaceous wetlands (SHW), BLH, riverfront forest (RF), moist soil	0 CT, 0 SHW, 0 BLH, 0 RF, 0 moist soil	4 CT, 1 SHW, 7 BLH, 5 RF, 0 moist soil	1 CT, 1 SHW, 1 BLH, 0 RF, 2 moist soil	3 CT, 1 SHW, 10 BLH, 6 RF, 0 moist soil	3 CT, 1 SHW, 10 BLH, 6 RF, 0 moist soil	4 CT, 3 SHW, 10 BLH, 6 RF, 1 moist soil	4 CT, 3 SHW, 10 BLH, 6 RF, 1 moist soil	4 CT, 3 SHW, 10 BLH, 6 RF, 1 moist soil	3 CT, 1 SHW, 5 BLH, 5 RF, 0 moist soil	3 CT, 1 SHW, 8 BLH, 4 RF, 0 moist soil
		Rank 10	Rank 7	Rank 6	Rank 8	Rank 4	addresses all habitat types; Rank 2	Addresses all habitat types; Rank 1	Rank 3	Rank 9	Rank 5
2-Large River	Main channel (MC), secondary channels (SC)	0 MC 0 SC	0 MC 8 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC	0 MC 10 SC
		Rank 9	Rank 8	Rank 9	Rank 1	Rank 1	Rank 1	Rank 1	Rank 7	Rank 1	Rank 1
3-Floodplain waterbodies	Meander scarp (MS), Borrow (B), slough (S)	0 MS, 0 B, 0 S	1 MS, 3 B, 3 S	1 MS, 7 B, 0 S	0 MS, 0 B, 1 S	1 MS, 0 B, 1 S	2 MS, 0 B, 2 S	2 MS, 11 B, 8 S	1 MS, 0 B, 2 S	0 MS, 0 B, 0 S	1 MS, 0 B, 0 S
		Rank 10	Rank 3	Rank 4	Rank 8	Rank 6	Rank 2	Addresses all habitat types; Rank 1	Rank 5	Rank 9	Rank 7
4-Recreation	Recreation Measure (RM)	0 RM	2 RM	2 RM	1 RM	1 RM	2 RM	2 RM	2 RM	1 RM	1 RM
		Rank 10	Rank 1	Rank 1	Rank 6	Rank 6	Rank 1	Rank 1	Rank 1	Rank 6	Rank 6
Final Rank (1 is best)		10	4	6	8	4	2	1	6	9	3

2.4.2 Cost-Effective and Incremental Cost Analyses

As previously described in Section 2.2.5, multiple iterations of the IWR Planning Suite were used to identify efficient (cost-effective) measures and combinations of measures to form the final array of alternatives and then ultimately inform the TSP selection. The initial iterations were used to evaluate and screen measures and identify the final array of alternatives (See Section 2.2.5 and the Economics Appendix 7). The final array of alternatives was identified based on the efficiency frontier and the break points in the scatter plot of average annual costs and outputs (Figure 2-4) and the bar chart of the resulting best buys (Figure 2-4) from the CEICA modeling analysis. Project objectives and the technical significance of the habitat were also considered in the identification of the final array.

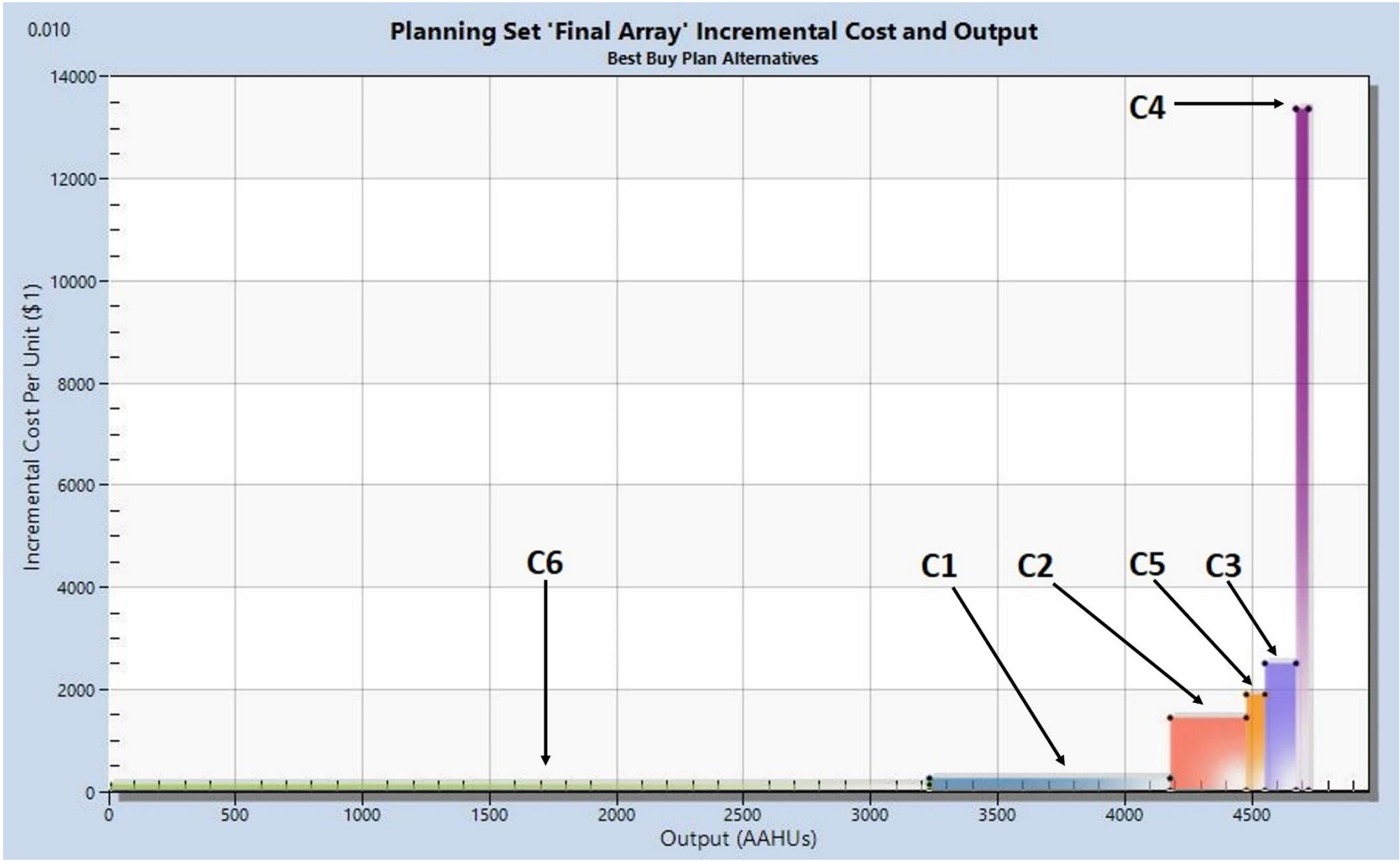
This section presents the results of the CEICA modeling analysis for the final array of alternatives. For environmental planning, in the absence of a common measurement unit for comparing the non-monetary outputs with the monetary costs of environmental plans, CEICA are valuable tools to assist in decision making. The cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each possible level of environmental output. A solution is defined as cost-effective when, for a given level of output or AAHUs, no other alternative plan has a lower cost. Similarly, a solution is cost-effective when no other alternative plan yields more output or AAHUs for the same or less cost. Subsequent ICA of the cost-effective solutions is conducted to reveal changes in costs for increasing levels of environmental outputs. The most efficient plans are identified as best buys and these plans provide the greatest increases in output for the least increases in cost and have the lowest incremental costs per unit of output for successively larger levels of output (USACE 2000).

Figures 2-4 and 2-5 and Tables 2-15 present the results of the IWR Planning Suite CEICA modeling for the final array of alternatives. The results of the model indicated that Alternative A and B were non-cost-effective and therefore, are not displayed on the figures. Alternatives C1, C2, C3, C4, C5, and C6 were identified as both cost-effective and best buy plans. Alternative C7 was identified as a cost-effective plan.



Note: The X-axis is net AAHUs; the Y-axis is the average annual cost ($).

Figure 2-4. Range of Cost-Effective Solutions: Round 3



Note: The X-axis is net AAHUs; the Y-axis is the incremental cost per AAHU.

Figure 2-5. Incremental Cost and Output for the Best Buy Plans: Final Array

Table 2-15. Final Array Average Annual Costs and Benefits

Alternative	CEICA Results	AAHU (Total Output)	Project First Cost ($1,000)	Incremental Cost ($1,000)	Incremental Cost Per Unit of Output	Average Annual Cost ($1,000)	Average Annual Cost/AAHU
B	Non-Cost-Effective	2,205	$23,758	-	-	$936	$424
A	Non-Cost-Effective	3,110	$24,803	-	-	$952	$306
C6	Best Buy	3,232	$11,233	$448	$138	$448	$138
C1	Best Buy	4,180	$17,989	$252	$266	$700	$167
C7	Cost-Effective	4,346	$27,853	$368	$2,217	$1,068	$246
C2	Best Buy	4,481	$29,536	$432	$1,435	$1,132	$253
C5	Best Buy	4,551	$32,757	$134	$1,914	$1,266	$278
C3	Best Buy	4,673	$41,244	$305	$2,500	$1,571	$336
C4	Best Buy	4,722	$58,970	$655	$13,367	$2,226	$471

Notes: Costs in the table above are shown at the 2023 price level and were annualized using the current FY23 Federal discount rate of 2.5 percent over a 50-year period of analysis.

Because C7 is not a Best Buy, incremental cost, and incremental cost per unit of output for C2 are calculated in relation to C1.

2.4.3 "Is It Worth It?" Analysis

It is important to keep in mind that the most useful information developed by the two methods of CEICA is what it tells decision makers about the relative relationships among solutions – that one will likely produce greater output than another, or one is likely to be more costly than another – rather than the specific numbers that are calculated. Furthermore, these analyses will usually not lead, and are not intended to lead, to a single best solution (as in economic cost-benefit analysis); however, they are intended to improve the quality of decision making by ensuring that a rational, supportable approach is used in considering and selecting alternative methods to produce environmental outputs.

Using the results of the CEICA analysis, the benefits associated with the environmental incremental outputs have to be evaluated against the incremental increase in costs. This analysis, called the “Is It Worth It?” analysis, evaluates each plan, its incremental outputs and costs, and the benefits provided by the plan to make a case that the plan is worth the Federal investment to achieve those benefits.

The “Is It Worth It?” analysis also considers technical significance of the habitat in the study area. Technical significance rankings factor in habitat scarcity and habitat importance to special status species (Table 2-3). Of the measures retained, meander scarps ranked the highest for technical significance. The importance of meander scarps is further described in Section 1.6.1.1. For more information on technical significance, please see Section 2.2.2.

Following the guidance to “reasonably maximize” ecosystem outputs while passing tests of CEICA, the goal was to select a plan that reasonably maximizes ecosystem restoration opportunities for the habitats with the highest technical significance while meeting with the goals and objectives established for the study.

The following analysis evaluates the best buy plans in ascending order of average annual cost: No Action, C6, C1, C2, C5, C3, and C4. The best buy plans are evaluated against the No Action Alternative.

2.4.3.1 No Action Alternative (CEICA)

The no action plan represents no Federal action to address declining ecosystem function across the 11 geographic complexes of the study area. The plan would not address the lack of hydrologic connectivity that poses adverse impacts to important spawning and nursery habitat and riparian dependent species. Adverse impacts from invasive species would continue. The plan would not address degraded vegetive conditions, such as fewer mast producing species, cypress-tupelo swamp habitats, and rivercane.

The outcome of the No Action Alternative is the FWOP condition. The forecast of the FWOP reflects the conditions expected during the period of analysis (2028-2078). Under the No Action Alternative, no ecosystem restoration would occur in any of the 11 geographic complexes and conditions would remain adversely impacted. While there is no investment cost associated with this plan, the No Action Alternative is not “worth it” because it does not address any of the planning objectives and leaves the study area in a degraded state.

2.4.3.2 Alternative C6 (CEICA)

Alternative C6, the second best buy plan (after No Action), provides restoration features in eight of the 11 geographic complexes for five habitat types, including BLH, cypress-tupelo, riverfront forest, seasonally herbaceous wetland, and secondary channels. Complexes with ecological measures not included are Hatchie Towhead Randolph and Hopefield Point Big River Park. Loosahatchie Wolf River does not contain ecological measures. Alternative C6 provides an environmental output of 3,232 AAHUs. The incremental cost per incremental AAHU is $138 at a first cost of $11,233,000. While Alternative C6 is an improvement over the No Action Plan, it does not address all of the planning objectives (i.e., it does not include any measures to meet the floodplain waterbodies objective) nor distribute restoration

measures across all of the geographic complexes. In comparison to other best buys, Alternative C6 does not capture all of the potential benefits and does not target habitats of greater technical significance, such as meander scarps.

2.4.3.3 Alternative C1 (CEICA)

Alternative C1 provides restoration features in nine of the 11 geographic complexes for six habitat types, including BLH, cypress-tupelo, riverfront forest, seasonally herbaceous wetland, secondary channels, and slough. The complex with ecological measures not included is Hopefield Point Big River Park. Loosahatchie Wolf River does not contain ecological measures. Alternative C1 increases the environmental output by 948 AAHUs over C6 for a total of 4,180 AAHUs. The incremental cost per incremental AAHU is $266 at a first cost of $17,989,000. While this plan is an improvement over C6 (e.g., it adds restoration to an additional geographic complex and the slough habitat type), it does not fully address all of the planning objectives (e.g., the floodplain waterbodies objective is only partially met through the inclusion of restoration of one slough) nor distribute restoration measures across all of the geographic complexes. In comparison to other best buys, Alternative C1 does not capture all of the potential benefits and does not target habitats of greater technical significance, such as meander scarps.

2.4.3.4 Alternative C2 (CEICA)

Alternative C2 provides restoration features in nine of the 11 geographic complexes for seven habitat types, including BLH, cypress-tupelo, meander scarp (1), riverfront forest, seasonally herbaceous wetland, secondary channels, and slough. The complex with ecological measures not included is Hopefield Point Big River Park. Loosahatchie Wolf River does not contain ecological measures. Alternative C2 increases the environmental output by 301 AAHUs over C1 for a total of 4,481 AAHUs. The incremental cost per incremental AAHU is $1,435 at a first cost of $29,536,000. In comparison to Alternative C1, Alternative C2 is better equipped to meet the planning objectives (e.g., all planning objectives are at least partially met), but does not distribute restoration measures across all of the geographic complexes. Alternative C2 is the first alternative to capture target habitats of greater technical significance by including 1 meander scarp. However, Alternative C2 does not capture all of the potential benefits and does not reasonably maximize restoration of habitats of greater technical significance (i.e., it does not reasonably maximize meander scarps).

2.4.3.5 Alternative C5 (CEICA)

Alternative C5 provides restoration features in 10 of the 11 geographic complexes for eight habitat types, including BLH, cypress-tupelo, meander scarp (1), moist soil units (alligator gar habitat), riverfront forest, seasonally herbaceous wetland, secondary channels, and slough. Alternative C5 increases the environmental output by 70 AAHUs over C2 for a total of 4,551 AAHUs. The incremental cost per incremental AAHU is $1,914 at a first cost of $32,757,000. Alternative C5 does include target habitats of greater technical significance by including one meander scarp and moist soil units (alligator gar habitat). However, Alternative C5 does not address restoration in all of the geographic complexes. Alternative C5 increases the environmental output by 70 AAHUs over C2 for a total of 4,551 AAHUs. The incremental cost per incremental AAHU is $1,914 at a first cost of $32,757,000.

2.4.3.6 Alternative C3 (CEICA)

Alternative C3 provides restoration features in all 11 geographic complexes for eight habitat types, including BLH, cypress-tupelo, meander scarp, moist soil units (alligator gar habitat), riverfront forest, seasonally herbaceous wetland, secondary channels, and slough. Alternative C3 increases the environmental output by 122 AAHUs over C5 for a total of 4,673 AAHUs. The incremental cost per incremental AAHU is $2,500 at a first cost of $41,244,000. Alternative C3 is an enhanced version of Alternative C5 in that all geographic complexes are represented, two meander scarps are included to fulfill scarce and critical habitats of greater significance (see Table 2-3), and public lands within the Meeman Shelby Complex are accessible. The additional cost of C3 is determined to be "worth it" because it is important to 1) restore as many scarce and significant meander scarps as possible; 2) spread ecosystem restoration outputs across as many of the geographic complexes in the study area as possible; and 3) restore as many different scarce and significant habitat types to meet planning objectives as possible. Furthermore, this alternative *reasonably* maximizes AAHUs compared to costs, while passing tests of CE/ICA, which is the underlying USACE policy for plan selection for ecosystem restoration projects.

2.4.3.7 Alternative C4 (CEICA)

Alternative C4 provides restoration features in all 11 geographic complexes for nine habitat types, including BLH, borrow areas, cypress-tupelo, meander scarp, moist soil, riverfront forest, seasonally herbaceous wetland, secondary channels, and slough. Alternative C4 increases the environmental output by 49 AAHUs over C3 for a total of 4,722 AAHUs. The incremental cost per incremental AAHU is $13,367 at a first cost of $58,970,000. Alternative C4 includes the same number of meander scarps as C3, but also captures borrow area restoration measures. However, borrow measures rank second to last with respect to technical significance of habitat types (Table 2-3); therefore, there is very little change in environmental output in scarce and significant habitats as comparison to C3. Costs significantly increase in comparison to Alternative C3 due to costly construction activities for borrow restoration. It is determined that borrow measure restoration costs are unjustified and are "not worth it" due to borrow habitat's lower technical significance.

2.4.4 P&G Criteria

The report "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G) (US Water Resources Council, 1983) requires that plan formulation consider four criteria: completeness, effectiveness, efficiency, and acceptability. The final array of alternatives was evaluated against the four P&G evaluation criteria as defined in P&G Section VI.1.6.2(c). See Table 2-16.

- *Completeness* is a determination of whether the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others.
    - All plans were determined to be complete and have necessary elements to function as standalone plans.

- *Effectiveness* is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities (P&G Section VI.1.6.2(c)(2)). Alternative plans that clearly make little or no contribution to the planning objectives should be dropped from consideration. Planning objectives were developed to alleviate the problems and achieve opportunities available in the study area, and all action alternatives were developed to achieve one or more objectives.
    - The following alternatives were determined to address study area problems and opportunities to various degrees A1, C1, C2, C3, C4, C5 and C7. The No Action Alternative did not address problems or opportunities or study objectives. Alternatives B and C6 did not address problems and opportunities in all habitat types. Alternative B did not address objective 2 since it did not contain large river habitat restoration. Alternative C6 did not address floodplain waterbody habitats under objective 3. See Table 2-16.

- *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)). Alternative plans that provided little additional benefit with increasing cost should be dropped from consideration.
    - CEICA was used to determine the efficiency of the final array of alternatives. Eight alternatives in the final array were determined to be cost-effective (including the no action). Seven alternatives (including the no action) were designated at best buys. Alternative A and B were determined not to be efficient.

- *Acceptability* is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies (P&G Section VI.1.6.2(c)(4). Acceptability means a measure or plan is technically, environmentally, economically, and socially feasible. Measures or plans that are clearly not feasible should be dropped from consideration.
    - The study team developed alternatives that are compliant with existing laws, regulations, and policies. The FIFR-FEA will be further reviewed for policy and legal compliance within USACE and by other Federal and state agencies with regulatory authority that applies to USACE projects.

Table 2-16. Summary Evaluation and Comparison of Final Array against P&G Criteria

	No Action	A	B	C1	C2	C3	C4	C5	C6	C7

Complete	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Effective	No-does not meet opportunities or objectives	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No-does not meet Objective 3	Yes
Efficient	Yes-No Investment	Non-Cost-Effective	Non-Cost-Effective	Best Buy	Best Buy	Best Buy	Best Buy	Best Buy	Best Buy	Cost-Effective Plan
Acceptable	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes

2.4.5 Risk and Uncertainty

Areas of risk and uncertainty have been analyzed and were defined so that decisions could be made with some knowledge of the degree of reliability of the estimated benefits and costs of alternative plans. Risk depends on the probability or likelihood for an outcome and the consequences of that outcome. Uncertainty refers to a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes. The team worked to manage risk during plan formulation. One way this was done was by using experience from past projects to identify potential risks and reduce uncertainty during the development of measures.

The team referenced successful similar ongoing and completed Federal, state, and local agency projects and used best professional judgment. The team also conducted an ARA during which project risks were factored into project costs (Appendix 4 Cost Engineering). The risks were labeled according to when the risk was or will be present: during the feasibility or study phase (‘Study’), the PED and construction phases (‘Implementation’), or once the project is complete and its outcomes can be assessed (‘Outcome’). These risks are summarized in the following paragraphs.

The risk and uncertainty apply to all alternatives in the final array and were not a distinguishing factor in evaluating differences between alternatives.

Climate Change (Outcome- Low Risk) - Temperature, average annual streamflow, and number of drought days are expected to increase over the next century. While annual average streamflow is projected to increase, a decrease in monthly average streamflow is projected for the months of July, August, and September. The projected reduction in flow to secondary channels and floodplain waterbodies during the summer months poses the

greatest threat to the ecological integrity of the project area. There is the potential need for increased OMRR&R and adaptive management measures in the future due to a decrease in streamflow during summer months and decreases in precipitation. However, many of the measures (culverts, channel excavation, river training structures, dike notching, etc.) are designed to increase flow connectivity to the secondary channels to address the impacts of climate change in the future with project scenario. Ultimately, the measures investigated for this project were selected to improve the aquatic and terrestrial ecosystems' resilience to climate change.

Hydrologic and Hydraulic Conditions (Study, Implementation-Low Risk) - To reduce the costs and duration of the study, detailed hydrological and hydraulic (H&H) analyses, including detailed culvert dimension, inverts, discharge and velocity calculations, riprap sizes, etc. were postponed until the PED phase of the project. Assumptions about H&H conditions, based on imprecise remotely available data (LiDAR and aerial imagery), and engineering judgment were used to formulate alternatives.

Low Level of Design (Study, Implementation-Low Risk) - Feasibility-level designs and quantities for TSP were developed based on limited data and data analysis with respect to site conditions, including not just H&H as discussed above, but also geotechnical conditions. More extensive field data collection and data analysis will occur in the PED phase.

Cost Estimates (Study-Low Risk, Implementation- Low Risk) - The cost estimates prepared during the feasibility phase, an estimate for the measures and a second more detailed estimate of the TSP, were based on relatively low levels of design. During PED, quantities will change as designs are refined, site conditions may differ from expected, material and fuel prices could fluctuate unexpectedly, and locations and costs for borrow and disposal sites could change. Risk and uncertainty associated with the cost estimates were managed through cost contingencies developed through the ARA for the alternatives, and through a cost and schedule risk analysis for the TSP.

Real Estate Acquisition (Study-Low Risk, Implementation- Medium Risk) - Landowner opposition could block measures, or at the very least, make it cost more and take longer to implement. The TSP proposes many measures in aquatic channels adjacent and connected to the navigation channel and other measures on public lands whose managers are supportive of restoration. The NFS will continue to coordinate with landowners.

Planting Availability (Implementation-Low Risk) - Measures propose hundreds of acres of planting. This demand may exceed the supply of floodplain tree seed and saplings. Risk would be managed by completing forestry actions over several years to space out demand.

Timing of Plantings (Implementation-Low Risk) - Planting and seeding of trees is time sensitive and success is highly dependent on favorable conditions, which typically exist in the project area for a few weeks in spring and fall. Unfavorable weather conditions during these times can make planting and seeding challenging and/or decrease plant survival. Risk would be managed by having a range of areas available for planting and contract options that allow for fall or spring planting.

Construction restrictions (Implementation-Medium to High Risk) - Restrictions to protect sensitive species, reduce noise, and prevent hunting disruption have a high potential to interrupt construction windows and limit the length of time work can be completed. This risk would be managed by working with resource agencies to identify options to work in the greatest practicable construction window under agreed-upon protective conditions. Restrictions could require multiple mobilizations and demobilizations. The risk could be mitigated by close coordination with construction engineers and resource agencies to reduce the risk for multiple seasons and or increased production rates leading to increased costs.

High water (Implementation Risk-Low Risk) - High water could limit access during construction. Risk would be managed by extending the construction window by 1 year.

Extreme Conditions (Outcome -Low Risk) - Flooding or drought may adversely impact tree plantings and construction. Risk would be managed by monitoring flow conditions and impacts to study area. Tree mortality would be mitigated by monitoring and replanting if necessary. None of the project measures are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed rehabilitation work.

Cost Estimates (Study-Low Risk, Implementation-Low Risk) - Cost estimate development of management measures for the TSP selection were based on historical knowledge and parametric cost estimates. Parametric cost estimates are typically used during feasibility studies, especially when there is a significant number of measures to screen. Estimates are derived from surveys completed via ArcGIS. There is the potential for cost estimates to be inaccurate due to the lack of data for the study area. An ARA was performed to assess this risk and contingencies added to the cost estimates.

Open Water Bottoms Ownership (Study-Low Risk, Implementation-Low Risk) - It was assumed that open water bottoms are state owned. This assumption carries a risk to cost. If the assumptions are incorrect, then the sponsor may have to acquire a real property interest for the water bottoms. If the water bottoms are state owned, there is a real estate cost for which the NFS receives credit.

Level of Design (Study- Low Risk, Implementation-Low Risk) - The project has been developed to a feasibility level of design. Design details are included in Engineering Appendix 3. As with all feasibility level studies, these details will be refined in the Plans and Specifications Stage.

Construction Schedule (Study-Low Risk, Implementation-Medium to High Risk) - Environmental conditions in the project area may change before construction begins; with increased uncertainty construction initiation is delayed. The PED activities preceding construction will account for changes in environmental conditions, land ownership, and address any changes to NEPA compliance and permitting. To reduce the chance of delay, a conservative construction schedule will likely be used. However, the project implementation schedule could be accelerated depending on NFS agreement, funding availability, and agency priorities. Construction would be in accordance with the USACE's regulations and standards. Phased construction of the measures is anticipated. Phased construction is anticipated which will require multiple mobilization and demobilization efforts or ensuring

there is work that can be completed in other areas. This risk could be mitigated by working with the area engineer.

Benefit Evaluation (Study-Low Risk) - Several ecological models were required to capture the environmental benefits associated with the diverse ecological measures proposed for this study. Ecological measures create a diverse array of local and regional immediate and long-term benefits to a wide array of species that cannot be fully evaluated by any model. Additionally, interactions and synergies of the measures are not captured. Thus, the benefit outputs are underestimated. Some of these additional benefits are documented for the TSP in Section 3.

Navigation Risks (Outcome-Low Risk) - There may be impacts from navigation operations to potential measures, such as woody debris traps in secondary channels. There is the possibility that barge operators could impact the proposed restoration measures.

2.5 COMPREHENSIVE BENEFITS

The USACE is required to comprehensively evaluate and provide a complete accounting, consideration, and documentation of the total benefits of alternatives across a full array of benefit categories, including NED, RED, EQ, and OSE. Alternatives are assessed to determine if they have net benefits in total and by type. Evaluation was done in collaboration with non-Federal partners and in consideration of other study interests and stakeholders using available data, analysis, input from peer review, and professional judgment.

2.5.1 National Economic Development Account

Per the P&G and ER 1105-2-100, the prime Federal goal in water and related land resources planning is to contribute to NED, consistent with protecting the nation’s environment, in accordance with national environmental statutes, applicable EOs, and other Federal planning requirements. For all study purposes except ecosystem restoration, the NED account displays changes in the economic value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the nation. Ecosystem restoration studies differ from traditional USACE planning studies in that ecological benefits typically are not expressed in monetary terms.

2.5.2 Regional Economic Development (RED) Account

The RED account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.

The final array would mostly result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short-term, this employment would contribute to local earnings, induce spending for goods and services, and generate tax revenues. At the scale of the study area, improvements to the environment, and greater abundance and diversity of desirable wildlife, fish, and vegetation, could

stimulate the local economy by increasing activities such as fishing, hiking, boating, bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences.

As the costs of action alternatives varied, regional benefits would also vary. All alternatives except the no action would have a positive impact on the regional economy. The No Action Alternative would result in no project expenditure and would have no positive or negative regional impact. See Appendix 7 Economics and Social Considerations for more information.

The highest cost alternative would generate the greatest benefit in RED. Alternative C4 is the highest cost alternative followed by Alternative C3. Alternatives A, B, C1, C2, C5, C6 and C7 would provide less RED benefits due to their lower costs. Project alternative construction would generate direct local, state, and national economic benefits in jobs and products. Ecosystem restoration resulting from construction would generate additional economic benefits.

2.5.2.1 RED Agricultural Analysis

Due to some measures being located in agriculturally productive acres, the PDT evaluated the regional loss of agricultural net income for measures with agricultural real estate throughout the study area. The loss of annual agricultural net income was calculated for each alternative and adjusted to account for the loss of productivity due to flood events expected to drive crop failure. Results from the analysis are included in the Economic Appendix in Section 6.

2.5.3 Environmental Quality Account

EQ accounts for non-monetary effects on ecological, cultural, and aesthetic resources, including the positive and adverse effects of ecosystem restoration plans. The expected EQ effects of implementing the alternatives are primarily beneficial, although there would be short-term adverse effects during construction. All action alternatives would have similar types of short-term impacts commensurate to the number and type of measures. Expected changes to the ecological, cultural, and aesthetic resources under the alternatives are described fully in the NEPA analysis in Section 3.

The USACE objective in ecosystem restoration is to contribute to NER via increases in the net quantity and/or quality of desired ecosystem resources. The net benefits were identified for the final array of alternative plans as described in Section 2.3. Alternative C4 produced the most net increase in restoration benefits followed by C3, C5, C2, C7, C1, C6, A, and B. The no action did not produce any restoration benefits. Alternative C4 produced the most acres restored.

In the long-term, EQ would be enhanced by construction of the measures included in the final array to varying degrees.

The No Action Alternative would result in a decrease in habitat functions and values throughout the site. The No Action Alternative would not have short-term adverse impacts; however, in the long-term, ecological and aesthetic resources would continue to decline and EQ would decrease.

To further determine which alternatives were most efficient at producing the restoration benefits for costs, the CEICA tool was used. See Section 2.4.2. Alternatives A and B were determined to be non-cost effective. Alternatives C1, C2, C3, C4, C5, C6, and C7 are all cost-effective means to meet study objectives. Alternatives C1, C2, C3, C4, C5, and C6 are the most efficient and provide the greatest increase in benefits for the least increase in cost (best buys).

Alternative C4 produces the highest AAHUs in the final array (4,722 AAHUs) followed closely by C3 (4,673 AAHU) (Table 2-17). The remaining alternatives in decreasing order of environmental benefits include C5 (4,551 AAHU), C2 (4,481 AAHU), C7 (4,346 AAHU), C1 (4,180 AAHU), C6 (3,232 AAHU), A (3,110 AAHU), B (2,205 AAHU), and the no action (0 AAHU).

Leisure and recreational opportunities and ecotourism (increased economic vitality) are enhanced in all alternatives except the no action. Users of the Meeman-Shelby Forest WMA and State Park would see improved public fishing, hunting, public access, hiking, wayfinding, and wildlife observation opportunities with the proposed measures. Boaters on the Wolf River at the Hernando Desoto Bridge would see improved public signage and fishing opportunities with the proposed measures.

An analysis was conducted via the Climate and Economic Justice Screening Tool (CEJST) to determine the benefits of each alternative within disadvantaged communities identified through the CEJST.

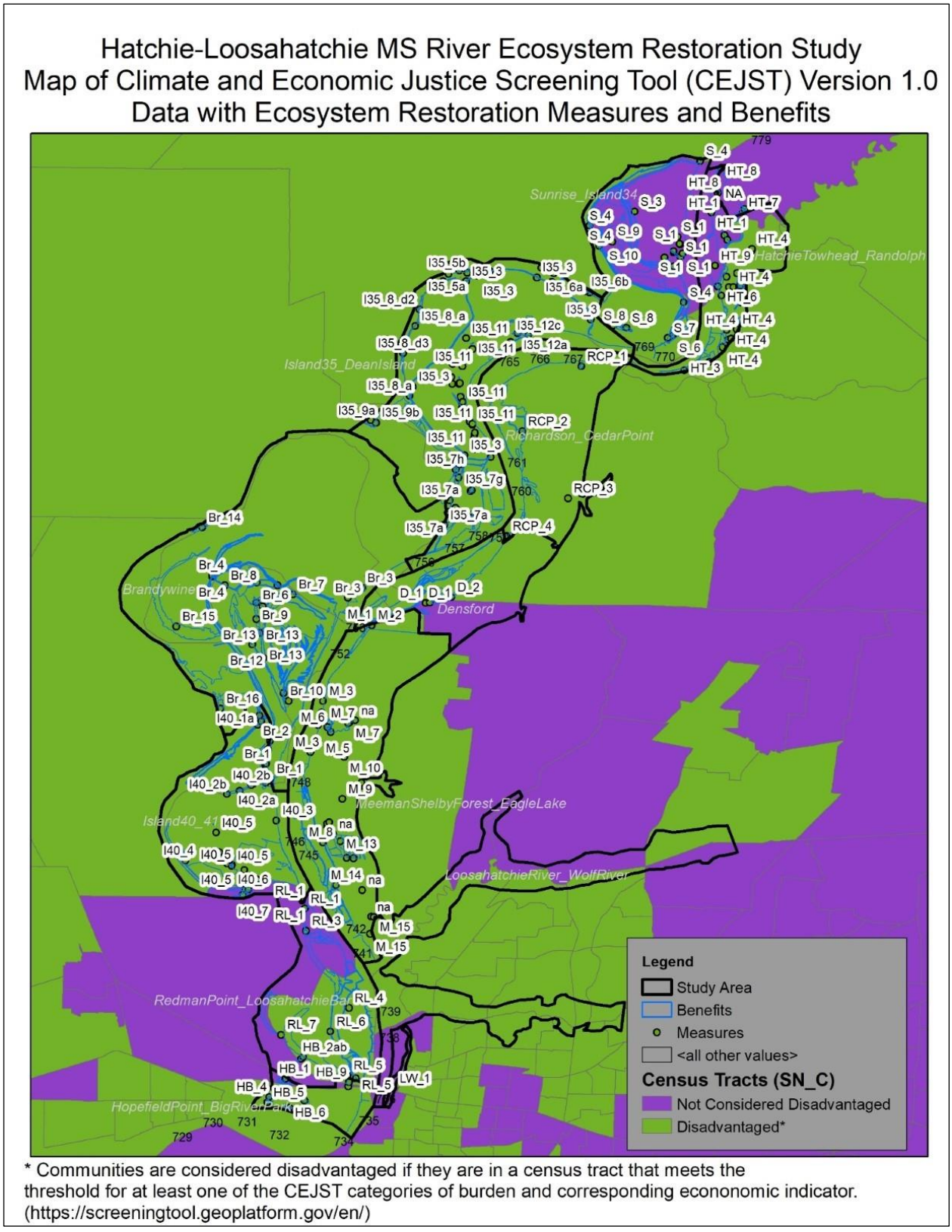


Figure 2-6. Location of Disadvantaged Communities in the Study Area, CEJST

Table 2-17. Short-term Impacts and Long-term Benefits to Habitats by Alternative

Alternative	# Measures	Net AAHU/AAFCU	Acres of short-term impacts to existing forest from access during construction	Acres exhibiting long-term benefits of forest and wetlands	Acres exhibiting long-term benefits to flowing (lotic) aquatic habitats	Acres exhibiting long-term benefits to slackwater (lentic) floodplain waterbodies	Benefits (AAHU/AAFCU) accrued in CEJST disadvantaged communities
No Action	0	0	0	0	0	0	0
A	34	3110	12	544	3464	248	2950
B	25	2205	6	45	3443	76	2196
C1	32	4180	3	2598	2735	161	4144
C2	33	4481	7	2598	3440	161	4445
C3	40	4673	7	2665	3440	177	4627
C4	57	4722	41	2665	3471	599	4668
C5	39	4551	7	2665	3567	42	4505
C6	25	3232	3	1428	2735	0	3196
C7	28	4346	7	2477	3440	0	4346

2.5.4 Other Social Effects Account

The OSE account addresses plan effects from perspectives that are relevant to the planning process but are not reflected in the other three accounts. Per the recent policy directive "Comprehensive Documentation of Benefits in Decision Document" (5 January 2021), the study team relied on the expertise of the interagency team and other local experts to determine OSE. The following were considered under the OSE account: Economic Vitality, Leisure & Recreation, Health & safety, and Environmental Justice. See Appendix 7 for additional details on the analysis.

Alternatives C3 and C4 provide the most positive OSE due to their larger AAHUs and due to the fact that they include restoration on publicly owned lands, which provide greater opportunities for the public to access these lands and the restored resources. Furthermore, restoration of the natural resources and the beneficial impacts to fisheries will support subsistence fishing, which has been identified as present in the region of interest. Subsistence fishing is harvesting fish to eat or sell to meet basic food requirements. Fishing for food can be central to culture and family life, household economies, and food security. Additionally, there are several communities in the surrounding census tracts that have been deemed food deserts in accordance with the USDA's definition – where there is no access to fresh food groceries within 0.5 miles for urban areas. This is further detailed in the Other Social Effects Health and Safety section of the economic appendix.

Section 3
Existing Resources and Environmental Consequences

This section identifies the resources and existing conditions of the resources in the study area and describes the environmental consequences of the alternatives compared to the no action FWOP condition. The depth of analysis of the alternatives corresponds to the scope and magnitude of the potential environmental impacts. This section provides the basis for the comparison of alternatives and describes the probable consequences (impacts and effects) of each alternative on the selected environmental resources. The purpose of characterizing the environmental consequences is to determine whether the resources, ecosystems, and human communities of concern are approaching conditions where additional stresses would have an important direct, indirect, or cumulative effect (Council on Environmental Quality (CEQ) 1997). For the purpose of this analysis, significance definitions (i.e., unaffected, less than significant, and significant) have been developed to assess the magnitude of adverse effects for all the affected resource categories resulting from implementing any of the reasonable alternatives:

- *Unaffected:* A resource was not affected, or the effects were not appreciable; changes were not measurable or perceptible consequence.
- *Less than significant:* Effects on a resource were detectable, although the effects were localized, small, and short-term.
- *Significant:* Effects on a resource were readily detectable and obvious, regional, large, and long-term.

The selected plan (Alternative C3) and No-Action Alternative are the primary actions evaluated and discussed in this section. The eight other action alternatives involve many of the same restoration measures and the type and degree of the adverse impacts and would not be appreciably different from those associated with the selected plan and are thus discussed collectively. Due to the integrated format of this document, the levels of effects and benefit comparisons of the alternatives were assessed in the planning sections (see Section 2.3-Plan Evaluation and Section 4-Plan Comparison and Selection) through the development, evaluation, and selection process. Additionally, Table 2-17 and Table 4-1 show the quantitative summaries of these comparisons. Therefore, the effects of the selected plan and No-Action Alternative are the primary emphasis in the subsections below with more detailed narratives of how these resources are affected.

3.1 PERIOD OF ANALYSIS

For planning purposes, the period of analysis for this study was established as 50-years and assumed to begin in year 2028 extending to 2078. The FWOP condition describes how

conditions in the study area will change over the period of analysis if no Federal action is taken as a result of this study.

3.2 GENERAL SETTING

The study area encompasses a 39-mile reach of the Mississippi River beginning at the mouth of the Hatchie River and extending south to the mouth of the Wolf River Harbor (River Mile 775-736) in Memphis, Tennessee. This reach occurs entirely within the MAV ecoregion. The study area is the active floodplain of the Mississippi River (i.e., batture) bounded on the east by the West Tennessee bluffs and on the west by the Mississippi River levee system and is located in Lauderdale, Tipton, and Shelby Counties, Tennessee and Mississippi and Crittenden Counties, Arkansas. Public lands are limited within this reach. Meeman-Shelby State Forest in Tennessee is the largest at 9,434 acres, but Eagle Lake Refuge (3,497 acres) and a small portion of the Hatchie NWR (approx. 9,400 total acres) are also located within the batture. Significant tributaries of the Mississippi River in this area are the Hatchie, Loosahatchie, and Wolf rivers.

The Memphis, Tennessee metropolitan area (population 1,163,000; 2020 U.S. Census), one of the largest cities on the LMR, borders the study reach. Other population centers in the vicinity of the study reach include West Memphis, Osceola, and Marion, Arkansas.

The study area contains a wide range of connectivity of aquatic and vegetative habitats with the Mississippi River, a critical component of biodiversity (Appendix 5, Ward et al. 1999). The LMR supports 136 freshwater fish species, 325 migratory bird species, and approximately 50 mammal species, including eight federally threatened or endangered species, three proposed or candidate species, numerous species of conservation concern, and several rare habitats, such as, river cane, meander scarps, and alligator gar spawning grounds (Appendix 2a, Appendix 2b, Final Fish and Wildlife Coordination Act Report in Appendix 8). These habitats also provide ecosystem services of clean air and water, flood control, pollination, and recreation. Because of this diversity, hunting, fishing, and wildlife watching are popular recreational activities in this region. Refer to Section 1.8.3 for a summary of FWOP conditions.

3.2.1 Land Use

3.2.1.1 Existing Conditions

The land cover of the study area is dominated with a fairly even split between BLH wetland forests (~38 percent) and cropland (~38 percent) followed by open water (~19 percent). No other category is greater than one percent (Table 3-1).

Table 3-1. Study Area Land Cover from 2019 National Land Cover Database

2019 NLCD Land Cover	Area (Acres)	Percent Composition
Cultivated Crops	54,899	38%
Woody Wetlands	54,652	37%
Open Water	28,311	19%
Developed, Open Space	1,515	1%
Emergent Herbaceous Wetlands	1,413	1%
Mixed Forest	1,242	1%
Deciduous Forest	1,055	1%
Developed, Low Intensity	666	0%
Developed, Medium Intensity	612	0%
Herbaceous	514	0%
Hay/Pasture	339	0%
Barren Land	306	0%
Developed, High Intensity	185	0%
Shrub/Scrub	164	0%
Evergreen Forest	57	0%
TOTAL	145,929	100%

Historically, a variety of vegetative communities were interspersed throughout the LMR floodplain. The soil and hydrologic regime influenced what species occurred in any given area. Species such as oak, hickory, pecan, tupelo, bald cypress, et al. were the most common species in the floodplain, but other species such as cottonwood, elm, ash, hackberry, et al. were also present. Forest types included cypress-tupelo, cottonwood-willow-sycamore, white oak-red-oak-hickory, hackberry-elm-ash, and many others (Klimas 1988, Stanturf et al. 2000, Gardiner et al. 2005). Drastic vegetation changes began after the levee system was complete and soybean prices rose in the 1950s. Between the 1950s and 1970s, nearly 300,000 acres in the Mississippi River Alluvial Valley were cleared and converted to agriculture every year (King et al. 2006).

3.2.1.2 No Action (Future Without Project)

The most significant land use conversion within the study area, from BLH forest to cropland, mostly pre-dates the study timeframe. No large-scale changes in this trend are expected within the next 50 years (Karstensen and Sayler 2009, Oswalt 2013, Gardiner 2015). Previous land use comparisons encompassing this study area have shown little changes in land cover trends over the past 25 years (USACE 2020). Without the project, no significant changes to land cover is expected.

3.2.1.3 Impacts of the Recommended Plan

Approximately 7 acres of forest land would be cleared for access during construction with the RP. The RP would actively reforest 445 acres of agricultural lands into BLH, cypress-tupelo, and riparian buffer forests adjacent to the Mississippi River through plantings and natural succession. Additionally, forest stand improvements through reduced ponding and canopy gap creation would occur on 2,136 acres of existing BLH forest. Approximately 23 acres of herbaceous land would be converted to forest to promote native species and establish native hard mast species available to wildlife. The RP would also restore 61 acres of seasonal herbaceous wetlands through hydrologic restoration, seeding of wetland plants, and establishing moist soil management areas from existing agricultural food plots. These effects on land use in comparison to the approximate 146,000-acre study area shown in Table 3-1 would be less than significant.

3.3 NATURAL ENVIRONMENT

3.3.1 Wetlands

3.3.1.1 Existing Conditions

Dense alluvial clays dominate LMR backwater areas that historically supported extensive wetlands. Natural levees form along the banks of the LMR. The riverbank can be 10 to 15 feet higher than the lowlands farther back from the river. Because of these natural levees, drainage within the floodplain frequently flows away from the Mississippi River to lower elevations near the valley walls, except near tributary confluences (Kleiss et al. 2000). Slackwater areas, access to backwaters, structurally complex riverbanks, and other habitats are important for biotic integrity of aquatic communities (Killgore 2012, Killgore et al. 2014).

LMR floodplain, including the Hatchie-Loosahatchie reach, has emergent, floating, and submersed aquatic vegetation, but occurrence and distribution is dependent on the flow regime and elevation relative to the main stem river. Submersed aquatic vegetation occurs in waterbodies furthest removed from the main stem river, such as borrow pits (personal communication, Dr. Jack Killgore, ERDC).

Robust emergent wetlands, also referred to as herbaceous wetlands, are identified in the Arkansas Wildlife Action Plan for research and monitoring as a critical habitat (https://www.agfc.com/en/wildlife-management/awap/). Emergent wetlands used by King Rails (*Rallus elegans),* a species of conservation concern in Tennessee and Arkansas, and other marsh birds have few to no invading trees and shrubs. These wetlands also have native emergent wetland vegetation, such as rushes, sedges and cattails, interspersed with shallow open water. The interspersion of open water and vegetation ideally approaches a ratio of 50 percent water to 50 percent emergent wetland vegetation. To maximize benefits to marsh birds, water depth should vary from four to eight inches during wintering, migrating, and breeding periods. During brood rearing, a depth that varies from exposed mudflats to no more than six inches deep maximizes chick survival.

The study area is located in the MAV that has been highly altered by human activity. Loss of connectivity, altered hydrology, altered geomorphology and changes in the biotic community

all contribute to changes in the wetland vegetative mosaic of the LMR. From an estimated original area of 9 to 10 million hectares of forested wetlands, Lower Mississippi Valley forests had been reduced by about 50 percent by 1937, and 50 years later less than 25 percent of the original area remained forested (Smith et al. 1993). Much of the remaining forest is highly fragmented, with the greatest degree of fragmentation occurring on drier sites (such as natural levees), and the largest remaining tracts being in the wettest areas (Rudis 1995). Nearly all of the remaining forests within the basin have been harvested at least once, and many have been cut repeatedly and are degraded due to past high-grading practices (Putnam 1951; Rudis and Birdsey 1986). This has made many hard mast producing species (e.g., oak species) that are valuable to wildlife being increasingly scarce, particularly within the batture. Cypress-tupelo swamps are another important wetland community that is also uncommon in the study area in part due to logging, changing hydrology, and land use. In many places, ditches excavated across the floodplain increase runoff and reduce ponding duration (Stanturf et al. 2000, Gardiner et al. 2005). Another native species that has become extremely rare in the study area (and LMR as a whole) is river cane. Cane is a disturbance adapted species forming dense stands in areas cleared by fire, flood, tornadoes, or ice storms that persist for 10 to 25 years before being replaced by other species (LMVJV 2007). These dense stands of cane are referred to as cane brakes. Cane brakes persist for 10 to 25 years before being replaced by other species (LMVJV 2007). Agricultural conversion and forestry practices have eliminated most stands reducing the prevalence of cane breaks by approximately 98 percent (Brantley and Platt 2001). Cane brakes provide high quality habitat for the Louisiana black bear and Swainson's warbler and several species of butterflies require river cane to complete their life cycle (Platt & Brantley 1997, Brantley & Platt 2001, Hendershott 2002, LMVJV 2007). Remnant river cane stands appear to be mostly present in the understory of existing forest and not present as the dense cane brakes that used to be present. Little science exists on river cane in the study area; however, groundwater wells have been installed on three different populations to improve our understanding of the relationship between cane and groundwater hydrology. Additional information regarding wetlands can be found in Appendix 2 and Appendix 5.

3.3.1.2 No Action (Future Without Project)

Without action, the wetlands in the study area would continue to exhibit similar trends. The amount of forested wetland habitat is not expected to change based on previous land use assessments, and Swampbuster provisions introduced in the Food Security Act of 1985 discouraging conversion within the floodplain. However, the degraded condition of the existing forested habitat in the study area is expected to continue, with few hard mast producing species, cypress-tupelo swamp habitats, and river cane habitats present. Forests subject to ponding from floodplain obstructions (e.g., improperly sized culverts), and associated degraded conditions would continue. Seasonal herbaceous wetland habitats would continue to be limited and unavailable for functions critical to various species life requisites, such as, alligator gar spawning. Additional details of how wetland functions and associated modeled variables are expected to shift over the period of analysis (i.e., 50 years) can be found in the assumptions documented in the habitat benefit analysis in Appendix 5).

3.3.1.3 Impacts of the Recommended Plan

The RP would have some short-term adverse impacts to wetlands during construction but overall long-term beneficial effects to the mosaic of LMR wetland habitats. Vegetative clearing for access and construction with the TSP would result in 7 acres of forest clearing. These effects would be less than significant. The RP would actively reforest 445 acres of agricultural lands into BLH, cypress-tupelo, and riparian buffer forests adjacent to the Mississippi River through plantings and natural succession. Additionally, forest stand improvements through reduced ponding and canopy gap creation would occur on 2,136 acres of existing BLH forest. Finally, 23 acres of herbaceous land would be converted to forest to promote native species and establish native hard mast species available to wildlife. The RP would also restore 61 acres of seasonal herbaceous wetlands through hydrologic restoration, seeding of wetland plants, and establishing moist soil management areas from existing agricultural food plots. Overall, the RP would directly benefit 2,415 AAFCUs of wetland functions across the 2,665 acres of wetland habitat. Additional details regarding the ecological modeling benefits can be found in Appendix 5.

3.3.2 Wildlife

3.3.2.1 Existing Conditions

The study area consists of a mosaic of floodplain habitat supporting a diverse assemblage of wildlife species, including five species of conservation concern listed as S1 (State Critically Imperiled) or S2 (State Imperiled) (Appendix 2b). Common mammalian species using the floodplain forests and interspersed aquatic habitats include raccoon, opossum, mink, bobcat, coyote, white tailed deer, muskrat, river otter, beaver, and several bat species. Bats roost during the day in snags, exfoliating bark, tree hollows, and foliage, and forage in open habitats, floodplain waterbodies, forest edges, and riparian habitats. Forested habitat in the study area is degraded compared to historic conditions. There are fewer hard mast producing species, cypress-tupelo swamp habitats, and river cane habitats present due to ponding from floodplain obstructions (e.g., improperly sized culverts), and other impacts as described in the wetlands section above. Bat species using the study area for foraging or roosting include eastern red bat, Seminole bat, southeastern myotis, little brown bat, big brown bat, northern long-eared bat, evening bat, tricolored bat, and Indiana bat. White-nose syndrome (WNS) is a fungal disease that kills bats. This emerging disease was first detected in the United States in 2006. It has since spread to 33 states and seven Canadian provinces and has caused severe decline in bat populations resulting in several new species being listed or proposed for Federal and state protection (Appendix 2a, Appendix 2b).

The mosaic of floodplain habitats in the study area supports a wide variety of birds, including waterfowl, songbirds, shorebirds, and raptors, including several species of conservation concern (Appendix 8 – Final Fish and Wildlife Coordination Act Report, Appendix 2b). The Arkansas and Tennessee Wildlife Action Plans identify 83 bird species that could potentially exist in the Hatchie-Loosahatchie reach. Of these bird species, 43 are S1 or S2 for either or both of the states (Appendix 2b). The study area is within the Mississippi flyway, an important bird migration route that connects central Canada to the region surrounding the Gulf of Mexico. Nearly 40 percent of the Mississippi flyway's waterfowl and 60 percent of all U.S. bird species migrate or winter in the MAV. The MAV is identified as the most important wintering location for mallard (*Anas platyrhyncos*) and wood duck (*Aix sponsa*) populations.

Additionally, the MAV winters significant numbers of Green-winged Teal (*A. crecca*), Northern Shoveler (*A. clypeata*), and Gadwall (*A. strepera*). Accordingly, the MAV was identified as a priority non-breeding site for waterfowl in the original North American Waterfowl Management Plan (1986) and became a part of one of the first established Joint Ventures (LMVJV). These habitats also provide critical resting areas and food sources for migratory birds while traveling to northern nesting grounds in the spring and to southern overwintering locations in the fall. The floodplain forests provide important nesting sites and forage for a number of neotropical migratory birds. Forest breeding species are one of the most important components of the avifauna in the MAV, despite the loss of nearly 80 percent of the forested wetlands in this region (LMVJV 2007). At least 70 species use BLH as a primary habitat. Almost 30 percent of the breeding populations of the S1 prothonotary warbler are found within forests in the MAV. Other typical state listed species include Northern Parula, Swainson's Warbler, Red-shouldered Hawk, and Red-headed Woodpecker.

The herpetofaunal community in the LMR is predominantly composed of wide ranging, generalist species. There are no federally listed species that occur within the study area; however, the alligator snapping turtle was proposed for listing in 2021 (Appendix 2a). There are also several species of conservation concern, including three species of amphibians and four species of reptiles that are listed as S1 or S2 in Tennessee and Arkansas (Appendix 2b). While the main channel of the river has been significantly altered to optimize navigation, the peripheral backwater, secondary channel, and meander scarp habitats that remain could harbor a variety of aquatic and semi-aquatic reptiles and amphibians. Water depth, velocity, and the presence of snags and logjams strongly influence whether or not these species will be present. Similarly, riparian areas composed of structurally diverse areas like floodplain forest, canebrakes, seasonal herbaceous wetlands, or other vegetative cover will provide optimal conditions for the presence of herpetofauna species. Frogs can be found along the banks, in riparian forests, or floodplain wetlands such as: fowler's toads (*Anaxyrus fowleri)*; cricket frogs (*Acris blanchardi)*; bullfrogs (*Lithobates catesbeianus)*; southern leopard frogs (*Lithobates sphenocephalus)*; and gray treefrog (*Dryophytes chrysoscelis)*. Several species of watersnakes inhabit floodplain waterbodies where water flow is minimal. These include the banded watersnake (*Nerodia fasciata)*, diamondback watersnake (*N. rhombifer)*, and plainbelly watersnake (*N. erythrogaster)*. Aquatic turtles, such as: Ouachita map turtle (*Graptemys ouachitensis)*, Mississippi map turtle (*G. kohni)*, redear slider (*Trachemys scripta)*, river cooter (*Pseudemys concinna)*, alligator snapping turtle (*Macrochelys temminckii)*, snapping turtle (*Chelydra serpentina)*, and musk turtle (*Sternotherus odoratus)*, reside in floodplain waterbodies with snags and rootwad debris. Two species of softshell turtles, smooth softshell (*Apalone mutica)* and spiny softshell (*A. spinifera)*, can be very abundant, where they can be seen basking in numbers on sand or silt bars in or adjacent to the Mississippi River. Lizard species are mostly restricted to riparian forests and limited in diversity. Five-lined skinks (*Plestiodon fasciatus)*, Broadhead Skinks (*P. laticeps)*, and possibly fence lizards (*Sceloporus consobrinus)* can be found in the study area. Intact swampy or marshy wetlands that persist in riparian areas could provide the necessary habitat for the eel-like three-toed amphiuma *(tridactylum)*, lesser siren *(intermedia)*, and the mudsnake (*Farancia abacura)* that feeds on them. While this section of the Mississippi River

is within the northern range of the American alligator *(mississippiensis)* observations in the study area are rare.

3.3.2.2 No Action (Future Without project)

Several wildlife species would be negatively impacted through the continued degraded state of ecosystem structure and function within the study area. Existing degraded forests with few hard mast producing species would result in fewer acres of high-quality habitat for forage and cover used by deer, squirrels, forest breeding birds, and bats. WNS, a fungal disease that causes mortality in bats, is expected to continue to negatively impact bat populations. Increasingly disconnected floodplain waterbodies would negatively impact many guilds of wildlife utilizing them for food, reproduction, and cover.

3.3.2.3 Impacts of the Recommended Plan

Wildlife would exhibit short-term minor adverse effects during construction due to activity and noise. These effects would be less than significant. WNS, a fungal disease that causes mortality in bats, is expected to continue to negatively impact bat populations. However, the proposed action's benefits to forested habitats should help to provide some resiliency to the bat populations in the larger MAV. Reforestation measures would benefit many neotropical migrants and forest breeding birds. Proposed reforestation includes areas mapped as high priority in LMVJV's decision support model (Elliott et al. 2020). The RP would result in long-term beneficial effects from the breadth of the restoration activities. Overall, the RP would directly benefit 2,415 AAFCUs of wetland functions across the 2,665 acres of vegetative habitat available for wildlife, as described in the wetlands section. In addition to these direct benefits quantified in the ecological models, the RP has indirect benefits to species that may use adjacent habitats at varying spatiotemporal scales. Wildlife species using restored habitat also benefit from connectivity to adjacent habitats. Wildlife are expected to indirectly benefit from an additional 15,050 acres of contiguous similarly classified habitat (e.g., existing forest adjacent to proposed reforestation area).

3.3.3 Aquatic Resources

3.3.3.1 Existing Conditions:

The study area contains over 28,000 acres of open water, including riverine habitats exhibiting unidirectional flow like the Mississippi River main channel, tributary mouths, secondary channels, meander scarps, and floodplain habitats exhibiting bidirectional flow like sloughs, crevasses, and borrow areas with varying levels of connectivity (Appendix 5). Seasonal hydrologic fluctuations support the numerous aquatic functions of these habitats, such as providing spawning and rearing habitat for a variety of fish species. Approximately 136 species of fish are likely to occur in these habitats, including several species of conservation concern. Table A2b-8 in Appendix 2b lists these fish species, their relative abundance, and conservation rankings. Eighteen of these fish species are listed as S1 or S2 (Table A2b-4 in Appendix 2b). Riverine species include species such as shads, striped bass, skipjack herring, goldeye, paddlefish, and large benthic fishes like shovelnose sturgeon, the endangered pallid sturgeon, blue sucker, carpsuckers, buffalofishes, and freshwater drum. Species using those floodplain waterbodies with bidirectional flow, like sloughs, include

inland silversides, brook silversides, bluegill, mosquitofish, orangespotted sunfish, pugnose minnow, largemouth bass, redspotted sunfish, and warmouth (Appendix 5). More isolated floodplain waterbodies, like borrow areas located adjacent to the mainline levee, are dominated by a wetland fish guild, including species such as: bluntnose darter, blackspotted topminnow, bantam sunfish, cypress darter, golden topminnow, blackstripe topminnow, flier, taillight shiner, banded pygmy sunfish, spotted gar, and mud darter (Appendix 5). These floodplain waterbodies are likely filling in over time from localized sedimentation due to agricultural practices and flood water deposition. Borrow areas, specifically, have been shown to lose on average 17 percent of their depth over a 38-year period (Appendix 5). Invasive carp, such as bighead carp, silver carp, and black carp, are also abundant across aquatic habitats as described in the Invasive species section and detrimentally impact mussels and fish species due to competition of resources. Both Arkansas and Tennessee have open commercial fishing seasons, but the Tennessee portion of the Hatchie-Loosahatchie Conservation Reach has an area closure due to contaminants issues. The primary groups of commercially targeted species include catfishes (Ictaluridae), buffaloes (Catostomidae), carps (Cyprinidae), suckers (Catostomidae), and drum (Scianenidae), paddlefish (Polyodontidae), bowfin (Amiidae), and gars (Lepisostidae).

Anadromous/catadromous aquatic species that routinely cross state boundaries as part of their reproductive life cycles and can be found in the study area include American eel (*Anguilla rostrata*), Alabama shad (*Alosa alabamae*), and the Ohio Shrimp (*Macrobrachium ohione*)).

The once diverse mussel fauna of the Mississippi River has drastically changed in the last 100 years due to large-scale navigation and flood control projects. These projects greatly reduced, and in some instances, eliminated the gravel shoal areas that are the preferred habitat of many riverine mussel species. As a result of these habitat alterations, freshwater mussels are restricted to off channel habitats, such as meander scarps, sloughs, and backwater areas that contain sand, silt, and clay or secondary channels with a courser substrate of a gravel and sand mixture. These habitats offer the flow refugia and substrate stability required for maintaining mussel populations at the local scale. Habitat alterations have resulted in a shift in the mussel community. With the loss of the riffle/shoal dwelling species, the mussel fauna is comprised mostly of habitat generalists such as: the bleufer (*Potamilus purpuratus)*; threeridge (*Amblema plicata)*; mapleleaf *(Quadrula quadrula)*; butterfly (*Ellipsaria lineolata)*; washboard (*Megalonaias nervosa)*; yellow sandshell (*Lampsilis teres)*; fragile papershell *(Leptodea fragilis)*; threehorn wartyback (*Obliquaria reflexa)*; bankclimber (*Plectomerus dombeyanus)*; pink papershell *(Potamilus ohiensis)*; wartyback (*Quadrula nodulata)*; ebonyshell (*Reginaia ebenus)*; and deertoe (*Truncilla donaciformis)*. This section of the Mississippi River contains at least nine mussel species that are species of greatest conservation need in Arkansas or Tennessee (Table A2b-4 in Appendix 2b). The federally endangered fat pocketbook (*Potamilus capax)* is known to occur in this section of the Mississippi River. Smaller secondary channels like meander scarps provide ideal habitat for the species due to refugia from high flows and the stable sand, silt, clay substrates. Meander scarps no longer form due to maintenance of the navigation channel in the Mississippi River. There are only 14 flowing meander scarps remaining in the entire LMR with three of these being located in the study reach located within the Sunrise Island 34, Island 35-Deans Island, and Brandywine Geographic Complexes (Appendix 2b).

Macroinvertebrates are an important component of the LMR food web and serve as prey items for a variety of species, including the federally endangered pallid sturgeon. There are over 200 species of macroinvertebrates that can be found in the mosaic of habitats along the Mississippi River with the dominant family being Chironomidae (Harrison and Morse 2012, Baker et al. 1991). Large scale navigation and flood risk management activities in the LMR have altered much of the available macroinvertebrate habitat in the LMR, which now consists of a mosaic of natural (e.g., woody debris, vegetated shorelines, gravel bars, sands, silts, and clays) and artificial habitat (e.g., dikes, riprap revetment, and articulated concrete mattress). Reduced connectivity of secondary channels, meander scarps, and other floodplain waterbodies negatively affects those resident communities. Macroinvertebrate community compositions within the aquatic habitats are dependent on the level of hydrologic connectivity (both time and space) and the substrate compositions present (Appendix 5). Larger secondary channels with unidirectional flow are dominated by sand substrates with chironomid species and oligochaetes being the dominant species. These channels also contain some silt, clay, and limited bank vegetation preferred by oligochaetes and mayfly species (Ephemeridae). Artificial rock structures such as riprap dikes and revetments are typically dominated by net spinning caddisflies (*Hydropsychidae*). Areas with a high diversity of substrates and increased structural complexity (e.g., meander scarps and areas with a mixture of woody debris, gravel, leaves, clay, silt, and sand) exhibit higher macroinvertebrate species richness (Appendix 5).

3.3.3.2 No Action (Future Without Project)

Aquatic communities would continue to exhibit degraded ecosystem functions, particularly during the summer and fall, as aquatic habitats become more disconnected from the Mississippi River negatively impacting fish, mussels, and macroinvertebrates. Floodplain waterbodies would continue to fill in over periods of time with reduced habitat quality for fish. Creation of new meander scarps and other new floodplain waterbodies would continue to be limited due to the navigation and flood risk management system.

3.3.3.3 Impacts of the Recommended Plan

Aquatic resources would exhibit minor short-term adverse impacts due to activity during construction. During construction activities, fish are expected to migrate upstream or downstream of the activities, and macroinvertebrates would be expected to be smothered or drift downstream. These effects would be less than significant. But overall, the RP would result in long-term beneficial effects to aquatic resources. The RP would result in 2,258 AAHUs of direct benefits to those aquatic guilds of species using 3,440 acres of lotic waterbodies (e.g., meander scarps, secondary channels typically exhibiting unidirectional flow), and to those aquatic guilds of species using 177 acres of lentic floodplain waterbody habitats like backwater sloughs. In addition to the direct benefits quantified in the ecological models above, the RP has indirect benefits to species that may use adjacent habitats at varying spatiotemporal scales. Aquatic species using restored habitat can use other connected waterbodies at different spatiotemporal scales helping to maintain the biodiversity in the LMR. Thus, aquatic species are expected to indirectly benefit from an additional 11,619 acres of lotic habitat and 445 acres of lentic habitat due to connectivity with downstream waterbodies. These indirect acres include the downstream aquatic areas

connected via primary flow channels within each geographic complex of the proposed measures in the RP.

3.3.4 Federally Threatened and Endangered Species

3.3.4.1 Existing Conditions

In letters dated 15 September 2021, and (updated) 17 November 2022, the USFWS provided a list of threatened, endangered, proposed and candidate species that may occur within the boundaries of the study area and/or may be affected by the proposed project. Additional coordination with USFWS resulted in one additional species (alligator snapping turtle) to be included as a proposed threatened species that may be affected by the proposed project. The list of species is shown in Table 3-2.

Table 3-3-2. Threatened, Endangered, or Candidate Species in Study Area

Species (Common Name)	Scientific Name	Species Group	Status
Indiana Bat	*Myotis sodalis*	Mammal	Endangered
Northern Long-eared Bat	*Myotis septentrionalis*	Mammal	Threatened*
Tricolored Bat	*Perimyotis subflavus*	Mammal	Proposed Endangered
Eastern Black rail	*Laterallus jamaicensis spp. jamaicensis*	Bird	Threatened
Piping Plover	*Charadrius melodus*	Bird	Threatened
Red Knot	*Calidris canutus rufa*	Bird	Threatened
Pallid sturgeon	*Scaphirhynchus albus*	Fish	Endangered
Fat Pocketbook Mussel	*Potamilus capax*	Clam	Endangered
Monarch Butterfly	*Danaus plexippus*	Insect	Candidate
Pondberry	*Lindera melissifolia*	Flowering Plant	Endangered
Alligator Snapping Turtle	Alligator Snapping Turtle	Reptile	Proposed Threatened

*Northern Long-eared Bat is being reclassified from threatened to endangered under the Endangered Species Act of 1973, as amended with an effective date of March 31, 2023 (88 FR 4908).

Detailed descriptions of each species, background, biology, life history, and potential for presence in the study area can be found in Appendix 2a and is integrated into the other relevant resources.

3.3.4.2 No Action (Future Without Project)

Ongoing threats, such as WNS to bat species and habitat fragmentation across species ranges would continue. Activities conducted by Federal agencies within the study area, and across the LMR, would still occur in coordination with the USFWS, pursuant to Section 7 of the ESA, to conserve federally listed species and designated critical habitats. No significant changes are expected to threatened and endangered species within the study area without the project.

3.3.4.3 Impacts of the Recommended Plan

The proposed measures were formulated to restore the ecological functions of LMR habitats, including threatened and endangered species habitats. USACE and the NFS, which includes stakeholders from various state and Federal wildlife agencies, formulated the measures in the RP for the overall benefit of federally listed threatened and endangered species, birds of conservation concern, and priority state listed species identified on the State Wildlife Action Plans as described throughout the report. However, there is the potential for some minor temporary impacts to listed species and/or their habitats, such as minimal tree clearing for access and temporary aquatic disturbances during construction. These effects would be less than significant. Thus, the effects determination for the RP is a may affect but NLAA determination for listed species. Concurrence with this effect determination was received from USFWS on 22 February 2023, pursuant to the ESA. A copy of the correspondence is included in Appendix 8 (Public Involvement and Coordination). Site-specific ESA surveys and associated tiered ESA consultations will be conducted for any measure in the RP prior to implementation. These surveys and associated tiered ESA consultations during implementation stages will allow for time-sensitive (1-2 years) effect determinations and will incorporate any changed habitat or species presence/absence conditions, or changes in listing status that could occur at each of the measure locations included in the RP prior to its implementation. Table 3-3 summarizes the determination of effects for each of the protected resources.

Table 33-3. Determination of Effects to Threatened, Endangered, and Proposed Listed Species

Species (Common Name)	Determination	Rationale
Indiana Bat	*May affect but not likely to adversely affect*	The project will result in additional forested lands and improved forested stands available for Indiana bat summer roosting. Some minor tree clearing may be needed for access; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Northern Long-eared Bat	*May affect but not likely to adversely affect*	The project will result in additional forested lands and improved forested stands available for northern long-eared bat summer roosting. Some minor tree clearing may be needed for access; however, site-specific surveys and tiered ESA consultations during implementation would avoid

Species (Common Name)	Determination	Rationale
		and minimize potential impacts.
Tricolored Bat	*May affect but not likely to adversely affect*	The project will result in additional forested lands and improved forested stands available for tricolored bat summer roosting. Some minor tree clearing may be needed for access; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Eastern Black rail	*May affect but not likely to adversely affect*	The project will result in an increase in vegetated wetlands and restored functions to existing wetlands for the eastern black rail. Some minor vegetative clearing may be needed for access; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Piping Plover	*May affect but not likely to adversely affect*	The project will result in restored functions to wetland complexes and secondary channels particularly through increased connectivity. There may be temporary disturbances to these and adjacent sandbar and mudflat habitats during construction; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Red Knot	*May affect but not likely to adversely affect*	The project will result in restored functions to wetland complexes and secondary channels particularly through increased connectivity. There may be temporary disturbances to these and adjacent sandbar and mudflat habitats during construction; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Pallid sturgeon	*May affect but not likely to adversely affect*	The project will restore functions to meander scarps and secondary channels through increased connectivity and large woody debris traps providing forage and increased habitat suitability for YOY pallid sturgeon. There will be temporary increases in turbidity to the aquatic habitats during construction; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Fat Pocketbook Mussel	*May affect but not likely to adversely affect*	The project will restore functions to meander scarps and secondary channels primarily through increased connectivity allowing for more suitable habitat for Fat Pocketbook Mussel particularly during low water times. There will be temporary increases in turbidity to the aquatic habitats during construction; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Monarch Butterfly	*May affect but not likely to adversely affect*	The project will result in an increase in nectar producing plants available to the monarch butterfly due to reforestation and wetland restoration. There may be temporary disturbances to vegetated habitats due to access during construction.
Pondberry	*May affect but not likely to adversely affect*	The project will result in an increase in wetland habitats available for Pondberry colonization. There may be temporary disturbances to vegetated habitats due to access during construction; however, site-specific surveys and tiered ESA consultations during implementation would avoid and minimize potential impacts.
Alligator Snapping Turtle	*May affect but not likely to adversely affect*	The project will result in restored functions to floodplain waterbodies including sloughs, meander scarps, and secondary channels, primarily through increased connectivity. There will be temporary increases in turbidity to these floodplain waterbodies during construction.

3.3.5 Invasive Species

3.3.5.1 Existing Conditions

Habitat changes have driven most of the population changes for birds and mammals, but the introduction (intentional or unintentional) of invasive species has caused significant impacts to native aquatic species. A variety of exotic aquatic species are established in the LMR. These species disrupt native species assemblages. Predation or competition with exotic species jeopardizes almost half of the species listed as threatened or endangered in the U.S. (Aquatic Nuisance Species Task Force (ANSTF) 2012).

Common carp were introduced in the early 20th century and have become so well established that they are often overlooked in discussions of invasive species. The four more recently introduced carp species (Bighead, Black, Silver, and Grass; collectively referred to as invasive carp) garner most of the attention and management focus, but all of the carp species have had negative impacts on native fishes (Conover et al. 2007). Bighead carp adversely impact mussels, larval fish, and several adult fishes such as gizzard shad, bigmouth buffalo, and paddlefish. Black carp pose a threat to many of the remaining populations of federally listed threatened and endangered mussels. Competition between black carp and native freshwater drum, the host for the endangered fat pocketbook mussel, is significant (Conover et al. 2007). Grass carp prefer a diet of submerged plants with soft leaves, but will also consume detritus, insects, small fish, earthworms, and other invertebrates. Grass carp can damage native aquatic vegetation. Silver carp lack a true stomach, so they feed almost continuously and competition with native planktivores is a major concern (Conover et al. 2007, Nico et al. 2023). Silver carp are also hazardous to boaters because they jump out of the water in response to boats. Invasive carp are prevalent in the majority of the waterbodies (main channel, secondary channels, meander scarps, sloughs, crevasses) connected to the Mississippi River. Some of the more isolated floodplain waterbodies (e.g., borrow areas) contain fewer to no invasive carp (Appendix 5). However, the threat of additional invasions to all waterbodies remains due to the annual hydrological fluctuations in the batture.

Northern snakehead *(Channa argus)* is a native fish of Eastern Asia that was unintentionally introduced by fish markets and the pet trade. It generally outcompetes native species, like bowfin *(Amia calva)*, that thrive in slack water habitats. Northern Snakehead populations have been established in several tributaries of the Mississippi, White, and Arkansas rivers in Eastern Arkansas. Northern snakehead are not yet prevalent in the study reach, but the threat of range expansion remains due to their presence in these downstream tributaries.

Zebra mussels were unintentionally introduced to U.S. waters through ballast water exchange into the Great Lakes. There are several connections between the Great Lakes and the Mississippi River basin. By 1991 they were found in the Illinois River and soon after were found throughout the Mississippi River basin. Zebra mussels are prolific and can reach high population densities quickly (ANSTF 2012, Benson et al. 2023). They can reduce the density of plankton (microzooplankton and phytoplankton), which is essential food for various life stages for many native fish and mussels. An estimated $200 million nationwide is spent annually to maintain intake pipes and screens that become clogged with zebra mussels (ANSTF 2012, Benson et al. 2023). Quagga mussels have also recently been found throughout the Mississippi River drainage, but very few within the study reach. Their origin and impact on the system is much the same as zebra mussels. Zebra and quagga mussels do not currently comprise a significant component or significantly affect the aquatic community in the study reach, but the on-going threat remains.

Numerous other non-native species have been introduced to U.S. waters through the release of ballast water from Great Lakes freight ships. There are several connections between the Great Lakes and the Mississippi River basin and there are at least 25 aquatic invasive species that have progressed into the Mississippi River basin or are close to moving into the system since the 1970s. New invasive species that are or will likely become

part of the fauna of the LMR include spiny waterflea, Eurasian ruffe, round goby, plus many species from groups of algae, annelids, daphnia, and copepods.

Invasive plant species pose a serious risk to native species. Kudzu was first introduced to the U.S. in 1876, and the erosion control programs of the 1930s to 1950s caused its spread. It now covers two million acres of forest land in the southern United States (Forseth & Innis 2004). Kudzu is an aggressive, fast-growing vine and is very heavy. It covers other plants blocking out sunlight, girdling stems, breaking branches, and even uprooting trees (Forseth and Innis 2004). Privet was introduced to the U.S. in the mid-19th century as an ornamental shrub. It has invaded many areas in the LMR that are now drier than they were historically. It crowds out native understory vegetation (Merriam and Feil 2002). Neither of these plants provides suitable habitat for native species. These two species do not currently comprise a significant component of the vegetative community in the batture within the study reach, but the on-going threat remains.

The U.S. Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act in 1990 to establish a broad national program to stop the introduction of nuisance species and control the spread of species already present. This legislation was reauthorized and expanded when the National Invasive Species Act was enacted in 1996 (ANSTF 2012). The ANSTF comprised of 13 Federal agencies and 13 ex-officio representatives (i.e., Mississippi Interstate Cooperative Resources Association or MICRA) is devoted to preventing and controlling aquatic invasive species (ANSTF 2012). The ANSTF Strategic Plan 2013-2017 focuses on prevention, monitoring, and control of aquatic nuisance species, and increasing public awareness of aquatic invasive species and their impacts (ANSTF 2012). Controlling nuisance species is primarily achieved through prevention, early detection, and rapid response. Public education, awareness, and collaboration are vitally important to control aquatic nuisance species.

3.3.5.2 No Action (Future Without Project)

Invasive carp would be expected to have impacts similar in intensity to current conditions or increase slightly due to the degraded aquatic habitats effects on native species as described in the aquatic resources section, depending on the extent of ANSTF and other conservation activities in the LMR. Similarly, zebra mussels, quagga mussels, northern snakehead and other invasive aquatic species introduced to U.S. waters through the release of ballast water from Great Lakes would be expected to have impacts similar in intensity to what is found in the study area currently. Moderate adverse impacts to the floodplain forest are expected to occur as privet, and other vegetative invasive species increase their range throughout the study area and adjacent habitats.

3.3.5.3 Impacts of the Recommended Plan

Alligator gar have few natural predators due to their large size and long life. An adult alligator gar can grow up to eight feet long and weigh more than 300 pounds. Alligator gar are one of the few natural predators that grow quick enough and large enough to feed on adult invasive carp. The RP promotes alligator gar spawning habitats, one of the only native species able to prey upon adult invasive carp, through increased aquatic habitat quality and through restoration of seasonal herbaceous wetlands and moist soil habitats for potential spawning

(Appendix 1 – Measure Descriptions, Appendix 5 – Ecological Models). This aligns with the Framework which includes seven goals and associated potential strategies to collectively prevent further expansion, reduce populations, and better understand the impacts of invasive carps (Rodgers 2019). Recommended strategies include promotion of native fish species, particularly native predators, such as alligator gar. Alligator gar spawning success requires floodplain inundation long enough for water temperatures to become sufficiently warm as well as vegetation for the eggs to adhere to. An alligator gar HSI was developed by USFWS to provide landscape-level spatial data to determine the extent and quality of floodplain habitat that may be available for Alligator Gar spawning (Allen et al. 2020). USFWS provided the alligator gar HSI data layer for this study reach and their experts assisted in siting measures during plan formulation. This information was used as a planning tool by an interagency team to evaluate priority measures for hydrologic/hydraulic restoration in the final array. Alternative selection also included review of the alligator gar HSI tool, as well as other considerations of species and habitat significance, to determine the optimum priority for the RP and eventual implementation in this conservation reach.

Invasive vegetative species would be removed as part of the reforestation and forest stand improvement measures and associated adaptive management activities. In addition, the planting of diverse native tree species would add resilience to the forest and improve native competition. Other invasive species would remain at similar levels compared to the no-action alternative. The RP would slightly reduce the level of invasive species in the study area. Effects on invasive species would be less than significant.

3.3.6 Recreation

3.3.6.1 Existing Conditions

This resource is institutionally important because of the Federal Water Project Recreation Act of 1965, as amended and the Land and Water Conservation Fund Act of 1965, as amended. Recreational resources are technically important because of the high economic value of these recreational activities and their contribution to local, state, and national economies.

Recreation areas were examined in and around the study area. The proposed actions are in proximity to one NWR, two Tennessee WMAs, one state refuge, two state parks, as well as other significant recreation areas located along the Mississippi River and within Memphis city limits. These areas are visited annually for recreational purposes and include miles of trails for hiking and biking, boat ramps, fishing piers, visitor centers or classroom spaces, and wildlife observation. These recreation areas provide opportunities for consumptive-use (hunting and fishing activities), as well as non-consumptive-use (hiking, biking, boating, bird watching, education, camping, picnicking, and sport activities). Appendix 2d, Table A2d-1 lists the state and Federal recreational facilities that are in or adjacent to the study area and provides information about size and recreational features. Outside of these parks, functional boat ramps remain scarce in the LMR, as documented during scoping and in previous reports (LMRRA 2015).

OSE relating to leisure and recreation are analyzed in the socioeconomics section and Appendix 7.

3.3.6.2 No Action (Future Without Project)

With implementation of this alternative, no direct or indirect impacts to recreational resources would occur. The decline in wildlife and fisheries habitat would accelerate the pattern of declining participation in consumptive and some non-consumptive recreational activities in the study area.

3.3.6.3 Impacts of the Recommended Plan

The proposed action would create temporary, negative impacts to recreational resources associated with wildlife habitat. Construction activity near or within riparian, wetland, and forested habitats would disturb wildlife in the vicinity. However, wildlife would return to these areas after construction. These effects would be less than significant. Long-term recreational resources associated with wildlife habitat would benefit in the study area. Habitat restoration within the reach will provide improved conditions for multiple species of fish, wildlife, and waterfowl. In turn, these improved conditions will provide more opportunities for successful outcomes while hunting and fishing, plus improve conditions for off channel recreational pursuits such as kayaking, beaching and bird watching. Getting to these areas will remain a challenge. While outside the scope of this study, increasing the number of functional boat ramps for the entire reach would be a positive outcome, especially when paired with habitat restoration.

Additionally, the proposed recreation trails and signage would provide individuals with unique, accessible recreational opportunities in the study area. Additional details regarding these measures can be found in the Measures Descriptions in Appendix 1 and in Engineering Appendix 3.

3.3.7 Aesthetics

3.3.7.1 Existing Conditions

This resource is institutionally important because of the laws and policies that affect visual resources, most notably the 1969 NEPA and USACE ER 1105-2-100. Visual resources are technically important because of the high value placed on the preservation of unique geological, botanical, and cultural features. Aesthetic resources are publicly important in that environmental organizations and the public support the preservation of natural pleasing vistas.

Bounded by the West Tennessee bluffs and the Mississippi River levee system, the study area is within the Northern Holocene Meander Belts ecoregion. This ecoregion is characterized by the extensive agricultural bottomland flatlands made possible by channelization and flood control systems, making it one of the more heavily altered ecoregions in the United States. This heavily cultivated landscape consists of a patchwork of thin strips with dense BLH forests that are juxtaposed with the straight borders and perimeters of neighboring agricultural land and historic development along the river corridor. (Chapman, S.S, Griffith, G.E., Omernik, J.M., Comstock, J.A., Beiser, M.C., and Johnson, D., 2004, Ecoregions of Mississippi, Reston, Virginia, U.S. Geological Survey)

Significant water resources in the study area include the Mississippi River and its tributaries the Hatchie, Loosahatchie, and Wolf Rivers. A unique attribute to note regarding the Hatchie River is that it is the longest free flowing, un-channelized, and un-impounded river in the state of Tennessee. Man-made levees are the dominant landform along these corridors and land use varies from cultivated crops to woody wetlands. These remaining forested stands typically consist of oak, hickory, pecan, tupelo, bald cypress, cottonwood, elm, ash, and hackberry canopies. Meeman-Shelby Forest WMA and State Park, Lower Hatchie NWR, John Tully WMA, and Eagle Lake Refuge provide user access to the limited public lands within the LMR Batture. Significant roadways providing primary vehicular access into the study area's visual landscape are the Hernando Desoto Bridge at I-40 and the I-55/US 61 bridge crossing the Mississippi River in Memphis.

3.3.7.2 No Action (Future Without Project)

With implementation of this alternative, no direct or indirect impacts to aesthetic resources would occur. Planning initiatives regarding desired visual resources include those of the Tennessee Wildlife Resources Agency (TWRA) and its managed lands in the study area. The agency maintains its mission "to preserve, conserve, manage, protect, and enhance the fish and wildlife of the state and their habitats for the use, benefit, and enjoyment of the citizens of Tennessee and its visitors."

3.3.7.3 Impacts of the Recommended Plan

The proposed action would create temporary, negative impacts to aesthetic resources associated with wildlife habitats. Construction activity near or within riparian, wetland, and forested habitats would disturb wildlife in the vicinity. However, wildlife would return to these areas after construction. These effects would be less than significant. The proposed action would augment the desired visual resources inherent with the TWRA mission "to preserve, conserve, manage, protect, and enhance the fish and wildlife of the state and their habitats for the use, benefit, and enjoyment of the citizens of Tennessee and its visitors."

Additionally, the proposed recreation trails & signage would provide individuals with unique, accessible aesthetic opportunities in the study area.

3.4 PHYSICAL ENVIRONMENT

3.4.1 Greenhouse Gases

3.4.1.1 Existing Conditions

Carbon dioxide (CO_2) is the primary greenhouse gas emitted from human activities, chiefly through combustion of fossil fuels. Greenhouse gases absorb reflected energy from the sun and warm Earth's atmosphere. Increases in green gases have resulted in measurable warming of the Earth's surface and ultimately changes to some ecosystems. Trees are able to reduce the amount of CO_2 in the atmosphere by sequestering the gas during photosynthesis and returning oxygen to the atmosphere as a byproduct.

3.4.1.2 No Action (Future Without Project)

Greenhouse gas emissions were calculated for the No Action Alternative by using the USDA COMET-Farm tool, version 4.1, for emissions in the agricultural lands in the study area (. In addition to agricultural emissions, greenhouse gas associated with equipment used for typical land management practices, such as, replacement of existing culverts, were calculated in areas of the proposed measures for comparison. Details on the GHG analysis are included in Appendix 2e. The total GHG emissions for the No Action (future without project) were 148.55 average annual metric tons of CO_2 equivalents with a total social cost of $1,308,79.17.

3.4.1.3 Impacts of the Recommended Plan

Project construction would result in release of some greenhouse gases as equipment burns fossil fuels. GHG emissions were calculated for the construction activities comprising the RP using the type, quantity, horsepower, total hours, and associated emission factors of the equipment across the 50-year project life to compare to the No Action/FWOP scenario. Total hours included both construction and O&M activities for the RP. In addition to the GHG emissions from construction and O&M, forested areas created and enhanced by the RP would have a beneficial long-term effect on greenhouse gases through carbon sequestration. The amount of carbon sequestered from the proposed 445 acres of reforestation efforts was calculated using the March 2022 EPA estimate of 0.84 metric tons of CO_2/acre/year from an average U.S. Forest (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-revision-history), allowing for the net values to be determined for the RP. The total greenhouse gas (GHG) emissions for the RP were -185.83 average annual metric tons of CO_2 equivalents with a total social cost savings of $1,286,074.47. This is in addition to the forest stand improvements and wetland restoration accomplished across another approximately 2,000 acres. Additional details on the GHG analysis are included in Appendix 2e. The effects on GHG would be less than significant. Overall, minor short-term adverse effects would be offset by the long-term beneficial effect of forest protection and reforestation through plantings and natural succession. The project would not affect the U.S. Greenhouse Gas Emissions Reduction Goal of meeting net-zero emissions by 2050.

3.4.2 Geology and Soils

3.4.2.1 Existing Conditions

The proposed project area is located within the MAV, which formed by glacial melt waters carrying large amounts of water, silt, sand, and gravel from the country's interior down to the Gulf Coast. The alluvial valley is bordered on the east by bluffs and on the west by merging valleys of the principal tributaries and ranges in width from approximately 30 to 90 miles (Saucier 1994). Quaternary deposits within the alluvial valley consist of various abandoned channels and point bar deposits of historic Mississippi River meander belts. The fluvial-geomorphic history determines the individual soil types at specific locations. The majority of the soils within the immediate footprints of the proposed measures are sand, silt, clay, and gravel alluvium.

The Mississippi River alluvial aquifer is a surficial aquifer that underlies about 32,000 square miles of Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee consisting of gravel, sand, silt, and clay of Quaternary age that is hydraulically connected with the

Mississippi River. Water levels fluctuate seasonally with precipitation and river stages. In Arkansas, the thickness of the Mississippi River alluvial aquifer ranges from approximately 50 to 150 feet (Czarnecki et. al., 2002). The quality of groundwater generally meets the standards recommended for public water supplies by the EPA. The alluvial aquifer relies on precipitation as the main source of recharge. In areas where the confining unit is thinned or absent, recharge rates are improved due to increased vertical permeability. Major rivers are incised into the aquifer and interactions between the surface water and groundwater can be dynamic. In predevelopment stages, groundwater within the aquifer flowed down slope topographically and contributed to stream base flows. Due to increased pumping, cones of depression have formed, particularly in Arkansas counties west of the study area, changing the hydrologic system (Czarnecki 2010). This lowering of the potentiometric surface within the aquifer substantially altered groundwater flow paths to the degree that present day river channels generally provide recharge to the aquifer (Ackerman, 1989). The degree to which rivers recharge the aquifer is governed by the permeability of the river deposits, the degree to which the river has been incised into the aquifer, and water level within the aquifer. In addition, dewatering of an aquifer can lead to permanent subsidence of the aquifer sediments, decreasing storage capacity and hydraulic conductivity (Kresse et. al., 2014). Primary concerns for the Mississippi River Valley alluvial aquifer in the Mississippi River alluvial valley are dewatering of the aquifer by overuse, contamination from agricultural fertilizer runoff and urban development due to a thinned or absent confining layer at the surface, and contamination by recharge from rivers.

3.4.2.2 No Action (Future Without Project)

No significant changes to the overall geology and soils are expected with no action. The detrimental effects to the surrounding Mississippi River alluvial aquifer from overuse, particularly in those agricultural dominant counties west of the study area, contamination of agricultural runoff and urban development, and recharge from rivers would continue.

3.4.2.3 Impacts of the Recommended Plan

Soils would be disturbed during construction of the measures. Flow restoration typically includes removal or replacement of obstructions, like culverts and bridges, requiring some soil disturbance and placement of riprap protection around structures. Soils would also be disturbed during tree planting via manual and mechanical equipment, and tree and seasonal herbaceous wetland seeding, such as discing, raking, or turning to allow seeds to reach mineral soil and germinate. Excavated material for restoring low flow channels would be reshaped on-site. Some excavated soil would be used for creation of berms at the proposed moist soil management sites. The plan would have temporary minor adverse impacts to soils and longer term minor beneficial effects to soils as the landscape would be restored to more natural and resilient conditions. The effects would be less than significant. Groundwater wells at the moist soil management measures would also be installed in the alluvial aquifer and used to supplement the local hydrology to promote wetland health and alligator gar spawning. The amount of water needed to supplement this hydrology would be minimal, resulting in only minor adverse impacts to groundwater levels.

3.4.3 Water Quality

3.4.3.1 Existing Conditions:

Water quality in the LMR impacts not only local freshwater aquatic ecosystems along its 950-mile length, but ultimately the wetlands, estuaries, and marine ecosystems of the Gulf of Mexico region, and the Gulf of Mexico. Water quality is an important aquatic habitat variable in the LMR (Baker et al. 1991). Low oxygen levels impact fish species richness and abundance in the smaller secondary channels, meander scarps, and floodplain waterbodies during low water conditions in summer and fall. Nutrient pollution has serious negative impacts for human and natural communities throughout the larger Mississippi River watershed. As the Mississippi River makes its way to the Gulf of Mexico, it picks up and carries a heavy load of nutrients from bordering states, delivering it to the Gulf of Mexico and creating one of the largest dead zones in the world. Some studies have been conducted to determine the overall aquatic health of the Mississippi River; however, there is a paucity of water quality monitoring sites on the LMR and unfortunately the sources and fates of nutrients, pathogens and contaminants in the river have not been clearly delineated (USACE 2015). A recent analysis of available data from USGS National Water Information System was completed comparing mean in situ water quality measurements in the Mississippi River collected sporadically from 1970 to 2019. This analysis of water quality moving downstream from Thebes, Illinois to New Orleans, Louisiana, showed temperature, pH, dissolved oxygen, specific conductance, and turbidity were all within acceptable limits for the National Recommended Water Quality Criteria for freshwater published by the EPA (USACE 2020). Similarly, mean dissolved trace metal concentrations were within acceptable aquatic life limits for acute and chronic exposure (FWA & FWC) for all metals. The report also highlighted five nutrients that are believed to be the primary drivers of gulf hypoxia, and the mean value for the period of record were also compared from Thebes to New Orleans. No standard criteria for rivers and streams (fresh water) for nutrients has been published by EPA or the representative environmental state agencies for Arkansas and Tennessee. The mean total nitrogen concentration decreased approximately 1.0 mg/L from Thebes to Memphis and continued to fall at a slower rate to New Orleans from 3.46 mg/L to 2.38 mg/L with an overall average of 1.80 mg/L, respectively. The mean nitrogen oxide concentration of 2.46 mg/L at Thebes decreased slowly to a concentration of 1.37 mg/L at Arkansas City before increasing slightly to an average of 1.48 mg/L at the lower three stations. The slight increase in concentration between Arkansas City and Vicksburg can likely be attributed to the time frame of sample collection. Approximately 75 percent of the samples for Arkansas City were collected in the 1980s and prior, while approximately 90 percent of the samples collected for Vicksburg were from the 2000 and 2010 decades. The mean concentration for total organic nitrogen (TON) demonstrated a more consistent downward trend from Thebes to New Orleans except for the lower concentration at Memphis. The concentration for the TON parameter fell from 0.97 mg/l at Thebes to 0.57 mg/L at New Orleans. The total phosphorous mean concentration of 0.34 mg/L at Thebes decreased to 0.19 mg/L at Memphis and then slowly increased to 0.24 mg/l at New Orleans. The mean concentration for orthophosphate decreased from 0.100 mg/L at Thebes to 0.059 mg/L at Vicksburg and then increased back to 0.100 mg/L at New Orleans. There are some localized areas of water quality concern in the study area around the city of Memphis. Contaminants are often elevated in samples taken from the Mississippi River near Memphis. This is reflected in the

Tennessee fish consumption advisory and commercial fishing closure in the Mississippi River due to chlordane, mercury, and other organics.

3.4.3.2 No Action (Future Without Project)

Previous analyses have shown that the overall water quality of the Mississippi River meets all aquatic life standards. The Mississippi River does carry excess nutrients, but this nutrient load does not have a measurable adverse effect on aquatic life. With existing protections under the CWA, no significant changes to this trend are expected with the No Action Alternative. Existing floodplain waterbodies in the study area act as sinks for nutrients and sediments. Floodplain waterbodies, and disconnected secondary channels and meander scarps, would continue to exhibit low dissolved oxygen conditions during summer and fall with low water conditions. These adverse effects are expected to be exacerbated with extended periods of drought from climate change. Improving water quality monitoring and management in the LMR continues to be a goal in the LMR (USACE 2015, USEPA 2008).

3.4.3.3 Impacts of the Recommended Plan

Construction of the measures in the RP with would have similar direct impacts of localized increases in turbidity and suspended solids. Implementation of BMPs for nonpoint pollution at construction sites would minimize these direct impacts to the water quality of the Mississippi River. The effects would be less than significant. The RP would have long-term beneficial effects to water quality in secondary channels and meander scarps through increased connectivity, resulting in higher dissolved oxygen during low water conditions compared to the future without project.

3.4.4 Cultural Resources

3.4.4.1 Existing Conditions

This study encompasses Crittenden and Mississippi Counties, Arkansas, and Shelby and Tipton Counties, Tennessee. Within these four counties, there are a multitude of known cultural sites within or adjacent to the study area ranging from prehistoric scatters, camps, and villages to tenant farming settlements and shipwrecks. According to Automated Management of Archaeological Site Data in Arkansas database, in Mississippi County, Arkansas, there are a total of 13 archaeological sites, including six historic sites, three woodland sites, and four Mississippian sites. Additionally, within the Mississippi County portion of the study area, there have been 18 surveys. In Crittenden County, Arkansas there were a total of six archaeological sites, five of which were historic, including two sunken ships, possibly the Sultana and the Pacific, and one possible prehistoric site. There have been 21 surveys in or adjacent to the study area. There are no National Register of Historic Properties (NRHP) sites within or adjacent to the study area.

According to data provided by the Tennessee Division of Archaeology for the Shelby and Tipton County areas, Shelby County, Tennessee has a total of 61 known sites within or adjacent to the study area. Of these 61 sites, 30 are prehistoric camps or scatters, 13 have no available data, seven are prehistoric villages, six are historic, two are aboriginal, two are multi-component and one is a Baytown site. Within the Shelby County area, there are 17

historic districts one on the NRHP. There are 194 documented NRHP individually eligible or listed properties within the downtown Memphis area. Tipton County has 13 known sites within or adjacent to the study area. Of those 13, five are prehistoric, including the eligible Richardson Landing site, three are historic including Fort Wright, four have no available data, and one includes a redeposited Mastodon bone. There have been 20 surveys in or adjacent to the study are in Shelby and Tipton counties. There are no NRHP sites within the Tipton County portion of the study area.

3.4.4.2 No Action (Future Without Project)

Under the future without project, impacts to cultural resources, where applicable, would continue to occur from erosion, flooding, and meandering of the Mississippi River.

3.4.4.3 Impacts of the Recommended Plan

The RP would be unlikely to have any impacts on known cultural resources as the plan has made every effort to avoid known resources within the footprint of the proposed measures. Currently, USACE has an executed PA with the Arkansas and Tennessee state historic preservation offices (SHPOs) and federally recognized Tribes that establishes protocols for additional surveys when needed prior to construction and ensures that any potential effects to cultural resources would be less than significant. See Appendix 8 for specifics on this coordination.

3.4.5 Air Quality

3.4.5.1 Existing Conditions

Mississippi County, Arkansas and Tipton County, Tennessee are classified as in attainment for air quality standards; whereas, the Memphis metropolitan area that includes Crittenden County, Arkansas and Shelby County, Tennessee was designated as a maintenance area of the currently applicable 2008 8-hour O3 standard with a marginal classification on 25 July 2016 (EPA 2023).

3.4.5.2 No Action (Future Without Project)

Under the No Action Alternative, there is no expected change from existing conditions.

3.4.5.3 Impacts of the Recommended Plan

The measures located in Mississippi County Arkansas, and Tipton County, Tennessee are located in areas classified as in attainment for air quality standards, and the equipment used is classified as a mobile source and exempt from permitting requirements. Construction of the measures located in Crittenden County, Arkansas and Shelby County, Tennessee would be below the de minimis value of 100 tons/year for the county's marginal classification per 40 CFR 93.153(b)(1). BMPs would be used during construction to minimize air quality impacts. Overall, no direct or cumulative impacts are expected with the proposed activities. Any effects to air quality would be less than significant.

3.4.6 Hazardous, Toxic, and Radioactive Waste (HTRW)

Site assessments were conducted to assess the potential for HTRW materials within the footprints of the proposed measures following the guidelines and procedures outlined in the USACE ER 1165-2-132, Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects (26 June 1992) and the American Society for Testing and Materials (ASTM) E 1527-13, Standard Practice for Environmental Site Assessments: Phase 1 Environmental Site Assessment Process (ASTM, 1997). The objective of the HTRW assessments was to identify HTRW problems early in the design of measures to ensure appropriate consideration of HTRW problems during detailed design. The HTRW assessments included: 1) a review of HTRW Phase I Environmental Database Review Corridor Reports and State and Federal databases (e.g., Resource Conservation and Recovery Act Information, Toxic Release Inventory, Superfund Enterprise Management System, Assessment, Cleanup and Redevelopment Exchange System, and state databases on underground storage tanks and hazardous waste programs, etc.) to identify recognized environmental conditions (RECs), and 2) site reconnaissance, where possible, to determine if RECs are within the proposed footprints of the measures in the final array. It should be noted that access to several measures was not available during the site reconnaissance due to access and entry limitations, as well as inundation from the Mississippi River. Based on the site assessments at the proposed measure locations, the overall risk associated with HTRW for the project is low. Should the construction methods or work items designs change, the HTRW risk would require reevaluation. Additionally, the aforementioned guidance states a Phase I ESA is not valid beyond one year. When the final study is completed, decision document is signed, and funding allocated, then a final, full Phase I ESA would be executed on individual measures prior to construction to secure “all appropriate inquiry” protection. Thus, HTRW would be unaffected.

3.5 BUILT ENVIRONMENT

3.5.1 Mississippi River and Tributaries Features

3.5.1.1 Existing Conditions

The Commerce, Missouri to St. Francis levee system bounds the study area to the west. This levee system was constructed as part of the MR&T project as authorized by the Flood Control Act of 1928. The levee system has reduced the natural floodplain of the Mississippi River isolating waterbodies historically connected to the river and changing flow patterns throughout the valley. The levees have also provided protection to acres/miles of productive farmland and communities in the region and prevented millions of dollars in flood damages. The channel improvement feature of the MR&T consists of construction and maintenance of channel improvement and stabilization works to stabilize the navigation channel, protect flood control structures, increase the flood-carrying capacity of the river, and maintain a favorable navigation alignment. River training structures, such as dikes, and revetments are constructed to maintain a navigation channel and reduce the need for dredging. This has restricted the channel from forming natural cutoffs and new meander bends. Approximately 150 different river training structures, and 33 miles of revetment have been constructed in the study area since the early 1930s. While this has provided huge benefits to the navigation industry, it has reduced the number of backwater and side-channel connections to the river

and resulted in the loss of wetlands with negative impacts to aquatic, semi-aquatic, terrestrial, and avian species. In recent years, the USACE Memphis District has partnered with the NFS to incorporate environmentally friendly designs into the CIP (Killgore et al. 2014, Benjamin et al. 2016). Within this reach, approximately 40 dike notches have been constructed to promote flow in secondary channels. Additional details regarding the MR&T features are included in Engineering Appendix 3.

In addition to the impacts from the levee and river training structures, this reach has been undergoing large scale geomorphic change due to the channel cutoff program in reaches further downstream (Biedenharn et al., 2017). The reach of river around Memphis has shown a decreasing trend in the specific gage records, indicating a state of degradation (i.e., the lowering of the channel bed). This has likely exacerbated the disconnection of secondary channels and floodplain water bodies from the main channel. Past (and future) trends of this degradation, included in Appendix 5, would continue.

In consultation with the Arkansas SHPO, levees will be given a site number and a site form will be filled out, which will include a description and measurements of the levee within the project area. National Register of Historic Places (NRHP) determinations will be made under future consultation as allowed for in the PA.

3.5.1.2 No Action (Future Without Project)

Without action, construction and maintenance of the flood control and navigation MR&T features would continue. The mainline levee along the western edge of the study area would continue to be maintained and deficiencies such as grade and seepage issues addressed. Construction and maintenance of channel improvement and stabilization works would continue to maintain the navigation channel. Trends of degradation (i.e., the lowering of the channel bed) throughout this reach would continue, including the disconnection of existing secondary channels, meander scarps, and floodplain waterbodies, as detailed in Appendix 5.

3.5.1.3 Impacts of the Recommended Plan

Ongoing construction and maintenance of the MR&T flood risk management features (e.g., mainline levee) and navigation features (e.g., channel improvement dikes and revetments) will continue throughout the period of analysis. The main flood risk management feature in the study area is the mainline levee, which the project is not affecting, as that was a project constraint. The measures are proposing to restore hydrology to uninhabited rural lands and waters in the active floodplain that are already frequently flooded. Further, there are no damages currently identified that would be outside of the project benefit areas, which are already proposed to be purchased in-fee.

Measures formulated for this study were developed to avoid impacts to the flood risk management and navigation, as described in the discussion of project constraints. Any measures that pose a safety concern to navigation would be added to the navigation charts. A two-dimensional HEC-RAS model (version 6.3.1) was created to develop inundation layers extents for the project area for various events and to evaluate the potential for adverse impacts to the navigation and flood risk management systems. Results for this

analysis showed that there would be no adverse impacts. Additional details are described in Section 1.14 of Engineering Appendix 3. The restoration activities in the RP work in concert with other conservation activities (e.g., dike notching, etc.) that are built into the MR&T coordination framework with other state and Federal agencies and the NFS to minimize impacts (Killgore et al. 2014). Additional details of conservation activities related to this framework are included in Cumulative Effects Section 3.9. Effects to the MR&T features would be less than significant. Impacts to flood risks outside of the MR&T system are similarly less than significant. The measures are proposing to restore hydrology to uninhabited rural lands and waters in the active floodplain that are already frequently flooded. Further, there are no damages currently identified that would be outside of the project benefit areas, which are already proposed to be purchased in-fee.

3.6 ECONOMIC ENVIRONMENT

3.6.1 Socioeconomics

3.6.1.1 Existing Conditions

The populations from 1970 – 2020, per the Census Bureau's decennial censuses, are reported for the five counties in Arkansas and Tennessee included in the study area and are shown in Table 3-4. In Lauderdale County, Tipton County, and Crittenden County, populations grew consistently over time. The Shelby County population grew at a higher rate starting in 1970 and had a significantly larger population than that of the other counties in the area. Mississippi County, Arkansas, is the only county in the study area to experience a large contraction in population. This population decrease is largely due to the closure of the Eaker United States Air Force base in Blytheville, Arkansas.

Table 3-4. Population of Study Area Counties

Population by County (Thousands) 1970 - 2020						
County	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**
Crittenden County, Arkansas	48.28	49.49	49.96	50.92	50.94	48.163
Mississippi County, Arkansas	62.28	59.47	57.56	51.85	46.38	40.685
Lauderdale County, Tennessee	20.33	24.5	23.57	27.11	27.73	25.143
Shelby County, Tennessee	724.13	776.21	828.45	898.21	928.63	929.744
Tipton County, Tennessee	28.08	33.01	37.9	51.58	61.15	60.97
Source: U.S. Census Bureau (BOC)						

The median age of Crittenden & Mississippi Counties in Arkansas is 35.3 and 36.8, respectively. These are just slightly younger than the median age of Arkansas of 38.5. The median age of Lauderdale County, Tennessee is 39.1; Shelby County, Tennessee is 35.8; and Tipton County, Tennessee is 38; whereas the median age of Tennessee in its entirety is 39.2.

Per capita personal income is listed in Table 3-5. The rate of growth for Per capita personal income is consistent for all of the counties within the study area.

Table 33-5. Per Capita Personal Income of Study Area Counties

Per Capita Personal Income (USD) by County (1970 - 2020)						
County	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**
Crittenden County, Arkansas	2,847	6,828	13,275	20,274	28,962	41,474
Mississippi County, Arkansas	2,851	6,807	13,673	18,748	28,867	37,730
Lauderdale County, Tennessee	2,342	5,917	12,206	18,160	22,798	35,267
Shelby County, Tennessee	3,760	9,744	19,180	31,733	39,534	53,855
Tipton County, Tennessee	2,690	7,353	14,387	23,533	30,267	43,147
Source: U.S. Bureau of Economic Analysis (BEA)						

The unemployment rates of five counties included in the study area are included in Table 3-6. In the year 2020, all of the counties in the study area experienced an increase in unemployment rate. This is due to the COVID-19 pandemic that occurred, affecting employment. Crittenden and Mississippi counties in Arkansas do have a higher unemployment rate than their neighboring counties in Tennessee.

According to the Bureau of Labor Statistics Quarterly Census of Employment and Wages, employment in each of the five counties included in the study area are heavily influenced by the trade, transportation, and utilities industry. Additionally, the manufacturing industry is prevalent in four of the counties, excluding Shelby County, Tennessee. The Leisure and Hospitality industry is also a large industry for Mississippi County, Arkansas; Shelby County, Tennessee; and Tipton County, Tennessee.

Table 3-6. Unemployment Rates of Study Area Counties

Unemployment Rates by County (2020)	
County	**Unemployment Rate (%)**
Crittenden County, Arkansas	5.8
Mississippi County, Arkansas	5.5
Lauderdale County, Tennessee	3.4
Shelby County, Tennessee	4.7
Tipton County, Tennessee	3.2
Source: U.S. Census Bureau (BOC)	

3.6.1.2 No Action (Future Without Project)

Under the No Action Alternative, there are not any expected changes in population for any of the counties within the study area. According to Moody's Analytics forecasting through 2045,

income per capita for all counties will continue to grow at a consistent rate. The employment rates for the counties within the study area are expected to remain consistent with minimal upward and downward movement according to Moody's Analytics forecasting.

3.6.1.3 Impacts of the Recommended Plan

The socioeconomic characteristics including population, median age, per capita income, and employment are not expected to experience any significant changes as a result of the RP (C3). Effects to socioeconomics would be less than significant.

3.6.2 Environmental Justice (EJ)

3.6.2.1 Existing Conditions

The study area comprises a 39-mile reach of the Mississippi River and the surrounding batture. There are approximately 1,338 people who reside within the census tracts of the study area, according to 2020 data available via the EPA EJ Screen Tool collected in December 2022. Most of this population appears to be located in census tracts near two tributaries, Wolf and Loosahatchie Rivers, around the Memphis metropolitan area. Anecdotal evidence suggests the majority of the population within the study area live/use camps or elevated structures since they are located in areas that flood frequently. The study area is the location for the construction of all of the ecosystem restoration measures.

Figure 3-1 shows the pollution sources and demographic data for the study area. EPA has developed an EJ mapping and screening tool called EJSCREEN, which is based on nationally consistent data and an approach that combines environmental and demographic indicators in the form indexes (https://www.epa.gov/ejscreen accessed 12/2022). Based upon the data shown in Figure 3-1, the entire study area is identified as an area of EJ concern. EPA's EJSCREEN lists demographic data and 12 environmental indicators and an area's percentile rank compared to the region, State, and the USA. The environmental indicator report helps determine if any of the areas of EJ concern are overburdened with different types of environmental pollution further reinforcing its identification as an area of EJ concern. If an EJ community's exposure to an environmental indicator is above the 80th percentile in the state or USA and the Federal action (i.e., constructing an ecosystem measure) exacerbates any of those environmental risks, mitigation may be required. Three of the EJSCREEN "Pollution and Sources" variables (particulate matter, ozone, and air toxics cancer risk) are at or above the 80th percentile, which is the point EPA considers the study area an area of EJ concern based upon the high burden that residents may experience from these pollutants.

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 (µg/m³)	8.96	8.21	85	8.67	61
Ozone (ppb)	45.2	42.6	96	42.5	77
Diesel Particulate Matter* (µg/m³)	0.225	0.233	55	0.294	<50th
Air Toxics Cancer Risk* (lifetime risk per million)	39	33	94	28	95-100th
Air Toxics Respiratory HI*	0.42	0.41	79	0.36	80-90th
Traffic Proximity (daily traffic count/distance to road)	80	360	44	760	30
Lead Paint (% Pre-1960 Housing)	0.21	0.19	65	0.27	49
Superfund Proximity (site count/km distance)	0.063	0.078	72	0.13	51
RMP Facility Proximity (facility count/km distance)	0.47	0.59	68	0.77	57
Hazardous Waste Proximity (facility count/km distance)	0.64	0.64	71	2.2	48
Underground Storage Tanks (count/km²)	0.85	1.3	57	3.9	45
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.0021	0.037	75	12	56
Socioeconomic Indicators					
Demographic Index	55%	32%	84	35%	79
People of Color	67%	27%	86	40%	77
Low Income	43%	34%	65	30%	72
Unemployment Rate	8%	5%	76	5%	76
Limited English Speaking Households	4%	1%	87	5%	71
Less Than High School Education	19%	12%	77	12%	79
Under Age 5	7%	6%	67	6%	67
Over Age 64	13%	16%	35	16%	40

Figure 3-1. USEPA Environmental Justice (EJScreen) Report, Version 2.1, of the Study Area. Approximate Population: 1,338-Input Area (sq. miles): 227.85

Source: USEPA's EJSCREEN tool. Data is form U.S. Census Bureau 2016-2020 American Community Survey.

Finally, the study area is considered an area of EJ concern based upon the socioeconomic indicators presented in Figure 3-1. The demographic index (an index that combines all of the socio-economic indexes) is 55 percent, which is very near or above the percentile in the USA and the States of Tennessee and Arkansas. Particularly, the study area is an area of EJ concern with 67 percent of the study area population identifying as a person of color which is in 86th and 77th percentile, for the State and the USA. The other socio-economic indicator that identifies the area as an EJ concern is the Limited English- Speaking Households, which the study area is in the 87th percentile for the state. Additionally, the study area is considered an area of EJ concern based upon the large percentage of low-income residents.

3.6.2.2 No Action (Future Without Project)

There would be no impacts to areas of EJ concern under the No Action Alternative since the project would not be constructed and there would be no effect on areas of EJ concern.

3.6.2.3 Impacts of the Recommended Plan

Since all the alternatives' measures for ecosystem restoration are located well outside areas where residents reside, there will be no high, adverse impacts to residents in areas of EJ concern. Additionally, most of the construction related to building the ecosystem measures does not create any substantial noise or traffic impacts associated with trucks traversing neighborhoods and these impacts are not considered high and adverse. Due to the remote nature of the project measures, no high, adverse disproportionate impacts to areas of EJ concern are expected.

Nonetheless, BMPs would be used as integral components of the proposed action, including several impact avoidance features to minimize effects of vehicular transportation. These effects would be less than significant. To the maximum extent practicable, specific routes would be designated in USACE contracts for construction-related traffic to avoid and minimize residential disturbance and traffic congestion. Staging areas for construction equipment and personnel would be located away from heavily populated areas. Streets that would serve construction-related traffic would be resurfaced, if needed and as appropriate, prior to initiation of construction activities, and maintenance of those streets would be provided during the construction period. Appropriate detour signage would be placed to preserve access to local streets during construction activities. Off-street parking would be provided for construction workers, and shuttle vans would be used to transport construction workers to the work sites, if necessary. Streets that are damaged by any and all construction activities would be repaired.

Minority and low-income populations may experience minor to moderate, temporary, adverse impacts due to transportation delays during the construction period, depending on the work involved.

Noise associated with restoration efforts may increase due to the temporary operation of equipment and vehicles used in the construction of the measures. While noise impacts may cause a temporary inconvenience to communities well removed from the activities, the noise levels associated with construction activities would be temporary and monitored to ensure acceptable standards are maintained. No permanent noise impacts as a result of construction are anticipated. All noise emissions are expected to be short-term, lasting only as long as construction activities. No long-term indirect effects on noise are anticipated.

Short-term noise impacts will be avoided, minimized, or mitigated by use of the following BMPs:

If work commences near residential areas, the contractor, as a BMP and as practicable, would restrict work to regular business hours (approximately 0700-1900) on weekdays to reduce potential effects from noise and increased truck traffic to areas of EJ concern and to the general public.

Construction equipment noise would be minimized during construction by muffling and shielding intakes and exhaust on construction equipment (per the manufacturer's specifications), and by shrouding or shielding impact tools.

All equipment, haul trucks, and worker vehicles would be turned off when not in use for more than 30 minutes.

Equipment warm-up areas, equipment storage areas, and staging areas would be located as far from existing residences as is feasible.

3.7 RELATIONSHIP TO SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The intent of this analysis is to outline tradeoffs in the relationship between short-term uses of the environment and maintenance and enhancement of long-term productivity of resources. Construction activities would temporarily disrupt fish, wildlife, and recreational use in the immediate vicinity of the proposed measures. Long-term productivity would benefit considerably by the construction of the considered action alternatives through increased reliability of the mosaic of aquatic and floodplain habitats and the species they support. With the increased habitat diversity, both game and non-game species would benefit, and in turn, both consumptive and non-consumptive users would realize heightened opportunities for recreational use. Table 2-17 summarizes these tradeoffs for the final array of alternatives.

3.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT TO RESOURCES

An irreversible or irretrievable commitment of resources refers to an adverse effect to the human environment that cannot be recovered or reversed. Irreversible impacts are those that cause use or consumption of nonrenewable resources in such a way that they cannot be restored or returned to their original condition. Irretrievable impacts refer to those losses of production or uses of natural resources for a period of time. The production or use of the resource could return in the future if the action is reversed, but the production is irretrievable. Construction activities of any of the considered action alternatives will temporarily disrupt natural resource productivity. As described in Section 3.3.1, the proposed action would irreversibly and irretrievably commit approximately 445 acres of frequently flooded agricultural lands as they are permanently converted to vegetated wetland habitats. If unknown historic or cultural resources were impacted by implementation of the proposed action, this would also be considered an irreversible effect. Irreversible commitments of resources would also include the fuel, labor, building materials, planning, technical expertise, and monetary resources needed for construction and maintenance of the proposed measures.

3.9 CUMULATIVE EFFECTS

The CEQ's regulations (40 CFR 1500-1508) implementing the procedural provisions of the

NEPA of 1969, as amended (42 U.S.C. 4321 et seq.) define cumulative effects as "effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.1)". Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.

Whereas, Section 3 describes the conditions of each resource, this section provides more depth to those relevant cumulative effects arising from the alternatives being evaluated as part of this study when combined with other ongoing or proposed actions within and near the

study area. Table 3-7 summarizes those actions for each resource category identified to have an incremental cumulative effect. Additional details on the effects from past, present, and reasonably foreseeable actions of related projects, such as activities associated with flood risk reduction that influenced land uses into the current form, and effects on riverine and floodplain habitats, are described in Section 3 and Appendix 2b of this report, the 1976 EIS (USACE 1976), the 1998 SEIS (USACE 1998), the 2020 SEIS II (USACE 2020), the LMRRA (USACE 2015), and the ESA, Section 7(a)(1) Conservation Plan for the LMR (Killgore et al. 2014), which are incorporated herein by reference.

The LMR is the keystone attribute of the study area. Navigation and flood control efforts in the LMR began in earnest as early as the 1800s, and the river system has been transformed from its natural meandering condition to a managed system promoting and facilitating commerce. Following the devastating flood of the Mississippi River Basin in 1927, Congress authorized the MR&T Project in 1928, which incorporates levees for containing flood flows, floodways for the passage of excess flows past critical reaches, dredging to maintain channel depths, revetments and dikes to train and stabilize the channel, and tributary modifications. The historical, present day, and future morphology of the LMR reflects an integration of these features with natural factors like floods and droughts, geologic outcrops, climatic variability, and other anthropogenic activities. Notably, levees have reduced the river connection to the historic extent of the floodplain (estimated 80 percent reduction of forested wetlands in the MAV), channel meandering has been eliminated by revetments resulting in channel simplification and reduced dynamism, cutoffs have altered the energy in the system contributing to lowering of the channel-bed elevation, and secondary channels have been altered by dike systems. While the study area has been altered by these activities, it is important to recognize that the LMR, unlike many other large rivers (e.g., Upper Mississippi River, Ohio River, Missouri River, etc.), is not heavily controlled by main channel dams and flow regulation. Thus, it has a fairly natural hydrograph allowing for some dynamic and morphologic adjustments to still occur, albeit, within the constraints of a river managed for flood risk reduction and navigation. Since about the 1960s, there has been a gradual increase in the cumulative number of dikes in the LMR that divert water to the main channel during low and moderate river stages to maintain a Congressionally mandated navigation channel 9-ft in depth and 300-ft in width. This increase in dike construction has greatly reduced the amount of dredging in the LMR; however, there has also been a gradual loss of secondary channels from closure structures used by riverine species.

In recognition of these habitat losses, interagency efforts have focused on habitat restoration within the region. The LMRCC formed in 1994 to provide the only regional forum dedicated to conserving the natural resources of the LMR and its floodplain. The focus of the LMRCC is habitat restoration, long-term conservation planning and nature-based economic development. By 2000, the LMRCC completed its Aquatic Resources Management Plan (LMRCC 2000). The plan outlines strategies for restoring aquatic resources within the river's active floodplain from the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois, to the Gulf of Mexico. From 2001-2004, the LMRCC held meetings in the six member states to identify projects to improve aquatic habitat and enhance public access to the river environment. Through the meetings, 239 restoration projects were identified. The restoration work of the LMRCC was coined "Restoring America's Greatest River" and is based on a unique partnership between the LMRCC, the USACE and the USFWS. The focus of these

proposed projects is to enhance LMR habitats and restore floodplain hydrology and connectivity when landowners are interested and opportunities exist. Beginning in 2006, the USACE and USFWS began working cooperatively to reconnect side channel habitat to restore this vital habitat in the LMR. USACE provides engineering plans to reconnect the side channels in a manner that will not jeopardize the nine-foot navigation channel and USFWS provides the funding to implement the notching or removal of channel structures to allow flow back into these side channel areas. After almost a decade of informal collaboration on side channel reconnection, the USACE, CEMVD, and USFWS, Southeast Region officially approved the Conservation Plan the Interior Least Tern, Pallid Sturgeon, and Fat Pocketbook Mussel in the Lower Mississippi River (ESA, Section 7 (a) (1)), July 23, 2013, updated in 2014 (Killgore et al. 2014). With this coordination, the two agencies agreed to use Section 7 (a) (1) to continue restoration using cost effective measures for side channel reconnection in the 954 miles of LMR. Through formal consultation, the USACE agreed to use programmatic mechanisms (e.g., implementing construction and maintenance and habitat restoration BMPs, sharing restoration, research and monitoring responsibilities with the interagency team, remaining active through annual interagency meetings, etc.), from the CIP of the MR&T project to maintain and improve habitat values for the recovery of endangered and other trust species inhabiting the river channel and protect migratory bird species occurring in the project area. To date, this collaborative effort has led to the reconnection of more than 115 miles of secondary channel at 33 locations to the main flowing portion of the LMR. This collaboration is expected to continue through these existing programs and is assumed to continue at the annual rate of reconnection continuing at the 6-10 miles per year. Within the Hatchie-Loosahatchie Reach, specifically, there are an estimated 13 secondary channels currently. The LMRCC/USACE implemented side channel restoration at the Loosahatchie Bar in 2008 where 11 notches were placed in eight dikes to restore flows to 11.25 miles of side channel. Densford Bar side channel notches (~5) were completed during August 2022, and Lower Cracraft Bar dikes were notched during September 2022. Operation and maintenance of the MR&T project will continue throughout the project life within the conservation framework established throughout the past several years. All of the considered action alternatives would complement these on-going conservation efforts without significantly impacting the flood risk reduction and navigation activities in the study area, and they would assist in providing some resiliency to the LMR riverine system by combating the degrading trends of those aquatic habitats and in providing long-term benefits to the aquatic community.

The MAV, where the study area is situated, was once a 24.7-million-acre complex of forested wetlands interspersed with cypress-tupelo swamps, river cane brakes, scrub-shrub wetlands and emergent wetlands. This vast complex of wetlands, through which nearly 40 percent of North America drains, provided wetland functions and wildlife values of incomparable worth. However, the landscape in the MAV has changed dramatically during the last 200 years, with the most rapid change occurring within the last 75 years. Beginning with the European settlers, BLH forest was converted to agricultural lands accelerating throughout the 19th and 20th century as improvements in flood risk reduction, drainage and farming technology made it possible to access previously saturated soils. Conversions of forested wetlands eventually slowed in the 1980s with the passage of “swampbuster” provisions in the Farm Bill. Today, only about 20 percent of the original forest remains in the MAV. The rest has been cleared for agricultural production, flood control or other land uses.

Within the last few decades, conservation of forest and wetland habitats throughout the MAV has received increased attention. The MAV was identified as a priority non-breeding site for waterfowl in the original North American Waterfowl Management Plan (1986) and became a part of one of the first established joint ventures, the LMVJV. Additionally, forest breeding bird species are one of the most important components of the avifauna in the MAV, despite the loss of nearly 80 percent of the forested wetlands in this region (LMVJV 2007). The LMVJV completed its Breeding Bird Forest Protection Model in 2019, which that provides priority forest patches for protection based on a variety of datasets. The model also found that just 109 large forest patches (of ≥2000 hectares (ha) of core forest) held 1.5 million ha of the total 2 million ha (1 ha = 2.47 acres) of areas meriting additional conservation–protection. Within the 109 large patches, over 1.3 million ha lack current conservation protection. Ducks Unlimited has named the MAV a priority I conservation area. They cite the historic floodplain of the valley is the most significant winter habitat for mallards in North America. The study area is well within this designation for Ducks Unlimited Priority 1 area. The MRT, a charitable, nonprofit conservation organization established in 2002, focuses its work on habitat conservation, conservation education and conservation policy. The MRT identifies sites for restoration, such as those owned by historically underserved landowners, including African Americans; assists landowners with easement applications; prepares sites for reforestation; hires crews to plant trees; and monitors reforested sites to ensure proper tree survival and grow. From 2012 to today, the MRT has spearheaded restoration of more than 32,000 acres of frequently flooded farmland — 50 square miles — to BLH forest in the LMR floodplain, with these private lands enrolled in the project being protected through Wetland Reserve Easements. Similarly, in their 2019 Lower Mississippi Alluvial Valley Business Plan the National Fish and Wildlife Foundation has set a goal of establishing and managing 25,000 acres of BLH forest in the MAV within the next 10 years to maintain and improve forest conditions for long-term mast production and for use by various fish and wildlife, primarily through Wetland Reserve Easements. The land cover of the approximate 146,000-acre study area is dominated with a fairly even split between BLH wetland forests (~38 percent) and cropland (~38 percent) followed by open water (~19 percent) with no other category greater than 1 percent. Of this, public lands providing valuable forested and wetland habitat include Meeman-Shelby Forest State Park in Tennessee (9,434 acres), Eagle Lake State Refuge (3,497 acres) and a small portion of the Lower Hatchie NWR (~ 9,400 total acres). Public ownership of forested wetlands is not the only means of conservation-protection. Private, voluntary conservation easements, such as those held by Ducks Unlimited, TNC, the MRT, National Fish and Wildlife Foundation, and other conservation organizations, can be equally effective at long-term conservation of these bottomland forests. In addition to these public lands, over 7,300 acres of the study area are under conservation easements with the NRCS. Ducks Unlimited is also partnering with Big River Park Conservancy (BRPC), and others to restore 1,500 acres of wetlands and to promote recreational and tourism opportunities in downtown Memphis and nearby West Memphis, mostly in and around the Delta Regional River Park located within the Hopefield Point-Big River Park Geographic Complex of the study area. All of the considered action alternatives would contribute to these on-going conservation protection efforts of wetland habitats in the MAV, helping to reduce habitat fragmentation, increase wetland community compositions, and provide long-term benefits to those wildlife and migratory birds using these wetland habitats at critical times in their life cycles.

Table 3-7. Cumulative Effects Summary

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Considered Action Alternatives
Land Use	*Conversion from forest to agriculture*	*Negligible changes of land use trends*	*Negligible changes of land use trends*	*Negligible changes of land use trends*	*Negligible changes of land use trends*
Wetlands	*Construction of MR&T and private flood risk reduction efforts; land use changes; habitat fragmentation and conversion; degraded wetland communities from land management (e.g., reduction in hard mast- producing species, cypress/tupelo swamp habitats, and river cane habitats)*	*Operation and maintenance of the MR&T; management of agricultural lands and other private lands*	*Operation and maintenance of the MR&T; management of agricultural lands and other private lands*	*Degraded conditions of wetland habitats, including lack of hard mast- producing species, cypress tupelo swamp habitats, and river cane*	*Increased wetland habitat and forest stand improvements; Temporary, minor, local impacts due to construction activities*
Wildlife	*Land use changes; loss of habitat both aquatic and wetland; USACE, other federal, state, and private habitat restoration and land management programs combat habitat loss*	*Maintenance of current habitat conditions due to maintenance of MR&T system and conservation frameworks; habitat restoration and land mgmt through USACE, other federal, state, and private programs; maintenance of current floodplain habitat conditions due to continued land uses; navigation impacts; native species continue to be impacted by exotic species*	*Maintenance of current habitat conditions due to maintenance of MR&T system and conservation frameworks; habitat restoration and land mgmt through USACE, other federal, state, and private programs; maintenance of current floodplain habitat conditions due to continued land uses; navigation impacts; native species continue to be impacted by exotic species*	*Continued decline of physical habitat (both aquatic and wetland); decline in wildlife use*	*Improved physical (both aquatic and wetland); long-term benefits to wildlife and migratory birds*

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Considered Action Alternatives
Aquatic Resources	*MR&T channel improvement activities for navigation and flood risk reduction; reduced channel dynamism; altered hydrology & connectivity*	*Continued maintenance and operation of aquatic resources by state and federal agencies under existing conservation frameworks; continued impacts due to navigation activities; degraded habitat for aquatic resources would continue*	*Continued maintenance and operation of aquatic resources by state and federal agencies under existing conservation frameworks; continued impacts due to navigation activities; degraded habitat for aquatic resources would continue*	*Continued decline of aquatic resources*	*Minor, short-term impacts to aquatic resources (e.g., turbidity and suspended solids) during construction activities; no negative cumulative effects expected; long-term benefits to aquatic resources*
T&E Species	*Land use changes; habitat fragmentation and conversion; loss of habitat both aquatic and vegetated; USACE, other federal, state, and private habitat restoration and land mgmt. programs combat habitat loss; recognition of T&E species through the ESA; listing of multiple T&E species*	*Maintenance of current habitat conditions due to programmatic frameworks; ESA*	*Maintenance of current habitat conditions due to programmatic frameworks; ESA*	*Potential decline in quality and quantity of ecosystem functions; continued loss of important habitat needed by T&E Species*	*Minor, short-term impacts due to minimal tree clearing for access and increased turbidity and suspended solids during construction that may affect, but not likely to adversely affect listed species; long-term benefits expected*
Invasive Species	*Introductions of aquatic and vegetated invasive species via intentional or unintentional; management through National Invasive Species Act and Aquatic Nuisance Species Task Force*	*Management through National Invasive Species Act and Aquatic Nuisance Species Task Force*	*Management through National Invasive Species Act and Aquatic Nuisance Species Task Force*	*Continued negative impacts from carp, zebra mussels, quagga mussels, northern snakeheads, other aquatic species; privet and other vegetative species range expansion.*	*Promotion of native species to combat invasive species populations*

Resource	Past Actions	Present Actions	Future Actions	No Action Alternative	Considered Action Alternatives
Water Quality	*Increasing human populations and industrialization result in increased water quality problems. Establishment of CWA, NEPA, USEPA, state environmental agencies and associated regulations greatly improve conditions.*	*Continued population growth and development result in increased potential for water quality impacts. Continued regulation enforcement and societal recognition prevent water quality degradation*	*Continued regulation enforcement and societal recognition. Continued population growth and development result in increased potential for water quality impacts*	*Increased sedimentation; increased turbidity; decreased dissolved oxygen concentrations*	*Localized, temporary increase in turbidity and suspended solids during construction activities; long-term benefits of improved depth, flow, dissolved oxygen concentrations*

Section 4
Plan Comparison and Selection

4.1 PLAN COMPARISON

Table 4-1 includes a summary of the comparison of alternatives, with more details provided in the previous evaluation sections (Section 2.4, Section 2.5 and Section 3). Green cells represent the more beneficial selections for each category and the red cells indicate the least beneficial selections.

From a NEPA perspective, all considered action alternatives were similar in that there were less than significant short-term impacts during construction followed by long-term benefits to the resources. Table 2-17 summarizes the quantification of these effects for the considered action alternatives and Section 3 provides details to the effects on individual resources.

The No Action Alternative, although a best buy since it does not require an investment, does not produce any ecosystem benefits, and does not meet study objectives. This alternative does not meet the P&G criteria of effectiveness and nor contribute to the Four Planning Accounts (NED, RED, EQ, and OSE).

Although Alternatives A and B met study objectives, they were determined to be non-cost-effective and do not meet the P&G efficiency criteria.

Alternative C1 was a best buy, but it does not address all habitat opportunities. This alternative ranked 8 out of all final array alternatives in its ability to meet project objectives. This alternative did not include restoration of the technically significant meander scarp and moist soil Alligator Gar habitat documented in Table 2-3. Alternative C1 is not as effective as C7, C2, C5, C3, or C4 in meeting project objectives. Furthermore, this alternative was not acceptable to the NFS. This alternative provided less benefits under the RED account than all other alternatives except the no action and Alternative C6. This alternative produces less NER, NED, EQ, and OSE benefits than C7, C2, C5, C3, and C4. Since this Alternative did not fully meet objectives nor address technically significant habitat, it was determined that the team would consider larger alternatives along the efficient frontier of alternatives that better maximized benefits (Figure 2-4). The alternative meets all P&G criteria and addresses nine geographic complexes.

Alternative C2 minimally meets objectives but does not address all habitat opportunities identified in the study objectives. This alternative includes one meander scarp, cypress-tupelo, and seasonal herbaceous wetlands, but does not address moist soil (alligator gar habitat) habitats, which were determined to be technically significant. Alternative C2 performs in the middle arrange of alternatives in contribution to NER, NED, RED, EQ, and OSE benefits. Alternatives C3, C4, and C5 perform higher. This alternative addresses nine geographic complexes.

Alternatives C3 meets study objectives. This alternative ranked second out of 10 alternatives, is a best buy plan, and maximizes opportunities to address technically

significant habitat. This alternative includes restoration to technically significant habitats, including two meander scarps (scarce geomorphic feature, T&E species); incorporation of institutionally recognized alligator gar habitat, cypress-tupelo habitat, and seasonal herbaceous wetlands (rivercane). This alternative also provides additional recreation, disadvantaged communities, and OSE benefits above alternatives C1, C2, C6, and C7. This alternative maximizes benefits in the NER, NED, and OSE accounts and performs second best of all alternatives in RED and EQ. The alternative meets all P&G criteria and addresses all 11 geographic complexes.

Alternative C4 showed the most benefits across multiple criteria. However, Alternative C4 had the highest costs in the final array. The additional costs and habitat gained in this alternative compared to C3 was due to the inclusion of borrow area restoration. Borrow habitat was ranked 11 out of 12 in habitat scarcity and importance to special species (Table 2-2). Although it is a best buy plan that fully meets study objectives, the incremental cost for these benefits is high. This alternative also provides additional recreation, disadvantaged communities, and OSE benefits above alternatives C1, C2, C3, C6 and C7. This alternative ranked similar to C3 in the OSE accounts and ranked highest in RED since it was the costliest alternative. The alternative meets all P&G criteria and addresses 11 geographic complexes.

Alternative C5 minimally meets objectives and not all habitat opportunities are addressed. This alternative ranked six out of ten in meeting project objectives. This alternative does not maximize restoration opportunities. This alternative does include the restoration of one meander scarp, but it is not as effective in addressing opportunities for technically significant habitat as C3 and C4 both include two meander scarps. Alternative C5 performs in the middle range of alternatives in contribution to NER, NED, RED, EQ, and OSE benefits. It performs better in these benefit categories than C2, C1, and C6 but not as well as C3 and C4. The alternative meets all P&G criteria and addresses 10 geographic complexes.

Alternative C6 is the least cost alternative. Alternative C6 does not meet Objective 3 and produces the least NER, NED, RED, EQ, and OSE benefits. This alternative does not include restoration of technically significant meander scarps or moist soil habitat for Alligator Gar. It also does not maximize recreational opportunities. Since this alternative did not fully meet the objectives or address technically significant habitat, it was determined that that the team would consider larger alternatives along the efficient frontier of alternatives that better maximized benefits (Figure 2-4). This alternative does not meet the P&G criteria of effectiveness and addresses restoration in 8 geographic complexes.

Alternative C7 minimally meets objectives and not all habitat opportunities are addressed. Ranked 3 out of the 10 alternatives in meeting study objectives (Table 2-14). This alternative does not maximize opportunities to restore riverfront forest or incorporate all potential recreation features. Alternative C7 was identified as cost-effective in the CEICA analysis (Section 2.4.2). It is not as efficient as the identified best buy plans (C1, C3, C3, C4, C5, C6) in achieving ecological benefits as compared to the plans identified as best busy. Alternative C7 performs in the middle range of alternatives in contribution to NER, NED, RED, EQ, and OSE benefits. The alternative meets all P&G criteria and addresses eight geographic complexes. This plan is not as efficient as a best buy plan in achieving ecological benefits.

Table 4-1 Summary of the Comparison of Alternatives

	# Measures	NER Outputs Net Benefits AAHU	Benefit Acres	Total Real Estate Acres	Real Estate Private Acres	Real Estate Public Acres	Project First Costs ($1,000)	Average Annual Measures Costs ($1,000)	Average Annual OMRR&R Costs ($1,000)	Average Annual Cost/AAHU	Complete	Effectively Meets Project Objectives (Rank from Table 2-14)	Efficient	Acceptable	Number of geographic complexes addressed	Number of habitats addressed	Technical Significance Addresses Highly Ranked Habitats (meander scarp, cypress-tupelo, moist soil, seasonally herbaceous wetlands)	OSE	RED	EQ
	Section 2.3	Section 2.2.3	Section 2.2.3	Section 2.2.4	Section 2.2.4	Section 2.2.4	Section 2.3	Section 2.4.2	Section 2.4.2	Section 2.4.2	Section 2.4.3	Section 2.4.1; Table 2-14	Section 2.4.3	Section 2.4.3	Section 2.3	Section 2.4.1	Section 2.2.2; Section 2.4.1	Section 2.5	Section 2.5	Section 2.5.3; Section 3
No Action	0	0	0				0	0	$0	N/A	Yes	No	Best Buy	No	0	0	No	Decreased benefits	Decreased benefits	Decreased benefits
A	34	3110	4,256	4,348	911	3,437	$24,803	$952	$37	$306	Yes	4	Non-Cost-Effective	Yes	10	8	1MS, 4CT; 0 moist; 1 SHW	Increased benefits	Increased benefits	Increased benefits
B	25	2205	3,564	3,546	205	3,341	$23,758	$936	$64	$424	Yes	6	Non-Cost-Effective	Yes	7	7	1MS; 1CT; 2 moist1 SHW	Increased benefits	Increased benefits	Increased benefits
C1	32	4180	5,494	5,493	2,758	2,735	$17,989	$700	$25	$167	Yes	8	Best Buy	No	9	6	0MS; 3CT; 0 moist; 1 SHW	Increased benefits	Increased benefits	Increased benefits
C2	33	4481	6,199	6,202	2,758	2,335	$29,536	$1,132	$44	$253	Yes	4	Best Buy	Yes	9	7	1MS; 3CT; 0 moist; 1 SHW	Increased benefits	Increased benefits	Increased benefits
C3	40	4673	6,282	6,379	2,896	3,483	$41,244	$1,571	$61	$336	Yes	2	Best Buy	Yes	11	8	2 MS;4CT; 1 moist; 3 SHW	Additional access public lands	Increased benefits	Increased benefits
C4	575	4722	6,735	6,943	3,499	2,970	$58,970	$2,226	$68	$472	Yes	1	Best Buy	Yes	11	9	2MS;4CT; 1 moist; 3 SHW	Additional access public lands	Increased benefits	Increased benefits
C5	397	4551	6,274	6,315	2,871	2,341	$32,757	$1,266	$56	$278	Yes	5	Best Buy	Yes	10	7	1MS;4CT; 1 moist; 3 SHW	Increased benefits	Increased benefits	Increased benefits
C6	25	3232	4,163	4,162	1,427	1,093	$11,233	$448	$23,662	$138	Yes	No	Best Buy	No	8	6	0MS; 3CT; 0 moist; 1 SHW	Increased benefits	Increased benefits	Increased benefits

	# Measures	NER Outputs Net Benefits AAHU	Benefit Acres	Total Real Estate Acres	Real Estate Private Acres	Real Estate Public Acres	Project First Costs ($1,000)	Average Annual Measures Costs ($1,000)	Average Annual OMRR&R Costs ($1,000)	Average Annual Cost/AAHU	Complete	Effectively Meets Project Objectives (Rank from Table 2-14)	Efficient	Acceptable	Number of geographic complexes addressed	Number of habitats addressed	Technical Significance Addresses Highly Ranked Habitats (meander scarp, cypress-tupelo, moist soil, seasonally herbaceous wetlands)	OSE	RED	EQ
C7	28	4346	5,917	5,920	2,476	2,174	$27,853	$1,068	$43,238	$246	Yes	3	Cost-Effective	Yes	8	6	1MS; 3CT; 3 moist; 1 SHW	Increased benefits	Increased benefits	Increased benefits

4.2 PLAN SELECTION

The USACE objective in ecosystem restoration planning is to contribute to the NER and contribution to the NER are increases in the net quantity and/or quality of desired ecosystem resources. From ER 1105-2-100, measurement of NER is based on changes in ecological resource quality (ER 1105-2-100 22 Apr 2000 2-2) as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indexes (but not monetary units).

Selecting the RP requires identification of the alternative that maximizes benefits over multiple benefit categories in NED, RED, EQ, and OSE, along with meeting planning objectives and constraints and reasonably maximizing environmental benefits. The RP must also pass the test of cost effectiveness and incremental cost analyses, significance of outputs, completeness, effectiveness, efficiency, and acceptability.

After reviewing the evaluation and comparison of the final array of alternatives, A and B were not selected since they did not meet the efficiency P&G criteria since they were not cost-effective. From the set of cost-effective plans, best buy plans are the most efficient and give the greatest increases in output for the least increase in cost. Although cost-effective, Alternative C7 was removed from further consideration since it was not a best buy and did not provide the greatest increase in output for the least increase in cost as compared to the best buy alternatives.

Evaluation of the best buy plans C1, C2, C3, C4, C5, and C6 in comparison to the no-action alternative allowed the study team to make well-informed decisions regarding restoration benefits of the alternatives. Progressing through the increasing levels of CEICA output helped determined whether the increase in output (habitat units) was worth the additional cost. In the evaluation of the seven action best buy plans, “break points” or significant increases or jumps in incremental cost per output were identified in Section 2.4.2 and Figures 2-6 and 2-7.

The No Action Alternative does not improve or maintain the ecosystem resources within the study area. No action would have no financial cost to the Federal government but would result in a decrease in habitat functions and values over the study period (see Section 3 for additional analysis). The No Action Alternative was not selected since the study produced best buy plans that addressed study area problems, opportunities, objectives, and technically significant habitat within the study area.

Alternative C1 minimally met project objectives but did not include measures to address meander scarps or moist soil (alligator gar habitat); habitats determined to be technically significant and ranked high based on habitat scarcity and importance to special status species. This alternative also ranked low in EQ, RED and OSE benefits. C2, C5, and C6 performed similarly in EQ, RED and OSE, being neither in the low or high range as compared to the other alternatives. C2 and C5 met project objectives but did not fully incorporate the high-ranking scarce habitats important to special status species. Alternative C6 did not fully address the opportunities and did not address habitats identified under Objective 3. Thus, these alternatives were also removed from consideration.

The objectives for this study focused on restoration of technically significant habitat, including meander scarps, cypress-tupelo swamp, seasonally herbaceous wetlands, and moist soil (alligator gar habitat) habitat. The importance of meander scarps was previously described in Section 1.6.1.1. There are only 14 flowing meander scarps remaining in the entire LMR and the study area includes three located in Brandywine, Island 35 Deans Island, and Sunrise Island 34. Through measure evaluation, the meander scarp at Island 35 Deans Island was screened based on efficiency and being a non-cost-effective solution. There were two alternatives in the final array (C3 and C4) that included restoration of the two remaining meander scarps at Brandywine and Sunrise Island 34. Alternative C1 and C6 do not include restoration of any meander scarps. Alternative C2 and C5 only include one meander scarp.

All alternatives in the final array included restoration of cypress-tupelo swamp and seasonally herbaceous wetlands to some degree so these habitats were not a deciding factor in plan selection.

Alligator gar are institutionally significant species as they are one of the few natural predators that grow quick enough and large enough to feed on adult invasive carp, one of the more recent threats to aquatic resources in the LMR and are identified in the Framework. Alligator gar spawning success requires floodplain inundation long enough for water temperatures to become sufficiently warm, as well as vegetation for the eggs to adhere to. Habitat suitability for alligator gar spawning requires unique combinations of inundation, temperature, and physical structure. USFWS provided the alligator gar HSI data layer for the Hatchie Loosahatchie conservation each and their experts assisted in citing measures during plan formulation for this importance species of concern. Alternatives C3, C4, and C5 include restoration of moist soil habitat for alligator gar spawning. Alternatives C1, C2, and C6 do not include any restoration of moist soil habitat.

Alternative C1 minimally met study objectives but did not include measures to address meander scarps or moist soil habitats, which were determined to be technically significant and ranked high based on the scarcity and importance of these habitats to species of special status. This alternative ranked low in NED/NER, EQ, RED, and OSE benefits.

Similarly, C2 and C5 met study objectives, but did not fully incorporate the habitats that ranked high as technically significant. C2 and C5 both included one meander scarp, but C3 did not include moist soil habitat important for alligator gar spawning.

The alternatives in the final array, which fully addressed the technically significant habitat, were C3 and C4.

Alternative C6 did not fully address the opportunities and did not address any of the habitats identified under objective 3. Alternatives C2, C5, and C6 performed similarly in EQ, RED, and OSE, being neither in the low nor high range, as compared to other alternatives.

Best Buy Plan Alternative C4 best met study objectives and produced the most restoration benefits. As shown in Table 4-1, it also scored best for most categories except those related to costs. The difference in AAHUs between C3 and C4 is 49 AAHUs and the additional AAHUs and EQ benefits would be obtained by through the restoration of borrow areas in C4,

which were determined not to be a technically significant habitat. The AAHUs between all of the final array ranged from 2,2,205 to 4,722. While Alternative C4 would achieve study objectives and contribute to the RED account to a greater extent than Alternative C3, it was determined that the additional cost was not worth the additional habitat benefits achieved.

With the elimination of C4 as the TSP, Alternative C3 was the next best plan in meeting project objectives and the other evaluation criteria. In fact, C3 scored the same as C4 in most categories (See Table 4-1).

The NER Plan, Alternative C3, was selected as the TSP and then RP as this plan provides positive ecosystem and social benefits that support the USACE's restoration mission and consistent with the study purpose. This plan also reasonably maximizes the benefits across all benefit categories and net benefits.

Section 5
The Recommended Plan

The RP (Alternative C3) is a comprehensive NER Plan that provides positive ecosystem and social benefits that support the USACE's restoration mission by addressing significant and important habitats in Arkansas and Tennessee. The RP is an effective, efficient, complete, and acceptable ecosystem restoration plan. The plan cost-effectively meets the study planning objectives for ecosystem restoration of nationally and technically significant resources. The RP includes 40 measures (38 restoration and two recreation) that would improve connectivity, enhance the aquatic channel, restore, and enhance natural vegetation, improve water management, and provide recreational opportunities. This section describes Alternative C3 and its implementation.

5.1 PLAN ACCOMPLISHMENTS

The RP, Alternative C3, is a comprehensive plan that collectively addresses historically and technically significant and ecologically important habitats across the 11 geographic complexes of the study area. The RP includes 38 different ecological restoration measures and two recreational measures that will benefit 6,282 acres. The RP provides 4,673 AAHUs to eight unique habitats, including BLH, cypress-tupelo, meander scarp, moist soil, riverfront, seasonally herbaceous wetland, secondary channels, and slough. The significance of these habitats is further explained in Section 5.1.2. These habitats support federally listed endangered aquatic species, and critical vegetative habitats that host numerous species of conservation concern. This RP selection contributes to the protection of meander scarps (rare geological features that no longer occur naturally due to engineering controls along the Mississippi River). Additionally, this supports the restoration of other technically significant habitat, including cypress-tupelo swamps, moist soil, and seasonally herbaceous rivercane habitat. These habitat types provide valuable aquatic and vegetative habitats for a variety of species, such as the federally endangered pallid sturgeon and fat pocketbook mussel and other rare species of conservation concern, such as the alligator gar, a native predator of invasive carp. Figure 5-1 shows where the restoration sites are located in the study area.

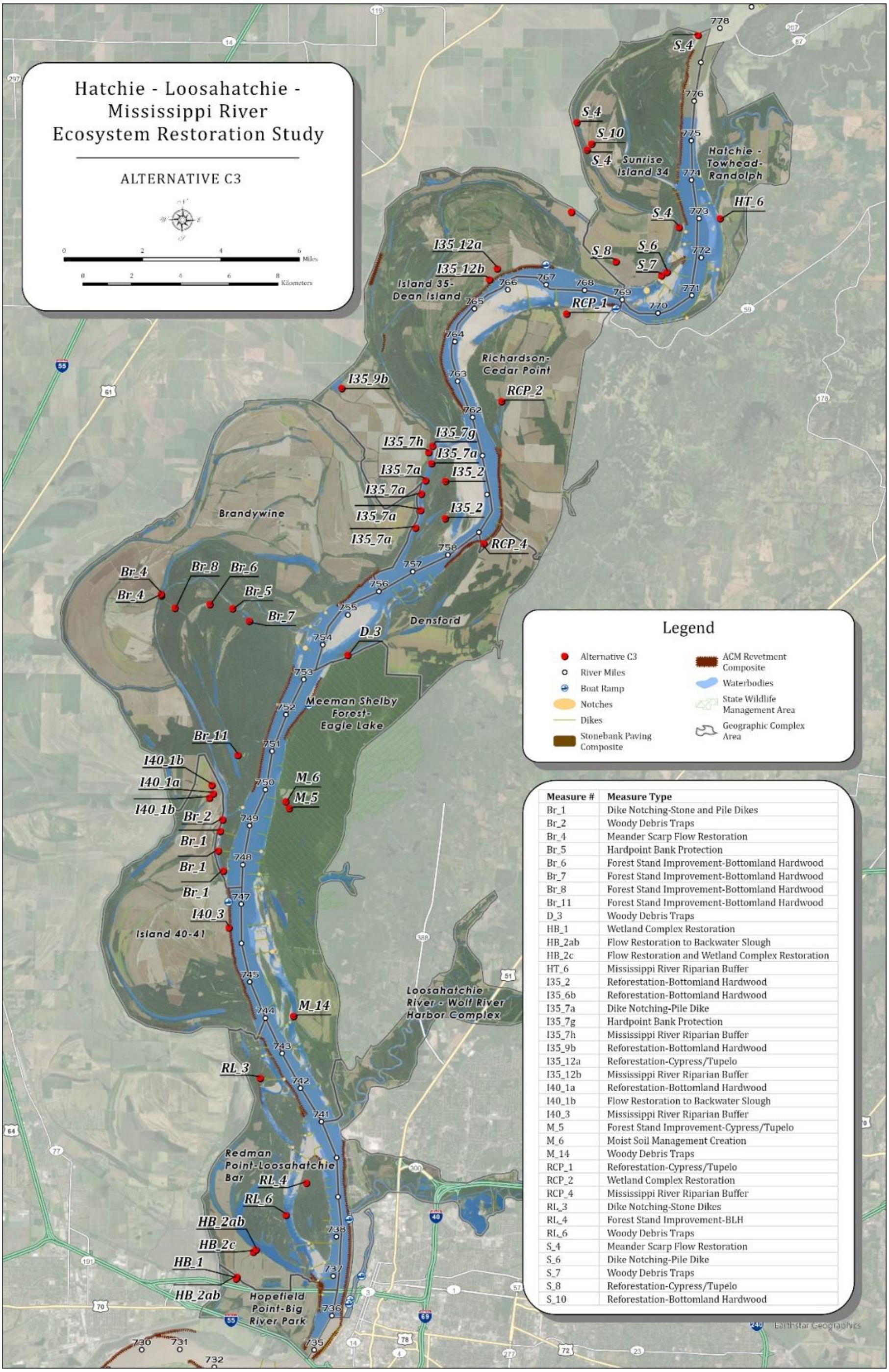


Figure 5-1. Recommended Plan

The expected environmental impacts of implementing the RP would be overwhelmingly beneficial to the flora and fauna, and the public living in the surrounding study area. As documented in this FIFR-FEA, no significant adverse environmental impacts would occur as a result of implementation of the RP.

This RP selection contributes to the restoration of meander scarps which are rare geological features that no longer form naturally due to engineering controls along the Mississippi River. There are only 14 remaining meander scarps in the entire LMR that maintain flow nearly all of the year, and the RP restores two of these. Restoring hydrologic connectivity to meander scarps would promote habitat resiliency for sensitive species that are at risk of endangerment as a result of increases in drought intensity due to climate change. The federally endangered pallid sturgeon and fat pocketbook mussel need these flowing habitats for critical life history requirements. Other federal trust species and species of tribal importance like the catadromous American eel use these important flowing habitats during their life cycle for foraging and refugia from the navigation channel.

The proposed restoration supports federally listed endangered aquatic species, such as the fat pocketbook mussel and the pallid sturgeon and critical vegetative habitats, such as river cane that host numerous species of conservation concern. The RP also restores moist soil habitats, which provide alligator gar spawning habitat. Increasing abundance of this rare species is one strategy to control and reduce populations of invasive carp.

In addition to ecological significance, the RP provides benefits under the OSE account. Over 95 percent of the benefits of the RP (Alternative C3) are located within disadvantaged communities identified through the CEJST. By enhancing hydrologic connectivity with resource-managed areas, communities will have greater access potential for recreational opportunities. Furthermore, restoration of the natural resources and the beneficial effects to fisheries supporting subsistence fishing relied on by underserved communities in the area. Fishing for food can be central to culture and family life, household economies, and food security.

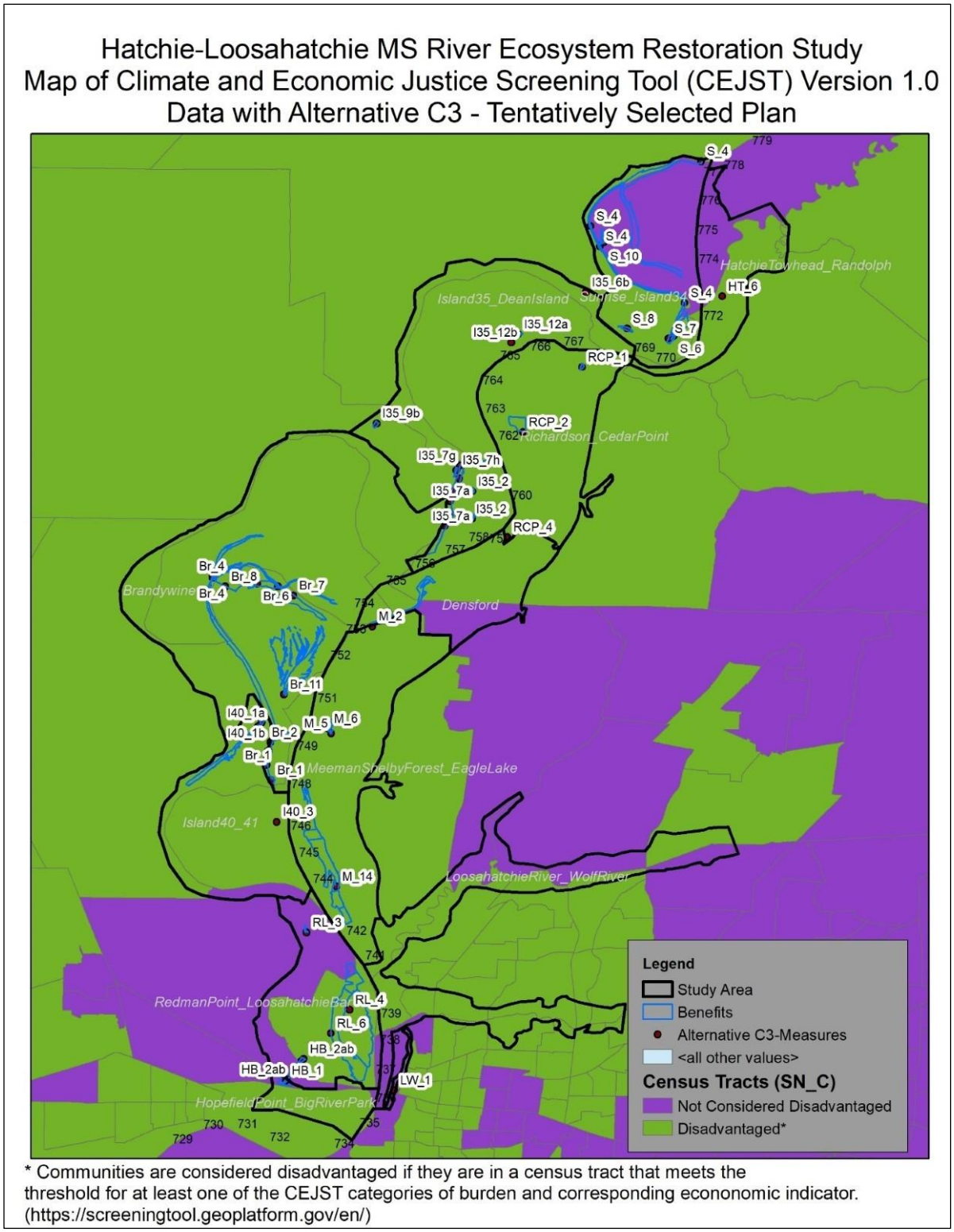


Figure 5-2. Location of Disadvantaged in the Study Area Communities Identified through the CEJST

If the following reviews: public, policy and compliance, agency technical and supervision and administration agree with the findings of this FIFR-FEA, a finding of no significant impact (FONSI) will be prepared as part of the final recommendation. The plan includes monitoring and adaptive management for no more than 10 years until ecological success criteria are met and adaptive management as described in Appendix 9. A final OMRR&R plan will be established upon completion of each restoration measure.

As part of plan formulation, USACE considers how the RP contributes to resiliency of affected ecological communities and affects the sustainability of environmental conditions in the affected area. Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue, in existence or a certain state, or in force or intensity, without interruption or diminution. The RP will increase the resiliency and sustainability of the study area by establishing habitat that will be more resilient to relative climate change and, restoring system dynamics and processes to more sustainable and self-regulating regimes. The RP represents a resilient, sustainable ecosystem solution that integrates multiple habitat features that can adapt to changes and can recover after a major disturbance naturally. The sites included in the RP were identified as important restoration opportunities that should be restored to address long-term regional ecosystem degradation trends. The RP addresses the most feasible and highest priority sites for USACE participation in the near-term and complements ongoing and future restoration work. The RP will work in concert with completed restoration work by others, in addition to ongoing and future projects to improve the sustainability of the entire LMR ecosystem. The RP would be a substantial first step in the large-scale restoration of the LMR. It complements past, ongoing, and planned restoration work by other parties, including the LMRCC, Restoring America's Greatest River Plan and the LMRRA Study.

The increase in spatial extent of scarce habitats and subsequent projected increased in biodiversity encourage resiliency with the implementation of the RP. The addition of diverse native species, novel physical features, and functional redundancy into the ecosystem will allow restored areas to better adapt to changing conditions and withstand and rapidly recover from disruption. This is important as climate change, water quality degradation, the introduction and proliferation of invasive species, and other stressors continue to influence the region. Recognizing the Federal government's commitment to ensure that development within the floodplain at each project site will not occur. State owned restoration sites and existing state and federal Clean Water Act protection on open water bottoms will further protect these locations from development and ensure ecosystem restoration feature outputs persist for the life of the project.

A RED analysis was run on Alternative C3. The expenditures associated with all work activities, with ability to customize impact area and work activity at rural are estimated to be $45,145,072. Of this total expenditure, $23,871,500 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added). The regional economic effects

are shown for the local, state, and national impact areas. In summary, the expenditures $45,145,072 support a total of 554.6 full-time equivalent jobs, $29,519,157 in labor income, $32,417,850 in the gross regional product, and $25,281,240 in economic output in the local impact area. More broadly, these expenditures support 1,214.4 full-time equivalent jobs, $66,242,662 in labor income, $79,433,7834 in the gross regional product, and $122,075,593 in economic output in the nation.

Table 5-1 provides a summary of C3 restoration measures. Please see Section 5.2 and Engineering Appendix 3 for more detailed information regarding components of the RP.

Table 5-1. Summary of Alternative C3 Features

Restoration Activity	Feature	Habitat	Acres	Total # Measures	Complexes
Altering Connectivity	Dike Notching	Secondary Channels	578	4	Brandywine, Island 35, Redman Point Loosahatchie Bar, Sunrise Island 34
Altering Connectivity	Flow Restoration	Meander Scarp	709	2	Brandywine, Sunrise Island 34
Altering Connectivity	Flow Restoration	Slough	169	2	Hopefield Point Big River, Island 40/41
Aquatic Channel Enhancement	Bank Protection	BLH/Secondary Channels	504	2	Brandywine, Island 35
Aquatic Channel Enhancement	Woody Debris Traps	Secondary Channels	1888	5	Brandywine, Densford, Meeman Shelby, Loosahatchie Bar, Sunrise Island 34
Enhance and Restore Natural Vegetation	Reforestation/Forest Stand Improvement	Cypress-tupelo	47	4	Island 35, Meeman Shelby, Richardson Cedar Point, Sunrise Island 34
Enhance and Restore Natural Vegetation	Reforestation/Forest Stand Improvement	Riverfront Forest/Riparian Buffer	206	5	Island 35, Island 40/41, Richardson Cedar Point, Sunrise Island 34, Hatchie Towhead Randolph
Enhance and Restore Natural Vegetation	Reforestation/Forest Stand Improvements	BLH	2232	10	Brandywine, Redman Point Loosahatchie Bar, Island 35, Island 40/41
Enhance and Restore Natural Vegetation	Wetland Complex Restoration	Seasonally Herbaceous Wetland/ River Cane	185	3	Hopefield Point Big River, Richardson Cedar Point
Recreation	Recreation	Recreation	-	2	Loosahatchie Wolf River, Meeman Shelby
Water Management	Moist Soil Creation and Improvements	Moist Soil	30	1	Meeman Shelby
Total				40 Total Measures	

The plan formulation process used the best available information at this phase of the study to develop the measures, identify the final array of alternatives and determine the RP. During the final phase, called the feasibility level design phase, and in PED, additional analyses will be completed to refine and optimize the design and cost estimates of the measures included in the RP. The revised design and costs and refined assessments of the performance and cost-effectiveness of the RP will be included in the FIFR-FEA. The final report will fully describe the RP, as well as its costs, benefits, and consequences. Because uncertainty cannot be eliminated, the final report will further document the levels of uncertainty and the associated risks that are inherent in the assumptions and analyses.

5.1.1 Resource Significance

Table 5-2 shows how the resources addressed by this study qualify as significant based on its “technical” merits, which are based on scientific knowledge or judgement of critical resource characteristics.

Table 5-2. Technical Significance of the Recommended Plan

Technical Criteria	Problem	NER Plan Benefit
Scarcity	• Secondary Channels – reduced connectivity, lack of woody debris, localized erosion in sensitive areas • Meander scarps – no longer created in the LMR • Scarce vegetative communities - 80% reduction of forested floodplain in MAV, lack of hard mast species in existing forest, Cypress/Tupelo, seasonal herbaceous wetlands, rivercane (98% reduction) • Missing large river riparian buffer habitat with associated erosion and sediment deposition • Floodplain waterbodies – reduced connectivity, reduced habitat complexity	• Increased connectivity and addition of large woody debris in secondary channels and meander scarps with benefits to species of conservation concern like Alligator Gar, Fat Pocketbook Mussel, pallid sturgeon, etc. and species of tribal importance like the American eel (dike notching, lowering invert elevations of obstructions, addition of large woody debris traps) • BLH hard mast restoration, cypress-tupelo restoration, wetland complex restoration, rivercane stand improvements • Bank stabilization and riparian buffers/riverfront forests • Increased connectivity and habitat complexity to floodplain waterbodies (lowering invert elevations and modifying obstructions).

Technical Criteria	Problem	NER Plan Benefit

Representativeness	• Habitat impairments representative of entire LMR
	  • Secondary channel and meander scarp conditions are critical to endangered species and other species of conservation concern (i.e., used as a surrogate for take under ESA).
		• Implementation of the project would restore many sensitive habitats
		  • Increased secondary channel and meander scarp connectivity and associated functions benefit endangered species (I.e., Fat Pocketbook Mussel and pallid sturgeon) as documented in federal and state action plans

Status and Trends	• Stressors to all LMR Habitats will persist • Flowing meander scarps will continue to be lost and not replaced due to maintenance of navigation channel • Floodplain waterbodies continue to fill in with a reduction in habitat complexity	• This project would arrest declining habitat trends and provide for a more resilient system climate change and existing Flood Risk Management and Navigation missions.

Connectivity	• Reduced Secondary channel connectivity
	• Reduced Meander scarp connectivity
	• Reduced connectivity to floodplain waterbodies
	  ○ Forest fragmentation in MAV
		• Increased connectivity and increased woody debris traps in secondary channels reduce aquatic stressors (low DO, etc.) and provide benefits to flowing water fish guild & aquatic macroinvertebrates
		• Increased connectivity to meander scarps reduces aquatic stressors (low DO, etc.) benefitting flowing water fish guild, aquatic macroinvertebrates, & freshwater mussels
		• Increased connectivity and habitat complexity in floodplain waterbodies benefits slackwater fish guild and floodplain spawners
		  ○ Floodplain reforestation provides increased habitat corridors (e.g., refugia during high water)

Limiting Habitat	• Refugia for large river aquatic species limited due to navigation channel • Meander cutoffs no longer occur due to maintenance of nav. channel (flowing meander scarps may be lost forever) • Lack of mast producers in BLH floodplain community due to past forestry practices	• Restoration of secondary channels and meander scarps provides benefits to large river aquatic species, including federal and state endangered species such as the pallid sturgeon and Fat Pocketbook Mussel. • Wildlife would benefit from restoring mast producing species in BLH community

Technical Criteria	Problem	NER Plan Benefit

	• Few floodplain waterbodies with sufficient permanent depth (most are < 3ft)
	  ○ Limited forest habitat in MAV (80% reduction)
		• Restored habitat complexity allows for increased fish and other aquatic diversity,
		  ○ Reforestation of riparian buffers along MS River provides foraging habitat, bat roosting habitat, and introduces large woody debris into the river. Large woody debris traps collect that debris in critical secondary channel areas.

Biodiversity	• Aquatic species endemic to the area are threatened by systemic degradation of highly altered waterbodies in the MAV
	• Invasive species threaten aquatic fish communities
	  ○ BLH loss within the Mississippi flyway
		• Project would benefit over 100 of species of conservation concern identified in state wildlife action plans.
		• Project would provide benefits to the mosaic of aquatic and floodplain habitats necessary for high biodiversity
		• Promoting Alligator Gar spawning habitats will help combat invasive carp
		  ○ Reforestation of acreage within the Mississippi Flyway is beneficial to neo-tropical migratory birds and will provide forage and resting habitat as recommended by the LMVJV

5.2 PLAN COMPONENTS

Table 5-3 displays the measures from CEICA included in the RP, along with the location restoration, and construction activities. Recreational measures were added following CEICA analysis. Please see Appendix 1 for additional information on each measure. Additional detailed supporting information for each site are presented in Appendix 3 (Engineering).

Table 5-3 Recommended Plan (Alternative C3) Measures

#	Measure	Location Complex	Restoration Type / Model	Habitat	Measure Activity	Construction Activity	Direct Benefit Acres	AAHU
1	BR_1	Brandywine	Altering Connectivity / Unidirectional	Secondary Channels	Dike Notching – Stone and Pile Dikes	Dike Notching	106	21.80
2	BR_2	Brandywine	Aquatic Channel Enhancement / Invertebrate	Secondary Channels	Woody Debris Traps	Woody Debris Traps	106	70.33
3	BR_4	Brandywine	Altering Connectivity / Unidirectional	Meander Scarp/Tertiary Channels	Meander Scarp Flow Restoration	Bridge Replacement; Weirs and Stoplog Structures	499	121.88
4	BR_5	Brandywine	Aquatic Channel Enhancement / Riverine Eddy	BLH	Hardpoint Bank Protection	Riprap Bank Protection	499	444.61
5	BR_6	Brandywine	Enhance and Restore Natural Vegetation / HGM	BLH	Forest Stand Improvements - BLH	Floodplain Vegetative	78	65.63
6	BR_7	Brandywine	Enhance and Restore Natural Vegetation / HGM	BLH	Forest Stand Improvements - BLH	Floodplain Vegetative	196	48.41
7	BR_8	Brandywine	Enhance and Restore Natural Vegetation / HGM	BLH	Forest Stand Improvements - BLH	Floodplain Vegetative; Culverts	207	133.14
8	BR_11	Brandywine	Enhance and Restore Natural Vegetation / HGM	BLH	Forest Stand Improvements - BLH	Culverts	600	626.60
9	D_3	Densford	Aquatic Channel Enhancement / Invertebrate	Secondary Channels	Woody Debris Traps	Woody Debris Traps	125	82.93
10	HB_1	Hopefield Point Big River	Enhance and Restore Natural Vegetation / HGM	Seasonally Herbaceous Wetland	Wetland Complex Restoration	Floodplain Vegetative	39	8.88
11	HB_2ab	Hopefield Point Big River	Altering Connectivity / Bidirectional	Slough	Flow Restoration to Backwater	Culverts	8	0.56

#	Measure	Location Complex	Restoration Type / Model	Habitat	Measure Activity	Construction Activity	Direct Benefit Acres	AAHU
					Slough			
12	HB_2c	Hopefield Point Big River	Enhance and Restore Natural Vegetation / HGM	Seasonally Herbaceous Wetland	Flow Restoration and Wetland Complex Restoration	Earthwork	22	39.00
13	HT_6	Hatchie Towhead Randolph	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest – Riparian Buffers	Restoring Habitat Complexity in Borrow Area	Floodplain Vegetative	52	25.50
14	I35_2	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	BLH	Reforestation-BLH	Floodplain Vegetative	23	64.72
15	I35_6b	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	BLH	Reforestation-BLH	Floodplain Vegetative	111	24.72
16	I35_7a	Island 35 Deans Island	Altering Connectivity / Unidirectional	Secondary Channels	Dike Notching-Pile Dike	Dike Notching	341	64.37
17	I35_7g	Island 35 Deans Island	Aquatic Channel Enhancement / Riverine Eddy	Secondary Channels	Hardpoint Bank Protection	Riprap Bank Protection	3	2.67
18	I35_7h	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest – Riparian Buffers	MS River Riparian Buffer	Floodplain Vegetative	8	18.02
19	I35_9b	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	BLH	Reforestation-BLH	Floodplain Vegetative	12	27.03
20	I35_12a	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	Cypress-tupelo	Reforestation-cypress-tupelo	Floodplain Vegetative	14	32.22
21	I35_12b	Island 35 Deans Island	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest – Riparian Buffers	MS River Riparian Buffer	Floodplain Vegetative	55	125.83
22	I40_1a	Island 40/41	Enhance and Restore	BLH	Reforestation-	Floodplain	37	46.28

#	Measure	Location Complex	Restoration Type / Model	Habitat	Measure Activity	Construction Activity	Direct Benefit Acres	AAHU
			Natural Vegetation / HGM		BLH	Vegetative		
23	I40_1b	Island 40/41	Altering Connectivity / Bidirectional	Slough	Flow Restoration to Backwater Slough	Culverts	161	2.47
24	I40_3	Island 40/41	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest – Riparian Buffers	MS River Riparian Buffer	Earthwork	59	101.52
25	M_5	Meeman Shelby	Enhance and Restore Natural Vegetation / HGM	Cypress-tupelo	Forest Stand Improvements – cypress-tupelo	Weirs and Stoplog Structures; Earthwork	6	8.00
26	M_6	Meeman Shelby	Water Management / HGM	Moist Soil	Moist Soil Management Creation	Weirs and Stoplog Structures; Earthwork	30	13.73
27	M_14	Meeman Shelby	Aquatic Channel Enhancement / Invertebrate	Secondary Channels	Woody Debris Traps	Woody Debris Traps	740	490.96
28	RCP_1	Richardson Cedar Point	Enhance and Restore Natural Vegetation / HGM	Cypress-tupelo	Reforestation – cypress-tupelo	Floodplain Vegetative	8	18.83
29	RCP_2	Richardson Cedar Point	Enhance and Restore Natural Vegetation / HGM	Seasonally Herbaceous Wetland	Wetland Complex Restoration	Culverts	115	176.99
30	RCP_4	Richardson Cedar Point	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest	MS River Riparian Buffer	Floodplain Vegetative	11	68.83
31	RL_3	Redman Point Loosahatchie Bar	Altering Connectivity / Bidirectional	Secondary Channels	Dike Notching-Stone Dikes	Dike Notching	4	0.42
32	RL_4	Redman Point Loosahatchie Bar	Enhance and Restore Natural Vegetation / HGM	BLH	Forest Stand Improvement-BLH	Floodplain Vegetative	1049	675.79
33	RL_6	Redman Point	Aquatic Channel	Secondary Channels	Woody Debris Traps	Woody Debris Traps	790	524.13

#	Measure	Location Complex	Restoration Type / Model	Habitat	Measure Activity	Construction Activity	Direct Benefit Acres	AAHU
		Loosahatchie Bar	Enhancement / Invertebrate					
34	S_4	Sunrise Island 34	Altering Connectivity / Unidirectional	Meander Scarp/Tertiary Channels	Meander Scarp Flow Restoration	River Training Structure and Bridge Replacement	705	300.16
35	S_6	Sunrise Island 34	Altering Connectivity / Bidirectional	Secondary Channels	Dike Notching-Pile Dike	Dike Notching	127	46.38
36	S_7	Sunrise Island 34	Aquatic Channel Enhancement / Invertebrate	Secondary Channels	Woody Debris Traps	Woody Debris Traps	127	84.26
37	S_8	Sunrise Island 34	Enhance and Restore Natural Vegetation / HGM	Cypress-tupelo	Reforestation – cypress-tupelo	Floodplain Vegetative	19	29.51
38	S_10	Sunrise Island 34	Enhance and Restore Natural Vegetation / HGM	Riverfront Forest – Riparian Buffers	Reforestation-BLH	Floodplain Vegetative	21	35.57
39	LW_1	Loosahatchie Wolf River	N/A	N/A	Recreation	Recreation	N/A	N/A
40	M_2	Meeman Shelby	N/A	N/A	Recreation	Recreation	N/A	N/A

This section describes the construction and associated restoration activities for the measures included in the RP. Specific details for construction implementation will be refined further during the feasibility phase and during PED phase. Design criteria for each of the recommended measures and design drawings can be found in the A-3 Engineering Appendix. The detailed analysis and design of these measures can be found in Appendices A-1 and A-5.

- Dike Notching – The primary purpose of dike notching, both pile and stone dikes, is to increase connectivity in secondary channels by allowing flow through the dikes at lower river stages. The RP proposed a total of 11 dike notches, including 8 pile dike notches and 3 stone dike notches. Pile dike notches vary in width and will be constructed to an assumed depth equal to the channel bed. A typical stone dike notch will be constructed to a zero LWRP with a 50-foot bottom width, 150-foot top width and 1V:2.5H side slopes. Design drawings of typical dike notching can be found in Appendix 3 Section 2.6.1.
- Woody Debris Traps – The primary purpose of a woody debris trap is to collect drifting wood as it floats downstream. The trapped debris creates a diverse habitat for fish and macroinvertebrates. The RP proposed a total of 5 woody debris traps.

Woody debris traps would be constructed from barge mounted equipment. Wooden piles are driven in strategic locations utilizing three, 40 to 50-foot wood pilings, driven in a “V” shape, approximately 3-5 meters apart. The traps are placed in permanently or near-permanently flowing water in close proximity of the island side of secondary channels. Design drawings of typical woody debris traps can be found in Appendix 3, Section 2.6.2 of the Engineering Appendix.

- Riprap Bank Protection – The primary purpose of riprap bank protection is to prevent future bank line erosion and forested buffer degradation. The RP proposed a total of two bank protection measures, one riprap bank paving measure in Brandywine Chute and one set of riprap hardpoints in the Island 35 Chute. For both measures, it is assumed work can be completed from the channel. Design drawings for riprap bank protection measures can be found in Appendix 3 Section 2.6.3 of the Engineering Appendix.
- River Training Structures – The primary purpose of river training structures is to maintain a navigation channel by directing flow and altering channel geomorphology; however, there are also ancillary environmental benefits of certain structures. The RP proposed one river training structure measure. The structure shall be a single stone chevron constructed at the upstream entrance to the Sunrise chute to divert additional water into the chute at various river stages and create diverse fish habitat. Design drawings for the structure can be found in Appendix 3, Section 2.6.4 Engineering Appendix.
- Grade Control Structures – The primary purpose of grade control structures is to regulate flow. They are typically constructed to prevent bed erosion, prevent head cutting and/or regulate water elevations by controlling the energy and velocity of the water as it passes over or through the structures. The RP proposed a total of four grade control structure measures, including three rock weirs and one stoplog structure. Design drawings for the grade control measures can be found in Appendix 3 Section Engineering Appendix.
- Culverts – The primary purpose of culverts is to serve as hydraulic conduits, conveying water from one location to another, generally through an embankment that ponds water. The RP proposed a total of five culvert measures for connectivity of water bodies, including two concrete box culverts and three corrugated metal pipe (CMP) culverts Culverts were sized to utilize the largest feasible culvert diameter based on LiDAR elevations. Design drawings for the culvert measures can be found in Appendix 3 Section 2.6.6 of the Engineering Appendix.
- Earthwork – Earthwork generally consists of channel excavation, berm construction and miscellaneous excavation associated with other measures. Numerous measures throughout the study area have a minimal amount of excavation required to construct the measure. This excavation would be completed with standard excavation equipment. The primary purpose of channel excavation is to remove sediment, to increase connectivity. The primary purpose of the berm construction is ponding of water for moist soil management practices. The RP proposed a total of five earthwork measures, including two swale cleanouts, one channel cleanout and two earthen berms. Design drawings for the

earthwork measures can be found in Appendix 3 Section 2.6.7 Engineering Appendix.

- Bridge Replacements – The primary purpose of the bridge replacements is to increase connectivity within the meander scarp by enhancing debris passage. The RP proposed a total of two bridge replacement measures. Bridge replacements will be designed, constructed, and maintained by the Arkansas Highway Department of Transportation as County Road bridges. Bridge replacement measures can be found in Section 2.6.8 of the Appendix 3 Engineering.
- Recreational Benefits– Two recreational features are proposed as part of this study, trail access improvements at Meeman Shelby Forest and interpretive media in Wolf River Harbor. Trail access improvements consists of constructing a new/refurbishing an existing walking trail and adding educational signage for the surrounding ecosystem restoration measures, which would include hazard signage for the proposed woody debris trap. Interpretive media and a woody debris trap demonstration will be constructed in the Wolf River Harbor for educational purposes. Design drawings for the recreational measures can be found in Appendix 3 Section 2.6.9 Engineering Appendix.
- Enhance and Restore Natural Vegetation – Floodplain vegetative measures are important for the enhancement and restoration of natural vegetation. This can be accomplished through a variety of methods, including canopy gaps, cypress-tupelo planting, herbaceous wetland planting and various forms of reforestation. The measure specific designs and costs were developed by wetland restoration experts at USACE -ERDC. Measure descriptions for the floodplain vegetative measures can be found in Appendix 3 Section 2.6.10.

5.3 COST ESTIMATE

The estimated cost for the RP (40 measures – 38 restoration and two recreation) is approximately $62 million. This includes the cost of acquiring lands, construction costs, PED, construction management, monitoring and adaptive management (up to 10 years), and contingencies. Cost assumptions are further detailed in Appendix 3, Engineering, and Appendix 4, Cost Engineering. Preliminary costs for Alternative C3 were refined after RP selection to include PED, construction management, and program costs for adaptive management and monitoring (AM&M). Additionally, a RP specific REP was developed which included administration costs. The project cost summary included in Table 5-4 reflect these updates. (See Section 4.5 for REP). Costs are shown at the 2024 price level.

The current cost information, Current Working Estimate (CWE), and Cost Schedule Risk Analysis (CSRA) have followed the most recent guidance in accordance with ER 1110-2-1302. The CWE and CSRA are based off current data and are not index based. The HL Study is currently in the Recommended Plan project phase which requires the CWE to undergo ATR review and to be certified by cost headquarters. The CWE for the HL Study is currently classified as a Class 3 estimate, which is in line with the additional guidance and ER 1110-2-1302 for this phase of the project, with a contingency in the typical range of 20-50% based off a completed CSRA which will also undergo ATR review. The cost estimate moved from a Class 4 to Class 3 estimate based off refinement of technical information. MCACES has been used to further develop the CWE estimate based on the most recent

technical information and will be further used to develop an accurate cost according to the PDT determination of technical information and class of estimate as the project progresses. For the Chief's Report, the PDT will need to incorporate the CWE at the 80% confidence level as well include the CWE at the 50% and 90% confidence levels. These costs will be pulled directly from the CSRA report from cost engineering.

Table 5-4. Project Cost Summary for RP (presented in $1,000s) based on FY24 price level and FY24 Federal Discount Rate of 2.75 Percent

Alternative C3 (40 Measures – 38 restoration and two recreation)	**Estimated Costs ($1,000s)**
Real Estate (Lands and Damages)	$17,576*
Construction, includes Mobilization and Demobilization	$28,355
Cultural Resource Preservation	$452
AM&M (Cost Shared up to 10 years)	$5,299
Subtotal	$51,682
PED (Includes Construction and Real Estate)	$5,326
Construction Management	$5,116
Estimated Cost	$62,124
Project First Costs	$55,538
Annualized OMRR&R	$133
Total Average Annual Costs (includes construction, OMRR&R, and AM&M)	$2,432

*Real estate administrative costs under the 30 Account are included in the construction estimated cost.

5.4 DESCRIPTION OF THE NON-FEDERAL SPONSOR'S PROJECT IMPLEMENTATION REQUIREMENTS, ROLES, AND RESPONSIBILITIES

The implementation of the RP will occur in two phases: PED, and construction. Prior to beginning each phase, USACE will execute an agreement for that phase with the NFS. A design agreement will be executed prior to the start of the PED phase, and a project partnership agreement (PPA) will be executed prior to the start of the construction phase. In conjunction with the agreements, a project management plan will be prepared to obtain agreement within the study team and between USACE and the NFS on goals and

expectations, particularly regarding scope, quality, safety, costs, schedule, and communications.

Prior to commencement of construction, the NFS must enter into a PPA with the Government to provide its required cooperation. The NFS must agree to meet the requirements for non-Federal responsibilities, as summarized below and in future legal documents.

Federal implementation of this project is subject to the NFS agreeing to comply with applicable Federal laws and policies in the PPA, including but not limited to:

1. The NFS shall provide 35 percent of the total direct and indirect project costs for the 38 restoration measures and 50 percent of the total direct and indirect project costs for the recreational measures in accordance with Section 103 of the WRDA of 1986, as amended (33 U.S.C. 2213).
2. The NFS shall provide the real property interests, relocations, and investigations for hazardous substances required for construction, operation, and maintenance of the Project.
3. The NFS shall prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce the outputs produced by the project, hinder operation, and maintenance of the project, or interfere with the project's proper function.
4. The NFS shall not use the project, or real property interests required by the PPA, as a wetlands bank or mitigation credit for any other project.
5. The NFS shall not use Federal program funds to meet any of its obligations under the PPA unless the Federal agency providing the funds verifies in writing that the funds are authorized to be used for the project. Federal program funds are those funds provided by a Federal agency, plus any non-Federal contribution required as a matching share therefor.
6. Except as provided in the PPA, the NFS shall not be entitled to any credit or reimbursement for costs it incurs in performing its responsibilities under the PPA.
7. In carrying out its obligations under the PPA, the NFS shall comply with all the requirements of applicable Federal laws and implementing regulations, including, but not limited to: Title VI of the Civil Rights Act of 1964 (Public Law No. 88-352), as amended (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); and the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Army Regulation 600-7 issued pursuant thereto.
8. The NFS shall acquire the real property interests that the Government has determined are necessary for the construction, operation, and maintenance of the project. The NFS shall provide the Government with authorization for entry thereto in accordance with the Government's schedule for construction of the project. The NFS shall ensure that real property interests provided for the project are retained in public ownership for uses compatible with the authorized purposes of the project.

9. The NFS shall perform or ensure the performance of the relocations that the Government has determined are necessary for the construction, operation, and maintenance of the project in accordance with the Government's construction schedule for the project.
10. The NFS shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 C.F.R. Part 24, in acquiring real property interests for construction, operation, and maintenance of the project and shall inform all affected persons of applicable benefits, policies, and procedures in connection with said act.
11. The NFS shall be responsible for undertaking any investigations to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601-9675), that may exist in, on, or under real property interests required for the construction, operation, and maintenance of the project.
12. In the event it is discovered that hazardous substances regulated under CERCLA exist in, on, or under any of the required real property interests, the NFS and the Government, in addition to providing any other notice required by applicable law, shall provide prompt written notice to each other, and the NFS shall not proceed with the acquisition of such real property interests until the parties agree that the NFS should proceed.
13. In accordance with Department of the Army policy, the Government is prohibited from undertaking HTRW work on behalf of the NFS. This prohibition also applies to undertaking this work as additional work requested by the NFS or as betterments. As between the Government and the NFS, the NFS is fully responsible for the performance and costs of required HTRW cleanup and response in, on, or under any real property interests required for the project.
14. If hazardous substances regulated under CERCLA are found to exist in, on, or under any required real property interests, the parties shall consider any liability that might arise under CERCLA and determine whether to initiate construction, or if already initiated, whether to continue construction, suspend construction, or terminate construction. Should the parties initiate or continue construction, the NFS shall be responsible, as between the Government and the NFS, for the costs of cleanup and response, including the costs of any studies and investigations necessary to determine an appropriate response to the contamination. Such costs shall be paid solely by the NFS without reimbursement or credit by the Government.
15. As between the Government and the NFS, the NFS shall be considered the operator of the project for purposes of CERCLA liability. To the maximum extent practicable, the NFS shall operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.
16. To the maximum extent practicable, no later than six months after it provides the Government with authorization for entry onto a real property interest or pays compensation to the owner, whichever occurs later, the NFS shall provide the Government with documents sufficient to determine the amount of credit to be

provided for the real property interest in accordance with the provisions of the PPA.

17. The NFS shall obtain, for each real property interest, an appraisal of the fair market value of such interest that is prepared by a qualified appraiser who is acceptable to the parties. Subject to valid jurisdictional exceptions, the appraisal shall conform to the Uniform Standards of Professional Appraisal Practice. The appraisal must be prepared in accordance with the applicable rules of just compensation, as specified by the Government.
18. For real property interests acquired by eminent domain proceedings instituted after the effective date of the PPA, the NFS shall notify the Government in writing of its intent to institute such proceedings and submit the appraisals of the specific real property interests to be acquired for review and approval by the Government.
19. Any credit afforded under the terms of the PPA for relocations for construction, operation, and maintenance of the project is subject to satisfactory compliance with applicable Federal labor laws covering non-Federal construction, including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (labor standards originally enacted as the Davis-Bacon Act, the Contract Work Hours and Safety Standards Act, and the Copeland Anti-Kickback Act). Notwithstanding any other provision of the PPA, credit may be withheld, in whole or in part, as a result of the NFS's failure to comply with its obligations under these laws.
20. The NFS shall not be entitled to credit for value of or costs it incurs for real property interests that were previously provided as an item of local cooperation for another Federal project.
21. No later than 60 calendar days prior to the beginning of a FY in which the Government will be incurring costs for construction, the Government shall notify the NFS in writing of the amount of funds required from the NFS during that FY. No later than 30 calendar days prior to the beginning of that FY, the NFS shall make the full amount of such required funds available to the Government.
22. Any suspension or termination shall not relieve the parties of liability for any obligation previously incurred. Any delinquent payment owed by the NFS pursuant to the PPA shall be charged interest at a rate, to be determined by the Secretary of the Treasury, equal to 150 per centum of the average bond equivalent rate of the 13-week Treasury bills auctioned immediately prior to the date on which such payment became delinquent or auctioned immediately prior to the beginning of each additional three-month period if the period of delinquency exceeds 3 months.
23. The NFS's costs for participation on the project coordination team shall not be included in the construction costs and shall be paid solely by the NFS without reimbursement or credit by the Government.
24. If at any time the NFS fails to fulfill its obligations under the PPA, the Government may suspend or terminate construction of the project unless the Assistant Secretary of the Army (Civil Works) determines that continuation of such work is in the interest of the United States or is necessary in order to satisfy agreements with other non-Federal interests.
25. The NFS, at no cost to the Government, shall operate, maintain, repair, rehabilitate, and replace the project. The NFS shall conduct its operation, maintenance, repair, rehabilitation, and replacement responsibilities in a manner

compatible with the authorized purpose of the project and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

26. The Government may enter, at reasonable times and in a reasonable manner, upon real property interests that the NFS now or hereafter owns or controls to inspect the project, and, if necessary, to undertake any work necessary to the functioning of the project for its authorized purpose.
27. The NFS shall hold and save the Government free from all damages arising from design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the Government or its contractors.
28. The parties shall develop procedures for maintaining books, records, documents, or other evidence pertaining to project costs and expenses in accordance with 33 C.F.R. 33.20 for a minimum of three years after the final accounting.
29. The NFS is responsible for complying with the Single Audit Act Amendments of 1996 (31 U.S.C. 7501-7507). To the extent permitted under applicable Federal laws and regulations, the Government shall provide to the NFS and independent auditors any information necessary to enable an audit of the NFS's activities under the PPA. The costs of non-Federal audits shall be paid solely by the NFS without reimbursement or credit by the Government.

5.5 LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, AND DISPOSAL

There are a total of 40 landowners holding 3,044 acres to be acquired for the project. This includes lands that are in open water. Open water bottom lands are assumed to be state owned lands. The acreage that is assumed to be state owned public land is 51 acres (10 acres of which are water bottoms). The acreage that needs to be acquired for private land is 2,993. Fifty-Six (56) acres of the 2,993 acres of private land is allocated for perpetual road easements and forty (40) acres is allocated for temporary work area easements. Three (3) acres of the 3,044 acres is allocated for two measures that incorporate recreation features. The measure numbers are LW_1 and M_2.

No utility relocations/facility alterations or disposal sites have been identified at this time. In the event that a potential utility relocation or potential facility alteration is identified, a final determination of compensable interest for the owner will be produced during the PED phase.

- Total real estate costs for the structural components on **private lands** (dike notching, woody debris traps, bank protection, forest stand improvements, wetland restoration, flow restoration, riparian buffers, moist soil management, and meander scarp restoration) is $17,161,800. This figure encompasses the cost of acquiring real property interest, damages, LERRD administrative costs, and contingencies, as well as cost for potential condemnations.
- Total Administrative Cost by Government (30 Account): $158,400
- Total Administrative Cost by Sponsor: $816,000
- Total NFS COST (Includes Administrative Cost by Sponsor) (01 Account): $17,003,400
- In the model PPA for Ecosystem Restoration projects, the non-federal sponsor receives credit for the value of lands the non-federal sponsor owns.

- Non-Federal Sponsor – Assumed to own 51 acres of **public land** with an estimated credit value of $572,520. The Government is estimated to incur $51,480 in Administrative Cost associated with the crediting of this land. This number includes administrative cost and contingencies.
- Total Administrative Cost by Government (30 Account): $51,480
- Total Administrative Cost by Sponsor: $249,600
- Total NFS COST (Includes Administrative Cost by Sponsor) (01 Account): $572,520
- Total Real Estate Cost is for the project is ($158,400 + $17,003,400) + ($51,480 + $572,520) = **$17,785,800**

As mentioned above in section 5.4, the NFS shall provide the real property interests, relocations, and investigations for hazardous substances required for construction, operation, and maintenance of the project. The NFS shall acquire the real property interests that the Government has determined are necessary for the construction, operation, and maintenance of the project. The NFS shall provide the Government with authorization for entry thereto in accordance with the Government's schedule for construction of the project. The NFS shall ensure that real property interests provided for the project are retained in public ownership for uses compatible with the authorized purposes of the project.

5.6 OPERATIONS, MAINTENANCE, REPAIR, REPLACEMENT, REHABILITATION (OMRR&R)

OMRR&R for the projects is the NFS's responsibility. The purpose of OMRR&R is to sustain the constructed project and to maintain the stated level of benefits at the completion of construction and throughout the life of the project. OMRR&R will begin when AM&M conclude. For nonstructural, non-mechanical components of ecosystem restoration projects, the NFS's responsibility for OMRR&R ends ten years after ecological success has been determined, per USACE implementation guidance for Section 1161 of the WRDA of 2016. For structural or mechanical components, such as the riprap for grade control structures, culverts, bank stabilization, river training structures and channel cleanouts. Woody debris traps and floodplain vegetative measures will have no assumed operation and maintenance costs, only AM&M costs.

Preliminary OMRR&R costs were estimated for each measure. By using costs based off previous studies and projects. The assumed OMRR&R included routine inspections and/or improvements to items such as culverts, channels, hardpoints, riprap protection, river training structures road surfaces, groundwater wells, recreational features, etc. The estimated costs were annualized and included in the economic analysis. The total estimated annual OMRR&R cost for the RP is $133,000 based on the current Federal FY24 discount rate (2.75 percent). OMRR&R assumptions for each type of measures can be found in Appendix 3 Section 2.8.

5.7 COST SHARING

Section 105(a) of the WRDA of 1986, Public Law 99-662, as amended (33 U.S.C. 2215(a)), specifies the cost-sharing requirements for the feasibility phase of this project. Shared study

costs for this feasibility study are projected to be $3,000,000. The NFS shall contribute 50 percent of the shared study costs in accordance with Article II and Article Ill of the feasibility cost-share agreement (FCSA) signed July 30, 2021. The Government's share is projected to be $1,500,000 and the NFS's share is projected to be $1,500,000. These amounts are estimates only that are subject to adjustment by the Government and are not to be construed as the total financial responsibilities of the Government and the NFS.

Section 103 of the WRDA of 1986, as amended (33 U.S.C. 2213), specifies the cost-sharing requirements applicable to the design and implementation phase of this project. The authorization for construction from Congress will confirm the cost-share for implementing the RP. The cost-share in the new authorization will apply to both the PED and construction phases. The NFS shall waive reimbursement for the value of real property interests and relocations that exceeds 35 percent of construction costs. Section 221 of the Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), provides that future signed Partnership Agreement(s) shall be enforceable in the appropriate district court of the United States. The NFS shall contribute 35 percent of construction costs, as follows: the NFS shall provide the real property interests and relocations required for construction, operation, and maintenance of the project. If providing in-kind contributions as part of its 35 percent cost share, the NFS shall obtain all applicable licenses and permits necessary for such work. The NFS may claim credit for its LERRD costs and put that credit towards its share of the costs. OMRR&R is the non-Federal sponsor’s responsibility.

In addition to providing its share of the costs of the PED and construction phases, acquiring LERRD, and OMRR&R, the NFS is responsible for remediating any HTRW that is discovered in the project areas prior to construction. The WRDA of 1986 (Public Law 99-662) and various administrative policies provide the basis for this division of responsibilities. The final division of specific responsibilities will be formalized in the agreements for the PED and construction phases.

The estimated cost for the RP (38 ecological measures plus two recreational measures) is approximately $62 million. The NFS may claim credit for its LERRD costs and put that credit towards its share of the costs. OMRR&R is the NFS’s responsibility. LERRD costs are projected to be $17.7 million. The estimated costs for OMRR&R are projected to be $7.5 million ($133,000 annualized). These amounts are estimates only that are subject to adjustment by the Government and are not to be construed as the total financial responsibilities of the Government and the NFS. Costs are shown at the 2023 price level and were annualized based on FY24 price level and FY24 Federal discount rate of 2.75 percent.

Table 5-5. Summary of Cost Sharing at FY24 Price Level ($1,000)

Ecosystem	Federal	Non-Federal	Estimated Cost
Ecosystem LERRDs	$0	$17,182	$17,182
Ecosystem Construction	$27,989	$0	$27,989

Ecosystem AM&M	$4,775	$524	$5,299
Ecosystem Cultural Preservation	$294	$158	$452
Ecosystem PED	$3,426	$1,845	$5,271
Ecosystem Construction Management	$3,290	$1,771	$5,061
Ecosystem Subtotal (65% Federal, 35% Non-Federal)	**$39,774**	**$21,480**	**$61,254**
Recreation LERRDs Subtotal	$0	$394	$394
Recreation Construction Subtotal	$366	$0	$366
Recreation PED	$15	$40	$55
Recreation Construction Management	$55	$0	$55
Recreation Subtotal (50% Federal, 50% Non-Federal)	**$436**	**$434**	**$870**
Estimated Cost	***$40,210***	***$21,914***	***$62,124***

5.8 PROJECT RISKS

Section 5.7.1 describes risks related to the implementation of the RP, as well as how those risks are to be or have been managed. Section 5.7.2 describes any residual risks that would remain after the project has been implemented and are denoted as outcome risks. Risks are presented in alphabetical order and not listed in order of priority or magnitude. For information on the risk and uncertainty for ecosystem restoration activities, see Section 2.4.4.

5.8.1 Implementation Risks of RP

- Construction Restrictions
    - Restrictions to protect sensitive species, reduce noise, and prevent hunting disruption have a high potential to interrupt construction windows and limit the length of time work can be completed. This risk would be managed by working with resource agencies to identify options to work in the greatest practicable construction window under agreed-upon protective conditions. Restrictions could require multiple mobilizations and demobilizations. The risk could be mitigated by close coordination with construction engineers

and resource agencies to reduce the risk for multiple seasons and or increased production rates leading to increased costs.

- Construction Schedule
  - Construction of the measures are anticipated to undergo phased construction. Environmental conditions in the project areas are subject to change. The PED activities preceding construction, will account for changes to environmental conditions and ownership and address any changes to NEPA compliance and permitting. A conservative construction schedule is expected to be used for the study; the project implementation schedule could be accelerated with NFS agreement, depending on available funding and agency priorities. Construction would be in accordance with the USACE's regulations and standards.
- High Water
  - High water could limit access during construction. Risk would be managed by extending the construction window by one year.
- Open Water Bottoms
  - It was assumed that open water bottoms are state owned. This assumption carries a risk to cost. If the assumptions are incorrect, then the sponsor may have to acquire a real property interest for the water bottoms. If the water bottoms are state owned, there is a real estate cost for which the NFS receives credit. The estimated value of the lands that the NFS owns is $712,218.
- Planting Availability
  - The RP proposes 100s of acres of planting. This demand may exceed the supply of floodplain tree seed and saplings. Risk would be managed by completing forestry actions over several years to space out demand.
- Timing of Plantings
  - Planting and seeding of trees is time sensitive and success is highly dependent on favorable conditions which typically exist in the project area for a few weeks in spring and fall, outside of dry summer months and high-water periods. Unfavorable weather conditions during these times can make planting and seeding challenging and/or decrease plant survival. Risk would be managed by having a range of areas available for planting and contract options that allow for fall or spring planting.
- Real Estate Landowner Willingness
  - Landowner opposition could block measures within the project, or, at the very least, increase the cost of the project and extend the implementation period. The RP proposes many measures that are located in adjacent aquatic channels connected to the main navigation channel. The RP also proposes measures located on public lands whereby managers are supportive of the restoration objectives. To manage the risk of landowner willingness in measures located on private lands, the NFS has maintained close coordination with private landowners and provided education on the project, as needed.
  - The PDT also completed a sensitivity analysis of the costs and benefits of measures of the RP to evaluate benefits achieved with and without certain

parcels of private land. The analysis categorized RP measures by their technical significance and risk of acquisition based on general feedback from the NFS. The sensitivity analysis is included in Appendix 1c.

5.8.2 Outcome Risks of RP

- Climate Change
  - Temperature, average annual streamflow, and number of drought days are expected to increase over the next century. While annual average streamflow is projected to increase, a decrease in monthly average streamflow is projected for the months of July, August, and September. The projected reduction in flow to secondary channels and floodplain waterbodies during the summer months poses the greatest threat to the ecological integrity of the project area. There is the potential need for increased OMRR&R and adaptive management measures in the future due to a decrease in streamflow during summer months and decreases in precipitation. However, many of the measures (culverts, channel excavation, river training structures, dike notching, etc.) are designed to increase flow connectivity to the secondary channels to address the impacts of climate change in the future with project scenario. Ultimately, the measures investigated for this project were selected to improve the aquatic and terrestrial ecosystems' resilience to climate change.
- Extreme Conditions
  - Flooding or drought may adversely impact tree plantings or other construction. Risk would be managed by monitoring flow conditions and impacts to study area. Tree mortality would be mitigated by monitoring and replanting if necessary.
- Navigation Risks
  - There may be impacts from navigation operations to potential measures such as large woody debris traps in secondary channels. There is the possibility that barge operators could impact the proposed restoration measures.

5.9 DESIGN AND CONSTRUCTION

Construction is currently estimated to begin in 2028 depending on project authorization, appropriation and availability of funding, full environmental compliance, and execution of a binding agreement with the NFS. A continuous funding stream is needed to complete this project within the anticipated timeline, which requires continuing appropriations from Congress and the NFS in order to fund the detailed design phase PED and fully fund construction contracts. Once construction funds are appropriated, the NFS and the Department of the Army enter into a PPA. After the signing of a PPA, the NFS will acquire the necessary land, easements, and rights of way to construct the project. Because project measures cannot be advertised for construction until the appropriate real estate interests have been acquired, obtaining the necessary real estate in a timely fashion is critical to

meeting the project schedule. At the completion of construction, or functional portions thereof, the NFS would be fully responsible for OMRR&R.

5.10 ENVIRONMENTAL COMMITTMENTS

5.10.1 Endangered Species Act of 1973, as Amended, and Fish and Wildlife Coordination Act of 1934, as Amended

As members of the LMRCC, the NFS for this study, the Tennessee Wildlife Resources Agency and Arkansas Game and Fish Commission, as well as the USFWS acting as the LMRCC coordinator, were integral members throughout the plan formulation process of this study and preparation of this report. Appendix 8 details the coordination process with the resource agencies, and Appendix 2b includes additional details specific to resource significance provided by the agencies. While the RP would provide overall long-term benefits to USFWS trust species (federally listed and at-risk species, migratory birds, and anadromous/catadromous aquatic species), there is the potential for short-term effects during construction. As recommended in the Final Fish and Wildlife Coordination Act Report (Appendix 8) and prescribed by Section 7 of the ESA (Appendix 2a), any short-term effects to listed or proposed species will be assessed during separate tiered consultations between the USFWS and USACE. It will likely be 2024 before this FIFR-FEA receives final approval and an indeterminate period before funding is approved and detailed planning completed for individual project measures. It is expected that the project would be constructed incrementally over a period of years. USACE and USFWS will work to meet the requirements of the ESA as individual measures are planned and funded. This tiered approach will allow for the consideration of new species information and updates to the listing status of existing and proposed listed species.

5.10.2 Clean Water Act of 1972, as Amended – Sections 401, 402, and 404(b)(1)

While the RP provides overall benefits to wetlands and waters of the U.S., there are unavoidable impacts from construction. The CWA sets and maintains goals and standards for water quality and purity. USACE administers regulations under Section 404(b)(1) of the CWA, which establishes a program to regulate the discharge of dredged and fill material into waters of the U.S., including wetlands. The Section 404 (b)(1) Evaluation is included in Appendix 2. Section 401 requires a Water Quality Certification from State water quality agencies that the proposed measures do not violate established effluent limitations and water quality standards. Section 401 State water quality certifications would be pursued programmatically with each construction element, as scheduled according to annual Congressional appropriation funding during the detailed design, to account for the exact timing and relevant site-specific information. In letters dated 13 February 2024 and 21 April 2023, respectively, the States of Arkansas and Tennessee stated that the RP appears to meet the requirements of the water quality certification, pending confirmation based on information to be developed during the PED phase (see Section 15.4.2 in Appendix 8). All conditions of the water quality certification will be implemented to minimize adverse impacts to water quality. Section 402 establishes the National Pollutant Discharge Elimination System Program, which the States also administer, requiring a permit for storm water discharges from construction sites or other areas of soil disturbance. A SWPPP would be

prepared in compliance with EPA and associated State regulations for each construction contract. The SWPPP would outline temporary erosion control measures such as silt fences, retention ponds, and soil dikes. The construction contract would include permanent erosion control measures such as turfing and placement of riprap and filter material.

5.10.3 Farmland Protection Policy Act of 1981, as Amended

The Farmland Protection Policy Act (FPPA) is intended to minimize the impact of Federal programs on the unnecessary and irreversible conversion of farmland to nonagricultural uses. Projects are subject to requirements if they may irreversibly convert farmland to nonagricultural use and are completed by or with assistance from a Federal agency. The RP recommends conversion of agricultural land to forest and wetland habitat. All agricultural lands are located riverside of the mainline levee in the active floodplain of the LMR. Some of this land is mapped as prime farmland, but none is mapped as unique, local, or statewide importance. The RP recommends reforesting a 300-feet buffer along the top bank of the Mississippi River in locations where it is not present. Lack of a forest buffer places this land and adjacent farmland at a high erosion risk. Wetland restoration and other reforestation is proposed for frequently flooded agricultural lands. Therefore, the overall impact to prime farmland is not considered significant, and mitigation is not proposed. Coordination with the NRCS State of Tennessee Office revealed that the proposed activities would not inflict irreversible damage to key soil properties that currently qualify agricultural lands as prime, and a FPPA review is not necessary. Coordination with NRCS State of Arkansas Office revealed there are 37.5 acres of prime farmland in Mississippi County. NRCS correspondence and the completed AD-1006 forms are included in Section 18 of Appendix 8.

5.10.4 National Historic Preservation Act of 1966, as Amended; Archeological and Historic Preservation Act of 1974, as Amended

The Section 106 process of the NHPA, implemented by regulations of the Advisory Council on Historic Preservation, 36 CFR § 800, requires agencies to define a project's APE, identify historic properties in that area that may be directly or indirectly affected by the project, assess the potential for adverse effects, resolve those adverse effects, and provide the Advisory Council on Historic Preservation a reasonable opportunity to comment on the undertaking. The Archaeological and Historic Preservation Act requires USACE to undertake recovery, protection, and preservation of significant cultural resources whenever its activities may cause irreparable loss or destruction of such resources.

USACE has determined that the effects on historic properties cannot be fully determined before congressional funding approval; and in accord with ER 1105-2-100, paragraph C-4(d)(5)(d)(2), USACE has elected to fulfill its obligations under Section 106 of the NHPA through the execution and implementation of a PA. Pursuant to 36 CFR 800.4(b)(2), Phased Identification and Evaluation and 800.8, Coordination with NEPA, USACE has notified the State Historic Preservation Officers for the States of Arkansas and Tennessee and the Federally recognized Tribes having an interest in the study area (Appendix 8). Consultation was initiated by letter on 25 January 2022, followed by a kick-off consultation meeting on 18 January 2023, to discuss and develop the language of the PA. Four additional consultation meetings took place to develop the PA. A copy of the executed PA can be found in

Appendix 8. The ACHP acknowledged receipt of the executed PA on 08 December 2023. A copy of the correspondence is included in Appendix 8. Environmental Operating Principles (EOP)

USACE has reaffirmed its commitment to the environment by formalizing a set of EOPs applicable to all of its decision-making and programs. The formulation of alternatives considered for implementation met all of the EOP. The EOPs are:

- Foster sustainability as a way of life throughout the organization;
- Proactively consider environmental consequences of all USACE activities and act accordingly;
- Create mutually supporting economic and environmentally sustainable solutions;
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments;
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs;
- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner; and
- Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.

The EOPs were considered during the plan formulation process. The proposed ecosystem restoration measures in the RP were formulated by a large interagency team of experts. Measures are intended to sustain scarce habitats in the remaining footprint of the floodplain. This, in turn supports the conservation and sustainability of numerous species of conservation concern, the support of federally listed species, the combat of invasive species, and the promotion of native species for the overall benefit of the nation. The measures were created without affecting other overlapping USACE missions such as flood risk management and navigation. Numerous stakeholders, public meetings, and public involvement activities throughout the duration of the study ensured sustainable and mutually supporting solutions were developed and communicated, as detailed in Appendix 8-Public Involvement and Coordination. The RP promotes sustainability and economically sound measures by incorporating the most natural and least cost methods for restoring habitat for technically significant resources.

5.11 VIEWS OF THE NON-FEDERAL SPONSOR

The RP has been developed by a study team comprised of USACE and the non-Federal cost sharing sponsor, the LMRCC. During the development of this RP, there have been opportunities for input from the LMRCC and a wide array of partners and stakeholders. The LMRCC has been working with our partners for over 25 years and this study is another chapter in our efforts to bring a comprehensive restoration and monitoring approach to the lower river. The 39 miles of the Hatchie-Loosahatchie reach contain three tributary mouths, several State and Federal lands, and three of only 14 remaining meander scarps in the entire LMR. The RP restores two of the three remaining meander scarps. The river is no

longer able to create these unique habitats and they are filling in over time. This critical study is addressing a plan for rehabilitation of these endangered habitats, in addition to improving habitats for many of our native iconic species such as alligator gar, and numerous other state and federally listed species. The LMRCC and USACE have worked as a team to tackle the largest ecosystem restoration study to date for the LMR. The LMRCC supports the RP and agrees it is the best path forward for this 39-mile reach.

Section 6
Environmental Laws and Compliance

6.1 ENVIRONMENTAL COMPLIANCE

The relationship of the RP to environmental protection statutes or other environmental requirements is summarized in Table 6-1 and discussed below.

Table 6-1. Relationship of Preferred Alternative to Environmental Protection Statutes or other Environmental Compliance

FEDERAL STATUTES	Compliance
Archaeological and Historic Preservation Act of 1974, as amended. *Compliance requires USACE to undertake recovery, protection, and preservation of significant cultural resources whenever its activities may cause irreparable loss or destruction of such resources.* **Full compliance would be achieved by following the provisions of the PA, specifically implementing treatment measures where appropriate (see PA in Appendix 8).*	FC*
Archaeological Resources Protection Act of 1979, as amended. *Compliance requires that a contractor, State or Federal agency obtain a federal permit under the act from the appropriate federal land manager for all archaeological work occurring within federal and Indian lands in the United States for the removal and subsequent disposition of archaeological collections from that land.*	NA
Clean Air Act of 1970, as amended. *Compliance requires coordination with the U.S. EPA and analysis of potential impacts on air quality.*	FC
CWA of 1972, as amended. *Compliance requires preparation of 404(b)(1) Evaluation and submission of such to Congress with the report or procurement of State water quality certification. See Appendix 2 for the 404(b)(1) evaluation.* **Full compliance will be received on a site-by-site basis, as State water quality certifications will be coordinated during detailed designs. OBJ OBJ OBJ OBJ, respectively, the States of Arkansas and Tennessee stated that the RP appears to meet the requirements of the water quality certification, pending confirmation based on information to be developed during the PED phase (see Section 15.4.2 in Appendix 8). All conditions of the water quality certification will be implemented to minimize adverse impacts to water quality.*	FC*
ESA of 1973, as amended.	FC

FEDERAL STATUTES	Compliance
Compliance requires coordination with the U.S. Fish and Wildlife Service (USFWS) to determine if any endangered or threatened species or their critical habitat would be impacted by the project. USACE received concurrence with a not likely to adversely affect determination on 22 February 2022 (see Section 15.4.2 in Appendix 8). Additional time-sensitive, tiered Section 7 Consultations will be coordinated during detailed designs and implementation of measures.	
Federal Water Project Recreation Act of 1965, as amended. *Compliance requires review by the Department of the Interior. Washington-level review of the final report would bring the project into full compliance.*	NA
Fish and Wildlife Coordination Act of 1934, as amended. *Compliance requires coordination with the USFWS and the State wildlife agencies. These agencies were part of the interagency team utilized during plan formulation. The Final Fish and Wildlife Coordination Act Report is included in the Appendix.*	FC
Migratory Bird Treaty Act of 1918, as amended. *The Migratory Bird Treaty Act (MBTA) prohibits the take of protected migratory bird species without prior authorization by the Department of the Interior, USFWS. Coordination related to migratory birds with an emphasis on those of conservation concern is included in the Fish and Wildlife Coordination Act Report included in the Appendix.*	FC
NHPA of 1966, as amended. *Compliance requires USACE to consider the impacts of project on any property included in or eligible for inclusion in the NRHP. USACE has elected to fulfill its obligations under Section 6 of the NHPA through the execution and implementation of a PA. An executed PA was developed in consultation with the federally recognized Tribes and the Arkansas and Tennessee SHPOs in accordance with 36CRF800.14(B)(1)(ii) and is included in Appendix 8.* **Full compliance would be achieved by following the process described in the PA.*	FC*
NEPA of 1969, as amended. *Compliance requires preparation of this EA, consideration of public comments, and preparation and public review of the final EA.* **Signing of the FONSI, or completion of an Environmental Impact Statement, if warranted, would bring this project into full compliance.*	FC*
Rivers and Harbors Act of 1899, as amended. *No requirements for USACE projects authorized by Congress.*	NA
FFPA of 1981, as amended. *Compliance requires coordination with the NRCS to determine if any designated prime or unique farmlands are affected by the project. Coordination with NRCS is included in Section 18 of Appendix 8.*	FC

FEDERAL STATUTES	Compliance
Wild and Scenic River Act of 1968, as amended. *Compliance requires coordination with Department of the Interior to determine if any designated or potential wild, scenic, or recreational rivers are affected by the project. Coordination has been accomplished and there are no such rivers in the project area.*	NA
EXECUTIVE ORDER/MEMORANDA	
Executive Order 11988, Floodplain Management. *Compliance requires an assessment and evaluation together with the other general implementation procedures to be incorporated into the EA.*	FC
Executive Order 11990, Protection of Wetlands. *Compliance requires results of analysis and findings related to wetlands be incorporated into EA.*	FC
Executive Order 12898, Environmental Justice in Minority and Low-income Populations. *Compliance requires assessment of project effects on minority and low-income populations.*	FC
Executive Order 13112, Invasive Species. *Compliance requires assessment of potential for the project to introduce invasive species to the project area.*	FC
Executive Order 13175, Consultation and Coordination with Indian Tribal Governments. Compliance requires the Agency to conduct coordination and consultation with Federally recognized Tribes to determine if Tribal Rights, Tribal lands, or protected tribal resources, would be significantly adversely affected by a proposed action. It is implemented though the USACE Tribal Consultation Policy, 1 Nov 2012.	FC
Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. Compliance requires the Agency to assess and consider potential effects of their actions on migratory birds, with an emphasis on species of concern.	FC
Executive Order 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. Compliance requires assessment of costs of greenhouse gas emissions to facilitate sound decision-making	FC
Executive Order 14008: Tackling the Climate Crisis at Home and Abroad. Compliance requires the Agency to ensure that Federal infrastructure investment reduces climate pollution, and to require that Federal permitting decision consider the effects of greenhouse gas emission and climate change	FC
STATE AND LOCAL POLICIES	
State Water Quality Standards	FC
State Air Quality Standards	FC

PC = Partial Compliance

FC = Full Compliance
NA = Not applicable

6.2 PUBLIC INVOLVEMENT

6.2.1 Scoping

Upon signing of the FCSA on 30 July 2021, a project e-mail (LMRRA-Hatchie-Loosahatchie@usace.army.mil) and project website: (https://www.mvm.usace.army.mil/Missions/Environmental-Stewardship/Hatchie-Loosahatchie-Mississippi-River-Ecosystem-Restoration-Study/) were created and continue to be used to provide study related information. Shortly thereafter, large interagency planning charrettes were conducted on 1, 21, and 22 September 2021 with over 131 stakeholders invited. Invitees included State water quality and wildlife agencies from the six States bordering the LMR, Federal environmental agencies, various conservation focused non-government organizations (NGOs), city representatives, dozens of Tribal and SHPO representatives, USACE-ERDC, the NFS, and the study team. There was an average of 65 attendees participating at these planning charrettes per day. The interagency team identified goals, objectives, problems, and opportunities, and began compiling pertinent data for use in plan formulation. As part of the charrette process, an online GIS portal was created and used to compile and share various data (*e.g.,* historic maps, elevation data, hydrologic data, soils, and other habitat related data layers). At the conclusion of the planning charrettes, sub-teams were developed with experts from the various stakeholders to further plan formulation in their areas of expertise (i.e., vegetated wetlands, large river aquatics, fisheries biologists and floodplain waterbodies, recreation, etc.). The conceptual information identified at the planning charrettes was presented to the public at a virtual scoping meeting on 18 October 2021. As the sub-teams began moving from conceptual ideas to site-specific measures, it became evident that the large study area needed to be divided into smaller reaches. The team broke the study area up into 11 geographical complexes based on hydrology, geomorphology, and the evolution of the floodplain habitats using historical river maps and various data available on the GIS portal. Sub-teams began developing site-specific measures within each of the 11 geographic complexes. Meetings with NRCS representatives from Arkansas and Tennessee were conducted to determine compatibility of the study goals with existing NRCS easements located within the study area. Additionally, a scoping meeting was conducted on 08 August 2022, with Ducks Unlimited and the BRPC to discuss lands they manage in the study area, look for opportunities, and receive feedback. Site-specific measures across all geographic complexes were presented to the public at three in-person scoping meetings at Fort Pillow State Park, Tennessee on 19 September 2022, Meeman Shelby Forest State Park, Tennessee on 26 September 2022, and at Marion, Arkansas City Hall on 03 October 2022. Internet connectivity was not sufficient to stream the meetings virtually. The meetings were filmed and placed on the project website. Public scoping comments received were generally in favor of the proposed ecosystem restoration conceptual ideas. Minimal site-specific feedback was received on individual measures from the public meetings. At the public scoping meetings, several members of the public voiced the need for more accessible paved boat ramps throughout the study area explaining the safety hazards and time it takes to help someone in need. Other members of the public voiced that they felt private landowners would be interested in participating through financial

incentives other than fee acquisition. Written scoping comments and materials presented during scoping can be found in the Public Involvement and Coordination Appendix 8.

6.2.2 Agency Coordination

Environmental agencies containing jurisdiction in the study area that have been coordinating with thus far include: the U.S. Fish and Wildlife Service, U.S. EPA, TWRA, Tennessee Department of Environment and Conservation, Arkansas Department of Energy and Environment - Division of Environmental Quality, Arkansas Game and Fish Commission, and the NRCS. Representatives from these agencies were part of the plan formulation team developing and siting measures throughout the study process. An official list of species within the study area, pursuant to the ESA was received on 15 September 2021, updated on 17 November 2022, and included: Indiana bat, northern long-eared bat, eastern black rail, piping plover, red knot, pallid sturgeon, fat pocketbook mussel, and pondberry. USACE also received public notice of the northern long-eared bat status change from threatened to endangered with an effective date of 31 March 2023. An HTRW background search was also completed in September 2021, revealing very little concerns within the study area. A Final Fish and Wildlife Coordination Act Report was received from the U.S. Fish and Wildlife Service on 28 August 2023 and is included in Appendix 8. Scoping meetings were conducted, as described in the previous section and additional details are included in Appendix 8.

6.2.3 Tribal Consultation

There are 23 federally recognized Tribes with interests in the study area and two SHPOs from Arkansas and Tennessee. Early coordination between the cultural resources team determined that a PA was appropriate for the study prior to the decision document. Background Research was conducted with Arkansas and Tennessee SHPOs in August of 2022 to identify known sites in the study area. Consultation meetings to develop the PA began on 18 January 2023 and the PA was executed 01 December 2023. Two species of tribal importance were also identified: rivercane and American eel. The PA and associated consultation documentation is included in Appendix 8.

List of Statement Recipients

Electronic copies or notices of availability of this report were sent to Federal, State, and local agencies, federally recognized Tribal Nations, newspapers, NGOs, and other interested parties. An electronic file of the complete distribution list is available by request.

Federally Recognized Consulting Tribes

Absentee-Shawnee Tribe of Indians

Alabama-Quassarte Tribal Town

Cherokee Nation

Chickasaw Nation

Choctaw Nation of Oklahoma

Coushatta Tribe of Louisiana

Eastern Band of Cherokee Indians

Eastern Shawnee Tribe of Oklahoma

Jena Band of Choctaw Indians

Kialegee Tribal Town

Kickapoo Tribe of Kansas

Mississippi Band of Choctaw Indians

Muscogee (Creek) Nation

Osage Nation

Poarch Band of Creek Indians

Ponca Tribe of Indians of Oklahoma

Quapaw Nation

Sac & Fox Nation of Oklahoma

Seminole Nation of Oklahoma

Shawnee Tribe

Thlopthlocco Tribal Town

Tunica-Biloxi Tribe of Louisiana

United Keetoowah Band of Cherokee Indians in Oklahoma

Federal Agencies

U.S. Department of the Interior, Fish and Wildlife Service, AR, TN, LA, LMRCC, LMVJV, West TN Refuges

U.S. Department of the Interior, National Park Service

U.S. Department of the Interior, United States Geological Survey

U.S. Department of Agriculture, Natural Resources Conservation Service, AR, TN

U.S. Coast Guard

U.S. Advisory Council on Historic Preservation

U.S. Environmental Protection Agency, Regions 4, 6

State Agencies

Arkansas Commissioner of State Lands

Arkansas Department of Energy and Environment

Arkansas Game and Fish Commission

Arkansas Historic Preservation Program and the Arkansas Archeological Survey

Arkansas Natural Resources Commission

Kentucky Department for Environmental Protection - Division of Water

Kentucky Department of Fish and Wildlife Resources

Mississippi Department of Environmental Quality

Missouri Department of Natural Resources

Louisiana Department of Environmental Quality

Tennessee Department of Environment and Conservation, Division of Natural Areas

Tennessee Department of Environment and Conservation, Division of Water

Tennessee Department of Environment and Conservation, Division of Archeology and Tennessee Historical Commission

Tennessee Wildlife Resources Agency

Fort Pillow State Park

Meeman Shelby Forest State Park

Local Governments

City of Memphis

City of Marion

Lauderdale County

Lauderdale County Highway Department

NGOs

Audubon Society
The Nature Conservancy
Wildlife Mississippi
Tennessee Wildlife Federation
Ducks Unlimited
Gulf Hypoxia Task Force
National Wildlife Federation

Newspapers

AR Times
Blytheville Courier News
Marked Tree Tri City Tribune
The Osceola Times
Commercial Appeal - Tom Charlier
East Arkansas News Leader
Stuttgart Daily Leader
The Daily Citizen
AR Times
Blytheville Courier News
Marked Tree Tri City Tribune
The Osceola Times
Commercial Appeal
East Arkansas News Leader
Stuttgart Daily Leader
The Daily Memphian

Other Interested Parties

Lists on file with USACE.

6.2.4 Public Comments Received and Responses

The DIFR-DEA was disseminated for review and comment to various agencies, organizations, and interested parties. A hybrid in-house/virtual public meeting was conducted during the comment period to discuss the findings of the DIFR-DEA on 6 March 2023. Information presented at the meeting, public comments, and associated responses to the DIFR-DEA are included in Appendix 8. Public comments to this FIFR-FEA are being solicited and will be included in the final report.

Section 7
Recommendation

I have considered all significant aspects of the problems and opportunities compilated in the Hatchie Loosahatchie Mississippi River Mile 775-736, TN, and AR Planning Study, which include environmental, social, and economic effects, as well as engineering feasibility.

The NER Plan and the RP, Alternative C3, collectively addresses historically significant and ecologically important habitats across the 11 geographic complexes in the States of Arkansas and Tennessee by restoring hydrologic connectivity to rare geological features that support special status species and critical vegetative habitats. The RP also supports the promotion of alligator gar spawning habitats, a species that is known to control invasive species such as invasive carp. It restores rare geological features, known as meander scarps, that no longer form due to modern river engineering controls. The NER Plan estimates to benefit 6,282 acres with a net gain of 4,673 AAHUs. All objectives set forth for this study are estimated with an estimated cost of $62 million.

Alternative C3 is a comprehensive plan that also provides additional recreational benefits to communities by enhancing hydrologic connectivity with resourced-managed areas enhancing access for recreational opportunities.

The recommendations contained herein reflect the information available at this time and current Department of the Army policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the United States Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States of Tennessee, and Arkansas, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

The NER Plan was developed in concert with and is fully supported by the NFS, the LMRCC, which is a nonprofit coalition of States in the LMR valley. Their participation ensured natural resource conservation and EQ issues important to the public were addressed throughout the study process. Shared study costs in accordance with Article II and Article Ill of the Feasibility Cost Sharing Agreement signed 30 July 2021, are as follows: feasibility study costs between the NFS and Federal are 50 percent; shared implementation costs of the 38 restoration measures are 35 percent and 65 percent, respectively, and 50 percent and 50 percent for the two recreation measures.

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Brian Sawser
Colonel, U.S. Army Corps of Engineers
District Commander

Section 8
List of Preparers

Name	Agency	Experience	Role
Allison Fowler	LMRCC-AGFC	Wildlife Diversity Program Coordinator for Arkansas Game and Fish Commission with expertise in rare species of the state	Environmental, NFS
Amanda Oliver	USACE-ERDC	MS in Biology, 6 years of experience in NEPA and Environmental Compliance, 10+ years of experience in GIS and riverine ecological research	Environmental
Andrew Perez	USACE	Master's degree in Urban and Regional Planning with 25 years of experience	Environmental Justice
Angela Erves	LMRCC-USFWS	LMRCC Coordinator with 20 years' experience	Environmental, NFS
Angeline Rodgers	LMRCC-USFWS	MS in Biological Sciences with 23 years of experience in aquatic ecosystems	Environmental, NFS-Lead
Audrey Harrison	USACE-ERDC	PhD in Biology, Research Entomologist, 13 years of experience in large river ecology, food web interactions, and benthic community dynamics	Environmental
Bill Reeves	LMRCC	Retired Director of Wildlife & Biodiversity Program of the Tennessee Wildlife Resources Agency	Environmental, NFS
Brian Johnson	USACE	18 years of experience with USACE in Natural Resource Management, 4 years of experience in Real Estate	Real Estate, Study Lead
Daniel Ward	USACE	23 years of experience with USACE in water resources management	Project Management
David Ruppel	USACE-ERDC	PhD Aquatic Resources and Integrative Biology, thirteen years of experience working with aquatic fauna in rivers and streams, with a focus on fish communities, distributions, and conservation status	Environmental
Ed Lambert	USACE	Professional with 33+ years of experience in environmental compliance	Environmental

Eric Brinkman	LMRCC-AGFC	MS in Natural Resource Ecology and Management with 20 years of experience in fisheries research and conservation	Environmental, NFS
Gretchen Benjamin	LMRCC-TNC	Retired leader of the Nature Conservancy with expertise in water policy, aquatic animal and plant species, and large-scale habitat restoration	Environmental, NFS
Holly Enlow	USACE	Professional Engineer (PE) with 6 years of experience in hydraulic modeling and watershed management	Engineering – Hydraulics and Hydrology, Study Lead
Isbell Cody	USACE	MS in Civil Engineering, PE with 6 years of experience in Civil/Geotechnical Engineering working on levee, flood protection, and river-based infrastructure	Engineering - Geotechnical
Jack Killgore	USACE-ERDC	PhD, Research Fisheries Biologist	Environmental
Jack Milazzo	USACE	MLA, Professional Landscape Architect for 10+ years	Recreation, Aesthetics
Jason Allmon	USACE	BS in Civil Engineering, Registered PE since 2003, 13 years of experience in Project Management	Project Management, Study Lead
Jason Henegar	LMRCC-TWRA	Assistant Chief of Fisheries for the Tennessee Wildlife Resources Agency with expertise in species and fisheries management	Environmental, NFS-Lead
Jeffrey Glass	USACE	Registered PE with 13 years of civil engineering experience	Engineering – Civil Design, Study Lead
Jim Wise	LMRCC-ADEE	MS in Biology with 30 years of experience in CWA implementation and environmental restoration	Environmental
Karina Bynum	LMRCC-TDEC	PhD and Registered PE with 20 years of water resource regulatory and engineering experience	Environmental
Katie Magoun	USACE	MS in Global Environmental Health Sciences with 18 years of experience in environmental compliance and policy, program and project management	Plan Formulation, Study Co-Lead
Kenneth Williams	USACE	BS in Human Resource Management, DoD Public Affairs Officer Qualification Course, 21 Years Photojournalism experience in US Air Force, 12 Years Public Affairs Officer experience in US Air Force, Veterans Affairs, and USACE	Public Affairs

Kyle Raburn	USACE	BS in Civil & Environmental Engineering with 2 years of experience in cost engineering; Engineer in Training (EIT)	Engineering – Cost, Study Lead
Landon Mills	USACE	Registered PE with 14 years of experience in site design and land development, 3 years of experience in river engineering	River Engineering
Lawrence Skaggs	USACE	MA in Geography, 30 years of experience in plan formulation and USACE policy	Plan Formulation
Lindsay Barrios	USACE	Professional with 18 years of experience in GIS, 8 years of experience with Environmental Compliance, 2 years of experience with Planning	Geospatial, Study Lead
Loren Labusch	LMRCC-ADEE	MS in Geology with 10 years of experience in hydrogeology and GIS	Environmental
Matthew Napolitano	USACE	MBA in Finance with over 20 years of experience in economics at USACE	Economics, Study Co-Lead
Michelle Meyers	USACE	MS Biology with 20 years of experience in ecosystem restoration and water resource planning, monitoring and adaptive management planning	Plan Formulation, Study co-lead
Mike Thron	USACE	MS in Biology with 20 years of experience in NEPA, environmental compliance and planning	Environmental, NEPA Coordination, Study Lead
Nicky Faucheux	USACE-ERDC	MS in Aquatic Resources, PhD in Forest Resources (Wildlife, Fisheries, and Aquaculture Conc.) with 2 years of experience in ecosystem restoration, ecological modeling, biological monitoring, and adaptive management implementation	Environmental
Pam Lieb	USACE	Cultural RTS with 20 years of experience in cultural compliance	Cultural Resources, Study Lead
Preston Snyder	USACE	Professional with 10 years engineering experience with 5 years river engineering experience	River Engineering, Study Lead
Randall Harms	USACE	Professional with 8 years of experience in construction management/contract administration	Engineering - Construction
Shannon Wheeler	USACE	BS in Economics with 6 years of experience in flood risk management and economics of water resource projects	Economics, Study Co-lead

Tim Axtman	USACE	BS in Civil Engineering, Registered PE, with over 40 years of experience in hydraulics and hydrology, planning,and project management.	Plan Formulation
Todd Slack	USACE-ERDC	PhD with 27 years of experience sampling and serving as the primary investigator on research studies focused native and non-native aquatic species (e.g., fishes, mussels) within watersheds in the Mississippi Alluvial Valley and Gulf Coastal Plain	Environmental
Travis Creel	USACE	BS, Environmental Management Systems: Resource Conservation, 20 years of experience in water resource planning and USACE policy	Plan Formulation

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List of Acronyms and Abbreviations

AAFCU	Average Annual Functional Capacity Units
AAHU	Average Annual Habitat Units
AM&M	Adaptive Management and Monitoring
ASTM	American Society for Testing Material
ANSTF	Aquatic Nuisance Species Task Force
APE	Area of potential effect
ARA	Abbreviated Risk Analysis
BLH	Bottom Land Hardwood
BMP	Best Management Practices
BRPC	Big River Park Conservancy
CEICA	Cost Effectiveness and Incremental Cost Analysis
CEJST	Climate and Economic Justice Screening Tool
CEM	Conceptual ecological model
CEMVM	Mississippi Valley Division, Memphis District
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CIP	Channel Improvement Program
CO_2	Carbon Dioxide
CWA	Clean Water Act
FEA	Final Environmental Assessment
FIFR	Final Integrated Feasibility Report
Eflows	Environmental Flows
EJ	Environmental Justice
EO	Executive Order
EOP	Environmental Operating Principles

EPA	Environmental Protection Agency
ER	Engineering Regulation
ERDC	Engineer, Research, and Development Center
ESA	Endangered Species Act
EQ	Environmental Quality
FCSA	Feasibility Cost Share Agreement
FIFR	Final Integrated Feasibility Report
FONSI	Finding of No Significant Impact
FPPA	Farmland Protection Policy Act
Framework	Lower Mississippi River Basin Invasive Carp Control Strategy Framework
FWOP	Future Without Project
FWP	Future With Project
FY	Fiscal Year
Ha	Hectares
H&H	Hydrological and Hydraulic
HGM	Hydrogeomorphic Model
HRMP	Habitat Restoration and Management Program
HTRW	Hazardous, toxic, radioactive waste
HSI	Habitat Suitability Index
ICA	Incremental Cost Analysis
IWR	Institute for Water Resources
LERRD	Lands, Easements, Rights of Way, Relocations, and Disposal
LiDAR	Light Detection and Ranging
LMR	Lower Mississippi River
LMRCC	Lower Mississippi River Conservation Committee
LMRRA	Lower Mississippi River Resources Assessment
LWRP	Low Water Reference Plane

MAV	Mississippi Alluvial Valley
MRT	Mississippi River Trust
MR&T	Mississippi River and Tributaries
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NFS	Non-Federal Sponsor
NHPA	National Historic Preservation Act
NLAA	Not Like to Adversely Affect
NRCS	National Resources Conservation Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
OMRR&R	Operations, Maintenance, Repair, Replacement, Rehabilitation
OSE	Other Social Effects
PA	Programmatic Agreement
P&G	Principles & Guidelines
PCX	Planning Center of Expertise
PED	Pre-Construction Engineering and Design
PPA	Project Partnership Agreement
REC	Recognized Environmental Conditions
RED	Regional Economic Development
REP	Real Estate Plan
RP	Recommended Plan
SHPO	State Historic Preservation Office
SWPPP	Stormwater Pollution Prevention Plan
TNC	The Nature Conservancy
TON	Total Organic Nitrogen

TSP	Tentatively Selected Plan
TWRA	Tennesse Wildlife Resources Agency
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area
WNS	White-Noise Syndrome
WRDA	Water Resources Development Act