Three Rivers Southeast Arkansas Integrated Feasibility Report and Environmental Assessment

Photograph: Entrance channel to the McClellan Kerr Arkansas River Navigation System and Montgomery Point Lock and Dam at the confluence of the Mississippi and White rivers, Arkansas

Final Report

April 2018

US Army Corps of Engineers®
Little Rock District

Arkansas Waterways Commission
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EXECUTIVE SUMMARY

Study Purpose

At the request of the Arkansas Waterways Commission, and under authority of Section 216 of the Flood Control Act of 1970 (Public Law 91-611), the U.S. Army Corps of Engineers (USACE) is conducting the Three Rivers Southeast Arkansas Feasibility Study (Three Rivers Study). The study recommends modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) that will ensure the long-term sustainability of reliable navigation on the MKARNS. In 2005, USACE undertook the Arkansas-White Cutoff General Reevaluation Study (Ark-White Study) to address this issue; however in 2009, USACE recommended the No Action Alternative and the study terminated. USACE was unable to identify a long-term solution that was environmentally acceptable under authorities and funding available at the time.

The Three Rivers Study is comprehensive, and embodies the newly developed tenets of USACE SMART planning. Throughout the study, the project delivery team leveraged expertise throughout USACE including the Little Rock District, the Regional Planning and Environmental Center (Southwestern Division), the Jacksonville District (South Atlantic Division), and the Inland Navigation Planning Center of Expertise (Huntington District). The study team also engaged other federal and state resource agencies such as the Arkansas Waterways Commission, Oklahoma Department of Transportation, the U.S. Fish and Wildlife Service, the Arkansas Game and Fish Commission and local governments to ensure that the study used the best and most current data, and eliminated redundancy inherent in large-scale water resources planning studies. The SMART planning process aims to save time and money; and most importantly, delivers solutions that are economically feasible and environmentally acceptable. Based on the results of the Three Rivers Study, USACE will seek specific authorization from Congress to implement the Recommended Plan.

Overview of the MKARNS

The MKARNS was the largest civil works project ever undertaken by USACE at the time of its opening in 1971. Today, it transports about $3.5 billion (approximately 12 million tons) worth of commodities to and from ports in Arkansas and Oklahoma each year and serves customers throughout the nation's heartland. The system is 445 miles long with 18 locks and dams and has an elevation differential of 420 feet from its beginning at river mile 599 on the Mississippi River to the head of navigation near Tulsa, Oklahoma (Figure A).

The MKARNS is a major conduit for U.S. agricultural exports, and transports various inbound cargoes such as fertilizers, fuels, chemicals and iron and steel. On average, transporting by barge on the MKARNS versus overland routes saves shippers roughly $50 per ton of cargo, and based on current traffic volumes, saves U.S. businesses and consumers nearly $600 million per year in transportation costs. Since the MKARNS opened, annual tonnage on the system has increased by about 180 percent, and study projections indicate that traffic on the river will continue to rise well into the foreseeable future.

Given its scale and ability to relieve landside congestion and related environmental impacts, in May of 2015 the U.S. Department of Transportation upgraded the MKARNS from a "Connector" system to "Corridor" system as part of the Maritime Administration America's Marine Highway Program.[1] The upgrade in status brings the MKARNS into the same category as other major inland waterways such as the Mississippi and Ohio rivers.

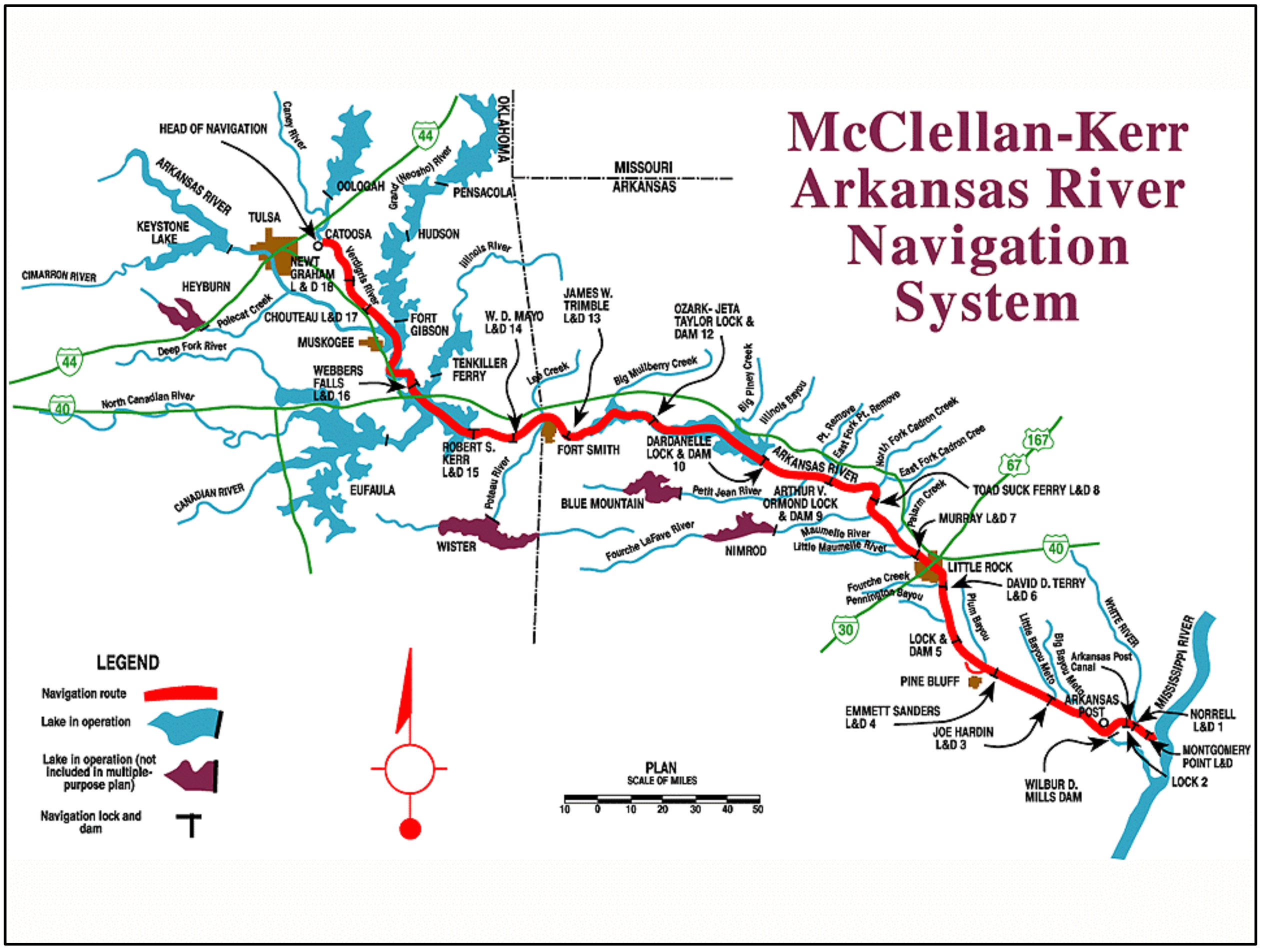

Figure A: McClellan-Kerr Arkansas River Navigation System

[1] According to the U.S. Maritime Administration, Corridors and Connectors identify routes where water transportation presents an opportunity to offer relief to landside corridors that suffer from traffic congestion, excessive air emissions or other environmental concerns and other challenges. Corridors are generally longer, multi-state routes whereas Connectors represent shorter routes that serve as feeders to the larger Corridors.

Study Area and Project Area

The study area encompasses 208 square miles in rural southeast Arkansas and includes the confluence of the Arkansas, White, and Mississippi rivers, and Montgomery Point Lock and Dam, which is the final MKARNS lock and dam where barges enter the Mississippi River. Today, about 80 percent of tonnage on the MKARNS is outbound or inbound meaning that it flows through Montgomery Point to and from the Mississippi. Approximately 64 square miles of the Dale Bumpers White River National Wildlife Refuge (Refuge), owned and operated by the U. S. Fish and Wildlife Service (USFWS), also lies within the study area. Other landowners include the Arkansas Game and Fish Commission (AGFC), USACE, the Anderson Tully Lumber Company, and several hunting clubs. As defined, the *study area* is large enough to capture potential indirect and long-term environmental impacts of alternative implementation, particularly impacts that may occur further upstream or downstream of the immediate project footprint due to changes in hydrology.

The *project area* is much smaller and consists of the isthmus between the Arkansas and White rivers where problems addressed in this study (described below) are occurring (Figures B and C). Landownership and landowner preferences for placement of structures were considered during formulation, however they were not key to identifying placement locations. All plan formulation was based upon features and locations that would best address the stated problems and objectives of the study.

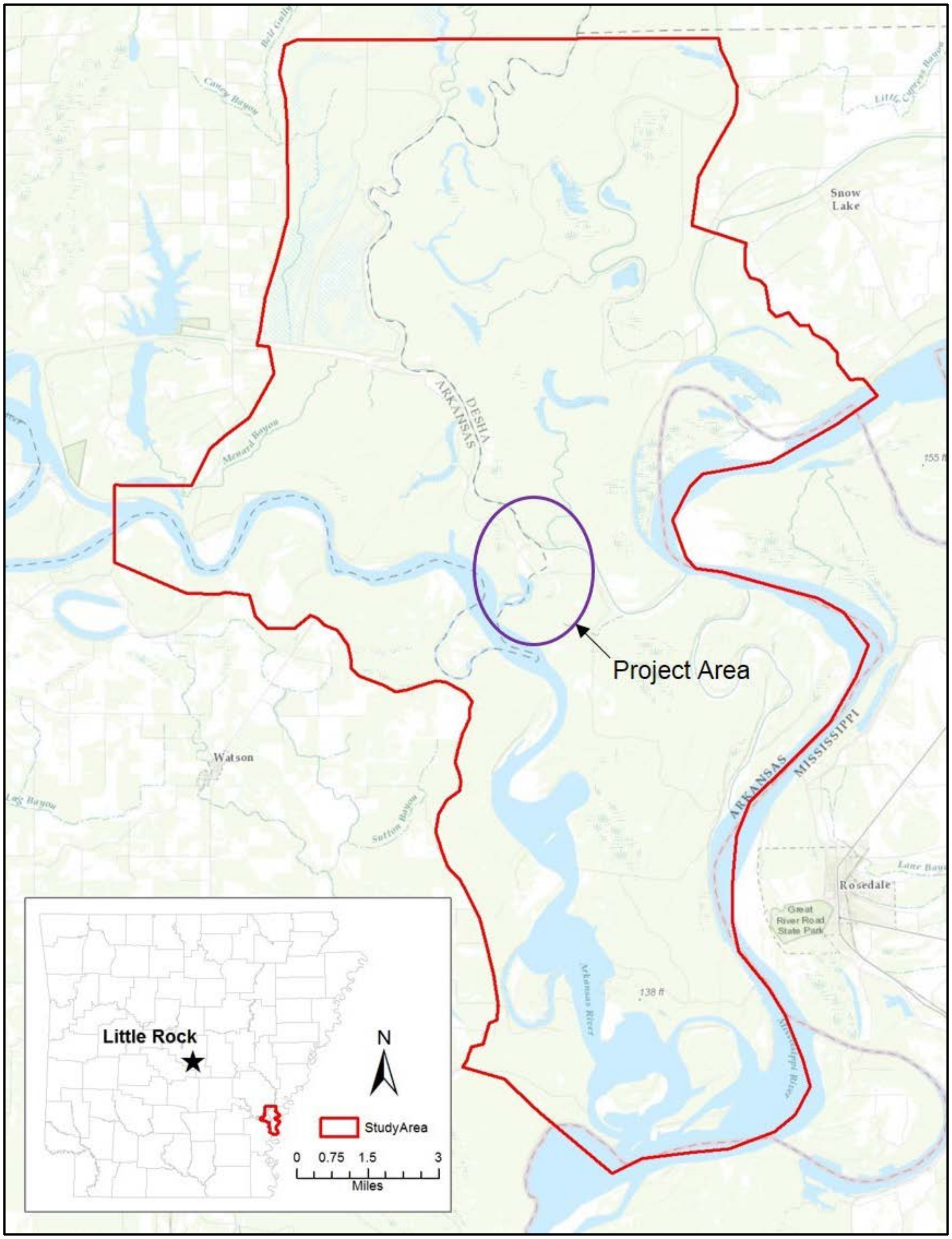

Figure B: Three Rivers Study Area and Project Area Boundaries

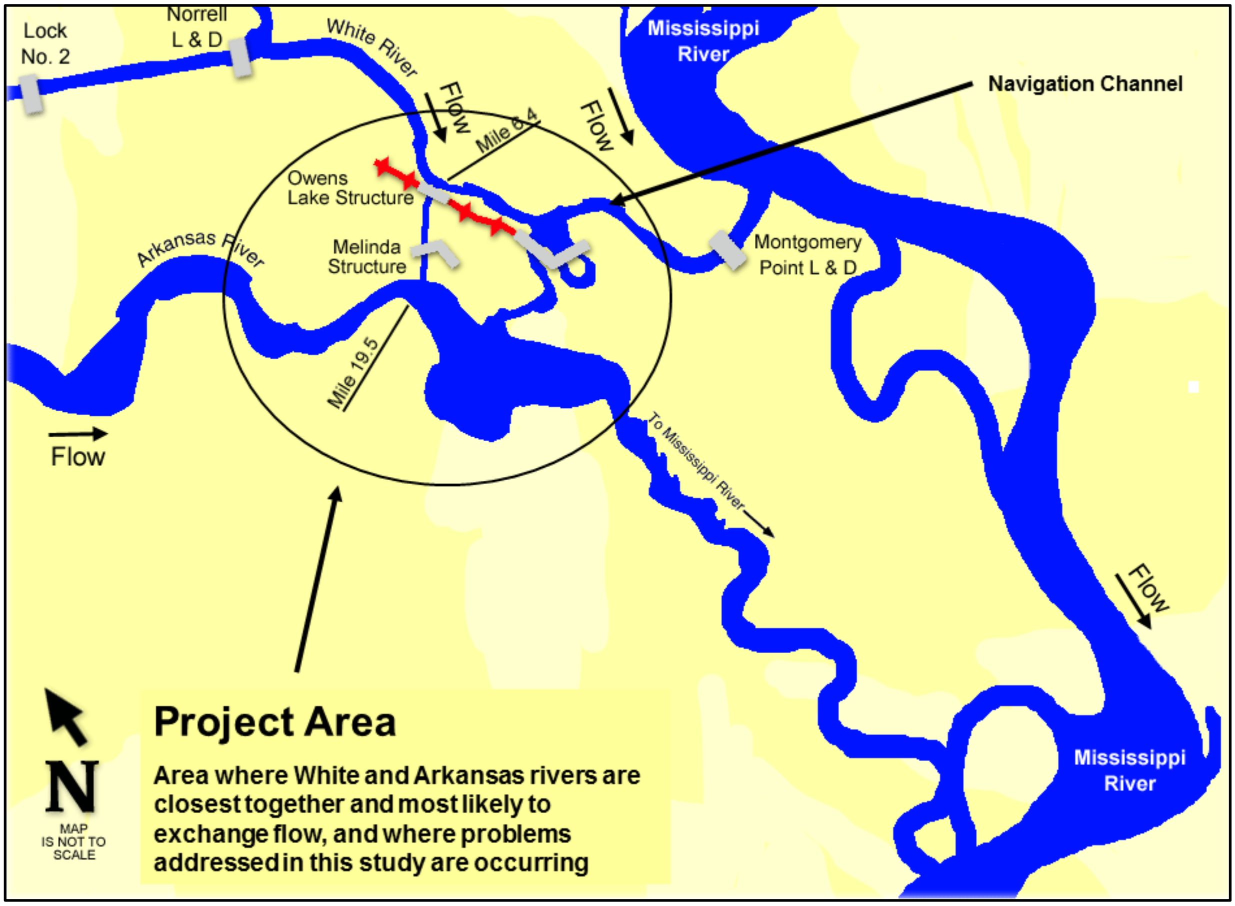

Figure C: Three Rivers Project Area

Problems and Opportunities

Since the early 1970s, head cutting[2] and erosion across the isthmus[3] have significantly increased the likelihood that a cutoff could form between the Arkansas and White rivers. The risk of a cutoff forming is caused in large part by water elevation differences (i.e., head differentials) that occur when one or both of the White or Arkansas rivers are above their bank. When one or both rivers are out of bank, flood waters tend to flow overland across the isthmus along several paths of least resistance.

The primary catalyst of overtopping flows is the Mississippi. When water elevation on the Mississippi reaches a certain level, it forces backwater into the White River. This water overflows across the isthmus into the Arkansas since the Mississippi backwater response time is shorter on the White than on the Arkansas. Occasionally, flooding

[2] Head cutting is a type of erosion in streams where an abrupt vertical drop or knick-point in a stream bed occurs. A knick-point, where a head cut begins, can be as small as an overly-steep riffle zone or as large as a waterfall. When not flowing, a head cut resembles a very short cliff or bluff. A small plunge pool may be present at the base of a head cut due to the high energy of falling water. As erosion of a knick-point and streambed continues, head cuts enlarge and migrate.

[3] Isthmus: a narrow piece of land connecting two larger areas across an expanse of water by which they are otherwise separated

results in flows from the Arkansas to the White. As flood waters move overland, the ground surface erodes as the head cutting process takes place. Eventually a new water course, or cutoff, may form that would redirect part or all of one river's flow to the other river, particularly if an existing head cut containment structure failed or breached during a high water event.

To prevent formation of a cutoff, USACE Little Rock District constructed a multi-component soil-cement system consisting of three primary structures:

1) The Historic Closure Structure that closed the path where water crossed the isthmus;

2) The Melinda Structure that contained head cutting from the Arkansas River into Owens Lake; and,

3) A linear soil-cement dike structure running east-west across the isthmus along the south side of the White River which includes the Owens Lake Structure.

Since 1989, USACE has spent about $23 million (FY 2018 dollars) on several containment structures in the project area including construction costs and repairs (an average of $522,000 per year). In the absence of federal action recommended in this study, Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) costs for existing containment structures will be significant and continue through the foreseeable future, and USACE will have to build similar small scale ad hoc structures in other areas where head cuts are migrating.

More importantly, if a cutoff formed, navigation through the project area would cease for extended periods due to dangerous cross currents during high flows, and draft constraints during low flows until USACE could mobilize their contingency plan and repair or close the cutoff, which would take at least six months. During the closure, most shippers would have to find alternative overland routes at much higher costs. In addition, sediment deposition would increase dredging requirements, and an estimated 200 acres of bottomland hardwood forest in the path of a cutoff would be destroyed as land converted to open water.

Thus, without federal action the problem is two-fold:

1) The risk and potential serious consequences of a cutoff between the Arkansas and White rivers forming will continue; and,

2) USACE will continue to accrue significant OMRR&R costs for existing structures and construction costs and subsequent OMRR&R on new structures.

With federal action, the risks and consequences of cutoff forming are drastically reduced, OMRR&R costs in the project area would decline, and the Recommended Plan would provide ancillary environmental benefits.

Alternative Formulation and Plan Comparison

The goal in formulating alternatives in this study was to maximize National Economic Development (NED) benefits while reducing maximum head differentials between the two rivers, reducing flow velocities through the isthmus, reducing the duration of overtopping events, and controlling where overtopping occurs. The study team built on plan formulation from the 2009 Ark-White Study, and developed three final alternatives.

- The **No Action Alternative** consists of a continued reliance on repairing and modifying existing containment structures and constructing new small structures similar to the Melinda Structure to contain other head cuts in the project area when they reach critical levels.
- **Alternative 1** consists of constructing a new stone containment structure on a different alignment than the version in the Ark-White Study; and, it adds a relief opening at the Historic Cutoff, removes the Melinda Structure, and adds an opening to the Owens Lake structure (Figure D). Changes to the 2009 design would significantly increase the effectiveness of the structure in reducing the magnitude and duration of damaging head differentials that in turn decreases overland scour and increases project resiliency. Appendix B provides details regarding the hydrology of the relief channel.
- **Alternative 2** consists of lowering portions of several existing structures and adding two new ones to allow multiple flow paths across the isthmus and would add a relief opening at the Historic Cutoff that is wider than that proposed in Alternative 1, at and optimized elevation between 115 and 135 feet. (Figure E). The alignment of the existing Soil Cement Structure would not change under Alternative 2.

USACE evaluated each of the final alternatives based on their respective costs and benefits. Project benefits stem from a comparison of No Action Alternative costs to the costs of constructing and operating alternative plans implemented. Benefits (i.e., avoided costs) consist of repairs and rehabilitation costs for several existing containment structures, and costs of new containment structures expected under the No Action Alternative. In addition, a major component of NED benefits is the potential forgone transportation cost savings due to restricted navigation if a cutoff formed, and the avoided costs of closing the cutoff.

As shown in Table 1, annualized reductions in NED benefits associated with the No Action Alternative total about $34 million. Implementation of Alternatives 1 or 2, negate most of the forgone NED benefits of the No Action Alternative. While both alternatives require construction funds and OMRR&R funding, their net benefits are positive and substantial. Mitigation costs were developed for Alternative 1, but while there would be some mitigation associated with Alternative 2; the PDT did not complete a mitigation plan for Alternative 2. For planning purposes, given the significant difference in cost between the two alternatives, adding mitigation to Alternative 2 would only further decrease net benefits. Mitigation for Alternative 2 would very likely be more than Alternative 1; however, the team decided to assume mitigation costs would be the same since mitigation costs would not affect the NED determination.

Alternative 1 has the highest annualized net benefits relative to annualized costs. Net annualized benefits for Alternative 1 are $26,137,000 versus $23,310,000 resulting in a benefit to cost ratio of 4.4 versus 3.2 for Alternative 2. Therefore, Alternative 1 is the NED plan. Project fist costs are $180,295,000, and the total investment including interest during construction is $187,651,000.

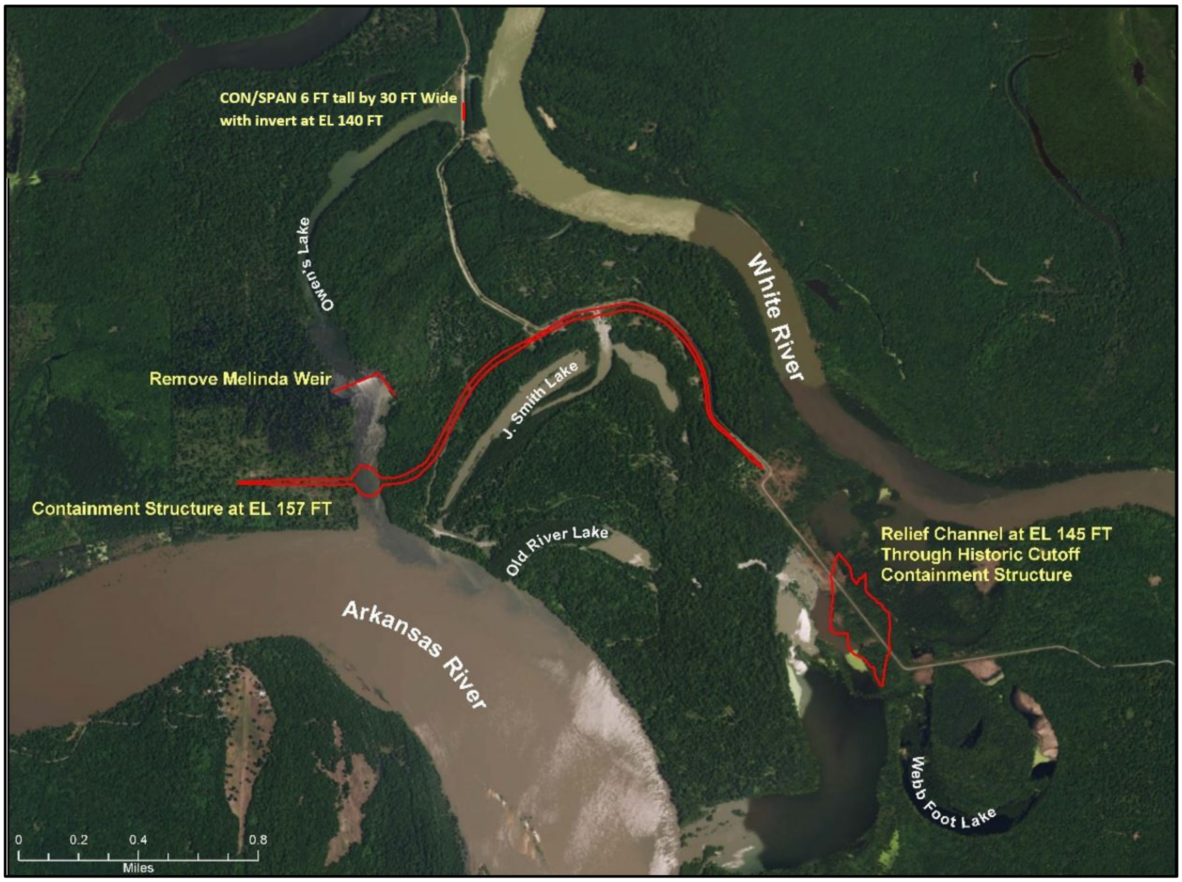

Figure D: Alternative 1 Structure Alignment

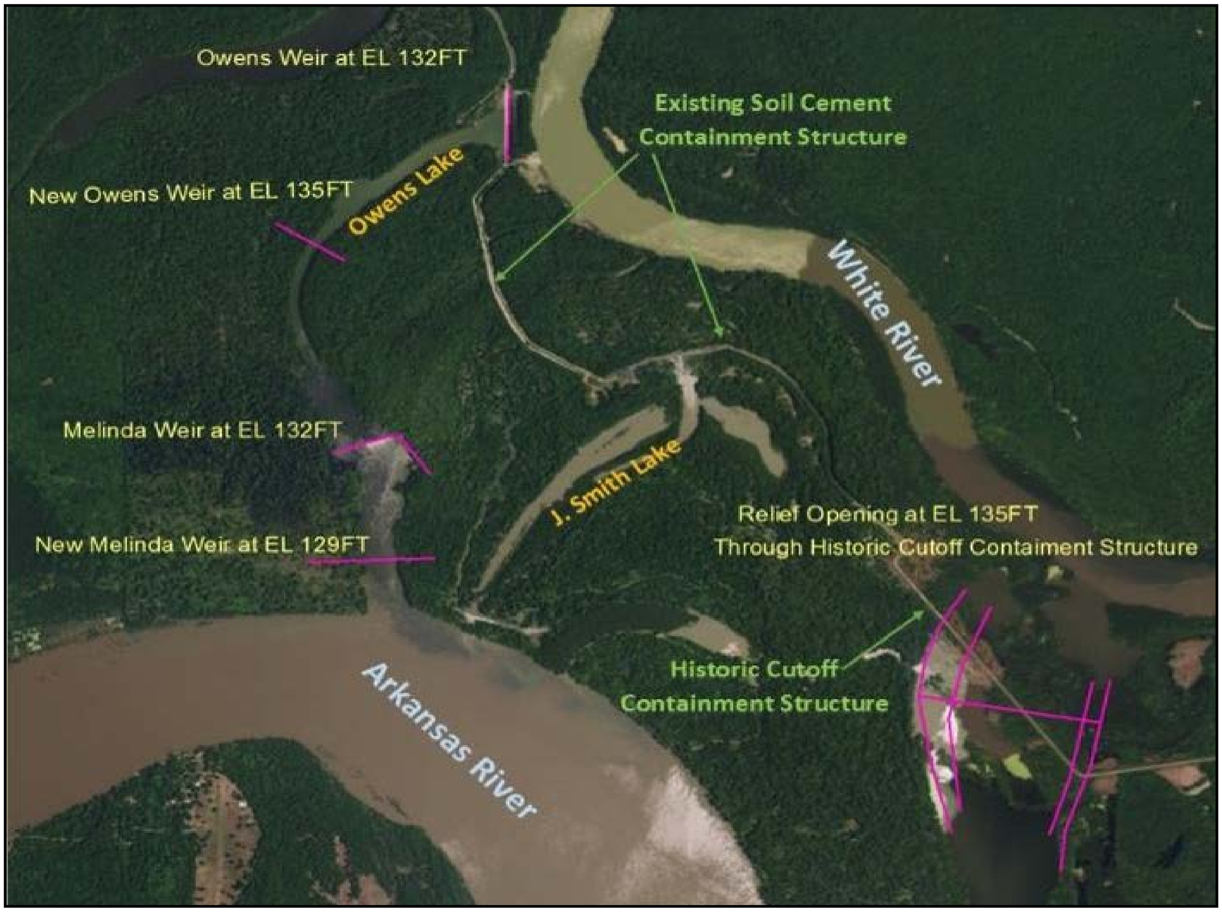

Figure E: Alternative 2 Feature Locations

Table 1: Costs and Benefits of Alternative Plans (FY18 – October 2017 prices, discount rate 2.75 percent)

	No Action	Alternative 1	Alternative 2
Construction, Real Estate and Interest	-	$186,967,000	$256,002,000
Mitigation	-	$684,000	$684,000
Total Investment	-	$187,651,000	$256,686,000
Annualized Costs[a]	$34,163,000	$7,674,000	$10,501,000
Annualized Benefits	$0	$33,811,000	$33,811,000
Net Benefits	$0	$26,137,000	$23,310,000
Benefit Cost Ratio	0	4.4	3.2

[a] Annualized cost includes interest and amortization and OMRR&R

Recommended Plan

Alternative 1 is the Recommended Plan, and consists of a new containment structure at an elevation of 157 feet above mean sea level with a relief channel through the Historic Closure Structure, and would dramatically reduce the risk of a cutoff forming. The structure would be approximately 2.5 miles long (Figure D), and would begin on natural high ground south and west of the Melinda Structure located on the south side of Owens Lake. As designed, it continues east and cross the Melinda head cut south of the Melinda Structure, and then heads northeast and connects to the existing containment structure north of Jim Smith Lake. It then continues to follow the Soil Cement Structure alignment and terminates at the Historic Closure Structure. This alignment takes advantage of natural high ground, in most locations the structure would only rise five to seven feet above the ground, and would be no more than 12 feet above the ground at its highest point. The relief opening at the Historic Cutoff would be at an elevation of 145 feet, and engineers and hydrologists would optimize the width of the opening during the Preconstruction, Engineering and Design (PED) phase of the project to ensure that flows through the Historic Cutoff, the natural path by which waters of the White River have historically flowed across to the Arkansas and vice versa, would not impact navigation.

Opening the Historic Cutoff would reduce maximum head differentials across the isthmus allowing USACE to better control the location of future overtopping events and would decrease the duration of head differentials and flow velocities and hence erosion across the isthmus. Lastly, the opening would restore ecosystem functions of Webfoot Lake and reduce erosion on the east side of the lake where there are knick-points that will likely lead to head cutting and a resultant decline in ecosystem function of Webfoot Lake. Similarly, removing the Melinda Structure would reconnect Owens Lake to its former southern limb, thereby returning open water ecosystem functions to the oxbow portion of the flooded bottomland hardwood forest. Demolition debris would be pushed into the deep scour hole at the top of the Melinda head cut to reduce water turbulence and erosion in the immediate Melinda Structure vicinity. Finally, opening the Owens

Lake Structure between Owens Lake and the White River would prevent water from backing up into Owens Lake, which may benefit adjacent bottomland hardwood forests. The opening's design would also provide a fish passage into Owens Lake that will be eliminated after the construction of the Containment Structure at elevation 157 feet.

Other than changes described above, implementation of the Recommended Plan would not alter hydrology in surrounding bottomland hardwood forests, and most importantly, navigation would continue with no operational changes to the MKARNS.

Environmental Assessment

The Recommended Plan balances structural and environmental sustainability requirements. The plan would have few long-term environmental impacts, and would result in habitat loss of only 4.4 Functional Capacity Units in the form of lost bottomland hardwood forest and conversion of waters of the U.S. to impervious surface. Mitigation would consist of purchasing 109 credits from the Fourche Bayou Mitigation Bank. Short-term impacts during construction such as increased turbidity, decreased air and visual quality, disruption in wildlife and aquatic use of the construction area would be temporary and would return to baseline conditions after construction. As noted previously, the Recommended Plan has several ancillary benefits including: reducing erosion on the Refuge and surrounding lands that would occur under the No Action Alternative, restoring the function of two oxbow lakes (Webfoot and Owens), and increasing fish passage into Owens Lake. Cumulative impacts for all resources have been determined to be less than significant or nonexistent.

An Environmental Assessment and draft Finding of No Significant Impact (FONSI) were prepared and integrated into the feasibility report showing compliance with all laws, regulations, executive orders, and guidance. Initially, the study anticipated requiring an Environmental Impact Statement (EIS); however, after environmental analysis of alternatives began, it was determined that none of the conditions requiring an EIS, per Engineering Regulation (ER) 200-2-2, were met. Comments received during the Ark-White Study were used as the basis for scoping. Solicitation of additional comments was sought through publication of a Notice of Intent in the Federal Register, during the 30-day public review period of the Draft Report, and at a public meeting that was held April 17, 2017 in Pine Bluff, Arkansas. However, the public did not provide any substantial comments. Significant resource agency coordination occurred throughout the study leading to all resource agencies supporting the Recommended Plan. The Corps intends to submit a Chief's Report summarizing the Three Rivers Recommended Plan to Congress for project implementation authorization and appropriation at the conclusion of the Feasibility Phase.

The study is in compliance with federal environmental laws and regulations including, but not limited to The National Environmental Policy Act, The National Historic Preservation Act, Fish and Wildlife Coordination Act, Clean Air Act and Clean Water Act. Table 21 in the main report contains a full list of laws and compliance status.

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(* indicates this section satisfies one or more requirements of the National Environmental Policy Act)

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DRAFT FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT –
THREE RIVERS SOUTHEAST ARKANSAS
FEASIBILITY INVESTIGATION
Arkansas and Desha Counties, Arkansas
March 2018

The Three Rivers Study Area is in portions of Arkansas and Desha counties in southeast Arkansas. It encompasses 208 square miles and includes the confluence of the Arkansas and White and Mississippi rivers and the Montgomery Point Lock and Dam, which is the final lock and dam on the McClellan Kerr Arkansas River Navigation System (MKARNS) where barges enter the Mississippi River. At the request of the Arkansas Waterways Commission, and under authority of Section 216 of the Flood Control Act of 1970 (Public Law 91-611), the Little Rock District Corps of Engineers conducted a feasibility study to recommend solutions to problems impacting the long-term sustainability of reliable navigation on the MKARNS.

There is a risk of breach of existing containment structures near the entrance channel to the MKARNS on the White River. During high water events, Mississippi River backwater creates significant head differentials between the Arkansas and White rivers. Existing containment structures are subject to damaging overtopping, flanking, and seepage that could result in structural failure. Formation of a cutoff would restrict navigation, increase the need for dredging, and adversely impact an estimated 200 acres of forested wetlands in the isthmus between the Arkansas and White rivers.

Structural and nonstructural alternatives were evaluated for consideration including restoring natural hydrologic connectivity between the Arkansas and White rivers, installing new and or modifying existing structures in the isthmus, operational changes on existing dams on the Arkansas River, construction of setback levees, and channelization of the lower Arkansas River.

Recommended Plan

The recommended plan includes the construction of a new containment structure approximately 2.5 miles long at elevation 157 feet with a relief channel through the Historic Closure Structure, beginning on natural high ground just south and west of the existing Melinda Cutoff Structure located on the south side of Owens Lake. It would continue east and cross south of the existing Melinda Structure, then head northeast and connect to the existing soil cement containment structure north of Jim Smith Lake where it would follow the existing containment alignment and terminate at the Historic Closure Structure. A section of the Historic Closure Structure ranging from 500 feet to 1,000 feet wide, would be lowered to elevation 145 feet to facilitate earlier water exchange during flooding to alleviate extreme head differentials between the two rivers. The Melinda Cutoff Structure would be demolished to reduce turbulence and erosion in the immediate Melinda Structure vicinity. This action would also reestablish the hydrologic connection of the two arms of Owens, increasing spawning and nursery habitat for native fish species. An opening would be constructed in the Owens Lake Structure to prevent changes in flood duration that could adversely impact forested wetlands (bottomland hardwood forest).

When considering the recommended plan, all practicable means to avoid or minimize environmental impacts have been considered. The recommended plan has been designed with the smallest practicable footprint to meet the requirements of the proposed project. However, implementation of the plan would still induce a permanent loss of 25.0 acres of bottomland hardwoods (wetlands), which equates to a loss of 4.4 functional capacity units (FCUs). To mitigate the wetland loss, 109 mitigation credits (equivalent to 4.4 FCUs and 19.38 acres) would be purchased from the Fourche Bayou Mitigation Bank or other certified mitigation bank located within Lower Arkansas River Basin 8-digit HUC (08020401). Credits would be purchased prior to construction. Implementation, oversight and monitoring of ecosystem restoration at the bank will be the responsibility of the mitigation bank owner as outlined in the Mitigation Banking Instrument approved by the USACE Regulatory office in Little Rock.

Environmental Compliance

In compliance with the National Environmental Policy Act (NEPA) of 1969, as amended (40 CF 1500-1508), an Environmental Assessment was prepared to evaluate the impacts associated with implementing the recommended plan, which included, but were not limited to, those related to water, biological, cultural, and geologic resources, land use, recreation, transportation, socioeconomics, aesthetics, and hazardous and toxic substances. Initially, the study anticipated requiring an Environmental Impact Statement (EIS); however, after environmental analysis of alternative began, it was determined that none of the conditions requiring an EIS, per Engineering Regulation (ER) 200-2-2, were met.

During EA preparation, no significant adverse impacts were identified for any of the relevant resources. Mitigation has been incorporated into the recommended plan to reduce wetland impacts to less than significant. The recommended plan is in compliance with all environmental laws, regulations, policies, and executive orders including but not limited to the Clean Air Act, Clean Water Act, Endangered Species Act (ESA), and National Historic Preservation Act (NHPA).

Specifically for the ESA, US Fish and Wildlife Service concurred with the USACE determination that the recommended plan may affect, but is not likely to adversely affect any federally listed threatened or endangered species or critical habitat. No conservation measures were required to mitigate impacts. Informal consultation is complete.

Per the Farmland Protection Policy Act, consultation with the Natural Resource Conservation Service was completed because implementation of the recommended plan would result in impacts to farmlands. NRCS determined that the loss of “Farmlands of Statewide Importance” would be permanent, but insignificant due to the small impact size in relation to similarly categorized lands in the area. No mitigation or further action is warranted.

For NHPA compliance, USACE has executed a Programmatic Agreement with the Arkansas State Historic Preservation Office (SHPO), Advisory Council on Historic Preservation (ACHP), and the appropriate federal recognized Tribes to ensure compliance with Section 106 prior to construction (Appendix K), which defers cultural resource investigations until the pre-engineering design (PED) phase. In accordance with 36 CFR Part 800.6(b), should adverse impacts to any cultural or historic resources throughout the project corridor be unavoidable, an appropriate mitigation plan would be sought in consultation with the Arkansas SHPO and other interested parties and agencies, and fully implemented prior to project construction. During construction, cultural resource monitoring would be implemented to ensure compliance with any avoidance zones identified during cultural resource surveys.

In compliance with NEPA and USACE policy, the public and resource agencies have had opportunities to review and comment on the feasibility study and EA. Comments received during a previous study (Ark-White Feasibility Study) were used as the basis for scoping. Solicitation of additional comments were sought through publication of a Notice of Intent in the Federal Register, during the 30-day public review period of the Draft Report, and at a public meeting that was held April 17, 2017 in Pine Bluff, Arkansas. The public did not provide any substantial comments. Significant resource agency coordination occurred throughout the study leading to all resource agencies supporting the recommended plan.

Conclusion

Based on a review of the information, it is determined that implementation of the Recommended Plan is not a major federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of NEPA. Therefore, the preparation of an Environmental Impact Statement (EIS) is not required.

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Robert G. Dixon Date

Colonel, US Army

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1 INTRODUCTION

At the request of the Arkansas Waterways Commission, and under authority of Section 216 of the Flood Control Act of 1970 (Public Law 91-611), the U.S. Army Corps of Engineers, (USACE) Little Rock District is conducting the Three Rivers Southeast Arkansas Feasibility Study (Three Rivers Study) to study modifications to the McClellan-Kerr Arkansas River Navigation System (MKARNS) to seek a long-term sustainable navigation system that promotes the continued safe and reliable use of the MKARNS. Based on the results of this study, USACE will seek specific authorization from Congress to implement the Recommended Plan.

USACE conducted this study in accordance with *Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook,* and the study is organized in the framework of the ER using the six-step planning process that originated in the *1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Principles and Guidelines or P&G). Implementation guidance provided for Section 3132, which mandates that USACE complete cost-shared studies using guidelines in ER 1105-2-100, Appendix H.

There is a substantial risk of cutoff forming near the entrance channel to the MKARNS between the Arkansas and White rivers, particularly if an existing containment structure fails (i.e., breaches). During high water events, Mississippi River backwater can create large head differentials between the Arkansas and the White rivers. When this happens, existing containment structures are subject to damaging overtopping, flanking, and seepage flows that could result in a breach and create a cutoff channel between the Arkansas and White. Formation of a cutoff would:

- Restrict navigation in the project area until USACE could repair the cutoff,
- Increase the need for dredging; and,
- Damage or destroy an estimated 200 acres of bottomland hardwood forest in the isthmus between the Arkansas and White rivers.

1.1 Study Location*

The study area encompasses 208 square miles in rural southeast Arkansas and includes the confluence of the Arkansas, White, and Mississippi rivers, and Montgomery Point Lock and Dam (Montgomery Point), which is the final MKARNS lock and dam where barges enter the Mississippi River. Today, about 80 percent of tonnage on the MKARNS is outbound or inbound meaning that it flows through Montgomery Point to and from the Mississippi. Approximately 64 square miles of the Dale Bumpers White River National Wildlife Refuge (Refuge), owned and operated by the U. S. Fish and Wildlife Service (USFWS), also lies within the study area. Other landowners include the Arkansas Game and Fish Commission (AGFC), USACE, the Anderson Tully Lumber Company, and several hunting clubs. As defined, the *study area* is large enough to capture potential indirect and long-term environmental impacts of alternative implementation, particularly impacts that may occur further up or downstream of the immediate project footprint due to changes in hydrology. The *project area* is much smaller and consists of the isthmus between the Arkansas and White rivers where problems addressed in this study (described below) are occurring (Figure 1). Landownership and landowner preferences for placement of structures were considered during formulation, however they were not key to identifying placement locations. All formulation was based upon features and locations that would best address the stated problems and objectives of the study.

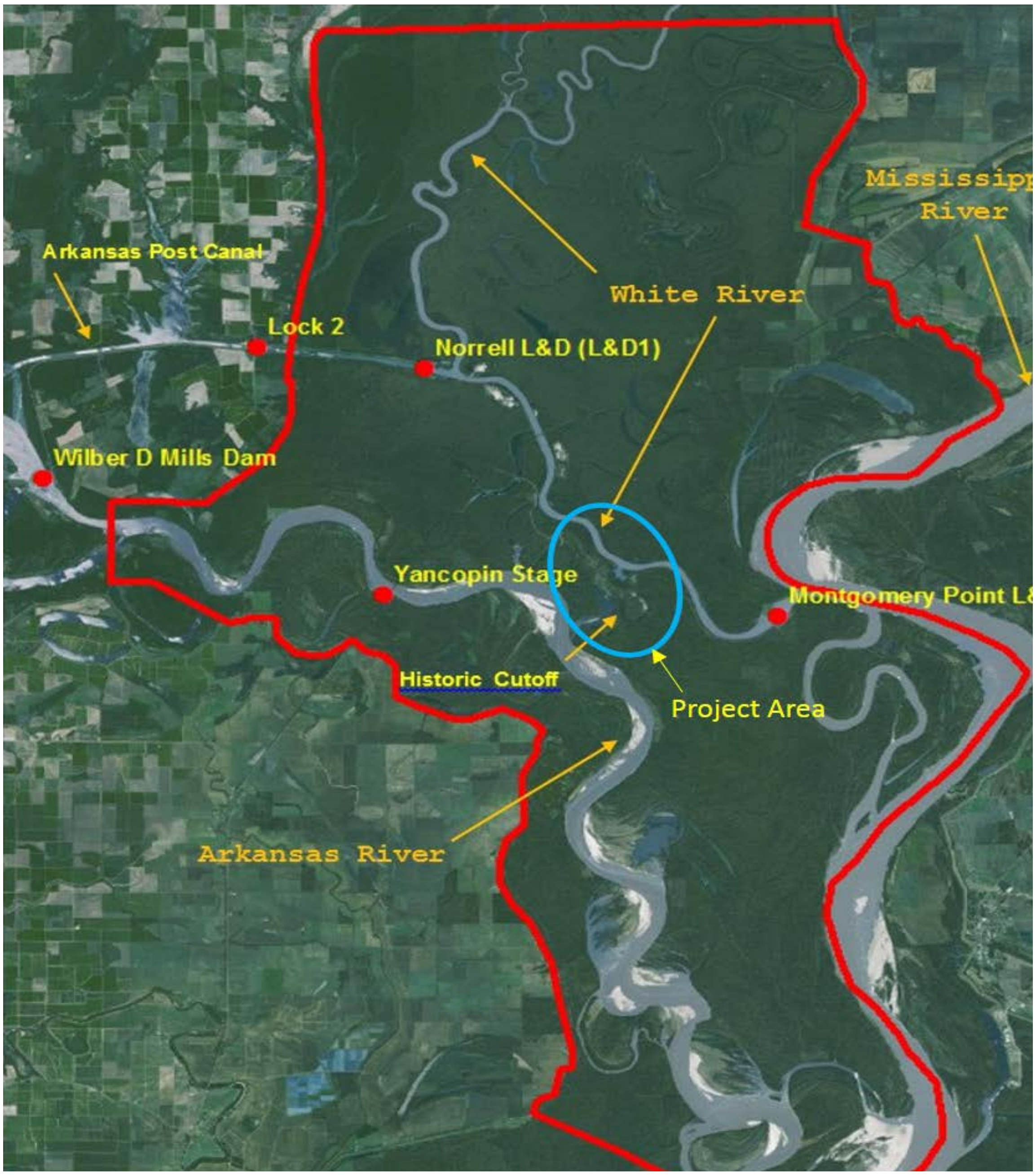

Figure 1: Project Location Map

1.2 Study Purpose and Need*

The purpose of this study is to develop and analyze alternatives to address head cutting in the study area, and reduce the risk of a cutoff forming between the Arkansas and White rivers.

Head cutting is a form of erosion that occurs when a channel is in its infancy, and in the process of forming a natural stream slope and channel capacity. Head cutting starts with a channel incision at a particular point, generally called a "knickpoint", as the streambed elevation adjusts to a particular flow or stream slope disturbance, either natural or man-made. As head cutting progresses, streambanks erode and slough into a stream. Eroded streams become more incised and unstable. If left in an unstable condition, head cutting then migrates upstream from the point of origin. Streambank and streambed erosion continues until equilibrium is reached between the stream slope and channel capacity causing flow velocities to become more uniform.

Head cutting is the cause of a potential cutoff between the Arkansas and White rivers in the study area. A cutoff would allow uncontrolled sediment deposition, cross flows dangerous to navigation or shallowing of the navigation channel in the White River. Navigation through area would become very unreliable and impractical for regular commercial shipping.

In the late 1980s, USACE constructed a head cut containment system to reduce the chance of a cutoff forming by containing active head cutting and erosion across the isthmus that began in the early 1970s. However, head cutting and risks of failure of any of existing containment structure continues to threaten navigation. Failure as defined in this study refers to the formation of an uncontrolled cutoff channel between the Arkansas and White rivers. Overtopping, erosion, flanking and seepage, or a combination of such processes, would likely be catalysts for structural failure.

Failure of any structure and subsequent formation of a cutoff would make navigation through the area very unreliable and potentially dangerous. Several of the containment structures have required significant repairs and modifications to prevent failure of the system (discussed in detail below).

1.3 Study Authority

Section 216 of the Flood Control Act of 1970 (Public Law 91-611) authorizes a feasibility study to examine significantly changed physical and economic conditions in the Three Rivers study area. The study evaluates and recommends modifications for long-term sustainable navigation on the MKARNS. Section 216 of the Flood Control Act of 1970 (Public Law 91-611) states:

> "*The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found*

> *advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest*."

Public Law 525, 79th Congress, Chapter 595, known as the Rivers & Harbors Act of July 24, 1946, authorized development of the Arkansas River and its tributaries for the purposes of navigation, flood control, hydropower, and recreation.

> *"Be it enacted…..That the following works of improvement of rivers, harbors, and other waterways are hereby adopted and authorized to be prosecuted……*
>
> *…..Arkansas River and tributaries, Arkansas and Oklahoma: The multiple-purpose plan recommended in the report of the Chief of Engineers dated September 20, 1945, and the letter of the Chief of Engineers dated March 19, 1946, is approved, and for initiation and partial accomplishment of said plan there is hereby authorized to be appropriated the sum of $55,000,000;"*

Public Law 91-649 stated that the project would be known as the McClellan-Kerr Arkansas River Navigation System (MKARNS). Construction of MKARNS began in 1957 and the current 9-foot channel opened to navigation in 1971. Section 136 of the Energy and Water Development Act of 2004 authorized a navigation channel up to a depth of 12 feet; however, USACE currently maintains the all but a small portion of the channel at 12 feet and to a minimum depth of 9 feet throughout most of the system.

1.4 Previous Studies

USACE conducted the Arkansas-White River Cutoff General Reevaluation Study (Ark-White Study) to address the same problems under the original 1946 Rivers & Harbors Act (USACE 2009). The Ark-White Study terminated in 2009 and recommended the No Action Alternative given that USACE could not identify a long-term solution that was both economically justified and environmentally acceptable under authorities and funding available at the time.

Alternatives from the Ark-White Study involved unacceptable levels of adverse environmental impacts, particularly on the Refuge. As a result, the USFWS, the AGFC, and several other resource agencies and interested parties would not support any proposed alternative, despite attempts to redesign alternatives and mitigation measures. Of particular concern were: 1) cumulative impacts associated with the alternatives and other planned projects in the Arkansas and White river basins; 2) further alteration of Refuge hydrology; 3) potential adverse impacts to high value fish and wildlife resources; and 4) continued ecological damage to the Refuge. Resource agencies supported USACE decision to adopt the No Action Alternative with the understanding that USACE would work aggressively toward completing a more comprehensive study (i.e., Three Rivers Study).

USFWS was also concerned about constructing features and flowage easements on the Refuge, which they deemed incompatible with requirements of the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. §§ 668dd-668ee). USFWS concluded that it was very unlikely that any alternative analyzed in the Ark-White Study would be compatible with their mission on the Refuge, and they could not issue a permit authorizing use of the Refuge, effectively making any study alternative noncompliant with federal law.

Information and data from the Ark-White Study were used where practicable in the current study, particularly in cases where conditions have not changed significantly since the Ark-White Study, or if new or additional modeling would not provide significantly different information that would affect plan selection. Problems, opportunities, measures, existing conditions and future without project conditions emanated from the Ark-White Study; however, much of the hydrologic, economic, and engineering analyses were unique to the Three Rivers Study, particularly since some data or methods from the Ark-White Study were outdated. For example, team hydrologists for the Three Rivers Study used 2-dimensional Hydrologic Engineering Center – River Analysis System (HEC-RAS) hydraulic models to analyze alternatives as opposed to older one dimensional models from the Ark-White Study. Team economists updated benefits using a new transportation rate savings data for waterway transportation versus alternative modes such as rail and truck; and team engineers developed costs and quantities for alternatives using more detailed designs. For environmental analysis, the future without project condition and the associated environmental modeling, data outputs, and impacts were not modified from that of the Ark-White Study.

1.5 Scope*

Based on Section 216 authority, the Three Rivers Study is investigating alternatives that would minimize the risk of cutoff development, and substantially reduce Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) costs for the head cut containment system in the project area, while minimizing adverse environmental impacts. The study also sought to address ecosystem degradation that has resulted from the construction, operation and maintenance of the MKARNS.

1.6 Overview of the MKARNS and Project Area Containment Structures

1.6.1 McClellan-Kerr Arkansas River Navigation System (MKARNS)

The MKARNS was the largest civil works project ever undertaken by USACE at the time of its opening in 1971. Today, it ships about $3.5 billion (roughly 12 million tons) worth of commodities to and from Arkansas and Oklahoma each year. The system is 445 miles long with 18 locks and dams and an elevation differential of 420 feet from its beginning at river mile 599 on the Mississippi River to the head of navigation near Tulsa, Oklahoma (Figure 2).

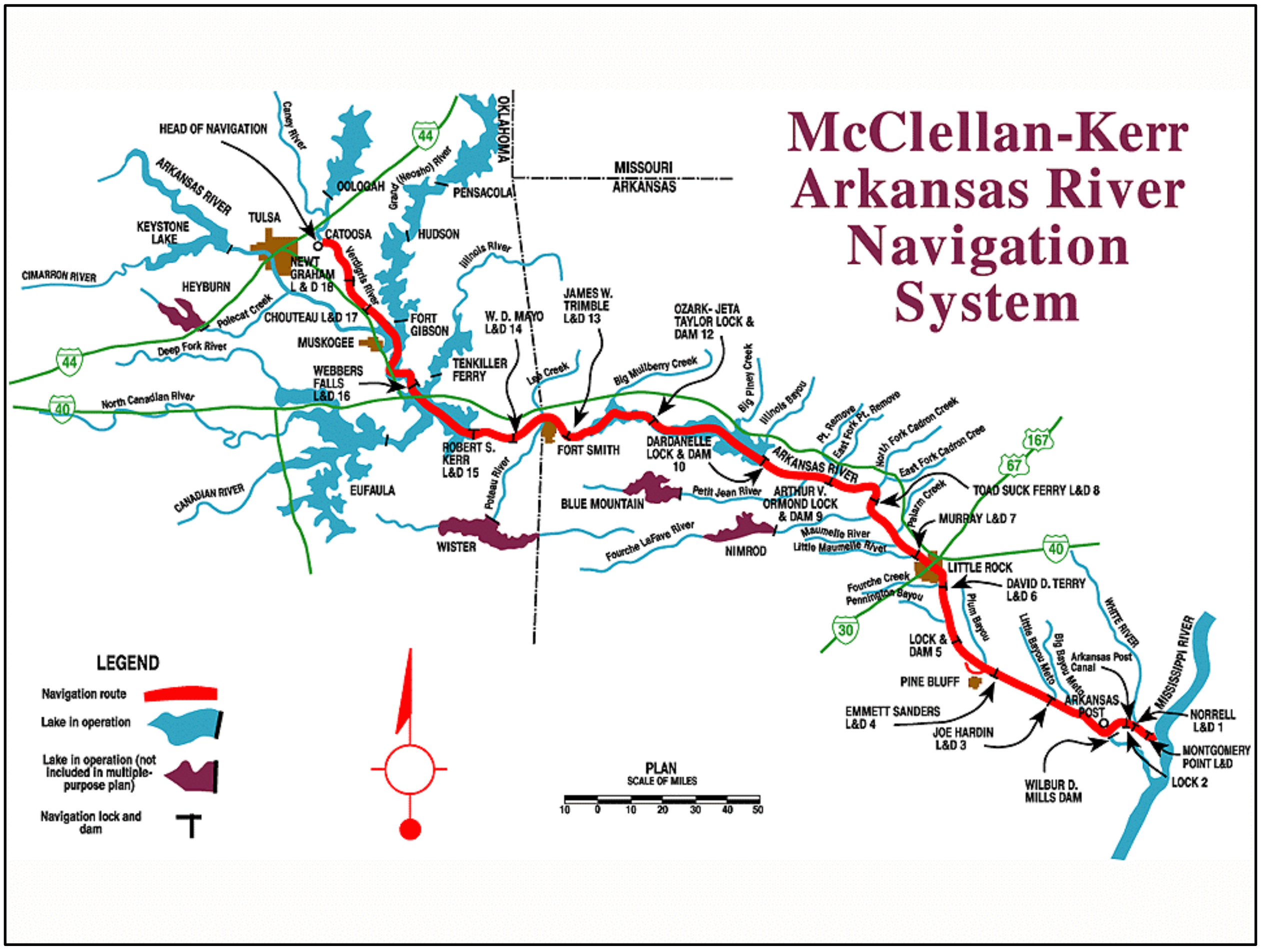

Figure 2: McClellan-Kerr Arkansas River Navigation System

The MKARNS is a major conduit for U.S. agricultural exports, and transports various inbound cargoes such as fertilizers, fuels, chemicals and iron and steel. On average, transporting by barge on the MKARNS versus overland routes saves shippers roughly $50 per ton of cargo. Based on current traffic volumes, this saves U.S. businesses and consumers nearly $600 million per year in transportation costs. Since the MKARNS opened, annual tonnage on the system has increased by about 180 percent. Study projections suggest that traffic on the river will continue to rise well into the foreseeable future.

Given its scale and ability to relieve landside congestion and related environmental impacts, in May of 2015 the U.S. Department of Transportation upgraded the MKARNS from a “Connector” system to “Corridor” system as part of the Maritime Administration America’s Marine Highway Program.[4] The upgrade in status brings the MKARNS into the same category as other major inland waterways such as the Mississippi and Ohio rivers.

1.6.2 Historic Closure Structure

Before construction of the MKARNS, the Historic Cutoff existed near river mile 4 on the White River and river mile 17 on the Arkansas River and allowed unrestricted flows between the Arkansas and White rivers in the study area. Allowing water to flow uncontrolled through the Historic Cutoff presented two problems: 1) dangerous cross currents would occur in the White River when flow passed through the cutoff, and 2) the Historic Cutoff would deposit sediment into the White River Entrance Channel at high rates when flows came across from the Arkansas to the White River because of the Arkansas River’s higher sediment load.

In 1963, as part of the MKARNS construction project, USACE built the Historic Closure Structure (a dredge fill structure built to an elevation of 170 feet above mean sea level) [5] to close the natural and relatively stable cutoff. Located at the White River end of the Historic Cutoff, the structure stops the principal flow between the two rivers and eliminates navigation hazards and extensive delays. The Historic Closure Structure prevents most flows from passing between the rivers, but is designed to overtop during especially high flows, although this rarely happens (Figure 3).

1.6.3 Existing Containment Structure System

The Historic Closure Structure performs as intended; however in 1973 during a year of unusually high water on the Mississippi following construction of the MKARNS, a small head cut appeared on the Arkansas River running up through the isthmus west of the Historic Cutoff. Over the next two decades, the head cut grew when Mississippi River stages, at the mouth of the White River, produced backwater high enough to push flow across the isthmus to the Arkansas River. The head cut channel came to be known as the Melinda Channel (also referred to as the Melinda Corridor).

[4] According the U.S. Maritime Administration, Corridors and Connectors identify routes where water transportation presents an opportunity to offer relief to landside corridors that suffer from traffic congestion, excessive air emissions or other environmental concerns and other challenges. Corridors are generally longer, multi-state routes whereas Connectors represent shorter routes that serve as feeders to the larger Corridors.

[5] Unless otherwise stated, elevations in this study are reported in National Geodetic Vertical Datum.

In the late 1980s, USACE began building several containment structures to control head cutting and overland flows in the study area including the Melinda Channel. The design memorandum for these structures stated that their purpose was to avoid excessive dredging costs and delays to navigation, minimize Arkansas River sediment deposition in the White River entrance channel, and control flows between the two rivers.

The Existing Containment Structure System consists of several distinct structures designed to perform together including the:

1. Historic Closure Structure
2. Containment alignment structure (Soil-Cement Structure),
3. Controlled overflow structure (Owens Lake Structure),
4. Overflow weir at La Grues Lake,
5. Melinda Structure,
6. Jim Smith Structure North; and,
7. Jim Smith Structure South.

All of these structures, with the exception of those on Jim Smith Lake (see below), are made of soil cement containing clean dredge material (sand) for the soil element. Filter fabric protection covers areas at high risk due to flow conditions and structural settlement, and riprap protection covers locations where flow conditions warrant protection. Except for underwater riprap, all riprap was constructed with a filter fabric placed between the subgrade and riprap. In its entirety, the containment system includes 17,300 feet of soil-cement containment structure, a rock weir at La Grues Lake, the Owens Lake Structure, and the Melinda Structure (Figure 3). The system reduces cross flows between the Arkansas and White rivers, while allowing some inflows into Owens Lake to sustain water levels.

1.6.4 Melinda Structure

The Melinda Structure was the first one built in 1990. It is a soil cement structure with large stone built to a crest elevation of 142 feet with a total length of 1,080 feet.

1.6.5 Soil-Cement Structure and Owens Lake Structure

Constructed in 1991, the 17,300 foot continuous dike style soil-cement structure, which incorporates the Owens Lake Structure, aligns from the western terminus of the Historic Cutoff west across Jim Smith, Owens and La Grues lakes. The main containment structure has 1-foot vertical on 2.5-foot horizontal side slopes with elevations varying from 150 to 152 feet mean sea level, except in the Owens Lake area (Owens Lake Structure) where it has a crest elevation of 145 feet. It has a crown width of 18 feet throughout, except at the Owens Lake Structure where it has a crown width of 24 feet and from the Historic Cutoff west approximately 440 feet where it has a crown width of 12 feet. The embankment along the containment is clay material overlain with a 3-foot blanket of soil cement except for the Owens Lake Structure that has a 4-foot soil cement overlay.

1.6.6 Jim Smith Lake Structures

In 2003, USACE built two containment structures near Jim Smith Lake to reduce the risk of a cutoff forming and to mitigate the Arkansas River's migration northward toward Jim Smith Lake. These structures are geotubes filled with sand and topped with soil and live willow fascines. One structure is on the south end of the lake near the Arkansas River (south structure) and the other lies on the north end adjacent to the Soil-Cement Structure (north structure).

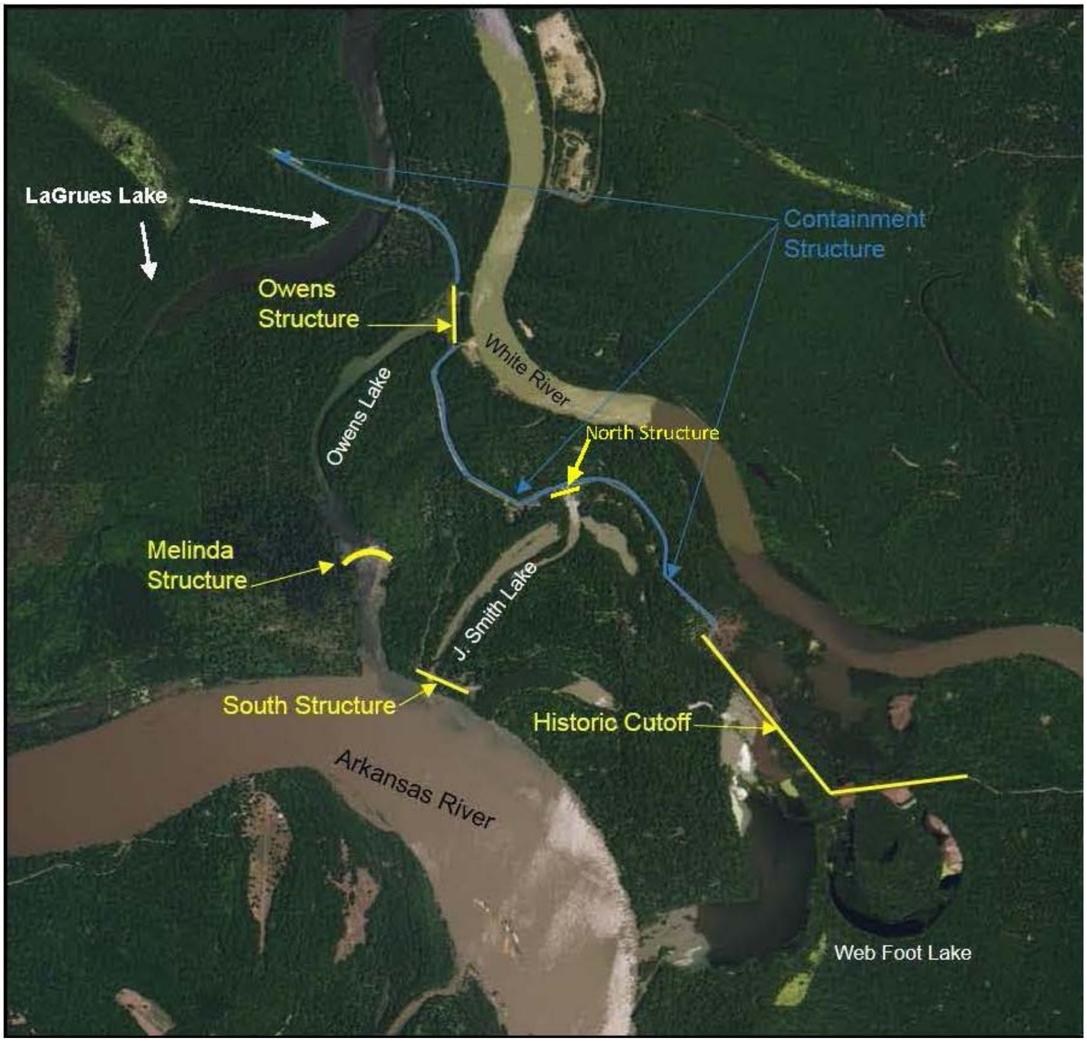

Figure 3: Previously Constructed Structures in the Project Area

1.7 History of Repairs to Structures

Several containment structures in the project area have suffered substantial and fairly frequent damage during high water events, particularly those in the Melinda Corridor and those near Jim Smith and Owens lakes.

1.7.1 Melinda Structure

The USACE has repaired the Melinda Structure numerous times since its inception due to damages sustained during flooding and continued widening and deepening of the head cut corridor. The first notable damages occurred in 1990 when spring flooding typical of the region inundated the project area. Not only was the structure damaged, but extensive erosion occurred between the White River and Owens Lake. The structure was repaired by adding larger rocks to a flatter slope than the original design specification and by adding a concrete cap to replace damaged layers of soil-cement. In February of 1991, half of the structure failed on the Arkansas River side and total failure occurred within weeks. As a result, USACE rebuilt the structure by adding larger rock to an even flatter slope and additional stone at the base to widen it further.

By 1994, the banks of the structure were eroding at a significant rate. To reduce flanking on the left descending bankline towards the Arkansas River, USACE added a 700-foot long revetment. To make matters worse, a scour hole developed on the Arkansas River side and grew to a depth of about 90 feet below the crest of the structure. In 1997, the hole caused a slope failure adjacent to the structure's crest. USACE replaced stone lost from the slope and identified additional measures to stabilize damage caused by the deep hole. In 2000, engineers filled the scour hole with sand dredged from the Arkansas River and capped it with large rock (5 foot thick with a maximum weight of 5,000 pounds) to stabilize the Melinda Structure. Then, in 2005, the structure was damaged again, but remained intact. Additional repairs took place in 2014 to control flanking around the western end of the structure after high flows caused damage in 2013.

Today, the structure is in poor condition because of displaced stone around its base, cracked and displaced soil-cement, and continued flanking erosion.

1.7.2 Jim Smith Lake Head cut Control Structures

In February of 2005, both geotube weirs on Jim Smith Lake suffered significant damage due to high water. In the same year, rock was added to the north end of Jim Smith Lake on a relatively flat slope to repair damaged geotubes and to better manage high flow that crosses to the Arkansas River. The structure at the south end could not be repaired at the time due to funding constraints. The slopes were constructed on a relatively flat slope (1 vertical: 10 horizontal). Compaction of fill material combined with fabric material between the dredged fill and rock provided for a mostly impervious structure.

Table 1 lists costs of completed repairs to date. Costs are indexed to FY2018 price levels using the USACE Civil Works Construction Cost Index System for levees and floodwalls. Funding for future repairs to structures in the Containment System will likely be limited given growing OMRR&R needs throughout the entire MKARNS. Furthermore, repairs on existing structures are less reliable over the long term, and many structures will require rehabilitation or replacement over the 50-year period of analysis in this study.

Table 1: Historical Costs of Repairs to Structures in the Three Rivers Study Area

Year	Event	Cost (FY18 Dollars)
1971-1989	None	$0
1990	Melinda Structure repaired	$1,029,887
1991	Soil Cement levee repaired	$2,265,752
1994	Melinda revetment constructed	$596,502
1998	Melinda slope failure repair	$695,971
2000	Melinda scour hole repaired	$3,163,600
2003	Geotubes installed	$2,498,509
2005	Geotubes levees repaired	$2,194,408
2014	Melinda and Jim Smith soil cement repairs and flanking repairs	$10,515,347
Total		**$22,959,976**
Annual Average		**$521,818**

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2 AFFECTED ENVIRONMENT*

2.1 Existing Conditions

Chapter 2 describes existing conditions in the study area and the future condition without implementation of a project (No Action Alternative). The No Action Alternative provides a baseline that serves as a frame of reference to evaluate performance of alternative plans. Existing conditions are described in terms of potential impacts to:

- Land use,
- Air quality,
- Climate,
- Geologic resources,
- Water resources,
- Biological resources,
- Cultural resources, recreation and aesthetics,
- Transportation,
- Socioeconomics,
- Environmental justice, and
- Hazardous, toxic, and radiologic waste.

Chapter 2 concludes with descriptions of the No Action Alternative, which is the baseline for measuring impacts and benefits of alternative plans. Based on the environment as described, the No Action Alternative assumes a period of analysis of 50 years beginning in 2025.

USACE developed the study area boundary in consultation with several resource agencies, including the USFWS, AGFC, the Arkansas Natural Heritage Commission (ANHC), Arkansas Natural Resource Commission (ANRC), and the National Park Service (NPS). The study area is large enough to capture long-term environmental impacts that could occur some distance from the project footprint due to hydrologic changes that an alternative could potentially generate. In contrast to the relatively large *study area*, the *project area* is limited to the where construction would occur along with direct impacts of the preferred alternative (Figure 4).

2.2 Land Use*

Land use in the study area includes timber production, agriculture, and public lands. Public lands, and some private lands are managed for wildlife and recreation. Based on Arkansas' Watershed Information System (CAST 2006), land use in Arkansas River Outlet Watershed (HUC 080204010405) comprises the following: forestland covers approximately 75 percent of the area; permanent water ~7 percent; sandbars ~5 percent; and agriculture (crops, pasture, and herbaceous) ~10 percent. The remaining land use includes roads and isolated residential or hunting camps. The Three Rivers Study Area is located in this 12-digit HUC, and is characteristic of these land uses.

2.2.1 Public Lands

Approximately 51,095 acres of the study area (38 percent) is made up of public lands owned by USACE, AGFC, and USFWS (Figure 5). The USFWS owns and manages most public lands in the area on the Dale Bumpers White River National Wildlife Refuge (Refuge). Established in 1935, the Refuge contains about 160,000 acres dedicated to protecting migratory birds while providing recreational opportunities such as boating, bird watching, hunting, and camping. The Refuge is one of the most important areas for wintering waterfowl in North America.

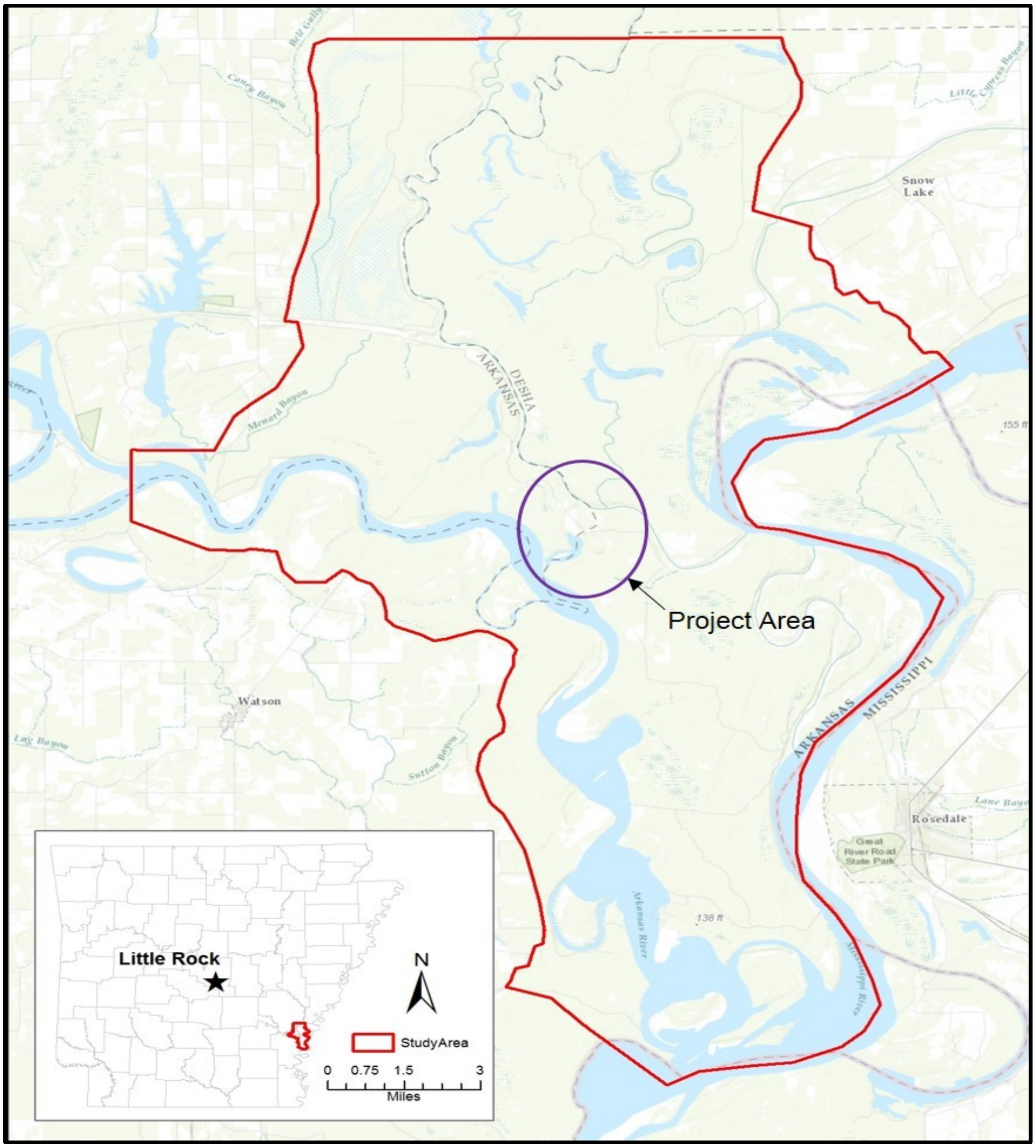

Figure 4: Three Rivers Study Area and Project Area Boundaries

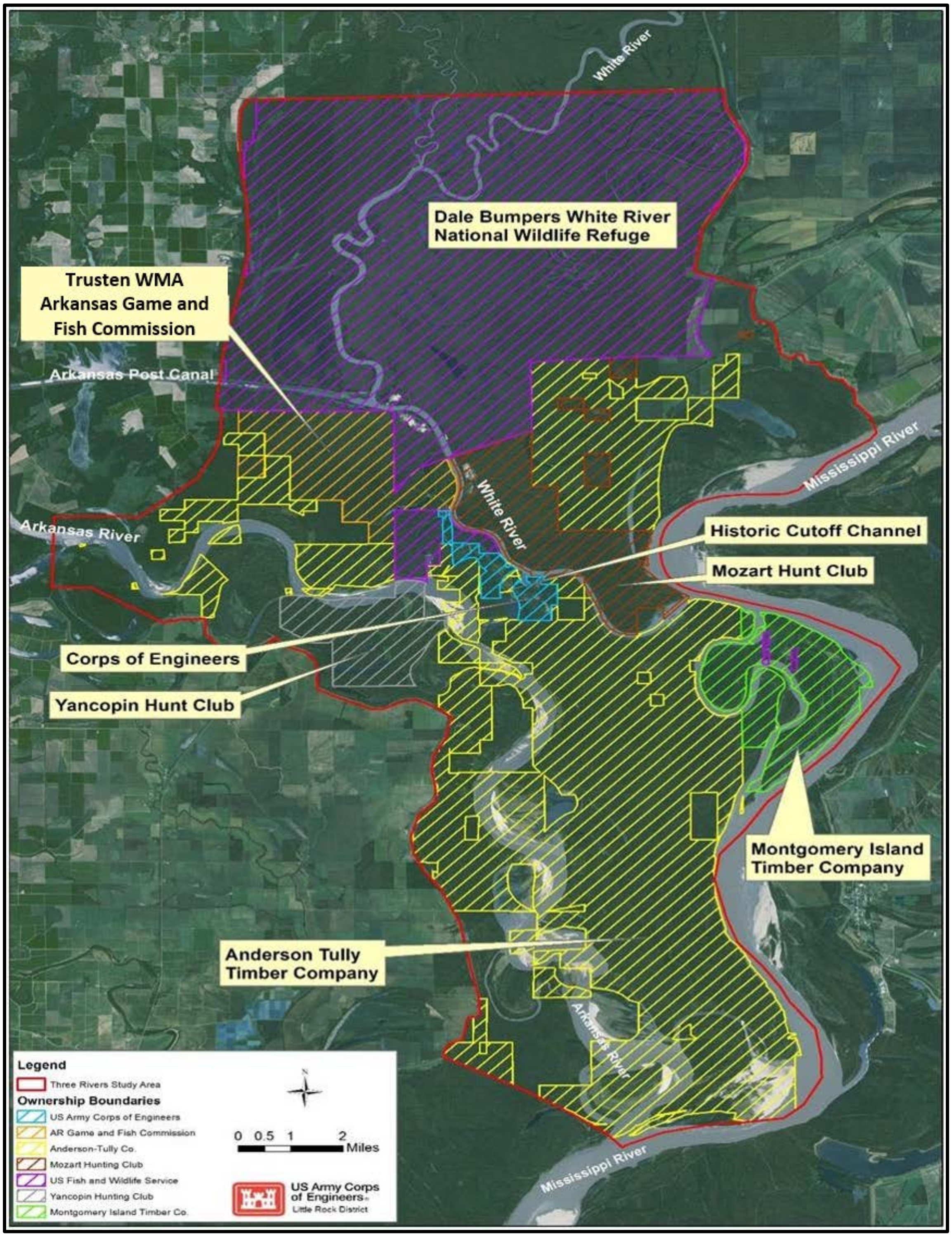

Figure 5: Property Ownership in the Study Area

Cooperatively owned and managed by AGFC, USACE and USFWS, the Trusten Holder Wildlife Management Area (WMA) contains 10,268 acres in Arkansas and Desha counties. The WMA and the Refuge share a footprint in this region. In the study area, AGFC owns 4,406 acres, USACE owns 911 acres, and USFWS owns 1,490 acres (sources are the respective agencies).

2.2.2 Private Lands

Private lands account for 83,648 acres (62 percent), and are predominantly used for agriculture, timber production, and hunting. Residential and commercial development is uncommon in or near the study area. Agricultural production including rice, cotton, soybeans, winter wheat, and corn occurs on private lands developed from bottomland hardwood forests. Large private landowners include: the Anderson-Tully Company (timber production) with nearly 42,000 acres (50 percent), the Mozart Hunting Club with 5,467 acres (7 percent), the Montgomery Island Timber Company that owns 4,272 acres (5 percent), the Yancopin Hunting Club with 2,978 acres (4 percent), and individual landowners with the remaining 28,931 acres (35 percent) (Figure 5).

2.3 Air Quality*

The U.S. Environmental Protection Agency (EPA) is primarily responsible for regulating air quality nationwide. The Clean Air Act (42 U.S.C. 7401 *et seq*.), as amended, requires EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards classified as either “primary” or “secondary.” Primary standards set limits to protect public health, including the health of at-risk populations such as people with pre-existing heart or lung diseases (such as asthma), children, and older adults. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings.

EPA has set NAAQS for six principal pollutants known as “criteria” pollutants. Criteria pollutants include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter less than 10 microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), sulfur dioxide (SO_2) and lead (Pb). If the concentration of one or more criteria pollutant in a geographic area is found to exceed the regulated “threshold” level for one or more of the NAAQS, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered either attainment or unclassifiable areas. The study area is located in the Central Arkansas Intrastate Air Quality Control Region (40 CFR Part 81). Given that it is in a rural and remote part of Arkansas with good air quality and no known sources of significant air pollution emissions, the study area is classified as “in attainment” for all NAAQS (ADEQ 2018).

2.4 Climate*

The climate of the study area is “humid subtropical” characterized by long summers, relatively mild winters, and a wide range in temperatures. Generally there is a significant amount of precipitation in every month and temperatures tend to be mild compared with the northern part of the country.

The average annual temperature is 63 degrees (Fahrenheit), with an average annual high temperature of 74 degrees and average annual low temperature of 41 degrees. Each year the area receives about 50 inches of rain, with August typically being the driest month. Late spring and late fall to early winter are typically the wettest periods. Summer precipitation primarily occurs during rainstorms, where locally high rainfall amounts occur over a short period. During the fall, winter, and early spring, precipitation events are usually less intense and of longer duration. Most precipitation falls as rain and, on rare occasion, snow. Although the area receives precipitation throughout the year, droughts of short duration are frequent and are accentuated by high evaporation rates during the growing season (Weatherbase 2018).

Severe weather is relatively frequent in Arkansas, especially during the spring. Severe weather often takes the form of ice storms, severe thunderstorms, high winds, hail, lightening, heavy rainfall, and tornadoes. From 1950 through 2013, 1,714 (more than 26 per year) tornadoes have occurred statewide, generally tracking from the southwest to northeast.

2.5 Geologic Resources

Geological resources consist of the topography, geology, mining, and soils of a given area. Topography describes the physical characteristics of the land such as slope, elevation, and general surface features. Geology includes bedrock materials and mineral deposits, and mining refers to the extraction of resources such as gravel or natural gas. The principal geologic factors influencing the stability of structures in the project area are soil stability, depth to bedrock, and seismic properties. Soil refers to unconsolidated earthen materials overlying bedrock or other parent material.

*2.5.1 Geology**

The study area is in the Mississippi River Alluvial Plain, a physiographic subdivision of the Gulf Coastal Plain Province. Deposits have been laid down by the Mississippi, Arkansas, White, and other rivers and streams traversing the area after the melting of the continental glaciers. Deposits are divided into two major classifications: 1) Quaternary Terrace and 2) Recent Alluvium. Generally these deposits grade from sand and gravel at their contact with the underlying Tertiary formation to heterogeneous deposits of sand, silt, and clay at the ground surface. The Quaternary deposits are generally at higher topographic positions and more firm due to their greater age. The surficial deposits of the Recent Alluvium have been divided into four categories: point bars, natural levees, back swamps, and channel fills. The four surface groups are generally not recognizable in the Quaternary deposits due to being reworked and deposited (USFWS 2012).

*2.5.2 Topography**

There is approximately 75 feet of topographical relief in the study area. Topographical relief ranges from approximately 115 feet msl in the southeast portion (bank of Mississippi River at river mile 580) to 190 feet msl in the northwest portion of the area on top of the levee. However, the natural topographic relief in the project area is much less at 45 feet with elevations ranging from 160 feet msl near Trusten Holder WMA to 115 feet msl at the bank of the Mississippi River.

Although relatively flat, the topography of the basin is somewhat complex with numerous stream and river channels, old meanders, and oxbow lakes surrounded by one or more terrace levels or bottoms. The topography is usually one of three basic types (USFWS 2012):

- Braided-stream terrace: displays a characteristic dendritic drainage pattern;
- Meander belts: contain areas of past or present channel migration with numerous parallel, crescent-shaped ridges and swales; and,
- Back swamps: flat areas that remained peripheral to channel migration and slowly filled with layers of fine sediments.

2.5.3 Minerals

There are no active oil and gas fields in the study area. Sand is the only potential mining resource available in the area; however, there are no existing or abandoned pits nearby.

*2.5.4 Soils**

Soils are for the most part hydric with spatial relationships of various soil types and associations presenting further evidence of their fluvial (riverine) origin and influence. Soils in the area are rich and fertile, which led to the drainage and clearing of most of the original forests for conversion to agricultural lands. Most soils have a high clay content, which results in their capacity to perch and pond water at the surface but also prevents most areas from contributing to significant groundwater recharge .

*2.5.4.1 Prime Farmlands**

Most of the area (109,100 acres) has soils with prime farmland characteristics; however, most acreage is not currently being farmed and is not likely to be farmed in the future due to current land use and ownership priorities. Approximately 60,500 acres are classified as “All areas are prime farmland” or “Farmland of statewide importance.” An additional 48,600 acres have been classified as prime farmland, but only if the land is drained or protected from flooding or not frequently flooded during the growing season. Prime farmland soils occur outside riverbanks and behind levees in areas that are not subjected to frequent ponding and have less than an 8 percent slope. The remaining 25,480 acres in the study area are classified as “Not prime farmland.” That includes open water, levees, pits and borrows, river wash, and soils with a slope greater than 8 percent.

2.6 Water Resources

Water resources include both surface water and groundwater; associated water quality; and floodplains. Surface water consists of lakes, ponds, rivers, streams, impoundments, and wetlands in a defined area or watershed. Subsurface water, commonly referred to as groundwater, is typically found in aquifers. Aquifers are areas with high porosity rock where water collects in pore spaces. Water quality describes the chemical and physical composition of water as affected by natural conditions and human activities. Floodplains are relatively flat areas adjacent to rivers, streams, watercourses, bays, or other bodies of water subject to inundations during flood events. A 100-year floodplain is an area that is subject to a one percent chance of flooding in any particular year, or on average once every 100 years.

2.6.1 Hydrology

Under pre-settlement conditions, complex hydrologic interrelationships existed between tributaries and primary rivers in the ecosystem. In the study area these interrelationships exist between the lower White River and the Mississippi and Arkansas rivers. All aspects of the hydrologic cycles of the Arkansas, White, and Mississippi rivers have been altered from historic conditions. The numerous development projects including lock, dam and levee construction, meander cutoffs, river training and dredging have each contributed to the alteration of stream gradients, flow regime, and sediment regime that characteristically maintained dynamic equilibrium of fluvial systems. Drainage patterns have altered to such an extent that they no longer resemble their natural state. The complex and interconnected hydrology of the three rivers now has reduced access to the numerous sloughs, bayous, channels, swales, oxbows and back swamps that historically provided conduits that moved massive quantities of water down the three rivers to converge in and near the study area.

Constriction of floodplains by levees, containment structures, and river training reduces overbank and backwater flooding and creates more extensive, prolonged, and deeper inundation than that in which the biotic components of the system evolved. Historically, the Mississippi River and its tributaries flooded millions of acres in the lower Mississippi River Alluvial Valley (MAV). Over 150 miles of flood control structures along the White River and the extensive levee system along the Arkansas River have not only reduced the extent of overbank flooding, but have induced forest clearing. Because previously flooded bottomland hardwoods were no longer being flooded, farmers quickly cleared the land for agricultural production. The varying distance of levees from the river channel along with elevated roadways and railroad embankments across the floodplain with limited bridge openings create “pinch” points that effectively increase flood heights above these features. Alterations to the floodplain affect all aspects of flood behavior including biogeochemical processes and physiological stress on vegetation and species associated with aquatic environments.

2.6.2 Surface Water

The study area falls within three Hydraulic Unit Code 8 watersheds: Lower Arkansas (08020401), Lower White (08020303), and Lower Mississippi-Helena (08020100). The dominant river in the Lower Arkansas watershed is the Arkansas, the White in the Lower White watershed, and the Mississippi in the Lower Mississippi-Helena watershed. According to the Natural Resources Conservation Service (NRCS) soil survey mapping, 18 percent of the area is water. Various types of surface water occur including lakes, oxbow lakes, shallow depressions, swales, chutes, sloughs, abandoned channels, flowing channels, and scour holes. Sandbars, point bars, rip-rapped banks, collapsing banks, and snags add to the diversity of water types. United States Geological Survey (USGS) topographical maps indicate that marsh and swampland cover 5 percent of the area.

The Arkansas River is one of the Mississippi's largest tributaries. It flows 1,450 miles from the Rocky Mountains in Colorado, through Kansas, Oklahoma, and Arkansas. The drainage basin is 160,500 square miles and includes portions of Missouri, New Mexico, and Texas in addition to the above-mentioned states. The White River drainage basin covers 27,765 square miles and is 720 miles long. This river flows from the Ozark Highlands through the Mississippi River Alluvial Plain physiographic regions. The White discharges into the Mississippi at River Mile 599.

The Arkansas and White rivers discharge into the Mississippi River in the alluvial Plain or Mississippi "Delta" physiographic region, occupying the lower Mississippi River basin. The alluvial plain of the Mississippi stretches across portions of seven states beginning at the confluence of the Mississippi and Ohio rivers near Cairo, Illinois and extending south to the Gulf of Mexico. This area encompasses nearly 24 million acres including parts of Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana. At Helena, Arkansas, near the confluence of the Arkansas, White, and Mississippi rivers, the mean annual flow of the Mississippi is 480,000 cubic feet per second. Based upon the much larger flow in the Mississippi compared to the Arkansas and White rivers, flows in the Mississippi have a major influence on the hydrology of the study area (U.S. Army Corps of Engineers 1990b).

Streams that discharge into or transverse the study area include Mild Ditch, Sixmile Bayou, Honey Locust Bayou, Scrubgrass Bayou, Deep Bayou, Menard Bayou, Mayhorn Bayou, and Mixture Bayou.

Water levels vary by season, with November through May being the wettest months and July to October the driest. There are roughly 120 small lakes and sloughs that are semi-permanently to permanently flooded. In addition, there are roughly 60 marsh or swamp areas that temporarily or seasonally flood. Large lakes and oxbows in the area include Goose Lake, Moon Lake, Alligator Lake, Swan Lake, Hole in the Wall Lake, La Grues Lake, Lake Dumond, and Callie Lake.

*2.6.2.1 Wetlands**

Wetlands are typically areas with frequent and prolonged standing water at or near the soil surface. Their presence drives the natural system including the type of soils (i.e., hydric soils) that form, the plants that grow and the fish and wildlife that use the habitat. Common types of wetlands in the area include: riparian forest, riparian shoreline, moist bottomland forest, flooded forest, shallow marsh, deep marsh, swamp, shrub swamp, shallow oxbow lakes, sloughs, sandbars, and mudflats.

Several sources of information were used to identify wetlands in the study area including: the National Wetland Inventory (NWI), soil survey, flood frequency, and vegetation maps in lieu of completing a wetland delineation following the 1987 Corps of Engineers Wetlands Delineation Manual or the 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region. All sources indicate that most of the study area and all of the project area is a wetland.

National Wetland Inventory (NWI) maps indicate that a variety of riverine, lacustrine, and palustrine wetlands exist in the study area (Figure 6). NWI maps about 70 different wetland classifications in the study area, which have been attributed to one of six wetland types. The palustrine system includes forested, emergent, scrub-shrub, and aquatic bed classes. The riverine system includes lower perennial and intermittent subsystems as well as open water, streambed, unconsolidated bottom, and unconsolidated shore classes. The lacustrine system includes limnetic and littoral subsystems as well as open water, unconsolidated shore, unconsolidated bottom, and aquatic bed classes. Water regimes include temporarily flooded, seasonally flooded, semi-permanently flooded, intermittently exposed, and permanently flooded (U.S. Fish and Wildlife Service 2015).

NWI maps depict wetlands using the USFWS (Cowardin) system of classification. The Cowardin system does not use hydric soils as a parameter and includes open water classifications. Approximately 85 percent of the study area is classified as wetland under the NWI classification system (U.S. Fish and Wildlife Service 2015).

There are 127,090 acres of the study area in the 5-year floodplain. The frequency of inundation in the study area contributes to the formation of hydric soils. This is further supported by NRCS Soil Survey mapping that indicates that most soils in the area are 90 to 100 percent hydric. Non-hydric soils are found on natural or manmade levees or outside of the 5-year floodplain, which makes up a small percentage of the overall study area.

The character of the study area including plant community composition and vigor is controlled by the hydrology, another key component to wetland identification. Areas inside levees are dominated by bottomland hardwood forest, a generalized classification of a wetland type that is dominated by gum, oak, tupelo, and bald cypress trees, all of which have unique characteristics that allow for inundation for extended periods (see Chapter 2 Biological Resources, Terrestrial Habitats for a description of vegetation).

2.6.2.2 Clean Water Act

The Clean Water Act (33 U.S.C. SS 1251 et seq.) requires federal agencies to protect waters of the U.S. The regulation implementing the Act disallows the placement of dredged or fill material into water unless it can be demonstrated that there are no practical alternatives that are less environmentally damaging. The sections of the Clean Water Act that apply to this study include Section 401 regarding discharges to waterways and 404 regarding fill material in waters and wetlands. The Clean Water Rule defines Jurisdictional Waters of the United States (WOTUS) as:

- Navigable waters, interstate waters, territorial seas, and impoundments;
- Tributaries to the traditionally navigable waters (water features with bed, banks, and ordinary high water marks that flow downstream, except for wetlands and open waters without beds, banks, and high water marks, which will be evaluated for adjacency);
- Adjacent wetlands/waters (includes waters adjacent to jurisdictional waters within a minimum of 100 feet and within the 100-year floodplain to a maximum of 1,500 feet of the ordinary high water marks); and,
- Isolated or “other” waters, which include specific waters as defined in the Final Rule and waters with a significant nexus within the 100-year floodplain of a traditional navigable water, interstate water, or the territorial seas, as well as waters with a significant nexus within 4,000 feet of jurisdictional waters.

The definition excludes ditches, groundwater, gullies, rills, non-wetland swales, and constructed components for Municipal Separate Storm Sewer Systems (MS4s), water delivery, and reuse and erosional features.

The Arkansas and White rivers are navigable waters of the U.S. and thus, jurisdictional WOTUS. All tributaries in the study area are considered jurisdictional WOTUS due to their proximity to navigable rivers and their location in the 100-year floodplain. Wetlands in the study area are also jurisdictional WOTUS based on NWI mapping, proximity to other jurisdictional waters, presence of hydric soils, and hydrology that is highly dependent on the navigable rivers.

A formal wetland delineation following the 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region was not completed. The available information (e.g., NWI maps, proximity to navigable rivers, hydrology, and soil types) is sufficient to make some assumptions regarding the presence or absence and location of jurisdictional WOTUS in lieu of completing field surveys. It is assumed from this available information that all areas of the focused project area are considered jurisdictional WOTUS.

*2.6.3 Groundwater**

The study area overlies the Mississippi River Valley (MRV) alluvial aquifer that consists of various geologic units, mainly unconsolidated and alternating layers of sands, gravels, silts, and clays. In this setting, fine-grained material impedes flow and serves as confining units and coarse-grained material serves as aquifers. The MRV alluvial aquifer is the most important in Arkansas in terms of use. Nationally, the state ranks fourth in groundwater use, with 94 percent of all groundwater coming from the MRV alluvial aquifer. The primary use of this aquifer is agricultural irrigation. Secondary uses include aquaculture, flooding of fields for duck hunting habitat, public supply, and self-supplied industrial and domestic use (Kresse et al. 2013).

Major rivers, such as the Arkansas, White, and Mississippi rivers, act as a source of recharge or serve as a regional drain depending on river stage. Natural groundwater flow paths may range from tens to hundreds of miles before encountering a major river, which acts as a hydrologic flow boundary and serves as a regional drain.

Purely by coincidence, the MKARNS has functioned for years as one of the most successful artificial recharge projects in the world. Water-level change data in the form of tables, maps, and hydrographs all indicate that the Grand Prairie groundwater supply has been augmented by navigation pools on the Arkansas River. The difference between river stage elevation and the potentiometric surface of the groundwater system creates a hydraulic gradient in which water flows from the river to the alluvial aquifer. Water moves into the aquifer through riverbank storage and floodplain percolation, then flows down-gradient toward the center of the cone of depression in the Grand Prairie near Stuttgart and DeWitt (outside the study area).

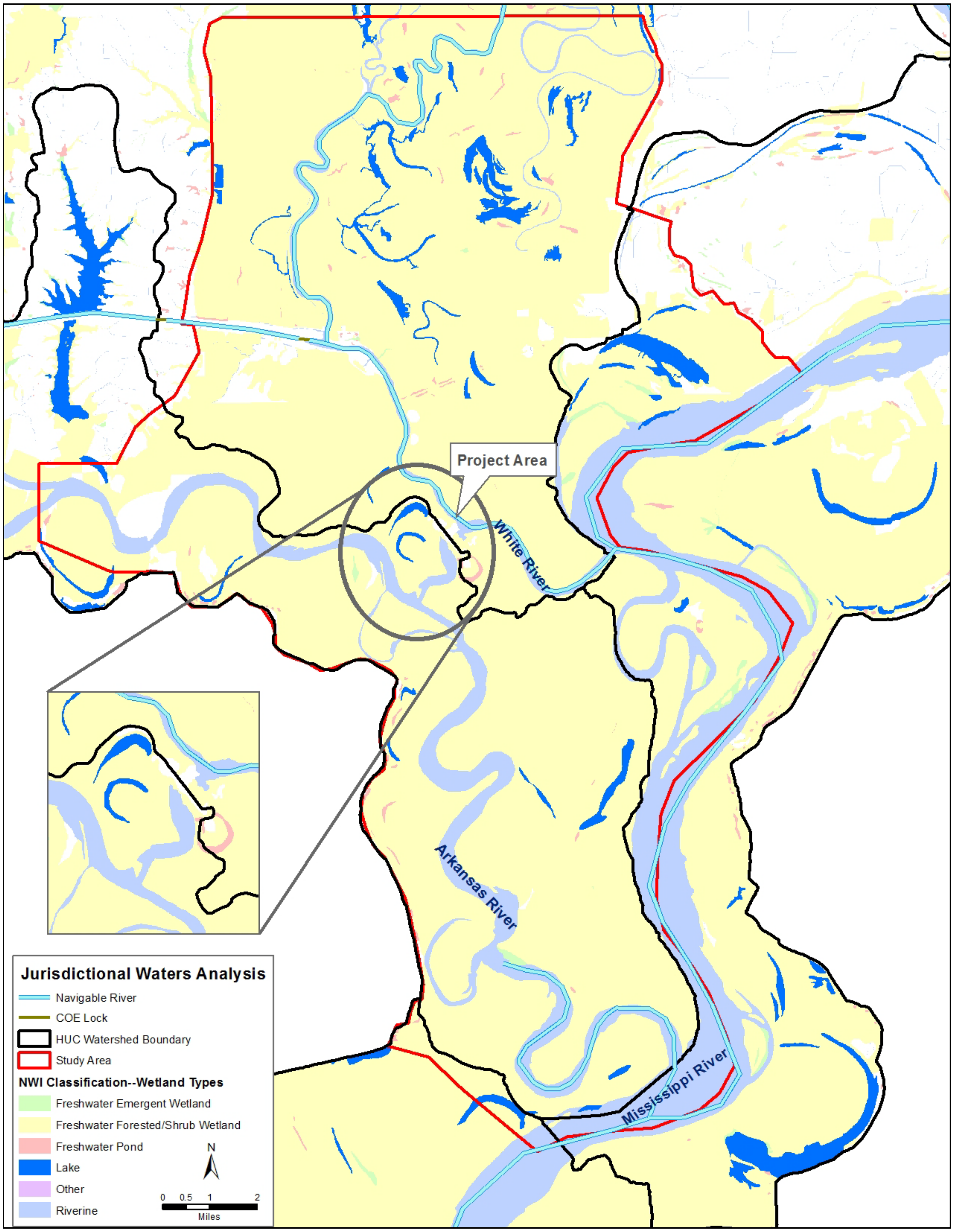

Figure 6: Wetland Types and Navigable Rivers in the Study Area

In 1998, ANRC designated the Grand Prairie Area as a Critical Groundwater Area due to drastic water-level declines in the MRV alluvial and Sparta aquifers. The Grand Prairie Area is bounded by Arkansas County boundaries in the most southern portion of the area, which also includes a portion of the study area, and extends northwest through portions of Jefferson, Lonoke, Pulaski, Prairie, White, and Woodruff Counties. Designation of Critical Groundwater Areas focuses resources, providing enhanced tax credits for conservation activities, focused educational programs, priority for federal programs and funding, and enhanced opportunities for locally-led groundwater conservation programs.

2.6.4 Water Quality

Section 305(b) of the Clean Water Act (CWA) requires states to assess the water quality of the waters of the state (both surface and groundwater) and prepare a comprehensive report documenting the water quality, which is to be submitted to the EPA every 2 years. In addition, Section 303(d) of the CWA requires states to prepare a list of impaired waters on which Total Maximum Daily Loads (TMDL) or other corrective actions must be implemented. Arkansas Department of Environmental Quality (ADEQ) is the state agency responsible for enforcing water quality standards and preparing the comprehensive report for submittal to EPA.

*2.6.4.1 Surface Water**

Surface water quality is strongly influenced by land uses. In general, surface waters in the study area have relatively high levels of turbidity and suspended solids. In contrast, dissolved oxygen levels tend to be low, and biochemical oxygen demand in surface waters tends to be relatively high.

Approximately 35 miles of the Arkansas River (Reach 001 of HUC 8020401), including the stretch through the study area, was included on the Draft 2016 303(d) list as an impaired waterbody without TMDLs (Category 5) (ADEQ 2016). Category 5 includes impaired water bodies, or those where one or more water quality standards have not been attained. Reach -001 of the Arkansas River is impaired by dissolved oxygen with an unknown source. The decreased dissolved oxygen has caused “nonsupport” of the “Fisheries Use” designated use category. The reach has a low priority ranking that indicates the lowest risk to public health or welfare and secondary impact on aquatic life.

The lower 30-mile portion of the Arkansas River, including the entire length found in the study area is designated as an Extraordinary Resource Water[6] (ADEQ 2016). This stream segment stretches from the Arkansas Post Lock and Dam, which is upstream of the study area, to the mouth of the Mississippi River. Barge traffic is diverted out of the Arkansas River above the lock and dam to the White River through the Arkansas Post

[6] This beneficial use is a combination of the chemical, physical, and biological characteristics of a waterbody and its watershed, which is characterized by scenic beauty, aesthetics, scientific values, broad scope recreation potential and intangible social values.

Canal. Thus, the lower 30-mile stretch receives little to no channel maintenance and remains free flowing. This portion of the Arkansas River is quickly becoming a favorite canoeing and camping destination, and offers excellent fishing and primary contact recreation opportunities.

2.6.4.2 Groundwater

In general, groundwater quality in the MRV alluvial aquifer is good based on EPA primary drinking water standards and is classified as calcium-bicarbonate water. In addition, sodium, magnesium, chloride, sulfate, silica, and iron comprise the major constituents by weight. Constituents show a wide variability based on residence time of groundwater and flow paths. Levels of dissolved solids in the groundwater throughout most of the aquifer are low enough for the water to be suitable for most uses (Kresse et al., 2013).

2.6.5 Floodplains

The floodplain in the study area exhibits a complex pattern of abandoned channels, oxbow lakes, back swamps, natural levees, deposits, meander scars, and active point bars typical of ridge and swale alluvial geomorphic landforms. The historic floodplain has been modified by an extensive system of levees and water control structures. Levees were constructed primarily to allow farming in rich bottomland alluvial soils.

Over 90 percent of the study area is in the Federal Emergency Management Agency (FEMA) 100-year (Zone A) floodplain. Zone A indicates that an area is High Risk, with a one percent annual chance of flooding and a 26 percent chance of flooding over 30 years. FEMA guidelines state that projects in Zone A cannot have a cumulative rise in Base Flood Elevation (BFE, 1 percent exceedance frequency) of more than one foot. Most of the study area also lies in a 2-year and 5-year floodplain.

Flood flows are attenuated by USACE navigation management operations during late winter and spring and extend into late summer and early fall. Usually the Arkansas and White rivers flood at the same time, but differences in flood stages of 16 to 25 feet have occurred. Differences are typically associated with precipitation events limited to either the White River or Arkansas River drainage areas.

2.7 Biological Resources

Biological resources include plants, animals, and their habitats. Biological resources are important because they: (1) influence ecosystem functions and values; (2) have intrinsic value and contribute to the human environment; and (3) are subject to various laws and regulations that may affect project implementation.

The lower Arkansas and White rivers and their floodplain ecosystems are extremely valuable due to their rich and diverse natural resources. Despite numerous projects constructed, the area still retains much of its original environmental characteristics and is among the richest, most functional ecosystems remaining in the Mississippi Alluvial

Valley. The lower White River basin contains the largest block of contiguous bottomland hardwoods remaining on any tributary of the Mississippi River, and provides habitat for more than 235 species of birds, 58 species of mammals, and 58 species of reptiles and amphibians. It is also the most important wintering area for mallards in North America. The White and Arkansas rivers and adjacent floodplain aquatic habitats provide habitat for at least 24 families and 132 species of fish, 37 species of freshwater mussels, and several federally listed species such as the Ivory-billed woodpecker.

The study area has resources of national and international importance, and holds several special designations. The lower White River basin is a Ramsar Wetland of International Importance, and an Important Bird Area based on criteria of the Audubon Society. The lower Arkansas River is a state listed ecologically sensitive waterbody and is listed by the National Park Service in the Nationwide Rivers Inventory.

The following information summarizes the USFWS 2003 Final Coordination Act Report (CAR) for the Ark-White Study and the USFWS 2016 Draft CAR for the current study, unless otherwise noted. For a more detailed description including a comprehensive list of species and historic conditions of the ecosystem in the study area, refer to Appendix J.

2.7.1 Aquatic Habitat

Aquatic habitats in the area include the main stem of the White and Arkansas rivers, Menard Bayou, Honey Locust Bayou, Wild Good Bayou, Island 73 Chute, and oxbow lakes adjacent to the river system including Lake Dumond, Owens Lake, Garland Lake, Jim Smith Lake, Moore Lake, La Grues Lake and Pelican Lake. These permanent and seasonal habitats available to fishes in the study area encompass a variety of riverine and floodplain habitat types including main channels, side channels, tributaries (i.e., sloughs, bayous, creeks), inundated flood plains (i.e., bottomland hardwood forest), and abandoned channel segments (i.e., oxbow lakes) with varying degrees of connectivity to the main channel.

2.7.1.1 Fisheries

At least 24 families and 132 species of fish inhabit the channel, tributaries, oxbow lakes, sloughs, and inundated floodplain of the lower White River. Fishery information for the Lower Arkansas River below Dam 2 is minimal; however, sampling efforts have showed that 42 species from 15 families exist in the river.

The White River supports a sustainable commercial fishery for both fish and mussels, although at levels much lower than the early 20th century. Commercial demand for wild freshwater fishes has declined over recent decades due in part to the advent of highly efficient aquaculture and competition from foreign sources. The number of commercial fisherman and fish harvested from the river depends greatly on fishing conditions (i.e., water levels) and wholesale prices. The primary commercial fishes in the lower White River include blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), flathead catfish (*Pylodictis olivaris*), smallmouth buffalo (*Ictiobus bubalus*), bigmouth buffalo (*Ictiobus cyprinellus*), black buffalo (*Ictiobus niger*), common carp (*Cyprinus carpio*), river carpsucker (*Carpiodes carpio*), longnose gar (*Lepisosteus osseus*), shovelnose sturgeon (*Scaphirhynchus platorynchus*), bowfin (*Amia calya*), and paddlefish (*Polydon spathula*). By far the most sought after and profitable commercial species are the catfishes (all three species) and the buffaloes (primarily smallmouth).

2.7.1.2 Mussels

Historically, the lower White River has supported considerable populations of freshwater mussels. Recent mussel surveys confirmed 37 native species of freshwater mussels from Newport to the confluence with the Mississippi. The mussel fauna of the lower White below Newport includes three endangered species. Virtually nothing is known about mussel resources in the White River below the Arkansas Post Canal or in the Arkansas River below Dam 2. The closest known mussel bed to the study area is located between one and two miles upstream of the Arkansas Post Canal in the White River. This is a major bed with a density above 10 individuals per square meter.

Nine major and 11 minor mussel beds were located in the lower reach of the White River. Major beds were typically located in substrates of sand, hard and soft clay, and gravel, with areas ranging from 200 to 10,300 square meters ($m^{2)}$. Mean densities range from 5,924 ± 2,046 to 189,679 ± 36,127 individuals in major beds and 9 to 19 individuals in minor beds. The mapleleaf (*Quadrula quadrula*) was the dominant species in most major beds, and the threehorn wartyback (*Obliquaria reflexa*) and fragile papershell (*Leptodea fragilis*) also contribute to large percentages to the community makeup. Butterfly (*Ellipsaria lineolate*), washboard (*Megalonaias nervosa*), hickorynut (*Obovaria olivaria*), and pimpleback (*Q. pustulosa*) were also common in the major beds. The mapleleaf also dominated the species composition in the minor beds. Other common species discovered in minor beds include the fragile papershell, threehorn wartyback, washboard, hickorynut, and threeridge (*Amblema plicata*). The deertoe (*Truncilla truncata*), a species that has declined in recent years in the White River, was also found in minor beds. Currently, the non-endangered freshwater mussels of the White River support a commercial harvest.

2.7.2 Terrestrial Habitat

Hydrology is important to the composition and vigor of ecosystems in the study area, including plant communities. Geomorphology and soils also play an important role in determining the plant communities present. Land cover in the study area is predominantly bottomland hardwood forests. The lower White and lower Arkansas River basins inside the levees are also dominated by bottomland hardwoods. In contrast, lands outside levees in the MAV portion of the river basins are primarily agriculture. Forest associations in the study area vary depending on the frequency and duration of flooding. Cypress-tupelo (*Taxodium distichum/Nyssa aquatic*) and scrub-shrub swamps are found in low lying areas that are permanently or semi-permanently flooded. Water hickory/overcup oak (*Carya aquatic/Quercus ovata*) associations are located in frequently flooded low lying areas. Somewhat more elevated areas, which are still influenced by overbank flooding, support American elm (*Ulmus americana*), ash (*Fraxinus spp.*), sugarberry (*Celtis laevigata*), sycamore (*Platinus occidentalis*), Nuttal oak (*Q. nuttallii*), willow oak (*Q. phellos*), and sweetgum (*Liquidambar styraciflua*). Infrequently flooded, poorly drained areas are vegetated with willow oak, water oak (*Q. nigra*), swamp chestnut oak (*Q. michauxii*), cherrybark oak (*Q. pagodifolia*), and shagbark hickory (*Carya ovata*). Black willow (*Salix nigra*) is common on elevated point bars and cottonwood (*Populus deltoids*), river birch (*Betula nigra*), and boxelder (*Acer nuegundo*) are found on natural levees. Differences between vegetative zones in the bottoms are scarcely visible, with vegetative community changes occurring at a matter of several inches to a foot difference in elevation.

The distribution of plant communities in the study area is directly and indirectly influenced by hydrology. Plant survival and reproduction are directly tied to the timing, depth, duration, and frequency of flooding, which also influences sediment distribution and soil formation. Soils indirectly influence water relationships in plant communities. Consequently, changes in flood frequency, duration, or elevation can affect habitat availability and overall wetland and ecosystem function in extensive areas.

Notable exceptions to the major land cover type in the study area are dredge disposal areas on private land and on the Refuge. Dredge disposal sites are 30 to 50 feet in elevation, and contain millions of cubic yards of dredged material. The sites are mostly unvegetated open sand with small plots of willow.

2.7.2.1 Birds

Birds are the largest single group of vertebrates in the study area. At least 265 species of migratory and resident birds including 26 species of waterfowl, 31 species of wading birds, 15 species of shorebirds, and 129 species of songbirds have been documented in the lower White River basin. One hundred twelve species of birds were identified during breeding bird surveys in the basin and bottomland hardwoods immediately south of the Arkansas River near the confluence of the White, Arkansas, and Mississippi rivers.

Avian species composition and abundance, as well as the habitats used by this large and diverse group vary widely with season. Waterfowl use both bottomland hardwoods and open flooded habitats primarily during the winter. Neotropical migratory songbirds use the bottomland hardwoods to meet breeding requirements and as a stopover during migration. Shore and wading birds use open water, mud flats, herbaceous wetlands, and wooded swamps for migratory, wintering, and breeding habitats. Grassland birds use remnant prairie grasslands and pastures. Thus, the breeding, wintering, and migration habitat provided by the bottomland hardwoods is one of the most important functions of the ecosystem.

The lower White River basin has long been renowned for its winter populations of waterfowl. Based on duck band recoveries, harvest records, and annual waterfowl surveys, the Cache River/Lower White River ecosystem is by far the most important wintering area for waterfowl in Arkansas and the single most important wintering area for mallards (*Anas platyrhunchos*) in North America. The area has been identified as one of six flagship areas identified in the North American Waterfowl Management Plan.

As a group, songbirds include the largest number of species (129) of birds using the Lower White River Basin. At least 65 species of songbirds breed in the basin. Many of the birds found in the area are further classified as neotropical migrants. These birds migrate from breeding areas in North America to wintering areas in Central and South America. Songbirds are also dependent on the extensive forests in the study area and the unbroken expanse of forest is vital to the maintenance of stable forest breeding bird populations in the MAV.

The Eastern wild turkey (*Meleagris gallopavo silvestris*) is the primary resident game bird in the ecosystem; a bird that was once distributed throughout the basin, but which is now generally confined to the larger blocks of forest. Turkey populations fluctuate dramatically with the incidence and timing of spring floods.

2.7.2.2 Mammals

Fifty-eight species of mammals are known or likely to occur in the lower White River basin, including 12 species of bats and 24 species of rodents. Little specific information is available on mammals in the lower White and Arkansas River basins.

White-tailed deer (*Odocoileus virginianus*) are important from a public interest and use perspective. Bottomland hardwoods provide quality habitat for deer, with potential carrying capacity reaching 1 deer per 10 acres or more. AGFC deer population objectives for WMAs in the study area range from 1 per 16 to 1 per 26 acres. Carrying capacity of bottomland hardwoods varies due to prolonged and or deep flooding in some portions of the area and by their proximity to cropland.

Black bears (*Ursus americanus*) in the area are descendants of the native black bear population that thrived on the Refuge when black bears were extirpated from the rest of the state making the Refuge home to the only native black bear population in Arkansas. By 2001, the black bear population in and around the Refuge was estimated at around 500 or more animals, with estimates of bear density on the southern portion of the Refuge at one bear per about 300 acres. Forested wetlands in the study area also support other game and non-game mammals including raccoon, beaver, river otter, mink, gray squirrel, fox squirrel, and red fox.

2.7.2.3 Reptiles and Amphibians

The lower White and Arkansas River basins provide habitat for approximately 58 species of reptiles and about 24 species of amphibians. Common amphibians include the marbled salamander (*Ambystoma opacum*), green frog (*Rana clamitans*), American toad (*Bufo americanus*), Woodhouse's toad (*B. woodhousei woodhousei*), and southern leopard frog (*R. utricularia*). Common reptiles include the five-lined skink (*Eumeces fasciatus*), the mud snake (*Farancia abacura reinwardti*), copperhead (*Agkistrodon contortrix contortrix*), and cottonmouth (*A. piscivorus leucostoma*). Common turtles include the three-toed box turtle (*Terrapene Carolina triunguis*), red-ear turtle (*Chrysemys scripta elegans*), map turtles (*Graptemys spp.*), soft-shell turtle (*Trionyx muticus*), and common snapping turtle (*Chelydra serpentine serpentine*). Another reptile documented in the area is the American alligator (*Alligator mississippiensis*), but since the Refuge is fairly far north, alligators are probably somewhat rare. Similarly, alligator snapping turtles (*Macroclemys temmincki*) have become increasingly rare, but can still be found. Population trends of herpetofauna in both basins are unknown; however, population trends would be roughly proportional to loss or retention of herpetofauna habitat.

*2.7.3 Threatened and Endangered Species**

USFWS oversees protection of threatened or endangered species under the federal Endangered Species Act (ESA). Mandates of the ESA ensures that federal agencies and departments use their authorities to protect and conserve endangered and threatened species. Section 7 of ESA requires that federal agencies prevent or modify any projects authorized, funded, or carried out by the agencies that are "likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of critical habitat of such species." Table 2 lists species identified in the 2015 Planning Aid Report and the USFWS Information for Planning and Conservation (IPaC) website. There are no candidate or proposed species for listing or designated critical habitat in or near the study area or in Arkansas or Desha counties, Arkansas. Appendix E contains the Biological Evaluation, which discusses detailed habitat requirements, historic and current occurrence, and threats to species in the area.

Table 2: Threatened and Endangered Species listed as Potentially Occurring in the Study Area

Species	Status	CAR	IPAC	Habitat	Occurrence in the Study Area
Birds					
Rufa red knot *Calidris canutus rufa*	T		X	Found primarily in intertidal, marine habitats, especially near coastal inlets, estuaries, and bays outside of breeding season. Stopover habitat includes river shorelines with muddy/sandy substrates.	Potential migratory resident, but presence has not been confirmed in or near the study area. Suitable habitat exists on the lower Arkansas and Mississippi rivers.
Ivory-billed woodpecker *Campephilus principalis*	E	X	X	Inhabits mature bottomland forest and cypress swamps with large hardwoods.	Suitable habitat exists and is within the potential range of occurrence as identified by USFWS. Surveys in and around the study area yielded no confirmation of occurrence.
Piping plover *Charadrius melodus*	T		X	Use wide, flat, open, sandy beaches with very little grass or other vegetation. Nesting territories often include small creeks or wetlands. Breed in northern US and Canada in the spring and summer and migrate south in the fall, wintering along the coast of the Gulf of Mexico or other southern locations.	Potential migratory resident, but presence has not been confirmed in or near the study area. Suitable habitat exists on the lower Arkansas and Mississippi rivers.
Interior least tern *Sterna antillarum athalassos*	E	X	X	Nest in small colonies on barren to sparsely vegetated sandbars along rivers, sand, and gravel pits, lake and reservoir shorelines, and occasionally gravel rooftops from April through August. Winter along the coastal areas of Central and South America and the Caribbean Islands.	Commonly observed during the summer along the Mississippi and lower Arkansas rivers. Nesting occurs throughout the study area on the Arkansas and Mississippi River, with the closest known site occurring on the Melinda Sandbar directly across the Arkansas River from the Melinda Channel. Commonly observed foraging along the lower White River but are not known to nest here.

Table 2: Threatened and Endangered Species listed as Potentially Occurring in the Study Area (continued)

Species	Status	PAL	IPAC	Habitat	Occurrence in the Study Area
Fish					
Pallid sturgeon *Scaphirhynchus albus*	E	X	X	Utilize main and secondary channels with silty bottoms and a natural hydrograph, and channel border habitats lacking flowing water which are removed from the main channel (i.e. backwaters and sloughs). Habitat preference has a diversity of depths and velocities formed by braided channels, sand bars, sand flats, and gravel bars. Habitat use varies with availability, life stage, and geographic location.	The southern portion of the study area is considered a high priority recovery area by USFWS. There is documentation of three radio-tagged individuals using the Arkansas River from the confluence with the Mississippi River upstream to Dam 2 in 2011-2012. There is no documentation of the species using the White River.
Mussels					
Pink mucket *Lampsilis abrupta*	E		X	Found in mud and sand and in shallow riffles and shoals swept free of silt in major rivers and tributaries.	Historically occurred throughout the White River. Recent occurrences are limited to sites approximately 145 and 211 river mile upstream of the study area. It is not known to inhabit the lower Arkansas River.
Scaleshell mussel *Leptodea leptodon*	E		X	Live in medium-sized and large rivers with stable channels, good water quality, and sand and gravel bottoms.	Closest known occurrence is on the White River approximately 246 river miles upstream of the study area.
Fat pocketbook *Potamilus capax*	T	X	X	Prefers sand, mud, and fine gravel bottoms of large rivers, in water ranging in depth from a few inches to eight feet.	Occurrence in the White River has been sporadic with no reports of live specimens since 1960s, except for a single live specimen in the main channel White River between river miles 11 and 12. The species could occur in the Arkansas River, but none have been documented.
Rabbitsfoot *Quadrula cylindrica*	T	X	X	Prefer shallow areas with sand and gravel along the bank and next to shoals, which provide a refuge in fast-moving rivers.	Closest recorded occurrence is near St. Charles, AR approximately 47 river miles upstream of the study area. It is not known to occur from the lower Arkansas River.

E = Listed Endangered **T** = Listed Threatened

2.7.4 Species of Concern

On October 23, 2015, the Arkansas Natural Heritage Commission (ANHC) provided a list of Species of Concern in the Three Rivers Study Area. The list identifies 23 species of concern and six Special Elements in the study area (Table 3).

Table 3: ANHC Elements of Special Concern in the Three Rivers Study Area

Scientific Name	Common Name	Status		Rank	
		Federal	State	Global	State
Arthropods					
Cicindela lepida	Little white tiger beetle	--	INV	G3G4	S2S3
Macrobrachium ohione	Ohio shrimp	--	INV	G4	S1?
Birds					
Haliaeetus leucocephalus	Bald eagle	--	INV	G5	S3B, S4N
Limnothlypsi swainsonii	Swainson's warbler	--	INV	G4	S3B
Riparia riparia	Bank swallow	--	INV	G5	S3B
Setophaga cerulean	Cerulean warbler	--	INV	G4	S3B
Sternula antillarum athalossos	Interior least tern	LE	SE	G4T2Q	S3B
Fish					
Acipenser fulvescens	Lake sturgeon	--	INV	G3G4	S2
Anguilla rostrate	American eel	--	INV	G4	S3
Atractosteus spatula	Alligator gar	--	INV	G3G4	S2
Cycleptus elongates	Blue sucker	--	INV	G3G4	S3
Erimyzon sucetta	Lake chubsucker	--	INV	G5	S3
Hiodon alosoides	Goldeye	--	INV	G5	S2
Mulgil cephalus	Striped mullet	--	INV	G5	S2
Platygobia gracilis	Flathead chub	--	INV	G5	SH
Polyodon spathula	Paddlefish	--	INV	G4	S3
Scaphirhynchus albus	Pallid sturgeon	LE	SE	G2	S1S2
Mussels					
Obovaria olivaria	Hickorynut	--	INV	G4	S3
Toxolasma lividum	Purple Lilliput	--	INV	G3Q	S3
Truncilla donaciformis	Fawnsfoot	--	INV	G5	S3

Table 3: ANHC Elements of Special Concern in the Three Rivers Study Area (Continued)

Scientific Name	Common Name	Status		Rank	
	Mammals				
Corynorhinus rafinesquii	Rafinesque's big-eared bat	--	INV	G3G4	S3
Myotis austroriparius	Southeastern bat	--	INV	G4	S3
	Reptiles				
Regina grahamii	Graham's crayfish snake	--	INV	G5	S2
	Special Elements (Natural Communities)				
Lower Mississippi River Bottomland Depression		--	INV	GNR	SNR
Mississippi River High Floodplain (Bottomland) Forest		--	INV	GNR	SNR
Mississippi River Low Floodplain (Bottomland) Forest		--	INV	GNR	SNR
Mississippi River Riparian Forest		--	INV	GNR	SNR
Willow Oak Forest		--	INV	GNR	S2
	Special Elements (Other)				
Colonial nesting site, swallows & swifts		--	INV	GNR	SNR

Key to Status and Ranks
LE= Listed Endangered under ESA
INV= Inventory Element, ANHC currently conducting active inventory work on these elements. Available data suggests these elements are of conservation concern.
SE= State Endangered, species is afforded protection under AGFC Regulation.
G2= Imperiled Globally, at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
G3= Vulnerable Globally, at risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
G4= Apparently Secure Globally. Uncommon but not rare; some cause for long-term concern
G5= Secure Globally. Common, widespread and abundant.
GNR= Not applicable.
T-Ranks= Given to global ranks when a subspecies, variety, or race is considered at the state level. Made up of a "T" plus a number or letter (1,2,3,4,5,H,U,X) with the same ranking rules as a full species.
S1= Critically imperiled in the state due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors making it vulnerable to extirpation.
S2= Imperiled in the state due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it vulnerable to extirpation.
S3= Vulnerable in the state due to a restricted range, relatively few populations (often 80 or fewer, recent and widespread declines, or other factors making it vulnerable to extirpation.
S4= Apparently secure in the state. Uncommon but not rare; some cause for long-term concern due to declines or other factors.
SH= Of historical occurrence, with some possibility of rediscovery.
SNR= Unranked. The state rank not yet assessed.
Q= Indicates element's taxonomic classification as a species is a matter of conjecture among scientists.
?= Used to denote an inexact numeric rank.
B= Refers to the breeding population of a species in the state.

2.7.5 Migratory Birds

Birds are protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act, both of which prohibit activities that result in taking of migratory birds or eagles unless authorized by USFWS. However, unlike the ESA, neither law prohibits taking of migratory birds that are unintentionally killed or injured. USFWS published the *Birds of Conservation Concern* (BCC) in December 2008 that identifies migratory and non-migratory bird species, beyond those already protected under ESA, with the highest conservation priorities. Bird species considered for listing in the BCC include nongame birds; gamebirds without hunting seasons; ESA candidates, proposed endangered or threatened species; and recently delisted species. The study area is in the Mississippi Alluvial Valley Bird Conservation Region 26. The USFWS IPaC website also lists migratory bird species that might occur in the study area. A total of 25 BCC are in Bird Conservation Region 26 and IPaC lists 22 species in the study area. Fourteen species are on both lists (Table 4).

Table 4: Birds of Conservation Concern listed for Bird Conservation Region 26

			Included on List	
Scientific Name	**Common Name**	**Breeding Status in ROI**	**BCC**	**IPaC**
Ammodramus henslowii	Henslow's sparrow	NB	X	
Ammodramus leconteii	LeConte's sparrow	NB	X	X
Asio flammeus	Short-eared owl	B	X	X
Botaurus lentiginosus	American bittern	NB		X
Caprimulgus carolinensis	Chuck-will's-widow	B		X
Cistothorus platensis	Sedge Wren	NB	X	X
Coturnicops noveboracensis	Yellow rail	NB	X	
Dendroica cerulea	Cerulean warbler	B	X	X
Elanoides forficatus	Swallow-tailed kite	NB	X	
Euphagus carolinus	Rusty blackbird	NB	X	X
Falco peregrinus	Peregrine falcon	B	X	
Haliaeetus leucocephalus	Bald eagle	B	X	X

Table 4. Birds of Conservation Concern listed for Bird Conservation Region 26 (continued)

Scientific Name	Common Name	Breeding Status in ROI	Included on List	
Helmitheros vermivorum	Worm eating warbler	B		X
Hylocichla mustelina	Wood Thrush	B	X	X
Icterus spurius	Orchard oriole	NB	X	X
Ictinia mississippiensis	Mississippi kite	B		X
Ixobrychus exilis	Least bittern	B	X	X
Ixobrychus exilis	Least tern	B		X
Lanius ludovicianus	Loggerhead shrink	B		X
Laterallus jamaicensis	Black rail	NB	X	
Limnodromus griseus	Short-billed dowitcher	NB	X	
Limnothlypis swainsonii	Swainson's warbler	NB	X	
Limosa fedoa	Marbled godwit	NB	X	
Limosa haemastica)	Hudsonian godwit	NB	X	
Melanerpes erythrocephalus	Red-headed woodpecker	B	X	X
Oporonis formosus	Kentucky warbler	B	X	X
Passerella iliaca	Fox sparrow	NB		X
Passerina ciris	Painted bunting	B	X	X
Protonotaria citrea	Prothonotary warbler	B	X	X
Spiza americana	Dickcissel	B	X	X
Tringa solitaria	Solitary sandpiper	NB	X	
Tryngites subruficollis	Buff-breasted sandpiper	NB	X	
Vireo bellii	Bell's Vireo	B		X

B= Occurs in BCR during breeding period (plus non-breeding where species occurs year-round)
NB= Occurs in BCR only during the non-breeding period

2.7.6 Invasive Species

Executive Order 13112, *Invasive Species*, dated February 3, 1999, directs federal agencies to expand and coordinate their efforts to combat the introduction and spread of invasive species (i.e., noxious plants and animals not native to the U.S.). Invasive species are one of the most pervasive, widespread threats to indigenous biota. The introduction and establishment of invasive species can have substantial impacts on native species and ecosystems. Invasive species capable of spreading and invading into new areas are typically generalists that can easily adapt to new environments and are highly prolific and superior competitors and predators. Some are very specialized and more efficient and effective than their native competitors at filling a particular niche. They compete for resources, alter community structure, displace native species, and may cause extirpations or extinctions. Invasive species often benefit from altered and declining natural ecosystems by filling niches of more specialized and displaced species with limited adaptability to changing environments. Fortunately routine and long duration flooding keeps most invasive species in check in the study area.

2.7.6.1 Terrestrial Species

Frequent flooding of the Arkansas, White and Mississippi river floodplains has precluded invasion of most non-native plant species in bottomland hardwood habitats. At higher elevations in the uplands some invasive species, such as sesbania, Johnson grass, and shattercane, are now present. These species are typically known as “crop pests” and occur on open farm and moist-soil sites. Chinese privet and Japanese honeysuckle are widespread along forest edges and in reforestation sites and in some timber harvest stands. Other problem plants include mimosa, Chinaberry, and non-native pine occasionally found in restored fields. Exotic bamboo and kudzu are found in localized pockets. Forsythia, orange day lily, yucca, crimson clover, and non-native pines are found as ornamentals on private lands. None of these invasive species have been formally mapped nor are they being monitored in the area.

Domestic swine are commonly introduced into the wild in Arkansas, creating populations of feral hogs. These hogs are also commonly captured and moved to unoccupied areas to create new hunting opportunities. AGFC has not completed any formal surveys for wild hogs in the study area; however, it appears from hunter reports that the greatest concentration appears to be on the Trusten Holder WMA. Feral hogs have not been able to gain a strong foothold in the study area most likely because of their susceptibility to long-duration flooding.

Beavers are native to Arkansas but were extirpated in the early 1900s. They reestablished in Arkansas in the late 1900s and have since reached a level at which they are often considered a nuisance species. The beaver’s natural behavior of building dams and the associated flooding of forested areas can provide beneficial wetland areas, but such extended flooding particularly during the summer months can change the vegetation composition leading to habitat conversion. On the Refuge, there are over 500 beaver dams and roughly 6,710 acres in dead timber and wetland scrub and shrub habitat as a result of these dams. The current trend indicates that an additional 200 to 300 acres convert each year without increased beaver control.

Several species of invasive birds, including Eurasian collared dove, European starling, and house sparrow, have been observed using the area, but none have been observed nesting or using bottomland habitat.

2.7.6.2 Aquatic Species

The two primary aquatic plant species of concern in the study area are water hyacinth and didymo. When water hyacinth takes over, boating and fishing become nearly impossible in covered areas, and dissolved oxygen concentration also decreases, which can lead to fish kills and a decline in the aquatic populations. When a nuisance bloom of didymo occurs, large benthic mats of up to two-foot long stalks attach themselves to the substrate. The mat can end up covering up to 100 percent of a streambed in some areas and reduce the availability of the area for aquatic invertebrates and fish spawning.

Four carp species have been identified within the area. Species such as the common carp and grass carp are well established and the effects of their introductions have long since been assimilated into the ecosystem. Two other carps, the bighead and silver, are more recent introductions and have not yet fully established populations within and throughout the watersheds. As the densities and range of these species expand in the watersheds, there will likely be substantial effects to native species including outcompeting native fish species for resources, indirectly altering water quality, and significantly impacting prey populations.

Asian clams are well established in the area and have affected surrounding ecosystems for many years. Zebra mussels, however, are a relatively new introduction and are currently not fully established. Limited navigation has aided in preventing or minimizing their establishment and upstream expansion in the White River and its tributaries. They are highly prolific and quickly dominate the benthic community, overwhelm native species, and cause mass suffocation, competition for resources, and alteration of water quality.

2.7.7 Fish and Wildlife Management Areas

Fish and wildlife management areas are lands designated as habitat for fish and wildlife or for propagation of such species and where wildlife habitat maintenance or improvement is appropriate. Private or exclusive group use of these lands is not permitted. Vehicles are typically not permitted, unless using for a wildlife-dependent recreational activity. Fish and wildlife management lands are generally available for selected low-density recreation activities such as hiking, hunting, fishing, nature study, nature photography, wildlife observation, and other related activities. Public access to wildlife management lands are restricted at certain critical periods when wildlife would otherwise be adversely affected, such as during critical breeding, nesting, and spawning periods. As discussed previously, the USFWS, USACE, and AGFC own and manage large portions of the study area and adjacent lands to the north and west. Professional staff, such as fish biologists, foresters, conservation officers, and wildlife biologists, conduct surveys, write management plans, and enforce game and natural resource laws and regulations.

2.8 Cultural Resources*

Cultural resources include buildings, structures, sites, districts, and objects eligible for or included in the National Register for Historic Places (NRHP), cultural items, Indian sacred sites, archaeological artifact collections, and archaeological resources. Appendix K details the cultural history of the region and contains other related research.

Few significant archeological resources have been recorded in the study area and there are no known sites listed on, or eligible for listing on, the NRHP in the project area. This is likely due to a lack of surveys of the area. However, one cultural resources survey was conducted prior to building a containment structure in the project area in 1988, and concluded that construction of the project would not affect cultural resources. The Arkansas State Historic Preservation Office (SHPO) concurred with this finding.

In December of 2006, USACE submitted a letter to SHPO and the Quapaw Tribe of Oklahoma concerning project alternatives described in the Ark-White Study. SHPO analyzed historic maps and discovered that a historic plantation site (Hirt's Plantation) is in the vicinity of the existing containment structure. Further research by SHPO determined that the plantation site was about 47 miles northwest of the project area.

2.9 Recreation and Aesthetics*

The lower Arkansas and White rivers and associated floodplain ecosystems are extremely valuable and diverse natural resources. The area is one in which a person can truly “lose themselves” in nature due to the remoteness of the area (Arkansas Natural Heritage Commission 1992). Despite numerous USACE projects, this area retains much of its original character and is among the richest, most functional ecosystems remaining in the Mississippi Alluvial Valley.

According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior 2011), Arkansans are avid anglers, hunters, and wildlife watchers, and both Arkansans and Americans in general are avid users of “The Natural State’s” wildlife resources. The 2011 Survey found that 1.3 million Arkansas residents and nonresidents 16 years old and older fished, hunted, or wildlife watched in Arkansas. Of the total number of participants, 555,000 fished, 363,000 hunted, and 852,000 participated in wildlife-watching activities, which includes observing, feeding, and photographing wildlife. The sum of anglers, hunters, and wildlife watchers exceeds the total number of participants in wildlife-related recreation because many people engage in more than one wildlife-related activity.

Forested lands in and surrounding the study area are very popular for sportsmen and sportswomen. Public lands are heavily used by hunters during the fall and winter. Deer hunting remains the most popular, followed by waterfowl, squirrel, rabbits, furbearers, turkey, quail, feral hogs, and alligator. Furbearer species include opossum, raccoon, striped skunk, river otter, beaver, mink, muskrat, nutria, red fox, gray fox, coyote, and bobcat. Black bear hunting is only permitted on the Refuge by special permit. Private lands in the area have large, and well-known hunting clubs, and are very popular for waterfowl hunting. Although, hunting levels vary year to year, it is fairly consistent and an important source of revenue for landowners and local businesses.

The area’s many oxbow lakes are popular spring and summertime destinations for anglers, especially during periods following overbank flooding. These floods provide hydrologic connections from the rivers, as well as inundate thousands of acres of bottomland forests – providing excellent spawning habitat for fishes. The most sought after species in these rich lakes include crappie, bass (largemouth and spotted), bluegill, red-eared sunfish, and catfish. Boat ramps have been installed on many of the larger lakes and at selected sites along the rivers to increase access for waterborne recreation and fishing.

Many outdoor enthusiasts are drawn to the Three Rivers region each year for activities including bird watching, hiking, camping, and boating. The Arkansas Department of Parks and Tourism is developing the Delta Heritage Trail State Park in the region. This 84.5-mile trail, including approximately six miles in the study area, is located along the abandoned Missouri-Pacific railroad line. The trail section in the study area includes several water crossings, most notably the Benzal Bridge, which spans the White River, and the Yancopin Bridge that spans the Arkansas River. Plans for this trail include walking and biking routes, trail heads, and interpretative kiosks.

There are five campgrounds found within the Refuge in the study area, including: Jack's Bay Campground, Prairie Lakes Campground, Six Mile Campground, East Moon Lake Campground, and Alligator Lake Campground. The Trusten Holder WMA has five primitive camping areas located in Arkansas County.

Immediately downstream of USACE Dam No. 2 and extending to the Arkansas River's confluence with the Mississippi River, the Arkansas River is designated by the State of Arkansas as an Extraordinary Resource Water and is on the National Rivers Inventory list as a potential Wild and Scenic River. This river reach draws outdoor enthusiasts interested in boating activities, particularly non-motorized boats.

2.10 Transportation*

Transportation refers to the movement of people, goods, or equipment on a surface transportation network that can include many different types of facilities serving a variety of transportation modes, such as vehicular traffic, public transit, and non-motorized travel (e.g., pedestrians and bicycles). The relative importance of various transportation modes is influenced by development patterns and the characteristics of transportation facilities. In general, urban areas tend to encourage greater use of public transit and/or non-motorized modes of transportation, especially if pedestrian, bicycle, and transit facilities provide desired connections and are well operated and maintained. More dispersed and rural areas tend to encourage greater use of passenger cars and other vehicles, particularly if extensive parking is provided or transit systems are unavailable.

2.10.1 Highways, Roadways, and Railways

There are no federal or state highways in the study area, but there are paved and gravel roads to USACE locks and dams, recreation areas, and private lands. In addition, there are hundreds of miles of trails on both public and private lands for hunting and recreation. Benzal Road is the only named road in the project area. It is on top of and traverses the Soil-Cement Structure and terminates at the Historic Cutoff. The road accesses private lands and recreational areas, and has limited accessibility during winter and periods of high water. The former Missouri-Pacific railroad crosses the study area at MKARNS and the Arkansas River near the town of Medina. The rail line has been abandoned and is now owned by the Arkansas Department of Parks and Tourism.

2.10.2 Navigation

The MKARNS system is 445 miles long with 18 locks and dams and an elevation differential of 420 feet from its beginning at river mile 599 on the Mississippi River to the head of navigation near Tulsa, Oklahoma (see Figure 2). Today it ships about $3.5 billion (roughly 12 million tons) worth of commodities to and from Arkansas and Oklahoma each year. Since the MKARNS opened in 1971, annual tonnage on the system has increased by about 180 percent, and study projections suggest that traffic on the river will continue to rise well into the foreseeable future.

2.11 Socioeconomics and Environmental Justice*

Socioeconomic resources encompass basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, an area's industrial base, and its economic growth.

The study area comprises portions of Arkansas and Desha counties in southeastern Arkansas. Data from the 2010 Census, the U.S. Bureau of Labor Statistics, and the 2014 American Community Survey for population and employment, was used to summarize socioeconomic conditions in Desha and Arkansas counties. As shown in Table 5, both counties have small populations relative to other areas of the state (15,341 and 20,749 respectively). Population in both counties population has fallen significantly since the 2000 Census with a 20 percent reduction in Desha County and a 10 percent decrease in Arkansas County. The nearest population centers to the project site are the City of Gillett (Arkansas County) and the City of Watson. Gillett is roughly 15 miles away (straight line distance), and Watson is about 11 miles (straight line distance). Both are sparsely populated, and have also seen their numbers decline since, 2000.

Table 5: Existing Population Levels and Trends in the Study Area (US Census Bureau 2014)

Region	2000 Population	2010 Population	2014 Population	Percent change (2010-2014)	Density (Persons/sq. mi.)
Arkansas	2,673,400	2,872,684	2,933,369	2.1%	51
Desha County	15,341	13,008	12,264	-20%	20
Arkansas County	20,749	19,019	18,594	-10%	21
Gillett	288	211	197	-32%	N/A
Watson	819	692	687	-16%	N/A

Key income indicators (per capita income and median household income) for counties in the project area vary with lower values characteristic of rural counties and higher values for urban counties (Table 6). With the exception of Arkansas County, median household incomes and per capita incomes in each area are lower than state level values. The distribution of employment by occupation category in most counties tends to follow national and state allotments.

Table 6. Existing Employment and Income near the Study Area (US Census Bureau 2014)

				Distribution of workforce by sector				
Region	**Per capita income**	**Median household income**	**Total civilian workforce**	**Management business, science, & arts**	**Natural resources, construction, & maintenance**	**Production transporta-tion**	**Sales & office work**	**Service**
United States	$28,155	$53,046	141,864,697	36%	18%	25%	9%	12%
Arkansas	$22,170	$40,768	1,245,432	31%	17%	24%	11%	17%
Desha County	$19,882	$28,680	4,960	28%	17%	20%	14%	20%
Arkansas County	$23,045	$39,633	8,681	28%	17%	20%	11%	24%
Gillett	$16,913	$25,500	49	22%	27%	6%	22%	22%
Watson	$19,222	$35,624	289	37%	7%	26%	18%	12%

2.11.1 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, addresses concerns over disproportionate environmental and human health impacts on minority and low-income populations. The impetus behind environmental justice is to ensure that all communities, including minority, low-income, or federally recognized tribes, live in a safe and healthful environment and that no group of people, including racial, ethnic, or socioeconomic, should bear a disproportionate share of the negative consequences resulting from the execution of federal, state, local, and tribal programs and policies. The goal of fair treatment is not to shift risks among populations, but to identify potential disproportionately high and adverse effects and identify alternatives that may mitigate these effects.

The purpose of Environmental Justice is to analyze whether the demographics of the affected area differ in the context of the broader region, and if so, do differences meet CEQ criteria for an Environmental Justice community. For environmental justice analysis, minority populations are identified where either the minority population for the affected area exceeds 50 percent or the minority population is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. The criteria used to identify low-income populations is where greater than 20 percent or more of households in the community have incomes below the poverty line, as identified in U.S. Census Bureau publications. With the exception of Desha County, minority populations do not make up more than 50 percent of the overall population, nor are there any predominate minority communities within the study area. In Desha County, Black or African American citizens make up 47.8 percent of the population at the county level; however, most of the county's residents live in communities along State Highway 165, which runs along the western boundary of the county approximately 15 to 20 miles from the project area (Table 7). Based on the above, there would be no environmental justice concerns for any project in the study area.

Table 7. Racial Composition, Poverty Indicators near the Study Area (US Census Bureau 2014)

Region	**Racial composition (%)**						**Poverty indicators (%)**		
	White	**African American**	**Native American or Indian**	**Asian**	**Hispanic or Latino**	**Other or two or more races**	**Unemployed**	**Below poverty line**	**Under age 17**
United States	56.1	12.6	0.9	4.8	16.3	9.3	6.2	15.4	23.7
Arkansas	70.6	15.4	0.8	1.2	6.4	5.6	5.1	15.8	24.2
Desha County	43.5	47.8	3.0	0.3	4.4	1	14.2	0.3	25.9
Arkansas County	69.1	24.5	0.2	0.5	2.7	3	8.2	0.2	23.7
Gillett	66.8	29.9	0.0	0.0	1.2	2.1	0.0	0.2	7.6
Watson	81.2	15.2	0.3	1.0	1.6	0.7	2.0	0.2	19.5

Because children may suffer disproportionately from environmental health risks and safety risks, Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, was issued on April 21, 1997 to help ensure that federal agencies' policies, programs, activities, and standards address environmental health and safety risks to children. Table 8 displays the number of children adjacent to the study area. There are no schools or parks in the study area.

Table 8. Number of Children near the Study Area (US Census Bureau 2015)

Region	Persons Under 5 (%)	Persons Under 18 (%)
Arkansas	6.4	24.4
Desha County	6.7	25.6
Arkansas County	6.6	23.1
Gillett	5.7	22.1
Watson	0.0	22.8

2.12 Hazardous, Toxic and Radioactive Waste*

No large industrial areas are in or immediately adjacent to the study area, and there are no known significant sources of hazardous or toxic substances. Herbicides, insecticides, fertilizers, and fungicides are non-point source substances used in the production of agricultural crops in the region. Barges that use the navigation system transport various products that include fuels, industrial chemicals, fertilizer, and other substances that are hazardous or toxic substances. Examples include benzene, toluene, caustic soda, methanol, ammonia, gasoline, jet fuel, fuel oil, petroleum coke, asphalt, and fertilizer. Annually, barges transport roughly 1.3 million tons of fertilizer, 565,000 tons of industrial chemicals, and 755,000 tons of refined petroleum products through the navigation system. Other products transported include metallic ore, lumber, scrap steel, pulp and paper, sand/gravel/clay, glass, cement, appliances, coal, and grain. Supplies for and/or products from food processing, oil and gas, and aerospace also are transported (U.S. Army Corps of Engineers 1990a). As part of USACE operations and maintenance of the MKARNS, dredging maintains required navigation depths. Sediments dredged from the river are tested for contaminants and to date none have been found.

FUTURE WITHOUT-PROJECT CONDITION*

The Future without Project Condition (FWOP) is synonymous with the “No Action Alternative” required under the National Environmental Policy Act (NEPA). The No Action Alternative is the most likely future scenario without the preferred plan recommended in this study.

In the absence of implementation of the preferred plan, existing containment structures would remain susceptible to overtopping and damages during high water events. Other activities, including management of the Refuge, navigation, and recreation, would continue in a manner consistent with existing conditions.

In the absence of federal action, the probability of an uncontrolled flow (cutoff) between the Arkansas and White rivers will increase. Formation of a cutoff would result in the loss of navigation in the MKARNS. The Ark-White Study determined that a 1,000-foot-wide cutoff could form along the Jim Smith Lake corridor (130 acres) and the Owens Lake/Melinda Corridor (70 acres) (Figure 7).

The FWOP assumes:

- USACE would attempt to keep the probability of a cutoff forming to less than 30 percent. Historically, the approach has been to reduce the probability of a cutoff forming by constructing a head cut containment levee and structures in La Grues Lake, Owens Lake and the Melinda Structure, followed by repair after significant damage.

- The probability of a cutoff (breach of the existing head cut containment levee system) is based on the results of an expert opinion elicitation process. Each expert provided their opinion of the probability of a cutoff given a range of specific combinations of head differentials and durations, with the assumption that USACE would continue conducting OMRR&R when necessary. This elicitation was completed during the Ark-White Study and was carried forward for this study. Appendix A (Economics) describes the process and results in detail.

- Independent of a potential cutoff developing, head cutting will continue in areas already experiencing land loss, and USACE would construct new structures to prevent failure paths from developing into high risk corridors.

If the No Action Alternative is selected, USACE Little Rock District would have to determine the appropriate authority under which they could perform construction as the needs arise.

Figure 7: Potential Cutoff Paths Forming under the No Action Alternative

Repair, rehabilitation, and replacement is expected to occur as needed and be limited to structures in the Owens Lake Corridor (Owens Lake and Melinda Structures) and the Jim Smith Lake Corridor (portion of soil-cement dike and both North and South Structures of Jim Smith Lake). The Melinda Structure would be the first structure that would require replacement due to its current condition of deterioration and instability and need for frequent repairs. Due to the Melinda Structure's poor condition, a new weir would need to be constructed towards the Arkansas River (Figure 8). For purposes of this analysis, if a new structure were constructed, it would have a 9-foot top width at an elevation of 142 feet msl and be constructed of either rock or gabions (wire baskets filled with small rock and stacked like blocks). In addition, USACE would need to build a temporary cofferdam surrounding the structure, if the gabion option is selected, in order to construct the structure in dry conditions. Extra soil material from excavation would go on top of the rock at Jim Smith Lake South Structure and be seeded with turf grass species.

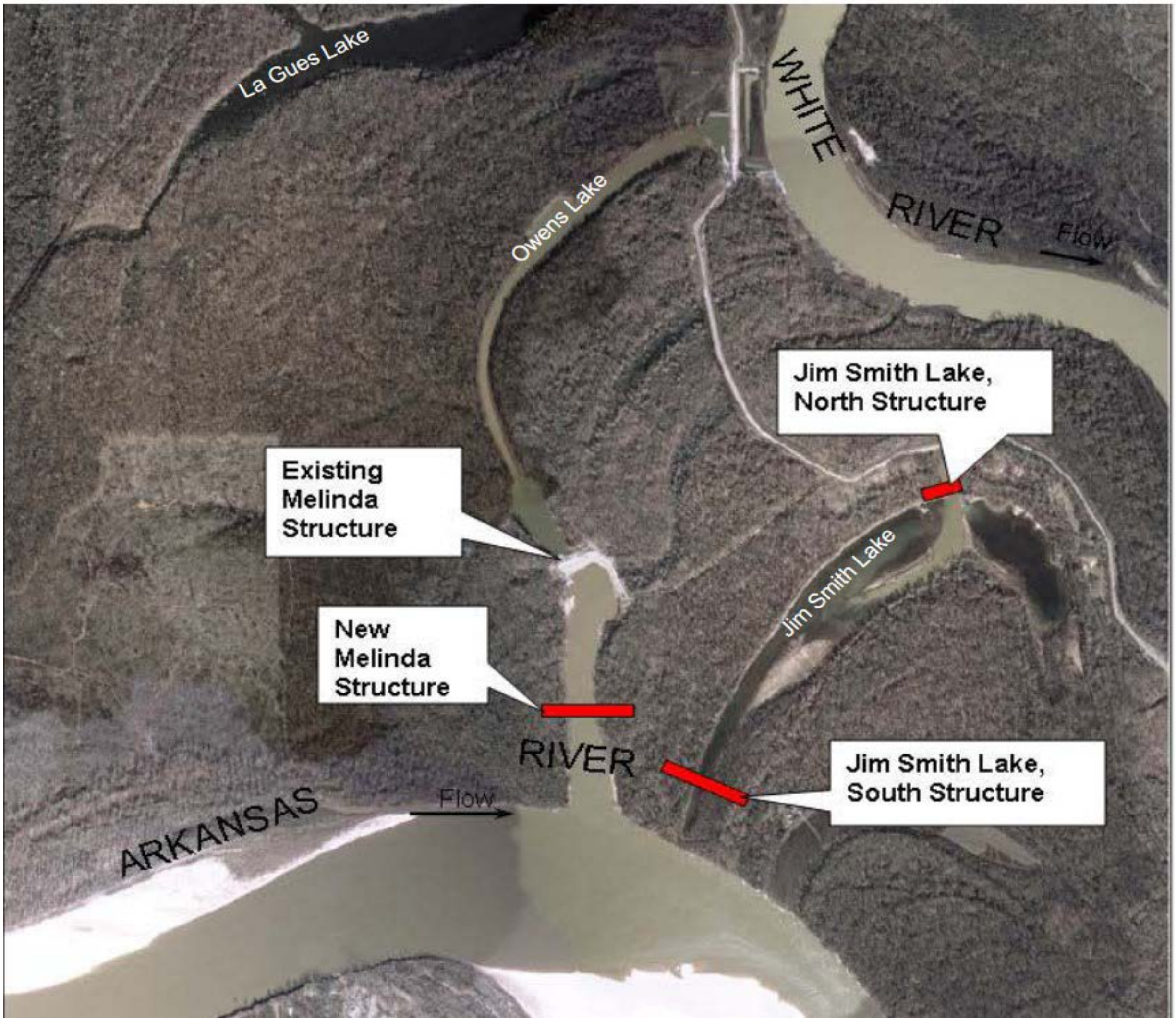

Figure 8: Potential Reconstruction of the Melinda Structure Required under the No Action Alternative

USACE estimates that three new structures would need to be constructed to prevent new failure paths from developing (Figure 9). Two are projected to be located along a line between the mouth of the Melinda Channel and La Grues Lake Structure to prevent flanking of the Melinda Structure and progression of head cutting toward the La Grues Lake Structure. The third structure is east of Jim Smith Lake near the end of the Historic Closure Structure to prevent a channel from developing adjacent to the containment levee. Construction of these structures is based on the progression of the Melinda Head Cut. While this type of construction certainly falls within USACE's OMRR&R responsibilities, major rehabilitation and replacement costs far exceed the normal operating budget for maintence on this section of the MKARNS. As such, funding availability is not guaranteed when the need arises for major rehab and construction activities. As a result, ad hoc or stop gap repairs may be undertaken to reduce potential damages in the short run, rather than the more permanent fix of full overhaul or replacement of damaged or ageing structures.

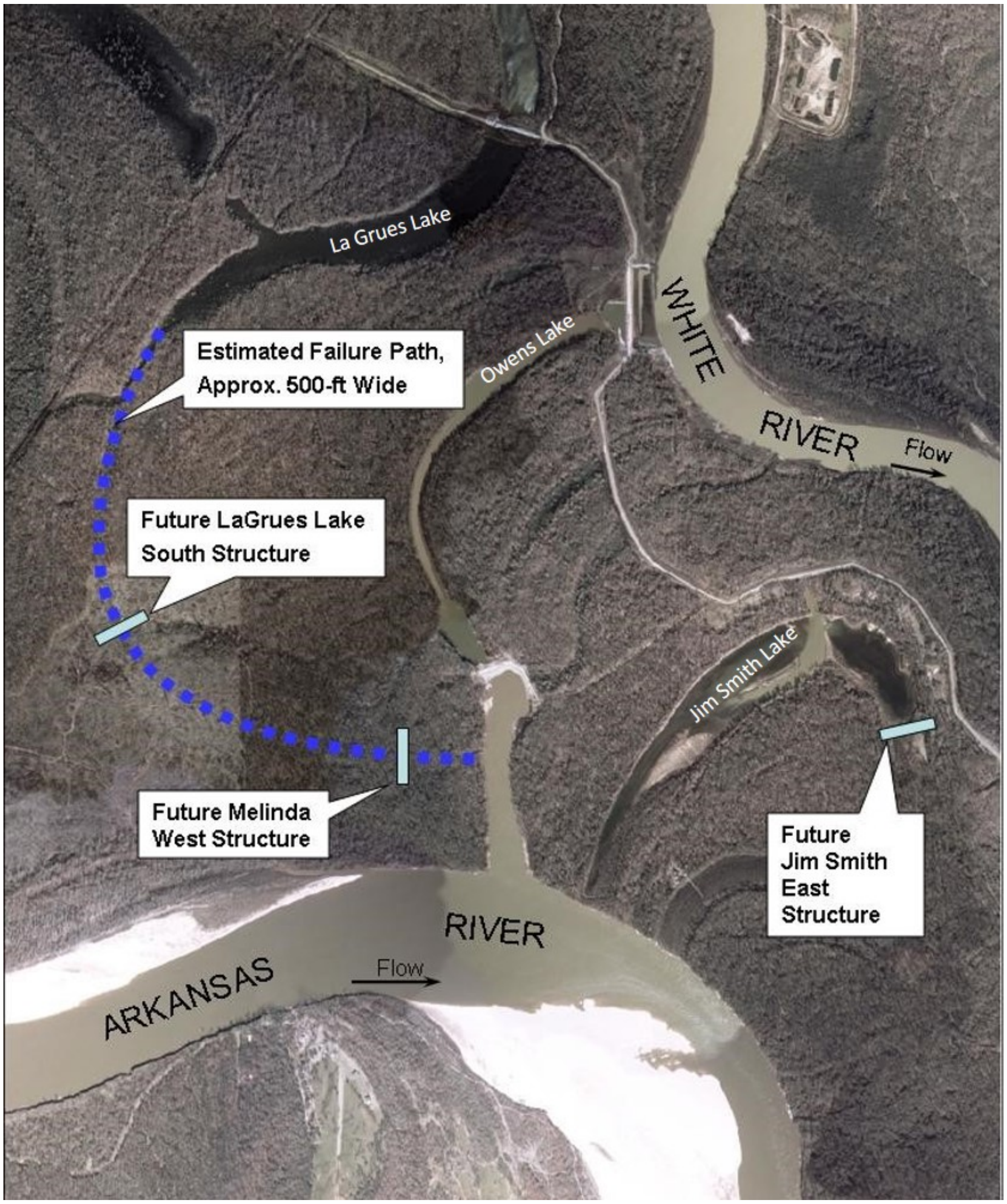

Figure 9: Potential New Structures under the No Action Alternative

When considering the impacts of implementing the no action alternative, it is assumed that best management practices (BMPs) identified in Appendix L would be applied during construction activities. The BMPs are recognized as industry, state and federal standards for construction activities and have been accepted as a best practice to minimize impacts. Some examples of BMPs include but are not limited to: use of silt fencing to limit soil migration and water quality degradation; refueling and maintenance of vehicles and equipment in designated areas to prevent accidental spills and potential contamination of water sources and the surrounding soils; and limiting idling of vehicles and equipment to reduce emissions. If the BMPs are not implemented, the impacts described in the FWOP section would minimally increase. However, the resulting impacts would not rise to the level of significant.

2.13 Land Use

Land ownership will not change significantly in the No Action Alternative other than some transfers of private land and clearing of forests in timber tracts. Public lands will likely remain under the auspices of owner agencies. However, from an ecological perspective the No Action Alternative may manifest itself in terms of cutoffs, head cuts, and new failure pathways that could alter future land types and ecosystems. Land use would gradually convert from bottomlands to open water or dry channels as head cuts develop. The Ark-White Study estimated that land use on 156 acres would change because of activities associated with continued maintenance, reconstruction of the Melinda Structure, the construction of three new future structures, and future head cutting. In addition and as noted previously, if existing containment structures fail and a cutoff channel forms, 200 acres of bottomland hardwood would be destroyed without recovery over the period of analysis.

2.14 Air Quality

Construction of new containment structures and potential construction activities associated with closing a cutoff might include new access roads, site clearing, and transportation of personnel and equipment; all of which would generate dust and fossil fuel emissions; however, these impacts would be temporary and would not affect NAAQS for the study area.

2.15 Climate

Analysis of climate data from as long ago as 1880, show that the Earth's surface temperature has increased by more than 1.4 degrees Fahrenheit over the past 100 years, with much of the increase taking place over the past 35 years (National Research Council 2012). Warming temperatures are often attributed to an increase in greenhouse gas (GHG) emissions, particularly carbon dioxide, which increased 80 percent between 1970 and 2004 (IPCC 2007).

To model future climate change, scientists use general circulation models (GCM). Climate change analysis becomes more complex for the future than the past because there is not one time-series for climate, but rather many future projections from different GCMs run with a range of carbon dioxide emissions scenarios (IPPC 2007). It is important not to analyze only one GCM for any given emission scenario, but rather to use ensemble analysis to combine the results of multiple GCMs and quantify the range of possibilities for future climates under different emissions scenarios. Human population growth and related GHG emissions and changes in land cover have been modeled under various scenarios to project future trends for global temperature and precipitation.

2.15.1 Predicted GHG Emissions Changes

In May 2008, the Center for Climate Strategies (CCS) completed a GHG emissions inventory and reference case projection to assist in understanding past, current, and possible future GHG emissions in Arkansas (CCS 2008). The report found that GHG emissions are rising faster than those of the nation as a whole. As is common in many states, the electricity and transportation sectors have the largest emissions and their emissions are expected to continue to grow faster than other sectors. The study also found that from 2005 to 2025, emissions associated with electricity generation to meet both in-state and out-of-state demand are projected to be the largest contributor to future emissions growth, followed by emissions associated with the transportation sector. Other sources of emissions growth include the residential, commercial, and industrial fuel use sectors, the transmission and distribution of natural gas, and the increasing use of hydrofluorocarbons and perfluorocarbons as substitutes for ozone-depleting substances in refrigeration, air conditioning, and other applications.

In 2008, Arkansas completed a Climate Action Plan with assistance from the CCS. Arkansas' plan focuses exclusively on the reduction of GHG, including a comprehensive set of sector-based policies and measures. Its design is consistent with the national climate proposal passed in the U.S. House of Representatives, but includes more specific listings and provisions for specific sector based policies and measures, but less specificity on design of national market-based mechanisms.

2.15.2 Predicted Temperature Changes

The Nature Conservancy's climate wizard is an interactive web tool that incorporates data from IPCC climate models and can be used to assess how climate has changed over time and to project what future changes might occur in a given area. It uses a non-parametric quantile-rank approach that maps out the 0 (minimum), 20, 40, 50 (median), 60, 80, and 100^{th} (maximum percentiles). The following information is from the Climate Wizard for changes in mean temperature and precipitation for Arkansas using an ensemble of GCMs and the three most widely accepted emissions scenarios (A2, A1B, and B1) for 50 years into the future.

Global temperatures are expected to increase 3 to 12 degrees Fahrenheit by 2100, while projections for the U.S. Southeast show a temperature increase of 4 to 8 degrees Fahrenheit over the same time period (IPCC 2007). In Arkansas, average annual temperatures by 2050 are expected to increase under each emissions scenario. The most significant increase is predicted under the moderate emissions scenario (5.1 degrees Fahrenheit). Under this scenario, the change in temperature is more widespread across the state. Under the high emissions scenario, an average increase of 4.9 degrees Fahrenheit is anticipated, with a higher increase in the northwest part of the state. Even with a dramatic decrease in emissions under the B1 scenario, the average annual temperature is predicted to increase by 3.6 degrees Fahrenheit.

Major consequences of warming include a significant increase in the number of hot days (above 95 degrees Fahrenheit) each year and an overall decrease in freezing events and frosts. More heat and less cooling may occur and result in more heat-related deaths, more vector-borne illness and a major shift in plant species (EPA 2016). Plant growing seasons would likely become longer and the types of plants that can survive may change.

2.15.3 Predicted Precipitation Changes

Global predictions for precipitation changes into the future point to an overall decrease. However, the Climate Wizard projects slight increases or decreases in Arkansas depending on the emissions scenario used. The average change in precipitation for Arkansas by 2050 is predicted to be +1.65 percent, -0.79 percent, and +1.74 percent under the A2, A1B, and B1 scenarios, respectively. Under each scenario, the southern portion of the state would see the greatest decrease in precipitation (not in the study area).

Though there is a great deal of uncertainty among the scenarios in projected precipitation amounts, rising temperatures will account for an increased rate of evapotranspiration and a decrease in available water (Kunkel et al. 2013, Carter et al. 2014). Further, climate change models project that precipitation will be produced in fewer and heavier rainfall events. If so, this could lead to a decrease in aquifer recharge because more rainfall would be lost to runoff and could also result in an increase in both drought and flooding events. The southeast region is thus predicted to see a significant reduction in water availability (Carter et al. 2014).

2.15.4 Predicted Streamflow

Team hydrologists relied on the Climate Preparedness and Resilience COP Applications Portal to analyze potential impacts of climate change as directed in ECB No. 2016-25. Two tools are available for this purpose:

1) The Non-stationarity Detection Tool (NDT) that enables users to apply a series of statistical tests to assess the stationarity of annual instantaneous peak streamflow data series at any USGS streamflow gage site with more than 30 years of annual instantaneous peak streamflow records; and,

2) The Climate Hydrology Assessment Tool (CHAT) that allows users to access both existing and projected climate data to develop repeatable analytical results using consistent information. CHAT guides users through the process of developing information and supplies graphics suitable for use in a report including: trend detection in observed annual maximum daily flow, and trend detection in annual maximum monthly flow models.

Both NDT and CHAT indicated that there are no statistically significant trends in annual peak instantaneous streamflow or projected annual maximum monthly flows in the selected gages upstream and downstream of the study area. See Appendix B for NDT and CHAT results.

2.15.5 Extreme Weather Events

The changing climate may increase inland flooding, particularly in communities along major rivers and in the study area. Since 1958, the amount of precipitation falling during heavy rainstorms has increased by 27 percent in the southeast and the trend toward increasingly heavy rainstorms may continue. The risk of flooding along the Mississippi River may also increase because the Midwest, which drains into the river, is also becoming wetter. Both annual rainfall and stream flows in the Midwest are increasing, and that trend is likely to continue (EPA 2016). Increase in flooding along the Mississippi River would be expected to back up into the Arkansas and White rivers causing significant head differentials as is seen under exiting conditions. The more intense or a higher frequency in flooding would be expected to increase the probability of overtopping, flanking, and/or seepage of existing containment structures that could result in a catastrophic breach.

Although climate change may increase the risk of flooding, droughts might become more severe. Droughts may be more severe because periods without rain will be longer and very hot days will be more frequent. Droughts pose challenges for water management and river transportation. If the spring is unexpectedly dry, reservoirs may have too little water during the summer resulting in the inability to maintain reliable and safe navigation depths, narrowed navigation channels, and forced lock closures. If droughts become more severe, restrictions on shipping may be implemented (EPA 2016).

2.15.6 Habitat Change

2.15.6.1 Terrestrial Habitats

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Arkansas, although the composition of those forests may change. Habitats that are drought-tolerant such as glades and barrens, dry upland forests, and open woodlands and savannas could fare better under future projected climate scenarios. These conditions are projected to cause an increase in the frequency and intensity of wildfires, thus potentially expanding these communities and improving habitat conditions for association of species of greatest conservation need (AGFC 2015).

Changing climate conditions may cause existing tree species to expand northward and be replaced by species from the south. Mesic forests would be more at risk to compositional changes due to drier conditions (AGFC 2015). Some of the species associated with these forests, such as sugar maple, would be expected to decrease (Brandt et al. 2014). The dominance in these communities would shift to more tolerant species, such as sweetgum, white oak, and red maple. Forests in general would experience a reduction in forest productivity, basal area, and canopy cover, if trees are stressed by higher temperatures and more droughts. Climate change is also likely to increase the damage from insects and diseases. However, longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors (EPA 2016).

Bottomland systems could be negatively impacted by the reduction of water coverage and altered hydrology. Upland forest cover in this system would be expected to increase with extended periods of dry weather and reduced water coverage. Seasonal/herbaceous wetlands and ephemeral ponds would especially be at risk for contraction and reduced habitat quality.

With overall warmer temperatures, conditions would be favorable for more non-native plant species from sub-tropical regions to invade communities (AGFC 2015). This would be especially true in areas where native species decline. Invasive non-native species would be an increased threat to all terrestrial habitats.

2.15.6.2 Aquatic Habitats

Aquatic systems could see substantial impacts from a changing climate. A reduction in available water, either due to decreased precipitation or increased evapotranspiration, would result in reduced stream flows and altered hydrology under the scenario in which there is a slight decrease in precipitation (AGFC 2015). Under the increase in precipitation scenarios, there would be, at a minimum, a temporary increase in aquatic habitat where conditions allow (i.e., river training has not occurred).

Warmer air temperatures would result in increased water temperatures and reduced dissolved oxygen (Meyer et al. 1999). Warmer temperatures can also increase the frequency of algal blooms, which can be harmful and further reduce dissolved oxygen. Summer droughts may amplify these effects, while periods of extreme rainfall can increase the impacts of pollution on streams, such as increased sedimentation, turbidity, nutrient loading and agricultural run-off (EPA 2016).

2.15.7 Impacts from FWOP Actions

Under the FWOP, actions would involve relatively small-scale construction activities and renovation projects occurring over a range of inconsecutive years. These activities would primarily generate GHG emissions as a result of construction equipment operations and other mobile source activities. There are no apparent carbon sequestration impacts that would result under the FWOP, thus the total direct and indirect impacts would be constrained to very small increases in GHG emissions to the atmosphere as a result of construction activities. These small increases would be far below the 25,000 metric ton per year threshold for discussion of GHG impacts (CEQ 2014). In years in which activities are implemented, emissions would incrementally contribute to global emissions for the very limited period of time, but are not themselves of such magnitude as to make any direct correlation with climate change.

2.16 Geologic Resources

Because soil types in the study area are highly susceptible to erosion, future head cutting and excessive erosion and instability upstream, in oxbow lakes, and in tributaries is expected. Soils in the path of the head cut progression would be buried, removed, or inundated resulting in soils and landforms in these areas that would be permanently altered. During head cutting, an excessive amount of sediment is released into the river system, the instability will extend downstream as the newly eroded sediment aggrades in flatter valley reaches.

Active head cutting will continue to the point that it must be stopped to prevent new failure pathways from developing into high risk corridors. Reconstruction in at least four areas in and around the Melinda Structure would be required to mitigate head cutting. Construction activities, including clearing, grading, backfilling, equipment traffic, and restoration of access roads, could adversely affect soil resources. Potential impacts could include temporary and short-term soil erosion, loss of topsoil, short- to long-term soil compaction, permanent increases in the proportion of large rocks in the topsoil, and soil horizon mixing. At the immediate site of the new structures, permanent long-term changes to soils would occur from compaction and conversion to impervious surfaces. At these locations, soil productivity would be lost. In addition, the new structures would alter the existing topography by increasing the elevation of the site.

During reconstruction, soils would be disturbed and the topsoil and several inches of subsoil would be removed to construct the access road and any staging areas. During removal, there is a chance that shallow soil horizons could be mixed, resulting in the blending of soil characteristics and types. Blending would modify physical characteristics of the soil structure, texture, and rock content, potentially leading to a loss of soil productivity and reduced reclamation potential. Compaction due to construction activities, such as grading of the access road, would reduce aeration, permeability, and water-holding capacity of the soils. An increase in surface runoff can be expected, potentially leading to erosion. After heavy precipitation events, particularly if overbank flooding occurs, additional soil impacts from water erosion may occur. When water saturated segment(s) on the access road become impassable, vehicles may still be driven over the road. Consequently, deep tire ruts would develop. Where impassable segments are created from deep rutting, unauthorized driving may occur outside the designated access roads. Wind erosion would be expected to be a minor contributor to soil erosion with the possible exception of dust from vehicle traffic during construction.

Upon completion of the structures, the topography of the area would be permanently altered to a higher elevation than under the existing condition.

2.16.1 Prime Farmlands

As discussed in Chapter 2, much of the study area has soils with prime farmland characteristics. Coordination with the NRCS indicated that "Farmlands of Statewide Importance" are found throughout the project area. Soil impacts described above will likely impact this category as well. In addition to these impacts, there is a large portion of land classified as "Farmlands of Statewide Importance" adjacent to the Historic Cutoff channel and Arkansas River that is in the Arkansas River channel migration path. A geomorphological discussion and assessment is included in Appendix B that describes the lateral migration of the Arkansas River. Based on that assessment, these "Farmlands of Statewide Importance" will likely be eroded by the Arkansas River in the future. Subsequent "land-building" would occur further downstream on an inside bend of the river, thus there may not be a "net loss" of acres, but rather a displacement of them.

2.17 Water Resources

2.17.1 Hydrology

The FWOP alternative would have no impact on the frequency or duration of flooding (Figure 10) within the floodplain when compared to the existing condition; however, the hydrology of the project area has already been severely altered and it is anticipated that the FWOP would not slow or reverse altered hydrologic conditions. There would be no impact to lake recharging or connectivity and channel instability would continue.

Reconstruction of the Melinda Structure as part of the No Action alternative would alter flows exiting the Melinda Corridor. To determine the effects that structure location has on the Melinda Corridor, velocities were first established using a hydraulic model at various cross-sections along the corridor with the structure in its current position. The structure was then replaced approximately 1,000 feet downstream (as anticipated under the No Action alternative). Both locations were also analyzed to determine what effects the change may have on the Arkansas River. Velocities from both situations were computed at each cross-section from January 1981 through October 1991. Figure 11 displays results from the unsteady flow analysis in the Melinda Corridor just upstream of the Arkansas River. Figure 12 shows the variation in velocities on the Arkansas River at the Arkansas-Melinda Corridor intersection. Negative flows along the Melinda corridor, or flows heading upstream, were small and considered throughout the analysis.

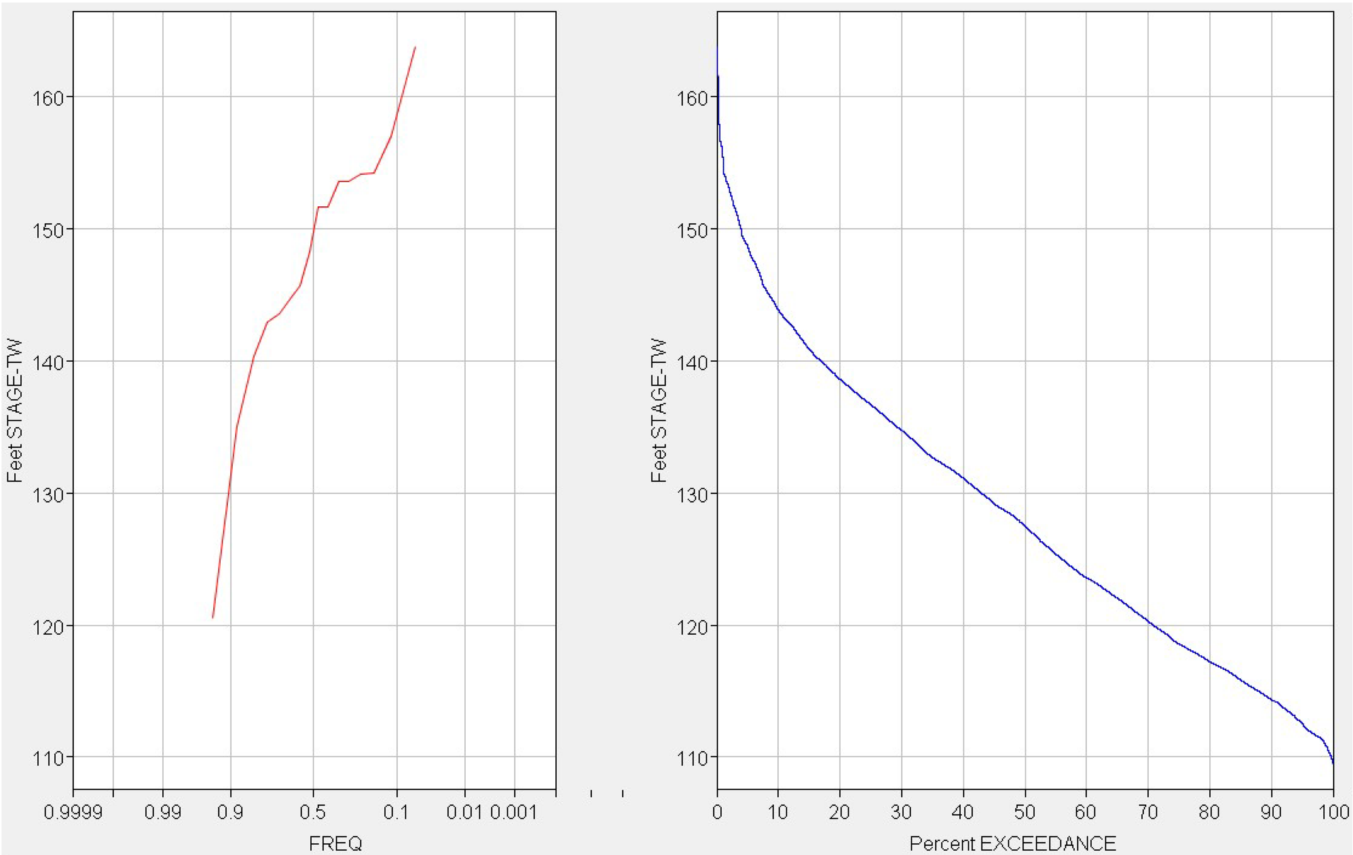

Figure 10: Montgomery Point Lock and Dam Elevation Frequency and Duration.

Resulting velocities from Figure 11 were only taken when the corridor was flowing. The reconstruction produced lower velocities in the Melinda corridor 95 percent of the time. The average percent difference in velocities between the existing condition and reconstruction was calculated to be 3.4 percent with a standard deviation of 4.2 percent. Therefore, the probable percent difference in velocity at the Melinda corridor just upstream from the Arkansas River may range from -0.8 to 7.7 percent. The negative percent difference signifies that the reconstruction produced greater velocities than the existing condition.

The variations in the Arkansas River velocities at the Arkansas-Melinda Corridor intersection were slight. The reconstruction produced lower velocities within the Arkansas River approximately 61 percent of the time when compared to the existing condition. The average percent difference was found to be 0.1 percent with a standard deviation of 0.4 percent, yielding a range of -0.3 to 0.5 percent difference.

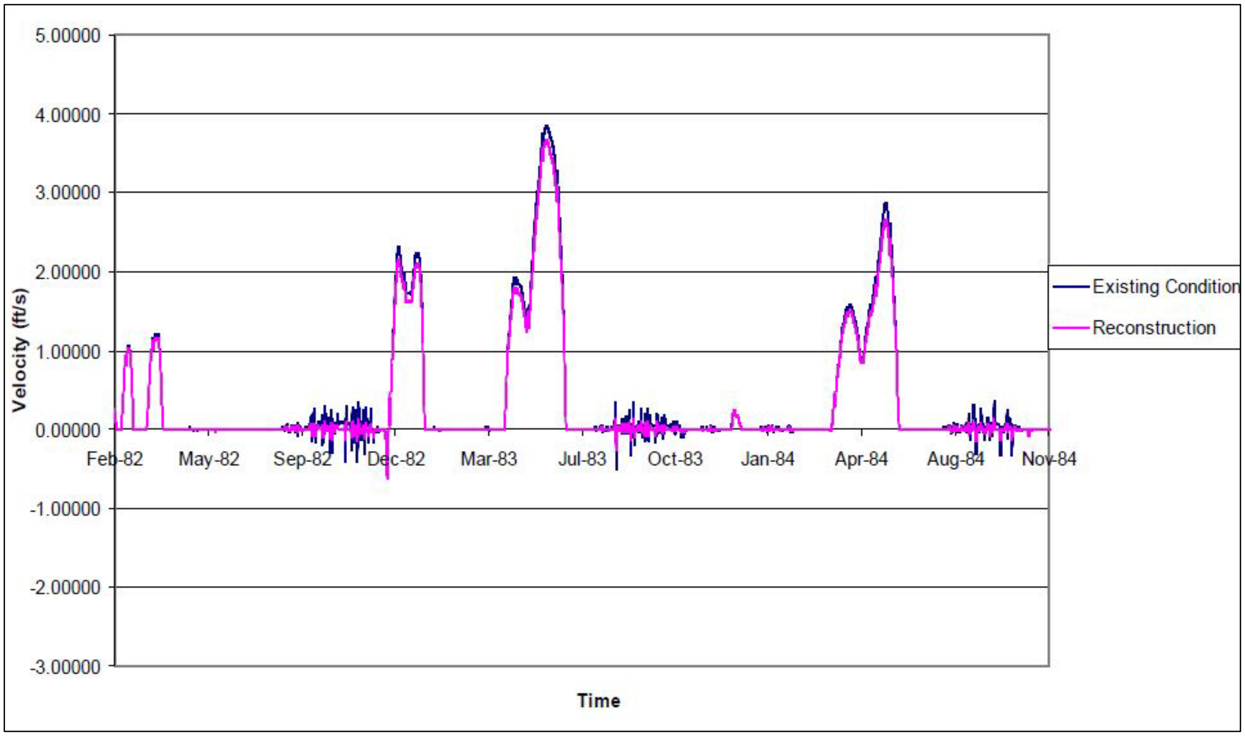

Figure 11: Melinda Corridor Velocities

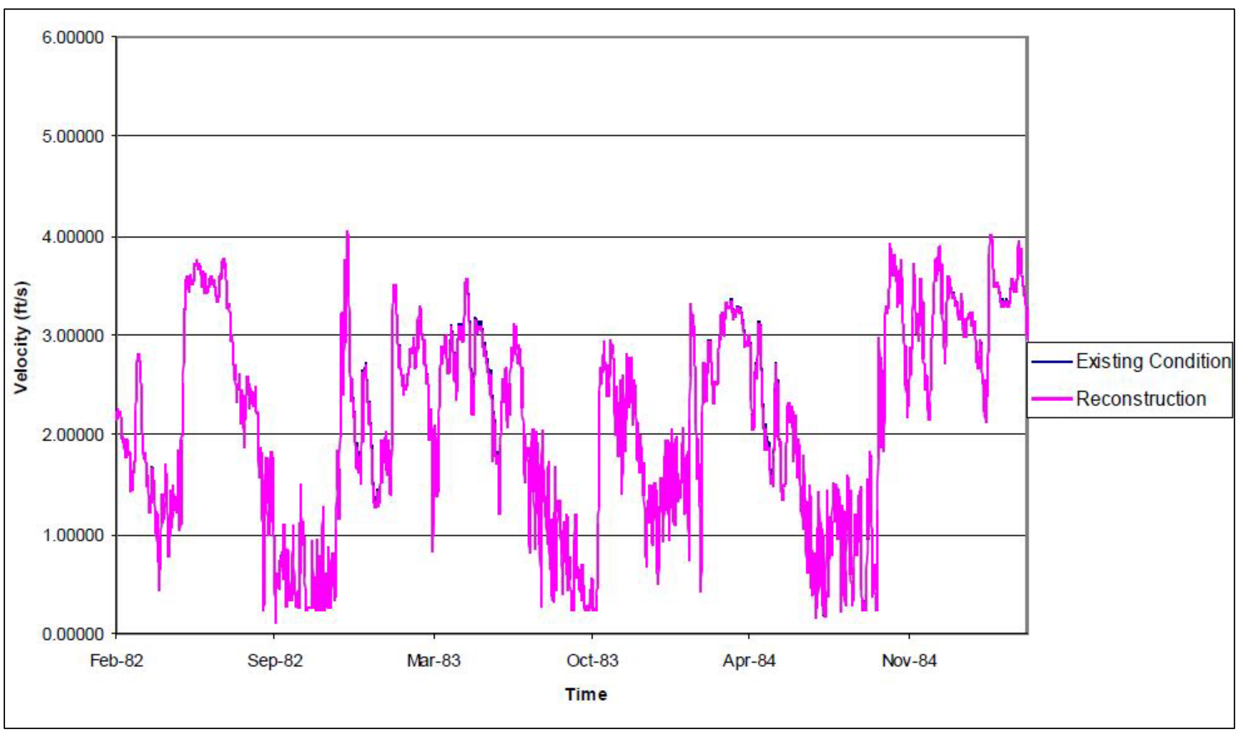

Figure 12: Arkansas River Velocities

2.17.2 Surface Water

As described in the FWOP Land Use section, 156 acres of land would convert to open water or dry channel. Both situations would, at a minimum, temporarily increase surface water availability in the study area. Reconstruction of the four structures would limit the increase in surface water over the existing condition. In the event of a breach, surface water would increase until the breach is closed off and/or the area dries out.

2.17.2.1 Jurisdictional Waters of the U.S.

Under the FWOP, no structures would be placed in a navigable WOTUS; however, reconstruction of the four structures (reconstruction of the Melinda Structure and three new structures) would benefit the Arkansas and White rivers by reducing the potential for a breach that would lead to temporary conditions that are not conducive to navigation. Structures would be placed within jurisdictional WOTUS and wetlands.

Repair of existing structures would occur under Nationwide Permit #3 “Maintenance”. WOTUS and jurisdictional wetlands would be directly impacted through reconstruction of the four structures. Impacts include filling in the WOTUS or wetland at the immediate site of each structure, temporary decreased wetland and water quality, and temporary interruption of hydrologic and wetland functioning within the construction footprint at each structure.

Additional Section 404 compliance would be required prior to implementing new construction actions under the FWOP alternative. No indirect or long-term impacts to wetland functions are projected to be incurred under the FWOP.

In the event of a breach, nearly 200 acres of jurisdictional wetlands would convert to open water and or dry channel beds. After the breach is closed off, wetlands would return to wetlands; however, by the end of the planning horizon, the wetlands would be an earlier successional stage of bottomland hardwoods. It is not anticipated that bottomland hardwoods would return to existing conditions within the planning horizon.

2.17.3 Groundwater

Under the FWOP, groundwater resources would not be impacted. Historic recharge is anticipated to continue similar to the existing condition despite reconstruction of the four structures.

2.17.4 Water Quality

As described in the FWOP Geology section, the soils are highly susceptible to erosion leading to bank instability. Bank instability and erosion frequently result in excessive sediment in stream channels. Sediment increases the turbidity of a stream and may adversely affect aquatic life and fisheries through sediment deposition in pools, spawning gravels, and stream-bottom habitat for aquatic invertebrates, and by restricting light penetration necessary for photosynthesis. Excessive sediment may also alter stream channel morphology and change the composition of aquatic habitats and associated fish and macroinvertebrate communities.

Activities during reconstruction of the four structures can modify the existing aquatic habitat, increasing runoff and the rate of in-stream sediment loading and turbidity. Clearing and grading of streambanks, in-stream trenching and backfilling, and trench dewatering can introduce sediment directly or indirectly into the water column causing temporary increases in total suspended solids and sedimentation.

Additionally, accidental spills and leaks of hazardous materials associated with equipment; the refueling or maintenance vehicles; and the storage of fuel, oil, and other fluids can have immediate effects on surface water and could contaminate downstream waterbodies. Impacts associated with spills or leaks of hazardous liquids would be avoided or minimized by restricting the location of refueling (at least 100 feet from a waterbody) and storage facilities and by requiring cleanup in the event of a spill or leak. The contractor would prepare a Spill Prevention, Control, and Countermeasure Plan to minimize potential surface water impacts associated with hazardous materials releases.

2.17.5 Floodplains

Under the FWOP, there would be only minor changes to the floodplains in the immediate area of the structures. This change has not been modeled due to the relatively minor increase. Increases outside the immediate structure site throughout the study area are not anticipated.

2.18 Biological Resources

The Ark-White Study estimated 156 acres of direct impacts from construction of up to three new structures, reconstruction of the Melinda Structure, and habitat loss associated with future head cutting, although impacts could be lower once the structures have been implemented. In the direct project footprint, wetlands would lose functionality during construction in contrast to future head cutting that would cause wetland function to gradually decrease over time as the area converts to open water or dry channel bed.

Under the FWOP, hydrologic conditions would not change, and there would be no impacts to wetland functions or waterfowl habitat. At least one of the new structures and a portion of the reconstructed Melinda Structure would occur on Refuge property; and therefore, is subject to compatibility requirements.

FWOP impacts were incorporated into the Hydrogeomorphic Approach (HGM) analysis conducted for the Ark-White Study. For the current analysis, it was assumed that all impacts are direct and result in a total loss of functionality. Because much of the forest in the impact area is not in a mature, fully functional condition, lost FCUs are less than the total number of acres impacted, meaning that the FCU values for all functions were less than 1.0.

Most of the impact is in the Riverine Backwater subclass, reflecting the small amount of acreage in the Flats class within the impact area, and the relatively poor condition of the impacted Flats forests (Table 9). Under the FWOP, Riverine Backwater would realize a total loss (all functions) of 840 FCUs and a total loss (all functions) of 4.0 FCUs in the Flats wetland class. While these totals are useful for understanding the magnitude of change associated with the alternative, the standard recommendation is to mitigate for the most-impacted function, thereby assuring that all other functional losses have been over-compensated. Therefore, mitigation for the Riverine Backwater class would be based on a loss of 134 FCU for the “Remove Elements and Compounds” function and any of the four functions with a loss of 1.0 FCU for the Flats class. Mitigation needs under this alternative would be refined further prior to re/construction of the four structures.

Table 9. Change in Functional Capacity Units (FCUs) for Riverine Backwater and Flats Wetlands under the FWOP Alternative

	Change in FCU							
Wetland Class	**Detain Floodwater**	**Detain Precipitation**	**Cycle Nutrients**	**Export Organic Carbon**	**Remove Elements and Compounds**	**Maintain Plant Community**	**Provide Wildlife Habitat**	**Total (all functions)**
Riverine	-120	-115	-114	-116	-134	-121	-121	-840
Flats	0	-1	-1	0	0	-1	-1	-4

During construction activities, it is anticipated that there would be a temporary decrease in aquatic habitat quality due to increased sedimentation from work being done in and near open water. During this time, it is anticipated that listed, special status, and non-listed fish and mussels, although to a lesser degree, would avoid the construction area. Fish and mussels that do not or cannot avoid the area are susceptible to mortality caused by heavy equipment. The quality of the habitat is expected to return to existing conditions when construction operations cease, at which time it is also anticipated that fish and mussels would resume their pre-construction use of river-side areas. Construction of the new structures would prevent fish migration into areas behind the structures that are accessible under the existing condition.

Construction-related activities are anticipated to impact listed, special status, and non-listed species, if they occur as a resident, migrant or incidental, within or near the project area. Impacts include habitat removal and/or fragmentation from re/construction of the four structures, associated access road creation, and habitat avoidance because of increased noise, dust generation, and vibrations. Losses of slow moving species (mammals and herpetofauna) are anticipated along the access roads and within the construction footprint. Faster moving species are expected to be able to avoid injury or death while crossing access roads and by avoiding the construction area. In general, most wildlife species would become habituated to the on-going work including adapting to the habitat changes; however, species with a low tolerance to activities are anticipated to be displaced for the duration of activities. The level and duration of the impacts is dependent on the final design of each structure, type of equipment used, duration of construction activities, and plans for restoration activities, if required. It is anticipated that once construction is complete, impacts to wildlife would cease.

For listed species, ESA Section 7 Consultation would be completed prior to any ground disturbance activities. With the level of impact anticipated, the FWOP is not anticipated to rise to the level of "jeopardy."

As with any ground-disturbance activity, the probability of introducing, spreading, and/or establishing new populations of invasive, non-native species, particularly plant species, exists. Contractors would be required to clean all equipment prior to entering the construction area to avoid the spread of invasive into the project area.

If a breach of the existing containment structure were to occur, the previous study estimated a loss of up to 200 acres of bottomland hardwoods with the creation of a cutoff through Owens Lake and Jim Smith Lake. There would be a temporary increase in aquatic habitat until the cutoffs are closed off by construction of the new structures. Impacts during construction of the structures to close off the cutoff would be similar to those described for re/construction of the four structures.

Continued channel adjustment in the lower Arkansas River and erosion in the study area is expected to occur with resultant loss of terrestrial habitat. New sandbars formed as the Arkansas River moved across its floodplain would provide habitat for endangered Least Terns and would eventually develop into willow bars, cottonwood forests, and finally riverfront hardwood communities.

2.19 Cultural Resources

There would be no change in cultural resources in the FWOP. However, as stated in the Geologic Resources section, soil types in the area are highly susceptible to erosion, which will lead to future head cutting, excessive erosion and instability upstream, in oxbow lakes, and in tributaries. These conditions could impact unidentified cultural resources. Prior to rehabilitation of existing structures or constructing new containment structures as expected with the FWOP, cultural resources would again be considered under Section 106 of the National Historic Preservation Act and other relevant laws. If necessary, USACE would conduct field work to avoid, minimize or mitigate adverse effects to significant cultural resources as required for those undertakings.

2.20 Recreation and Aesthetics

For the safety of both the public and construction workers, recreation would halt in the immediate vicinity of construction areas during construction of new containment structures. This will be made a contract provision for any construction projects. Recreationists in the general area, and recreationists may experience increased noise from equipment that could impact their ability to seek solitude, or may reduce the success of wildlife dependent recreation activities such as hunting. During construction, similar recreation opportunities would remain available on adjacent lands, and once construction finished, conditions would return to baseline.

The aesthetic value of the area suffers each time there is any intrusion in the natural environment by man-made structures. The primary issue associated with visual resources is the degree of visible change that may occur in characteristic landscapes, viewsheds, and areas with high scenic value. Construction can introduce differing elements of form, line, color, and texture into the landscape through construction or placement of features such as roads, structures, equipment, or manipulation of vegetation. Effects can also result when actions change scenic integrity or result in conditions that produce unattractive landscapes.

Impacts associated with the FWOP on aesthetics include visibility of constructed structures and temporary roads. Vegetation clearing to construct the structures and temporary access roads and the structures themselves would present an obvious contrast in color with the surrounding vegetation. The cleared areas and structures may be visually prominent at foreground and middle ground distance zones. These areas would be most obvious immediately after construction. The structures have the greatest potential to permanently alter visual conditions, while impacts from the access roads would be temporary, but could remain on the landscape for a decade or more. Impacts from temporary roads would decrease as the disturbed surface began to blend in color, form, and texture as natural reclamation occurs. Final structure height will play a significant role in determining the level of long-term visual impacts. Based on preliminary designs, visual disturbance would be limited to those who travel by foot through the area or by watercraft on the White or Arkansas rivers. The height of each of structure is low enough so that surrounding bottomland hardwoods would mask the structures from other areas. Short-term impacts may occur where construction equipment and dust would be visible to observers. The same impacts would occur during repair and rehabilitation of new containment structures.

2.21 Transportation

2.21.1 Highways, Roadways, and Railways

Under the FWOP, additional temporary roads would be constructed to access the locations of the four structures. The access roads would be closed to the public during and after construction. The roads would not be maintained after construction is done and allowed to naturally restore. Access road(s) to the new structures may be reopened if future repair is required; however, after work is complete the road would again be allowed to naturally restore. In the event of a breach of the existing containment structure, existing roads in the flow path would be washed out and remain inundated until flood waters recede and a close-off structure is constructed.

2.21.2 Navigation

If a cutoff formed between the Arkansas and White rivers in the project area, on average 130 of the 260 days required for repair and closure of the cutoff would be non-navigable with a standard deviation of 41 days. Given the hydrologic dynamics of the river system, the estimated number of non-navigable days is not consecutive. The number of non-navigable days assumes that either water surface elevation in the entrance channel was less than 105.5 feet msl leading to draft constraints for barges, or flows through the cutoff exceeding 50 percent of upstream White River flows resulting in unnavigable cross currents in the navigation channel near the cutoff. Navigation between ports upstream of the study area would continue; however, much of the traffic coming from and going to the Mississippi River would halt during the repair period. In the event of an extended period of closure, shippers would respond in a number of ways including, but not limited to: holding shipments until the MKARNS is opened, rerouting through other waterways, or shipping cargo by truck or rail. Under the FWOP, if a cutoff forms, there would be significant adverse impacts to navigation. See Appendix A for more detailed information on the impacts to navigation from a breach.

2.22 Socioeconomics and Environmental Justice

2.22.1 Socioeconomics

Socioeconomic impacts are assessed in terms of direct effects on the local economy and population, and related indirect effects on other socioeconomic resources within the study area or adjacent to the study area, in this case, Arkansas and Desha counties. Socioeconomic impacts would be considered significant if the alternative resulted in a substantial shift in population trends or notably affected regional employment, earnings, or community resources such as schools.

Construction activities would be expected to directly affect the local economy through a temporary increase in economic activity in the construction sector. Temporary increases in employment, income, business activity, and local tax revenues would be anticipated in years in which re/construction of the structures are implemented, so there could be up to four independent periods of temporary increase. No permanent change in population or demand on local public services would be expected.

No negative impacts associated with reduced recreation, in particular hunting and fishing opportunities, are anticipated as public access to the NWR and WMA would be maintained. In the event of a breach, adverse impacts to socioeconomics could be expected due to the inability of barges to navigate the MKARNS (see Future without Project Condition—Transportation section).

2.22.2 Environmental Justice

Environmental justice impacts are assessed in terms of direct effects on overburdened populations (i.e., minorities, Indian tribes, low-income residents, and children) within or adjacent to the study area. Environmental justice impacts would be considered significant if impacts related to the various resource sections analyzed would result in disproportionate impact to the identified populations.

Desha County has been identified as an Environmental Justice population. Most of the communities are greater than 10 miles from the project areas, therefore it is very unlikely that implementation of re/construction of the four structures would impact these communities. Although recreational opportunities, particularly hunting and fishing, would be temporarily reduced in the immediate project area, similar opportunities are available in adjacent public lands. No access to public lands or associated recreational areas would be impacted.

Because there are no schools or parks in the vicinity of the project area, nor are there any children residing in or near (>2 miles) the project area, implementation of the no action is not anticipated to disproportionally affect children.

2.23 Hazardous, Toxic and Radioactive Waste

Because there are no existing HTRW sites, there would be no change under the FWOP. Some of the cargo shipped through the project area is considered HTRW (e.g. benzene, toluene, caustic soda, methanol, ammonia, gasoline, jet fuel, fuel oil, petroleum coke, asphalt, and fertilizer). Under the FWOP, there is a chance that HTRW could be introduced to the project area if the cargo spilled overboard or a navigation accident occurred. If this situation arises, immediate action would be taken to contain the spill to the smallest area possible and clean-up would be implemented as soon as possible following all clean-up laws, rules, and regulations. Remediation of the impacts to the surrounding environment would likely be implemented following the clean-up actions.

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3 PLAN FORMULATION

Plan formulation and evaluation of alternatives used for this study are conducted in accordance with the USACE Planning Guidance Notebook (Engineer Regulation 1105-2-100) which emanates from the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, which were approved by the U.S. Water Resources Council and the President in 1983, pursuant to the Water Resources Planning Act of 1965 (Public Law 89-80).

Based on guidance and policy, USACE has a well-defined six-step process used to identify and respond to problems and opportunities associated with federal water resources planning objectives, and specific state and local concerns:

1. Identify Problems and Opportunities
2. Inventory and Forecast Conditions
3. Formulate Alternative Plans
4. Evaluate Alternative Plans
5. Compare Alternative Plans
6. Select Recommended Pan

Chapter 3 describes development of measures and alternatives to address study problems and objectives. Alternatives are compared to a No Action plan (synonymous with the Future without Project Condition), and alternatives with greater outcomes than the No Action Plan were compared to one another to identify a plan with the greatest net economic benefits to the nation.

3.1 Study Problems and Opportunities

Problems are undesirable, negative conditions, and opportunities are achievable desirable conditions in the future. Conditions are those expected to exist during a forecasted period of analysis. Problems are forecasted for conditions expected to exist in the absence of a federal project recommended in a study, while opportunities are projected for conditions expected to exist with a federal project. Plan formulation generally uses a 50-year period of analysis based on an expected lifecycle of a project. The Three Rivers Study period of analysis runs from 2025 through 2075, which would allow time for construction of the proposed plan after project authorization. Benefits begin to accrue after project construction.

3.1.1 Conditions Summary

Over time, modifications to the Mississippi River such as dredging, stone bank stabilization, and removing bendway cutoffs[7] has steepened the stream slope and accelerated water velocities in the river causing an immediate flowline lowering during higher flows near Arkansas City (35 miles downstream of the mouth of the White River), and a migration of the Mississippi into the White River. This had two effects: 1) the

[7] Bendway removal effectively shortened the Mississippi by about 150 miles between Memphis, Tennessee and Old River, Louisiana.

White connects to the Mississippi at a higher water surface elevation than it had previously, and 2) the shortened White River stream length results in a shorter backwater response time in the Historic Cutoff; the natural path by which waters of the White historically flowed across to the Arkansas and vice versa. Changes in the Mississippi allowed more water to flow through the Historic Cutoff because it was closer to the Mississippi River in stream distance and because the mouth moved upstream to be affected by a higher Mississippi River stage.

The risk of a cutoff forming between the White and Arkansas rivers is caused by head differentials that occur when one or both rivers rise above their banks. When one or both rivers are out of bank, flood waters tend to flow overland across the isthmus along several paths of least resistance. The primary source of overtopping flows is the Mississippi. When water elevation on the Mississippi reaches a certain level, it forces backwater into the White River, and this water would overflow across the isthmus into the Arkansas since the Mississippi backwater response time is shorter on the White than on the Arkansas. Occasionally, flooding results in flows from the Arkansas to the White. As flood waters move overland, the ground surface erodes as the head cutting process takes place. Eventually a new water course, or cutoff, may form that would redirect part or all of one river’s flow to the other river.

While USACE constructed the existing Containment Structure System in the project area to address potential uncontrolled flows between the rivers, subsequent cutoffs have been developing due to head differentials between the two rivers. This geomorphic process continues to threaten the MKARNS and costs to maintain and repair existing structures are increasing and becoming more frequent. If a cutoff forms, navigation through the study area would cease for extended periods (i.e. over 100 days) due to dangerous cross currents during high flows, and draft constraints during low flows. In addition, sediment deposition would increase dredging requirements, and an estimated 200 acres of bottomland hardwood forest would be lost as it is converted to open water due to a breach.

Specific planning problems and opportunities are described below.

3.1.2 Problems

1. Due to overtopping and erosion, existing Containment Structure System requires significant and frequent OMRR&R.
2. A breach in the existing Containment Structure System and subsequent formation of a cutoff would make navigation through the project area very unreliable.
3. Construction of the existing Containment Structure System has impaired the function of the oxbow lakes in the project area.
4. A cutoff would damage or destroy approximately 200 acres of bottomland hardwood forest ecosystem.

3.1.3 Opportunities

1. Contain head cutting and reduce the risk of a cutoff forming in the project area and reduce OMRR&R costs for containment structures.
2. Reduce the risk of extended navigation closures.
3. Restore, to the extent practicable, functionality of impaired oxbow lakes.
4. Reduce the risk of damages to sensitive bottomland hardwood ecosystem resulting from the formation of a cutoff.

3.2 Planning Goal and Objectives

Objective statements provide a qualitative or quantitative metric used to evaluate measures and alternatives identified to achieve desirable conditions described by opportunity statements. The goal of the study is to formulate a means to ensure long-term sustainable navigation on the MKARNS, and specific objectives over the period of analysis are to:

1. Reduce OMRR&R costs for containment structures in the project area.
2. Reduce the likelihood of cutoff formation in the project area.
3. Restore hydrologic connectivity to oxbow lakes in the study area.
4. Reduce the risk of damages to the bottomland hardwood forest ecosystem in the isthmus.

3.3 Planning Constraints

Constraints can be *universal constraints* that would apply to similar categories of studies and *study specific constraints* that are unique to an individual study. Planners formulate alternatives to achieve objectives and avoid constraints. Universal constraints (not listed below) include applicable laws, policy, guidance, and other federal government requirements.

Because a significant portion of the study area is owned and managed by the USFWS, the PDT engaged USFWS personnel from the Refuge and the USFWS Arkansas Field Office in Conway, Arkansas as well as staff from the AGFC and ANHC throughout the study process. Interagency coordination has ensured stakeholder concerns were identified and considered throughout plan formulation. As a result, the PDT has identified one study specific planning constraint:

To avoid changes to project area hydrology to the extent practicable.

Through the planning process, project alternatives were developed to meet navigation objectives and to provide ancillary ecosystem restoration benefits, or at a minimum, to not significantly alter forest hydrology in the study area without regard to ownership boundaries.

3.4 Special Planning Considerations

As noted previously, the project area is adjacent to the Refuge. A portion of the Refuge lands intersect the footprint of existing containment structures and some construction resulting from this study would take place on the Refuge (Figure 13). The Refuge contains 160,000 acres of prime bottomland hardwood habitat in the floodplain of the lower White River next to the navigation channel. The Refuge is a small part of a larger expanse consisting of over 500,000 contiguous acres of bottomland hardwood forest ecosystem, of which over 250,000 acres have been recognized by the Convention on Wetlands of International Importance (Ramsar Convention). Bottomland hardwood forests in the area flood frequently and are highly influenced by changes in land or water elevation.

USFWS manages the Refuge, pursuant to the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-6689ee), reviews and issues compatible use permits for construction on Refuge land. Because of the proximity of the forest ecosystem to the navigation channel and containment structures, modifications to the structures could impact the forest, through changes in hydrology resulting from containment structure placement and function. For this reason, plan formulation considered changes to hydrology that could result from a given measure; and, where practicable, provide environmental benefits to bottomland hardwoods, wetlands, and oxbow lake functions in the isthmus and in the Refuge while preserving the integrity and long-term dependability of the navigation entrance channel to the MKARNS.

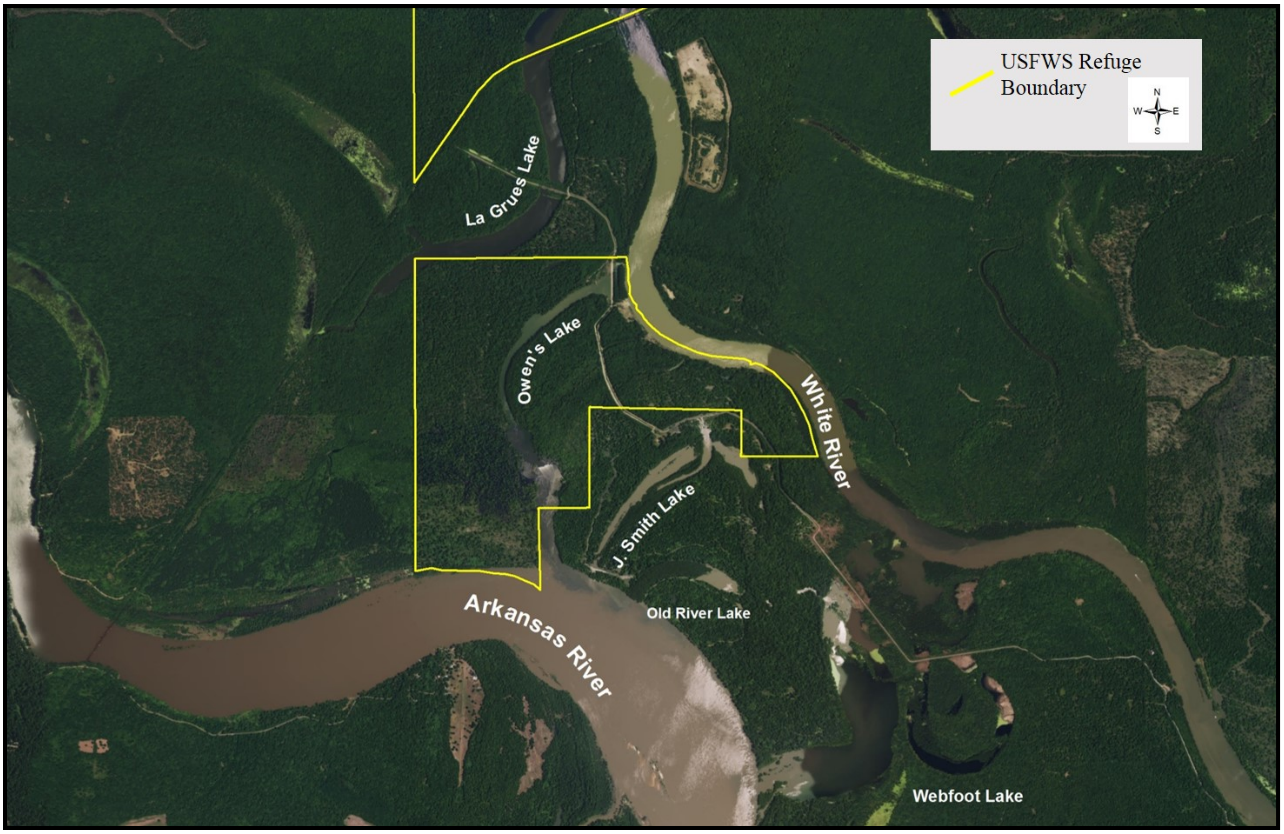

Figure 13: USFWS Refuge Boundary in Relation to Project Area

3.5 Development and Screening of Measures

Plan formulation began with a review of measures considered during the Ark-White Study, meeting with agencies and the public, and industry surveys and interviews. Measures are generalized concepts or approaches that may address one or more opportunities. Measures from the Ark-White Study were screened again and further developed with a focus on goals, problems and opportunities outlined above.

Since there are limited historical precedents for a long term disruption in navigation in the study area, USACE conducted industry surveys and interviews via a contract with Gulf Engineers and Consultants, LLC (GEC) who have extensive knowledge of the MKARNS and maritime industry contracts. USACE received approval from the Federal Office of Management Budget to conduct interviews in July of 2016 and GEC conducted fieldwork in the summer and fall of 2016. Interviews focused on how unplanned navigation disruptions might affect the industry, and was conducted in person via interviews with key port personnel, terminal operators and shippers. More details about industry surveys and interviews can be found in Appendix A – Economics.

3.5.1 Measures Carried over from the Ark-White Study

The Ark-White Study developed an array of measures and alternatives including:

1. **No Action**: As required by NEPA, the No Action alternative is the most likely condition expected to occur in the future in the absence of the proposed action. In this case, no long-term solutions to the problem affecting the continued reliability of navigation on the MKARNS would be recommended for congressional authorization and funding. The No Action alternative was considered in the Ark-White Study and carried forward throughout formulation to ensure any plan considered for selection would be better than taking no action.

2. **Restore Natural Historic Hydrology with a Relief Structure**: Release flows to the Arkansas River to raise the river and decrease head differentials, which would effectively restore the natural hydrology and Historic Cutoff channel that USACE closed in the early 1960s. Decreased head differentials would also reduce erosive forces and the need to maintain the Melinda and Jim Smith Lake structures. Measure 2 would consist of an active gated structure similar to the others on the navigation system, or a passive weir.

3. **Modify Owens Lake and Melinda Corridor:** Reconfigure and enlarge existing containment structures and channels, including stabilizing banks, for prolonged stability and increased conveyance as needed to withstand head differentials.

4. **Combination of Measures 2 and 3:** Construct Melinda Corridor enhancement (Measure 3) coupled with a controlled opening of the Historic Cutoff (Measure 2) for increased efficiency at reducing head differentials and periods of potential navigation closures due to cross currents.

5. **Combination of Measure 2 and Remove Soil-cement Dike:** Construct a gated or weir structure as described in Measure 2 and remove a large portion of the existing soil-cement dike. The premise would be to balance stages of the Arkansas and White rivers while restoring the area to better mimic its historical condition. If Measure 1 balanced river stages, the need for the existing soil-cement dike would decrease. Owens Lake Structure and approximately 1,000 feet of the structure north of Jim Smith Lake would remain to prevent possible erosion in this high risk area (i.e., risk of cutoff formation).

6. **Raise or Extend Existing Soil-cement Dike:** Raise the existing soil-cement dike and the Owens Lake Structure to an elevation where head differentials are low enough to minimize or eliminate damage by effectively separating the Arkansas and White rivers. The Owens Lake Structure overtops where flow is confined in the Owens Lake Melinda channel corridor until the White River exceeds an elevation of 150 feet. At this elevation, the entire structure submerges and flow usually comes from the White and flows into the Arkansas with great force, depending on the Arkansas River's stage. Raising the dike

would further divide the White and Arkansas rivers and reduce the regularity of the White overtopping the structure and resultant erosive forces while it flows toward the Arkansas River. When the dike overtops, head differentials would likely decrease and a deeper plunge pool on the Arkansas River side would help absorb erosive energy. The dike would be extended upstream along an existing road adjacent to the White River and connect to high ground near Lock 2 to minimize damage when flow is directed around the ends of the dike.

7. **Operational Changes:** Create an operational plan that equalizes surface water elevations on the White and Arkansas rivers (i.e., non-structural approach to minimize head differentials).

8. **Construct Dam on the lower Arkansas River:** The dam would raise water levels on the Arkansas River, thereby reducing head differentials between the White and Arkansas when the Arkansas would normally be lower. However, this measure would require additional levee systems and the dam would need to be larger than most of the dams currently operating on the Arkansas River.

9. **Setback Levees:** Expand the width of the Arkansas, White and Mississippi river floodplains to decrease river stages and head differentials by allowing water to spread over a larger area. This would also create wetland habitat.

10. **Stabilize Riverbanks to Allow Cross Flow Overbank Spillage:** Stabilize banks on the Arkansas River to prevent further bank migration toward the White River and allow overbank flow from the White River.

11. **Non-overflow Dike:** Raise and extend the existing soil-cement dike to prevent 100-year frequency Mississippi River stages from overtopping and separating the Arkansas and White rivers. The elevation would be approximately 170 feet (20 feet higher than the existing soil-cement dike).

12. **Shorten Stream Distance on Arkansas River from the Melinda Corridor to Mouth:** If the Arkansas were modified to move its mouth upstream closer to the mouth of the White River, the influence of the Mississippi River would be similar on both the Arkansas and White rivers; and thus, head differentials would significantly decrease. Today, the mouth of Melinda Corridor is approximately 17 miles upstream from the mouth of the Arkansas, which is 20 miles downstream of the mouth of the White. The Arkansas is typically lower than the White during high Mississippi River stages because of the distance from the Mississippi and the Mississippi's stream slope.

13. **Grade Control Structures:** Grade control structures are weir-type structures, such as the Melinda and Owens Lake structures, that help minimize surface water elevations and help control water surface slopes and water velocities, and thus erosion.

14. **Additional Structures near Jim Smith Lake:** Jim Smith Lake provides an unobstructed path between the soil-cement dike and the Arkansas River. Additional structures would slow water velocities and erosive forces and could significantly reduce the chance of a cutoff.

15. **Allow Multiple Smaller Flow Paths (Historic, Melinda, and La Grues corridors):** Remove a portion of the existing soil-cement dike to allow more flow from the White River to cause a rise in the Arkansas River, thereby reducing head differentials. This measure is similar to restoring natural historic hydrology, but would release water to the Arkansas River at a significantly lower rate.

16. **Long-term Research and Monitoring:** Research and monitoring would allow technology and additional experience managing the area to help make a more informed decision to resolve regional bank instability and head cutting in the watersheds of the White, Arkansas and Mississippi rivers that are threatening ecosystems, navigation, recreation, flood damage reduction and watershed protection.

The Ark-White Study team screened the above measures and alternatives based on technical, environmental and economic completeness, effectiveness, efficiency and acceptability. Thirteen of the 16 were screened from further consideration for the following reasons:

- **Measure 3: Modify Owens Lake and Melinda Corridor (additional weirs or replacement).** Measure would not have provided a long-term solution, and thus was incomplete. Additional structures would have been needed near Jim Smith Lake in addition to the three new structures described in the future without project condition. In spite of these structures, there would still be significant OMRR&R costs for existing containment structures, and a high risk of structure failure and cutoff formation.

- **Measure 4: Combination of Measures 2 and 3.** Although Alternative 2's restoration structure would have reduced flows through the Melinda Corridor, the Melinda Corridor would need to pass at least its original capacity of flow in order for the Alternative 2 structure to be reduced. Because the channel is undersized for flow capacity, structures would have to have been significantly larger. Total costs for the reduced Alternative 2 structure and enlarged Melinda Structure would have been more than the original Alternative 2 structure. Therefore, Alternative 4 was eliminated as it was not technically feasible or economically efficient.

- **Measure 5: Combination of Measure 1 and Removal of the Soil-cement Dike.** Alternative was carried forward for the second round of screening in the Ark-White Study, but was eventually eliminated due to high construction costs compared to the net benefits gained.

- **Measure 7: Operational Changes.** During the Ark-White Study, a hydraulic investigation concluded that the Arkansas River could not be raised during low flows because of the navigation pool upstream of Dam 2. The investigation involved researching flood wave travel times from regulated projects to the study area. White River dams are over 220 miles upstream, and Arkansas River dams are not designed to store flood waters. Any operational changes on the Arkansas and White rivers were deemed insignificant compared to a relatively high Mississippi River that controls water surfaces in the study area when erosion occurs. Therefore, Alternative 7 would have been ineffective.

- **Measure 8: Dam on the Lower Arkansas River.** Measure 8 would have involved damming water at least 10 feet above the Arkansas River's top bank, which would have required levee modification, real estate acquisition and other requirements of constructing a large structure. Increased flooding would have damaged bottomland hardwoods; and as a result, Alternative 8 was eliminated due to significant environmental impacts and high financial costs (i.e., low economic efficiency).

- **Measure 9: Setback Levees.** The land area needed to affect river stages was not economically feasible considering high real estate costs, loss of crop production due to inundated land, and substantial expenses of reconstructing levees.

- **Measure 10: Stabilize Riverbank to Allow Cross Flow Overbank Spillage.** A geomorphic study by the Corps of Engineers Engineering, Research and Development Center concluded that bank stabilization was unnecessary to protect existing containment structures. In addition, environmental stakeholders objected to this alternative, and it was incomplete as a long-term technical solution because the hydrologic conditions that would cause a cutoff would not change.

- **Measure 11: Non-overflow Dike.** Measure 11 was eliminated as it was environmentally unacceptable due to changes in hydrology that would have reduced groundwater recharge in wetlands and increased flood elevations. Flooding impacts to the Mississippi River would also have to be evaluated. A lower dike would significantly reduce risk (refer to Alternative 6) because medium-sized Mississippi floods generally cause more problems than large floods approaching the 100-year frequency interval.

- **Measure 12: Shorten Stream Distance on Arkansas River from Melinda to Mouth.** Measure 12 would have significantly altered wetlands and aquatic habitats by clearing a path for the channel and indirectly by increasing sedimentation and bank erosion in downstream reaches of the Arkansas. In addition, head cutting and erosion would have moved from the Arkansas-White area to the Mississippi-Arkansas area. The Arkansas would tend to flow into its former natural channel. Alternative 12 would have had unacceptable environmental impacts of creating long channel, and changing hydrology.

- **Measure 13: Grade Control Structures.** Measure was similar to Alternative 3 but on a larger scale over the entire study area. It was eliminated because it would have required many structures to prevent erosion and the structures could have transferred erosion to other locations. Therefore, Measure 13 was incomplete.

- **Measure 14: Additional Structures in Jim Smith Lake.** Measure 14 was incomplete and eliminated as a stand-alone alternative that would not have addressed other head cutting presently occurring in Owens Lake, Melinda Channel, Jim Smith Lake, and La Grues Lake.

- **Measure 15: Allow Multiple Smaller Flow Paths (Historic Cutoff, Melinda Corridor, and or La Grues Lake Corridor).** Measure was similar to the restoration structure of Alternative 2, but would have released water into the Arkansas at significantly lower rates. Alternative 2's structure and the Melinda Corridor were designed to pass at least 120,000 and 40,000 cubic feet per second, respectively. Notches in the existing soil-cement dike would have negligibly increased these flows and would not have reduced head differentials between the Arkansas and White. Therefore, Measure 15 was ineffective.

- **Measure 16: Long-term Research and Monitoring.** Alternative 16 was incorporated into the No Action Plan. It was screened from further consideration because it would not have provided a long-term solution as defined by planning objectives.

Upon reviewing screening rationale, the study team decided that the above measures would not carry forward for further analysis. Remaining measures were considered as alternatives for more detailed consideration. In addition, the team added a measure that allowed for multiple openings at existing structures, which is similar to Measure 3 and 4 from the Ark-White Study, but is not limited to structures in the Melinda Corridor or Historic Cutoff. Thus, the three measures or alternatives developed during the Ark-White Study and included in the final array for the Three Rivers analysis in addition to the No Action Alternative are:

1. Open Historic Cutoff (based on Measure 2 from the Ark-White Study);
2. Raise, Extend, and Realign the Soil Cement Structure (based on Measure 6 from the Ark-White Study); and,
3. Allow Multiple Flow Paths (Historic Cutoff, Owens Lake, Melinda Corridor, La Grues Lake, and or Jim Smith Lake).

3.5.2 Failure Path Analysis

To begin developing alternatives, the study team identified major potential failure paths across the isthmus. The Ark-White Study specified four main failure pathways: 1) the Melinda Channel and Owens Lake corridor, 2) the Melinda Channel and Owens Lake slough, 3) the La Grues Lake corridor and 4) the Jim Smith Lake corridor. Since completing the Ark-White Study, new knickpoints have developed and the Arkansas River has meandered further. As a result, the study team identified seven potential failure paths across the isthmus, including the four identified during the Ark-White Study. Probable failure paths are based on the current primary flow path between the Arkansas and White rivers, the hydraulic resistance of each pathway, the pathway exhibiting the most damage from existing flows between the two rivers, and the area with the potential to experience the greatest head differentials as coupled with high flow rates. As of 2016, probable failure paths in order of likelihood of failure based on the above variables are listed below and depicted in Figure 14:

1. Melinda Channel Owens Lake Corridor caused by flanking and rupturing of the Owens Lake Structure and the Melinda Structure.
2. Jim Smith Lake Corridor stemming from the Arkansas River's House Bend's east by east-west movement, which is captured by the lake effectively making the Jim Smith Lake corridor the shortest, most damaged, and least hydraulically resistant flow path between the two rivers.
3. Historic Cutoff where two sink holes have appeared along the Historic Closure Structure, one in 2014 and one at the end of 2016. The appearance of the sink holes indicates a growing seepage path through the Historic Closure Structure. As the seepage path erodes away soil under the structure, the structural stability of the soil is compromised and collapses in on the seepage path. When soil loss gets large enough, sink holes will appear at the surface. If continued unchecked, the Historic Closure structure could collapse.
4. Jim Smith Lake Historic Cutoff Corridor caused by a lengthy head cut and knickpoint moving through the woods from the Historic Cutoff toward Jim Smith Lake.
5. La Grues Lake Corridor with elements of the Owens Lake and or Melinda outflow channel included in the failure path resulting from a knickpoint that has developed moving along a swale toward La Grues Lake.
6. Melinda Channel Owens Lake Slough caused by a breach through the containment structure where it is built to elevation of 152 feet.
7. Webfoot Lake where knickpoints have developed along the east side of Webfoot Lake. A resulting head cut would move across Big Island and connect to the White River about 2 miles upstream of its confluence with the Mississippi.

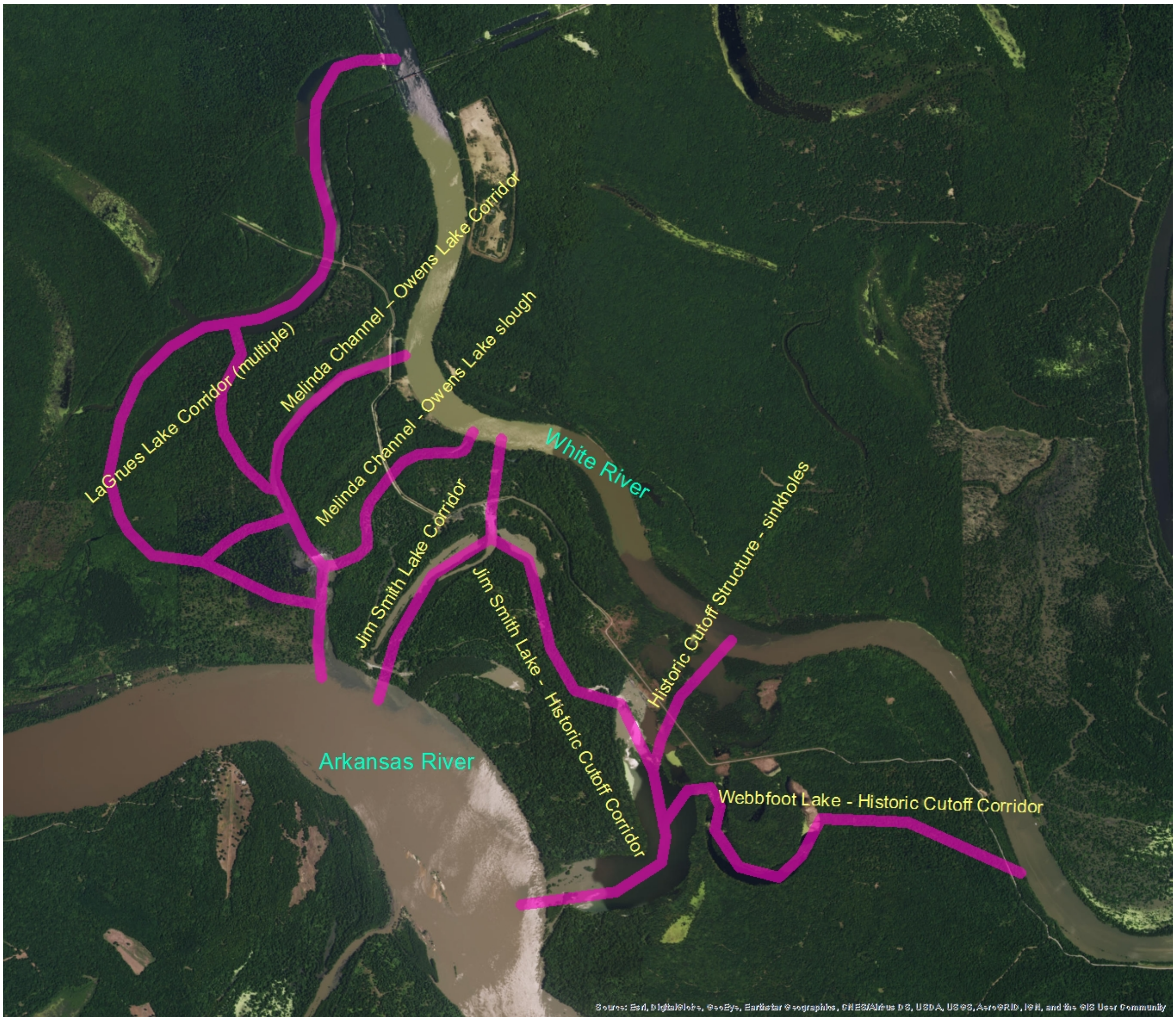

Figure 14: Probably Future Failure Paths within the Project Area.

3.5.3 Hydrologic and Hydraulic Design Criteria

Given the measures considered most effective and knowing the highest risk failure path (Melinda Channel and Owens Lake Corridor), team engineers developed six design criteria for alternatives:

1. Velocity of flows across the isthmus;
2. Magnitude of head differentials;
3. Duration of head differentials;
4. Location of overtopping;
5. Change in hydrology in surrounding bottomland hardwood forest, and;
6. Creation of cross currents in navigation channel.

The goal in formulating alternatives was to maximize National Economic Development (NED) benefits while reducing maximum head differentials, reducing isthmus velocities, reducing the duration of the extreme values during overtopping events, and controlling the location of overtopping events. While Appendix B provides detail regarding how criteria were modeled and measured, the basic process is discussed below.

The Hydrologic Engineering Center River Analysis System (HEC-RAS) program produces georeferenced gridded hydrologic velocity maps of an area. Team hydrologists and engineers used HEC-RAS maps to pinpoint locations in the isthmus where scour is most likely to occur. Identification of potential scour locations increased the effectiveness of alternative formulation by identifying measures that target problem areas. Controlling the location(s) of overtopping events would include armoring relief channels against erosion and could consist of multiple step-down structures to minimize damaging head differentials across each structure. Severe damage has not been observed for events with head differentials less than four feet so reducing the head differential to less than four feet or minimizing the duration of damaging head differentials defined the threshold for preventing head cutting erosion across the isthmus.

Environmental benefits for terrestrial and aquatic habitat health, form, and function directly relate to the timing and location of flood duration. For aquatic habitat, several stage duration analyses were performed at selected locations to determine potential changes in oxbow recharge, fish passage capabilities, and in-channel changes across the alternatives. Terrestrial habitat and bottomland hardwood health depends on overland flooding duration and location. In addition to the elevation duration analysis, the study team used HEC-RAS to develop “Percent Time Inundated” grids, based on the growing season starting on 15 March ending on 15 November for each possible alternative. An alternative’s effects on the duration of flooding in the Refuge with respect to existing conditions helped to pinpoint locations that would experience the greatest change in hydrology for each alternative.

The final design consideration is the impact of cross-currents on navigation. Specific configurations of alternatives could have a significant effect on the safety of the shipping lane. While a two-dimensional mathematical model can provide details regarding in-channel velocities, it cannot capture the effects of incorporating important variables like typical tow boat capabilities, tow configuration, and vessel operator experience. Modeling these additional variables will require a ship tow simulator, which would take place during the design phase of the project.

3.6 Development of Ecosystem Restoration Measures

Pursuant to the Section 216 authority, the Three Rivers Study sought to integrate ecosystem restoration features into the final array of alternatives to address ecosystem degradation that has resulted from the construction, operation, and maintenance of the MKARNS. In consultation with USFWS, AGFC, the Arkansas Natural Heritage Commission (ANHC), and the Arkansas Natural Resources Commission (ANRC), the

PDT identified problems, opportunities, and possible ecosystem restoration measures. Problems identified include:

- Water depths, durations, and timing of flows through the study area have changed due to leveeing and flood control and navigation structures resulting in a change in vegetative species composition and faunal species use of bottomland hardwoods and wetlands along the White and Arkansas rivers.
- Historic flow paths have been modified, resulting in scouring through bottomland hardwoods, washing away of vegetation, seeds, and soils with each new flow path that forms. This has changed the disturbance regime in the forest, which is accelerating the ongoing species composition shift.
- Some of the historic flow paths have been blocked which is reducing downstream sediment inputs and causing a sediment starved downstream riverine system. In addition, the blockages have resulted in a disconnect between the floodplains, oxbow lakes, and main river channels causing loss of access to important aquatic habitat and altering the overall form and function of floodplain system.
- Bank sloughing and head cutting is increasing sedimentation in the immediate area of the erosion site, resulting in a loss of bottomland hardwoods, change in channel morphology, loss of hydrologic connections, and contributing to increased turbidity and poor water quality which affects aquatic species use of the area.

Additional measures were not developed to address the first three problems because there is uncertainty and disagreement amongst the literature and resource professionals about changes that have occurred over time. Some indicate that the study area is becoming wetter, while others suggest it has become drier. The PDT agreed that ecosystem restoration is warranted for identified problems, but until additional research resolves the discrepancy, developing ecosystem restoration measures to address specific problems is inappropriate and could lead to unintentional adverse effects (i.e., could exacerbate existing problems or create new ones).

After reviewing historic and existing conditions of the functionality and degradation of various natural systems in the study area, the team determined that oxbow lakes have been significantly altered from the historic state as a result of the construction and operation of the MKARNS and could benefit most from ecosystem restoration. Measures developed would restore form and function to oxbow lakes, including fish passage structures for reliable access to spawning and nursery habitat during critical periods. Measures included:

1. Fish passage structure at the north end of La Grues Lake – passage to the White River.

2. Fish passage structure in the Owens Lake Structure – passage to the White River.

3. Fish passage structure in the "new" section of Owens Lake – passage to the White River.

4. Fish passage structure in the south end of Jim Smith Lake – passage to the Arkansas River.

5. Removal of the containment structure bisecting La Grues Lake westward to the railroad track.

6. Restore Mossy Lake by constructing a dam on the north end of the lake.

Formulation did not move beyond developing the above measures given that USACE was unable to secure a non-federal sponsor to cost share ecosystem restoration features as required by Section 7007 of the Water Resources Development Act of 1986, as amended. Therefore, ecosystem restoration did not progress through alternative development, and the remainder of this report does not include additional discussion of ER.

3.7 Alternative Formulation

Alternatives are either stand-alone measures or combinations of measures that address identified problems in a study area and meet study objectives. As stated above, measures carried forward to develop alternatives for the Three Rivers Study are:

1. Open the Historic Cutoff (Measure 1 from the Ark-White Study).
2. Raise and Extend the Existing Soil-Cement Structure (Measure 6 from the Ark-White Study).
3. Allow Multiple Flow Paths (Historic Cutoff, Owens, Melinda, La Grues, and or Jim Smith).

Alternative development began with an engineering analysis of the erosional properties of soils in the project area to first determine velocities the soils could tolerate to reduce the risk of erosion. Flows of two feet per second is the upper threshold, so any alternative that resulted in faster flows was eliminated. HEC-RAS modeling also determined changes in head differentials, duration of those differentials and changes in hydrology that may impact bottomland hardwood forests in the area. Appendix B details the modeling effort, assumptions, and outputs.

3.7.1 No Action Alternative

The No Action Alternative (Future Without Project Condition), defines the most likely future conditions that would exist in the study area if action is not taken as a result of this study. For the purposes of this study, the No Action Alternative assumes that USACE would continue periodic OMRR&R on existing containment structures to maintain the authorized navigation system and construct new containment structures as head cutting in the study area develops. In addition, the No Action Alternative includes quantified systemic risks and consequences if a cutoff formed.

3.7.2 Alternative 1: Containment Structure at Elevation 157 with an Opening at the Historic Cutoff

Alternative 1 was first formulated using measure 2 as a stand-alone alternative; however, it became evident that realigning the containment structure alone would improve (i.e., more effective in reducing head differentials) by opening the Historic Cutoff (Measure 1) to act as a relief channel. The relief channel would decrease the magnitude and duration of damaging head differentials, which would decrease overland scour and increase the resiliency of the project. Furthermore, opening the Historic Cutoff would ensure that hydrology in the Refuge does not change. Appendix B provides more detail regarding the hydrology of the relief channel.

The alternative that emerged from this combination is a new containment structure built to an elevation of 157 feet. This elevation was optimized during the Ark-White Study as the elevation that maximized risk reduction in terms of a cutoff forming, and the study team believes it serves as a logical elevation for the current study. The new containment structure would be around 2.5 miles long and begin on natural high ground just south and west of the Melinda Structure on the south side of Owens Lake. From there, it would continue east and cross south of the Melinda Structure and then head northeast and connect to the Soil Cement Structure north of Jim Smith Lake. It would then follow the existing containment alignment and terminate at the Historic Cutoff. Several alignments were considered, but the final alignment chosen was based on effectiveness of reducing scouring velocities, topography, watershed drainage, and the least amount of hydrological disturbance to the study area. The containment alignment is also cost effective and resilient because it takes advantage of existing high ground lies along the natural watershed drainage divide which eliminates the need for drainage structures, pump stations, and corresponding operation and maintenance, through the structure itself.

In addition to realigning the containment structure, Alternative 1 includes a relief channel through the Historic Cutoff (Figure 15). Scales of the relief channel width were analyzed and an opening ranging from 500 feet to 1,000 feet wide at elevation 145 feet would be effective in reducing both duration and magnitude of head differentials. This is the current elevation that the White and Arkansas rivers exchange flows through the Melinda Corridor. Changing the location of overtopping from Owens Lake to the Historic Cutoff would eliminate the ongoing erosion problems through Owens Lake, Jim Smith Lake, and the threat of new head cuts moving toward La Grues. Channel width would be optimized during Pre-Construction Engineering and Design (PED) via a ship tow simulation to find a width that would minimize cross currents (See Appendix B for more detail). USACE would also demolish the Melinda Structure to reduce overland sour in the immediate vicinity and to reduce turbulence and erosion in the immediate Melinda Structure vicinity. Removal of the Melinda Structure would also allow the two sides of Owens Lake to reconnect creating open water habitat. The structure on the north end of

Owens would be altered to prevent water from backing into Owens Lake, which could damage surrounding bottomland hardwood habitat.

Currently Owens Lake connects to the White River at elevation 145 feet over Owens Structure and connects to the Arkansas River at elevation 140 feet over the Melinda Structure. These current elevations give the Arkansas River greater influence on Owens Lake hydrology then the White River. The Three Rivers Recommended Plan includes the elimination of the Melinda Structure and the addition of a containment structure at a higher elevation of 157 feet just south of the current Melinda Structure location. This will shift the hydrological influence to the White River and, assuming no leakage through Owens Structure or the new containment structure, will raise Owens Lake maximum elevation from 140 feet to 145 feet. The additional 5 feet in lake elevation has the potential to flood over an additional 100 acres of bottomland hardwood forest and the higher Owens Structure elevation will reduce fish passage window into Owens Lake. A 5 by 30 foot precast concrete bridge with an invert of 140 feet will be constructed through the Owens Structure to maintain current hydrology of Owens Lake, adjacent bottomland hardwoods and fish passage.

Alternative 1 would incorporate existing and natural high ground as part of its design, which would minimize disturbance to terrain and to the natural hydrology of the land. It would also provide an opportunity to restore form and function to oxbow lakes in the isthmus, and provide a long-term solution for reducing the risk of a cutoff by reducing the frequency, duration, location, and damaging head differentials of overtopping events.

Figure 15: Alternative 1 Containment Structure Alignment

3.7.3 Alternative 2: Multiple Opening Alternatives

Alternative 2 would use existing footprints of oxbow lakes and the Historic Cutoff as multiple relief openings (Figure 16). USACE would place several step-down structures in Owens Lake, and possibly the Historic Cutoff and Jim Smith Lake to facilitate exchange of water at an environmentally optimized elevation. Scales of elevations were analyzed and a range between 115 and 135 feet would be effective. Not all structures would be at the same elevation, and optimization would occur during PED. Alternative 2 would restore some pre-Historic Closure Structure hydrology between the Arkansas and the White rivers and some historic ecological conditions. The Arkansas River carries a larger sediment load than the White; and therefore a sediment transport model would identify changes in deposition and scour in both rivers. Alternative 2 would provide a long-term solution for reducing the risk of a cutoff by minimizing the duration and controlling the location of damaging head differentials during overtopping events. As is the case for Alternative 1, more investigations would be needed to determine the effects of potential cross-currents on navigation.

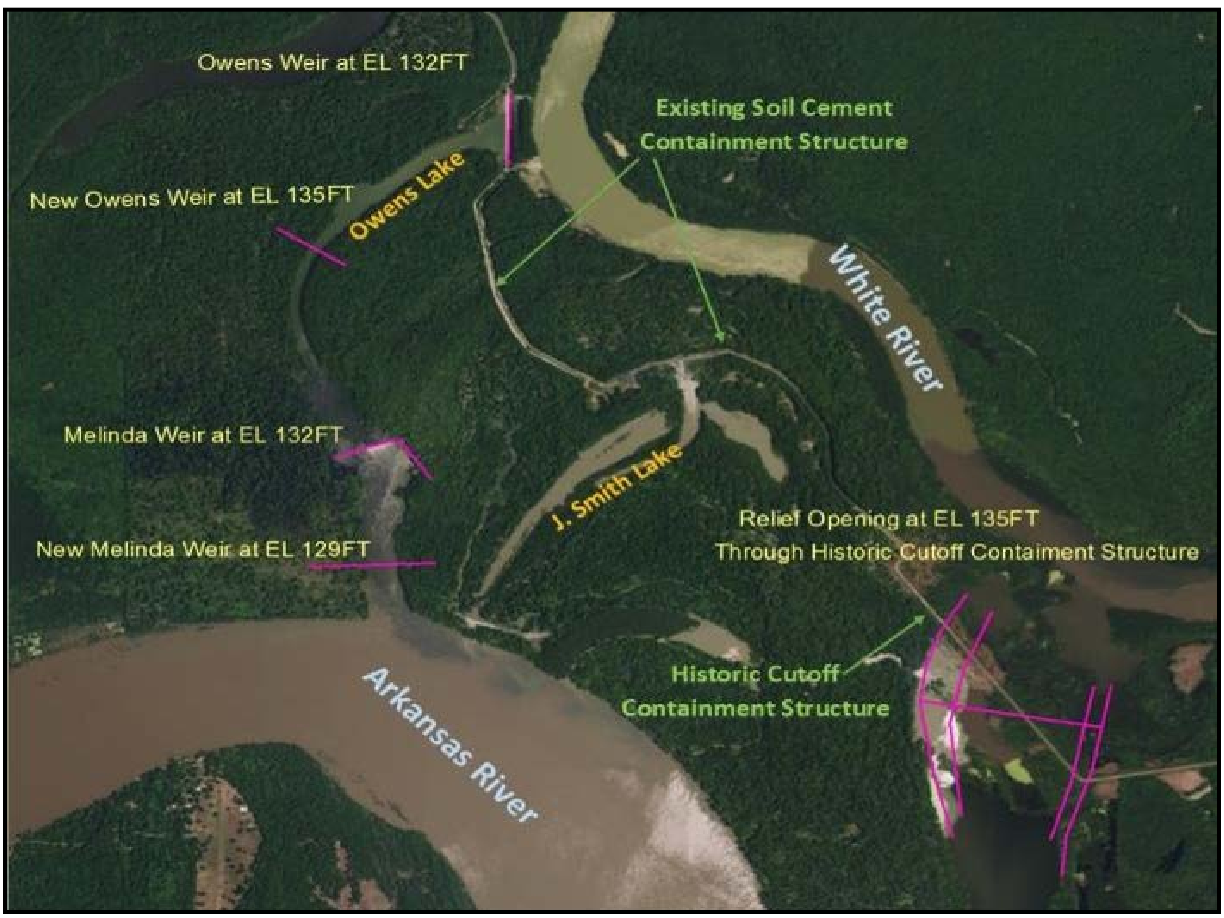

Figure 16: Alternative 2 Containment Structure Alignment

3.8 Evaluation of Alternatives against the Design Criteria

Once the basic alternatives were developed, they were compared to the No Action Alternative to ensure they produced more desirable conditions than the No Action. The six design criteria were used to make that comparison and determine the effectiveness of each plan to address problems identified earlier in the report:

1. Velocity of flows across the isthmus;
2. Magnitude of head differentials;
3. Duration of head differentials;
4. Location of overtopping;
5. Change in hydrology in surrounding bottomland hardwood forest, and;
6. Creation of cross currents in navigation channel

3.8.1 No Action Alternative

Under the No Action Alternative, existing containment structures would remain susceptible to overtopping and failure during high-water events. The No Action Alternative fails to decrease isthmus velocities (criterion 1), fails to minimize the magnitude or duration of head differentials (criteria 2 and 3), and does not control the location of overtopping (criterion 4). In addition, under the No Action Alternative, USACE would continue repairing existing structures and construct new structures as needed. As part of the No Action Alternative, it is assumed that current structural problems at existing containment structures, including sink holes, would be repaired and remain in place and operational over the period of analysis. Other activities, including management of the Refuge, navigation, and recreation would continue in a manner consistent with existing conditions. In the absence of federal action resulting from this study, 156 acres (120 Functional Capacity Units) of bottomland hardwood forest and wetland habitat would be lost due to future head cutting and construction to mitigate head cutting. Direct impacts would result from construction (new and existing) and maintenance of structures and scouring across the isthmus should structures overtop or fail. Indirect impacts would occur due to head cutting, which would change wetland classification and function in the affected area.

3.8.2 Alternative 1: Containment Structure at elevation 157 with an Opening at the Historic Cutoff

Alternative 1 combines Measure 2 (raising and extending the containment structure) and Measure 1 (opening the Historic Cutoff), and consists of a newly constructed containment structure at an elevation of 157 feet. The structure would be approximately 2.5 miles long (Figure 15), and would begin on natural high ground just south and west of the Melinda Structure on the south side of Owens Lake. From there, it would continue east and cross the Melinda head cut south of the Melinda Structure, and continue northeast and connect to the existing containment structure north of Jim Smith Lake.

After following the existing containment structure, it would terminate at the Historic Closure Structure.

Because the design of Alternative 1 takes advantage of natural high ground, in most locations it would only rise about five to seven feet above the ground surface, and would not exceed 12 feet above the ground at its highest point. Alternative 1 would also open the Historic Cutoff. Feasibility level design indicates the opening would be between 500 and 1000 feet wide. A ship tow simulation will be completed during to PED to help determine the optimal width of the opening, but regardless of width, the opening would be at an elevation of 145 feet. Lowering the Historic Cutoff would reduce maximum head differentials across the isthmus allowing USACE to control the location of overtopping events and would decrease the duration of head differentials (criteria 2, 3 and 4), which provides for safe navigation (criterion 6), and it would decrease isthmus flow velocities (criterion 1). Furthermore, the opening would restore ecological functions of Webfoot Lake and reduce erosion on the east side of the lake, which has existing knickpoints that may lead to future head cutting.

In addition to constructing the containment structure, USACE would demolish the Melinda Structure and place demolition debris into the deep scour hole at the top of the head cut. This would reduce overland erosion in the immediate vicinity. Removing the structure would also allow Owens Lake to reconnect to its former southern limb, returning open water function to the oxbow element of the flooded bottomland hardwood ecosystem that has degraded due to the construction, operation and maintenance of the MKARNS. Finally, the alteration to the structure at the north end of Owens Lake to prevent water from backing up into the lake would provide fish passage between the White River and Owens Lake. Overall, the current hydrology in the surrounding bottomland hardwood forest would not change (criterion 5). Navigation would continue with no operational changes to the MKARNS.

3.8.3 Alternative 2: Multiple Openings

Alternative 2 is based on measure 3 and allows for multiple flow paths through existing structures within the project area (Figure 16). Multiple step down structures would be built in Owens Lake, and based on optimized elevation, possibly La Grues Lake, the Historic Cutoff, and Jim Smith Lake to facilitate water exchange. USACE considered three elevations for the various structures, 115 feet, 125 feet and 135 feet; however, the structures would not necessarily be lowered to the same elevation, and the final elevation for each would be optimized during PED. Alternative 2 would provide a long-term solution for reducing the risk of a cutoff by minimizing the duration and magnitude of damaging head differentials and controlling the location of overtopping (criteria 2, 3, and 4). Navigation would continue with no operational changes to the MKARNS, but more investigation, via a ship tow simulation, would need to be performed to determine the effects of cross-currents on navigation under this alternative; and thus, it is not known whether Alternative 2 meets criterion 6. In addition, current hydrology in the surrounding bottomland hardwood forests would not change significantly (criterion 5).

3.9 Economic Analysis

The period of the economic analysis is 50 years and ends in 2075 and assumes:

- The feasibility study completes in June 2018;
- Project receives Congressional authorization in 2019;
- PED begins in 2019 and require 3 years; and,
- Construction requires three years.

Thus, the base year in which project benefits begin to accrue is 2025. The current FY2018 discount rate of 2.75 percent applies to annualized figures.

Project benefits stem from a comparison of without project condition costs to the costs of constructing and operating alternative plans. Differences between the economic costs of an alternative and the economic costs of the without project condition are either a positive cost savings (if costs of an alternative are less than the cost of the without project condition), or a negative cost savings (if costs of an alternative are more than the cost of the without project condition). Benefits (i.e., avoided costs) consist of repairs and rehabilitation costs for existing containment structures (Jim Smith and Melinda) and costs of new containment structures expected over the 50-year period.

Data and methodology for determining the probability of a cutoff forming, and costs of future maintenance, operation and rehabilitation of existing structures and the cost of new containment structures come from the 2009 Ark White Study (updated to FY2018 prices levels). Projections of future commodity flows are based on recent commodity flow data and macroeconomic conditions in the region, the U.S. and on a global level. Similarly, estimated transportation cost savings of shipping on the MKARNS versus least cost alternative routes and potential shipper response to navigation closures are based on data and research conducted in 2016 and 2017. Appendix A details economic assumptions, data, and analysis.

3.9.1 No Action Alternative

The No Action Alternative, or Future without Project Condition assumes that USACE would continue to perform ad hoc repairs to containment structures as they have in the past, and build new structures to prevent new cutoffs from forming. Two types of economic costs occur in the Future without Project Condition. Some occur regardless of whether a cutoff forms, and some ensue only if a cutoff forms. New containment structures, and repairs and rehabilitation to existing structures would take place whether or not a cutoff forms given that the analysis assumes USACE would continue to keep the rivers separated in the same manner as it has in the past. Remaining costs accrue only if a cutoff forms and consist of:

1. Loss of commercial navigation resulting in higher transportation costs;
2. Costs of the emergency contingency plan to close a cutoff and restore navigation;

3. Increased dredging costs due to increased sediment deposition near a cut-off; and,

4. Costs to repair damaged infrastructure at the Montgomery Point Lock and Dam.

Costs associated with a cutoff are stochastic in nature; and thus, an important component of the study involved estimating the likelihood of a cutoff forming in the future. This probability is based on a joint frequency analysis using expert elicitation from a panel of hydrologists and engineers, and empirical hydrologic data for the Arkansas and White rivers. Historical data generated by District hydrologists and engineers provided the frequency at which head differentials occur and the frequency of their duration. These estimates were then combined with the expert panel's probability estimates of a cutoff developing, to produce a probability that a cutoff would occur given frequencies and duration of head differential. Estimated costs of a cutoff including lost navigation benefits are weighted by the annual probability of a cutoff forming (i.e., risk times consequence). In addition, team economists generated a stochastic range for benefits (i.e., avoided costs) using historical data, professional judgment and statistical modeling techniques.

Appendix A discusses any additional assumptions. Notable assumptions associated with the No Action Alternative are:

1. If a new cutoff forms, it would be the same size as the Historic Cutoff.
2. A new cutoff would have a streambed elevation equal to that of the White and Arkansas rivers.
3. If a cutoff occurs, USACE would close the cutoff with a structure made of sheet pile, stone and soil cement.
4. A cutoff channel would be open for approximately 260 days after a breach occurs until USACE could access the area and survey and evaluate conditions, and then design, and implement a project to close the cutoff.
5. Conditions would be intermittently un-navigable due to cross currents and draft constraints until the cutoff is closed. Estimates based on historical hydrologic data indicate that conditions after a cutoff formed would be unnavigable for about 30 consecutive days immediately after the event followed by an average of 125 intermittent days of unnavigable conditions.
6. Seventy-five percent commercial barge traffic through the study area would route to least cost alternative modes and routes during the 260-day period.
7. USACE would not allow existing containment structures to degrade to less than 70 percent of their designed structural integrity.
8. USACE would reconstruct existing containment structures when structure integrity decreases to 70 percent.

As summarized in Table 10, total annualized costs that will or could emanate under the without project condition range from $27.5 million (95 percent exceedance) to $43.5 million (5 percent exceedance) with a midpoint of $34.2 million (50 percent exceedance). Reductions in any of these costs via implementation of a project alternative are NED benefits. Benefits for proposed alternatives consist of the No Action costs avoided through implementation of a plan. Since the cost of taking no action as a result of this study are $34.2 million, this dollar amount serves as the benefits realized for both of the alternatives under consideration.

Table 10: Annualized Costs and Lost NED Benefits Associated with the No Action Alternative (FY18 – October 2017 prices, discount rate 2.75%)

Type of Cost	Dollars	95% Exceedance	5% Exceedance
Costs without Cutoff			
New structures	$796,000	$87,800	$1,637,000
Rehabs and repairs to containment structures	$809,000	$552,700	$1,917,000
Costs with Cutoff and Navigation Closures			
Repairs and dredging	$3,133,000	$2,825,000	$3,415,000
Lost transportation cost savings	$29,425,000	$23,997,000	$36,478,000
Total	**$34,163,000**	**$27,462,500**	**$43,447,000**

3.10 With Project Condition

3.10.1 Alternative 1: Containment Structure at Elevation 157 with an Opening at the Historic Cutoff (C157HC145)

Costs for Alternative 1 primarily include construction of the containment structure and opening the Historic Cutoff. The containment structure takes advantage of high ground where possible, which reduces materials requirements. Construction includes expenses for excavating and opening the Historic Cutoff to allow flows at an elevation of 145 feet (reduced from its current elevation of 170 feet) and assumes a 1,000 foot opening (the widest deemed functional). An opening of this size would require excavation of soil and placement of stone plus sheet pile to stabilize and armor against erosion flanking and seepage (see Appendix C for quantities associated with this alternative). Mitigation costs are based on the costs identified in the Mitigation Plan (Appendix N). Real estate costs are based on the current design drawing identified real estate needs. As is the case with the No Action Alternative, the PDT considered failure risk of the final array of alternatives. The methodology used to evaluate failure risk of alternatives is identical to the methodology used to estimate the probability of cut-off forming in the without project condition (i.e., joint probability analysis via expert elicitation and historic hydrologic data), and relies on analysis from the Ark-White Study. Benefits for project alternatives are adjusted accordingly. Table summarizes estimated costs and benefits for Alternative 1.

Table 11 Costs and Benefits for Alternative 1 (rounded to nearest thousand) (FY18 – October 2017 prices, discount rate 2.75%)

Total Capital Outlays	
Construction	$178,694,000
Mitigation	$684,000
Real Estate	$917,000
Interest During Construction	$7,356,000
Total Investment	$187,651,000
Annualized Costs	
Interest	$5,160,000
Amortization	$1,790,000
OMRR&R[a]	$724,000
Total Annualized Costs	$7,674,000
Annualized Benefits (Stochastic Range in Parenthesis, 95% and 5% Exceedance)	
Navigation NED Benefits[b]	$29,122,000 ($23,410,000 - $37,035,000)
OMRR&R Savings[c]	$4,689,000 ($3,769,000 - $5,963,000)
Total Cost Savings	$33,811,000 ($27,179,000 - $42,998,000)
Benefit to Cost Ratio	4.4 (3.5 – 5.6)
Net Annualized Benefits	$26,137,000 ($19,505,000 - $35,324,000)

[a] Operations, Maintenance, Repair, Replacement, and Rehabilitation.
[b] Consists of avoided lost transportation benefits if a cutoff formed and the shipping channel became unnavigable.
[c] Includes avoided costs of repairing and rehabilitating existing containment structure, costs of new containment structures expected in the future without projection conditions, and potential costs of repairing a cutoff.

3.10.2 Alternative 2: Multiple Opening Alternatives (M115-135)

As with Alternative 1, costs for Alternative 2 primarily include excavation and armoring associated with modifying existing structures to allow multiple flow paths. However, construction costs, as shown in Table 12, are more extensive than for Alternative 1. This is due to the multiple locations requiring excavation and the much larger scale of excavation needed for the Historic Cutoff. In Alternative 2, the opening at the Historic

Cutoff would be about 3,500 feet long and the elevation would reduce from its current height of 170 feet to 115 feet. Alternative 2 requires more stone and additional linear feet of sheet pile when compared to Alternative 1 (see Appendix C for quantities). Table 12 displays costs and benefits for Alternative 2. Note that while Alternative 2 would have minimal mitigation costs, they were not developed for this study. Even including zero cost for mitigation for Alternative 2 would not change plan selection. The PDT chose to use the same mitigation costs for both Alternatives to represent the fact that both plans would require some form of mitigation.

Table 12: Costs and Benefits for Alternative 2 (rounded to nearest thousand) (FY18 – October 2017 prices, discount rate 2.75%)

Total Capital Outlays	
Construction	$245,000,000
Mitigation	$684,000
Real Estate	$917,000
Interest During Construction	$10,086,000
Total Investment	$256,687,000
Annualized Costs	
Interest	$7,059,000
Amortization	$2,449,000
OMRR&R[a]	$993,000
Total Annualized Costs	$10,501,000
Annualized Benefits (Stochastic Range in Parenthesis, 95% and 5% Exceedance)	
Navigation NED Benefits[b]	$29,122,000 ($23,410,000 - $37,035,000)
OMRR&R Savings[c]	$4,689,000 ($3,769,000 - $5,963,000)
Total Cost Savings	$33,811,000 ($27,179,000 - $42,998,000)
Benefit to Cost Ratio	3.2 (2.6 – 4.1)
Net Annualized Benefits	$23,310,000 ($16,678,000 - $32,479,000)

[a] Operations, Maintenance, Repair, Replacement, and Rehabilitation.
[b] Consists of avoided lost transportation benefits if a cutoff formed and the shipping channel became unnavigable.
[c] Includes avoided costs of repairing and rehabilitating existing containment structure, costs of new containment structures expected in the future without projection conditions, and potential costs of repairing a cutoff.

Table 13 compares the costs and benefits of each Alternative, including the No Action plan. Alternative 1 (Containment Structure at Elevation 157 feet with a Relief Channel through Historic Cutoff at Elevation 145 feet) has the greatest net benefits of the three alternatives and is the NED plan. The width of the relief channel has yet to be determined, but further investigation and optimization during PED would define the width for that opening, which may decrease construction costs (costs are currently based on the maximum opening size).

Alternative 1 is similar to the Recommended Plan from the Ark-White Study, which the USFWS deemed incompatible with the mission of the Refuge. The Ark-White Study version consisted of raising the entire length of the existing soil cement containment structure and the Owens Lake Structure, and extending the structure from just east of La Grues Lake, following the White River upstream some 6 miles to Lock 2. Alternative 1 differs from the Ark-White Study plan in that this alternative would have a smaller footprint for the structure that would minimize disturbance to natural hydrology in the bottomland hardwood forest without impacting efficiency of reducing head differentials and thus the risk of failure and subsequent cutoff formation. The current design has significantly fewer direct environmental impacts than the Ark-White Study design and would require less environmental mitigation. Further, the current design provides an opportunity to restore structure and function to at least two oxbow lakes in the isthmus, while also preventing new head cuts from forming at Webfoot Lake, a problem not identified in the Ark-White Study. The ancillary oxbow restoration is above and beyond avoiding, minimizing, or mitigating for impacts, something the former design did not provide. Finally, Alternative 1 would only require 0.63 miles of containment structure to be built on Refuge land and total long-term impacts from construction are anticipated to be less than 10 acres.

Table 13: Benefits and Costs for Alternative Analyzed (rounded to nearest thousand) (FY18 – October 2017 prices, discount rate 2.75%)

	No Action	Alternative 1	Alternative 2
Construction, Real Estate and Interest	-	$186,967,000	$256,002,000
Mitigation	-	$684,000	$684,000
Total Investment	-	$187,651,000	$256,686,000
Annualized Costs[b]	$34,163,000[c]	$7,674,000	$10,501,000
Annualized Benefits	$0	$33,811,000	$33,811,000
Net Benefits	$0	$26,137,000	$23,310,000
Benefit to Cost Ratio	0.0	4.4	3.2

[a] While Alternative 2 would have slightly higher mitigation costs, they were not developed for this study. Even including zero cost for mitigation for Alt 2 would not change plan selection. The PDT chose to use the same mitigation costs for both Alternatives to represent the fact that both plans would require some form of mitigation.

[b] Annualized Cost for Alternatives 1 and 2 includes Interest and Amortization and OMRR&R
[c] Includes costs of repairing and rehabilitating existing containment structure, costs of new containment structures, and potential costs (i.e., risk time consequence) in the event of cutoff formation including costs of repairing cutoff and damages to Montgomery Point infrastructure, increased dredging costs and lost navigation NED benefits.

3.11 National Economic Development Plan

The National Economic Development Plan is the alternative which provides the greatest net benefits to the nation. Alternative 1 has net benefits of $26,137,000 while those for Alternative 2 are only $23,310,000; and therefore, Alternative 1 is the NED plan.

4 FUTURE WITH PROJECT CONDITIONS*

Chapter 4 describes the probable impacts of implementing study alternatives (i.e., the Future with Project condition or FWP). In addition, Chapter 4 discusses potential impacts of the Future without Project alternative (FWOP), which is synonymous with the "No Action Alternative" as required by NEPA. Effects can be either beneficial or adverse, and are considered over the 50-year period of analysis (2025-2075).

When considering impacts, a notable assumption is that at a minimum best management practices (BMPs) identified in Appendix L would apply during project construction. Assumed BMPs are based on widely accepted industry, state and federal standards for construction activities. Examples include:

- Use of silt fencing to limit soil migration and water quality degradation;
- Refueling and maintenance of vehicles and equipment in designated areas to prevent accidental spills and potential contamination of water sources and the surrounding soils; and,
- Limiting idling of vehicles and equipment to reduce emissions.

If, for some reason, the BMPs, are not implemented, the impacts of either action alternative would increase slightly from those described in this chapter; however, the increase would not rise to the level of "significant."

4.1 Land Use

Land use outside of the project area would not change. Implementation of either alternative would negate potential land use changes (bottom land hardwood conversion to open water or dry channels) due to erosion and future head cutting or from the formation of a cutoff.

Under Alternative 1, approximately 25 acres of bottomland hardwoods would permanently convert to a structure dressed in crushed stone or soil cement. It is unlikely that trees would regrow in the footprint of the containment structure. Work completed at the Historic Cutoff and at the existing structure in Owens Lake would not change land use, except to allow water to flow through more frequently than in the past. Debris removed from the Historic Closure Structure would be placed in a 20 acre area that is currently void of vegetation and would continue to be void of vegetation into the future. Removing the Melinda Structure would convert the demolition area to open water. As the area dried out and the existing scour hole filled, open water could convert to bottomland hardwood. Direct impacts in Alternative 1 would be permanent, but insignificant given the amount of bottomland hardwoods in the area and implementation of this alternative would save hundreds of BLH acres that would be lost in the FWOP.

As discussed in Section 3.7.3 above, Alternative 2 would use existing footprints of oxbow lakes and the Historic Cutoff as multiple relief openings (see Figure 16). USACE would place several step-down structures in Owens Lake, and possibly the Historic

Cutoff and Jim Smith Lake to facilitate exchange of water at an environmentally optimized elevation. A preliminary hydraulic analysis of this alternative with different numbers of structures indicated unacceptable levels of hydrologic change on the Refuge, thus violating a fundamental constraint of the study. Since Alternative 2 also provided fewer net benefits than Alternative 1 (see Section 3.10 above), Alternative 2 was screened from further feasibility level design. Therefore, a precise number of acres impacted was not calculated for Alternative 2. The PDT estimates between 20 – 50 acres of bottomland hardwood would be impacted by tying structures to the banks, and construction of permanent access roads to each structure for OMRR&R. These impacts would be in addition to an estimated 15 acres of permanent and seasonal open water impacted by the structures. Construction would convert areas behind each structure to permanent open water or bottomland hardwoods depending on the location of each structure. For example, the north side of the Melinda Structure would become seasonally wet rather than permanently wet, and the area between the two Owens Structures would convert to bottomland hardwoods over time, depending on the seasonality and permanence of water in the area. These impacts would be permanent, yet insignificant given the amount of bottomland hardwoods in the area. All of the acre impacted by Alternative 2 would require full mitigation.

Opening up the historic cutoff in either alternative would also directly impact up to 300 acres of private land on the Arkansas River side of the structure. Once the historic channel is re-opened, the channel is expected to migrate in a natural sinuous manner over the planning horizon similar to conditions before the Historic Closure Structure was installed. The sinuosity is expected to remove jurisdictional wetlands in the migration path; however, the lack of flowing open water in the natural channel path is expected to offset any jurisdictional wetland losses through development of additional jurisdictional wetlands in a previously open water location (i.e. accretion and erosion). Therefore, mitigation is not warranted.

4.2 Air Quality

Alternatives 1 and 2 would have similar impacts in the FWOP condition. Both would have a longer single duration of criteria pollutant emissions compared to the FWOP; however, each would only have one construction period rather than up to four separate periods as is the case with the FWOP. Alternatives 1 or 2 would have minor adverse impacts on air quality, but not at levels that would cause non-attainment under NAAQS. Overall, construction would be short and limited to a small disturbance area. Impacts would be temporary and insignificant.

4.3 Climate

Implementation of Alternative 1 and 2 would yield similar impacts to the FWOP condition. Both alternatives would have a longer single duration of GHG emissions compared to the FWOP; however, both alternatives would have only one duration of construction rather than up to four separate periods of construction as is the case with the FWOP. GHG emissions would incrementally contribute to global emissions for the limited construction, but not enough to affect climate change. Impacts would be temporary and insignificant.

4.4 Geologic Resources

Both alternatives would negate future water quality impacts from erosion associated with head cutting and a breach. Impacts from construction of either alternative would be similar to the FWOP condition, in that temporary and short-term soil erosion, loss of topsoil, short to long-term soil compaction, permanent increases in the proportion of large rocks in the topsoil, and soil horizon mixing would occur. There are no anticipated changes to geology or mineral resources.

4.4.1 Alternative 1

Alternative 1 would permanently convert roughly 25 acres of soil to impervious surfaces. At these locations, soil productivity would be lost. In addition, the containment structure would alter topography by constructing the structure to an elevation of 157 feet. The greatest elevation change would occur near the Melinda head cut with an increase of 12 feet. But for the most part, the new structure would be only seven feet higher than the existing elevations, while areas near the Jim Smith Lake natural berm (south side of the proposed alignment) would be lower than the natural berm. Removal of the Melinda Structure would reduce structure elevation to match that of the surrounding environment, and return topography to historic pre-structure conditions. Lowering the Historic Cutoff to 145 feet would alter existing topography by reducing the elevation closer to historic conditions. All direct impacts listed would be permanent, but insignificant as they prevent a greater loss than the FWOP.

4.4.2 Alternative 2

Alternative 2 would permanently change 15 acres of soils to impervious surface, including changes during construction and the addition of permanent access roads. Access roads would minimally alter topographic elevations. Based on current design, access roads would not have aggregate surfacing, so long-term soil erosion from wind and water would occur. Roads would also require periodic maintenance to mitigate tire rutting and loss of surface substrate.

Like Alternative 1, the elevation of the Historic Cutoff would decline under Alternative 2. Impacts would be similar to those for Alternative 1, except the opening would be significantly larger, and the elevation of the Melinda and Owens Lake structures would lower to an elevation of 132 feet. The reduction in elevation would more closely match surrounding elevations; however, both structures would still be prominent topographic features on the landscape. Two new structures, one halfway between the Owens Lake and Melinda structures and the other south of the Melinda Structure, would be constructed at elevations of 135 and 129 feet, respectively. Both structures would increase the topography of the area and become prominent features of the landscape. All direct impacts listed would be permanent, but insignificant as they prevent a greater loss than the FWOP.

4.5 Prime Farmlands

Under Alternative 1, construction of the containment structure would occur on lands classified as “Farmlands of Statewide Importance” (60 percent of the disturbance area) and lands classified as “Not Prime Farmland” (40 percent of the disturbance area). During consultation, the Natural Resource Conservation Service (NRCS) determined that 27.9 acres of Farmlands would permanently convert to impervious surface and no longer meet the criteria for Prime Farmlands. Removal of the Melinda Structure. Opening the Historic Cutoff, adding an opening in the Owens Lake structure, and purchasing mitigation bank credits would not change the status of farmlands. Impacts to “Farmlands of Statewide Importance” would be permanent, but insignificant due to the small impact size in relation to similarly categorized lands in the area. Additionally, implementation of Alt. 1 would prevent greater losses than the FWOP.

Under Alternative 2, land in the footprint of the new structures is classified as “Not Prime Farmlands.” However, construction and operation of the access road would occur in lands classified as “Farmlands of Statewide Importance” or “All Areas are Prime Farmland.” Construction in these areas could potentially alter classification of prime farmlands by mixing soil horizons and creating compact surfaces. It is assumed that with implementation of BMPs, access road construction would limit mixing and compaction of soils; and therefore, these areas would remain eligible as prime farmland. It is unlikely that other actions associated with Alternative 2 would affect the status of farmlands. Impacts to “Farmlands of Statewide Importance” would be permanent, but insignificant due to the small impact size in relation to similarly categorized lands in the area. Additionally, implementation of Alt. 2 would prevent greater losses than the FWOP.

Under both alternatives, opening the historic cutoff may directly impact lands on the Arkansas River side of the structure. Once flow is restored, the historic channel is expected to migrate in a natural sinuous manner over the planning horizon similar to conditions before the closure structure was installed. This migration is expected to impact “Farmlands of Statewide Importance” between the closure structure and the Arkansas River. However, while natural stream migration leads to erosion of land in outer meander bands, “new” land is created through development of point bars on the inside of the meander bends. Since much of the soils impacted are not “lost”, but rather transported to a new location, there would be no net loss of “Farmlands of Statewide

Importance" by opening the Historic Cutoff Structure in either alternative, therefore no net impacts.

4.6 Water Resources

Water resource impacts would involve hydrologic changes related to frequency and duration of flooding and changes to groundwater recharge and connectivity between lakes and river channels.

4.6.1 Hydrology

Modeled Changes in Flooding Frequency and Duration

Flood duration maps allowed comparison of changes in flooding for both alternatives. Specifically, maps showed changes in flood duration for the annual growing season defined as 15 March to 15 November (245 days) for the period of record (2000 through 2014). Appendix B contains these maps.

4.6.1.1 Alternative 1

Under Alternative 1, flood duration and frequency would not change from existing conditions in most of the study area (Table 14). Most changes would occur between river banks, except for one location in the project area. Construction of a new containment structure south of the Melinda Structure would create a single outlet running north over the Owens Lake Structure. Flood durations would increase here to the point of potentially changing habitats in the eastern half of Owens Lake. To mitigate this increase, Alternative 1 incorporates a water passage through the Owens Lake Structure at a lower elevation that mitigates changes to hydrology and returns it to patterns close to those under existing conditions.

Table 14. Change in Flooding Duration (Percent of the Study Area)

Alternative 1	- 7 Days (Drier)	No Change	+ 7 Days (Wetter)
500-foot opening	0.71%	98.65%	0.64%
1,000-foot opening	0.65%	98.72%	0.63%

4.6.1.2 Alternative 2

Under Alternative 2, the overall hydrology of the study area would change from existing conditions depending upon final design elevations of the structures. Some flood events could shorten in duration due to increased flows across the isthmus into the Arkansas River. Alternatively, flood frequency and duration in some areas might increase due to lowered connection elevations and reverse flows from these changes. Appendix B contains figures depicting the specific location of changes in inundation under Alternative 2

4.6.2 Changes to Hydrology in the National Wildlife Refuge

A significant concern from the beginning of the study surrounded potential inundation changes that would occur on the Refuge. Table 15 shows the changes expected in the specific landform microsite regions of the Refuge. Alternative 1 would not change the average annual days inundated, therefore no impacts.

Under Alternative 2, seven of the nine landform microsites would experience fewer (1 to 8 days) average annual days of inundation when compared to existing conditions. Changes would not be consecutive, but would occur in one or two day increments during each flooding event. As a result, it is unlikely that 8 fewer days of inundation spread across the growing season would alter habitats. Impacts would be permanent but insignificant.

Table 15. Change in Seasonal Inundation in the Dale Bumpers National Wildlife Refuge Based on Refuge Landform, Microsite, and Elevation

	Average Annual Days Inundated	Change in Average Annual Days Inundated (-) Drier (+) Wetter				
Landform, Microsite based on Elevation	Existing	Alt 1 w/ 500 ft. opening	Alt 1 w/ 1,000 ft. opening	Alt 2 at Elev. 115	Alt 2 at Elev. 125	Alt 2 at Elev. 135
PVL2 Flats <147.5 ft	50	0	0	-4	-4	-4
PVL2 Flats >147.5 ft	13	0	0	-8	-8	-8
HPS Ridges <145 ft	42	0	0	-2	-2	-2
HPS Ridges >145 ft	20	0	0	-4	-4	-4
HPS Natural Levees <145 ft	55	0	0	0	0	0
HPS Natural Levees >145 ft	13	0	0	-7	-7	-7
HPS Flats <142 ft	66	0	0	0	0	0
HPS Flats >142 ft	43	0	0	-3	-3	-3
Three Rivers back swamp final	73	0	0	0	0	-1

4.6.3 Surface Water

The frequency, duration, and timing of lake connectivity to the White and Arkansas rivers in the project area should not change significantly with either alternative. Under Alternative 1, opening the Historic Closure Structure, which approximates the elevation and capacity of existing flow paths across the isthmus, should result in minimal changes to hydrology and lake connectivity. The exception is at Owens Lake that currently receives flows above 145 feet from the White River over the Owens Lake structure and above 140 feet from the Arkansas River over the Melinda Structure. Constructing a new containment structure at an elevation of 157 feet south of the Melinda Structure would create an outlet north over the Owens Lake Structure. This would affect vegetation in the area adjacent to Owens Lake and would affect the frequency and duration of fish passing in and out of the lake. Alternative 1 incorporates a water passage through the Owens Lake Structure at a lower elevation to mitigate some of the floodplain disconnect. In addition, removing the Melinda Structure would reconnect the two limbs of Owens Lake restoring connectivity to Owens Lake. Impacts would be permanent and insignificant.

Under Alternative 2, high velocity flows would continue to pass through the Owens Lake and Melinda Channel corridors and serve as a conduit for flows between the White and Arkansas rivers. Constructing the structures would further exacerbate the Owens Lake disconnect between the two limbs created by the Melinda Structure. Impacts would be permanent, and insignificant since adverse impacts (flows and lake disconnect) already occur in the FWOP.

4.6.3.1 Clean Water Act

Direct impacts of Alternative 1 would result in filling in 20 acres of jurisdictional wetlands and 5 acres of WOTUS across the Melinda Channel from construction of the containment structure. This equates to net loss of approximately 4.4 functional capacity units that would require mitigation. Opening up the historic cutoff would also directly impact up to 300 acres of private land on the Arkansas River side of the structure. Once the historic channel is re-opened, the channel is expected to migrate in a natural sinuous manner over the planning horizon similar to conditions before the closure structure was installed. The sinuosity is expected to remove jurisdictional wetlands in the migration path; however, the lack of flowing open water in the previous channel path is expected to offset any jurisdictional wetland losses through development of jurisdictional wetlands in a previously open water location (i.e. accretion and erosion). Thereby not requiring any mitigation.

Based on Hec-Ras model runs, Alternative 1 would also have very minor indirect impacts to jurisdictional wetlands in the study area, but outside the project area. Alternative 1 does not alter flood duration and only minimally changes flood frequency, resulting in indirect permanent impacts to 100 acres of wetlands by shifting those acres from a Flats wetland subclass outside the five-year floodplain to a Riverine Backwater subclass in the five-year floodplain (Table 16). Section 4.7.2.1 and Appendix I provide more detail on these subclasses, such as functions performed, and typical vegetation type. While these existing "Flats" acres flood less frequently than Riverine Backwater wetlands, they are still flooded on a regular basis (perhaps every 5.5 or 6 years). Flood depth on these areas would remain essentially the same (less than 0.05 foot difference from FWOP) as they become wetter, they simply flood slightly more frequently. As such, this shift in subclasses would not result in a loss of jurisdictional wetlands. New Riverine Backwater wetlands would be fully functional; and as a result, there would be no net loss in wetland acres. Since both wetland subclasses provide many similar functions and have similar vegetation communities, no mitigation would be necessary for indirect impacts of Alternative 1. Indirect impacts for Alternative 1 would be permanent and insignificant. Since both wetland subclasses remain fully functional (and provide similar functions), this shift is neither beneficial nor adverse.

In addition to the above impacts, Alternative 1 would remove the Melinda Structure, which is in the channel of a WOTUS. Removing this structure would provide ancillary environmental benefits by restoring connectivity of Owens Lake (35 acres) to approximately 45 acres of former oxbow habitat (east arm of Owens Lake isolated by Melinda Structure) and restore this portion of the WOTUS to conditions prior to construction. Conversely, Alternative 2 does not restore any WOTUS or wetlands, and would further disrupt the connectivity of WOTUS and wetlands in and near the proposed structures.

Under Alternative 2, several new structures would be built in Owens Lake between Melinda and Owens Lake weir, and possibly the Historic Cutoff and Jim Smith Lake, to facilitate exchange of water in an environmentally optimized elevation. As discussed in Section 4.1, a preliminary hydraulic analysis of this alternative indicated too much hydrology change on FWS and AGFC property, thus violating a fundamental constraint of the study. As a result, there was no feasibility level design completed for this alternative. The PDT Hydraulic Engineer estimated anywhere between 20 – 50+ acres of BLH would be impacted due to tying structures to the banks, and construction of permanent roads to each structure (for inspection and O&M). These acres would be in addition to an estimated 15 acres of permanent and seasonal open water impacted by the structures. All direct impacts would require full mitigation. Mitigation costs would have only increased the economic costs, making this alternative that much less cost-effective.

Alternative 2 would have more indirect impacts to jurisdictional wetlands in the study area, but outside the project area. Change in flood frequency would impact 4,822 acres by shifting those acres from a Flats wetland subclass outside the five-year floodplain to a Riverine Backwater subclass in the five-year floodplain (Table 16). This shift in wetland subclasses would result in similar flood frequency impacts as those described for Alternative 1 above. A minor change in flood duration would occur on a small area under Alternative 2 (change in only a few hours on each side of a flood hydrograph), but would not impact wetland types. No mitigation would be necessary for indirect impacts to wetlands from Alternative 2. Impacts described above for Alternative 2 would be permanent and, while greater than those in Alternative 1, do not rise to a level of great concern, therefore they are insignificant.

During construction of either alternative, surrounding wetlands and WOTUS may experience a temporary decline in wetland and water quality, and a temporary interruption of hydrologic and wetland function in construction footprint of new structures and at the Historic Cutoff. Impacts to wetlands and water quality may include increased turbidity, decreased clarity, increased temperatures, and potential contamination of wetlands and waters if mechanical issues occur were to occur with construction equipment. A stormwater pollution prevention plan would be prepared prior to construction to address and mitigate potential contamination of wetlands and WOTUS. The hydrology of the area may be temporarily disrupted by placing barriers around the construction site in order to construct in drier conditions. These barriers would be re-moved immediately after construction is complete. In addition, modifying the Historic Cutoff Structure as proposed for either alternative would improve the hydrology in the area by increasing water exchange between the White and Arkansas rivers, thereby moving the system towards a more natural condition and partially restoring a portion of WOTUS. After construction, hydrology and water quality in wetlands and WOTUS would return to baseline conditions. Construction-related impacts would be temporary and insignificant.

4.6.3.2 Section 401 and 402

Any project that involves placing dredged or fill material in waters of the U.S. or wetlands, or mechanized clearing of wetlands requires a water quality certification from the state agency as delegated by EPA. The Arkansas Department of Water Quality (ADEQ) Water Division performs all state certifications under Section 401 and 402 of the Clean Water Act. USACE has received this certification (See Appendix D). USACE will pursue a Short Term Activity Authorization, which allows instream work that may cause a water quality violation in waters of the state or disturbance to any part of surface water tributaries, from ADEQ after the ADM. Because construction disturbance exceeds one acre, a National Pollutant Discharge Elimination System (NPDES) permit would also be pursued and would need to be issued prior to construction.

Table 16: Flood Frequency Analysis

	Study Area			HEC-RAS 2D Area		
Alternative	**5-year floodplain (acres)**	**Difference in 5-year floodplain**	**Percent change**	**5-year floodplain in**	**Difference in 5-year floodplain**	**Percent change**
Existing 5-year floodplain	127,090	0	0.0%	527,779	0	0.0%
C157HC145_500ft_5yr	126,910	180	0.1%	527,760	19	0.0%
C157HC145_1000ft_5yr	126,989	102	0.1%	527,722	57	0.0%
M135	122,268	4,822	3.8%	504,864	22,915	4.3%

4.6.3.3 Section 404

Actions associated with Alternative 1 were designed to reduce impacts on the environment and are the least environmentally damaging when compared to the FWOP or Alternative 2. Alignment of the containment structure relied on connecting high ground along the shortest path that met the objectives of the study. This design is approximately 9.5 miles shorter than that designed in the Ark-White Study and provides that same level of protection. As well, the alternative was designed in such a way that there would be minimal (<0.1 percent) increase in the 5-year floodplain inundation (flood frequency) and no change in the number of days the area is inundated (flood duration) when compared to the existing condition. Design of this alternative would also provide ancillary ecosystem restoration benefits, such as restoring the function of oxbow lakes and reducing erosion that was imminent under the FWOP or is seen under the existing condition.

Implementation of Alternative 2 includes the construction of new structures in Owens Lake (and possibly the Historic Cutoff and Jim Smith Lake) that would permanently impact 20 – 50 acres of BLH and another estimated 15 acres of WOTUS. Under this alternative, approximately 3.8 percent of the study area will shift into the 5-year floodplain which is expected to move the existing wetland type to one that is consistent with more frequent flooding. Portions of the area are modeled to become slightly drier over the course of eight, non-consecutive days per year. Although this change is unlikely to result in significant wetland changes, there is disagreement surrounding the historic, existing, and future composition of the surrounding bottomland hardwood forest, so the PDT and resource agencies agreed that even minimal change should be considered when identifying a Recommended Plan.

See Appendix D for the Section 404(b)(1) analysis.

4.6.3.4 Executive Order 11990

Executive Order (EO) 11990 directs federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction, to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of the EO.

Implementation of Alternative 1 would adversely impact vegetated wetlands, specifically bottomland hardwood forests. Long-term direct impacts of approximately 25 acres include filling in wetlands to construct the containment structure. Wetland vegetation would be removed throughout the length of the containment structure and converted to impervious surface. An additional 25 acres are anticipated to be temporarily impacted through removal of wetland vegetation, decreased hydrologic flow into the wetlands, altered water temperature, pH, nutrient levels, oxygen, and carbon dioxide as a result of construction activities. The water quality and hydrologic flow into the wetlands are expected to return to baseline conditions after construction activities cease. Herbaceous wetland vegetation is expected to return within one growing season. Woody wetland vegetation is anticipated to return; however, by the end of the planning horizon, the wetlands would be an earlier successional stage of bottomland hardwood forest than under the existing condition.

The HGM model results were used to calculate the mitigation requirements for the 25 acres of long-term direct impacts. In summary, 4.0 functional capacity units must be mitigated in-kind. An analysis of mitigation alternatives and cost was conducted, resulting in a recommended action to purchase mitigation credits from an approved mitigation bank. Details on mitigation can be found in Appendix N.

Alternative 2 would adversely impact 15 acres of WOTUS from construction of new structures in Owens Lake (and possibly Jim Smith and in the historic cutoff). Adverse impacts to 20 – 50 acres of forested wetlands would occur from new permanent roads needed for construction, inspection and maintenance of the structures. These permanent impacts would degrade Owens Lake, remove BLHs and fill wetlands for the roads. An additional 25 – 50 acres are anticipated to be temporarily impacted through removal of wetland vegetation, decreased hydrologic flow into the wetlands, altered water temperature, pH, nutrient levels, oxygen, and carbon dioxide as a result of construction activities. The water quality and hydrologic flow into the wetlands are expected to return to baseline conditions after construction activities cease. Herbaceous wetland vegetation is expected to return within one growing season. Woody wetland vegetation is anticipated to return; however, by the end of the planning horizon, the wetlands would be an earlier successional stage of bottomland hardwood forest than under the existing condition.

Alteration of the Historic Closure Structure elevation under both alternatives would have permanent indirect impacts to forested wetlands. The elevation change in Alternative 1 would impact 100 acres by increasing the flood frequency. This hydrologic change is not expected to result in any change in forest species composition or relative abundance. The elevation change with Alternative 2 would impact 4,822 acres in a similar fashion, although there could be a change in the relative abundance of some wetland tree species on higher elevation ground. Details on these changes can be found in Section 4.7.2.1. There would also be a minor change in flood duration on a limited number of acres. These sites would experience up to 8 days per year of drier conditions. This 8-day total would be spread out over several flood events, with water receding from these acres a few hours to perhaps a day sooner. While the change in flood frequency and duration that would be experience with Alternative 2 is not considered significant, or even measurable in some instances, the PDT and resource agencies felt that this level of change may cumulatively have a much greater impact to the immediate area and could result in a gradual shift in BLH species (relative abundance) over time in some areas.

Permanent, direct wetland impacts from either alternative would be mitigated with coordination from state and federal agencies. These impacts, while permanent, are considered insignificant.

Impacts to wetlands related to construction from either alternative would be temporary. These wetlands would return by the end of the period of analysis; however, they would be at an earlier successional stage of bottomland hardwood forest and not fully mature. These impacts would be insignificant.

4.6.4 Groundwater

Implementation of either alternative would not affect groundwater resources.

4.6.5 Water Quality

Both alternatives would negate future water quality impacts from erosion associated with head cutting and a breach. Construction of either alternative could increase runoff, the rate of in-stream sediment loading, and turbidity, and potentially decrease water quality. Additional impacts associated with construction would be the same as the FWOP condition. Impacts would be temporary and insignificant.

4.6.6 Floodplains

Because the project area is in FEMA Zone A, alternatives considered cannot cause a cumulative rise in the Base Flood Elevation (BFE, 1 percent exceedance frequency) of more than 1.0 foot. Implementation of either alternative would have essentially no impact to the 100 year floodplain. The 100-year floodplain inundation map for Alternative 1 (500ft and 1000ft openings) and existing conditions were the same with less than 0.05 feet difference in water surface elevations (Appendix B). HEC-RAS modeling of the two alternatives indicates that the 2 and 5-year floodplain would not change significantly from the existing condition. Under Alternative 1 with either opening, floodplains are almost identical to the existing condition, and Alternative 2 resulted in a slight increase (Figure 17, Figure 18 and Table 16).

4.6.6.1 Executive Order 11998

EO 11998 requires federal agencies to avoid, to the extent possible, short and long-term adverse impacts associated with occupancy and modification of floodplains. federal agencies must avoid direct and indirect support of floodplain development wherever there are practicable alternatives. In accomplishing this objective, "*each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilitie*s."

As stated earlier, both alternative project areas are in a 100-year floodplain as mapped by FEMA. Currently, there is no development in the floodplain in or near the project areas, and neither alternative would encourage development since the area is highly susceptible to flooding (in the 2 and 5-year floodplain). New structures for both alternatives would reduce natural floodplain interchange between the Arkansas and White rivers, which includes restricted floodplain interchange. However, opening the Historic Cutoff Structure (in both alternatives) would reestablish this floodplain interchange.

Overall, Alternative 1 would have fewer direct impacts to floodplains than Alternative 2. Impacts from either alternative would be permanent, but insignificant.

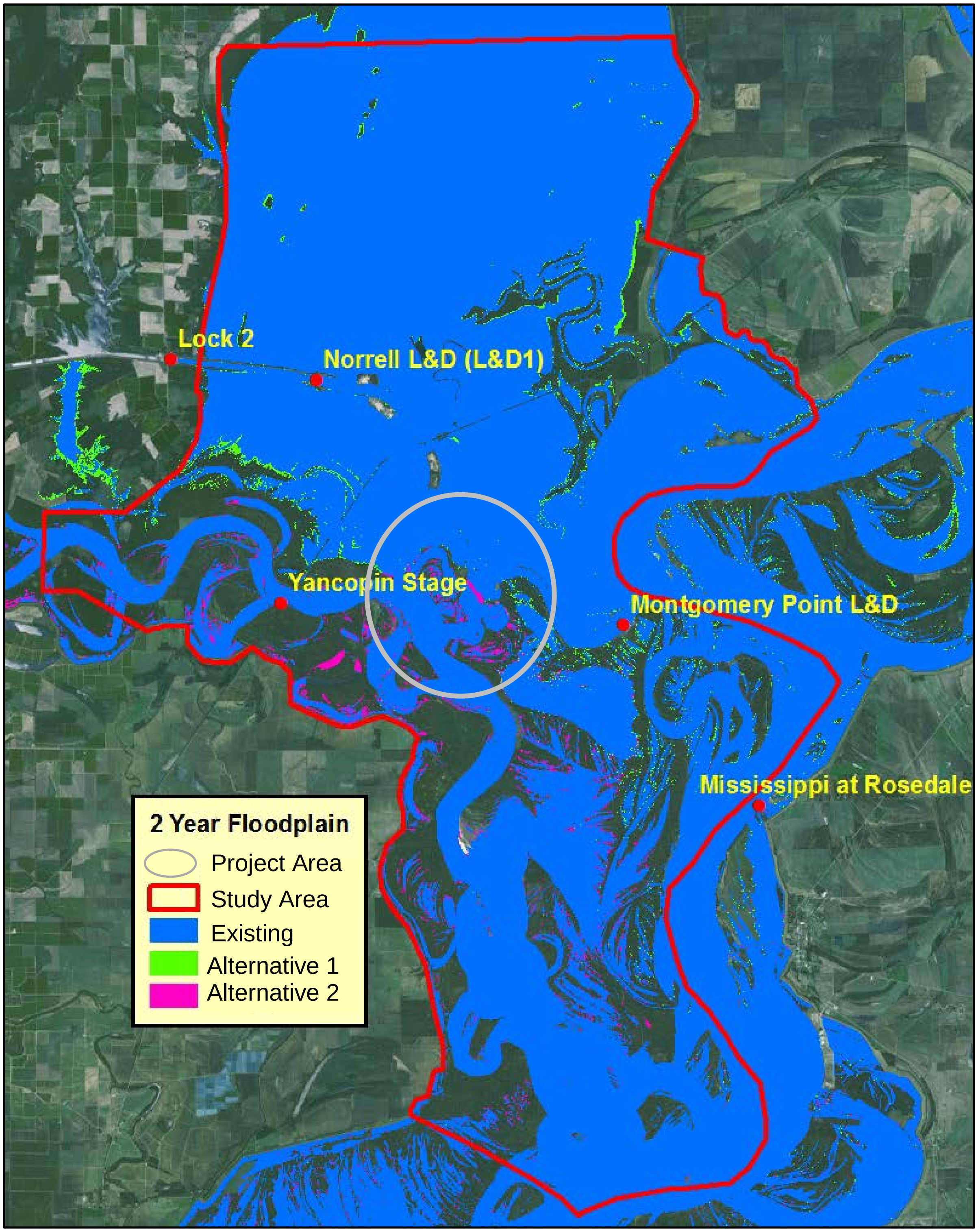

Figure 17: 2-year Floodplain Inundation under the Existing Condition and Alternatives 1 and 2

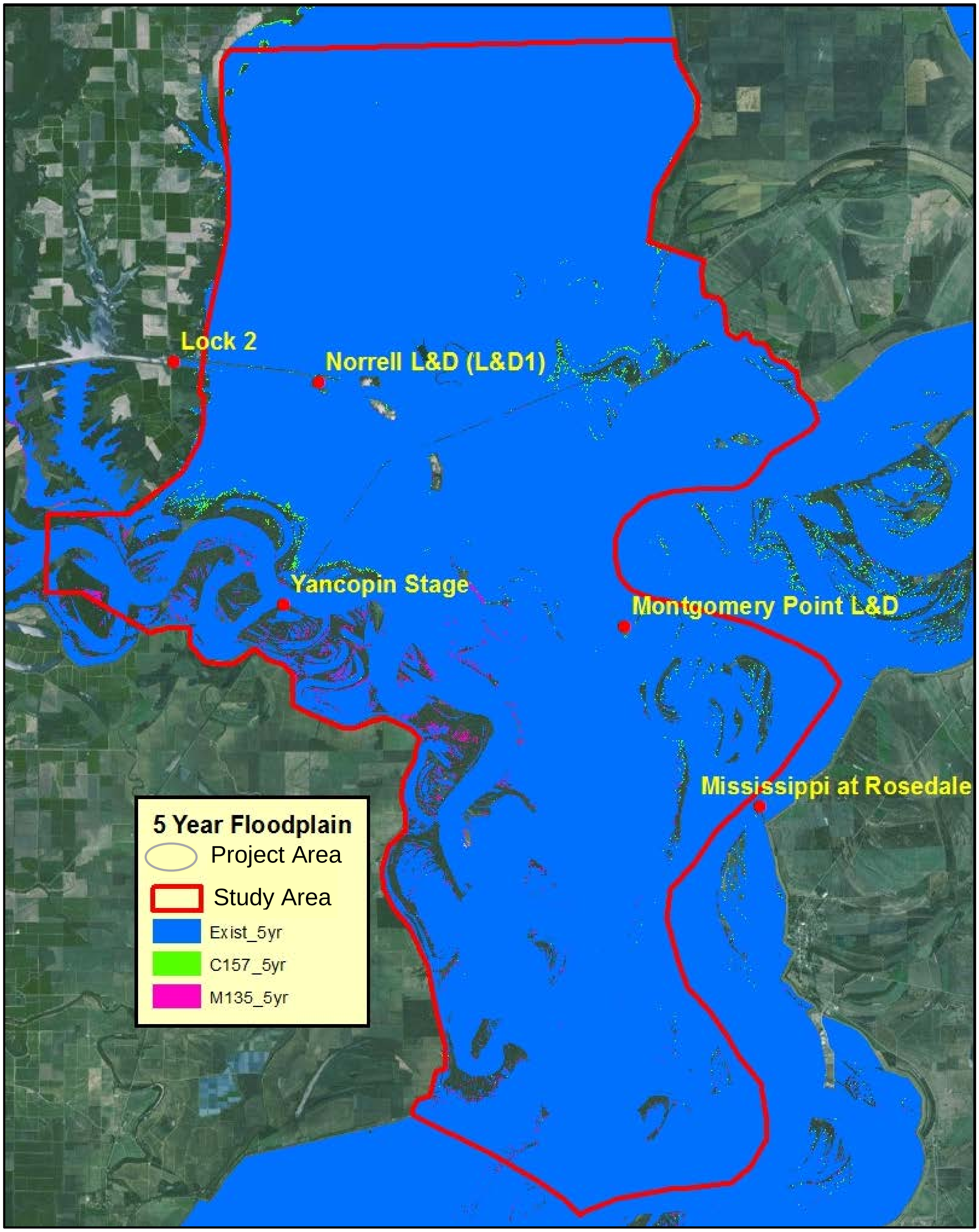

Figure 18: 5-year Floodplain Inundation under the Existing Condition and Alternatives 1 and 2

4.7 Biological Resources

Impacts to biological resources during construction are expected to be very similar to those described in the FWOP condition and include:

- Temporary decreases in aquatic habitat quality due to increased sedimentation;
- Temporary to permanent habitat removal or fragmentation associated with the structures and access roads;
- Habitat avoidance because of increased noise;
- Dust generation and vibrations from construction equipment; and,
- Mortality of slower moving species or species that were unable to leave the construction area.

The level and duration of impacts would depend on the final design of each alternative, type of equipment used, duration of construction, and plans for restoration, if required. However, once construction finished, construction impacts to aquatic species and terrestrial wildlife would cease and return to near baseline conditions.

As with any ground disturbance, the possibility of introducing, spreading, or establishing new populations of invasive, non-native species, particularly plants, exists. Contractors would clean all equipment prior to entering the construction area to avoid the spread of invasives, and would restore construction areas with native vegetation as needed. Although it is possible, most invasive species of concern would probably not have the opportunity to establish given frequent flooding that occurs in the study area. Therefore, it is unlikely that restoration of disturbed lands would be critical in preventing the introduction of invasive species. The adaptive monitoring and management plan for the study includes a section that addresses monitoring and response to invasive species.

4.7.1 Aquatic Habitat

Impacts described in the Future Without Project Condition Water Resources section also apply to aquatic habitats. In addition, in both Alternative 1 and 2, the Historic Cutoff would be opened creating a much wider flow path with less velocity than currently exists through the Melinda Corridor. This would allow water from the Arkansas and White rivers to interchange at an elevation closer to historic conditions, and provide a more frequent exchange of nutrients, as well as more fish passage. Furthermore, the opening would restore ecological function of Webfoot Lake by reducing or eliminating active erosion on the east side of the lake that adversely affects aquatic habitat.

Under both Alternatives, fish passage to Owens Lake from the Arkansas River would decline relative to existing conditions due to the increased height of the new structure through the Melinda Corridor (Alternative 1), and raising the existing Melinda Structure and adding two additional structures in Owens Lake (Alternative 2). Fish passage into Owens Lake from the White River would increase due to the opening through the existing Owens Structure under Alternative 1. However, fish passage between the White River and Owens Lake would not change under Alternative 2.

Alternative 1 has ancillary ecosystem benefits resulting from the removal of the Melinda Structure on the south end of Owens Lake for hydrologic reasons. Removal would reconnect the two halves of Owens Lake that the Melinda Structure severed when it was built, and thus increase available fish habitat (from 35 to 80 acres), particularly spawning and nursery habitat. Conversely, construction of Alternative 2 would adversely impact 15 acres of aquatic habitat in Owens Lake and possibly Jim Smith Lake. In addition, the two halves of Owens Lake would remain separate under this alternative.

Impacts from both alternatives would be permanent and insignificant.

4.7.2 Terrestrial Habitat

4.7.2.1 Modeling Efforts

The Hydrogeomorphic Approach Model (HGM) was used to assess wetland functions in the project area (Klimas et al 2004). Wetland functions assessed by the HGM approach include fish and wildlife habitat, nutrient cycling, plant community maintenance, and floodwater and precipitation detention. It was assumed that impacts to wetland functions assessed using HGM, while not specific to any particular wildlife species, represent a measure of ecosystem health and value to wetland dependent wildlife.

TThe HGM approach first groups wetlands into regional subclasses based on functional similarities within a given hydrogeomorphic setting. Wetland functions for each subclass are assessed using field collected or other sources of information. As discussed elsewhere in this report, there are two wetland subclasses present in the Study Area. The Flats subclass is composed of wetland acres located outside of the five year floodplain, while the Low Gradient Riverine Backwater subclass is composed of wetland acres located within the five year floodplain. These two subclasses share all of the functions listed above, with the exception of floodwater detention, which is a function unique to Low Gradient Riverine Backwater wetlands, due to the more frequent flooding. These two subclasses also share many similar vegetation types, especially in the Study Area, which is predominantly low-lying forestland. BLH forest composition is predominately overcup oak (*Quercus lyrata*), willow oak (*Quercus phellos*), sugarberry (*Celtis laevigata*), and water hickory (*Carya aquatica*). Baldcypress (*Taxodium distichum*) water tupelo (*Nyssa aquatica*), and buttonbush (*Cephalanthus occidentalis*) become dominant on sites with standing water and/or saturated soils. As you move farther away from the five year floodplain (higher elevations, but still Flats wetlands) species like Nuttall oak (Quercus nuttallii), cherrybark oak (*Quercus pagoda*), and eastern cottonwood (*Populus deltoides*) become more dominant. These higher Flats types are more frequent on the northern part of the Study Area, and farther north in the Dale Bumpers White River National Wildlife Refuge.

Specific information collected that characterizes the wetland functions comprises the variables that are inserted into a simple logic model that describes the level to which each function is being performed by the particular wetland subclass. For example, vegetative data may be directly measured using standard forest sampling methods, while flood frequency data may be obtained from gage data, flood zone mapping or other sources. The HGM approach is similar to Habitat Evaluation Procedure (HEP) in that it generates a Functional Capacity Index (FCI) which is multiplied by the wetland area to calculate the amount of Functional Capacity Units (FCU) for each assessed function. These FCU can then be used to compare wetlands within the same regional subclass.

Detailed information associated with the HGM wetland analysis can be found in the Appendix I—HGM Analysis.

Construction of Alternative 1 would directly and permanently impact 25 acres and temporarily affect 25 acres of forested bottomland hardwood wetlands. Affected acres are Riverine Backwater wetlands based on the HGM methodology. The HGM assessment determined the permanently affected acres would lose (all functions) of 16.5 Functional Capacity Units (FCUs) across six wetland functions (Table 17). While total FCU loss is useful for understanding the magnitude of change associated with the alternative, the standard recommendation is to mitigate for the most-impacted function, thereby assuring that all other functional losses have been overcompensated. Therefore, mitigation for the Riverine Backwater class for Alternative 1 would be based on a loss of 4.4 FCUs for the “Provide Wildlife Habitat” function. Appendix 1 contains detailed information associated with the HGM wetland analysis.

Table 17: Change in Functional Capacity Units (FCUs) for Riverine Backwater

Functions	Pre-Project			Post-Project			Net Loss		
	FCI	Adj. FCIs	Adj. FCUs	FCI	Adj. FCIs	Adj. FCUs	FCI	Adj. FCIs	Adj. FCUs
Detain Floodwater	0.89	0.00	0.00	0.73	0.00	0.00	-0.16	-0.16	-1.60
Detain Precipitation	0.73	0.73	7.30	0.33	0.33	3.33	-0.40	-0.40	-4.00
Cycle Nutrients	0.86	0.86	8.60	0.69	0.69	6.90	-0.17	-0.17	-1.70
Export Carbon	0.86	0.86	8.60	0.69	0.69	6.90	-0.17	-0.17	-1.70
Maintain Plant Communities	0.79	0.79	7.90	0.48	0.48	4.80	-0.31	-0.31	-3.10
Habitat	0.89	0.89	8.90	0.45	0.45	4.50	-0.44	-0.44	-4.40
Totals	**5.02**	**5.02**	**50.20**	**3.37**	**3.37**	**33.70**	**-1.65**	**-1.65**	**-16.50**

Constructing new structures in Owens Lake between the existing Melinda and Owens Lake structures, and possibly between Jim Smith Lake and the Historic Cutoff, as part of Alternative 2 would directly impact an estimated 15 acres of oxbow lake habitat and 20 to 50 acres of forested wetland. Mitigation calculations were not done for Alternative 2, as the PDT did not complete a feasibility level design given the significant difference in construction costs between the projects (roughly $179 million versus $245 million). Mitigation requirements for Alternative 2 would likely be more than Alternative 1 in terms of both acres and cost. For calculating BCRs, the PDT opted to assume that mitigation costs for both alternatives are the same since any differential in mitigation costs between the two would not affect selection of the preferred alternative.

Lowering the Historic Closure Structure to elevation 135 feet or lower in Alternative 2 would also affect flood duration on a very small area of higher ground in the northwest part of the study area in the Refuge. The lower elevation of the Historic Closure Structure would cause water to recede from high ground faster after each flood event (only a few hours for each event, resulting in an average annual decrease of 8 days). Because the duration of individual flood events only changes a few hours, it is unlikely result in any change in forest species presence or abundance.

Both alternatives will have some indirect impacts in the study area. Implementation of Alternative 1 with either opening width in the HSC will result in approximately 0.1 percent of existing Flats subclass acres (180 acres @ 500 feet; 102 acres @ 1,000 feet) becoming wet enough to move into a Riverine Backwater subclass. Alternative 2 has more indirect impacts, with 3.8 percent of existing Flats subclass acres (4,822 acres) becoming wet enough to shift to a Riverine Backwater subclass. Affected acres are in the isthmus between the Arkansas and White rivers. Wetland functions would remain similar on all acres as the wetland subclass changes, with the exception of detaining floodwaters. The minor wetland shift associated with Alternative 1 (100 acres) would occur in a low-lying area where the five-year floodplain shifts to less frequent flooding. As discussed previously, Riverine Backwater and Flats wetlands in these low-lying areas share many similar characteristics, thus it is unlikely that any change in forest species composition or relative abundance would occur. The change in wetland subclass associated with Alternative 2 would impact a much larger area (4,822 acres) that would result in some Flats wetlands at slightly higher elevations converting to Riverine Backwater wetlands. Some of these Flats wetlands at slightly higher elevations probably have similar forest species, but they may have slightly different relative abundance of those species (e.g. there could be more Nuttall oak and less overcup oak than on Flats located at lower elevations). Because of this possible difference in abundance, it is possible that some change in forest composition (i.e. relative abundance) would occur. The new Riverine Backwater wetlands under both alternatives would be fully functional, and thus there would be no net loss of wetland acres, just a change in wetland type. As such, no mitigation is necessary for indirect impacts of either alternative.

Under both alternatives, opening the historic cutoff may directly impact lands on the Arkansas River side of the structure. Once flow is restored, the historic channel is expected to migrate in a natural sinuous manner over the planning horizon similar to conditions before the closure structure was installed. As the channel migrates, forested wetlands in its path will be lost. However, the lack of flowing open water in the previous channel path would result in development of forested wetlands in this area, thus offsetting any wetland losses (i.e. accretion and erosion). Therefore, mitigation is not required for this impact.

All impacts described above would be permanent and insignificant.

4.7.3 Threatened and Endangered Species Effects Determinations

USACE prepared a Biological Evaluation that included analysis of Alternative 1, and transmitted the evaluation to USFWS on March 8, 2017 (Appendix E). USFWS concurred with the following effects determinations in a letter dated March 17, 2017 (Appendix E). Although the Biological Evaluation did not specifically address Alternative 2, impacts would be very similar. In summary, the evaluation made the following determinations.

4.7.3.1 Pallid Sturgeon

Alternative 1 **may affect, but is not likely to adversely affect** the Pallid Sturgeon.

- Pallid sturgeon use of the lower Arkansas River is thought to be incidental by experts studying this species. The current theory is that this species moves in to the lower Arkansas during flood events on the Mississippi River to avoid high water flows.
- Temporary impacts would reduce the quality of potentially suitable habitat in the lower Arkansas River; however, construction would likely occur during low water conditions when pallid sturgeon prefer the Mississippi.
- Pallid sturgeon are not known to occur in the lower White River.

4.7.3.2 Fat Pocketbook Pearly Mussel

Alternative 1 **may affect, but is not likely to adversely affect** the Fat Pocketbook Pearly Mussel.

- No change in the frequency or duration of flooding, and thus no impact.
- Construction may increase sediment in the lower Arkansas River; however, the duration would be short and would likely occur during low-flow conditions.
- Presence of suitable habitat downstream of the project area on the lower White River is unlikely due to maintenance dredging for navigation.

4.7.3.3 Rabbitsfoot Mussel

Alternative 1 **may affect, but is not likely to adversely affect** the Rabbitsfoot Mussel.

- Closest known populations are near St. Charles, Arkansas, 47 river miles upstream of the project area.
- Dredging and incision on the lower White River has likely destroyed any suitable habitat that may have once been present.
- Not known to occur in the lower Arkansas River. Past mussel surveys on the lower Arkansas River have failed to record any mussel species.
- USFWS PAR states that this species is very unlikely to occur in areas potentially affected by project alternatives, therefore no impacts to this species anticipated.

4.7.3.4 Pink Mucket Pearly Mussel

Alternative 1 **may affect, but is not likely to adversely affect** the Pink Mucket Pearly Mussel.

- Most pink mucket pearly mussel populations occur in the Ouachita Mountain ecoregion of west Arkansas.
- Closest specimens documented in the White River are 150 to at least 200 miles upstream of the study area.
- Preferred habitat is medium to large rivers in gravel with sand substrate. Gravel substrate is uncommon in the project area.
- Dredging and incision on the lower White River has likely destroyed any suitable habitat that may have once been present.
- Pink Mucket Pearly mussels are not known to occur in the Arkansas River. Past mussel surveys on the lower Arkansas River have failed to record any mussel species.
- USFWS PAR states that this species is very unlikely to occur in areas potentially affected by project alternatives, therefore no impacts are anticipated.

4.7.3.5 Scaleshell Mussel

Alternative 1 **may affect, but is not likely to adversely affect** the Scaleshell Mussel.

- Closest documented occurrence in the White River is 236 river miles above the project area.

- Harris and Christian (2009) indicate that the Scaleshell Mussel prefers small to medium sized rivers in Arkansas and is an Ozark Highlands species.

- Preferred habitat is stable riffles and runs with gravel or mud substrate and moderate current velocity. The lower White and Arkansas rivers lack riffle-run habitat, and gravel substrate.

- Not known to occur in the Arkansas River. Mussel surveys on the lower Arkansas River have failed to record any mussel species.

- Dredging and incision on the lower White River has likely destroyed any suitable habitat that may have once been present.

4.7.3.6 Ivory-billed Woodpecker

Alternative 1 **may affect, but is not likely to adversely affect** the Ivory-billed Woodpecker.

- Surveys of potential habitat in the Big Woods region failed to document any Ivory-billed Woodpeckers (IBWO).

- Construction would not direct effect the IBWO. Approximately 25 acres of bottomland hardwood forest would be lost due to construction, but several thousand acres of suitable habitat exists adjacent to this area.

- Indirect effects are possible during construction (habitat avoidance from noise and activity); however, they would be temporary and of short duration. Presence of several thousand acres of contiguous habitat in the Big Woods area provides ample room for wildlife to escape disturbance.

- USFWS PAR no longer recommends official pre-project surveys; however, any observations of birds or potential signs of occupation (foraging signs or cavities) should be reported to the USFWS.

4.7.3.7 Interior Least Tern

Alternative 1 **may affect, but is not likely to adversely affect** the Interior Least Tern.

- Interior Least Tern are known to use sandbars near the project area for nesting. The closest known nest site is on the Melinda Sandbar immediately across the Arkansas River from the Melinda Structure.

- Flood frequency and duration data indicate no direct impacts to nests due to sandbar elevations versus elevation of water exchange from the proposed action.

- Construction would temporarily increase noise and human disturbance, which could lead to habitat avoidance; however, ample habitat exists elsewhere on Arkansas and Mississippi rivers if disturbance is an issue.

- Construction would likely occur during low-flow conditions (summer and fall), when the birds are in Central and South America and the Caribbean.

4.7.3.8 Piping Plover

Alternative 1 **may affect, but is not likely to adversely affect** the Piping Plover.

- While suitable stopover habitat is present, no birds have been documented in the study area.

- Flood frequency and duration data indicate no direct impacts to habitat due to sandbar elevations versus elevation of water exchange from the proposed action.

- Construction would temporarily increases noise and human disturbance, which could lead to habitat avoidance; however, ample habitat exists nearby on lower Arkansas and Mississippi rivers if disturbance was an issue.

- Plovers typically use stopover sites for only a few days, and thus they would relocate regardless of any disturbance.

4.7.3.9 Rufa Red Knot

Alternative 1 **may affect, but is not likely to adversely affect** the Rufa Red Knot.

- Rufa Red Knots are uncommon in Arkansas, as they primarily use coastal areas during migration and wintering.

- While suitable stopover habitat is present, no birds have been documented in the study area.

- Flood frequency and duration data indicates that there would be no direct impacts to red knot stopover habitat due to elevations of sandbars, versus elevation of water exchange from the proposed action.

- Construction would temporarily increase noise and human disturbance, which could lead to habitat avoidance by red knots; however, ample habitat exists nearby on lower Arkansas and Mississippi rivers if disturbance was an issue.

- Rufa red knots typically use stopover sites for only a few days, and thus would relocate regardless of disturbances.

All impacts mentioned above are construction related, thus are temporary and insignificant.

4.7.4 Fish and Wildlife Management Areas

Both alternatives would involve construction on the Refuge. While a compatibility determination is not yet complete, Alternative 1 could be more compatible than Alternative 2. Alternative 1 would not substantially change the hydrology of the Refuge or surrounding properties. This is important because there are no studies completed to determine whether changes in hydrology would be a benefit or detriment to Refuge habitats. In absence of such studies, the best option is not to institute additional changes. Alternative 1 accomplishes study objectives, maintains connectivity between the White and Arkansas rivers via the Historic Cutoff with minimal direct impacts to the Refuge (i.e., 0.63 miles of containment structure on less than 10 acres).

4.8 Cultural Resources

The Area of Potential Effect for this study is the horizontal and vertical footprint for all actions involved with construction of an alternative. For both Alternative 1 and 2, proposed actions do not overlap any identified archaeological sites.

Given the long history of human activity along the waterways and inland through the study area, encountering any prehistoric archaeological sites in the project area is a possibility. Construction of the containment structure alignment for Alternative 1 would potentially affect previously unrecorded prehistoric cultural resources since portions of the alignment are in undisturbed areas or on high ground. Potential effects consist of direct impacts from earth moving, excavation activities, borrow locations, using access road and routes, staging areas, and other associated actions. Creating a relief channel through the Historic Closure Structure could potentially bury or uncover archaeological sites due to changes in water movement due to new relief channel. Likewise changes in the elevations of various structures proposed in Alternative 2 could also bury or uncover new archaeological sites, resulting in similar impacts. None of the proposed actions would affect the existing channel; and therefore; would not affect any submerged cultural resources.

While impacts are not anticipated with either alternative, should any occur to cultural resources, they would be permanent and significant.

A cultural resources survey would be required prior to construction of either alternative to comply with the National Historic Preservation Act of 1966, as amended. To ensure compliance during PED, USACE has developed a Programmatic Agreement with the Arkansas State Historic Preservation Office (SHPO), the Advisory Council on Historic Preservation, and the appropriate federally recognized Indian tribes with ancestral connections to the region. The Programmatic Agreement is in Appendix K to this document.

4.9 Recreation and Aesthetics

Recreation and aesthetic impacts would be very similar to the FWOP condition in that during construction there would be temporary reductions in recreational opportunities in the immediate vicinity of the construction footprint. Alternative 1 and 2 would have a longer single duration of temporary recreation loss compared to the FWOP; however, both alternatives would only have one duration of construction rather than up to four separate periods of construction as is the case with the FWOP.

Alternative 1 would require fewer temporary access roads resulting in less short-term visual disturbances to the landscape. However, the structure would be significantly longer than any of the FWOP structures resulting in a larger permanent visual disturbance to the landscape. As designed, the proposed structure is tallest east of the Melinda head cut at an elevation of 12 feet; but for the most part, the structure is only seven feet taller than the existing structure and the adjacent road surface, while areas near the Jim Smith Lake natural berm (south of the proposed alignment) would be lower than the natural berm. Visual disturbance would be limited to those who travel on the adjacent road or by watercraft on the White or Arkansas rivers. The height of the structure is low enough so that the surrounding bottomland hardwoods would mask the structure from areas further away.

Alternative 2 would install two new structures and modify two existing structures in the Melinda Corridor. Despite having an additional structure to construct, construction would require fewer miles of temporary access road. Unlike the FWOP where each structure would require its own set of temporary roads, structures for Alternative 2 would be fairly close together, and construction crews could use the same system of access roads for several structures. Visibility of the structures would be similar to the FWOP condition.

Adverse impacts to recreation and aesthetics are anticipated from implementation of Alternative 1 or 2, but only temporarily and extremely localized, thus insignificant. Construction of access roads and presence of construction equipment would result in temporary aesthetic impacts. Once constructed, there would be some loss of aesthetics, but only in the immediate area, and although permanent, they would not rise to level of significant.

4.10 Transportation

4.10.1 Highways, Roadways, and Railways

Either alternative would temporarily close roads in the project area. Affected roads are not main highways or arterial streets regularly used by the public and are predominately used by recreationists such as hunters or timber company staff. Temporary closures would not limit access to public or private lands because lands can be accessed by alternate routes. Implementation of either alternative would not cause undue hardship to motorists, therefore impacts would be insignificant.

4.10.2 Navigation

Based on feasibility level designs, both alternatives would reduce the probability of a full breach of the containment structure. As discussed previously, engineers and hydrologists will refine designs during PED to ensure that significant cross currents would not occur in the navigation channel.

4.11 Socioeconomics and Environmental Justice

Socioeconomic impacts would be very similar to the FWOP condition in that during construction there would be temporary increases in employment in the construction sector and increased revenue in the regional economy. Alternative 1 and 2 would have a longer single duration of temporary increases compared to the FWOP; however, both alternatives would have only have one duration of construction rather than up to four separate periods of construction as is the case with the FWOP. Impacts to Environmental Justice populations and children would be identical to the FWOP.

4.12 Hazardous, Toxic, and Radioactive Waste

Proposed alternatives would not affect HTRW. Construction of either alternative would require monitoring to prevent hazardous materials releases, and during construction USACE would adhere to all appropriate federal, state, and local laws, regulations, and permits to ensure that no hazardous wastes were introduced into the environment.

4.13 Cumulative Impact Analysis

This section presents the cumulative impacts of Alternative 1 and 2. NEPA regulations require that cumulative impacts of a proposed action be assessed and disclosed in an EIS. Council on Environmental Quality (CEQ) regulations define a cumulative impact as "*the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time*." (40 CFR 1508.7)

USACE used NEPA guidance to identify resource topics discussed in the cumulative impact analysis (40 CFR 1508.25). Based on a review of the likely environmental impacts analyzed in Chapter 2 (Affected Environment and Future Without Project Condition) and in this chapter (Future With-Project Condition), USACE determined that the analysis of cumulative impacts would be limited to: land use, air quality, geology and soils, water resources, biological resources, recreation and aesthetics, and socioeconomics (Table 18).With respect to the remaining resource topics such as climate, environmental justice, and HTRW, the future with-project condition shows that either alternative would:

1. Not result in any direct or indirect impacts and therefore would not contribute to a cumulative impact; or,

2. That the nature of the resource is such that impacts do not have the potential to cumulate. For example, impacts related to geology are site specific and do not cumulate; or,

3. That the future with or future without project condition analysis is a cumulative analysis and no further evaluation is required. For example, because climate change is global in nature, the future without project condition and future with project condition analysis is inherently a cumulative impact assessment.

For each resource topic carried forward for cumulative impact analysis, the timeframe for analysis is 60 years in the past (1955) and 50 years in the future (2075). This timeframe accounts for periods when the MKARNS opened and significant modifications on the White River completed, and the time frame captures periods when a significant number of environmental laws such as NEPA were enacted that prioritized environmental protection. The future timeframe aligns with the economic period of analysis.

Past, present, and reasonably foreseeable future actions are diverse and too numerous to list each individual activity but they can be categorized by the following types of activities:

- Reservoir and hydropower operations of USACE, Southwest Power Administration, and public utilities;
- USACE OMRR&R activities such as dredging and flood control structure such as levees;
- USACE regulatory actions (i.e., Section 404 permitting);
- Fish and wildlife management activities of the USFWS, AGFC, non-government entities, and private landowners;
- Land use on federal and private lands; and,
- Source point and non-point source pollutant activities by public and industrial sectors.

Table 18 summarizes cumulative impacts (past, present and reasonably foreseeable) for relevant resource topics.

Table 18: Cumulative Impacts

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Land Use	• Relatively minor change in land use consisting of shift from BLH*/wetlands and previously disturbed areas to structural features of the alternatives. • Reduction in erosion and head cutting.	• MKARNS construction and related projects has changed the land use of hundreds of acres from BLH/wetlands to construction footprints of projects; • Previous BLH/wetlands have been converted to agricultural fields; • Timber stands have been harvested for industry use and converted to a monoculture of even-aged forest • Reduction in land due to conversion to open water and/or dry streambed.	• Land use is normally constant consisting of state and federal wildlife management areas, private hunting clubs, timber production stand maintenance, and MKARNS operation and maintenance (O&M) activities. • Protection of the contiguous BLH in the MAV as a unique and valuable resource. • Continual erosion and head cutting.	• Continuation of present actions. Additional timber harvesting resulting in a conversion of hardwood stand to open grass areas which will begin a successional progression towards a mature hardwood stand. • MKARNS deepening may require additional dredge disposal sites that will convert existing land use to a disposal pile. • Area is not anticipated to be developed in the future.	• The conversion of BLH/wetlands and previously disturbed areas to impervious surface would be less than that converted under the past actions and would not cumulatively impact any future land use changes. Mitigation would offset any impacts. • Beneficial cumulative impact by reducing ongoing erosion and head cutting, significantly reducing the risk of a breach.
Air Quality	Minor construction related air emissions in the form of fugitive dust and vehicle emissions during construction only.				Cumulatively the impacts from either Alternative wouldn't cause the area exceed NAAQS. No cumulative impacts anticipated.

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Geology and Soils	• No geology impacts. • Minor alternation in soils as a result of construction of alternatives. Impact limited to footprint of each alternative. • Reduction in erosion from existing head cutting. • Loss of approximately 15 acres of prime farmland. • Changes in topography.	• No geology impacts. • Soil modifications in construction areas due to compaction and borrow material placement; • Continual loss and replacement of soils in the area due to flooding. • Erosion from head cutting. • Loss of prime farmlands from construction of structures; Gain of prime farmlands from construction of flood control structures and dewatering activities • Changes in topography from construction of structures;	• No geology impacts. • O&M activities of existing structures can result in minor soil modification from compaction and borrow material placement. Dredging activities results in the removal of sediment from the system. • Continual loss and replacement of soils in the area due to flooding. • Erosion from head cutting. • Loss of prime farmland if O&M activities require construction of access roads or widening of structures.	• MKARNS will be deepened to 12 feet removing additional sediment from the system and adding additional sediment to the existing and/or new placement areas. • Soil loss and replacement from future flooding events.	• No cumulative impacts to geology. • Cumulatively impacts are expected to be minor. Alternative 1 would result in a further reduction in potential sediment moving between the Arkansas and White rivers, but is likely to be offset by opening the Historic Cutoff. • Beneficial cumulative impact by reducing ongoing erosion and head cutting, significantly reducing the risk of a breach.

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Water Resources	• No change in hydrology (Alt 1) or minimal change in hydrology (Alt 2) • Reduction in WOTUS**, specifically wetlands. Mitigation required. • Minimal change in floodplains • Beneficial change in lake connectivity at Owens Lake. • Temporary decrease in water quality associated with construction activities.	• Corps Construction activities (MKARNS dredging, Historic Cutoff, Montgomery Point Lock & Dam., etc.) resulted in modification of frequency and duration of flooding from the Arkansas and White rivers within the study area. Significant impacts were mitigated primarily through reforestation activities. • Significant reduction in floodplain function, including lake connectivity, due to river training and flood control actions. • Significant reduction in BLH/wetlands because of conversion to agriculture fields and timber harvest stands. • Increase in surface water due to erosion and head cutting.	• MKARNS dredging and O&M on existing Corps projects in the area continue to have mainly temporary impacts to water resources in the study area. • Increase in surface water due to erosion and head cutting. • Decreased water quality due to barge traffic on the MKARNS and temporary decrease in water quality during O&M activities.	• Continued OMRR&R on Corps projects would have temporary impacts on water resources in the study area. • No major flood control projects or river training actions are projected, except for deepening of the MKARNS, which would increase the surface water depth. • Continued decreased water quality due to barge traffic on the MKARNS.	Corps activities have permanently modified the water resources in the study area. Impacts from the alternatives are insubstantial compared to the changes experienced in the past. Cumulatively the alternatives are anticipated to result in less than significant impacts to water resources due to no/insignificant change in hydrology, floodplains, and water quality; reconnection of Owens Lake; and mitigation of BLH/wetlands loss.

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Biological Resources	• Impacts from conversion of BLH/wetlands would occur, but would be appropriately mitigated. • Temporary impacts from increased noise, vibration, and dust would occur during construction.	Significant impacts to fish and wildlife resources have occurred due to the construction of past Corps projects in the area and conversion of habitats. USACE and USFWS projects have been mitigated, but state and private land impacts have not.	O&M activities, depending upon the scale, of existing projects would likely impact biological resources (wetlands, aquatic species, etc.) and would require mitigation.	Future O&M or construction of additional structures if needed would more than likely impact wetland resources and would require full mitigation.	Cumulatively, less than significant adverse impacts are anticipated, but would be appropriately mitigated to offset the habitat loss. Other impacts are temporary in nature and cumulatively should not have any impact of biological resources.
Threatened & Endangered Species	T&E may be affected by the alternatives, but are not likely to be adversely affected.	Previous river training, dredging, conversion of BLH/wetlands to agricultural lands, clearcutting of timber stands, and other past activities have reduced the available habitat for T&E species, particularly species that prefer slow and shallow rivers with cobble beds.	Impacts from current O&M activities (i.e. dredging activities, USFWS and AGFC management activities, private land timber maintenance) have had section 7 or section 10 consultation completed.	Any future activities will require full compliance and coordination with the USFWS and state agencies to ensure the protection of any T&E species in the area.	No significant cumulative impacts are anticipated. See Appendix E for a more detailed analysis.

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Cultural Resources	Monitoring during construction would be conducted and if any cultural resources are discovered work would cease until A determination of eligibility for the National Register of Historic Places could be made. For resources determined eligible, appropriate mitigation would be performed to reduce impacts to the resource before construction could continue.	Previous Archeological surveys have found minimal cultural resources in the area. Past projects have had no impact on any known cultural resources.	Current O&M activities are monitored for cultural resources. If found, proper investigation are conducted.	Any future new projects or O&M activities of existing structures would be monitored for the presence of cultural resources. Proper investigations would be conducted if significant resources are uncovered.	No significant cumulative impacts are anticipated.
Recreational and Aesthetic Resources	• Temporary reduction in recreational use of the immediate project area; however, in the future, flooding would not occur as frequently increasing the availability of recreation activities. • Aesthetically, the area would be impacted by the construction of any of the alternatives to varying degrees.	• Minor impacts to recreation due to minor losses in fish and wildlife habitat. • Beneficial impacts in the form of improved access. • Flood control structures and river training activities have modified the natural setting of the area.	• Current projects such as O&M activities should only have temporary impacts to recreational activities. • O&M activities should only have temporary adverse effects to aesthetic values due to presence of construction equipment and personnel and restoration of disturbed areas following construction.	Future actions are expected to be similar to the present action.	• No cumulative impacts to recreation are anticipated. • Aesthetic values of the area would have less than significant cumulative impacts to the natural setting of the area.

Resource Area	Alternative 1 or 2	Past Actions	Present Actions	Reasonably Foreseeable Future Actions	Cumulative Impacts
Transportation	• Alternative 1 would result in the construction of temporary haul roads that would not be maintained. Alternative 2 would result in construction of permanent access roads to new structures. Navigation would be protected due to alternatives constructed. • Reliable navigation is anticipated.	• Haul roads were constructed to aid in the construction of past structures in the area, access timber harvest stands, and for recreational purposes. • Navigation has been protected due to past Corps projects, but periodically is shut down due to unsafe conditions.	• Roads in the study area are currently maintained by USACE, USFWS, AGFC and private landowners but are frequently closed due to flooding. • Navigation is maintained by USACE, but remains at risk due to potential breach of the existing containment structure.	• No additional modification or additions to existing roads are anticipated. • The protection of Navigation interests are a major concern and future projects, if required, would be constructed to protect these national interests.	• Beneficial cumulative impacts associated with implementation of either alternative are anticipated since the existing access roads would not flood as frequently and proposed access roads would be temporary. • Beneficial cumulative impacts are anticipated due to increased safe and reliable navigation with implementation of either alternative.
Socioeconomics	Minor beneficial impacts were/would be realized due to temporary increase in employment and local revenue during construction.		Current projects such as the Montgomery Point lock and dam provide only a minor input into the local economy. Timber production provides employment opportunities and minor economic benefits to the local economy. Recreation provides local revenue, particularly during hunting season.	Minor beneficial impacts would be realized due to temporary increase in employment and local revenue during construction.	Temporary beneficial cumulative impacts are anticipated.

*BLH = Bottomland hardwoods
**WOTUS = Waters of the United States

4.14 Irreversible and Irretrievable Commitment of Resources

Study alternatives involve the use of both natural and socioeconomic resources. Irreversible and irretrievable economic resource commitments associated with implementation of either alternative include: capital resources, labor resources, fuels, and other construction-related materials. Use of economic resources would not adversely impact the availability of such resources for other projects both now and in the future. Natural resources used or changed under any of the action alternatives would include biotic resources, water resources, existing land uses and visual resources. In general terms, the use or associated changes of natural and industrial resources are irretrievable under any of the alternatives. Most adverse impacts associated with each alternative can be mitigated.

4.15 Mitigation

After all possible minimization and avoidance measures were incorporated into the Recommended Plan design features, adverse long-term impacts to 25 acres of bottomland hardwood would be unavoidable. Impacts are due to converting bottomland hardwood to impervious surface along the containment structure alignment. Alternative 1 would result in the loss of 4.4 FCUs for the “Provide Habitat for Fish and Wildlife” function (the most-impacted function), whereas Alternative 2 results in adverse long-term impacts to 15 acres of WOTUS and 20 – 50 acres of forested wetlands. The standard recommendation is to mitigate for the most-impacted function, thereby assuring that all other functional losses have been overcompensated.

Compensatory mitigation for impacts related to Alternative 1 was determined by applying the HGM approach to calculate functional gains based on trajectories published in the Delta HGM Guidebook (Klimas et al. 2004). Using the HGM approach, the environmental team calculated the number of FCUs needed to compensate wetland impacts then converted them to acres by analyzing change in wetland functionality for a typical acre of restored wetland under a variety of different scenarios for the Riverine Backwater subclass.

The environmental team proposed several potential mitigation measures, such as purchasing restoration bank credits, restoring wetlands along the existing containment structure, restoring an agricultural or fallow fields to wetlands, increasing or decreasing drainage in a few identified areas, preservation and “out-of-kind” measures. Two measures carried forward (mitigation banking and fallow field restoration) for development of alternatives. The team determined that two measures could be stand-alone mitigation alternatives, although three scales of the fallow field restoration alternative had been identified for a total of four mitigation alternatives carried through the cost effective/incremental cost analysis (CE/ICA) process. Appendix N (Mitigation Plan) describes measures considered and the screening process.

Per ER 1105-2-100, the team performed incremental cost analysis for recommended mitigation plans to identify and describe the least cost plan. The Mitigation Plan was selected using the certified IWR Planning Suite software (version 2.0.9 RC). The IWR

Planning Suite uses a CE/ICA to weigh costs of plans against nonmonetary outputs. Costs of each mitigation alternative were entered into the Annualizer program in the year they are projected to be expended. Table 19 lists the estimated costs of mitigation alternatives in FY17 dollars.

Table 19: Estimated Costs for Mitigation, Monitoring and Adaptive Management

	Mitigation Alternative 1 Mitigation Bank	Mitigation Alternative 2a Bare Root (20 acres)	Mitigation Alternative 2b Spiral Wrap (20 Acres)	Mitigation Alternative 2c 3-Gallon Potted Trees (17 Acres)
Mitigation Bank expense @ $3,000/credit	$507,000	---	---	---
Mitigation (restoration plus real estate @ $3,500/acre)		$332,000	$672,000	$672,500
Monitoring/Adaptive Management	*Costs included in fees to mitigation bank	$220,000	$220,000	$220,000
TOTAL	**$507,000**	**$552,000**	**$892,000**	**$892,500**

Table 20 summarizes average annual equivalent monetary costs and benefits, and average annual non-monetary costs and benefits considered during development of each mitigation alternative. In addition to annualized costs and benefits total cost and total benefits associated with each alternative are also shown (FY17 dollars) for each alternative.

Table 20: Total and Average Cost for Mitigation Alternatives

Alternative	Output (AAHUs)	Cost ($1000)	Average Cost
Mitigation Bank	11.00	$507.00	$46.09
Bare Root Planting	11.00	$552.00	$50.18
Spiral Wrap Planting	11.00	$892.00	$81.09
3 gallon Potted Trees	11.00	$892.50	$81.14

Based on the CE/ICA analysis, purchasing 109 credits from the Fourche Bayou Mitigation Bank is the least cost mitigation alternative and is the Mitigation Plan. Appendix N describes mitigation alternatives and their costs.

4.16 Environmentally Preferred Alternative

The environmentally preferred plan is the same as the Least Environmentally Damaging Practicable Alternative (LEDPA).

Adverse environmental impacts are significant for the FWOP alternative. Cutoffs, head cuts, and new failure pathways would alter the type of land available in the future. Land use would gradually convert from bottomlands to open water and or dry channels as head cuts develop. The Ark-White Study estimated that 156 acres of forested bottomland hardwood wetlands would convert resulting in land use changes from continued maintenance, reconstruction of the Melinda Structure, construction of three new structures, and future head cutting. Additionally, a breach of the existing containment structure would destroy 200 additional acres of bottomland hardwoods that would convert to open water or dry channels with the creation of cutoffs through Owens Lake and Jim Smith Lake. After new structures are installed to close a cutoff, changes in land use would not return to existing conditions by the end of the period of analysis.

Adverse environmental impacts are relatively minor for both alternatives. Since the beginning of the Three Rivers Study, USFWS and AGFC have informed USACE that any change to hydrology (flood duration or frequency) in the study area, particularly on the Dale Bumpers White River National Wildlife Refuge and Trusten Holder Wildlife Management Area, is a more significant impact than removing a relatively small number of trees. Therefore, the study team identified “changes to hydrology” as a planning constraint.

Construction of the Preferred Alternative (Alternative 1), would directly and permanently impact 25 acres of forested bottomland hardwood wetlands, and temporarily impact 25 acres of forested wetlands due to temporary road construction. However, Alternative 1 would not change flood duration, and would only minimally change flood frequency, resulting in indirect impacts to 100 acres of forested wetlands by shifting those acres from a Flats wetland subclass (outside the five-year floodplain) to a Riverine Backwater subclass (in the five-year floodplain). As discussed elsewhere, this shift would result in only a minor change in function (detention of floodwater), and would not change the vegetative community.

Alternative 1 also has ancillary ecosystem benefits resulting from alterations to two existing structures at Owens Lake (oxbow lake). The design also includes an opening in the Owens Lake Structure on the north end of the lake for hydrologic purposes that would increase fish passage between the lake and the White River. USACE would also remove the Melinda Structure on the south end of the lake. This change would reconnect the two halves of Owens Lake that were severed by construction of the Melinda Structure, resulting in an increase from 35 to approximately 80 acres of oxbow lake habitat. This would increase fish habitat in the lake, particularly spawning and nursery habitat. Additionally, Alternative 1 would stop current head cutting at Webfoot

Lake. The ecological benefits are not monetarily significant because of the high quality existing bottomland hardwood system throughout the study area. If costs could be calculated, which is questionable due to the sensitivity of the HGM model, inclusion would not change the net benefits of either alternative to sway selection of a different plan.

Alternative 2 would have direct and permanent impacts to an estimated 15 acres of oxbow lake habitat (Owens, Jim Smith), and 20 – 50 acres of forested wetlands due to tying the new structures to the banks, and construction of permanent access roads.. This alternative would alter flood duration and frequency in the study area as the result of lowering the Historic Closure Structure to an elevation of 135 feet or lower. This alteration results in indirect permanent impacts to 4,822 acres of low-lying forested wetlands, most located in the isthmus between the Arkansas and White rivers (property owned by USFWS and AGFC). Flood frequency would increase on these acres as they move from a Flats subclass (outside the 5-year floodplain) to a Riverine Backwater subclass (inside the 5-year floodplain). As discussed earlier, this change in wetland subclass could possibly shift forest composition (relative abundance) on some of these acres. Since the new wetland subclass would be fully functional, the impacts are neither beneficial nor adverse. Alteration of the Historic Closure Structure would also impact flood duration on a much smaller area of higher elevation ground in the northwest part of the study area by allowing water to recede from the high ground faster after each flood event (only a few hours for each event, resulting in an average annual decrease of 8 days).

Unlike Alternative 1, Alternative 2 would not provide any ancillary environmental benefits. Conversely, the construction of two new structures between the Owens and Melinda structures would further degrade aquatic habitat in Owens Lake.

4.16.1 LEDPA Determination

LEDPA determination was based on the following:

Future without Project

- Direct, adverse and permanent impacts to 156 acres of bottomland hardwoods due to the construction of at least three new structures to contain head cutting; and,
- Direct, adverse and permanent impacts to roughly 200 acres of bottomland hardwoods (conversion to open water) with formation of cutoff due to a breach of the existing containment structure.

Alternative 1

- Direct, adverse, and permanent impacts to 25 acres of forested wetlands;

- Temporary impacts to 25 acres of forested wetlands;

- Indirect impacts to approximately 100 acres (increases the 5-year floodplain by less than 0.1 percent). Impacts neither beneficial nor adverse;

- Restoration of oxbow lake habitat (from 35 to 80 acres); and,

- Meets planning constraint of “no changes in Refuge hydrology.”

Alternative 2

- Direct, adverse, and permanent impacts to 15 acres of WOTUS and 20 – 50 acres of forested wetlands;

- Indirect impacts to 4,822 acres of wetland (increases the 5-year floodplain by 3.8 percent). Impact neither beneficial nor adverse;

- No ancillary environmental benefits; and,

- Does not meet the planning constraint of “no change to Refuge hydrology.”

Based on this analysis, the study team determined that the combination of direct and indirect impacts associated with Alternative 1 (125 acres), are less environmentally damaging than those of Alternative 2 (4,887 acres) or the FWOP (356 acres). Combined with the ancillary environmental benefits in Alternative 1, and the full support of the resource agencies, Alternative 1 is the LEDPA.

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5 RECOMMENDED PLAN

Alternative 1, the containment structure at elevation 157 feet with an opening at the Historic Cutoff is the Recommended Plan, and the NED plan.

5.1 Description of the Recommended Plan

Alternative 1 is the Recommended Plan, and consists of a new containment structure at an elevation of 157 feet above mean sea level, and would dramatically reduce the risk of a cutoff forming. The structure would be approximately 2.5 miles long, and would begin on natural high ground south and west of the Melinda Structure located on the south side of Owens Lake. As designed, it continues east and cross the Melinda head cut south of the Melinda Structure, and from there, heads northeast and connects to the existing containment structure north of Jim Smith Lake. It then continues to follow the Soil Cement Structure alignment and terminates at the Historic Closure Structure. Because this alignment takes advantage of natural high ground, in most locations the structure would only rise five to seven feet above the ground, and would be no more than 12 feet above the ground at its highest point. The relief opening at the Historic Cutoff would be at elevation of 145 feet, and engineers and hydrologists would optimize the width of the opening during the Preconstruction, Engineering and Design (PED) phase of the project to ensure that flows through the Historic Cutoff would not impact navigation.

Opening the Historic Cutoff would reduce maximum head differentials across the isthmus allowing USACE to better control the location of future overtopping events and would decrease the duration of head differentials, and flow velocities and hence erosion across the isthmus. Lastly, the opening would restore ecosystem functions of Webfoot Lake and reduce erosion on the east side of the lake where there are knickpoints that will likely lead to head cutting and a resultant decline in ecosystem function of Webfoot Lake. The Melinda Structure will be removed to eliminate vicinity erosion and to reduce water turbulence and erosion in the immediate Melinda Structure vicinity. Debris would be pushed in the deep sour hole at the top of the Melinda head cut. Similarly, removing the Melinda Structure would reconnect Owens Lake to its former southern limb, thereby returning open water ecosystem functions to the oxbow portion of the flooded bottomland hardwoods. Finally, opening the Owens Lake Structure with a 5 by 30 foot precast concrete bridge at elevation 140 feet between Owens Lake and the White River would prevent water from backing up into Owens Lake and flooding an additional 100 acres of bottomland hardwood forests. The bridge would also provide fish passage into Owens Lake that was eliminated with the Containment Structure at elevation 157 feet.

Other than changes described above, implementation of the Recommended Plan would not alter hydrology in surrounding bottomland hardwood forests, and most importantly, navigation would continue with no operational changes to the MKARNS. The Recommended Plan balances structural and environmental sustainability requirements. The design attempts to relieve the instability resulting from extreme head differentials between the White and Arkansas rivers and the resulting threats to navigation while not changing the hydrology of the surrounding bottomland hardwood habitats and allowing navigation to continue with no change in the current operation of the MKARNS. Minimal long-term impacts include a habitat loss of 4.4 Functional Capacity Units (FCUs) in the form of bottomland hardwood forest/wetlands and waters of the US conversion to impervious surface. Mitigation of the 4.4 FCUs would be achieved through the purchase of 109 credits from the Fourche Bayou Mitigation Bank. Short-term impacts such as increased turbidity, decreased air and visual quality, disruption in wildlife and aquatic use of the construction area would occur during construction but would likely return to baseline conditions following completion. The Recommended Plan has several ancillary benefits including: reducing erosion on the Refuge and surrounding lands that would occur under the future without project condition, restoring the function of two oxbow lakes (Webfoot and Owens), and increasing fish passage into Owens Lake. Cumulative impacts would be less than significant or no impact.

To increase resiliency and reduce operation and maintenance, the new opening through the Historic Closure Structure will consist of a cutoff wall to keep it from being undermined and will have approach slopes of 1V:20H (or more gradual) riprap blanket on both sides of the opening. This will allow more energy to dissipate through the opening before entering the existing channels. There will be extra self-launching or sacrificial stone placed at the toe of each side of the new opening that will armor the existing channel bed if necessary. Flow is directed toward the middle of the channel before exiting the opening. This will minimize direct flow attack on the channel banks. Riprap is the material of choice since it has the ability to move and settle and fill in voids as necessary. Additionally, more riprap can be added to repair it back to design standards as operation and maintenance, which is easily done by USACE Operations Division. Riprap was chosen over concrete, which was used at Melinda Weir, because it has collapsed due to undermining erosion. This type of failure is difficult and expensive to repair since the concrete has to be broken into smaller pieces or removed to correctly fix the voids under the concrete cap.

The Arkansas River meander migration no longer threatens to erode the location of the proposed containment structure at elevation 157 or the proposed opening through the Historical Closure Structure. See Appendix B for historical bank line progressions from 1994 to 2017. Historically, head differentials of four feet or less do not appear to cause significant damage. The maximum head differential across the proposed containment structure at elevation 157 feet is three feet with an average differential of 1.4 feet when elevation 157 feet is exceeded. To increase resiliency and reduce operation and maintenance for the new containment structure, it will be entrenched in locations where the height of the structure is less than three feet to prevent toe scour.

Appendix L lists best management practices (BMPs) that are assumed to occur during construction of the Recommended Plan. BMPs were identified using various industry, state and federal standards for activities accepted as a best practices to minimize impacts. Some examples include but are not limited to: use of silt fencing to limit soil migration and water quality degradation; refueling and maintenance of vehicles and equipment in designated areas to prevent accidental spills and potential contamination of water sources and the surrounding soils; and limiting idling of vehicles and equipment to reduce emissions. Additional BMPs may be identified during the development of plans and specifications. Implementation of the BMPs would not increase project costs; however, it would further reduce the impacts described in Chapter 4. If BMPs, are not implemented, the nature of impacts of the Recommended Plan would not change, and although they may increase somewhat, it is very unlikely that the incremental change would not rise to the level of significant.

5.2 Status of Environmental Compliance

Table 21 below lists the status of compliance with required environmental laws and policies.

Table 21: Status of Environmental Compliance

Policies	Compliance
Public Laws	
Archeological and Historic Preservation Act, 1974, as amended	Compliant
Archeological Resources Protection Act, 1979, as amended	Compliant
Clean Air Act, 1977, as amended*	Compliant
Clean Water Act, 1972, as amended*	Compliant
Coastal Zone Management Act, 1972, as amended	Not Applicable
Endangered Species Act, 1973, as amended*	Compliant
Farmland Protection Policy Act	Compliant
Fish and Wildlife Coordination Act, 1958, as amended*	Compliant
Magnuson Fisheries Conservation and Management Act	Not Applicable
Migratory Bird Treaty Act, 1918, as amended	Compliant
National Environmental Policy Act, 1969, as amended	Compliant
National Historic Preservation Act, 1966, as amended	Compliant
Native American Graves Protection and Repatriation Act, 1990	Not Applicable
Rivers and Harbors Act, 1899	Compliant
Wild and Scenic Rivers Act, as amended	Compliant
Executive Orders	
Environmental Justice (EO 12898)*	Compliant
Flood Plain Management (EO 11988)	Compliant
Protection of Wetlands (EO 11990)	Compliant
Protection of Children from Environmental Health Risks (EO 13045)	Compliant
Invasive Species (EO 13112)*	Compliant
Migratory Birds (EO 13186)*	Compliant

5.3 Project Implementation

5.3.1 Pre-Construction Engineering and Design

For navigation projects, PED is completed at 100 percent federal cost. Prior to initiating PED, the design team would develop a Project Management Plan (PMP) defining the scope of work, work breakdown structure, schedule, and budget. Additional items in the PMP include value management and engineering, quality control, communication, change management, and acquisition strategy. The draft PMP must be developed, negotiated, and agreed upon by all parties prior to initiating the PED phase. PED activities include: a Design Documentation Report (DDR), plans and specifications (P&S), execution of the Project Partnership Agreement (PPA), and contract award activities.

5.3.1.1 Value Engineering Study

ER 11-1-321 specifies processes for executing Value Engineering in USACE's Project Management Business Process, and mandates that Value Management is completed by implementing the Value Management Plan (REF8023G) from the USACE Business Process Manual. USACE will complete a Value Engineering Study during the design and construction phase per ER 11-1-321.

5.3.1.2 Detailed Design Report

Development of the DDR includes completing the final design of project features. As part of the DDR, the team would complete ground surveys, utility surveys, and drilling and testing for subsurface (geotechnical) conditions as necessary to complete the final design. Measure footprints would be further defined based on surveys. Design parameters for project features would be defined for development of plans and specifications. Continued coordination with SHPO would ensure requirements for archeological resource investigations and mitigation continue to be met.

5.3.1.3 Plans and Specifications

Plans and specifications include developing project construction drawings and specifications, estimating final quantities, and completing government cost estimates. USACE will provide drawings and specifications to contractors during the bidding process, and draft several sets of plans and specifications for the containment structure and the opening in the Historic Cutoff. Arrangements for onsite archeological monitoring during construction, if necessary, would be finalized prior to the conclusion of P&S.

5.3.2 Real Estate Acquisition

The USACE Real Estate Office, Little Rock District Real would coordinate real estate activities. Also, prior to solicitation of construction contracts, the District Chief of Real Estate would certify in writing that sufficient real property interest is available to support construction of the contract. The Real Estate Plan for the Alternative 1 can be found in Appendix G.

5.4 Project Construction

After award of the construction contract, the Government would manage project construction. Inherent with such contracts, a warranty period for actual construction items and plantings would be specified. Construction of the containment structure and lowering of the portion of the Historic Cutoff is expected to take 2.5 to 3 years to complete.

5.4.1 Contract Advertisement and Award

Once plans and specifications are complete, and all required real property interests are certified as available by USACE Real Estate Division, a construction contract would be solicited and advertised. The contract would be awarded to the lowest responsive bidder and notice to proceed typically occurs within 30 to 45 days from bid opening.

5.5 Monitoring and Adaptive Management

ER 1105-2-100 allows for project monitoring and adaptive management during and after construction. Adaptive management for complex, specifically authorized projects may be recommended, particularly those projects. When recommended, the cost of adaptive management is limited to three percent of the total project cost excluding monitoring costs. No project-specific ecological monitoring or adaptive management measures are included as part of the Proposed Action for the Three Rivers Southeast Arkansas Project. Adaptive management and monitoring for the Mitigation Plan is not needed since mitigation involves purchasing mitigation bank credits. All monitoring and adaptive management are the responsibility of the Mitigation Bank per their instrument.

5.6 Operation, Maintenance, Repair, Replacement, Rehabilitation

Upon completion of the project, USACE Little Rock District would be responsible for operating and maintaining the structures. Structures include the Owens Lake Structure Arched Bridge; the Stone Containment Structure and the Historic Closure Structure. Structures would need inspection to ensure that no cracking, erosion, settlement or scour holes develop on or near the structures. The new arched bridge would also need annual inspections for damage, deterioration and debris accumulation. Observed damage should be repaired immediately to prevent further deterioration. Therefore, USACE recommends that structures receive annual and periodic inspections especially after major flood events. Current estimated annual OMRR&R costs total $511,634 per year; however, this may change after the PED phase.

5.7 Project Implementation Schedule

The project implementation schedule is under development pending information regarding contractor capability and timing of funding, but USACE expects that construction would not require more than 36 months (Table 22). The final schedule would be coordinated and approved by the non-federal sponsor and included in the PED Project Management Plan.

Table 22: Proposed Project Implementation Schedule

Activity	Start	End
Signed Chief's Report	-	July 2018
Planning and Design	October 2019	October 2021
Construction Management	October 2021	September 2024
Construction*	October 2021	September 2024

*Currently lumped into one contract, specific features will be separated into multiple contracts as design progresses. Total construction NTE 36 months

5.8 Project Cost

Plan formulation was done using estimated costs in FY2018 (October 2017) price levels and a federal discount rate of 2.75 percent per Economic Guidance Memorandum 18-01. Table 23 presents project first costs, interest during construction, and annual cost based on certified cost estimates. Average annual OMRR&R costs stated at current price levels is not affected by the date that PED or OMRR&R would commence.

Table 23: Project First Cost based on FY2018 (October 2017) price levels and the federal discount rate of 2.75%

Item	Cost
Investment Costs	
Construction	$178,694,000
Mitigation	$684,000
Real Estate	$917,000
Interest during Construction	$7,356,000
Total Investment	$187,651,000
Annual Costs	
Interest and Amortization	$6,950,000
OMRR&R	$724,000
Total Annual Costs	$7,674,000
Annual Benefits	
Total Annualized Benefits	$33,811,000
Net Benefits	$26,137,000
Benefit to Cost Ratio	4.4

5.9 Cost Sharing

Construction cost share is 50 percent U.S. Treasury funds and 50 percent funds from the Inland Waterways Trust.

5.10 Financial Plan and Capability Assessment

Implementation of the Recommended Plan will be completed with 100 percent federal funding with no Nonfederal cost share partner. As such, no statement of financial assessment or plan is included.

5.11 Views of the Local Sponsor

The local sponsor, the Arkansas Waterways Commission, supports the Recommended Plan; however, since it would be fully funded by the federal government, they will not participate in plan implementation.

5.12 Resource Agency Coordination

As noted previously, the study team worked closely with state and federal resource agencies, including six that formally served as cooperating agencies pursuant to 40 CFR §1501.6 including: the USFWS, AGFC, ANHC, ANRC, AGS and the NPS. Correspondence via e-mail, webinars, and phone with the resource agencies occurred throughout the study. USACE held bi-weekly environmental team meetings to update both the study team and agencies on study progress, model updates, and to ensure agency concerns were addressed. USACE held several meetings and site visits with resource agencies. In addition, AGFC and USFWS staffed assisted in site selection and data collection for the Hydrogeomorphic (HGM) analysis of project impacts.

On 30 July 2015, study coordination was initiated with the Department of Arkansas Heritage's (DAH) Historic Preservation Program (i.e., State Historic Preservation Officer) and appropriate federally recognized tribes with responses received from the Choctaw and Quapaw tribes. On 5 January 2017, USACE held additional conversations with the DAH archeologist and confirmed requirements for a cultural resources survey prior to construction. Coordination would continue throughout PED and construction as the Programmatic Agreement is implemented in compliance with Section 106 of the National Historic Preservation Act.

5.13 Public Involvement

USACE held multiple public workshops and meetings regarding the Ark-White Study, and as a result scoping meetings were not necessary for the Three Rivers Study given that both studies address the same problem.

As part of the Ark-White Study, USACE published a Notice of Intent (NOI) to prepare an EIS in the Federal Register on 20 June 20 2003, and held a Public Meeting on 26 June 2003 in Pine Bluff, Arkansas to inform the public about the study and receive comments and concerns. Over 270 people attended the workshop including: federal, state, and non-profit agency staff representing environmental, navigation, and high traffic interests; representatives from the energy, logging, shipping, and towing industries; landowners along the river; and private individuals with general interest in the study area. Fifteen comments were received during the 30-day public scoping period. Before release of the Draft EIS for the Ark-White Study, USACE recommended the No Action alternative, and the study terminated.

On 14 September 2015, USACE published an NOI in the Federal Register notifying the public of USACE intent to prepare an Integrated Feasibility Report and EIS for the Three Rivers Feasibility Study. USACE provided a news release to the local paper that was also published on the Little Rock District website. A 30-day scoping period was provided for public comment acceptance, during which time no comments were received. No public scoping meetings or workshops were held for the Three Rivers Study prior to release of the draft Integrated Feasibility Report. The Three Rivers Study no longer met the criteria for an EIS and USACE published a withdrawal of the NOI in the Federal Register in May 2017.

The public review period for the draft Integrated Feasibility Report and EA was 31 March 2017 through 30 April 2017. A public meeting was held on 17 April, 2017 from 4 to 7 pm at the Delta Rivers Nature Center in Pine Bluff, Arkansas. One comment was received from a private individual supportive of the study. Two agency responses were received, one from USFWS and one from EPA during the public review period. Neither agency had comments on the draft report. They acknowledged receipt and stated that they had no comments (see Appendix H).

5.14 Environmental Operating Procedures

USACE's seven Environmental Operating Principles encourage Corps of Engineers employees to consider the environment in everything they do. They set the direction for USACE to achieve greater synergy between sustainability and execution of its projects and programs. Within the Civil Works planning arena, the Environmental Operating Principles guide the identification, evaluation, and selection of plan components to encourage implementation of productive and sustainable projects. The Recommended Plan for the Three Rivers Southeast Arkansas study embodies this approach and philosophy as described below.

1) Foster Sustainability as a way of life throughout the organization

The Recommended Plan would prevent future cutoffs from forming and reduce head cutting in multiple locations throughout the project area. If cutoffs form, infrastructure could suffer damage, and navigation through the project area would become very unreliable. If a cutoff forms or additional head cutting occurs, bottomland hardwoods and wetlands would permanently convert to open water or dry channel beds leading to further ecosystem degradation. USACE will also incorporate principles of sustainability during construction and demolition of project features to minimize emissions, control runoff, and would recycle construction debris when possible.

2) Proactively consider environmental consequences of all Corps activities and act accordingly

Plan formulation focused specifically on finding an environmentally sustainable alternative that would reduce head cutting and the risk of cutoffs forming while limiting potential impacts to the surrounding bottomland hardwood ecosystems. Team engineers designed the alignment of the containment structure for Alternative 1, the Recommended Plan, to incorporate existing topography as much as possible rather than creating a straight line structure. By doing this, the length and overall footprint of the structure is roughly 50 percent less than the containment structure designed in the Ark-White Study. In addition, the Recommended Plan has an opening at Owens Lake to reduce ponding behind the proposed structure; thereby, reducing potential changes in land cover changes and impacts to bottomland hardwoods.

3) Create mutually supporting economic and environmentally sustainable solutions

The alignment of the new containment structure takes advantage of natural high ground to minimize the footprint of the structure and reduce environmental impacts. In addition, removal of the Melinda Structure would create an open water habitat that was lost when USACE installed the Melinda Structure.

4) Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps which may impact human and natural environments

As discussed in chapters 4 and 5 of this report, the Recommended Plan fully complies with legal and policy requirements to consider impacts of the projects on people and natural environment.

5) Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs

Chapter 3 of this report discusses risk and uncertainty, and concludes that despite predictive uncertainty inherent in water resources planning over a long period of analysis, there is a good deal of confidence that the Recommended Plan is economically justified and consistent with federal NED objectives and environmental operating procedures.

6) Leverage scientific, economic, and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner

The Three Rivers Study is more comprehensive, and embodies the newly developed tenants of USACE SMART planning. Throughout the study, the project delivery team leveraged expertise throughout USACE including the Little Rock District, the Regional Economic and Planning Center (Southwest Division), the Jacksonville District (South Atlantic Division), and the Inland Navigation Planning Center of Expertise (Huntington District). The study team also engaged other federal and state resource agencies such as the Arkansas Waterways Commission, Oklahoma Department of Transportation, the U.S. Fish and Wildlife Service and the Arkansas Game and Fish Commission and local governments to ensure that study uses the best and most current data, and eliminates redundancy inherent in large-scale water resources planning studies. The SMART planning process saves time and money; and most importantly, delivers solutions that are economically feasible and environmental acceptable.

7) Employ an open, transparent process that respects the view of individuals and groups interested in Corps activities

USACE coordinated with resource agencies on a bi-weekly basis throughout most of the study. Concerns of all resource agencies were taken into consideration throughout the planning process and impacts to resources of concern were minimized to an acceptable level.

5.15 Conclusions

The Little Rock District recommends the approval and implementation of the NED plan described in this document. This conclusion is based on the study findings in connection with the Feasibility Report and Integrated Environmental Assessment.

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Recommendation

I propose the structural features designed to promote sustainable navigation identified as the Recommended Plan in the Three Rivers Southeast Arkansas Feasibility Report and Integrated Environmental Assessment, proceed with implementation in accordance with the cost sharing provisions set forth in this report.

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineers policies governing formulation of individual studies and projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

Robert G. Dixon
Colonel, U.S. Army
Commanding

Date 2 Apr 2018

6 LIST OF PREPARERS, ACRONYMS AND REFERENCES

The following USACE personnel made up the PDT:

Dana Coburn	Project Management
Mitch Eggburn	Construction
James Fisher	Office of Counsel
Melinda Fisher	Environmental Resources
Catherine Funkhouser	Hydrology and Hydraulics
Roderick Gaines	Operations
Norman Gartner	Civil Design
Craig Hilburn	Environmental Resources
Stuart Norvell	Economics
Nancy Parrish	Planning
Brian Raley	Real Estate
Martin Regner	Cost Engineering
Kelly Turner	Cost Engineering
Seth Sampson	Cultural Resources

LIST OF ACRONYMS

ACHP	Advisory Council on Historic Preservation
AGFC	Arkansas Game and Fish Commission
AGS	Arkansas Geological Survey
ANHC	Arkansas Natural Heritage Commission
ANRC	Arkansas Natural Resources Commission
APE	Area of Potential Effect
BCC	Birds of Conservation Concern
BCR	Benefit to Cost Ratio
BFE	Base Flood Elevation
BLH	Bottomland Hardwood
BMP	Best Management Practice
CAR	Coordination Act Report (USFWS)
CCS	Center for Climate Strategies
CWA	Clean Water Act
DAH	Department of Arkansas Heritage
DDR	Design Documentation Report
EA	Environmental Assessment
EC	Engineer Circular
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ER	Engineering Regulation
ESA	Endangered Species Act
FCI	Functional Capacity Index
FCU	Functional Capacity Unit
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
FWOP	Future Without Project

GCM	General Circulation Models
GHG	Greenhouse Gas
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEP	Habitat Evaluation Procedures
HGM	Hydrogeomorphic Approach
HTRW	Hazardous, Toxic, and Radioactive Wastes
IPaC	Information for Planning and Conservation
LEDPA	Least Environmentally Damaging Practicable Alternative
MKARNS	McClellan-Kerr Arkansas River Navigation System
MAV	Mississippi Alluvial Valley
NAAQS	National Ambient Air Quality Standards
NED	National Economic Development
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NOI	Notice of Intent
NWI	National Wetland Inventory
NPS	National Park Service
NRHP	National Register of Historic Places
OMRR&R	Operation, Maintenance, Repair, Replacement, and Rehabilitation
P&G	Principles &Guidelines for Water & Related Land Resources
P&S	Plans and Specifications
PDT	Project Delivery Team
PED	Pre-Construction Engineering and Design
PMP	Project Management Plan
PPA	Project Partnership Agreement
SHPO	State Historic Preservation Office
USFWS	U.S. Fish and Wildlife Service
USACE	U.S. Army Corps of Engineers
WOTUS	Waters of the U.S.

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