Left Embankment Repair, Emmett Sanders Lock and Dam #4
DRAFT Compensatory Mitigation and Adaptive Management Plan

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US Army Corps
of Engineers
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Overview

This document presents the compensatory mitigation plan for unavoidable habitat impacts associated with the Emmett Sanders Lock and Dam # 4 (ESLD), Left Embankment Repair Project (LER) and associated work near the LER as displayed in Figure 1. The purpose of the mitigation is to compensate for the permanent removal of the bottomland hardwood forest (BHF) immediately north of the left embankment of the ESLD as displayed in below Figure 2. This BHF would be removed to allow room for the toe of the embankment to be relocated to provide a shallower slope, which would reduce the risk of future erosion. Additionally, removal of the BFH would protect the left embankment from future damage as result of trees falling over and damaging the embankment. The removal would also allow safe passage of emergency vessels to the navigation pass during high water events. The navigation pass would be built as a part of the LER.

This plan addresses only compensatory mitigation work and not the sequence of other activities performed during project planning to avoid, minimize, rectify, or reduce habitat impacts from each project alternative (see Engineer Regulation (ER) 1105-2-100, Section C-1(e)(8). Details of those sequence actions are included in the plan formulation and environmental consequences sections of the study's main report and environmental compliance document, and are incorporated into the mitigation objectives of this plan. The planning work performed to document those sequencing actions is complete and led the team to the need to develop a compensatory habitat mitigation plan for unavoidable impacts to fish and wildlife resources. This document details the work to be performed, including coordination, plan formulation, and environmental compliance, to develop the compensatory habitat mitigation plan.

Requirements

The authority and requirements for compensatory mitigation are founded in Federal laws and regulations. The legal foundation for mitigation for ecological resources includes the Clean Water Act, various Water Resources Development Acts, and other environmental laws. These laws are implemented and administered through rules, guidance, regulations, and policies issued by Executive Branch agencies.

The relevant laws and regulations specific to compensatory mitigation planning for Corps of Engineers civil works projects are listed in the References section of this document. The specific procedures followed to develop this compensatory habitat mitigation plan are found in ER 1105-2- 100, Appendix C. Other forms of mitigation, such as plans for cultural resources conservation or induced flood damages, may also be required for a project. Those types of mitigation requirements are not directly related to fish and wildlife habitat impacts and are not covered in this plan.

Compensatory mitigation is the "restoration (re-establishment or rehabilitation), establishment, enhancement, and/or in certain circumstances preservation of aquatic resources for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved" (see 40 CFR 230.92). It is the policy of the Corps of Engineers civil works program, and in accordance with Section 906 of WRDA 1986, as amended, to demonstrate that impacts to all significant ecological resources, both terrestrial and aquatic, have been avoided and minimized to the extent practicable, and that any remaining unavoidable impacts have been compensated to the extent possible. Section 906(d) of WRDA 1986, as amended, requires functional assessments to be performed to define ecological impacts and to set mitigation requirements for impacted habitats. Corps of Engineers policy in ER 1105-2-100, paragraph C-3(e), requires the use of a habitat-based methodology, supplemented with other appropriate information, to describe and evaluate the impacts of the alternative plans, and to identify the mitigation needs.

Figure 1. Project Area and Location

Figure 2. Display of the Location and extent of Repair and Associated Work Part 1 of 3

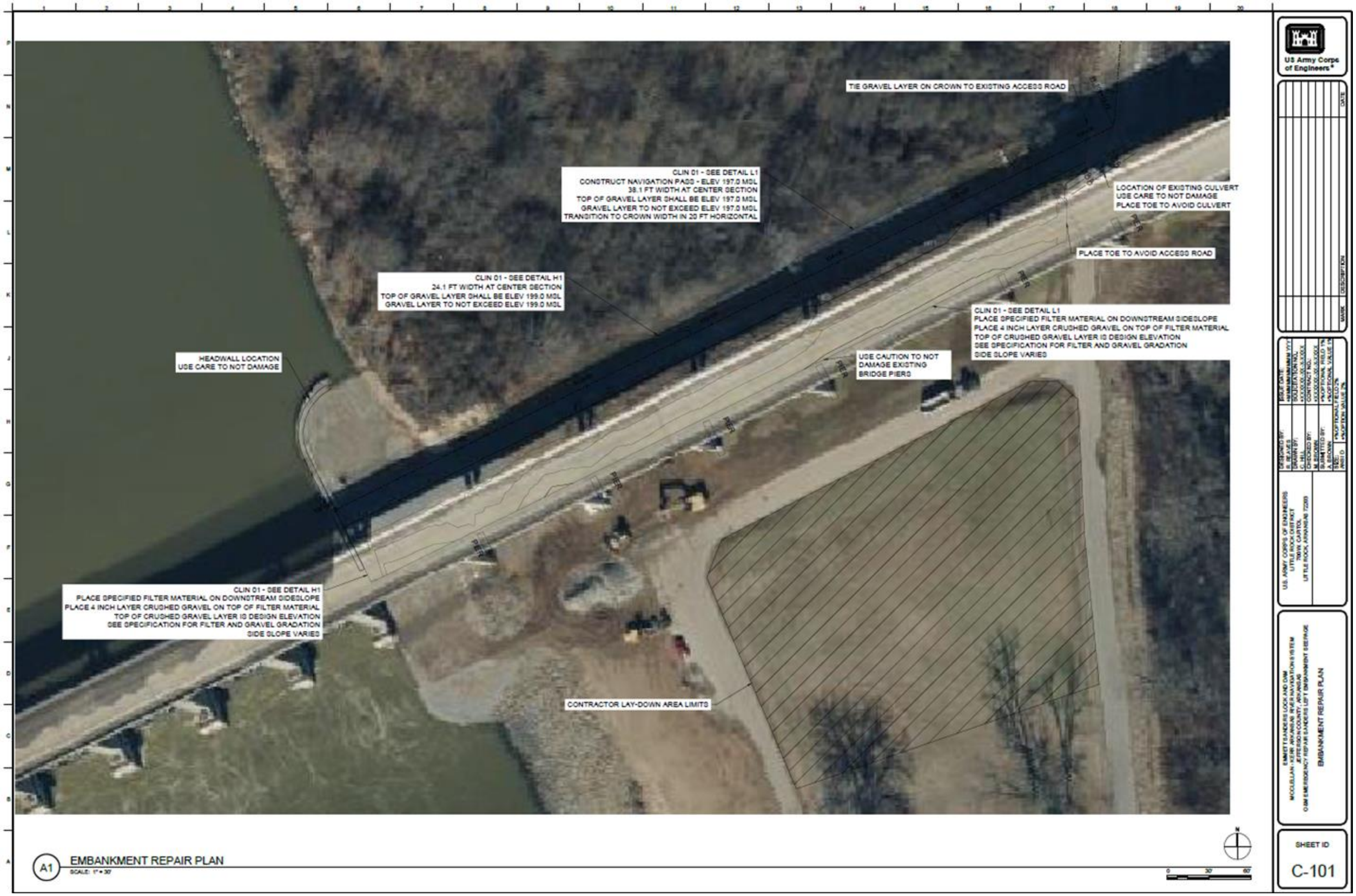

Figure 3. Display of the Location and extent of Repair and Associated Work Part 2 of 3

Figure 4. Display of the Location and extent of Repair and Associated Work Part 3 of 3

Coordination and Collaboration

Development of this plan involved coordination and collaboration with state and federal natural resource agencies and the public. Public input is currently being sought through the release of the draft report and environmental compliance document. Comments from the public related to habitat impacts and mitigation will be incorporated into this publication as appropriate.

A Monitoring and Adaptive Management Team (MAMT) consisting of members from the USACE Southwestern Regional Planning Environmental Center (RPEC), and the USACE SWL Operations Division met throughout the study and contributed expertise and information to support the identification of impacts and the development of compensatory mitigation plan alternatives.

Ecological Resources

The LER lies within the Lower Arkansas watershed (Figure 3). A timber survey of the proposed project area was conducted by U.S. Army Corps of Engineers (USACE) Little Rock District (SWL) foresters on August 9, 2024. Results of the proposed project indicated that the area consists of a mid-successional BHF dominated by a mix of water oak (*Quercus nigera*), sugarberry (*Celtis laevigata*), and American sycamore (*Platanus occidentalis*) (Table 1). BHF are considered a significant resource because they provide important ecosystem services such as nutrient cycling, flood control, wildlife habitat, and recreational opportunities. These forests have been severely impacted by land conversion, fragmentation, and altered hydrology; experiencing significant declines in quantity throughout the U.S. and within the Lower Arkansas River Watershed (>80% decline).

Table 1. BHF Habitat Results

EMMETT SANDERS 1. 65 Acre Clearing	**Diameter at Breast Height (DBH)**	**6"**	**7"**	**8"**	**9"**	**10"**	**11"**	**12"**	**14"**	**16"**	**19"**	**20"**	**21"**	**24"**	**Total Trees**	**% species (Spp)**
Spp. Common Name	**Scientific Name**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
American elm	*Ulmus americana*	1	-	-	1	-	-	-	-	-	1	-	-	-	3	**5.3%**
Water oak	*Quercus nigra*	5	1	7	1	2	1	-	-	-	-	-	-	-	17	**29.8%**
Sugarberry	*Celtis laevigata*	4		2		1	1	-	-	-	-	-	-	-	8	**14.0%**
Box elder	*Acer negundo*	-	-	-	1	1		-	-	-	-	-	-	-	2	**3.5%**
A. persimmon	*Diospyros virginiana*	-	-	1	-	2	1	-	-	-	-	-	-	-	4	**7.0%**
Black willow	*Salix nigra*	-	-	8	-	1	-	2	1	1	-	-	-	-	13	**22.8%**
Bald cypress	*Taxodium distichum*	-	-	-	-	-	-	-	-	-	-	1	-	-	1	**1.8%**
Sweetgum	*Liquidambar styraciflua*	-	-	-	-	-	-	-	-	-	-	-	1		1	**1.8%**
A. sycamore	*Platanus occidentalis*	1	-	3	-	2	-	-	-	1	-	-	-	1	8	**14.0%**
Total Number of Trees		11	1	21	3	9	3	2	1	2	1	1	1	1	-	**-**
Percentage of trees in each size category		**19.3%**	**1.8%**	**36.8%**	**5.3%**	**15.8%**	**5.3%**	**3.5%**	**1.8%**	**3.5%**	**1.8%**	**1.8%**	**1.8%**	**1.8%**	**57**	**-**
Snags	**DBH**	**-**	**-**	**-**	**9"**	**10"**	**11"**	**12"**	**14"**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Spp. Common Name	**Scientific Name**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	-	-	-	-	**-**
Oak	Quercus spp.	-	-	-	9	-	-	-	-	-	-	-	-	-	9	**64.3%**
Black willow	*Salix nigra*	-	-	-	-	1	-	1	-	-	-	-	-	-	2	**14.3%**
Box elder	*Acer negundo*	-	-		-	1	-	-	1	-	-	-	-	-	2	**14.3%**
Sugarberry	*Celtis laevigata*	-	-	-	-	1	-	-	-	-	-	-	-	-	1	**7.1%**
Total Number of Trees	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**14**	**-**

Understory Spp. Comp	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Rough-leafed dogwood	*Cornus drummondii*	Too numerous to count on the east end.	1	-	-	-	-	-	-	-	-	-	-	-	1	2.2%
Possumhaw	*Ilex decidua*	Too numerous to count on the west end.	1	-	-	-	-	-	-	-	-	-	-	-	1	2.2%
Peppervine	*Nekemias arborea*		2	-	-	-	-	-	-	-	-	-	-	-	2	4.4%
Box elder	*Acer negundo*		3	-	-	-	-	-	-	-	-	-	-	-	3	6.7%
Sugarberry	*Celtis laevigata*		4	-	-	-	-	-	-	-	-	-	-	-	4	8.9%
A. persimmon	*Diospyros virginiana*		5	-	-	-	-	-	-	-	-	-	-	-	5	11.1%
willow oak	*Quercus phellos*		6	-	-	-	-	-	-	-	-	-	-	-	6	13.3%
Native pecan	*Carya illinoinensis*		7	-	-	-	-	-	-	-	-	-	-	-	7	15.6%
Black oak	*Quercus velutina*		8	-	-	-	-	-	-	-	-	-	-	-	8	17.8%
Silver maple	*Acer saccharinum*		8	-	-	-	-	-	-	-	-	-	-	-	8	17.8%
Total			45	-	-	-	-	-	-	-	-	-	-	-	45	-

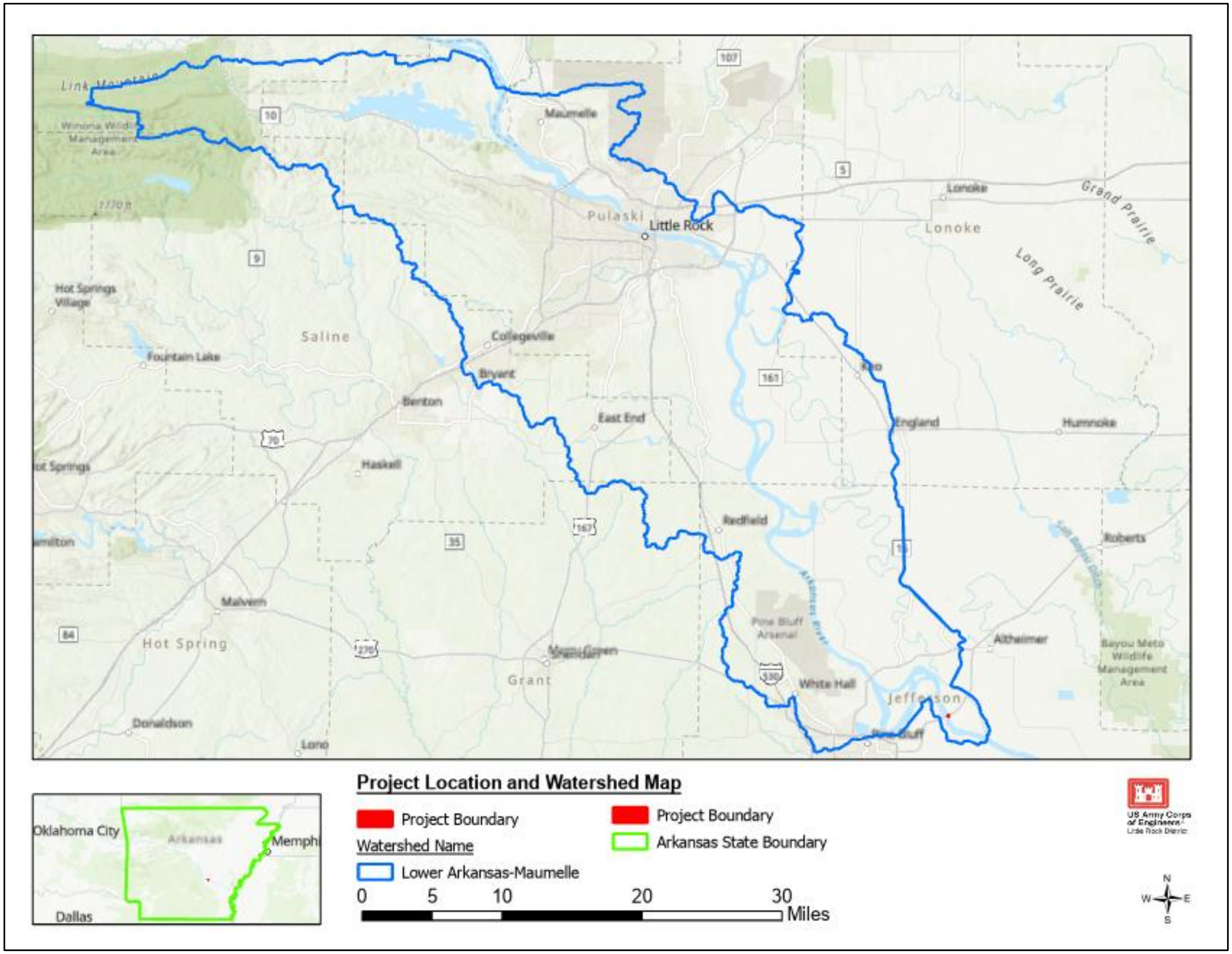

Figure 5. Project Location and Watershed Map

Significant Net Losses

Based upon the type(s) of habitat(s) in the project area, it was determined that the USFWS Habitat Evaluation Procedure (HEP) would be an appropriate tool to assess the project's impacts on fish and wildlife habitat and other ecological resources. The model is certified for use by the Corps of Engineers Ecosystem Restoration National Planning Center of Expertise. Model outputs measure habitat values in average annual habitat units (AAHU). The tool is also suitable for assessing mitigation potential at alternative mitigation sites in the watershed.

Habitat Evaluation Procedure

Only one habitat type, BHF, was assessed for the LER project due to the historical conditions of the project area and the ecosystem restoration goals for the Compensatory Mitigation Plan.

A baseline assessment using the HEP was required before any habitat impacts to the study area could be quantified. Developed by the USFWS in order to quantify the impacts of habitat changes resulting from land or water development projects (USFWS 1980), HEP is a species-habitat approach for assessing environmental impacts of proposed water and land resource development projects. The method is used to document the quality and quantity of available habitat for selected wildlife species. The procedure provides information for two general types of wildlife habitat comparisons: the relative value of different areas at the same point in time; and the relative value of the same areas at future points in time. By combining the two types of comparisons, the impact of proposed or anticipated land and water use changes on wildlife habitat can be quantified.

HEP is based on species-specific suitability models that provide a quantitative assessment of the habitat requirements for a species or group of species. HEP involves defining the study area, delineating habitats (i.e. cover types) within the study area, and characterizing the study area based on the results of the HEP. In order to determine the type of habitat data to be collected, habitat suitability indexes (HSI) are selected for species likely to be present in the study area, or serve as a suitable surrogate for those species. The Barred Owl, Downy Woodpecker, and Hairy Woodpecker HSI models were selected to assess the ecological integrity and habitat conditions of existing and future BHF habitats (USFWS 1987A; USFWS 1987B,and USFWS 1987C). The models were chosen based on professional judgment and past experience on working in the surrounding area.

A HEP assessment of the LER within the study area was conducted on August 9, 2024. A timber survey of the entire impact area conducted by USACE SWL foresters. Information collected included a list of tree and shrub species present, the diameter at breast height (dbh) for those species over 6 inches (Table 1), and the overall habitat condition (e.g. quality) of the area based on professional judgement.

Habitat quality is estimated using the HSI models selected to represent each specific habitat type(s). Each model consists of a list of variables or Suitability Indices (SIs) that are essential to satisfy the life requisites (e.g. reproduction, food, cover, etc.) of a particular species. Each SI can be expressed as a mathematical function with each habitat metric as an independent variable. Each SI ranges from 0.1 to 1.0, with 1.0 representing optimal condition for the variable in question. The SIs for each specific life requisite are then calculated using a mathematical formula to estimate the Life Requisite Suitability Index (LRSI) for each life requisite. The final Habitat Suitability Index (HSI) of the habitat type can then be calculated as a function of the LRSIs.

The HSI methodology and calculations for the barred owl, downy woodpecker, and hairy woodpecker HSIs are provided in Tables 2, 3, and 4. The barred owl HSI is calculated using the Reproduction Life Requisite. For the downy woodpecker, two LRSIs are calculated (food and reproduction). Because the two downy woodpecker life requisites are assumed to be of equal importance, the HSI is equal to the lowest LRSI. For the hairy woodpecker, two LRSIs are calculated (reproduction and cover). The suitability index for the cover component is assumed to directly modify the suitability index for the reproduction component to yield an overall HSI value for the hairy woodpecker in the habitat being evaluated. At optimal cover component conditions, the reproduction component will determine the habitat suitability index. If cover conditions are anything less than optimal, then the reproduction value will be reduced based on the quality of the cover conditions.

Table 2. Barred Owl Habitat Suitability Index Metrics

Formula Name	**Formula**
LRSI=Reproduction SI (SIR)	$HSI = SIR = \sqrt[\square]{SI_1 \times SI_2} \times SI_3$
LRSI	Life Requisite Suitability Indices
HSI	HSI Formula
SI	Suitability Index
SIR	Reproduction Suitability Index
dbh	Diameter at Breast Height
SI_1	The relationship between the number of trees ≥51 cm dbh/0.4 ha and reproductive habitat quality for barred owls.
SI_2	The relationship between mean dbh of overstory trees and reproductive habitat quality for barred owls.
SI_3	The relationship between percent canopy cover of overstory trees and reproductive habitat quality for barred owls.

Table 3. Downy Woodpecker Habitat Suitability Index Metrics

Formula Name	**Formula**
LRSI= Food Reproduction	$HSI = MIN\ (V1, V2)$
LRSI	Life Requisite Suitability Indices
HSI	HSI Formula
V	Variable
dbh	Diameter at Breast Height
ha	Hectare = 2.471 acres

V1	Basal area [the area of exposed stems of woody vegetation if cut horizontally at 1.4 m (4.5 ft) height, in m^2/ha (ft^2/acre)].
V2	Number of snags > 15 cm (6 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, greater than 15 cm (6 inches) diameter at breast height (1.4 m/4.5 ft), that are at least 1.8 m (6 ft) tall. Trees in which at least 50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].

Table 4. Hairy Woodpecker Habitat Suitability Index Metrics

Formula Name	Formula
LRSI= Reproduction Cover	HSI= [SIV1 + (0.75 x SIV2)] x (SIV3 x SIV4 x SIV5)
LRSI	Life Requisite Suitability Indices
HSI	HSI Formula
SI	Suitability Index
dbh	Diameter at Breast Height
V	Variable
ha	Hectare = 2.471 acres
SIV_1	Number of snags ~25 cm dbh per ha [actual or estimated number of standing dead trees ~25 cm dbh and ~1.8 m tall. Trees in which ~50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].
SIV_2	Mean dbh of overstory trees [the mean diameter at breast height (1.4 m) above the ground of those trees that are ~80% of the height of the tallest tree in the stand].
SIV_3	Mean dbh of overstory trees [the mean diameter at breast height (1.4 m) above the ground of those trees that are ~80% of the height of the tallest tree in the stand].
SIV_4	Percent canopy cover of trees [the percent of the ground surface that is shaded by a vertical projection of all woody vegetation >6.0 m tall].
SIV_5	Percent overstory pine canopy closure [the percent of the ground surface that is shaded by a vertical projection of all pines (Pinus spp.) >6.0 m tall-ana-~80% of the height of the tallest tree in the stand; recommended for use in eastern U.S. forests only].

Target Year (TY) 0 habitat conditions are represented by the existing, or baseline, habitat conditions. The field and desktop collected data were used to quantify the habitat quality of that baseline condition. Target Year 0 conditions serve as a basis of comparison for both Future Without-Project (FWOP) and Future-With Project (FWP) scenarios.

Additional TYs were identified based on when implemented measures would be expected to elicit community responses represented by changes in the projected habitat variables.

TY 1 is used as a standard comparison year to identify and capture changes in habitat conditions that occur within one year after measures have been constructed. Amount of wetted area, reduction in invasive species, and water regimes are likely variables that may improve within this time period.

TY 5 was selected to capture the increase in habitat quality associated the restoration measures that provide ecological benefits relatively quickly such as natural plant establishment, aquatic vegetative abundance, and plant diversity.

TY 15 is used as a point after the initial growth of vegetation and the likely increase in size and benefits plantings have sustained.

Similarly, TY 25 was selected to capture the growth of BHF plant abundance and diversity are also key response variables for this target year.

TY 50 is the planning life span of the project and is used as the last projected TY for the study. Restoration measures should produce mature habitat by this target year and represent the habitat types within the study area.

USACE quantifies the existing, FWOP, and FWP Ecosystem Restoration (ER) benefits using a Habitat Unit (HU) metric. HUs are calculated as the product of the HSI and the number of acres of the habitat of interest. HUs for each FWOP and FWP are then annualized over the 50-year period of analysis utilizing Equation 1 below.

Equation 1: Annualization of Habitat Units for the FWOP and FWP Conditions

$$\int_0^T HU\,dt = (T_2 - T_1)\left[\left(\frac{A_1H_1 + A_2H_2}{3}\right) + \left(\frac{A_2H_1 + A_1H_2}{6}\right)\right]$$

Where:

$$\int_0^T HU\,dt = Cumulative\ HUs$$

T_1= first target year of time interval
T_2 = last target year of time interval
A_1 = area of available habitat at beginning of time interval
A_2= area of available habitat as the end of time interval
H_1 = Index score at the beginning of time interval
H_2 = Index score at the end of time interval
3 and 6 = constants derived from integration of Index score x Area for the interval between any two target years

This formula was developed to estimate cumulative HUs when either the HSI and/or area between two time intervals (T_x to T_{x+1}). The sum of these time intervals over the period of analysis divided by the total number of years of that analysis (50 years for this study) provides an Average Annual Habitat Unit (AAHU). This annualization accounts for the temporal shifts in the log rhythmic rate of accumulating ecological benefits that is common when dealing with the unevenness found in nature (USFWS 1980).

As ecological systems are rarely static. The AAHUs for the FWOP may not be equal to the AAHUs of the existing condition. Therefore, the impact of a project is quantified by calculating the difference between the FWP scenarios and the FWOP. The difference in AAHUs between the FWOP and the FWP represents the net impact attributable to the project in terms of habitat quantity and quality.

In order to accurately assess the impacts of the proposed project implementation, the existing and FWOP conditions are compared to the FWP condition using the same area (acres) and existing values for the model metrics. From there the conditions are projected into the future and annualized over a 50-year period. Using the habitat models used to establish the existing habitat quality, the MAMT projected what the future habitat conditions for the FWOP and FWP conditions by consensus based on best professional judgment.

<u>Existing and Future Without-Project Conditions</u>

This section describes the existing and future without-project conditions for various resources within the study area and the projected conditions of the study area without the proposed project, over the next 50-year period.

The existing condition of the LER project area consists of bottomland hardwood tree species of varying sizes (Table 2). Currently, this area has an average suboptimal condition for a BHF, which is reflected in the year “0” across all models (Table 6).

Under the FWOP condition there would be no repairs to the ESLD, and the associated work would not happen; however, it is anticipated that normal activities by the public and natural ecological processes would continue to occur. This continuation of ecological processes would result in the existing BHF continuing to grow and mature. As a result, the values for each habitat metric increase over time for all three species. It is anticipated that the FWOP condition of the LER area would result in an AAHU of 0.96 by the end of the planning period (50 years [Table 5]).

In order to accurately assess the impacts of the proposed project implementation, the existing and FWOP conditions are compared to the FWP condition using the same area (acres) and existing values for the model metrics. From there, the conditions are projected into the future and annualized over a 50-year period.

The existing habitat in the proposed mitigation area is an open grass-covered field currently used as a parking lot. Because there is no suitable vegetation for any of the three species evaluated, the habitat metric values at year 0 for each model would be 0 (Table 6).

It is expected that the FWOP condition for the proposed mitigation area would remain an open grassy field for the planning horizon. Therefore, future habitat metric values would also remain a 0 for all years, resulting in an AAHU of 0.0 (Table 6).

Table 5. The LER BHF Tree Cutting Area Site Future Without-Project Habitat Suitability Index for Barred Owl, Downy Woodpecker, and Hairy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units.

Tree Cutting Area Alternative:	Coverage	TY	ACREAGE	SPECIES	V1	V2	V3	V4	V5			Species HSI	Interval HAB Value	AAHU FOR HABITAT
FWOP	BHF	0	1.6	Barred Owl	2	7	100					0.37	NA	NA
FWOP	BHF	1	1.6	Barred Owl	2	7	100					0.37	0.58	NA
FWOP	BHF	5	1.6	Barred Owl	4	8	100					0.45	2.60	NA
FWOP	BHF	15	1.6	Barred Owl	6	10	100					0.58	8.20	NA
FWOP	BHF	25	1.6	Barred Owl	10	15	100					0.82	11.16	NA
FWOP	BHF	50	1.6	Barred Owl	20	25	100					1.00	36.34	1.18
FWOP	BHF	0	1.6	Downy Woodpecker	33	14						0.50	NA	NA
FWOP	BHF	1	1.6	Downy Woodpecker	33	14						0.50	0.8	NA
FWOP	BHF	5	1.6	Downy Woodpecker	35	20						0.50	3.2	NA
FWOP	BHF	15	1.6	Downy Woodpecker	40	27						0.50	8	NA
FWOP	BHF	25	1.6	Downy Woodpecker	45	35						0.50	8	NA
FWOP	BHF	50	1.6	Downy Woodpecker	55	40						0.50	20	0.80
FWOP	BHF	0	1.6	Hairy Woodpecker	5	10	10	100	0			0.40	NA	NA
FWOP	BHF	1	1.6	Hairy Woodpecker	5	10	10	100	0			0.40	0.64	NA
FWOP	BHF	5	1.6	Hairy Woodpecker	7	12	12	100	0			0.40	2.56	NA
FWOP	BHF	15	1.6	Hairy Woodpecker	10	15	15	100	0			0.40	6.40	NA
FWOP	BHF	25	1.6	Hairy Woodpecker	15	20	20	100	0			0.60	8.00	NA
FWOP	BHF	50	1.6	Hairy Woodpecker	15	30	30	100	0			0.80	28.00	0.91
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.96

Table 6. The LER BHF Mitigation Area Site Future Without-Project Habitat Suitability Index for Barred Owl, Downy Woodpecker, and Hairy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units.

Mitigation Area Alternative	Coverage	TY	ACREAGE	SPECIES	V1	V2	V3	V4	V5	Species HSI	Interval HAB Value	AAHU FOR HABITAT
FWOP	BHF	0	1.75	Barred Owl	0	0	0			0	NA	NA
FWOP	BHF	1	1.75	Barred Owl	0	0	0			0	0.00	NA
FWOP	BHF	5	1.75	Barred Owl	0	0	0			0	0.00	NA
FWOP	BHF	15	1.75	Barred Owl	0	0	0			0	0.00	NA
FWOP	BHF	25	1.75	Barred Owl	0	0	0			0	0.00	NA
FWOP	BHF	50	1.75	Barred Owl	0	0	0			0	0.00	0.00
FWOP	BHF	0	1.75	Downy Woodpecker	0	0				0.00	NA	NA
FWOP	BHF	1	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWOP	BHF	5	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWOP	BHF	15	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWOP	BHF	25	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWOP	BHF	50	1.75	Downy Woodpecker	0	0				0.00	0.00	0.00
FWOP	BHF	0	1.75	Hairy Woodpecker	0	0	0	0	0	0	NA	NA
FWOP	BHF	1	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWOP	BHF	5	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWOP	BHF	15	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWOP	BHF	25	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWOP	BHF	50	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	0.00
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Future With-Project Conditions

The FWP conditions evaluates the impacts to the ecosystem that the BHF removal and proposed mitigation would have. As was done when calculating the FWOP conditions, ecosystem impacts were assessed and projected with the habitat models by USACE using professional judgment for each target year.

In the FWP condition for the LER area, the existing BHF would be permanently removed, resulting in no suitable habitat for the three species utilized in the HEP analysis as reflected in the year “0” across all models (Table 7). These values would remain a “0” over the planning horizon (50 years) as the area would be regularly maintained by mowing to prevent woody vegetation from becoming reestablished. A comparison of the FWOP and FWP conditions for the LER area reveal a loss of 0.96 AAHUs on the proposed 1.6 acre impact area (BHF removal area).

The existing condition of the proposed mitigation area has no suitable habitat for the three species used for the HEP analysis. By projecting future forest growth (basal area) and percent canopy cover for the FWP condition, HEP scores were calculated for the planning horizon, with indexes estimated for 1, 5, 15, 25, and 50 years after the initial planting. A period of 50 years was selected to allow the maturing of the woody vegetation to fulfill the life requisites for the barred owl, downy woodpecker, and hairy woodpecker. Because the proposed mitigation site will be completely lacking suitable vegetation for these species upon project implementation, there is an enormous habitat unit lift from Year 0 to Year 50 for every metric. Mean dbh, and percent canopy cover of trees for food and for cover/reproduction will significantly increase at TY 15 (Table 8).

In order to mitigate for the loss of 0.96 AAHUs from the LER area, an appropriate amount of acres of open grass field habitat has to be calculated using the HSI models. As shown in Table 9, it will take approximately 1.75 acres of the selected open field area to mitigate for the AAHU loss. The slightly higher acreage needed for mitigation is because the restored site does not start providing any habitat metric benefits until TY 15. Therefore a slight increase in acres is necessary to be able to reach an appropriate AAHU value by the end of the planning horizon (50 years). As shown in Table 8, the projected AAHU value of the mitigation area would be 0.94 at year 50. Since the calculated AAHUs are based on professional judgement, the slight difference in values is considered insignificant.

Table 7. The LER <u>Tree Cutting Area Future With-Project</u> Habitat Suitability Index for Barred Owl, Downy Woodpecker, and Hairy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units.

Tree Cutting Area Alternative	Coverage	TY	ACREAGE	SPECIES	V1	V2	V3	V4	V5	Species HSI	Interval HAB Value	AAHU FOR HABITAT
FWP	BHF	0	1.6	Barred Owl	0	0	0			0.00	NA	NA
FWP	BHF	1	1.6	Barred Owl	0	0	15			0.00	0.00	NA
FWP	BHF	5	1.6	Barred Owl	0	5	50			0.00	0.00	NA
FWP	BHF	15	1.6	Barred Owl	6	8	100			0.45	3.92	NA
FWP	BHF	25	1.6	Barred Owl	10	12	100			0.68	9.90	NA
FWP	BHF	50	1.6	Barred Owl	20	25	100			1.00	36.83	1.01
FWP	BHF	0	1.6	Downy Woodpecker	10	0				0.00	NA	NA
FWP	BHF	1	1.6	Downy Woodpecker	10	0				0.00	0	NA
FWP	BHF	5	1.6	Downy Woodpecker	17	14				1.00	3.5	NA
FWP	BHF	15	1.6	Downy Woodpecker	30	27				0.50	13.125	NA
FWP	BHF	25	1.6	Downy Woodpecker	45	35				0.50	8.75	NA
FWP	BHF	50	1.6	Downy Woodpecker	55	40				0.50	21.875	0.95
FWP	BHF	0	1.6	Hairy Woodpecker	0	0	0	0	0	0.00	NA	NA
FWP	BHF	1	1.6	Hairy Woodpecker	0	0	0	15	0	0.00	0.00	NA
FWP	BHF	5	1.6	Hairy Woodpecker	0	0	0	50	0	0.00	0.00	NA
FWP	BHF	15	1.6	Hairy Woodpecker	5	10	10	100	0	0.40	3.50	NA
FWP	BHF	25	1.6	Hairy Woodpecker	10	20	20	100	0	0.60	8.75	NA
FWP	BHF	50	1.6	Hairy Woodpecker	15	30	30	100	0	0.80	30.63	0.86
NA	NA		NA	NA	NA	NA	NA	NA	NA	NA	NA	0.94

Table 8. The LER Mitigation Area Future Without-Project Habitat Suitability Index for Barred Owl, Downy Woodpecker, and Hairy Woodpecker Habitat Units for Each Target Year, Average Habitat Units for Each Target Year between the Models, and the Average Annual Habitat Units.

Mitigation Area Alternative	Coverage	TY	ACREAGE	SPECIES	V1	V2	V3	V4	V5	Species HSI	Interval HAB Value	AAHU FOR HABITAT
FWP	BHF	0	1.75	Barred Owl	0	0	0			0	NA	NA
FWP	BHF	1	1.75	Barred Owl	0	0	0			0	0.00	NA
FWP	BHF	5	1.75	Barred Owl	0	0	0			0	0.00	NA
FWP	BHF	15	1.75	Barred Owl	0	0	0			0	0.00	NA
FWP	BHF	25	1.75	Barred Owl	0	0	0			0	0.00	NA
FWP	BHF	50	1.75	Barred Owl	0	0	0			0	0.00	0.00
FWP	BHF	0	1.75	Downy Woodpecker	0	0				0.00	NA	NA
FWP	BHF	1	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWP	BHF	5	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWP	BHF	15	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWP	BHF	25	1.75	Downy Woodpecker	0	0				0.00	0.00	NA
FWP	BHF	50	1.75	Downy Woodpecker	0	0				0.00	0.00	0.00
FWP	BHF	0	1.75	Hairy Woodpecker	0	0	0	0	0	0	NA	NA
FWP	BHF	1	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWP	BHF	5	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWP	BHF	15	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWP	BHF	25	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	NA
FWP	BHF	50	1.75	Hairy Woodpecker	0	0	0	0	0	0	0	0.00
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0

Mitigation Planning Objectives

The project includes mitigation sequencing actions employed during the development and refinement of details for each alternative plan. These sequencing actions include steps to avoid, minimize, rectify, and reduce/eliminate habitat impacts for each alternative. These actions are part of the overall mitigation plan for the project. The need for compensatory mitigation is driven by the remaining unavoidable impacts to significant ecological resources.

The goal of this mitigation plan is to fully compensate for the unavoidable impacts to significant ecological resources that would occur with project implementation. The objectives of the mitigation plan are defined by the results of the habitat impact assessment model using quantified units. The same habitat assessment model is used to estimate potential project impacts and potential outputs of mitigation measures. The objectives of this mitigation plan are:

- Compensate for the loss of 1.6 acres of bottomland hardwood forest habitat (0.96 AAHUs) in the Lower Arkansas watershed.

Other factors may influence planning objectives and the development of strategies, measures, and alternative plans. These may even play a role in plan selection depending on specific project circumstances and opportunities. Some of these factors are based on legal requirements and policies and others are derived from scientific or technical standards. For example, acquisition of lands or interests in lands for mitigation must be acquired before construction of the project commences or concurrently with acquisition of lands and interests in lands for other project purposes; and the physical construction of the mitigation work is required to be carried out before or concurrently with project construction (see Section 906(a) of WRDA 1986, as amended). This introduces an implementation time factor to consider later in plan evaluation and selection. Another example, from a scientific perspective, larger contiguous land tracts may offer better habitat value for fish and wildlife compared to dispersed smaller areas. This may influence site selection and land considerations for a mitigation project.

Land Considerations

Several USACE fee owned lands on the Arkansas River were assessed for potential use as a mitigation site. The USACE kept their consideration to USACE fee owned lands because the abundance of it along the Arkansas River that are near enough to offset the habitat loss that would occur from the project impacts. The selected mitigation site would consist of 1.75 acres of open field/grassland habitat at the Sheppard Island Public Use Area.

Mitigation Strategies

Planning strategies are different means employed to develop an alternative plan or plans to achieve a project goal. The use of one or more strategies helps teams focus on an approach to developing a plan. For mitigation planning work, strategies may range from the purchase of mitigation bank credits to the construction of a project or projects to achieve the objectives and compensate for unavoidable habitat impacts. Strategies may also involve different approaches to site selection such as the use of public lands or identifying contiguous sites to enhance wildlife corridors or expand wildlife populations. In addition, Section 2036(c) of WRDA 2007, as amended, requires to the Corps of Engineers to consider mitigation banks and in-lieu fee programs where appropriate. The strategies considered for planning this mitigation project are described below.

- Purchase of mitigation bank credits. Mitigation banks sell credits for mitigation work performed at an approved site. The banks are approved and legally bound through banking instruments that hold the operators to certain standards of performance and reporting. The use of mitigation banks for a project may offer advantages to the government and non-federal sponsor by reducing performance risk and eliminating project specific requirements for operations and maintenance work and the development of monitoring and adaptive management plans.
- Construction of a mitigation project. The government may choose to construct a mitigation project. This construction strategy offers some potential advantages in tailoring a project to specific needs or locations. In addition, the partners may bring special expertise to the project gained from previous work on similar projects in the area.

Identify Measures and Formulate Alternative Mitigation Plans

A conceptual ecological model (CEM) was developed to assess the impacts that the LER would have and how the proposed mitigation strategy would compensate for those impacts. This model is a qualitative representation of a system or sub-system that serves as a basis for the organization of processes that can be utilized to understand and communicate the function of that process and the identification of factors impairing the optimal performance of the systems. The models, as applied to ecosystems are simple and qualitative, represented by a diagram or description that describes general functional relationships among the essential components of an ecosystem.

The CEM provides a framework enabling the team to characterize the drivers and effects of impediments to ecosystem functions, potential measures to address these impediments, and methodologies to characterize and quantify ecosystem benefits resulting from any restoration actions. The CEM format utilized here follows a top-down hierarchy of information. The LER CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather, the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem restoration and monitoring goals.

The CEM includes the following components:

- **Drivers:** Includes major external driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g. climate change) or anthropogenic (e.g. hydrologic alteration) in nature. Anthropogenic drivers provide opportunities for finding relevant solutions to problems. Natural drivers, however, cannot be influenced directly by human interference. Some drivers are both anthropogenic and natural in nature.

- **Ecological Stressors:** Includes physical or chemical changes that occur within the natural systems, which are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.
- **Ecological Effects:** Includes biological, physical, or chemical responses within the natural system that are produced or affected by stressors. CEMs propose linkages between one or more ecological stressors and ecological effects and attributes to explain changes that have occurred in ecosystems.
- **Attributes:** This component is a prudent subset of all potential elements or components of natural systems representative of overall ecological conditions. Attributes may include populations, species, communities, or chemical processes.
- **Performance Measures**: Includes specific features of each attribute to be monitored to determine the degree to which attribute is responding to projects designed to correct adverse effects of stressors (i.e. to determine success of the project).

Table 9 lists the CEM specific components for the ESLD LER Project.

Table 9. Emmett Sanders L&D Left Embankment Repair Conceptual Ecological Model

Component	LER CEM Component Description
Drivers	Flood regime and manmade embankment
Ecological Stressors	Invasive species and habitat fragmentation
Ecological Effects	Reduced diversity and restricted corridor
Attributes	Species composition, canopy cover composition, and number of snags
Performance Measures	Percentage of invasive species, percentage of non-native species, and canopy cover composition

Management measures are actions or activities that work towards accomplishing planning objectives. Each measure is linked to one or more stressors or drivers in the conceptual ecological model. A measure may stand alone as a single activity that serves as an alternative plan. Two or more individual measures may be combined to form an alternative plan.

- Measure 1 - Purchase mitigation bank credits. This measure addresses the mitigation objectives through the purchase of in-kind credits from an approved mitigation bank located in the basin.
- Measure 2 – Construct a BHF mitigation project. This measure addresses the mitigation objectives by planting native BHF species to create future functioning BHF habitat.

A qualitative analysis of the potential effectiveness of each measure towards achieving the mitigation planning objectives was performed. Mitigation banks within the Lower Arkansas River watershed were considered, but none were found.

Measure 2 – Construct a mitigation project – was brought forward as a standalone alternative. The USACE would plant 1.75 acres of BHF within the Sheppard Island Public Use Area to mitigate the permanent loss of 1.6 acres of BHF that would occur as result of implementing the proposed LER. (Figure 1). This effort as modeled and documented in Tables 6 and 8 would have a similar habitat value within 50 years (planning lifecycle) as the area where BLH trees were removed.

The first phase of the mitigation involves site preparation activities. The USACE would remove any invasive species that may occur on the 1.75 mitigation site, mow the remaining vegetation (grass). Subsequent to mowing, and prior to planting, the ground surface within the mitigation site would be subsoiled (ripped) to fracture the soil (12 to 16 inches deep). Ripping would occur in parallel rows 12” apart (to allow for the 12” x 12” spacing of seedlings). The ripped furrows (slits) allow the native bareroot seedling roots to have direct and complete contact with the soil, thereby allowing better root development and increased survival.

Once the site preparation is complete, BLH seedling planting would occur. The MAMT selected a species mixture consisting of an equal number of cow oak/chinquapin oak (*Quercus muehlenbergii*), Shumard oak (*Quercus shumardii*), native pecan (*Carya illinoinensis*), water hickory (*Carya aquatica*), black gum (*Nyssa sylvatica*), and persimmon trees (*Diospyros virginiana*) seedlings. Species selection was based on knowledge of the surrounding mature BHF species composition. If these species are not available at time of planting, other native BHF species that are deemed appropriate by the MAMT would be substituted.

The stocking rate (i.e. seedlings/acre) for this project is based on BHF bare root seeding planting for wildlife purposes (302 seedlings/acre on a 12” x 12” spacing = 528.5 seedlings / rounded to 530). The goal of this planting rate is to have a survival rate of 125 trees/acre after 3 years (total ~ 219 trees). Conservation organizations and agencies have successfully reforested thousands of acres of agricultural land in the Lower Mississippi Alluvial Valley (MAV) in the past several decades using this stocking/planting rate. Additionally, numerous research efforts have determined that this stocking rate is optimal to achieve a successful afforestation effort for wildlife purposes.

Monitoring would begin the first summer after planting. The goals and methods of monitoring is discussed in the Criteria for Determining Ecological Success Section below. If drought conditions occur that threaten survival of the seedlings, the site would be watered to increase survival probability. Should monitoring indicate that seedling survival is low, additional plantings would occur. Details on those plantings are discussed in the Monitoring and Adaptive Management Section below.

Costs of Mitigation Plan Increments and Alternatives

Since no mitigation banks were identified, the only cost estimate developed was for the "Construct BHF Mitigation Project" alternative. The team used various information sources to estimate the cost for this alternative, including details from recently completed nearby ecosystem restoration projects. The study team also considered other cost factors such as site access, fuel and equipment, and the availability of plant materials. Table 10 displays the costs and outputs for each alternative plan.

Table 10. Estimated Costs of Alternative Plans

Alternatives	Cost	Plan Outputs
No Action Alternative	$0	0
Proposed Action Alternative– plant and maintain a new BHF	$67,200	*0.94 AAHU*

Plan Selection Considerations

For this project the availability of BHF mitigation credits were researched in the USACE Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS) with none being found within the primary, secondary, and tertiary service areas.

Since the LER project area is located within the USACE MKARNS fee boundary, research for suitable mitigation sites was kept to USACE fee owned properties. This was done because of the abundance of potential USACE-owned property and to reduce mitigation costs. Potential site selection was restricted to areas with suitable topography and soils, relative ease of access to reduce costs, and sites that were unencumbered by lease agreements.

Recommended Compensatory Mitigation Plan

The recommended plan for compensatory mitigation is to plant and maintain 1.75 of BHF, which will be monitored to ensure planting success. Specifically, the mitigation area would be in the LER project boundary (Sheppard Island Public Use Area – Figure 1), and would occur in the manner discussed in the Identify Measures and Formulate Alternative Mitigation Plans Section of this report. The estimated mitigation cost is $67,200, as described in detail in the Costs of Mitigation Plan Increments and Alternatives and Monitoring and Adaptive Management sections of this plan.

Implementation Risks

The planning team identified a suite of foreseeable implementation risk factors across each phase of implementation (Pre-Construction Engineering and Design, Construction, and Operations). These factors are based upon experience from similar projects and the consideration of regional risks generally associated with design and construction work in wet environments. Each risk was assessed and assigned a significance level. Potential risk management measures were identified and will be considered should the need arise during implementation or adaptive management (Table 11).

Table 11. Risk Assessment and Management Measures

Risk Factor	Risk Potential	Risk Rating	Risk Management Measures
Pre-Construction Engineering and Design Phase: Increase in habitat impacts	Low	Low	Include mitigation sequence commitments in project and site (P&S) development. Employ Best Management Practices in P&S. Confirm during BCOES review.
Construction Phase: Excessive rainfall or flooding	Medium	Medium	Plan for construction during more favorable weather seasons. Anticipate weather events before initiating weather-dependent phases of construction. Use appropriate equipment for site conditions.
Construction Phase: Construction management	Medium	varies	Monitor use of Best Management Practices during construction work. Confirm construction as-built requirements are met. Document all conditions pre- and post-construction at site.
Construction Phase: Spread of Invasive Species	High	High	Ensure that all construction equipment is rinsed off of debris prior to entering the mitigation area, remove all invasive species from the mitigation area prior to beginning work. Plant only native species.
Operations Phase: Herbivory	High	varies	Monitor vegetation for survival and resistance to herbivores. Adaptively manage with exclusion or treatment measures to address impacts.
Operations Phase: Drought	High	High	Monitor local weather patterns, adjust watering of the mitigation site accordingly until the plants are well established. Up to 3 times annually for 1st 2 years.
Operations Phase: Spread of Invasive Species	High	High	Monitor for invasive species until the BHF community is well established.

Criteria for Determining Ecological Success

Criteria were selected based upon a review of scientific literature related to BHF restoration. Table 12 below shows the mitigation objective in habitat units and different success criteria for vegetation characteristics. Specific metrics are identified and quantified along with time periods for meeting the metrics. Identifying the time periods to attain the criteria is linked to when monitoring activities should be undertaken to measure project performance.

Table 12. Ecological Success Criteria

Objective	0.94 AAHU

Success Criteria Post-Planting of hardwood seedlings – Year 1	Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat. • Collect data on seedling trunk diameter and height
Success Criteria Post-Planting of hardwood seedlings – Year 2	Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat. • Collect data on seedling trunk diameter and height
Success Criteria Post-Planting of hardwood seedlings – Year 3	• Visual evidence of planted species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat. • Seedlings show positive growth in trunk diameter and overall height • Minimum 150 trees/acre. Number can include volunteer species, but need to ensure diversity of native species is still present.
Success Criteria Post-Planting of hardwood seedlings – Year 5	• Stocking rate of 150+ trees/acre. Number can include volunteer species, but need to ensure diversity of native species is still present. • 50+ hard-mast producing trees/acre • Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species. If above criteria are met, planting considered successful. Discontinue monitoring. • If above criteria are not met, plant additional native BHF species to achieve successful stocking rate of 150 trees/acre and 50+ hard-mast producing trees/acre.
Success Criteria Post-Planting of hardwood seedlings – Year 7 (if needed)	• Stocking rate of 150+ trees/acre. Number can include volunteer species, but need to ensure diversity of native species is still present. • 50+ hard-mast producing trees/acre • Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species. • If above criteria are met, planting considered successful. Discontinue monitoring. • If above criteria are not met, plant additional native BHF species to achieve successful stocking rate of 150 trees/acre and 50+ hard-mast producing trees/acre.
Success Criteria Post-Planting of hardwood seedlings – Year 10	• Stocking rate of 150+ trees/acre. Number can include volunteer species, but need to ensure diversity of native species is still present. • 50+ hard-mast producing trees/acre • Less than 25% canopy cover of invasive species with no area >0.25 acres in size with >25% invasive species. If above criteria are met, planting considered successful. • If above criteria are not met, planting considered unsuccessful. Meet with agency partners to determine additional mitigation measures.

Section 906(d)(4) of WRDA 1986, as amended, requires the District to hold an annual mitigation consultation meeting with the appropriate Federal and state agencies. For each mitigation project, the meeting should focus on the ecological success criteria, the likelihood that the project will achieve success, the timeline to achieve success, and any recommendations to improve the likelihood of success. The "Coordination and Collaboration" section of this plan identifies the agencies invited to the District's annual meeting. Once ecological success criteria are met, review of the project is no longer needed at the annual meeting.

Monitoring and Adaptive Management

Monitoring

The MAMT developed and reviewed a plan for site monitoring to determine the success of the mitigation work. Table 13 includes the cost and duration of monitoring work. The elements of the monitoring plan are designed to measure the attainment of ecological success criteria at key points over the course of the mitigation construction and operation periods. Please note the costs below are for a local USACE employee to conduct these activities.

Table 13. Monitoring Activities

Years	Activity	Data	Cost
0	Pre-construction monitoring	Baseline ecological data	$3,000
1	Vegetation survey/Report	Plant survivorship, plant species composition	$3,000
2	Vegetation survey/Report	Plant survivorship, plant species composition	$3,000
3	Vegetation survey/Report	Plant survivorship, plant species composition	$3,000
5	Vegetation survey/Report	canopy cover percentage, plant survivorship, plant species composition	$3,000
7 (if needed)	Vegetation survey/Report	canopy cover percentage, plant survivorship, plant species composition	$3,000
10 (if needed)	Vegetation survey/Report	Determine success/failure	$3,000
7 or 10	Final monitoring report	Comprehensive report	$3,000

Assessment

The results of the monitoring program will be assessed annually by the MAMT. Monitoring results will be assessed to ensure the ecosystem response is on track to meet the restoration performance measures and goals. This assessment process will measure the progress of the project and determine if adaptive management actions are needed. Assessments will also inform the MAMT if other factors are influencing the response that may warrant further research.

USACE will document and report the monitoring results, assessments, and the results of the MAMT deliberations to the project team and decision-makers. USACE, with assistance from the MAMT, will also produce annual reports that show progress towards meeting project objectives as characterized by the performance measures. Results of the assessments will be used to evaluate adaptive management needs and inform decision-making.

Adaptive Management

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. It is important that a science-based monitoring plan target the collection of performance information to help inform potential adaptive management actions. Adaptive management allows the project team to use monitoring feedback to make changes to project features or operations to improve attainment of ecological success criteria. This contingency plan outlines a range of corrective actions in cases where monitoring demonstrates that mitigation features are not achieving ecological success goals.

Decision-Making

The information generated by the monitoring plan will be used by USACE in consultation with the MAMT members to guide decisions on adaptive management that may be needed to ensure that the mitigation project achieves success. Final decisions on implementation of adaptive management actions will be made by USACE.

If monitoring determines that a management trigger has been "activated", the MAMT may determine that more data is required and continue or modify monitoring methods; or identify and implement a remedial action (Table 13).

Table 14. Adaptive Management Actions

Element	Expected Condition	Potential Issue	Potential Corrective Action
Vegetation community composition	Healthy BHF forest free of invasive species. Survivorship of native species, 150 trees/acre (can include volunteer species, but species diversity similar to planting rate) and a minimum of 50 hard-mast producing trees per acre.	Invasive species dominance, poor tree survival or sub-optimal tree growth.	Invasive species control, replanting, or other forest management practices.

Decision Criteria

Decision criteria, also referred to as adaptive management triggers, are used to determine if and when adaptive management should be implemented. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions. Several potential decision criteria are identified below, based on the project objectives and performance measures. More specific decision criteria, possibly based on other parameters such as hydrology, geomorphology, and vegetation dynamics, may be developed during PED.

If assessments show that any of these triggers are met, USACE would consult with the MAMT to discuss whether an adaptive management action is warranted, and if so, what that action will entail. Investigations may be required to determine the cause of need for action in order to inform the type of adaptive management response that should be implemented, if needed. Additionally, prior to enacting any adaptive management measures, USACE would assess whether supplemental environmental analyses are required. Efforts will be made to make lessons learned available to the USACE community for incorporation into future projects.

Performance Measure: **BHF restoration.**

Success Criteria Stocking rate of minimum 150 trees/acre (can include volunteer species, but species diversity similar to planting rate) and a minimum of 50 hard-mast producing trees per acre, 5 years post-planting.

Monitoring Design and Rationale: Current site condition is open grass field; thus pre-construction sampling isn't required. Initial control/removal of unwanted plants will be evaluated, and determinations made during PED, however hardwood reforestation on similar sites near the study area have shown that the planting trees will out-compete existing grass and eventually shade it out. Additionally, the presence of grasses will aid in preventing the establishment of invasive species.

Vegetation sampling will occur at Post-Planting Years 1, 2, 3, 5, and years 7 and 10 (if necessary). Sampling will occur during spring months, at the peak of the growing season. A minimum of 3 1/10th-acre monitoring plots will be located randomly during each monitoring period. Additional plots may be sampled, if necessary, to determine whether success criteria is met. The distance between plots will be dependent on the project site area and variability. Monitoring will measure percent cover of native and non-native plant species and structural diversity. If all success criteria are met at Year 5 Post-Planting, the planting can be considered successful.

Trigger: By year 5, the stocking rate is <150 trees/acre (including volunteer plant species, but only if the species is consistent with the species diversity goals and is not a dominant component of the restoration target composition) and/or <50 mast-producing trees/acre.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms for the successful establishment of BHF habitats may include drought or extreme storm events, predators (invertebrates and vertebrates), incompatible plant species selection, and/or infestation of non-native invasive and native noxious species.

Potential Adaptive Management Measures: Adaptive management measure would include irrigation during drought conditions (during construction period or afterwards during Adaptive Management period); predator control (i.e., exclosures) to ensure the vitality and survival of the plantings; supplemental planting to replace dead seedlings, changing the target plant species to those be more tolerant of site specific abiotic conditions; treating reforestation sites with herbicides to manage invasive and noxious plant species in the restoration areas.

This mitigation plan involves active manipulation (as needed) to sustain project goals and objectives, primarily by applying an iterative process of assessing and learning from the results of management actions. The application of adaptive management principals in this project will therefore provide decision support tools to address site changes that may occur as the project progresses, as well as integrate additional project resources or technologies as needed. In some cases additional resources may be needed to address issues that occur (such as management of infestations of invasive species), but in most cases reallocation of resources (e.g., modifying planting lists/species selection based upon successes and failure of earlier plantings) can be used to meet or exceed project goals as defined by tree, shrub, vine, and herbaceous plant establishment combined with nuisance plant control.

Reporting

Evaluation of the success of the LER project will be assessed at least (more frequently if necessary) until all performance standards are met. An annual report will be completed each year, shared with SWL Operations staff, and filed in the Project Folder.

Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports.

Adaptive Management Costs

Costs for the adaptive management program were based on estimated level of effort and potential frequency of need, and include participation in the MAMT and reporting. The bottomland hardwood restoration mitigation measure has been successfully implemented with very similar designs in close proximity to the project area; therefore, the desired outcomes are expected and reasonable based on experience. The likelihood that extreme measures, such as complete replacement of all native vegetation, is very low. The current total estimate for implementing the adaptive management program is up to $67,200 (Table 15).

Table 15. Preliminary Cost Estimates for Mitigation **Implementation**, **Monitoring**, **and Adaptive Management Plan – ESLD-LER**

Activities	PED Set-up	Construction	Post Planting	Total
Monitoring: Planning and Management: Monitoring workgroup, drafting detailed monitoring plan, working with PDT	$3,000	NA	NA	$3,000
Monitoring, Data Analysis, and Annual Reporting: Monitoring hardwood planting (est. X hrs @ $3K/yr for years 1,2,3,and 5 [7and 10 if needed – reforestation])	NA	$3,000 for RPEC monitor	$21,000	$24,000
Implement Mitigation and Adaptive Management Program: Establish 1.75 acres of BHF	NA	$8,500	NA	$8,500

Implement Mitigation and Adaptive Management Program: Replant hardwood seedlings @ year 5 if needed. (est. 25% replant)	NA	NA	$700	$700
Implement Mitigation and Adaptive Management Program: Irrigation of seedlings for replanting (in event of severe drought only	NA	NA	$4,000	$4,000
Invasive species Mgt.	NA	NA	$27,000	$27,000
TOTAL	$3,000	$11,500	$52,700	$67,200

References

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