Appendix D. Investigations and Analyses Report

Whitewater River Watershed Plan
for
Whitewater River Watershed
Cape Girardeau and Scott Counties, Missouri

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D1.INTRODUCTION

This Investigations and Analyses Report provides relevant resource research, investigation, and analysis details for the Whitewater River Watershed, proposed actions, and proposed alternatives.

D1.1. Summary of Principles, Requirements, and Guidelines

The following PR&G Guiding Principles constitute the overarching concepts the Federal government seeks to promote through Federal investments in water resources now and into the foreseeable future. These Principles are presented in no particular order, and their organization denotes no hierarchy or rank.

- **Healthy and Resilient Ecosystems**. Federal investments in water resources should protect and restore the functions of ecosystems and mitigate any unavoidable damage to these natural systems.
- **Sustainable Economic Development**. Federal investments in water resources should encourage sustainable economic development.
- **Floodplains**. Federal investments in water resources should avoid the unwise use of floodplains and flood-prone areas and minimize adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used.
- **Public Safety**. Threats to people, including both loss of life and injury, from natural events should be assessed in the determination of existing and future conditions, and ultimately, in the decision-making process.
- **Watershed Approach**. A watershed approach to analysis and decision making facilitates evaluation of a more complete range of potential solutions and is more likely to identify the best means to achieve multiple goals over the entire watershed.

In accordance with Executive Order 14173, Environmental Justice has been removed from consideration in this Plan and Appendices.

Federal investments in water resources should strive to maximize public benefits, with appropriate consideration of costs. Public benefits encompass environmental, economic, and social goals, include monetary and nonmonetary effects and allow for the consideration of both quantified and unquantified measures (USDA 2017).

D2.LAND USE

Land use and land cover within the watershed and project area were estimated using recent and historical aerial photography; USGS National Land Cover Database (NLCD); and field observations. Cultivated crops are the primary land cover, comprising approximately 64 percent of the watershed (see Table D2-1). Deciduous forest is the second largest land cover in the watershed (approximately 14 percent), followed by hay/pasture cover, which comprises approximately 12 percent of land cover. The proposed project area is comprised of the levee banks of Ditch Number 1 with a small buffer of land from the top of slope outward, typically about 50 feet. Some of this top of slope buffer is farmed; however, much of the riparian corridor along Ditch Number 1 is herbaceous. Scattered trees and small forest stands exist along the project corridor; however, these areas are generally outside of the herbaceous riparian corridor. Larger forested tracts exist adjacent to the project area within managed conservation areas. Banks of Ditch Number 1 in the project area are generally vegetated with herbaceous and scrubby vegetation. See observed vegetation in Section 5. The watershed has been dominated by row crop farming for generations and is anticipated to continue in agricultural use.

Table D2-1. Land Cover in the Watershed and Project Area (PA).

Land Cover Classification	Watershed		PA	
	Acres	**Percent**	**Acres**	**Percent**
Cultivated Crops	**35,083**	**64**	**37**	**76**
Deciduous Forest	7,391	14	0	0
Hay/Pasture	6,380	12	0	0
Developed, Low Intensity	1,486	3	0	1
Developed, Open Space	1,751	3	0	0
Developed, Medium Intensity	828	2	0	0
Developed, High Intensity	336	1	0	0
Developed, All Intensities Combined	**4,401**	**9**	**0**	**0**
Woody Wetlands	543	1	10	21
Open Water	331	0	0	0
Herbaceous	143	0	0	0
Emergent Herbaceous Wetlands	114	0	1	2
Mixed Forest	75	0	0	0
Shrub/Scrub	22	0	0	0
Barren Land	15	0	0	0
Evergreen Forest	0	0	0	0
Total	**54,496**	**100**	**48**	**100**

Source: NLCD 2019.

Farming is the primary land use in the watershed. Table D2-2 lists the number and income of farms in the counties with the watershed as well as the top commodity per county.

Table D2-2. Number of Farms and Average Income per Farm by County, Census of Agriculture 2017

County	Number	Income	Top Commodity
Cape Girardeau	1,111	$19,276	soybeans
Scott	450	$124,623	poultry and eggs

Source: University of Missouri Extension. 2023.

D3.SOILS

Soils information for the watershed and Project Area was obtained from Web Soil Survey. The soils in the watershed and Project Area are predominantly silt loams. Table D3-3 describes the soil map units, proportions in the watershed and Project Area (respectively), drainage class, and hydrologic soil group (HSG).

D3.1. Drainage Class and Hydrologic Suitability Group

The soils in the watershed range from a poorly drained to well drained drainage class, with most of soils in the somewhat poorly drained class. Eighty-eight percent of the soils in the Project Area are somewhat poorly drained. Drainage class accounts for the occurrence and length of wet periods comparable to the conditions the soils were formed under. The seven drainage classes are excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. Table D3-1 defines the drainage classes.

Table D3-1. Drainage classes definitions from the Soil Survey Manual (USDA 2018).

Drainage Class	Definition
Well drained	Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit root growth for significant periods during most growing seasons. The soils are mainly free of, or are deep or very deep to, redoximorphic features related to wetness.
Moderately well drained	Water is removed from the soils somewhat slowly during some periods of the year. Internal free water occurrence is commonly moderately deep and transitory through permanent. The soils are wet only for a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low to lower saturated hydraulic conductivity in a layer within the upper 1 meter, periodically receive high rainfall, or both.
Somewhat poorly drained	Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. Internal free water occurrence is commonly shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: low or very low saturated hydraulic conductivity, a high water table, additional water from seepage, or nearly continuous rainfall.

Drainage Class	Definition
Poorly drained	Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. Internal free water occurrence is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow depth. Free water at shallow depth is common. The water table is commonly the result of low or very low saturated hydraulic conductivity, nearly continuous rainfall, or a combination of these.

Most of the soils in the Project Area (89 percent) are mapped as HSG D or B/D. There are four soil hydrologic groups (A, B, C, and D) that are designated based on runoff potential and rate of infiltration when they are saturated and precipitation is received from storms. Table D3-2 defines the hydrologic soil group. Where soils are assigned to a dual group (e.g. C/D), the first letter refers to drained areas and the second to undrained.

Table D3-2. Hydrologic Soil Group (USDA 2018).

Group	Definition
A	Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
B	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
C	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Table D3-3. Soil Map Units in the Watershed and Project Area (PA). Drainage Class and Hydrologic Soil Group (HSG).

Map Unit Name	Watershed		PA		Drainage Class	HSG
	Acres	Percent	Acres	Percent		
Sharkey silty clay, 0 to 1 percent slopes, occasionally flooded	12,583	23	40	82	Poorly drained	D
Memphis silt loam, 15 to 35 percent slopes, severely eroded	9,809	18	0	0	Well drained	B
Falaya silt loam, 0 to 1 percent slopes, occasionally flooded	7,352	13	0	0	Somewhat poorly drained	B/D
Memphis silt loam, 3 to 8 percent slopes	4,707	9	0	0	Well drained	B
Adler silt loam, 0 to 1 percent slopes, occasionally flooded	4,057	7	0	0	Moderately well drained	C
Adler silt loam, 0 to 3 percent slopes	3,813	7	0	0	Moderately well drained	C
Memphis silt loam, 8 to 15 percent slopes, severely eroded	2,450	4	0	0	Well drained	B
Adler silt loam, 0 to 3 percent slopes, rarely flooded	2,314	4	0	0	Moderately well drained	C
Mhoon silt loam, 0 to 1 percent slopes, rarely flooded	1,883	3	0	0	Poorly drained	B/D
Adler silt loam, 0 to 1 percent slopes, rarely flooded	1,314	2	0	0	Moderately well drained	C
Falaya silt loam, 0 to 1 percent slopes, rarely flooded	1,004	2	0	0	Somewhat poorly drained	B/D
Mhoon silt loam, 0 to 1 percent slopes, occasionally flooded	984	2	3	7	Poorly drained	B/D
Commerce silty clay loam, 0 to 1 percent slopes, rarely flooded	727	1	0	0	Somewhat poorly drained	C/D

Map Unit Name	Water shed	PA	Drain age	HSG	Map Unit Name	Water shed
	Acres	Percent	Acres	Percent		Acres
Memphis silt loam, 1 to 5 percent slopes	466	1	0	0	Well drained	B
Falaya silt loam, 0 to 3 percent slopes	396	1	0	0	Somewhat poorly drained	B/D
Levees-Borrow pits complex, 0 to 25 percent slopes	274	1	0	0	Somewhat poorly drained	NA
Water	197	0	0	0	NA	NA
Commerce silty clay loam, 0 to 1 percent slopes, occasionally flooded	166	0	5	12	Somewhat poorly drained	C/D
Total	**54,496**	**100**	**48**	**100**		

D3.2. Prime and Unique Farmland and Farmland Soils of Statewide Importance

NRCS classifies soil map units based on soil characteristics that are best suited to growing food, feed, fiber, forage, and oilseed crops. Of the 54,496 acres in the watershed, 81 percent of the project watershed is classified as prime farmland, prime farmland if drained, and farmland of statewide importance.

Table D3-4. Farmland Classification in the Watershed and Project Area

Classification	Watershed		PA	
	Acres	Percent	Acres	Percent
All Areas Prime Farmland	11,964	22	0	0
Prime Farmland if Drained[1]	25,095	46	48	100
Farmland of Statewide Importance	7,160	13	0	0
Not Prime Farmland	9,809	18	0	0
Water/Borrow Pits	468	1	0	0
Totals	**54,496**	**100**	**48**	**100**

Source: USDA-NRCS Soil Survey

[1] Nearly all the project area is drained.

D4.GEOLOGY

D4.1. Geologic Setting

Published geology maps (USGS 1981) (USGS 1985) show surface geology consists of Quaternary System, Pleistocene and Holocene series formation “Fluviatile1 and Fluvio-lacustrine2 Deposits”, mapped as Qf1 on Chaffee Quad and as “Deposits of Ancestral Mississippi River,” Qtm on Oran Quad, that is composed of silt, clay, sand, and gravel in part intermixed and interbedded. Silt clayey, locally sandy, partly derived from local loess deposits. Silt constitutes much of the alluvium underlying major lowlands and along larger streams. Clay, commonly silty, thinly laminated, is dominant lithology of the fluvio-lacustrine deposits. Sand, in part silty, common along streams in areas of McNairy Formation. Gravel, angular to subrounded sandstone and chert fragments. The unit includes colluvium along the base of steep slopes. These deposits vary from 118-feet to 180-feet thickness.

Published Geologic Maps (MDNR 2024), show the bedrock underlying the Quaternary System deposits in site area is generally deeper than 200 feet (MDNR 2023). Surface elevations in the watershed are generally below 400 feet mean sea level. The bootheel has the lowest elevations in the state of Missouri and the lowest point in the state is the Little River at the state line at 230 feet msl (MDNR 2002). The bedrock is mapped primarily as the “Jefferson City, Cotter, Powell, and Smithville Dolomites,” which is indicated as “Ojcps” on the published maps. The Ojcps is characterized as dull brown to light gray, finely crystalline dolomite. Chert is present throughout but most common in lower portions. Thin sandstones and shales are present throughout. Total thickness exceeds 800 feet in local wells.

The Project Area is located in the Mississippi Delta Cotton and Feed Grains Region Land Resource Region, which consists of the Southern Mississippi River Alluvium Major Land Resource Area. This region begins south of where the Mississippi and Ohio rivers converge and is characterized by thick alluvial deposits along the Lower Mississippi River.

D4.2. Geologic Investigations

A geotechnical investigation was not conducted as part of this watershed planning process.

D5.ENGINEERING

D5.1. Land Rights Assessment of Project Area

Land rights maps were created for the Project Area (see **Appendix C**). These maps provide a visual representation of ownership of land parcels adjacent to the Project Area and the relationship of these parcels to easements maintained by Little River Drainage District along the ditches that they manage. These maps were created utilizing ArcGIS software, incorporating overlays from National Agricultural Imagery Program aerial imagery (USDA 2024), nationwide parcel data (Regrid 2024), and drainage district easements. The drainage district easements were created utilizing the descriptions contained in legal documents of the ditch easements maintained by Little River Drainage District (LRDD 2024). This legal document is available in **Appendix A**.

D5.2. Geotechnical

D5.2.1. Slope Stability Analyses

The existing channel slopes appear to be gradually eroding/sloughing to a roughly "U" shaped configuration with most slopes slightly flatter than 2-horizontal to 1-vertical (2:1). The existing slopes appear to be stable with respect to general balance of the forces tending to cause failure versus the forces resisting failure. That balance indicates a general factor of safety against slope failure of at least 1.0. A slight change in the forces that drive failure, such as wetting of the slope or freeze-thaw action, could overwhelm the resisting force and result in a slope failure.

In general, most geotechnical engineers would consider a slope inclination of 2:1 to be adequately stable, presuming soil strength properties are within typical parameters. "Adequately stable" would imply that the factor of safety is at least 1.3 (resisting force / driving force) for a 2:1 slope inclination.

We understand that the existing slopes have been in their current configuration for many years and have experienced many freeze-thaw cycles, many wetting-drying cycles, and, most likely, several earthquakes.

D5.2.2. Conclusions

To correctly define the factor of safety against slope failure, the proper steps should be taken to test, analyze, and document the areas soil strength parameters and perform slope stability analyses. These steps should include:

- Survey the existing slope configurations
- Sample a sufficient number the soils within the expected failure zones and foundations of the slopes (i.e., drilling and sampling)
- Test a sufficient number of samples to assess the project area's soil strength properties
- Analyze a sufficient number of the existing and proposed slope configurations
- Prepare a report to document those results

Depending upon the Owner's or Regulator's aversion to risk and the consequences of slope failure, in WSP's professional opinion, the cost and time required to perform a suitable study seems to be evenly balanced with taking an observational approach. The observational approach would be to assume that the 2:1 design slope is adequate and budget for annual maintenance cost for minor

repairs of small slides and sloughs. If the Owner's or Regulator's has a greater aversion to risk than that, the team can design slopes flatter, say 2.5:1 or 3:1 and budget for annual maintenance cost for minor repairs of small slides and sloughs. The final choice would be to take the analysis steps listed above.

D5.3. Hydrology and Hydraulics

D5.3.1. Hydrology and Hydraulic Analyses

HEC-RAS version 6.3.1, published by the United States Army Corps of Engineers, was utilized for hydrologic and hydraulic modeling purposes. Each model incorporated terrain, soil, landcover, and Manning's grids as well as MSE5 rainfall distributions for each frequency event. The terrain used is high-resolution (one-meter) bare-earth lidar datasets that provide precise and comprehensive information on the topography of the study area. Soil spatial data was obtained from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey which includes an aggregate hydrologic soil group for individual soil series. Landcover data was taken from the 2016 National Land Cover Database. The soils and landcover data were then combined to determine the infiltration using the Curve Number (CN) method developed by USDA National Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS). The SCS CN method estimates the runoff as a function of the total precipitation, hydrologic soil group, and land use with an antecedent runoff condition (ARC) of II assumed as it is representative of typical conditions. In addition to the landcover being used in the infiltration, it is also a contributing factor in the determination of Manning's roughness coefficients. Manning's roughness coefficients are a numerical representation of the ease at which water flows over a surface, with the higher the value signifying a greater resistance to flow.

Hydraulic structures were added to the models based on field surveys that were conducted. Field notes consisting of structure dimensions, channel geometry, and structure material (i.e. corrugated metal pipe, concrete box culvert, etc.) were used to accurately represent the structures within the HEC-RAS models. Channel elevation data gathered during the field surveys was also utilized in estimating the reduction in channel capacity due to sedimentation.

2D HEC-RAS Rain on Mesh (RoM) modeling was used to compare and evaluate flood reduction benefits of the works of improvement. This was accomplished by completing a flood frequency study with channel improvements compared to estimated channel capacities being reduced by existing sedimentation of the drainage ditches. The flood frequency analysis was completed using the 50%, 20%, 10%, 4%, 2%, 1% and 0.2% (2yr, 5yr, 10yr, 25yr, 50yr, 100yr and 500yr respectively) frequency rainfalls on the watershed. Floodplains for each frequency event were developed to compare the floodplain extents with the project and without the project. The floodplain comparisons were then used in the economics analysis to determine the extent of flood reduction benefits. A summary of how the floodplain area changes at each rainfall frequency can be found in Table D5-1. 1% annual chance (100 yr) floodplain comparison maps are located in Appendix C.

Table D5-1. Floodplain area comparison with and without works of improvement

Flood Return Period	Floodplain Without Project Area (Acres)	Floodplain With Project Area (Acres)	Floodplain Reduction Area (Acres)
2yr	5,625.8	4,910.0	715.8
5yr	9,207.7	8,753.0	454.7
10yr	12,089.3	10,851.5	1,237.7
25yr	14,981.5	14,405.1	576.4
50yr	16,958.9	16,577.3	381.6
100yr	19,895.3	18,717.9	1,177.4
500yr	23,040.5	22,714.3	326.2

D5.4. Conceptual Plan Development

D5.4.1. Riprap Armoring

Ditch Number 1 is steeper and eroding the ditch banks more heavily. The banks and sediment deposits would be excavated and have riprap installed to improve bank stability. Details of the proposed work can be found in the Preliminary Draft Conceptual Plans (located in **Appendix C**).

D5.4.2. Native Grass Seeding

Excess bank material from the excavation would be spread out with topsoil and seeded a vegetation mix consisting predominantly of native grasses. See Table D5-2 for seeding details.

Table D5-2. Proposed Native Grass and Cover Crop Species and Seeding Application Matrix

Common Name	Scientific Name	PLS lbs per acre	% of Mixture PLS
Big Bluestem	*Andropogon gerardii*	3.000	24.64%
Indiangrass	*Sorghastrum nutans*	2.000	19.90%
Little Bluestem	*Schizachyrium scoparium*	1.250	17.13%
Switchgrass	*Panicum virgatum*	0.750	11.06%
Virginia Wildrye	*Elymus virginicus*	0.500	2.85%
Blackeyed Susan	*Rudbeckia hirta*	0.040	3.59%
False or Oxeye Sunflower	*Heliopsis helianthoides*	0.500	2.96%
Foxglove Beardstongue	*Penstemon digitalis*	0.200	4.56%
Grayhead Coneflower	*Ratibida pinnata*	0.200	4.87%
Hoary Vervain	*Verbena stricta*	0.150	5.01%
New England Aster	*Aster novae-angliae*	0.050	3.01%
Swamp Milkweed	*Asclepias incarnata*	0.050	0.44%
	Grasses Total:	7.500	75.58%
	Wildflower/Forb/Legume Total:	1.190	24.42%
	Total Mixture:	**8.690**	**100.00%**

D6.BIOLOGY

D6.1. Waters of the U.S. (Streams, Lakes, and Wetlands)

The watershed includes over 198 miles of Caney Creek, Hindman Creek, Little Caney Creek, and Old Channel Hubble Creek and their tributaries. The project area includes approximately 11,600 linear feet (LF) of five ditch reaches as identified in Table D6-1.

Table D6-1. WOTUS Features Identified in the Project Area

Feature	Type	Measure
Streams		**Linear Feet (LF) (approximate)**
Ditch Number 1	Perennial	11,200
Caney Creek	Perennial	100
Ditch Number 19A	Perennial	100
Ditch Number 20	Perennial	100
Ditch Number 15	Perennial	100
Total		**11,600**

Ditch Number 1 is a man-made ditch measuring approximately 50 feet wide with 15- to 20-foot-high banks at approximately a 2:1 slope. The bed is primarily comprised of clay, silt, sand, gravel, and riprap adjacent to previous stabilization projects. The ditch was observed to have approximately two to three feet of water and support fish, turtles, and other aquatic species. Except for the Old Caney Basin, farming occurs up to the top of the Ditch Number 1 slopes. The remaining streams (drainage ditches) in the project area are also man-made or altered with the same general characteristics of Ditch Number 1 except narrower, ranging from 10 to 25 feet wide.

Within the Whitewater River Watershed, over 1,300 acres of wetland and riverine habitat has been mapped by the National Wetland Inventory (NWI) as depicted in Table D6-2. The project area consists of Ditch Number 1 and its slopes and generally, the top of ditch slopes are 15 to 20 feet above the ordinary high water mark, disconnecting the ditches from its floodplain and providing an upland habitat. A large wetland complex in the Old Caney Basin Conservation Area was observed adjacent to the project area. However, wetlands were not observed in the project during the wetland delineation conducted by Prairie Engineers in September 2023.

Table D6-2. NWI-Mapped Wetland and Water Features in the Watershed and Project Area

NWI Mapped Feature	Watershed		Project Area	
	Number	**Acres**	**Number**	**Acres**
Freshwater Emergent Wetland	99	49	3	22
Freshwater Forested/Scrub-shrub Wetland	11	538	0	0
Freshwater Pond	473	265	0	0
Lake	3	78	0	0
Other	239	696	0	0
Riverine	200	409	7	7
Total	**786**	**1,339**	**10**	**29**

Source: USFWS 2023d.

D6.2. Threatened and Endangered Species

Both the overall Whitewater River watershed and the project area were reviewed via USFWS IPaC to obtain federally listed threatened and endangered (T&E) species that are protected under the Endangered Species Act (see Table D6-3and Table D6-4). The two queries resulted in the same species. Critical habitat for listed species was not identified in the IPaC reports. Further, state status of listed species was reviewed on MDC's *Missouri Species and Communities of Conservation Concern Checklist*. The state status of each listed species is also identified in the tables below.

Through interagency scoping for the project, MDC provided a Natural Heritage Review Report (NHRR) for the overall Whitewater River Watershed on October 2, 2023. The NHRR indicates that records of wildlife preserves; designated wilderness areas or critical habitats; and federal-listed species do not exist in the watershed, public land survey sections, or adjacent sections. MDC indicated that state-listed endangered species do not occur in the watershed; however, state-ranked species were identified near the watershed and are listed below in Table 2-2. Note that no current regulatory requirements are associated with these state-ranked species other than voluntary stewardship. The IPaC reports and NHRR are included in Appendix A.

Table D6-3. Threatened and Endangered Species Listed in the Watershed and Project Area

Scientific Name	Common Name	Federal Status	State Status
Mammals			
Myotis grisescens	gray bat	E	E
Myotis sodalis	Indiana bat	E	E
Perimyotis subflavus	tricolored bat	PE	N/A
Reptiles			
Macrochelys temminckii	alligator snapping turtle	PT	N/A
Insects			
Danaus plexippus	monarch butterfly	C	N/A

Sources: USFWS 2025 and MDC 2022.
E = endangered, T = threatened, C = candidate species; PE = proposed endangered;
PT = proposed threatened

Table D6-4. State-Ranked Species near the Watershed

Scientific Name	Common Name	State Rank	Proximity to Watershed	Primary Habitat
Mammals				
Taxidea taxus	American badger	S3	< 3 miles	grassland matrix, savanna pasture/orchard, row/close grown crops
Fish				
Erimyzan sucetta	lake chubsucker	S2	< 6 miles	rivers/streams
Notropis texanus	weed shiner	S3	< 6 miles	rivers/streams
Opsopoeodus emiliae	Pugnose minnow	S4	< 4 miles	rivers/streams
Amphibians				
Pseudacris illinoensis	Illinois chorus frog	S2	< 6 miles	grassland matrix, ephemeral pools, wet ditches
Plants				
Carex oxylepis	sharp-scale sedge	S2	< 6 miles	forest matrix

Source: MDC 2023
S2 = Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state (6 to 20 occurrences or few remaining individuals; S3 = Vulnerable in the state either because rare and uncommon, or found only in a restricted range

(even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically, 21 to 100 occurrences or between 3,000 and 10,000 individuals; SU = Currently unrankable due to a lack of information or due to substantially conflicting information about status or trends.

During the field assessment, a few scattered trees exhibiting characteristics of potentially suitable habitat for the Indiana and tricolored bats were observed in and adjacent to the project area. A significant population of common milkweed (*Asclepias syriaca*) was observed along the eastern bank of Ditch Number 1, extending from near Country Road (CR) 266 to the northern reach of Old Caney Basin. The milkweed along with an abundant and diverse population of native wildflowers was observed supporting a significant population of monarch butterflies within this reach of Ditch Number 1 levee slope. Table D6-5 lists the findings of the T&E assessment for the project area.

Table D6-5. Threatened and Endangered Species Listed in the Project Area and Study Findings

Scientific Name	Common Name	Federal Status	State Status	Findings	Potential Habitat or Population Present	Carried Forward for Analysis
Mammals						
Myotis grisescens	gray bat	E	E	Caves are not in the vicinity; therefore, this species was removed from consideration	no	no
Myotis sodalis	Indiana bat	E	E	Potentially suitable habitat for this species exists in the vicinity. The few trees that do exist in the project area exhibit evidence of potentially suitable summer roosting habitat. Trees will be avoided and if needed, conservative winter clearing will occur.	yes	yes
Perimyotis subflavus	tricolored bat	PE	N/A	Potentially suitable habitat for this species exists in the vicinity. The few trees that do exist in the project area exhibit evidence of potentially suitable summer roosting habitat. Trees will be avoided and if needed, conservative winter clearing will occur.	yes	yes

Scientific Name	Common Name	Federal Status	State Status	Findings	Potential Habitat or Population Present	Carried Forward for Analysis
Reptiles						
Macrochelys temminckii	alligator snapping turtle	PT	N/A	Suitable habitat for this species was not observed in the project area.	no	no
Insects						
Danaus plexippus	monarch butterfly	C	N/A	A significant population of monarchs and common milkweed (*Asclepias syriaca*) was observed along the eastern bank of Ditch Number 1 adjacent to Old Caney Basin Conservation Area.	yes	yes

Sources: USFWS 2023a, 2023b and MDC 2022.
E = endangered, T = threatened, C = candidate species; PE = proposed endangered;
PT = proposed threatened

D6.3. Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act

Bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (BGEPA) as well as the Migratory Bird Treaty Act (MBTA). Bald and golden eagles are both known to exist in the watershed. Other migratory birds protected under the MBTA were identified as potentially occurring in the watershed. Eagle and migratory bird species potentially occurring in the watershed as identified in the USFWS IPaC review are listed in Table D6-6. Neither bald eagle individuals nor nests were observed in the project area.

Table D6-6. Eagles and Migratory Birds Listed in the Watershed

Scientific Name	Common Name	Breeding Season
Haliaeetus leucocephalus	bald eagle	Sep 1 – Jul 31
Pluvialis dominica	American golden-plover	breeds elsewhere
Chaetura pelagica	chimney swift	breeds Mar 15 to Aug 25
Oporornis formosus	Kentucky warbler	breeds Apr 20 to Aug 20
Tringa flavipes	lesser yellowlegs	breeds elsewhere
Egretta caerulea	little blue heron	breeds Mar 10 to Oct 15
Calidris melanotos	pectoral sandpiper	breed elsewhere

Scientific Name	Common Name	Breeding Season
Protonotaria citrea	prothonotary warbler	breeds Apr – Jul 31
Melanerpes erythrocephalus	red-headed woodpecker	breads May 10 – Sep 10
Euphagus carolinus	rusty blackbird	breeds elsewhere
Elanoides forficatus	swallow-tailed kite	breeds Mar 10 – Jun 30
Hylocichla mustelina	wood thrush	breeds May 10 – Aug 31

Source: USFWS 2023a,2023b

D6.4. Vegetation

Table D6-7 lists plant species identified during biological fieldwork conducted for the project by Prairie Engineers, a partner of Conservation Works Joint Venture, in September 2023 (PEPC 2024).

Table D6-7. Vegetation Observed in the Project Area

Scientific Name	Common Name	Wetland Indicator Status (AGCP Region[1])	Native (N) or Introduced (I)
Scattered tree stands adjacent to or along edge of construction limits			
Liquidambar styraciflua	sweet gum	FAC	N
Populus deltoides	cottonwood	FAC	N
Quercus palustris	pin oak	FACW	N
Quercus phellos	willow oak	FACW	N
Taxodium distichum	bald cypress	OBL	N
Herbaceous vegetation along ditch slopes – includes scrub-shrub species and young saplings			
Amaranthus spinosus	spiny amaranth	FACU	N
Ambrosia trifida	**ragweed**	**FAC**	**N**
Andropogon gerardii	big bluestem	FAC	N
Anoda cristata	crested anoda	FAC	N
Apocynum cannabinum	Indian hemp	FACU	N
**Arundinaria gigantea*	giant cane	FACW	N
Asclepias syriaca	common milkweed	UPL	N

Scientific Name	Common Name	Wetland Indicator Status (AGCP Region[1])	Native (N) or Introduced (I)
Campsis radicans	trumpet creeper	FAC	N
Cirsium sp.	thistle	FACU	I
Desmanthus illinoensis	Illinois bundleflower	FAC	N
Fallopia scandens	**climbing false buckwheat**	**FAC**	**N**
Gleditsia triacanthos	honeylocust	FAC	N
Helianthus hirsutus	hairy sunflower	UPL	N
Humulus japonicus	Japanese hop	FAC	I
Lespedeza cuneata	**sericea lespedeza**	**FACU**	**I**
Oenothera pilosella	meadow evening primrose	FACU	N
Panicum virgatum	switchgrass	FAC	N
Paspalum pubiflorum	hairyseed paspalum	FACW	N
**Persicaria amphibia*	water smartweed	OBL	N
**Persicaria hydropiperoides*	swamp smartweed	OBL	N
**Persicaria pensylvanica*	pinkweed	FACW	N
Phalaris arundinacea	reed canarygrass	OBL	N
Rhus glabra	**smooth sumac**	**UPL**	**N**
Schizachyrium scoparium	little bluestem	FACU	N
Setaria faberi	**giant foxtail**	**UPL**	**I**
Setaria pumila	yellow foxtail	FAC	I
Solidago altissima	tall goldenrod	FACU	N
Sorghum halepense	**johnsongrass**	**FACU**	**I**
Toxicodendron radicans	poison ivy	FAC	N
Trifolium pratense	**red clover**	**FACU**	**I**
Trifolium repens	**white clover**	**FACU**	**I**

Scientific Name	Common Name	Wetland Indicator Status (AGCP Region[1])	Native (N) or Introduced (I)
Verbesina helianthoides	yellow crownbeard	UPL	N
Verbesina virginica	white crownbeard	FACU	N
Vernonia missurica	Missouri ironweed	FAC	N
**Typha latifolia*	broadleaf cattail	OBL	N

Bold text = dominant species
*Primarily found at toe of ditch slope or in erosive areas of sloughing.
[1] AGCP = Atlantic and Gulf Coastal Plain Region

D7.ECONOMICS

D7.1. General

The project economic evaluation is summarized in this section.

Economic benefits gained by implementing the preferred alternative were calculated to determine the relative benefit/cost ratio for the preferred alternative. This was accomplished by comparing the average annual benefit with the average annual costs.

The benefit cost analysis (BCA) indicated that the B/C ratio for this proposed project is estimated to be 1.3:1.0 for the proposed project life of 50 years with a net annual benefit of $24,000 as compared to the No Action Alternative. The project is expected to reasonably maximize net national economic benefits consistent with protecting the Nation's environment. This report provides an explanation of the BCA process and results.

The results of this project benefit analysis were used to determine the relative benefit/cost ratio for each project alternative by comparing the average annual benefit with the average annual costs.

The following is brief outline of the Project Benefit Analysis:

- Inventory the impact area and determine benefits and damages attributable to with and without project scenarios (described in the following text).
- Estimate costs for channel improvement measures (construction, engineering, operation and maintenance, etc.)
- Determine the flood damage reduction benefits allocated to the project.

D7.2. Determining Project Damages

Flood damage reduction benefits were calculated consistent with Principles, Requirements and Guidelines for Federal Investments in Water Resources (PR&G) and National Resources Economics Handbook (NREH) part 611 (USDA 2013).

To determine project benefits, damages occurring under both with and without channel improvement scenarios were calculated and compared.

Due to the rural nature of this project, agricultural damages were exclusively considered for consideration of project benefit. No habitable structures were identified in the project benefit/damages area.

D7.2.1. Agricultural Damages

For the agriculture evaluation, the USDA National Agricultural Statistics Service (NASS) 2024 Cropland Data Layer was downloaded. This data was used in combination with the With Project and Without Project scenario floodplains to develop agricultural grids necessary to calculate flood damage. Crops with more than 2 acres within the benefit area were evaluated. Table D7-1 provides the data used to estimate the value of lost crops. This data was compiled using the National Agricultural Statistics Service Quick Stats (*https://quickstats.nass.usda.gov/*), the University of Missouri Cooperative Extension planning budgets based on 2024 price forecasts

(*https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pub/pdf/agguides/agecon/g00653.pdf*), and local input. Table D7-2 details the single-event crop damage information for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events. The benefit shown in the last column represents the difference between With Project and Without Project implementation. Annualized damages were derived by multiplying the total damage value for each interval by the probability of recurrence and then summing the interval damages (Table D7-3).

Table D7-1. Data used to Calculate Agricultural Losses

Crop	Cost of Production (per acre)	Income (per Acre)	Market Price ($ Per Unit)	Unit	Yield (per acre)	Income over total cost (per acre)
Soybeans	$585.53	$698.50	$12.70	BU	70	$112.97
Corn (assume irrigated)	$1,214.61	$1,268.50	$5.90	BU	220	$53.89
Other Hay/Non Alfalfa	$159.60	$172.90	$133.00	ton	1.3	$13.30
Cotton	$816.33	$1,070.40	$0.80	lb	1750	$254.07
Rice	$847.99	$1,230.46	$0.15	lb	7990	$382.47

Sources used:

https://quickstats.nass.usda.gov/

https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pub/pdf/agguides/agecon/g00653.pdf

Table D7-2. Agricultural Losses per Single Event

		With Project * (Acres)	With Project Losses * (Profit and Costs)	Without Project / No Action (Acres)	Without Project / No Action Losses (Profit and Costs)	Total Benefit
2YR	Soybeans	3398	$5,010,072	3515	$5,183,526	**$527,334**
	Corn (assume irrigated)	996	$2,473,086	1140	$2,831,329	
	Other Hay/Non Alfalfa	15	$4,885	13	$4,207	
	Cotton	3	$6,397	4	$8,090	
	Rice	76	$ 158,126	73	$152,747	
5YR	Soybeans	5808	$ 8,563,775	5688	$8,386,901	**$ (104,578)**
	Corn (assume irrigated)	2073	$5,146,390	2103	$5,223,125	
	Other Hay/Non Alfalfa	38	$12,776	31	$10,264	
	Cotton	8	$14,805	8	$15,209	
	Rice	91	$188,211	89	$185,879	
10YR	Soybeans	7295	$10,756,216	7491	$11,045,524	**$193,155**
	Corn (assume irrigated)	2914	$7,234,780	2873	$7,133,854	
	Other Hay/Non Alfalfa	63	$20,844	58	$19,405	
	Cotton	9	$17,570	9	$7,583	
	Rice	100	$207,409	103	$213,607	
25YR	Soybeans	8926	$13,161,386	9223	$13,599,680	**$420,074**
	Corn (assume irrigated)	3716	$9,226,648	3707	$9,203,752	
	Other Hay/Non Alfalfa	73	$24,302	71	$23,751	
	Cotton	12	$21,970	12	$22,813	
	Rice	115	$238,168	117	$242,552	
50YR	Soybeans	10153	$14,970,430	10282	$15,160,673	**$259,598**
	Corn (assume irrigated)	4301	$10,680,769	4331	$10,754,238	
	Other Hay/Non Alfalfa	79	$26,418	79	$26,153	
	Cotton	14	$25,698	14	$25,674	
	Rice	126	$260,966	124	$257,141	
100YR	Soybeans	11059	$16,306,264	11593	$17,093,493	**$1,852,857**
	Corn (assume irrigated)	5126	$12,727,297	5546	$13,771,387	
	Other Hay/Non Alfalfa	86	$28,530	85	$28,402	
	Cotton	17	$32,493	19	$35,738	
	Rice	180	$373,359	188	$391,779	
500YR	Soybeans	13019	$19,196,640	13170	$19,418,954	**$303,158**
	Corn (assume irrigated)	6487	$16,107,206	6519	$16,188,518	
	Other Hay/Non Alfalfa	101	$33,570	100	$33,277	
	Cotton	26	$48,561	26	$48,980	
	Rice	202	$419,086	201	$418,492	

*Flood damages are equivalent for Alternatives 2-5 and therefore referred to as “With Project”

Table D7-3. Agricultural Annual Flood Damage Calculations (With & Without Project)

Agricultural Flood Damage Estimate - With Project						
Flood Return Interval	**Probability**	**Probability Interval**	**Damages per Single Event ($)**	**Damages ($)**	**Interval Damage Calculation ($)**	**Summation of Expected Annual Damages ($)**
2-YR	0.5		$7,652,565			
		0.3		$10,789,379	$3,236,814	$3,236,814
5-YR	0.2		$13,926,193			
		0.1		$16,081,624	$1,608,162	$4,844,976
10-YR	0.1		$18,237,055			
		0.06		$20,454,882	$1,227,293	$6,072,269
25-YR	0.04		$22,672,710			
		0.02		$24,318,613	$486,372	$6,558,641
50-YR	0.02		$25,964,517			
		0.01		$27,716,347	$277,163	$6,835,805
100-YR	0.01		$29,468,178			
		0.008		$32,636,738	$261,094	**$7,096,899**
500-YR	0.002		$35,805,298			

Agricultural Flood Damage Estimate - Without Project/No Action						
Return Interval	**Probability**	**Probability Interval**	**Damages per Single Event ($)**	**Interval Average Damages ($)**	**Interval Damage Calculation ($)**	**Summation of Expected Annual Damages ($)**
2-YR	0.5		$8,179,899			
		0.3		$11,000,757	$3,300,227	$3,300,227
5-YR	0.2		$13,821,614			
		0.1		$16,125,912	$1,612,591	$4,912,818
10-YR	0.1		$18,430,209			
		0.06		$20,761,497	$1,245,690	$6,158,508
25-YR	0.04		$23,092,784			
		0.02		$24,658,449	$493,169	$6,651,677
50-YR	0.02		$26,224,115			
		0.01		$28,772,575	$287,726	$6,939,403
100-YR	0.01		$31,321,035			
		0.008		$33,714,746	$269,718	**$7,209,121**
500-YR	0.002		$36,108,456			

Table D7-4. Annual Damages and Benefits [1]

SCENARIO	Est. Annual Flood Damage	Est. Annual Damage Benefit [2]
Without Project / No Action	$7,209,000	-
Alternative 2	$7,097,000	$112,000
Alternative 3	$7,097,000	$112,000
Alternative 4	$7,097,000	$112,000
Alternative 5	$7,097,000	$112,000
Analysis Period:	50 years	
Discount Rate:	0.0275 (National Bulletin 200-23-2)	

[1] Price Base 2024

[2] Difference between damages occurring under each alternative minus the damages occurring under No Action.

D7.3. Benefit-Cost Analysis

Following the calculation and annualization of damages for each alternative, construction cost estimates, project administration costs, and operation and maintenance costs were incorporated into a comprehensive benefit-cost analysis (BCA) for the proposed 50-year project life. This analysis evaluates each alternative by comparing its total benefits to its total costs. While a Benefit-Cost Ratio (BCR) of 1.0 or greater generally indicates that an alternative is cost-effective, it is important to note that BCRs alone do not determine the relative cost-efficiency among alternatives. Other factors—such as feasibility, environmental impact, and alignment with project objectives—must also be considered. For example, the Preferred Alternative 4 (With Project – Half Bank with Rock Bedding) has a BCR of 1.3, indicating it is cost-effective and provides greater net benefits than the other alternatives analyzed. See Table D7-5 for detailed results of the analysis.

Table D7-5. Benefit/Cost Ratio [1]

SCENARIO	Est. Annual Flood Damage	Est. Annual Damage Benefit	Average Annual Costs	**B/C Ratio (50 Year)**
Without Project	$7,209,000	-	-	-
Alternative 2	$7,097,000	$112,000	$125,400	0.9
Alternative 3	$7,097,000	$112,000	$180,400	0.6
Alternative 4	$7,097,000	$112,000	$88,000	1.3
Alternative 5	$7,097,000	$112,000	$130,000	0.9
Analysis Period:	50 years			
Discount Rate:	0.0275 (National Bulletin 200-23-2)			

[1] Price Base 2024

D7.4. Alternative Cost Estimates

The Project Team prepared predictions of probable costs for all alternatives. The predictions of probable costs are intended for comparing the alternatives. Unless otherwise noted, predictions of probable costs were prepared using the RS Means method for engineering cost estimation. Table D7-6 summarizes the raw Project Alternative Cost Estimates. All costs will be rounded to the nearest $100 for subsequent analyses in this study. Engineering cost estimates for each alternative are provided in Section D.7.6.

Table D7-6. Project Alternative Cost Estimates (Whitewater River Watershed)

ITEM	Project Alternatives [1]					
	No Action/Future Without Federal Investment [2]	**Alt 2 - Option 1 Full Bank**	**Alt 3 - Option 2 Full Bank**	**Alt 4 - Option 1 Half Bank**	**Alt 5 - Option 2 Half Bank**	**Alt 6 - Non-Structural – Buyouts[3]**
Total Construction Cost	-	$ 2,578,100	$ 3,786,100	$ 1,742,100	$ 2,665,500	
NRCS - Construction	-	$ 2,578,100	$ 3,786,100	$ 1,742,100	$ 2,665,500	
Sponsor - Construction	-	-	-	-	-	
NRCS - Easements	-	-	-	-	-	$ 86,250,000
Sponsor - Easements						$ 28,750,000
NRCS - Project Design, Construction Engineering	-	$ 515,600	$ 757,200	$ 348,400	$ 533,100	
Sponsor - Project Design, Construction Engineering	-	-	-	-	-	
NRCS - Project Administration	-	$ 128,900	$ 189,300	$ 87,100	$ 133,300	$ 4,312,500
Sponsor - Project Administration	-	-	-	-	-	$ 1,437,500
Federal, State and Local Permits	-	$ 10,000	$ 10,000	$ 10,000	$ 10,000	
Total Installation Cost	$ 30,700 [2]	$ 3,232,600	$ 4,742,600	$ 2,187,600	$ 3,341,900	$ 120,750,000

[1] Price base 2024

[2] All costs are Average Annual Costs. No installation costs are associated with this alternative.

[3] Assumes 75%/25% cost share for floodplain conservation easement (share determined by State Conservationist based on comparison with other federal programs.)

D7.5. Comparative Cost Analysis

A comparative cost analysis was completed for alternative plans carried forward for detailed study, which is shown in Table D7-7. Cost items include:

- Construction-related activities such as mobilization, clearing and grubbing, erosion and sediment control, site work, earthwork, fencing, and seeding.
- Engineering activities such as completing design, surveys, construction observations, and Project administration.

Table D7-7. Comparative Cost Analysis of Alternative Plans

ITEM	Project Alternative [1]					
	No Action/Future Without Federal Investment [3]	Alt 2 - Option 1 Full Bank	Alt 3 - Option 2 Full Bank	Alt 4 - Option 1 Half Bank	Alt 5 - Option 2 Half Bank	Alt 6 - Non-Structural – Buyouts [3]
Total Investment	$ -	$ 3,232,600	$ 4,742,600	$ 2,187,600	$ 3,341,900	$ 120,750,000
P.L. 83-566 Funds	$ -	$ 3,222,600	$ 4,732,600	$ 2,177,600	$ 3,331,900	$ 90,562,500
Other Funds	$ -	$ 10,000	$ 10,000	$ 10,000	$ 2,187,000	$ 30,187,500
Average Annual Benefits [2]	$ -	$ 112,000	$ 112,000	$ 112,000	$ 112,000	$ 7,209,000
Average Annual Costs [2]	$ 30,700	$ 125,400	$ 180,400	$ 88,000	$ 130,000	$ 4,400,200
Net Beneficial	$ -	$ (13,400)	$ (68,400)	$ 24,000	$ (18,000)	$ 2,808,800
Average Annual O&M Costs	$ 30,700	$ 7,400	$ 7,400	$ 8,000	$ 8,000	$ 8,000

[1] Price Base 2024
[2] Amortized over 50 years at a discount rate of 2.75 percent. Amortization includes Average Annual O&M Costs in presented in table.
[3] All costs are Average Annual Costs for FWOFI. No construction costs are associated with this alternative.

D7.5.1. Alternative 1 FWOFI Cost

Table D7-8 presents the estimated Annual Operation and Maintenance costs for the Future Without Federal Investment Alternative 1.

Table D7-8. Estimated Annual Cost – FWOFI

Line	Item	Quantity	Unit	Unit Cost	Total *	Notes
1	Hydraulic Mowing (3-Year Cycle)	15	AC	$150	$750	Total of 15 acres mowed on a 3-year cycle
2	Spray Wood Vegetation (3-Year Cycle)	15	AC	$85	$425	Total of 15 acres sprayed on a 3-year cycle
3	Sediment Removal (5-10 Year Cycle)	0.3	MI	$85,000	$25,500	Total of 2 miles cleaned every 8 years
		Total Annual Cost (includes 15% contingency):			**$30,676**	

*** All Costs are Annual Costs**

D7.5.2. Alternative 2 Installation Cost

Table D7-9 presents the estimated installation costs for Alternative 2.

Table D7-9. Estimated Installation Cost – Alternative 2

Line	Item	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$50,000	$50,000
2	Riprap	94060	TN	$20.00	$1,881,208
3	Excess Earthwork	148000	CY	$0.77	$113,960
4	Rock Bedding	12587	TN	$20.00	$251,748
5	Erosion Matting, TRM	0	SY	$2.00	$-
6	Seeding	24	AC	$100.00	$2,400
				Subtotal 1 :	**$2,299,316**
			Erosion and Sediment Control :	5%	$114,966
			Dewatering :	5%	$114,966
			Construction Contingency :	15%	$344,897
				Subtotal 2 :	**$2,874,145**
			2024 RS Means Location Factor (Sikeston, MO)	0.897	$2,578,108
				Subtotal 3 :	**$2,578,108**
			Permitting :		$10,000
			Easement Acquisition (Construction Easements) :		-
				Subtotal 4 :	**$2,588,108**
			Project Design, Construction Engineering, Contracting, Inspection :	*20% of subtotal 3*	$515,622
			Project Administration :	*5% of Subtotal 3*	$128,905
				Total :	**$3,232,635**

D7.5.3. Alternative 3 Installation Cost

Table D7-10 presents the estimated installation costs for Alternative 3.

Table D7-10. Estimated Installation Cost – Alternative 3

Line	Item	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$50,000	$50,000
2	Riprap	160,516	TN	$20.00	$3,210,312
3	Excess Earthwork	148,000	CY	$0.77	$113,960
4	Rock Bedding	0	TN	$20.00	$ -
5	Erosion Matting, TRM	0	SY	$2.00	$ -
6	Seeding	24	AC	$100.00	$2,400
				Subtotal 1 :	**$3,376,672**
			Erosion and Sediment Control :	5%	$168,834
			Dewatering :	5%	$168,834
			Construction Contingency :	15%	$506,501
				Subtotal 2 :	**$4,220,840**
			2024 RS Means Location Factor (Sikeston, MO)	0.897	$3,786,093
				Subtotal 3 :	**$3,786,093**
			Permitting :		$10,000
			Easement Acquisition (Construction Easements) :		-
				Subtotal 4 :	**$3,796,093**
			Project Design, Construction Engineering, Contracting, Inspection :	20% *of subtotal 3*	$757,219
			Project Administration :	5% *of subtotal 3*	$189,305
				Total :	**$4,742,617**

D7.5.4. Alternative 4 Installation Cost

Table D7-11 presents the estimated installation costs for Alternative 4.

Table D7-11. Estimated Installation Cost – Alternative 4

Line	Item	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$50,000	$50,000
2	Riprap	59980	TN	$20.00	$1,199,604
3	Excess Earthwork	148000	CY	$0.77	$113,960
4	Rock Bedding	8236	TN	$20.00	$164,724
5	Erosion Matting, TRM	11100	SY	$2.00	$22,200
6	Seeding	32	AC	$100.00	$3,200
				Subtotal 1 :	**$1,553,688**
			Erosion and Sediment Control :	5%	$77,684
			Dewatering :	5%	$77,684
			Construction Contingency :	15%	$233,053
				Subtotal 2 :	**$1,942,110**
			2024 RS Means Location Factor (Sikeston, MO)	0.897	$1,742,073
				Subtotal 3 :	**$1,742,073**
			Permitting :		$10,000
			Easement Acquisition (Construction Easements) :		-
				Subtotal 4 :	**$1,752,073**
			Project Design, Construction Engineering, Contracting, Inspection :	20% *of subtotal 3*	$348,415
			Project Administration :	5% *of subtotal 3*	$87,104
				Total :	**$2,187,591**

D7.5.5. Alternative 5 Installation Cost

Table D7-12 presents the estimated installation costs for Alternative 5.

Table D7-12. Estimated Installation Cost – Alternative 5

Line	Item	Quantity	Unit	Unit Cost	Total
1	Mobilization	1	LS	$50,000	$50,000
2	Riprap	109396	TN	$20.00	$2,187,920
3	Excess Earthwork	148000	CY	$0.77	$113,960
4	Rock Bedding	0	TN	$20.00	$-
5	Erosion Matting, TRM	11100	SY	$2.00	$22,200
6	Seeding	32	AC	$100.00	$3,200
				Subtotal 1 :	**$2,377,280**
			Erosion and Sediment Control :	5%	$118,864
			Dewatering :	5%	$118,864
			Construction Contingency :	15%	$356,592
				Subtotal 2 :	**$2,971,600**
			2024 RS Means Location Factor (Sikeston, MO)	0.897	$2,665,525
				Subtotal 3 :	**$2,665,525**
			Permitting :		$10,000
			Easement Acquisition (Construction Easements) :		-
				Subtotal 4 :	**$2,675,525**
			Project Design, Construction Engineering, Contracting, Inspection :	20% *of subtotal 3*	$533,105
			Project Administration :	5% *of subtotal 3*	$133,276
				Total :	**$3,341,907**

D7.5.6. Alternative 6 Non-Structural Buyouts Cost

Table D7-13 presents the estimated installation costs for Alternative 6.

Table D7-13. Estimated Non-Structural Buyouts Cost – Alternative 6

Line	Item	Quantity	Unit	Unit Cost	Total
1	Transfer of 100-Year Floodplain Area into floodplain conservation easement	20,000	Acres	$5,000	$100,000,000
				Subtotal 1 :	**$100,000,000**
				Construction Contingency : 15%	$15,000,000
				Subtotal 2 :	**$115,000,000**
				Project Administration : 5%	$5,750,000
				Total :	**$120,750,000**

D8.HUMAN ENVIRONMENT

D8.1. Socioeconomic Issues

The U.S. Census Bureau (USCB) American Community Survey (ACS) was reviewed for demographic information for the state, counties, and municipalities within the watershed. Table D8-1 and Table D8-2 summarize the region's median age, number of households, per capita income, median household income, and the percentage of the population living below the poverty line. Data is provided by the USCB ACS estimates for years 2015 through 2019. Based on the USCB data, Cape Girardeau County has over twice the population compared to Scott County; slightly lower per capita income than the state average; and is in line with state averages for median household income and person below the poverty line. However, the population of Scott County has a significantly lower average median household income than the state average and more persons living below the poverty line than the state average or Cape Girardeau County.

Table D8-1. Household Age and Income; Persons Below Poverty Line

Geography	Population	Median Age	Number of Households	Per Capita Income	Median Household Income	Persons Below Poverty Line
State of Missouri	6,154,913	39.2	2,468,726	$34,593	$61,847	12.7%
Cape Girardeau County	82,113	36.7	32,800	$31,113	$61,330	12.1%
Scott County	38,161	39.6	15,001	$27,221	$50,556	16.4%
Chaffee	1,071	39.3	1,071	$23,989	$42,113	14.2%
Benton	866	38.2	332	$26,899	$57,679	14.5%
New Hamburg*	131	23.2	131	$25,563	Not available	1.2%
Delta	376	44.2	142	$17,848	$32,917	18.5%

Source: U.S. Census Bureau, 2015-2019 American Community Survey 5-Year Estimates.
* 2015-2019 5-Year Estimates not available for New Hamburg; 2016-2020 Estimates used.

Table D8-2. Per Capita and Median Household Income (MHI)

Geography	Per Capita Income	MHI	MHI < $50,000	MHI $50,000-$100,000	MHI $100,000-$200,000	MHI > $200,000
State of Missouri	$34,593	$61,847	40.7%	31.7%	21.3%	6.4%
Cape Girardeau County	$31,113	$61,330	41.7%	32.2%	21.5%	4.6%
Scott County	$27,221	$50,556	49.6%	31.5%	15.9%	3.0%
Chaffee	$23,989	$42,113	58.0%	33.5%	7.3%	1.2%
Benton	$26,899	$57,679	42.1%	33.5%	20.5%	3.9%
New Hamburg*	$25,563	Not available	51.9%	3.1%	45.0%	0.0%
Delta	$17,848	$32,917	68.4%	23.9%	7.7%	0.0%

Source: U.S. Census Bureau, 2015-2019 American Community Survey 5-Year Estimates.
* 2015-2019 5-Year Estimates not available for New Hamburg; 2016-2020 Estimates used.

Regarding educational attainment, Cape Girardeau County exceeds the state average for individuals possessing a higher education; however, Scott County has a significantly less educated population than state averages (see Table D8-3).

Table D8-3. Educational Attainment

Geography	Population	High School Diploma or Higher	Bachelor's Degree or Higher
State of Missouri	6,154,913	91.6%	31.7%
Cape Girardeau County	82,113	91.3%	33.3%
Scott County	38,161	85.6%	20.3%
Chaffee	1,071	38.4%	5.8%
Benton	866	30.0%	13.9%
New Hamburg*	131	28.5%	24.1%
Delta	376	55.6%	6.9%

Source: U.S. Census Bureau, 2015-2019 American Community Survey 5-Year Estimates.
* 2015-2019 5-Year Estimates not available for New Hamburg; 2016-2020 Estimates used.

Regarding housing, owner-occupied housing in Cape Girardeau is in line with the state average and Scott County has a slightly lower percentage of owner-occupied housing than the state average (see Table D8-4).

Table D8-4. Occupied Housing Units by Tenure

Geography	Households	Owner Occupied	Renter Occupied
State of Missouri	2,468,726	68.8%	31.2%
Cape Girardeau County	32,800	68.8%	31.2%
Scott County	15,001	66.5%	33.5%
Chaffee	1,071	62.7%	37.3%
Benton	332	70.2%	29.8%
New Hamburg*	131	73.3%	26.7%
Delta	142	70.4%	29.6%

Source: U.S. Census Bureau, 2015-2019 American Community Survey 5-Year Estimates.
* 2015-2019 5-Year Estimates not available for New Hamburg; 2016-2020 Estimates used.

Regarding race in the watershed, the area is predominantly white with little diversity (see Table D8-5).

Table D8-5. Racial and Ethnic Composition

Geography	Population	White	Black	Hispanic	Other
State of Missouri	6,154,913	4,740,335	699,840	281,445	433,293
Cape Girardeau County	82,113	67,937	6,503	2,234	5,439
Scott County	38,161	30,595	4,476	935	2,155
Chaffee	3,057	2,784	27	61	185
Benton	866	772	31	0	63
New Hamburg	217	209	0	1	7
Delta	376	354	0	2	20

Source: U.S. Census Bureau, 2020 DEC Redistricting Data (PL 94-171).

Regarding age in the watershed, generally the median age of the population in the watershed is in line with state averages; however, Cape Girardeau County has a slightly younger population than the state or Scott County (see Table D8-6).

Table D8-6. Age Distribution

Geography	Median Age	Under 18 Years	18 Years and Over	65 Years or Over
State of Missouri	39.2	22.7%	77.3%	16.8%
Cape Girardeau County	36.7	21.4%	78.6%	17.2%
Scott County	39.6	24.2%	75.8%	18.2%
Chaffee	39.3	24.2%	75.8%	14.6%
Benton	38.2	21.8%	78.2%	13.0%
New Hamburg*	23.2	45.2%	54.8%	8.2%
Delta	44.2	20.1%	78.7%	26.7%

Source: U.S. Census Bureau, 2015-2019 American Community Survey 5-Year Estimates.
* 2015-2019 5-Year Estimates not available for New Hamburg; 2016-2020 Estimates used.

In summary, while the Cape Girardeau County population characteristics are generally in line with state demographic averages, Scott County is significantly less populated, affluent, and educated as neighboring Cape Girardeau County or the state of Missouri.

D9.CULTURAL RESOURCES

D9.1. Cultural Resources Survey

D9.1.1. Survey Methodology

The project methods follow the MO SHPO's Guidelines for Phase I Archaeological Surveys and Reports. Areas within the APE exhibiting greater than 25 percent ground surface visibility, greater than 20 percent slope, that were wet and/or inundated, that were protected wetlands, or that were obviously disturbed were pedestrian surveyed at no more than 5-m (16.4-ft) interval transect. Mapping for the project was completed using a handheld GPS unit capable of sub-meter accuracy. Detailed notes were maintained daily regarding the areas surveyed, methods employed within sections of the project area, and environmental conditions within the project area.

Architecture fieldwork entailed inspection and documentation of aboveground structures over 50 years of age within the architectural survey areas. The architectural APE extended 2.09 miles along the original Headwater Division Channel "Ditch No. 1." Ditch No. 1 is the longest channel within the Little River Drainage District, extending approximately 98 miles. Fieldwork included written and photographic documentation of resources to determine the architectural and historic details of each historic property. Aboveground resources recorded in the field were given individual Architectural Resource (AR) numbers. In addition to the MO SHPO literature review, detailed archival research was also conducted. Archival research, which included local histories, atlases, historic maps, aerial photographs, and other pertinent information, were researched to identify specifications of existing resources and to gain a better understanding of the history and development of the project. This research was used to help determine a variety of attributes such as date of construction, when alterations may have occurred, as well as materials.

D9.1.2. Phase I Cultural Resource Survey

A Phase I Archaeological Survey was completed to locate, identify, and record all archaeological resources within the project area on December 14, 2023. The APE is defined as an approximately 3,370-linear meter (11,056 feet / 2.09 miles) section of the drainage ditch. The width of survey was 30 meters (98.4 feet) from center of the ditch, totaling 50 acres in size. Due to excellent surface visibility, or where the ground slope was greater than 20 percent, the APE was systematically pedestrian surveyed. The architectural survey area consisted of a rural agricultural landscape. The architectural survey APE consisted of the aforementioned 2.09-mile-long segment of the original Ditch No. 1.

D9.1.3. Background Research

Historic maps were reviewed to gain insight into the historic land use of the area and to investigate the presence of historic structures. The 1930 W. W. Hixson & Co. Plat of Scott County, Missouri; the 1934 USGS Morley, Missouri 15-minute series topographic map; and the 1963 USGS Chaffee and Oran, Missouri 7.5-minute series topographic maps were reviewed for the presence of historic structures or cultural features. The 1930 plat map shows the land parcels within the vicinity of the APE and lists the names of the landowners circa 1930. The 1934 topographic map depicts nineteen structures to the east, west, southeast, and southwest of and outside the current APE. It also shows

a swamp area where Caney Creek now drains north to south, called Old Caney Basin. Many of these residences disappear or have been demolished in the 1963 topographic map.

D9.1.4. Previous Surveys

No previously conducted surveys occur within or adjacent to the APE. Likewise, no previous surveys have been conducted within a one-mile (1.61 km) buffer of the APE.

D9.1.5. Previously Recorded Archaeological Sites

No previously recorded sites occur within or adjacent to the APE. Likewise, no sites have been recorded within a one-mile (1.61 km) buffer of the APE.

D9.1.6. Results of Archaeological Fieldwork

The APE covers approximately 3,370 linear meters (11,056 feet / 2.09 miles) along the drainage ditch, which is located in agricultural fields, partially wooded areas, and wetlands. The width of the APE measures 30 meters (98.4 feet) on either side from center of the ditch. Vegetation consisted of wetland grasses, mixed deciduous trees with varying levels of underbrush, tall grass, and bare or harvested agricultural fields. Ground surface visibility varied from 25 to 100 percent, depending on location. Portions of the APE that were in agricultural fields predominantly had a high degree of surface visibility (80 to 100 percent), while one field still contained plant material from the previous harvest resulting in a lower surface visibility (40 to 50 percent). The APE was investigated completely by pedestrian survey in 5-meter transects. During the survey, no sites or cultural materials were identified.

Architectural Resource-1 (AR-1) is a segment of the original Ditch No. 1. Ditch No. 1 is the longest channel within the Little River Drainage District, extending approximately 98 miles. AR-1 is located along the southernmost stretch of the drainage system's Southern District. Although the exact construction date of the ditch segment associated with AR-1 is unknown, it was likely built between 1914 and 1920 based on archival research and historic mapping. Construction of Ditch No. 1 began in 1914, in Cape Girardeau County, then extending southeast into Scott County. As such, the Scott County portion that includes AR-1 would have been the last section to be completed.

D9.1.7. Summary

The APE was investigated completely by pedestrian survey. It exhibited over 25 percent surface visibility or greater than 20 percent slope and was surveyed at 5-m intervals. The APE was also photographed at varying intervals, depending on accessibility. During the survey, no new archaeological sites or cultural materials were identified or recovered. NRCS recommends no further archaeological work.

A total of one resource over 50 years of age and older was identified within the architectural survey area. This resource, a man-made earthen ditch designated AR-1, dates from between 1914 and 1920 based on archival research and historic map review. AR-1 was determined eligible due to a direct and significant association with the development of southeastern Missouri, flood control, land reclamation, as well as the tremendous engineering efforts and architectural designs,

spearheaded by Otto Kochtitzky that made these goals possible. Moreover, this resource has retained much of its material integrity.

While there are proposed changes to the NRHP eligible ditch system, the alterations are consistent with upgrades and continued improvements to the drainage ditches that do not change its historic integrity of location, association, setting, material, and feeling. Nor does it change the historic function from which the Little River Drainage Ditch No. 1 gains its historic significance. The planned rehabilitation design will continue to generally maintain the current look and style of the existing elements. As such, NRCS determined that there would be no adverse effect to the system. No further work is recommended for this resource.