



Appendix D. Investigations and Analyses Report

Watershed Plan

for the

**West Ditch – Main Ditch Subwatershed
Stoddard County, Missouri**

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D1. INTRODUCTION

This Investigations and Analyses Report provides relevant resource research, investigation, and analysis details for the West Ditch – Main Ditch Subwatershed, proposed actions, and proposed alternatives. The information contained in this appendix supplements the analyses presented in the Plan (Plan) and provides detailed documentation to support planning decisions and conclusions.

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 its 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, including monetary and non-monetary effects and allow for the consideration of both quantified and unquantified measures (USDA 2017).

D2. LAND USE

Land use and land cover within the Subwatershed and Project Area were characterized using a combination of recent and historical aerial imagery, the U.S. Geological Survey (USGS) National Land Cover Database (NLCD) (USGS 2023), and field observations. Agricultural land use including cultivated crops, hay/pasture, and grassland/herbaceous cover, dominates the Subwatershed and accounts for approximately 87 percent of total land cover (**Table D2-1**). Developed land represents the second most prevalent land cover type at approximately nine percent, primarily associated with the communities of Dexter and Malden, Missouri.

The proposed Project Area encompasses the drainage ditch system of the West Ditch–Main Ditch Subwatershed, including West Ditch – Main Ditch, East Lateral Nos. 1 and 2, DD Walker Lateral, West Lateral, Garner Lateral, and Tuttle Lateral. A buffer extending outward from the top of bank, typically approximately 200 feet (ft), surrounds much of this system. Portions of this buffer are actively farmed; however, much of the riparian corridor along the ditches is dominated by herbaceous vegetation. Scattered trees and small forested stands occur intermittently along the Project corridor, although these areas generally lie outside the herbaceous riparian zone. Larger forested tracts are present adjacent to the Project Area within managed conservation lands. Ditch banks throughout the Project Area are primarily vegetated with herbaceous and scrub-shrub communities (see Section 6 for observed vegetation). The subwatershed has been dominated by row-crop agriculture for generations and is anticipated to remain in agricultural use.

Table D2-1. Land Cover in the Subwatershed and Project Area

Land Cover Classification	Subwatershed		Project Area	
	Acres	Percent	Acres	Percent
Cultivated Crops	14,800	83.9	241	71.0
Developed, all intensities combined	1,768	9.9	100	28.5
Developed, Low Intensity	908	5.1	67	19
Developed, Open Space	698	3.9	33	9.5
Developed, Medium Intensity	142	1.0	0	0.0
Developed, High Intensity	20	0.1	0	0.0
Hay/Pasture	581	3.3	0	0.0
Deciduous Forest	395	2.2	0	0.0
Woody Wetlands	35	0.2	1	0.5
Mixed Forest	32	0.18	0	0.0
Open Water	16	0.09	0	0.0
Emergent Herbaceous Wetlands	4	0.02	0	0.0
Total	17,631	100	341	100.0

Source: USGS NLCD 2023.

Farming is the primary land use throughout the Subwatershed. **Table D2-2** summarizes the number of farms and average farm-related income in Stoddard County. Soybeans represent the top agricultural commodity in the County. Farms within the Missouri Bootheel Region are generally larger than the statewide average and tend to generate higher per farm income, reflecting the region's emphasis on large-scale row-crop production.



***Table D2-2. Number of Farms and Average Farm-related Income per Farm by County,
(Census of Agriculture 2022)***

County	Number	Farm-Related Income	Top Commodity
Stoddard	637	\$31,029	Soybeans

Source: NASS 2022.

D3. SOILS

Soils information for the watershed and Project Area was obtained from USDA NRCS Web Soil Survey. The soils in the Subwatershed and Project Area are predominantly loamy or clayey in texture and reflect long-term agricultural use supported by artificial drainage. **Table D3-3** describes the soil map units present, their relative proportions within the Subwatershed and Project Area, associated drainage class, and hydrologic soil groups (HSGs).

D3.1. Drainage Class and Hydrologic Soil Group

Soils in the Subwatershed range from poorly drained to well drained, whereas soils within the Project Area are predominantly classified as poorly drained to somewhat poorly drained. Drainage class describes the frequency and duration of wet periods in the soil profile under natural conditions similar to those under which the soils formed. The seven drainage classes are excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. Definitions of applicable drainage classes are provided in **Table D3-1**.

Table D3-1. Drainage Classes Definitions (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.

Hydrologic Soil Groups describe the relative infiltration capacity of soils when thoroughly wetted and are a key indicator of runoff potential. Within the Subwatershed and Project Area, soils classified as dual HSG B/D are dominant, comprising approximately 37 percent and 56 percent of the total area, respectively. These soils typically exhibit moderate infiltration rates under drained conditions but very slow permeability when undrained, reflecting shallow water tables and low saturated hydraulic conductivity common in low-lying agricultural landscapes. These characteristics necessitate reliance on surface and subsurface drainage systems to support crop production. As a result, agricultural productivity in the area is highly dependent on effective surface and subsurface drainage systems.

Soils classified as HSG C/D represent an additional approximately 37 percent of the Project Area and similarly exhibit restricted infiltration under undrained conditions. These soils have slow permeability and a high runoff potential when saturated, further contributing to surface ponding, prolonged soil saturation, and increased reliance on engineered drainage infrastructure to maintain field access and crop viability.

Overall, hydrologic soil conditions within the Subwatershed and Project Area reflect a mixed drainage landscape characterized by variable permeability, shallow groundwater conditions, and extensive artificial drainage. These soil properties strongly influence surface runoff, infiltration, and water management challenges and are a key factor in the erosion, sedimentation, and floodplain processes addressed by the proposed Project.

Table D3-2 defines the HSGs. Where soils are assigned to a dual group (e.g., B/D or C/D), the first letter represents the soil condition when artificially drained, and the second letter represents the undrained condition.

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

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

Map Unit Name	Subwatershed		Project Area		Drainage Class	HSG
	Acres	Percent	Acres	Percent		
Lilbourn fine sandy loam, 0 to 1 percent slopes, rarely flooded	4,626.0	26.2	138.7	40.6	Somewhat Poorly Drained	B/D
Tuckerman fine sandy loam, 0 to 1 percent slopes, rarely flooded	1,637	9.3	97.9	28.7	Poorly Drained	C/D
Dubbs silt loam, 1 to 5 percent slopes	1,332.9	7.6	0	0.0	Well Drained	B
Canalou loamy sand, 0 to 1 percent slopes, rarely flooded	1,044.5	5.9	8.8	2.6	Moderately Well Drained	A
Dundee loam, 0 to 1 percent slopes, rarely flooded	995.3	5.6	23.7	6.9	Somewhat Poorly Drained	C/D
Falaya silt loam, 0 to 3 percent slopes	915	5.2	3.4	1.0	Somewhat Poorly Drained	B/D
Broseley loamy fine sand, 0 to 5 percent slopes	851.2	4.8	0	0.0	Well Drained	B
Malden loamy sand, 1 to 5 percent slopes	814.1	4.6	0	0.0	Excessively Drained	A
Overcup silt loam, 0 to 1 percent slopes, rarely flooded	751.4	4.3	14.2	4.2	Poorly Drained	D
Gideon loam, 0 to 1 percent slopes, occasionally flooded	670.5	3.8	32.8	9.6	Poorly Drained	B/D
Farrenburg fine sandy loam, 0 to 1 percent slopes, rarely flooded	576.1	3.3	0.3	0.1	Moderately Well Drained	C
Bosket fine sandy loam, 1 to 5 percent slopes, eroded	460.7	2.6	0	0.0	Well Drained	B
Eustis-Memphis complex, 15 to 35 percent slopes	418.5	2.4	0	0.0	Somewhat Excessively Drained	A
Loring silt loam, 3 to 8 percent slopes, west, upland phase	380.5	2.2	0	0.0	Moderately Well Drained	C
Loring silt loam, 3 to 8 percent slopes, severely eroded	307.0	1.7	0	0.0	Moderately Well Drained	C



Map Unit Name	Subwatershed		Project Area		Drainage Class	HSG
	Acres	Percent	Acres	Percent		
Malden fine sand, 1 to 5 percent slopes	305.7	1.7	0	0.0	Excessively Drained	A
Sikeston loam, 0 to 1 percent slopes, occasionally flooded	255.2	1.4	16.1	4.7	Poorly Drained	B/D
Amagon silt loam, 0 to 1 percent slopes, rarely flooded	208	1.2	1.4	0.2	Poorly Drained	C/D
Loring silt loam, 3 to 8 percent slopes, eroded	164.6	0.9	0	0.0	Moderately Well Drained	C
Loring silt loam, 8 to 15 percent slopes, severely eroded	152.2	0.9	0	0.0	Moderately Well Drained	C
Loring silt loam, 1 to 5 percent slopes	117.8	0.7	0	0.0	Moderately Well Drained	C
Forestdale silty clay loam, 0 to 1 percent slopes, occasionally flooded	110.7	0.6	1.8	0.5	Poorly Drained	C/D
Commerce silt loam, 0 to 1 percent slopes, rarely flooded	94	0.5	1.9	0.6	Somewhat Poorly Drained	C/D
Lilbourn fine sandy loam, 0 to 3 percent slopes	68.5	0.4	0	0.0	Somewhat Poorly Drained	B/D
Canalou loamy sand, 0 to 3 percent slopes	55.6	0.3	0	0.0	Excessively Well Drained	A
Scotco loamy sand, 0 to 5 percent slopes, rarely flooded	55.2	0.3	0	0.0	Excessively Well Drained	A
Memphis silt loam, 8 to 15 percent slopes	38.3	0.2	0	0.0	Well Drained	B
Falaya silt loam, 0 to 3 percent slopes, occasionally flooded	29.8	0.2	0	0.0	Somewhat Poorly Drained	B/D
Wardell loam, 0 to 1 percent slopes, rarely flooded	24.3	0.1	0.8	0.2	Poorly Drained	B/D
Memphis silt loam, 8 to 15 percent slopes, severely eroded	20.6	0.1	0	0.0	Well Drained	B



Map Unit Name	Subwatershed		Project Area		Drainage Class	HSG
	Acres	Percent	Acres	Percent		
Dundee silt loam, 0 to 1 percent slopes, rarely flooded	19.0	0.1	0	0.0	Somewhat Poorly Drained	C/D
Askew silt loam, 1 to 5 percent slopes, rarely flooded	17.6	0.1	0	0.0	Moderately Well Drained	C
Dundee loam, 0 to 1 percent slopes	17.6	0.1	0	0.0	Somewhat Poorly Drained	C/D
Dubbs silt loam, 0 to 1 percent slopes	16.2	0.1	0	0.0	Well Drained	B
Calhoun silt loam, 0 to 3 percent slopes	12.5	0.1	0	0.0	Poorly Drained	C/D
Overcup silt loam, 0 to 1 percent slopes	9.8	0.1	0	0.0	Poorly Drained	D
Falaya silt loam, 0 to 1 percent slopes, occasionally flooded	9.4	0.1	0	0.0	Somewhat Poorly Drained	B/D
Pits-Dumps complex	8.7	0.0	0	0.0	N/A	N/A
Sharkley silt clay loam, 0 to 1 percent slopes, occasionally flooded	8.7	0.0	0	0.0	Poorly Drained	D
Collins silt loam, 0 to 3 percent slopes	8.6	0.0	0	0.0	Moderately Well Drained	C
Roellen silty clay, 0 to 1 percent slopes, occasionally flooded	8.0	0.0	0.6	0.2	Poorly Drained	C/D
Memphis silt loam 15 to 35 percent slopes, eroded	6.3	0.0	0	0.0	Well Drained	B
Memphis silt loam, 3 to 8 percent slopes	5.5	0.0	0	0.0	Well Drained	B
Dundee silt loam, 0 to 1 percent slopes	2.1	0.0	0	0.0	Somewhat Poorly Drained	C/D
Total	17,631	100	341	100		

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

The NRCS classifies soil map units according to their suitability for producing food, feed, fiber, forage, and oilseed crops, based on physical and chemical soil characteristics, drainage conditions, and long-term productivity. Within the 17,631-ac Subwatershed, approximately 80 percent of soils are classified as prime farmland, prime farmland if drained, and farmland of statewide importance (**Table D3-4**), reflecting the high agricultural capacity of the area.

Soils classified as prime farmland if drained dominate the Subwatershed and Project Area, indicating that artificial drainage is a critical factor supporting agricultural productivity. Nearly all soils within the Project Area fall into this category, consistent with the extensive drainage infrastructure maintained by DD01. Areas classified as all areas prime farmland and farmland of statewide importance represent smaller portions of the Subwatershed and reflect soils with slightly greater limitations or regional significance.

The predominance of prime agricultural soils underscores the importance of maintaining drainage system function to prevent erosion, sedimentation, and prolonged ponding that could result in the degradation or loss of productive farmland.

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

Classification	Subwatershed		Project Area	
	Acres	Percent	Acres	Percent
Prime Farmland if Drained ¹	9,712	55	341	100
All Areas Prime Farmland	4,363	24.7	0	0
Not Prime Farmland	3,492	20	0	0
Farmland of Statewide Importance	64	0.3	0	0
Total	17,631	100	341	100

Source: NRCS 2025.

¹ Nearly all soils within the Project Area are artificially drained.

D4. GEOLOGY

D4.1. Geologic Setting

According to the Geologic Map of Stoddard County (Farrar and McManamy 1937), the Project Area is underlain by Cenozoic-era alluvium (approximately 66 million years ago to present). This alluvium consists primarily of unconsolidated clay, silt, sand, and gravel deposited by the Mississippi River and its tributaries, and reflects the long-term fluvial processes that have shaped the Missouri Bootheel region.

Based on The Stratigraphic Succession in Missouri (Howe and Koenig 1961), the underlying bedrock geology in the Project Area includes the McNairy Formation, the Midway Group, and the Wilcox Group. The McNairy Formation consists of sand, sandstone, and lignitic silt and reaches thicknesses of up to approximately 138-ft. The Midway Group is composed of green, calcareous, fossiliferous, glauconite-bearing sands and clays, with varying amounts of limonite, as well as dark gray, partly silty or sandy clays; this unit may reach thicknesses of up to approximately 650-ft. The Wilcox Group consists of discontinuous beds and lenses of sand and clay with limited lateral and vertical continuity. Minor chert and heavy mineral grains are present, and gravels occur as rounded quartz and polished black chert granules. The Wilcox Group reaches thicknesses of up to approximately 1,300-ft.

The Project Area lies within the Mississippi Delta Cotton and Feed Grains Land Resource Region and the Southern Mississippi River Alluvium Major Land Resource Area (MLRA 131A). This region extends southward from the confluence of the Mississippi and Ohio rivers and is characterized by thick alluvial deposits associated with the Lower Mississippi River floodplain.

D4.2. Geologic Investigations

A site-specific geotechnical investigation was not conducted as part of this watershed planning effort. Geologic characterization for planning purposes was based on published geologic mapping, regional stratigraphic literature, and existing soil and groundwater information. Site-specific geotechnical investigations would be conducted, as necessary, during final design to support detailed engineering of proposed structural measures.

D5. ENGINEERING

D5.1. Land Rights Assessment of Project Area

Land rights maps were developed for the Project Area to depict parcel ownership adjacent to the drainage ditches and the relationship of those parcels to easements maintained by DD01 (see **Appendix C**). The maps provide a spatial framework for evaluating access, construction feasibility, and long-term operation and maintenance responsibilities.

The land rights mapping was prepared using ArcGIS software and incorporates National Agricultural Imagery Program (NAIP) aerial imagery (USDA 2024b), nationwide parcel datasets (Regrid 2024), and drainage district easement information. Drainage district easements were delineated based on legal descriptions contained in official easement documentation maintained by DD01 (DD01 2024). Copies of these legal documents are included in **Appendix C**.

D5.2. Ditch and Alternatives Analysis

D5.2.1. Slope Stability Analyses

Bank stability under existing and alternative conditions was evaluated using the Bank Stability and Toe Erosion Model (BSTEM v5.4), developed by the USDA Agricultural Research Service. BSTEM evaluates slope stability by accounting for soil properties, bank geometry, saturation conditions, and the presence or absence of vegetation and structural protection to calculate a “factor of safety” against failure.

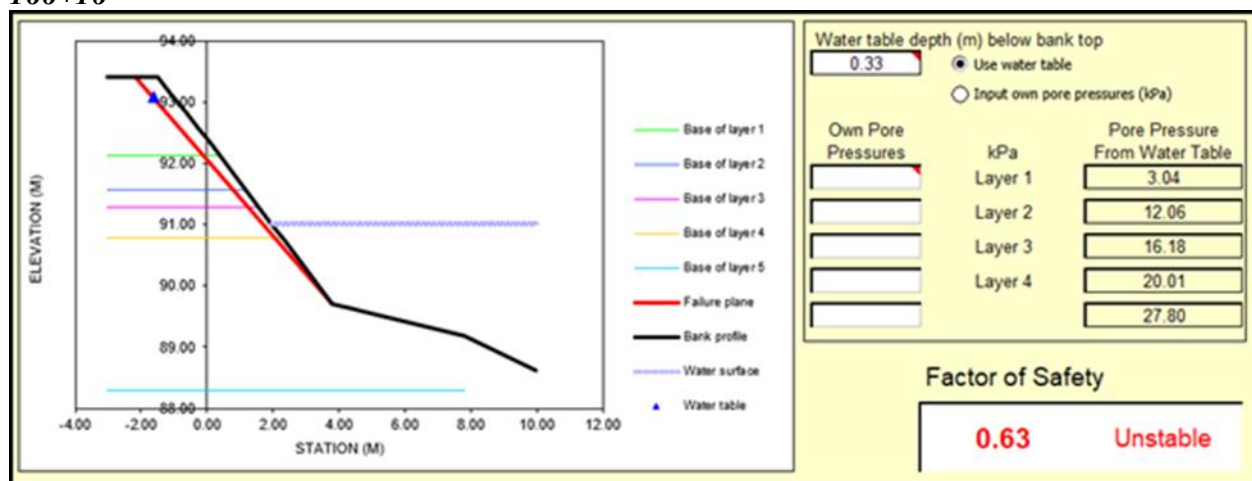
Soil profile inputs for the model were developed using descriptions from the USDA NRCS Web Soil Survey. The lowest described soil layer in each profile was assumed to extend downward indefinitely. BSTEM includes a library of pre-loaded bank material properties; these materials were selected and matched to the mapped soil horizons as closely as possible using best professional judgment. For all cross sections analyzed, the shear emergence elevation was assumed to occur at the top of the bank toe, consistent with BSTEM conventions and observed field conditions.

Two soil map unit symbols (Lilbourn fine sandy loam and Tuckerman fine sandy loam) dominate the soils within the drainage district easements associated with the West Ditch – Main Ditch and its laterals. Together, these soil types account for approximately 69 percent of the roughly 237 acres within the easements (see **Table D3-3**). Because these soils represent the majority of the affected area, they were the primary focus of the stability analyses. All soil data used in the modeling were obtained from the NRCS Web Soil Survey and associated map unit descriptions.

D5.2.2. Groundwater Impacts on Slope Stability

BSTEM allows evaluation of multiple bank-stability scenarios by adjusting water table and surface water elevations. For assessment of existing slope stability, a water surface elevation representative of typical (“normal”) conditions was simulated and compared to a scenario with the groundwater table positioned approximately 1-ft below the top of bank, representing a conservative worst-case condition in which pore-water pressures, and associated destabilizing forces, are maximized. **Figure D5-1** presents model results for Lilbourn series soils at Station 166+16, where a field-surveyed cross section was collected by NRCS staff.

Figure D5-1. BSTEM Model of Existing Conditions of West Ditch – Main Ditch Station 166+16

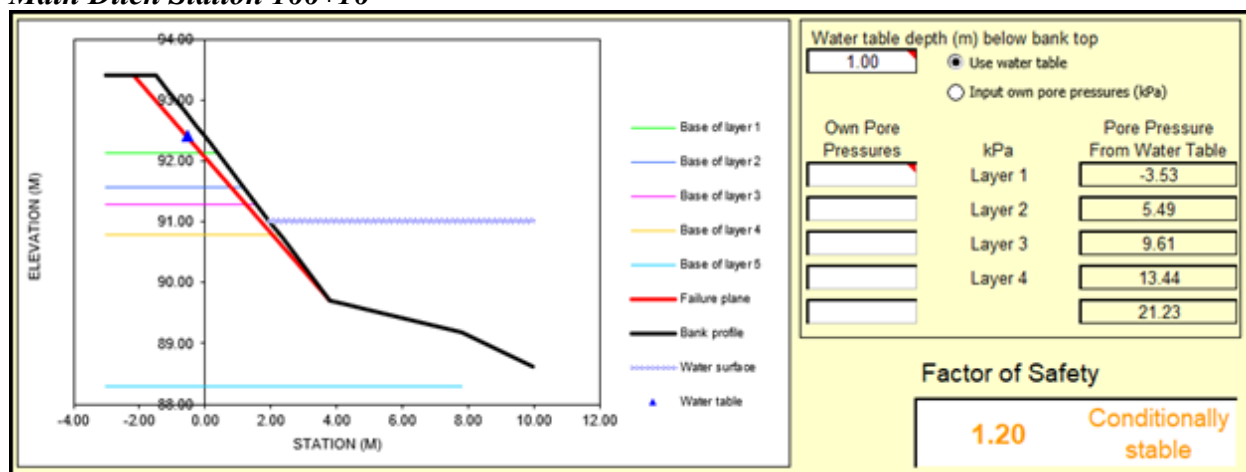


In this scenario, the groundwater table is modeled at 0.33 meters (m) (1.08-ft), as indicated by the blue triangle on the graph. The resulting factor of safety is 0.63, indicating an unstable slope condition. The factor of safety represents the ratio of resisting forces to driving forces; therefore, a value of 0.63 indicates that resisting forces are insufficient to counteract failure mechanisms under these conditions.

To evaluate the potential slope-stability benefits of installing subsurface drains parallel to the ditch banks, the modeled groundwater elevation was lowered. To achieve at least conditionally stable conditions, subsurface drains were assumed to be installed approximately 3-ft below the ground surface. This depth is consistent with typical agricultural drainage installation practices, avoids interference with tillage operations in adjacent fields, and provides sufficient groundwater relief.

This condition was simulated by adjusting the modeled groundwater depth to 1.0-m (3.28-ft). **Figure D5-2** presents the corresponding BSTEM results, which indicate an improved factor of safety under the parallel subsurface drain scenario.

Figure D5-2. BSTEM Model of Installation of Parallel Sub-surface Drains of West Ditch – Main Ditch Station 166+16



D5.2.3. Bank Toe Protection Analysis

BSTEM was also used to evaluate potential bank toe erosion under existing conditions and alternative toe protection scenarios. The model allows toe erosion to be assessed for baseline conditions and with various stabilization measures. One proposed alternative involves installing riprap toe protection at high-priority or vulnerable channel locations. By modifying the soil profile layer materials within BSTEM, simulations were conducted to estimate the effectiveness of this treatment.

Figure D5-3 presents the predicted channel profile following a 12-hour flow duration at the modeled water surface elevation, with the red line indicating the post-event channel geometry. To simulate installation of riprap at the toe of the bank and extending several feet upslope, soil layers 4 and 5 were reassigned as “cobble,” which have a median particle diameter (D_{50}) of 0.128-m (5-in). This material is preloaded within BSTEM and represents the closest available approximation to the proposed riprap alternative discussed later in this document.

Results of this simulation are shown in **Figure D5-4**. Under these conditions, negligible erosion is predicted following implementation of the riprap toe protection measure.

Figure D5-3. BSTEM Model of Predicted Toe Erosion at Station 166+16

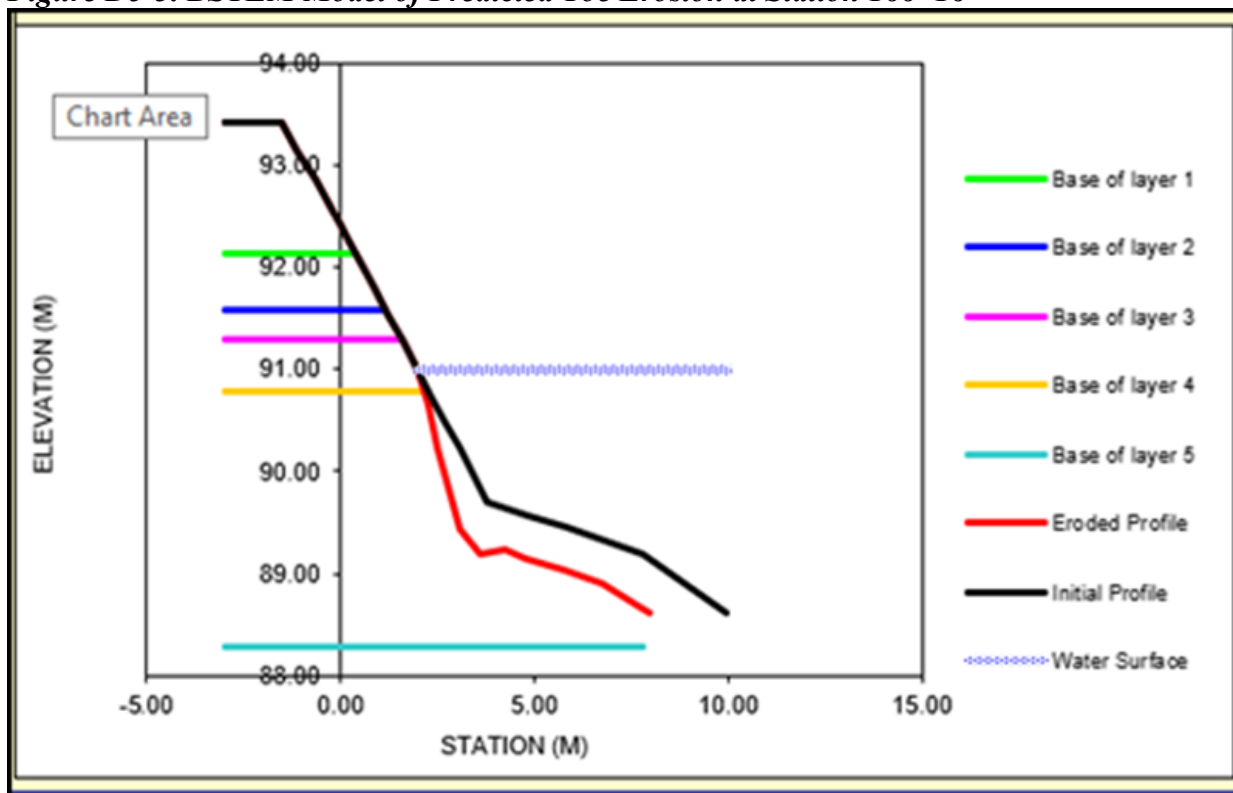
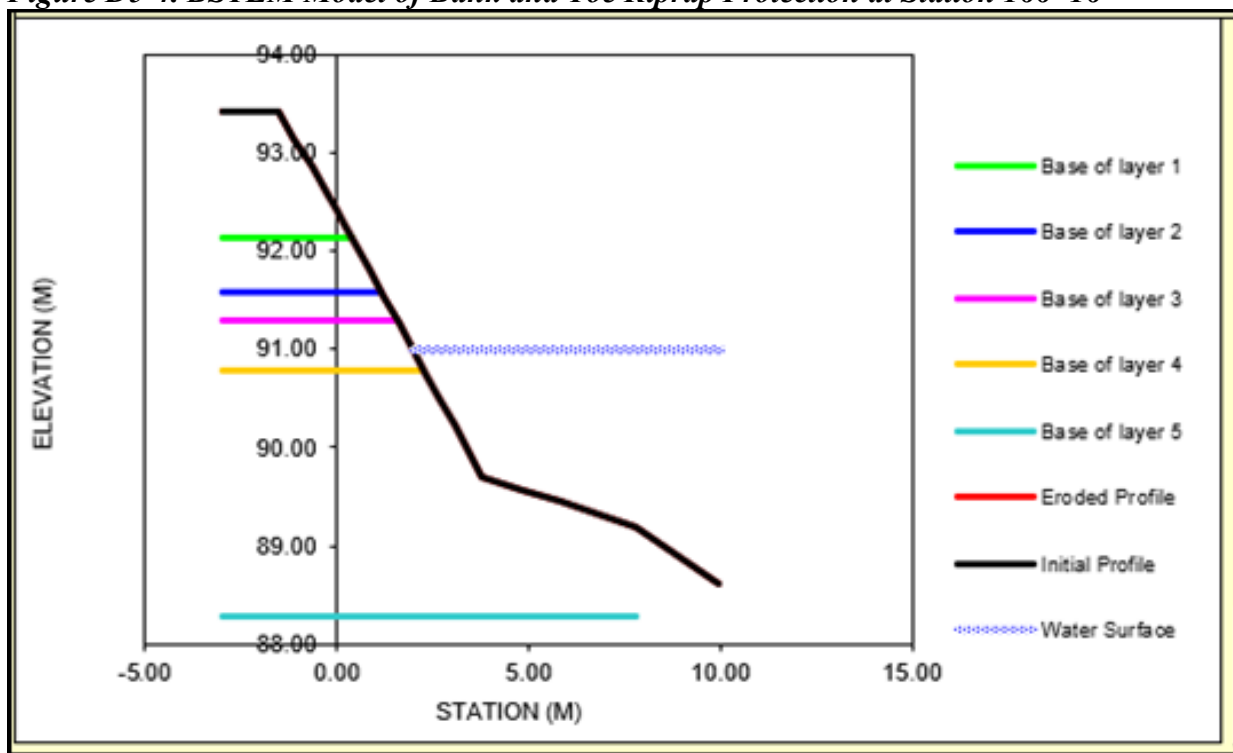
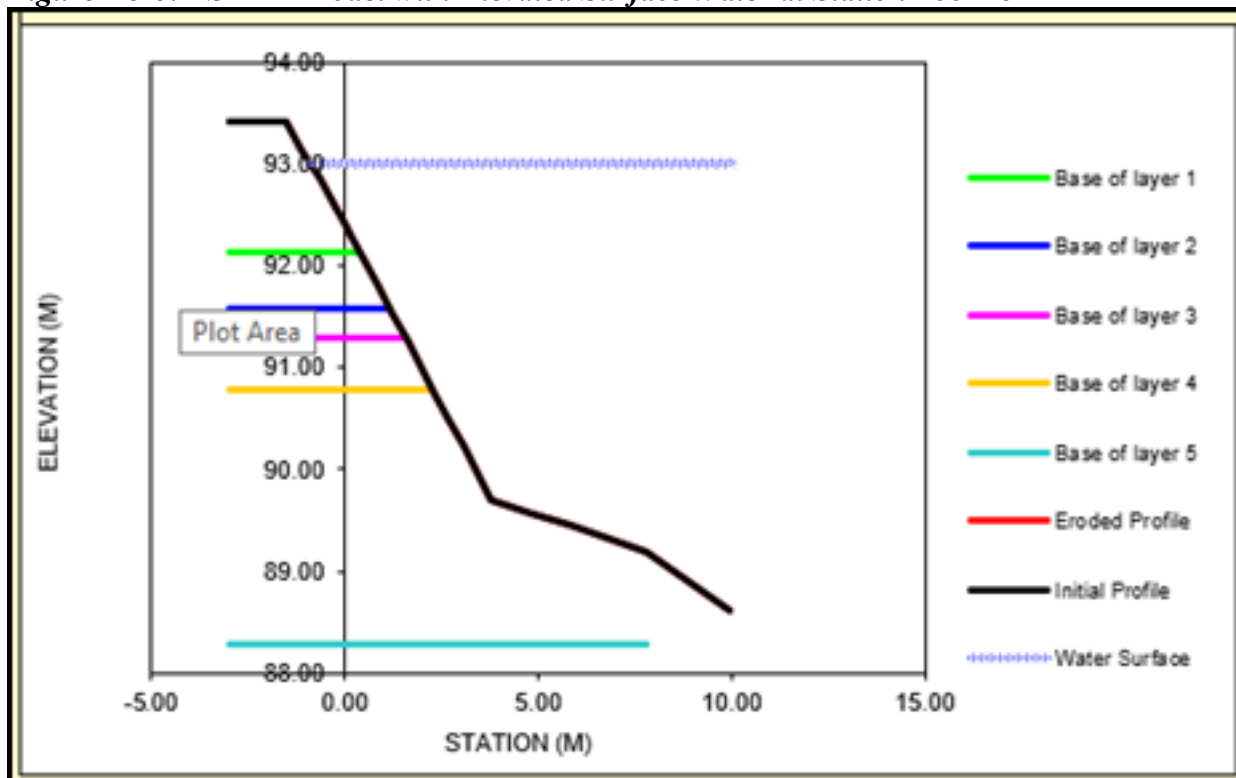


Figure D5-4. BSTEM Model of Bank and Toe Riprap Protection at Station 166+16



To further evaluate performance under conservative conditions, the modeled water surface elevation was increased to near the top of bank to represent a worst-case, bank-full flow scenario (Figure D5-5).

Figure D5-5. BSTEM Model with Elevated Surface Water at Station 166+16

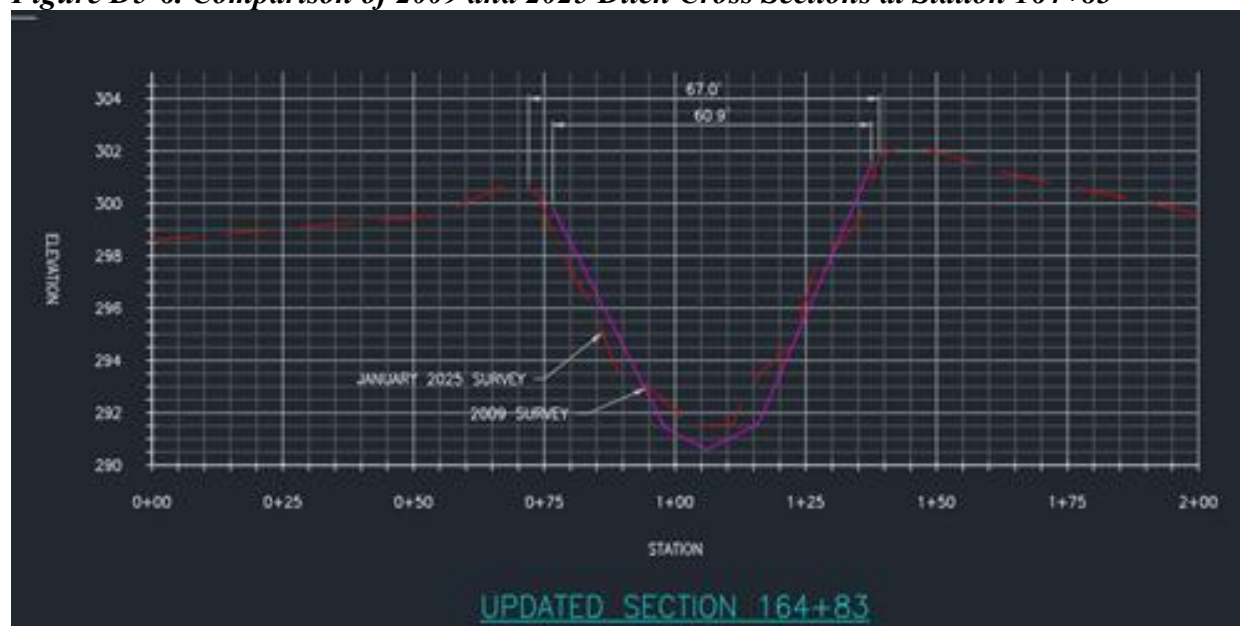


At this cross-section, model results indicate that lining the toe and lower portion of the bank (extending upward to the base of Layer 4, shown as the yellow line) with riprap would likely provide adequate protection and overall bank stability, even during elevated flow conditions. Under this scenario, predicted erosion rates are substantially reduced, supporting the effectiveness of targeted toe stabilization as a conservation treatment.

D5.2.4. Sedimentation Analysis

For purposes of estimating sediment loading from streambank erosion within the Project Area, methods outlined in the Michigan NRCS Technical Guide were applied. A comparative analysis of bank-top widths derived from 2009 and 2025 survey data indicates changes ranging from 0.4-ft to 10.2-ft. Over the 14-year interval between surveys, this corresponds to an average lateral recession rate of approximately 0.31-ft per year (total bank width). Based on the referenced guidance, this rate of change is classified as “severe” channel erosion.

Figure D5-6. Comparison of 2009 and 2025 Ditch Cross Sections at Station 164+83



Using this guidance, annual sediment loss for the channel system was estimated. Based on dominant soil types within the ROW, a sandy loam classification was assumed, with an average bulk density of 100 pounds per cubic foot (lb/ft³), consistent with values provided in the Technical Guide. An average channel depth of 10 ft and existing side slopes of approximately 2.5H:1V were used to estimate bank surface area. Applying these parameters across the total channel length results in an estimated sediment loss of approximately 46,231 tons per year from the channel system.. This estimate was developed using standard NRCS planning-level equations for bank erosion (**Equations D5-1 and D5-2**)¹.

Equation D5-1. Bank Erosion Sediment Loss Estimation (MI Technical Guide)

$$\frac{(\text{Bank Length} \times \text{Channel Length})(\text{Recession rate})(\text{Density})}{2000 \text{ lbs/ton}} = \text{erosion in ton/year}$$

Equation D5-2. Application of Equation 5-1 to Estimate Sediment Loss for the West Ditch – Main Ditch Project Area

$$\frac{(26.9 \text{ ft} \times 110,880 \text{ ft})(.31 \text{ ft/yr})(100 \text{ lbs/ft}^3)}{2000 \text{ lbs/ton}} = 46,231 \text{ tons/year}$$

These results are considered appropriate for planning-level analysis and comparison of alternatives; however, more detailed site-specific measurements would be required to refine sediment yield estimates during final design. Results from the BSTEM modeling indicate that alternatives incorporating riprap bank or toe protection could substantially reduce erosion rates, potentially into the “slight” category (approximately 0.01 to 0.05-ft per year) as defined by NRCS

¹ Source: USDA NRCS (2009), Michigan Field Office Technical Guide, Section I – Water Erosion.

guidance. Additional refinement of sediment reduction estimates would be expected once specific measures are selected and implemented.

D5.2.5. Conclusions

The BSTEM model and analytical approach used for this evaluation have inherent limitations. The primary limitation is the assumption that the lowest soil horizon described in the USDA Web Soil Survey extends continuously to the channel bottom. While appropriate for a screening-level, planning analysis, this assumption introduces uncertainty in characterizing subsurface stratigraphy and associated shear strength parameters that govern slope stability.

A more rigorous assessment of slope stability and factors of safety would require additional site-specific investigation. Such efforts would include detailed surveying of existing bank geometries; subsurface exploration and sampling within anticipated failure zones and slope foundations; laboratory testing to determine relevant soil strength parameters; and analysis of representative existing and proposed slope configurations. Results would be documented in a geotechnical engineering report.

Not only would the steps laid out above provide the data needed for improved slope stability analysis, but would also provide data needed for improved accuracy in the sedimentation analysis by providing better soils data as well as a finer survey resolution for ditch bank erosion comparisons.

D5.3. Hydrology and Hydraulics

D5.3.1. Hydrology and Hydraulic Analyses

Hydrologic and hydraulic analyses were conducted using the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS), version 6.6. The models incorporated high-resolution (1-m) bare-earth lidar terrain data, spatially distributed soils and land cover, and Manning's roughness grids. Rainfall inputs were based on MSE5 temporal distributions for each frequency event.

Soil data were obtained from the USDA NRCS Web Soil Survey and include aggregated HSG classifications for individual soil series. Land cover was derived from the 2016 National Land Cover Database. Soils and land cover were combined to estimate infiltration using the NRCS Curve Number method, assuming Antecedent Moisture Condition II to represent typical watershed conditions. Land cover data were also used to assign Manning's roughness coefficients, which reflect surface resistance to flow.

Hydraulic structures within the Project Area were incorporated into the HEC-RAS models based on field surveys. Survey data included channel geometry, structure dimensions, and construction materials (e.g., corrugated metal pipe, concrete box culvert). Channel bed elevations observed during field surveys were used to estimate reductions in conveyance capacity associated with sediment accumulation.

Two-dimensional HEC-RAS Rain-on-Mesh (RoM) modeling was used to evaluate flood reduction benefits associated with the proposed works of improvement. Flood frequency analyses were

performed for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year events (corresponding to 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% annual exceedance probabilities). Floodplain extents were compared between existing conditions and conditions with the proposed improvements to quantify changes in inundation area. These comparisons were subsequently used in the economic analysis to estimate flood damage reduction benefits. Summary results are provided in **Tables D5-1 and D5-2**. Floodplain maps for the 1-percent annual chance event are included in Appendix C (**Figures 13a–13e**). Figure 5-7 presents a representative cross section comparing the existing channel geometry with the proposed design.

Figure D5-7. Representative Channel Cross Section Comparison

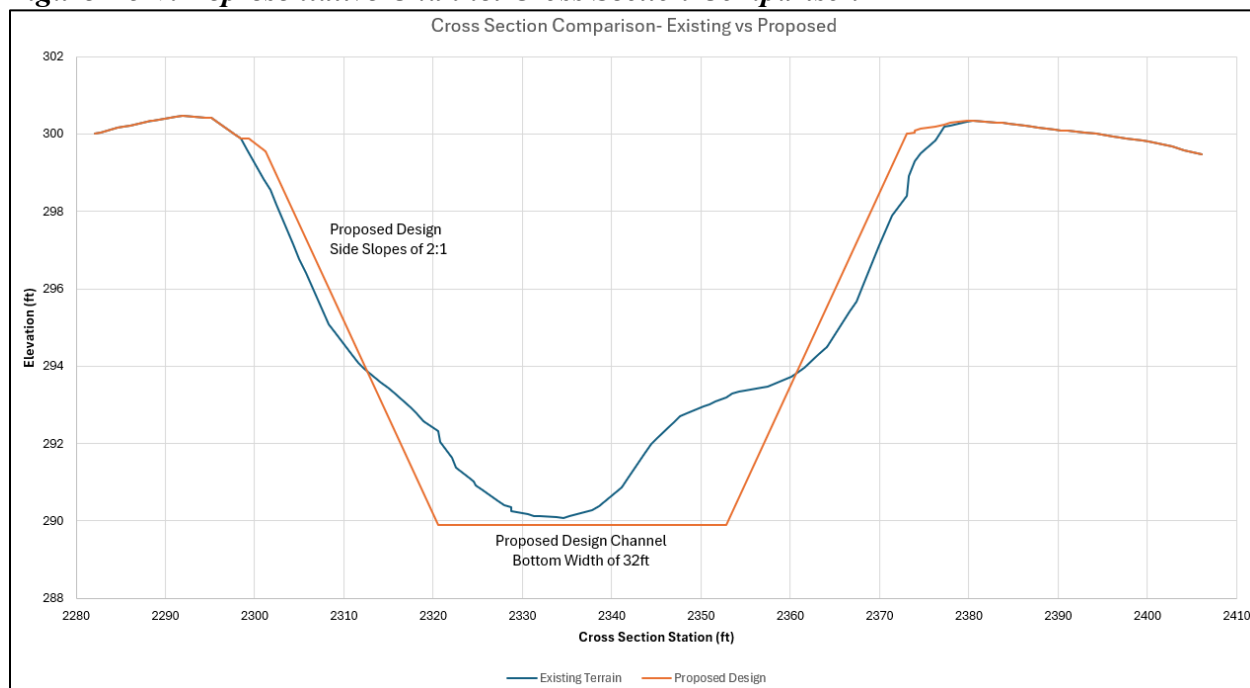


Table D5-1. Floodplain Area Comparison With and Without Works of Improvement (High Priority)

Flood Return Period	Floodplain Without Project Area (Acres)	Floodplain With Project Area (Acres)	Floodplain Reduction Area (Acres)
2-yr	3,107.8	2,719.7	388.1
5-yr	4,550.9	3,929.9	621.0
10-yr	5,613.2	5,243.3	369.9
25-yr	6,823.2	6,611.3	211.9
50-yr	7,747.9	7,611.9	136.1
100-yr	8,403.5	8,242.6	160.9

Flood Return Period	Floodplain Without Project Area (Acres)	Floodplain With Project Area (Acres)	Floodplain Reduction Area (Acres)
500-yr	9,777.0	9,752.2	24.9

Table D5-2. Floodplain Area Comparison With and Without Works of Improvement (High and Medium Priority)

Flood Return Period	Floodplain Without Project Area (Acres)	Floodplain With Project Area (Acres)	Floodplain Reduction Area (Acres)
2-yr	3,107.8	2,225.1	882.7
5-yr	4,550.9	3,632.2	918.7
10-yr	5,613.2	4,825.7	787.4
25-yr	6,823.2	6,385.2	438.0
50-yr	7,747.9	7,517.8	230.1
100-yr	8,403.5	8,206.5	197.0
500-yr	9,777.0	9,641.8	135.2

D5.4. Structural Measures and Conceptual Design

Conceptual measures were developed to address observed bank instability, erosion, sedimentation, and hydraulic inefficiencies within the West Ditch – Main Ditch Subwatershed. These practices are intended to be applied selectively based on site conditions and include vegetative buffers, ditch bank toe and bank armoring with riprap, parallel subsurface drainage, and grade stabilization structures. Final selection, sizing, and extent of these measures would be refined during subsequent geotechnical and topographic investigations.

D5.4.1. Riprap Armoring

In areas exhibiting severe degradation due to high channel velocities, erodible soils, or active bank failure, full-bank armoring with riprap is recommended as a stabilization measure. This practice would be applied on a limited basis in locations with the highest risk of failure and where vegetation alone would not provide adequate protection. Specific reaches requiring full-bank armoring would be identified during detailed geotechnical evaluation and survey-based assessment of bank geometry and erosion mechanisms.

D5.4.2. Parallel Subsurface Drains

As discussed in Section D5.2.2, elevated groundwater conditions within certain soil types contribute to reduced bank stability by increasing groundwater pressures within the bank profile. Bank stability analyses indicate that lowering the groundwater table can improve the “factor of safety” against slope failure. This would be accomplished through the installation of perforated subsurface drainage tubing placed parallel to the ditch banks at depths sufficient to intercept



shallow groundwater and relieve subsurface pressure. Use of parallel drains would be limited to areas with suitable soil conditions and shallow groundwater tables, as confirmed through additional geotechnical investigation.

D5.4.3. Additional Structural Practices

Site reconnaissance and desktop review identified localized areas where concentrated surface or subsurface flows discharge into the main channel, including pipe outlets, side channels, and crossings. These locations often exhibit increased velocities, abrupt grade changes, and active erosion. Stabilization at these points would be addressed through installation of riprap armoring, bedding, or grade stabilization structures, as appropriate, to dissipate energy, protect banks, and prevent continued channel widening.

Typical conceptual details for these practices are provided in Appendix C.

D5.4.4. Native Grass Seeding and Vegetation Stabilization

Excess material generated from bank excavation would be spread along re-graded slopes and capped with topsoil. These areas would be seeded with a native grass and forb mixture designed to establish deep root systems, stabilize soils, and reduce long-term maintenance needs. Native species were selected for their adaptability to site conditions and compatibility with adjacent agricultural land uses. Proposed seeding rates and species composition are provided in **Table D5-3**.

Table D5-3. Proposed Native Grass and Herbaceous Species and Seeding Matrix

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

D5.5 Nonstructural Easement Acquisition

This nonstructural alternative would involve the acquisition of conservation easements or buyouts of agricultural lands that are subject to flooding during the 100-year storm event. Areas eligible under this alternative are those currently used for agricultural production but located within the mapped 1-percent annual chance floodplain.

Based on hydrologic and hydraulic analyses, approximately 850-ac within the Subwatershed would be affected under this scenario. Implementation would remove these lands from active agricultural use and allow for conversion to wetland or floodplain functions, thereby reducing exposure of cropland to flood damages. While this alternative could provide long-term floodplain and ecological benefits, it would require extensive land acquisition, result in the permanent loss of productive farmland, and involve substantial costs and landowner participation.

D6. BIOLOGY

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

The Project Area includes approximately 18-mi of Main Ditch, Lateral No.2, and numerous unnamed laterals (**Table D6-1a**). The ditches are fed by 12 tributaries in the Project Area. No wetlands or open water features were identified within the Project Area beyond the ditch network itself.

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

Feature			Subwatershed Area		Project Area		
	Type	Miles (mi)	Linear Feet (LF)	Percentage	Miles (mi)	Linear Feet (LF)	Percentage
West Ditch – Main Ditch	Perennial	8.1	42,874	16.2	7.1	37,616	40.1
Lateral No. 2	Perennial	2.0	10,984	4.2	1.3	7,016	7.5
Unnamed Laterals	Perennial	40.2	212,196	79.6	9.3	49,142	52.4
Total		50.3	266,054	100		93,774	100

Streams in the Project Area are manmade ditches measuring approximately 40 to 80-ft wide at the top of bank with 8 to 20-ft-high banks at approximately a 2H:1V slope. Streambeds are primarily comprised of clay, silt, sand, and gravel. Varying depths of water were observed in the ditches within the Project Area; however, in general, approximately 1 to 3-ft of water supporting fish, turtles, and other aquatic species was observed.

Within the Subwatershed, 335-ac of wetland and riverine habitat have been mapped by the National Wetlands Inventory (NWI) as depicted in **Table D6-1b**. A wetland delineation was conducted by Prairie Engineers in November 2024, which did not find any wetlands within the Project Area (Prairie Engineers 2024, **Appendix E**). The wetlands delineation process followed the regional protocol established by USACE (USACE 2010).

Table D6-2b. NWI Wetland and Water Features in the Subwatershed and Project Area

NWI Mapped Feature	Subwatershed Area		Project Area	
	Acres	Percentage	Acres	Percentage
Riverine	152	46	30	71
Freshwater Forested/Scrub-shrub Wetland	84	25	9	21
Freshwater Pond	69	21	0	0
Freshwater Emergent Wetland	29	9	3	7
Total	335	100	42	100

Source: USFWS 2024a.

D6.2. Surface Water Quality (Clean Water Act)

Current water quality conditions of the streams (ditches) in the Project Area were reviewed through Missouri Department of Natural Resources (MDNR) and U.S. Environmental Protection Agency (USEPA) resources. The water quality of the streams in the Project Area is currently unknown, with none listed on Missouri's 2020 303(d) list of impaired waters (MDNR 2020a). See **Table D6-2**.

Table D6-2. Water Quality Conditions of Streams in the Project Area

Stream Name	State Waterbody ID	Listed on Missouri 2020 303(d) List ¹	Waterbody Condition ²
Main Ditch	MO_3115.00	No	Unknown

¹ MDNR 2020a.

² USEPA 2024a.

D6.3. Threatened and Endangered Species

The West Ditch–Main Ditch Project Area was reviewed using the USFWS Information for Planning and Consultation (IPaC) system on June 30, 2026, to identify federally listed T&E species protected under the Endangered Species Act (USFWS 2026; see **Table D6-3a**). No designated critical habitat was identified within the Project Area.

A limited field assessment of potentially suitable habitat for listed species was conducted in November 2024. During the field assessment, scattered trees exhibiting characteristics consistent with potentially suitable habitat for Indiana bat (*Myotis sodalis*), northern long-eared bat, and tricolored bat (*Perimyotis subflavus*) were observed in and adjacent to the Project Area. Individual monarch butterflies (*Danaus plexippus*), as well as suitable habitat, were also observed. Findings of the T&E assessment are summarized in **Table D6-3a**.

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

Scientific Name	Common Name	Federal Status	State Status	Findings	Potential Habitat or Population Present	Carried Forward for Analysis
Mammals						
<i>Myotis sodalis</i>	Indiana bat	E	E	Potentially suitable habitat observed in the Project Area.	yes	yes
<i>Perimyotis subflavus</i>	tricolored bat	PE	N/A	Potentially suitable habitat observed in the Project Area.	yes	yes
Reptiles						
<i>Macrochelys temminckii</i>	alligator snapping turtle	PT	N/A	Species unlikely to occur in the Project Area due to the degraded condition of	no	no

Scientific Name	Common Name	Federal Status	State Status	Findings	Potential Habitat or Population Present	Carried Forward for Analysis
				the heavily sedimented drainage canals.		
Insects						
<i>Danaus plexippus</i>	monarch butterfly	PT	N/A	Individual monarchs as well as suitable habitat were observed in the Project Area.	yes	yes

Sources: USFWS 2026 and MDC 2024a.

E = endangered, T = threatened, C = candidate species, PE = proposed endangered, PT = proposed threatened

State-listed species status was reviewed using the Missouri Department of Conservation (MDC) Missouri Species and Communities of Conservation Concern Checklist (MDC 2024a). Through interagency scoping, MDC provided a Natural Heritage Review Report (NHRR) for the Project Area on February 18, 2025. The NHRR indicates that no records of wildlife preserves, designated wilderness areas, critical habitat, or federally listed species occur within the Project Area, associated public land survey sections, or adjacent sections.

The NHRR documented the Illinois chorus frog (*Pseudacris illinoensis*) within approximately 1-mi of the Project Area. In addition, Indiana bats (*Myotis sodalis*) are known to occur in Stoddard County and may be present within the Project Area where suitable habitat exists; therefore, these species are assumed present where appropriate habitat occurs. The NHRR also identified karst features as known geologic resources in the vicinity and recommends establishment of a minimum 100-ft buffer around such features to minimize potential impacts to species that may utilize karst habitats.

The NHRR further identified 23 additional state-ranked species documented within 5-mi of the Project Area (**Table D6-3b**). Of these, sharp-scale sedge (*Carex oxylepis*) is the only species known to occur within 1-mi of the Project Area and is associated with forest matrix habitat. These state-ranked species do not carry regulatory protections beyond voluntary stewardship measures; however, state conservation ranks are provided for informational purposes. IPaC and MDC documentation is included in Appendix A.

Table D6-3b. State-Ranked Species in the Project Area

Scientific Name	Common Name	State Rank	Proximity to Watershed	Primary Habitat
Bird				
<i>Lanius ludovicianus</i>	Loggerhead Shrike	S2	<5-mi	Grassland matrix, Old field/shrub, Savanna pasture/orchard, Savanna
<i>Ixobrychus exilis</i>	Least Bittern	S3	<5-mi	Marsh
<i>Porzana carolina</i>	Sora	S2	<5-mi	Marsh, Moist edge/mudflat
Fish				
<i>Erimyzon sucetta</i>	Lake Chubsucker	S2	<2-mi	River/stream, Swamp, Pond/ lake/deep oxbows & slough
<i>Fundulus dispar</i>	Starhead Topminnow	S2	<5-mi	Swamp, Pong/lake/deep oxbows & slough, Shallow oxbow/slough
<i>Lepomis symmetricus</i>	Bantam Sunfish	S2	<5-mi	Swamp, Shallow oxbow/slough
<i>Notropis chalybaeus</i>	Ironcolor Shiner	S1	<2-mi	River/stream
<i>Notropis texanus</i>	Weed Shiner	S3	<1-mi	River/stream
Mammal				
<i>Sylvilagus aquaticus</i>	Swamp Rabbit	S2	<5-mi	Forrest bottomland, Wetland matrix
Amphibian				
<i>Pseudacris illinoensis</i>	Illinois Chorus Frog	S2	<1-mi	Sand prairie/savannah, Crop field, Ephemeral pools, Wet ditches
<i>Scaphiopus holbrookii</i>	Eastern Spadefoot	S2	<5-mi	Grassland matrix, Ephemeral pools, Wet ditches
Reptile				
<i>Farancia abacura reinwardtii</i>	Western Mudsnake	S2	<5-mi	Forrest bottomland, Wetland matrix
Crustacean				
<i>Creaserinus fodiens</i>	Digger Crayfish	S2S3	<3-mi	Wetland matrix, River/stream
Insect				
<i>Satyrodes appalachia leeuwi</i>	Appalachian Eyed Brown	S1	<5-mi	Woodland, Swamp
<i>Euphyes dukesi</i>	Duke's Skipper	S1	<4-mi	Shrub swamp, Shallow oxbow/slough, Swamp

Scientific Name	Common Name	State Rank	Proximity to Watershed	Primary Habitat
Plant				
<i>Carex albolutescens</i>	Greenish-white Sedge	S1S2	<5-mi	Fen/seep, Forest bottomland, Wet ditches
<i>Carex reniformis</i>	Reniform Sedge	S1	<5-mi	Forest bottomland
<i>Carex oxylepis</i>	Sharp-scale Sedge	S2	<1-mi	Forest matrix
<i>Carex triangularis</i>	Triangular Sedge	S2	<4-mi	Swamp, Forest bottomland, Roadside/railroad
<i>Limnoscadium pinnatum</i>	Pinnate Dogshade	S1	<5-mi	Glade complex, Grassland native prairie, Roadside/railroad
<i>Peltandra virginica</i> ssp. <i>virginica</i>	Arrow Arum	S2	<5-mi	Wet ditches, Shallow oxbow/slough, Moist edge/mudflat
<i>Physostegia intermedia</i>	A False Dragonhead	S1	<5-mi	Wet ditches, Fen/seep, Swamp, Roadside/railroad
<i>Pycnanthemum muticum</i>	Blunt Mountain Mint	S2	<3-mi	Forest bottomland, Wet ditches, Swamp, Fen/seep
<i>Spermolepis diffusa</i>	Rough-fruit Spermolepis	S1	<4-mi	Grassland native prairie, Roadside/railroad
<i>Wolffiella gladiata</i>	Wolffiella	S1	<5-mi	Pond/lake/deep oxbows & slough

Source: MDC 2025.

S1: Critically Imperiled: Critically imperiled in the state because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2: Imperiled: Imperiled in the state because of rarity due to very restricted range, very few populations or occurrences, steep declines, or other factors making it very vulnerable to extirpation from the state.

S3: Vulnerable: Vulnerable in the state due to a restricted range, relatively few populations or occurrences, recent and widespread declines, or other factors making it vulnerable to extirpation.

S#S#: Range Rank: A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species.

Based on IPaC review, field observations, and MDC coordination, Indiana bat, tricolored bat, and monarch butterfly were carried forward for further analysis.

D6.4. Migratory Bird Treaty Act/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. No other MBTA-protected migratory birds were identified as potentially occurring in the Project Area. Eagle and migratory bird species potentially occurring in the watershed as identified in the USFWS IPaC review are listed in **Table D6-4**. During the field assessment, habitat for migratory birds was observed, and several shorebirds were observed along the drainage laterals in the Project Area. Bald eagles were not observed within or adjacent to the Project Area.

Table D6-4. Eagles and Migratory Birds Listed in the Project Area

Scientific Name	Common Name	Breeding Season
<i>Haliaeetus leucocephalus</i>	bald eagle	Breeds September 1 to July 31
<i>Chaetura pelagica</i>	chimney swift	Breeds Mar 15 to Aug 25
<i>Geothlypis formosa</i>	Kentucky warbler	Breeds Apr 20 to Aug 20
<i>Tringa flavipes</i>	lesser yellowlegs	Breeds elsewhere
<i>Egretta caerulea</i>	little blue heron	Breeds Mar 10 to Oct 15
<i>Calidris melanotos</i>	pectoral sandpiper	Breeds elsewhere
<i>Setophaga discolor</i>	prairie warbler	Breeds May 1 Jul 31
<i>Protonotaria citrea</i>	prothonotary warbler	Breeds Apr 1 to Jul 31
<i>Melanerpes erythrocephalus</i>	red-headed woodpecker	Breeds May 10 to Sep 10
<i>Euphagus carolinus</i>	rusty blackbird	Breeds elsewhere

Source: USFWS 2026.

D6.5. Vegetation

Table D6-5 lists plant species identified during biological fieldwork conducted for the Project Area in November 2024 (Prairie Engineers 2024, **Appendix A**). Invasive species were observed in the Project Area. Invasive species of concern include mimosa (*Albizia julibrissin*), autumn olive (*Elaeagnus umbellata*), Japanese hop (*Humulus japonicus*), sericea lespedeza (*Lespedeza cuneata*), foxtail species (*Sertaria spp.*), and Johnsongrass (*Sorghum halepense*).

Table D6-5. Vegetation Observed in the Project Area

Scientific Name	Common Name	Wetland Indicator Status (AGCP Region ¹)	Native (N) or Introduced (I)
Scattered trees adjacent to drainage canals			
<i>Acer saccharinum</i>	silver maple	FAC	N
<i>Gleditsia tricanthos</i>	honey locust	FAC	N
<i>Populus deltoides</i>	cottonwood	FAC	N
<i>Platanus occidentalis</i>	sycamore	FACW	N
<i>Salix nigra</i>	black willow	OBL	N
Herbaceous vegetation along ditch slopes – includes scrub-shrub species and young saplings			
<i>Albizia julibrissin</i>	Mimosa	N/A	I
<i>Amaranthus spinosus</i>	spiny amaranth	FACU	N
<i>Ambrosia trifida</i>	ragweed	FAC	N
<i>Andropogon gerardii</i>	big bluestem	FAC	N
<i>Anoda cristata</i>	crested anoda	FAC	N
<i>*Arundinaria gigantea</i>	giant cane	FACW	N
<i>Asclepias syriaca</i>	common milkweed	UPL	N
<i>Campsis radicans</i>	trumpet creeper	FAC	N

Scientific Name	Common Name	Wetland Indicator Status (AGCP Region ¹)	Native (N) or Introduced (I)
<i>Cephalanthus occidentalis</i>	buttonbush	OBL	N
<i>Elaeagnus umbellata</i>	autumn olive	UPL	I
<i>Equisetum hyemale</i>	rough horsetail	FACW	N
<i>Fallopia scandens</i>	climbing false buckwheat	FAC	N
<i>Gleditsia triacanthos</i>	honeylocust	FAC	N
<i>Humulus japonicus</i>	Japanese hop	FAC	I
<i>Lespedeza cuneata</i>	sericea lespedeza	FACU	I
<i>Morus alba</i>	white mulberry	FACU	I
<i>Oenothera pilosella</i>	meadow evening primrose	FACU	N
<i>Panicum virgatum</i>	switchgrass	FAC	N
* <i>Persicaria amphibia</i>	water smartweed	OBL	N
* <i>Persicaria hydropiperoides</i>	swamp smartweed	OBL	N
* <i>Persicaria pensylvanica</i>	pinkweed	FACW	N
<i>Phalaris arundinacea</i>	reed canarygrass	OBL	N
<i>Potamogeton sp.</i>	pondweed	OBL	N
<i>Rhus glabra</i>	smooth sumac	UPL	N
<i>Ranunculus repens</i>	creeping buttercup	FACU	I
<i>Rumex crispus</i>	curly dock	FAC	I
<i>Setaria faberi</i>	giant foxtail	UPL	I
<i>Setaria pumila</i>	yellow foxtail	FAC	I
<i>Solidago altissima</i>	tall goldenrod	FACU	N
<i>Sorghum halepense</i>	johnsongrass	FACU	I
<i>Toxicodendron radicans</i>	poison ivy	FAC	N
<i>Vernonia missurica</i>	Missouri ironweed	FAC	N
* <i>Typha latifolia</i>	broadleaf cattail	OBL	N

FAC = facultative, FACU = facultative upland, FACW = facultative wetland, UPL = upland, OBL = obligate

*Primarily found at toe of ditch slope or in erosive areas of sloughing.

¹ AGCP = Atlantic and Gulf Coastal Plain Region (USACE 2010).

D6.6. Fish and Wildlife Habitat

The drainage ditches and their vegetated banks within the Project Area, while not typically high-quality habitat, serve as corridors for many species of mammal, bird, reptile, etc. in a landscape that is otherwise predominantly cultivated crop fields. Wetland areas within and adjacent to the project area were observed supporting many thousands of migratory waterfowl and shorebirds.

Scattered trees within and adjacent to the Project Area may provide suitable habitat for endangered bat species. Should trees exhibiting potential bat habitat need to be cleared as part of the final alternative(s), recommended conservation measures would include clearing these trees only during the winter months of November 16 through March 31 (USFWS 2024b).



D6.7. Invasive Species

Several invasive plant species were identified within the Project Area. These plants would be removed during construction and replaced with a cover of native warm-season grasses and forbs. Once native grasses have been established, mowing and herbicide application would be used to control vegetation and help to deter invasive species.

D7. ECONOMICS

D7.1. General

The Project economics evaluation is summarized in this section.

Project benefits were calculated consistent with *Guidance for Conducting Analyses Under the Principles, Requirements, and Guidelines for Water and Land Related Resources Implementation Studies and Federal Water Resource Investments* (USDA 2017) and *National Resources Economics Handbook (NREH) part 611* (NRCS 2014). All economic benefits and costs are provided in 2026 dollars and have been discounted and amortized to an average annualized value using the 2026 federal water resources planning rate of 3.25 percent. Economic benefits gained by implementing each preferred alternative were calculated and used to determine the net monetized benefit for the project alternatives. This was accomplished by comparing the average annual benefit with the average annual costs.

The benefit/cost Analysis (BCA) indicated that the benefit/cost Ratio (BCR) for this proposed Project is estimated to be 1.4 (Alternative 2a) for the proposed project life of 52 years (50-year design life plus 2 years for design and construction) with an annual net monetized benefit of \$112,100. Alternatives were evaluated by considering monetary benefits, ecosystem services benefits, and other non-monetized benefits. See Section 9 in the Watershed Plan for the rationale behind the selection of the Preferred Alternative. This section provides an explanation of the BCA process and results.

The Project Area and the flood impact zone were assessed during the field survey. The predominant land uses in the benefit area were qualitatively inventoried. The results of this project benefit analysis are used to determine the relative BCR and annualized net monetized benefit for the project alternatives by comparing the average annual benefit with the average annual costs.

D7.2. Determining Project Damages

Two categories of damages were evaluated for the Project Area: flood-related damages and sediment-related damages. Flood-related damages were further subdivided into three damage categories: structural damages, roadway damages, and agricultural (cropland) damages.

Flood damage reduction benefits were estimated in accordance with the Principles, Requirements, and Guidelines for Federal Investments in Water Resources (PR&G) and the Natural Resources Conservation Service (NRCS) National Resources Economics Handbook (NREH), Part 611 (NRCS, 2014). Consistent with this guidance, damages were quantified on an expected annual damage (EAD) basis using stage-damage relationships and probability-weighted flood events.

Within the Project Area, flood-related damages were developed for structures, transportation infrastructure (roadways), and agricultural cropland. Structure damages were estimated based on depth-damage relationships applied to the building inventory. Roadway damages were estimated considering roadway overtopping, erosion potential, and repair costs associated with flood events. Agricultural damages were based on crop type, acreage, and associated yield losses.

The procedures and assumptions used to estimate damages for each damage category are described in the following sections.

D7.2.1. Structural Damages

For structure losses, the Federal Emergency Management Agency (FEMA) Hazus Flood Assessment Structure Tool (FAST) was utilized to provide an estimate of risk. Hazus FAST predicts damages based on depth/damage curves derived by depth grids from the HEC-RAS modeling discussed in the H&H details in Section D.5.3. Hazus FAST relies on the National Structure Inventory (<https://nsi.sec.usace.army.mil/downloads/>) developed by USACE which provides building characteristics including location, lowest adjacent grade, and estimated finished floor elevations. Losses assessed by Hazus FAST include building damage, inventory loss and content loss.

For this Project, Hazus FAST was run for the following scenarios.

- Alternative 1: No Action/FWOFI
- Alternative 2a: Structural (High Priority)
- Alternative 2b: Structural (High and Medium Priority)
- Alternative 2c: Structural (2-Stage High and Medium)
- Alternative 4: Structural (2-Stage Only)

The No Action/FWOFI alternative scenario primarily uses the existing conditions hydraulic model to assess damages. This scenario was modeled with the assumption that conditions will continue to deteriorate with regard to stream bank erosion and channel degradation and resulting sediment accumulation within the channel. Damages for each scenario were calculated for various recurrence intervals (2-, 5-, 10-, 25-, 50-, 100-, and 500-year events). The nonstructural alternative assumes that all cropland acres located within the Alternative 1-No Action/FWOFI 100-year floodplain would be protected through the implementation of conservation easements, and that all 23 structures within that same floodplain would be acquired through a voluntary buyout program. Unit costs of \$8,500 per acre for conservation easements and \$100,000 per structure for buyouts were applied in the analysis.

Estimated single event and annualized damage results from the Hazus analysis for each alternative are provided in **Table D7-1**.



Table D7-1. Estimated Structural Damages from Hazus Analysis

Return Period	Loss Type	Alt 1 - No Action / FWOFI	Alt 2a - High Priority	Alt 2b -High and Medium	Alt 2c- 2 Stage High And Medium	Alt 4 - 2 Stage Only
2yr	Total Loss	\$32,448	\$31,169	\$31,100	\$0	\$0
	Building (Structure) Loss	\$20,010	\$19,210	\$19,167	\$0	\$0
	Content Loss	\$12,438	\$11,958	\$11,932	\$0	\$0
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	1	1	1	0	0
5yr	Total Loss	\$77,317	\$74,924	\$74,684	\$72,884	\$79,048
	Building (Structure) Loss	\$51,808	\$50,074	\$49,934	\$53,252	\$57,851
	Content Loss	\$25,509	\$24,851	\$24,750	\$19,632	\$21,197
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	2	2	2	2	3
10yr	Total Loss	\$168,799	\$88,649	\$88,627	\$113,709	\$117,903
	Building (Structure) Loss	\$118,039	\$59,597	\$59,590	\$83,090	\$86,821
	Content Loss	\$50,760	\$29,053	\$29,037	\$30,620	\$31,083
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	5	3	3	4	4
25yr	Total Loss	\$373,559	\$294,383	\$298,027	\$247,719	\$221,094
	Building (Structure) Loss	\$261,338	\$205,730	\$208,353	\$177,985	\$162,636
	Content Loss	\$112,221	\$88,653	\$89,673	\$69,734	\$58,458
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	10	8	8	8	7
50yr	Total Loss	\$963,013	\$826,618	\$830,579	\$618,359	\$610,818
	Building (Structure) Loss	\$613,787	\$526,047	\$528,852	\$380,587	\$375,772
	Content Loss	\$349,226	\$300,571	\$301,727	\$237,772	\$235,046
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	16	14	14	11	10
100yr	Total Loss	\$1,222,795	\$1,124,301	\$1,101,439	\$882,839	\$900,401
	Building (Structure) Loss	\$786,756	\$726,459	\$710,101	\$551,465	\$564,930
	Content Loss	\$436,039	\$397,842	\$391,337	\$331,374	\$335,470
	Inventory Loss	\$0	\$0	\$0	\$0	\$0
	Count of Damaged Structures	23	22	21	15	16



Economics

Return Period	Loss Type	Alt 1 - No Action / FWOFI	Alt 2a - High Priority	Alt 2b -High and Medium	Alt 2c- 2 Stage High And Medium	Alt 4 - 2 Stage Only
500yr	Total Loss	\$2,418,579	\$2,052,848	\$2,004,748	\$1,924,003	\$1,932,604
	Building (Structure) Loss	\$1,375,043	\$1,235,092	\$1,204,910	\$1,175,582	\$1,179,756
	Content Loss	\$1,042,631	\$816,987	\$799,095	\$747,807	\$752,237
	Inventory Loss	\$904	\$768	\$744	\$614	\$611
	Count of Damaged Structures	39	38	36	35	36
Average Annualized Loss	Total Loss	\$83,901	\$69,257	\$69,004	\$58,499	\$59,082
	Building (Structure) Loss	\$55,047	\$45,262	\$45,107	\$39,791	\$40,461
	Content Loss	\$28,850	\$23,991	\$23,894	\$18,705	\$18,618
	Inventory Loss	\$4	\$3	\$3	\$2	\$2
	Count of Damaged Structures	39	38	36	35	36

D7.2.2. Road Damages

For the road damage estimate, the lidar data and hydraulic water surface grids from the H&H modeling results were used to determine the length of road overtopped for each frequency event within the watershed. The average depth of overtopping at each road for each frequency event was then calculated. The percent of road damage was based on depth damage equation derived from Global Flood Depth-Damage Functions, Huizinga et. al. (2017):

$$\% \text{ Damage} = -0.321(d)^2 + 11.19(d) + 2.241$$

Where d = the average depth of overtopping across each road

Based on an average repair/replacement cost of \$271.00 per foot of two-lane road in SE Missouri, the damages for each road segment at each frequency event was calculated with the following equation:

$$\text{Damage (\$)} = \text{Length (ft)} \times \% \text{ Damage} \times \$271/\text{ft}$$

The damages for each overtopped road segment for each frequency event were then summed for a total amount of road damage for each frequency event. **Table D7-2** shows the road damages for each alternative based on the frequency event.

Table D7-2. Summary of Road Damages

Return Period	Alternative 1		Alternative 2a		Alternative 2b	
	Overtopped Road Length (miles)	Road Damage (\$)	Overtopped Road Length (miles)	Road Damage (\$)	Overtopped Road Length (miles)	Road Damage (\$)
2-Yr	1.2	\$131,806	0.8	\$116,505	0.5	\$87,973
5-Yr	2.6	\$229,772	2.1	\$188,842	2.2	\$191,386
10-Yr	4.3	\$353,998	3.8	\$314,649	3.7	\$296,668
25-Yr	7.3	\$622,019	6.8	\$555,585	6.4	\$542,001
50-Yr	9.6	\$879,105	9.2	\$825,939	9.2	\$822,202
100-Yr	11.6	\$1,137,896	11.0	\$1,085,143	11.0	\$1,078,465
500-Yr	18.4	\$2,012,731	18.1	\$1,967,292	17.8	\$1,941,433
Annualized Damages	\$150,404		\$132,664		\$126,691	
Annualized Benefits	\$0		\$17,740		\$23,713	
Return Period	Alternative 2c		Alternative 3		Alternative 4	
	Overtopped Road Length (miles)	Road Damage (\$)	Overtopped Road Length (miles)	Road Damage (\$)	Overtopped Road Length (miles)	Road Damage (\$)
2-Yr	0.7	\$125,629	1.2	\$131,806	1.2	\$146,387
5-Yr	2.5	\$246,718	2.6	\$229,772	2.4	\$232,276
10-Yr	4.0	\$364,681	4.3	\$353,998	4.4	\$377,388
25-Yr	7.1	\$635,964	7.3	\$622,019	7.4	\$631,963



50-Yr	9.2	\$835,990	9.6	\$879,105	9.4	\$838,278
100-Yr	10.9	\$1,066,204	11.6	\$1,137,896	10.9	\$1,052,127
500-Yr	17.8	\$1,929,806	18.4	\$2,012,731	17.9	\$1,914,799
Annualized Damages	\$152,656		\$150,404		\$153,585	
Annualized Benefits	-\$2,252		\$0		-\$3,181	

D7.2.3. Agricultural Damages

For the agricultural damage estimate, the USDA National Agricultural Statistics Service (NASS) 2024 Cropland Data Layer was downloaded. This data was used in combination with the H&H modeling results (floodplain inundation areas and depth grid data) to develop agricultural grids necessary to calculate flood damage. **Table D7-3** provides the data used to estimate the value of lost crops due to flooding. 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. Using the data provided in **Table D7-3** and the agricultural grids, total crop damages were determined. **Tables D7-4** through **D7-8** detail the single-event crop damage information for the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year storm events for the stated alternative. **Table D7-9** provides a summary of agricultural losses.

Table D7-3. 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	\$889	\$12.70	BU	70	\$303.47
Corn (Assume Irrigated)	\$1,214.61	\$1,298	\$5.90	BU	220	\$83.39
Other Hay/Non-Alfalfa	\$159.60	\$172.90	\$133.00	ton	1.3	\$13.30
Cotton	\$816.33	\$1,400	\$0.80	lb.	1750	\$583.67
Rice	\$847.99	\$1,230.46	\$0.15	lb.	7990	\$382.47
Winter Wheat	\$518.50	\$542.50	\$7.75	BU	70	\$24.00

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

<https://extension.missouri.edu/media/wysiwyg/Extensiondata/Pro/AgBusinessPolicyExtension/Docs/2024-budgets.pdf>

Table D7-4. Agricultural Losses per Single Event (Alternative 1 - No Action/FWOFI)

Alternative 1: No Action/FWOFI		Acres in Watershed	Loss (Profit and Costs)	Total Loss per Event
2-yr	Corn	444	\$575,825	\$3,498,221
	Cotton	1146	\$1,603,781	
	Rice	13	\$15,978	
	Soybeans	1465	\$1,302,635	
	Winter Wheat	0	\$3	
	Other Hay/Non Alfalfa	0	\$0	
5-yr	Corn	641	\$831,455	\$5,160,920
	Cotton	1752	\$2,452,237	
	Rice	13	\$16,577	
	Soybeans	2093	\$1,860,641	
	Winter Wheat	0	\$10	
	Other Hay/Non Alfalfa	0	\$0	
10-yr	Corn	855	\$1,110,352	\$6,405,155
	Cotton	2193	\$3,070,129	
	Rice	14	\$16,783	
	Soybeans	2484	\$2,207,874	
	Winter Wheat	0	\$16	
	Other Hay/Non Alfalfa	0	\$0	
25-yr	Corn	1090	\$1,414,360	\$7,818,812
	Cotton	2699	\$3,778,700	
	Rice	14	\$17,089	
	Soybeans	2934	\$2,608,638	
	Winter Wheat	0	\$24	
	Other Hay/Non Alfalfa	0	\$0	
50-yr	Corn	1218	\$1,581,065	\$8,930,359
	Cotton	3192	\$4,468,609	
	Rice	14	\$17,280	
	Soybeans	3221	\$2,863,380	
	Winter Wheat	0	\$25	
	Other Hay/Non Alfalfa	0	\$0	
100-yr	Corn	1392	\$1,806,180	\$9,716,738
	Cotton	3471	\$4,859,595	
	Rice	14	\$17,450	
	Soybeans	3412	\$3,033,482	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$4	
500-yr	Corn	1697	\$2,203,013	\$11,375,620
	Cotton	4126	\$5,776,239	
	Rice	15	\$17,914	
	Soybeans	3800	\$3,378,421	
	Winter Wheat	0	\$28	
	Other Hay/Non Alfalfa	0	\$4	



Table D7-5. Agricultural Losses per Single Event (Alternative 2a)

Alternative 2: High Priority		Acres in Watershed	Loss (Profit and Costs)	Total Loss per Event
2-yr	Corn	375	\$486,933	\$3,056,412
	Cotton	1009	\$1,412,496	
	Rice	13	\$15,491	
	Soybeans	1284	\$1,141,490	
	Winter Wheat	0	\$2	
	Other Hay/Non Alfalfa	0	\$0	
5-yr	Corn	531	\$689,810	\$4,444,623
	Cotton	1514	\$2,119,738	
	Rice	13	\$16,119	
	Soybeans	1821	\$1,618,947	
	Winter Wheat	0	\$9	
	Other Hay/Non Alfalfa	0	\$0	
10-yr	Corn	758	\$983,637	\$5,968,126
	Cotton	2053	\$2,874,779	
	Rice	13	\$16,604	
	Soybeans	2354	\$2,093,090	
	Winter Wheat	0	\$17	
	Other Hay/Non Alfalfa	0	\$0	
25-yr	Corn	1045	\$1,356,824	\$7,578,478
	Cotton	2625	\$3,674,854	
	Rice	14	\$17,055	
	Soybeans	2846	\$2,529,721	
	Winter Wheat	0	\$24	
	Other Hay/Non Alfalfa	0	\$0	
50-yr	Corn	1193	\$1,548,295	\$8,774,376
	Cotton	3140	\$4,396,525	
	Rice	14	\$17,224	
	Soybeans	3163	\$2,812,306	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$0	
100-yr	Corn	1272	\$1,651,031	\$9,514,766
	Cotton	3450	\$4,829,998	
	Rice	14	\$17,379	
	Soybeans	3393	\$3,016,328	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$4	
500-yr	Corn	1689	\$2,192,036	\$11,346,333
	Cotton	4118	\$5,765,318	
	Rice	15	\$17,867	
	Soybeans	3792	\$3,371,080	
	Winter Wheat	0	\$28	
	Other Hay/Non Alfalfa	0	\$4	



Table D7-6. Agricultural Losses per Single Event (Alternative 2b)

Alternative 3: High & Med Priority		Acres in Watershed	Loss (Profit and Costs)	Total Loss per Event
2-yr	Corn	362	\$470,122	\$2,482,328
	Cotton	748	\$1,047,774	
	Rice	12	\$14,854	
	Soybeans	1068	\$949,578	
	Winter Wheat	0	\$0	
	Other Hay/Non Alfalfa	0	\$0	
5-yr	Corn	529	\$687,121	\$4,110,790
	Cotton	1373	\$1,921,935	
	Rice	13	\$15,513	
	Soybeans	1672	\$1,486,217	
	Winter Wheat	0	\$4	
	Other Hay/Non Alfalfa	0	\$0	
10-yr	Corn	691	\$896,298	\$5,486,046
	Cotton	1883	\$2,635,749	
	Rice	13	\$16,214	
	Soybeans	2180	\$1,937,772	
	Winter Wheat	0	\$14	
	Other Hay/Non Alfalfa	0	\$0	
25-yr	Corn	987	\$1,280,788	\$7,312,506
	Cotton	2539	\$3,554,618	
	Rice	14	\$17,047	
	Soybeans	2767	\$2,460,031	
	Winter Wheat	0	\$23	
	Other Hay/Non Alfalfa	0	\$0	
50-yr	Corn	1186	\$1,539,902	\$8,655,780
	Cotton	3075	\$4,304,963	
	Rice	14	\$17,201	
	Soybeans	3143	\$2,793,690	
	Winter Wheat	0	\$25	
	Other Hay/Non Alfalfa	0	\$0	
100-yr	Corn	1279	\$1,659,927	\$9,471,980
	Cotton	3422	\$4,791,211	
	Rice	14	\$17,383	
	Soybeans	3378	\$3,003,429	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$4	
500-yr	Corn	1699	\$2,204,718	\$11,198,423
	Cotton	4011	\$5,615,497	
	Rice	15	\$17,910	
	Soybeans	3780	\$3,360,266	
	Winter Wheat	0	\$27	
	Other Hay/Non Alfalfa	0	\$4	



Table D7-7. Agricultural Losses per Single Event (Alternative 2c)

Alternative 4: 2-Stage High & Med Priority		Acres in Watershed	Loss (Profit and Costs)	Total Loss per Event
2-yr	Corn	403	\$523,093	\$2,725,374
	Cotton	831	\$1,163,599	
	Rice	13	\$15,599	
	Soybeans	1151	\$1,023,084	
	Winter Wheat	0	\$0	
	Other Hay/Non Alfalfa	0	\$0	
5-yr	Corn	573	\$743,884	\$4,458,664
	Cotton	1479	\$2,071,183	
	Rice	14	\$16,734	
	Soybeans	1830	\$1,626,859	
	Winter Wheat	0	\$4	
	Other Hay/Non Alfalfa	0	\$0	
10-yr	Corn	778	\$1,009,289	\$5,767,932
	Cotton	1918	\$2,684,513	
	Rice	14	\$17,189	
	Soybeans	2314	\$2,056,928	
	Winter Wheat	0	\$14	
	Other Hay/Non Alfalfa	0	\$0	
25-yr	Corn	989	\$1,283,146	\$7,557,057
	Cotton	2675	\$3,745,099	
	Rice	14	\$17,400	
	Soybeans	2825	\$2,511,388	
	Winter Wheat	0	\$23	
	Other Hay/Non Alfalfa	0	\$0	
50-yr	Corn	1170	\$1,518,151	\$8,537,062
	Cotton	3023	\$4,231,554	
	Rice	14	\$17,631	
	Soybeans	3116	\$2,769,701	
	Winter Wheat	0	\$25	
	Other Hay/Non Alfalfa	0	\$0	
100-yr	Corn	1272	\$1,651,428	\$9,354,885
	Cotton	3358	\$4,701,153	
	Rice	14	\$17,801	
	Soybeans	3357	\$2,984,478	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$0	
500-yr	Corn	1644	\$2,133,410	\$11,175,101
	Cotton	4028	\$5,638,655	
	Rice	15	\$18,297	
	Soybeans	3807	\$3,384,710	
	Winter Wheat	0	\$27	
	Other Hay/Non Alfalfa	0	\$1	



Table D7-8. Agricultural Losses per Single Event (Alternative 4)

Alternative 5: 2-Stage Only		Acres in Watershed	Loss (Profit and Costs)	Total Loss per Event
2-yr	Corn	416	\$540,252	\$3,301,901
	Cotton	1119	\$1,565,995	
	Rice	13	\$16,270	
	Soybeans	1327	\$1,179,382	
	Winter Wheat	0	\$2	
	Other Hay/Non Alfalfa	0	\$0	
5-yr	Corn	634	\$823,040	\$4,765,589
	Cotton	1584	\$2,217,768	
	Rice	14	\$16,989	
	Soybeans	1921	\$1,707,782	
	Winter Wheat	0	\$9	
	Other Hay/Non Alfalfa	0	\$0	
10-yr	Corn	850	\$1,102,909	\$6,186,878
	Cotton	2100	\$2,939,793	
	Rice	14	\$17,216	
	Soybeans	2393	\$2,126,944	
	Winter Wheat	0	\$17	
	Other Hay/Non Alfalfa	0	\$0	
25-yr	Corn	1115	\$1,446,675	\$7,888,766
	Cotton	2765	\$3,870,815	
	Rice	14	\$17,483	
	Soybeans	2873	\$2,553,767	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$0	
50-yr	Corn	1177	\$1,527,407	\$8,634,686
	Cotton	3074	\$4,303,222	
	Rice	14	\$17,651	
	Soybeans	3134	\$2,786,381	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$0	
100-yr	Corn	1294	\$1,679,710	\$9,439,138
	Cotton	3394	\$4,751,634	
	Rice	14	\$17,800	
	Soybeans	3363	\$2,989,967	
	Winter Wheat	0	\$26	
	Other Hay/Non Alfalfa	0	\$0	
500-yr	Corn	1648	\$2,139,327	\$11,365,111
	Cotton	4139	\$5,793,970	
	Rice	15	\$18,307	
	Soybeans	3840	\$3,413,479	
	Winter Wheat	0	\$28	
	Other Hay/Non Alfalfa	0	\$1	

Table D7-9. Summary of Agricultural Losses

Flood Event	Alternative 1: No Action/FWOFI		Alternative 2a				Alternative 2b		
	Acres	Total Loss per Event	Acres	Total Loss per Event	Benefit	Acres	Total Loss per Event	Benefits	
2-yr	3067	\$3,498,221	2681	\$3,056,412	\$441,808	2191	\$2,482,328	\$1,015,892	
5-yr	4499	\$5,160,920	3880	\$4,444,623	\$716,296	3587	\$4,110,790	\$1,050,130	
10-yr	5546	\$6,405,155	5179	\$5,968,126	\$437,029	4766	\$5,486,046	\$919,109	
25-yr	6737	\$7,818,812	6530	\$7,578,478	\$240,334	6307	\$7,312,506	\$506,306	
50-yr	7645	\$8,930,359	7511	\$8,774,376	\$155,984	7418	\$8,655,780	\$274,579	
100-yr	8289	\$9,716,738	8129	\$9,514,766	\$201,972	8094	\$9,471,980	\$244,758	
500-yr	9638	\$11,375,620	9613	\$11,346,333	\$29,287	9504	\$11,198,423	\$177,197	
Annualized Damages	\$2,648,990				2,390,610			\$2,185,769	
			Annualized Benefit		\$258,400	Annualized Benefit		\$463,200	
Flood Event	Alternative 2c			Alternative 3			Alternative 4		
	Acres	Total Loss per Event	Benefit	Acres	Total Loss per Event	Benefit	Acres	Total Loss per Event	Benefit
2-yr	2,398	\$2,725,374	\$772,846	0	0	\$3,498,221	2,875	\$3,301,901	\$196,319
5-yr	3,896	\$4,458,664	\$702,256	0	0	\$5,160,920	4,153	\$4,765,589	\$395,331
10-yr	5,023	\$5,767,932	\$637,223	0	0	\$6,405,155	5,356	\$6,186,878	\$218,277
25-yr	6,503	\$7,557,057	\$261,755	0	0	\$7,818,812	6,766	\$7,888,766	-\$69,954
50-yr	7,322	\$8,537,062	\$393,297	0	0	\$8,930,359	7,399	\$8,634,686	\$295,673
100-yr	8,002	\$9,354,885	\$361,853	0	0	\$9,716,738	8,066	\$9,439,138	\$277,600
500-yr	9,493	\$11,175,101	\$200,519	1348	\$1,658,882	\$9,716,738	9,641	\$11,365,111	\$10,509
Annualized Damages			\$2,321,206			\$8,294			\$2,518,837
	Annualized Benefit		\$327,800	Annualized Benefit		\$2,640,696	Annualized Benefit		\$130,200

D7.2.4. Sediment Damages

Ditch bank erosion is noticeable in many areas and based on the equations presented Section 5.2.4 of this appendix produces an estimated 11,000 tons/year of sediment in the “high” priority segments and an additional 24,000 tons/year in the “medium” priority segments. This is equivalent to 8,000 cubic yards per year and 17,500 cubic yards per year respectively. Assuming \$15 per cubic yard for sediment removal and disposal, this equates to roughly \$122,000 per year for “high” priority segments and \$264,000 per year for “medium” priority segments. It was assumed for benefit comparison purposes that rip rap toe protection and parallel slope protection drains will effectively reduce erosion in the modified ditches to negligible levels. It was also assumed that 2-stage channel modifications (alternatives 2c and 4) were equivalent in erosion reduction to rip rap toe protection and parallel slope protection drains. Erosion/sediment reduction benefits are not calculated based flood frequency events but simply on an annual basis. Erosion/sediment damages and damage reduction benefits for each alternative are summarized in Table D7-10:

Table D7-10. Summary of Sediment Damages

Alternative	Bank Erosion (Tons/Yr)	Sediment Removal /Disposal (CY/Yr)	Annualized Sediment Damage Costs (\$/Yr)	Annualized Sediment Damage Reduction Benefits (\$/Yr)
Alt 1	34,700	25,700	\$385,400	\$0
Alt 2a	23,700	17,600	\$263,700	\$121,700
Alt 2b	0	0	\$0	\$385,400
Alt 2c	0	0	\$0	\$385,400
Alt 3	34,700	27,700	\$385,400	\$0
Alt 4	23,700	17,600	\$385,400	\$121,700

D7.2.5. Project Damages Summary

The following Table D7-11 provides a summary of total combined expected annual damages (EAD), including both flood-related and sediment-related damage components, as estimated for existing (without-project) and alternative conditions within the Project Area.

Table D7-11. Combined Annual Damages by Alternative

Scenario	Estimated Annual Damage ^{1,2}
Alternative 1: No Action/FWOFI	\$3,268,680
Alternative 2a: High Priority	\$2,856,220
Alternative 2b: High & Med. Priority	\$2,381,464
Alternative 2c: 2-Stage High & Med. Priority	\$2,532,361
Alternative 3: Nonstructural	\$547,207
Alternative 4: 2-Stage Only	\$2,995,194



¹ Price Base 2026.

² Calculated using the FY 26 discount rate of 3.25% over a period of 52 years (50-year design life plus 2 years for design and construction). This value includes agricultural, structural, roads, and sediment damages.

The nonstructural alternative assumes that all cropland acres located within the 100-year floodplain would be protected through the implementation of conservation easements, and that all 23 structures within the 100-year floodplain would be acquired through a voluntary buyout program. Unit costs of \$8,500 per acre for conservation easements and \$100,000 per structure for buyouts were applied in the analysis.

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 D7-12**).



Table D7-12. Combined Annual Flood Damage Calculation (Includes Agriculture, Structures, and Road Damages)

Annual Flood Damage Estimate – Alternative 1: No Action/FWOFI						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$3,662,474			
		0.3		\$4,565,241	\$1,369,572	\$1,369,572
5-yr	0.2		\$5,468,008			
		0.1		\$6,197,980	\$619,798	\$1,989,370
10-yr	0.1		\$6,927,952			
		0.06		\$7,871,171	\$472,270	\$2,461,641
25-yr	0.04		\$8,814,390			
		0.02		\$9,793,434	\$195,869	\$2,657,509
50-yr	0.02		\$10,772,477			
		0.01		\$11,424,953	\$114,250	\$2,771,759
100-yr	0.01		\$12,077,429			
		0.008		\$13,942,180	\$111,537	\$2,883,296
500-yr	0.002		\$15,806,930			
Annual Flood Damage Estimate – Alternative 2a: High Priority						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$3,204,086			
		0.3		\$3,956,238	\$1,186,871	\$1,186,871
5-yr	0.2		\$4,708,389			
		0.1		\$5,539,907	\$553,991	\$1,740,862
10-yr	0.1		\$6,371,424			
		0.06		\$7,399,935	\$443,996	\$2,184,858
25-yr	0.04		\$8,428,447			
		0.02		\$9,427,690	\$188,554	\$2,373,412
50-yr	0.02		\$10,426,932			
		0.01		\$11,075,571	\$110,756	\$2,484,168



Annual Flood Damage Estimate – Alternative 2a: High Priority						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
100-yr	0.01		\$11,724,210			
		0.008		\$13,545,341	\$108,363	\$2,592,530
500-yr	0.002		\$15,366,472			
Annual Flood Damage Estimate – Alternative 2b: High & Med Priority						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$2,601,401			
		0.3		\$3,489,130	\$1,046,739	\$1,046,739
5-yr	0.2		\$4,376,859			
		0.1		\$5,124,100	\$512,410	\$1,559,149
10-yr	0.1		\$5,871,340			
		0.06		\$7,011,937	\$420,716	\$1,979,865
25-yr	0.04		\$8,152,534			
		0.02		\$9,230,548	\$184,611	\$2,164,476
50-yr	0.02		\$10,308,561			
		0.01		\$10,980,223	\$109,802	\$2,274,278
100-yr	0.01		\$11,651,884			
		0.008		\$13,398,244	\$107,186	\$2,381,464
500-yr	0.002		\$15,144,604			
Annual Flood Damage Estimate – Alternative 2c: 2-Stage and High & Med Priority						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$2,851,004			
		0.3		\$3,814,635	\$1,144,390	\$1,144,390
5-yr	0.2		\$4,778,266			
		0.1		\$5,512,294	\$551,229	\$1,695,620



10-yr	0.1		\$6,246,322			
		0.06		\$7,343,531	\$440,612	\$2,136,232
25-yr	0.04		\$8,440,739			
		0.02		\$9,216,075	\$184,322	\$2,320,553
50-yr	0.02		\$9,991,411			
		0.01		\$10,647,670	\$106,477	\$2,427,030
100-yr	0.01		\$11,303,928			
		0.008		\$13,166,419	\$105,331	\$2,532,361
500-yr	0.002		\$15,028,910			
Annual Flood Damage Estimate – Alternative 3: Nonstructural						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$131,806			
		0.3		\$180,789	\$54,237	\$54,237
5-yr	0.2		\$229,772			
		0.1		\$291,885	\$29,188	\$83,425
10-yr	0.1		\$353,998			
		0.06		\$488,009	\$29,281	\$112,706
25-yr	0.04		\$622,019			
		0.02		\$750,562	\$15,011	\$127,717
50-yr	0.02		\$879,105			
		0.01		\$1,008,501	\$10,085	\$137,802
100-yr	0.01		\$1,137,896			
		0.008		\$3,002,647	\$30,026	\$167,828
500-yr	0.002		\$4,867,397			
Annual Flood Damage Estimate – Alternative 4: 2-Stage Only						
Return Interval	Probability	Probability Interval	Damages per Single Event (\$)	Interval Average Damages (\$)	Interval Damage Calculation (\$)	Summary Expected Annual Damages (\$)
2-yr	0.5		\$3,301,901			
		0.3		\$4,033,745	\$1,210,124	\$1,210,124
5-yr	0.2		\$4,765,589			



Economics

		0.1		\$5,476,234	\$547,623	\$1,757,747
10-yr	0.1		\$6,186,878			
		0.06		\$7,037,822	\$422,269	\$2,180,016
25-yr	0.04		\$7,888,766			
		0.02		\$8,261,726	\$165,235	\$2,345,251
50-yr	0.02		\$8,634,686			
		0.01		\$9,036,912	\$90,369	\$2,435,620
100-yr	0.01		\$9,439,139			
		0.008		\$10,402,125	\$83,217	\$2,518,837
500-yr	0.002		\$11,365,111			

D7.3. Benefit/Cost Analysis (BCA)

Following the estimation and annualization of damages for each alternative, capital construction costs, project administration expenses, and long-term operation and maintenance (O&M) costs were incorporated into a comprehensive benefit-cost analysis (BCA). The analysis was conducted over a 52-year evaluation period, consisting of a 50-year project life preceded by one year of design and one year of construction, consistent with standard federal water resources planning guidance.

Each alternative was evaluated by comparing the present value of total benefits (e.g., avoided damages, risk reduction, and other monetized impacts) to the present value of total project costs, with both benefits and costs converted to equivalent annual values using the applicable federal discount rate. Key performance metrics include the benefit-cost ratio (BCR) and annualized net monetized benefits (i.e., annual benefits minus annual costs).

The nonstructural alternative assumes that all cropland acres located within the 100-year floodplain would be protected through the implementation of conservation easements, and that all 23 structures within the 100-year floodplain would be acquired through a voluntary buyout program. Unit costs of \$8,500 per acre for conservation easements and \$100,000 per structure for buyouts were applied in the analysis. Based on these assumptions, a benefit-cost (B/C) analysis was conducted, resulting in a B/C ratio of 0.8 for the nonstructural alternative.

While a BCR greater than or equal to 1.0 generally indicates that an alternative is economically justified, BCRs and net benefits alone are not sufficient to determine the most cost-efficient or preferred alternative. Incremental cost-effectiveness, sensitivity to key assumptions, and diminishing returns at higher investment levels must also be considered. In addition, non-monetized factors including engineering feasibility, environmental and social impacts, regulatory compliance, constructability, and consistency with project objectives—are critical components of the overall alternatives evaluation and selection process. Detailed results of the economic analysis are provided in **Table D7-13**.

Table D7-13. Benefit/Cost Ratio (BCR)

Scenario	Est. Annual Damage ^{1,2}	Est. Annual Damage Benefit ³	Average Annual Costs	B/C Ratio (50-yr)
Alternative 1: No Action/FWOFI	\$3,268,680		\$12,900	
Alternative 2a: High Priority	\$2,856,220	\$412,460	\$300,500	1.4
Alternative 2b: High & Med. Priority	\$2,381,464	\$887,216	\$693,500	1.3
Alternative 2c: 2-Stage High & Med. Priority	\$2,532,361	\$736,319	\$779,400	1.0
Alternative 3: Nonstructural	\$547,207	\$2,721,473	\$3,523,600	0.8
Alternative 4: 2-Stage Only	\$2,995,194	\$273,486	\$357,400	0.8

¹ Price Base 2026.

² Calculated using the FY 26 discount rate of 3.25% over a period of 52 years (50-year design life plus 2 years for design and construction).

³ Difference between damages occurring under No Action/FWOFI minus the damages occurring under each alternative.

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. **Table D7-14** summarizes the raw Project Alternative Cost Estimates. All costs will be rounded to the nearest \$100 for subsequent analyses in this study.

For the preliminary plan, the following 5 conceptual cost options are presented to support Sponsor review during the preliminary planning stage:

- Alternative 2a (High Priority reaches),
- Alternative 2b (High and Medium Priority reaches),
- Alternative 2c (2-Stage and High and Medium Priority reaches), and
- Alternative 3 (Nonstructural – Floodplain Conservation Easements and Buyouts)
- Alternative 4 (2-Stage only).

Detailed line-item installation estimates for each option are provided in **Tables D7-15** through **D7-19**.

Table D7-14. Project Alternative Cost Estimates

ITEM	No Action/Future Without Federal Investment ²	Project Alternatives ¹				
		Alternative 2a	Alternative 2b	Alternative 2c	Alternative 3	Alternative 4
Total Construction Cost	-	\$5,827,500	\$13,739,000	\$14,778,300	-	\$6,262,200
NRCS - Construction	-	\$5,827,500	\$13,739,000	\$14,778,300	-	\$6,262,200
Sponsor - Construction	-	-	-	-	-	-
NRCS - Easements³	-	-	-	\$600,000	\$60,807,500	\$600,000
Sponsor - Easements³	-	-	-	-	\$20,269,200	-
Real Property	-	-	--		\$2,300,000	-
NRCS - Project Design, Construction Engineering	-	\$874,100	\$2,060,900	\$2,306,700	-	\$1,029,300
Sponsor - Project Design, Construction Engineering	-	-	-	-	-	-
NRCS - Project Administration³	-	\$218,500	\$515,200	\$576,700	\$3,126,600	\$257,300
Sponsor - Project Administration³	-	\$72,800	\$171,700	\$192,200	\$1,042,200	\$85,800
Federal, State and Local Permits	-	\$10,000	\$10,000	\$10,000	-	\$10,000
Total Installation Cost	-	\$7,002,900	\$16,496,800	\$18,463,900	\$87,545,500	\$8,244,600

¹ Price Base 2026.

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

³ Assumes 75% NRCS /25% Sponsor cost share for floodplain conservation easement (share determined by State Conservationist based on comparison with other federal programs) and project administration.



Table D7-15. Estimated Installation Cost – Alternative 2a

Line	Item	Quantity	Unit	Unit Cost	Total
1	Grade Stabilization Structures	7	Each	\$50,000.00	\$350,000.00
2	Existing Subsurface Drain Outlet Protection	34	Each	\$1,500.00	\$51,000.00
3	Bank protection at crossings - Rip Rap	6500	tons	\$44.00	\$286,000.00
4	Bank protection at crossings - Bedding	3500	tons	\$44.00	\$154,000.00
5	Mobilization	1	LS	\$50,000.00	\$50,000.00
6	20' Vegetative Buffer - High Priority Areas	29	Acres	\$1,500.00	\$43,500.00
7	Channel Excavation High priority areas	99000	cu yds	\$3.00	\$297,000.00
8	Channel Compacted Earthfill High priority areas	9000	cu yds	\$5.00	\$45,000.00
9	Riprap - D50 = 6"	46000	tons	\$38.00	\$1,748,000.00
10	Stone Bedding	26000	tons	\$44.00	\$1,144,000.00
11	Excavation*	44000	cu yds	\$3.00	\$132,000.00
12	Erosion Control Blanket	102000	sq yds	\$2.00	\$204,000.00
13	Seeding	20	acres	\$1,500.00	\$30,000.00
14	4" Dia. Cor. Plastic Tubing - High priority areas	52536	L.F.	\$2.00	\$105,072.00
15	Outlet Markers	64	Each	\$100.00	\$6,400.00
16	Riprap - D50 = 12"	350	tons	\$44.00	\$15,400.00
17	Excavation*	220	cu yds	\$3.00	\$660.00
Subtotal 1:					\$4,662,032
Erosion and Sediment Control:				5%	\$233,102
Dewatering:				5%	\$233,102
Construction Contingency:				15%	\$699,305
Subtotal 2:					\$5,827,540
Permitting:					\$10,000
Easement Acquisition (Construction Easements):					
Subtotal 3:					\$5,837,540
Project Design, Construction Engineering, Contracting, Inspection:				15%	\$874,131
Project Administration:				5%	\$291,377
Total:					\$7,003,048



Table D7-16. Estimated Installation Cost – Alternative 2b

Line	Item	Quantity	Unit	Unit Cost	Total
1	Grade Stabilization Structures	7	Each	\$50,000	\$350,000
2	Existing Subsurface Drain Outlet Protection	34	Each	\$1,500	\$51,000
3	Bank protection at crossings - Rip Rap	6500	tons	\$44	\$286,000
4	Bank protection at crossings - Bedding	3500	tons	\$44	\$154,000
5	Mobilization	1	LS	\$50,000	\$50,000
6	20' Vegetative Buffer - High Priority Areas	81	Acres	\$1,500	\$121,500
7	Channel Excavation High priority areas	164000	cu yds	\$3	\$492,000
8	Channel Compacted Earthfill High priority areas	16,000	cu yds	\$5	\$80,000
9	Riprap - D50 = 6"	130000	tons	\$38	\$4,940,000
10	Stone Bedding	72000	tons	\$44	\$3,168,000
11	Excavation*	124000	cu yds	\$3	\$372,000
12	Erosion Control Blanket	288000	sq yds	\$2	\$576,000
13	Seeding	55	acres	\$1,500	\$82,500
14	4" Dia. Cor. Plastic Tubing - High priority areas	110616	L.F.	\$2	\$221,232
15	Outlet Markers	135	Each	\$100	\$13,500
16	Riprap - D50 = 12"	730	tons	\$44	\$32,120
17	Excavation*	460	cu yds	\$3	\$1,380
				Subtotal 1:	\$10,991,232
				Erosion and Sediment Control:	5% \$549,562
				Dewatering:	5% \$549,562
				Construction Contingency:	15% \$1,648,865
				Subtotal 2:	\$13,739,040
				Permitting:	\$10,000
				Easement Acquisition (Construction Easements):	
				Subtotal 3:	\$13,749,040
				Project Design, Construction Engineering, Contracting, Inspection:	15% \$2,060,856
				Project Administration:	5% \$686,952
				Total:	\$16,496,848



Table D7-17. Estimated Installation Cost – Alternative 2c

Line	Item	Quantity	Unit	Unit Cost	Total
1	Grade Stabilization Structures	7	Each	\$50,000	\$350,000
2	Existing Subsurface Drain Outlet Protection	34	Each	\$1,500	\$51,000
3	Bank protection at crossings - Rip Rap	6500	tons	\$44	\$286,000
4	Bank protection at crossings - Bedding	3500	tons	\$44	\$154,000
5	Mobilization	1	LS	\$50,000	\$50,000
6	20' Vegetative Buffer - High & Med Priority Areas	81	Acres	\$1,500	\$121,500
7	Channel Excavation 2-stagehigh & med. priority areas	426,000	cu yds	\$3	\$1,278,000
8	Channel Comp Earthfill 2-stagehigh & med. priority areas	39,000	cu yds	\$5	\$195,000
9	Bridge Modification/Replacement	3	Each	\$873,000	\$2,619,000
10	Riprap - D50 = 6"	84000	tons	\$38	\$3,192,000
11	Stone Bedding	46000	tons	\$44	\$2,024,000
12	Excavation*	80000	cu yds	\$3	\$240,000
13	Erosion Control Blanket	433200	sq yds	\$2	\$866,400
14	Seeding	85	acres	\$1,500	\$127,500
15	4" Dia. Cor. Plastic Tubing - High priority areas	110616	L.F.	\$2	\$221,232
16	Outlet Markers	135	Each	\$100	\$13,500
17	Riprap - D50 = 12"	730	tons	\$44	\$32,120
18	Excavation*	460	cu yds	\$3	\$1,380
Subtotal 1:					\$11,822,632
Erosion and Sediment Control:				5%	\$591,132
Dewatering:				5%	\$591,132
Construction Contingency:				15%	\$1,773,395
Subtotal 2:					\$14,778,290
Permitting:					\$10,000
Land Acquisition:					\$600,000
Subtotal 3:					\$15,388,290
Project Design, Construction Engineering, Contracting, Inspection:				15%	\$2,306,744
Project Administration:				5%	\$768,915
Total:					\$18,463,948

**Table D7-18. Estimated Installation Cost – Alternative 3 – Nonstructural Alternative**

Line	Item	Quantity	Unit	Unit Cost	Total
1	Floodplain Conservation Easement (100-Yr Floodplain Area)	8259	Acre	\$8,500	\$70,201,500
2	Structure Buyouts	23	Each	\$100,000	\$2,300,000
				Subtotal 1:	\$72,501,500
				Construction Contingency: 15%	\$10,875,225
				Subtotal 2:	\$83,376,725
				Project Administration: 5%	\$4,168,836
				Total:	\$87,545,561



Table D7-19. Estimated Installation Cost – Alternative 4

Line	Item	Quantity	Unit	Unit Cost	Total
1	Grade Stabilization Structures	7	Each	\$50,000	\$350,000
2	Existing Subsurface Drain Outlet Protection	34	Each	\$1,500	\$51,000
3	Bank protection at crossings - Rip Rap	6500	tons	\$44	\$286,000
4	Bank protection at crossings - Bedding	3500	tons	\$44	\$154,000
5	Mobilization	1	LS	\$50,000	\$50,000
6	20' Vegetative Buffer - 2 Stage Only	29	Acres	\$1,500	\$43,500
7	Channel Excavation 2-stage	334,945	cu yds	\$3	\$1,004,835
8	Channel Comp Earthfill 2-stage	23,209	cu yds	\$5	\$116,045
9	Bridge Modification/Replacement	3	Each	\$873,000	\$2,619,000
10	Erosion Control Blanket	145,200	sq yds	\$2	\$290,400
11	Seeding	30	acres	\$1,500	\$45,000
Subtotal 1:					\$5,009,780
Erosion and Sediment Control:				5%	\$250,489
Dewatering:				5%	\$250,489
Construction Contingency:				15%	\$751,467
Subtotal 2:					\$6,262,225
Permitting:					\$10,000
Land Acquisition:					\$600,000
Subtotal 3:					\$6,872,225
Project Design, Construction Engineering, Contracting, Inspection:				15%	\$1,029,334
Project Administration:				5%	\$343,111
Total:					\$8,244,670

D7.5. Comparative Cost Analysis

A comparative cost analysis was completed for alternative plans carried forward for detailed study, which is shown in **Table D7-20**. Cost items include construction-related activities (mobilization, clearing and grubbing, erosion and sediment control, site work, earthwork, fencing, and seeding) and engineering activities (surveys, design, construction observation, contracting/inspection, and project administration).

Table D7-20. Comparative Cost Analysis of Alternative Plans

ITEM	Project Alternative ¹					
	No Action/Future Without Federal Investment ³	Alternative 2a	Alternative 2b	Alternative 2c	Alternative 3	Alternative 4
Total Investment	-	\$7,002,900	\$16,496,800	\$18,463,900	\$87,545,500	\$8,244,600
P.L. 83-566 Funds	-	\$6,920,100	\$16,315,100	\$17,661,700	\$63,934,100	\$7,548,800
Other Funds	-	\$82,800	\$181,700	\$802,200	\$23,611,400	\$695,800
Average Annual Benefits ²	-	\$412,600	\$887,200	\$736,400	\$2,721,500	\$779,400
Average Annual Costs ²	-	\$300,500	\$693,500	\$779,400	\$3,523,600	\$357,400
Annual Net Beneficial	-	\$112,100	\$193,700	\$(43,000)	\$(802,100)	\$422,000
Average Annual O&M Costs	\$12,900	\$19,700	\$32,000	\$39,000	\$12,900	\$26,800

¹ Price Base 2026

² Amortized over 52 years at a discount rate of 3.25 percent. Amortization values on this row include Average Annual O&M Costs presented in last row of table.

³ All costs are Average Annual Costs. No construction costs are associated with this alternative.

As presented in **Table D7-20**, Alternatives 2a, 2b, and 4 produce positive annualized benefits when assessed over the project planning horizon using standard economic evaluation procedures (e.g., discounting to present value and converting to equivalent annual benefits). Alternative 2b yields the highest estimated annual monetized net benefit, reflecting greater gross benefits associated with enhanced performance (e.g., increased damage reduction, improved system reliability, or expanded level of service). However, this alternative also requires substantially higher initial capital investment and corresponding increases in annualized costs.

Alternative 2a is identified as the preferred alternative based on its more favorable economic efficiency. Specifically, it achieves positive net annual benefits at a lower total project cost and produces the highest benefit-cost ratio among the alternatives evaluated. This indicates that Alternative 2a maximizes return on investment per dollar expended while still delivering meaningful project benefits, making it the most cost-effective and economically justified option under current assumptions and evaluation criteria.

These results reflect preliminary quantities, conceptual designs, and planning-level unit costs may be refined as project design advances and benefit assumptions are further developed.

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 and the county within the Subwatershed. **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 are provided by the USCB ACS estimates for years 2018 through 2022. Based on the USCB data, the Project Area is in a county with a relatively small population. Per capita income and median household income are lower in the county than the state median. Further, the percentage of persons living below the poverty line in the county exceeds the state percentage.

The economy of Stoddard County is based primarily on manufacturing (21 percent) and management occupations (Data USA 2022). Agriculture (cultivated crops and pastureland) is the dominant land use in the Subwatershed, accounting for approximately 87 percent of the land area, and accounts for approximately 71 percent of the land in the Project Area. This land use, specifically row-crop production, directly employs approximately 9 to 12 percent of the county's workforce, which can contribute 10 to 35 percent of household income, depending on crop prices (MDA 2021, USCB 2020, and 2023a-p).

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	6,168,000	38.9	2,485,000	\$34,400	\$61,043	12.6%
Stoddard County	28,400	41.3	11,600	\$27,400	\$51,700	16.5%
Malden	3,818	38.6	1,554	\$22,813	\$38,786	23.3%
Bernie	1,872	48.2	760	\$22,014	\$42,417	17.2%

Source: USCB, 2018-2022 ACS (5-Year Estimates)

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

Geography	Per Capita Income ¹	MHI ¹	MHI < \$50,000 ²	MHI \$50,000-\$100,000 ²	MHI \$100,000-\$200,000 ²	MHI > \$200,000 ²
State of Missouri	\$34,400	\$61,043	36.5%	30.8%	24.6%	8.1%
Stoddard County	\$27,400	\$51,700	47.1%	31.7%	19.2%	2.0%
Malden	\$22,813	\$38,786	60.9%	26.9%	9.7%	2.5%
Bernie	\$22,014	\$42,417	55.4%	30.4%	13.8%	0.4%

Sources: USCB, 2018-2022 ACS (5-Year Estimates)¹; Census Reporter 2023 ACS (5-Year Estimates)²

Regarding educational attainment, the population in the county has lower levels of higher education than the state average (see **Table D8-3**).

Table D8-3. Educational Attainment

Geography	Population ¹	High School Diploma or Higher ²	Bachelor's Degree or Higher ²
State of Missouri	6,168,000	91.6%	33.2%
Stoddard County	28,400	82.4%	16.4%
Malden	3,818	80.9%	8.4%
Bernie	1,872	41.4%	15.0%

Sources: USCB, 2018-2022 ACS (5-Year Estimates)¹; Census Reporter 2023 ACS (5-Year Estimates)²

Regarding housing, the percentage of owner-occupied housing in Stoddard County and the town of Bernie is generally in line with the state average. However, Malden has a lower owner-occupied rate (see **Table D8-4**).

Table D8-4. Occupied Housing Units by Tenure

Geography	Households ¹	Owner Occupied ²	Renter Occupied ²
State of Missouri	2,485,000	67.9%	32.1%
Stoddard County	11,600	70.7%	29.3%
Malden	1,554	51.5%	48.5%
Bernie	760	68.4%	31.7%

Sources: USCB, 2018-2022 ACS (5-Year Estimates)¹; Census Reporter 2023 ACS (5-Year Estimates)²

Regarding race in the Subwatershed, the area is predominantly White with little diversity (see **Table D8-5**).

Table D8-5. Racial and Ethnic Composition

Geography	Population ¹	White ²	Black ²	Hispanic ²	Other ²
State of Missouri	6,168,000	4,737,581	680,587	311,924	437,908
Stoddard County	28,400	26,586	275	597	942
Malden	3,818	2,986	528	162	142
Bernie	1,872	1,592	33	65	182

Sources: USCB, 2018-2022 ACS (5-Year Estimates)¹; Census Reporter 2023 ACS (5-Year Estimates)²

The median population age of the county is in line with state averages; however, the population aged 65 years and older is slightly higher in the county. The town of Bernie is the exception, with a higher median age than the county and state. The city also has a higher proportion of residents aged 65 years and over compared to the other towns, Stoddard County, and the State of Missouri (see **Table D8-6**).

Table D8-6. Age Distribution

Geography	Median Age ¹	Under 18 Years ²	18 Years and Over ²	65 Years or Over ²
State of Missouri	38.9	22.5%	60.0%	17.5%
Stoddard County	41.3	22.3%	57.3%	20.4%
Malden	38.6	28.1%	54%	17.9%
Bernie	48.2	19.1%	56.3%	24.7%

Sources: USCB, 2018-2022 ACS (5-Year Estimates)¹; Census Reporter 2023 ACS (5-Year Estimates)²

In summary, the county and towns within the Subwatershed are generally less populated, less educated, less diverse, and have a higher percentage of individuals living below the poverty line than state averages.

D9. CULTURAL RESOURCES

D9.1. Survey Methodology

The Area of Potential Effect (APE) contains a series of ditches and levees surrounded by cropland with some forestland and wetlands (USFWS 2023b). Elevations are between 307 and 337-ft above mean sea level. As the area has been continually disturbed since the drainage features were installed in the early 1900s, a literature review and reconnaissance pedestrian survey were conducted within the APE to document current conditions and previous disturbances. Approximately 14-ac of the 341-ac Project APE, selected in consultation with NRCS staff and the Missouri State Historic Preservation Office (MO SHPO), were targeted for field investigation, as most of the survey area involved non-ground disturbing activities or exempted activities of soil spreading and reseeding (MO SHPO 2018, 2023).

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. 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, was 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.

D9.2. Phase I Archaeological Survey

A Phase I Archaeological Survey was completed to locate, identify, and record all archaeological resources within the Project Area on December 5-6, 2024. The archaeological survey consisted of a reconnaissance survey within designated areas of importance in the APE as defined by proximity to nearby archaeological sites and estimated level of disturbance needed for the potential project activities. As the proposed project activities were to be within 60-ft from the centerline of the ditches, the pedestrian survey was limited to this area. The APE was either covered in wetland grasses, mixed deciduous trees with varying levels of underbrush, tall grass, and bare or harvested agricultural fields. No cultural features or structures were encountered within the APE.

D9.3. Historic Resources Survey

A reconnaissance-level historic resources survey was conducted for historic-age buildings, structures, and site features within the APE and was conducted alongside the archaeological survey. This work involved archival investigation and field verification. Based on completed

archival research of the area, West Ditch – Main Ditch and some associated lateral ditches (AR-1) between Malden, Missouri and Bernie, Missouri were already established and depicted on historic mapping by at least 1940. AR-1 is currently in good condition and has undergone no alterations since its original construction. AR-1 is recommended as not eligible individually for National Register of Historic Properties (NRHP) listing on both a regional and national level due to its lack of historic and architectural significance.

D9.4. Background Research

An archaeological review of literature was conducted to determine if NRHP districts or archaeological sites had already been documented in the APE or if any recent disturbances had occurred that may have affected cultural resources. This review included consultation with the Missouri Cultural Resources Inventory and Historic Districts and Sites Map, as well as historical maps and aerial photographs on Google Earth Pro, Nationwide Environmental Title Research Online, the Missouri Geological Survey, and the State Historical Society of Missouri. In support of the NRHP-eligibility recommendations, historical and archival research was also conducted, specifically for Main Ditch, Lateral No. 1 and No. 2, DD Walker Lateral, West Lateral, Garner Lateral, and Tuttle Lateral.

Background research revealed that no previously recorded archaeological sites or previously recorded surveys occur within the APE. One previous survey was conducted in a portion of the current APE. Additionally, the search identified four previously recorded sites and three previous surveys have been recorded within the one-mile Project Buffer. No previously recorded historic architectural resources, NRHP-listed resources, or previous architectural surveys occur within the APE. However, two previously recorded historic architectural resources are located within the 1-mi Project Buffer.

D9.5. Summary

The cultural resources investigation for the Project APE included both a Phase I reconnaissance survey and an archaeological review of literature. During the pedestrian surveys, no cultural features or structures were encountered within the APE beyond the ditches themselves. The literature review revealed that previous investigations and surveys have been recorded. However, no NRHP-eligible or listed historic properties were identified within a 1-mi radius of the APE. No new archeological sites or cultural materials were identified or recovered. A total of one resource 50 years of age and older was identified within the architectural survey area. Sections of this resource, a man-made earthen canal designated AR-1, date from prior to 1903, with later alterations and improvements added between 1914 and 1920 based on archival research and historic map review.

AR-1 was determined as not eligible for NRHP listing on both a regional and national level due to its lack of historic and architectural significance. AR-1 is not significant under Criterion A as it is not significant within the context of flood control and land drainage of the Mississippi River watershed in the area, being constructed piecemeal on an as-needed basis. Under Criterion B, AR-1 does not have any significant associations with persons important to the local, state, or national history of the area. It is not significant under Criterion C as it is a common example of its type that



lacks distinction. The NRCS determination was a finding of *No Adverse Effect to Historic Properties* for AR-1 with SHPO concurrence in the March 27, 2025, letter mentioned above.