# UPPER MISSISSIPPI RIVER RESTORATION
# FEASIBILITY REPORT
# WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

## GILEAD SLOUGH
## HABITAT REHABILITATION AND ENHANCEMENT PROJECT

**POOL 25, UPPER MISSISSIPPI RIVER MILES 252-248**
**CALHOUN COUNTY, IL**

Appendix G: Hydraulics and Hydrology

US Army Corps of Engineers
St. Louis District

**January 2026**
Draft Version

Upper Mississippi River Restoration
Leading · Innovating · Partnering

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# 1 INTRODUCTION

## 1.1 Project Location

The proposed Upper Mississippi River Restoration (UMRR) Gilead Slough Habitat Rehabilitation and Enhancement Project (HREP) is located on the left descending back of the Mississippi River from river mile (RM 246-248), approximately five miles north northwest of Batchtown, Illinois. The study area is located within Calhoun County, Illinois on federally owned lands, managed by the U.S. Fish and Wildlife Service (USFWS) under a cooperative agreement with United States Army Corps of Engineers (USACE). The study area is in Pool 25 within the Lower Impounded Cluster as identified by the Habitat Needs Assessment II.

The 1200-acre study area consists of a side channel, tertiary channel, floodplain forest, and a large backwater complex. Previously, the area supported a more diverse mosaic of plant community types, including bottomland forest, submersed aquatics, deep marsh, emergent herbaceous, shrub-scrub, wet meadow, and mudflats. Today, floodplain forest and emergent herbaceous types are the dominant plant communities. Wildlife that uses the area include migratory waterbirds (e.g., waterfowl, wading birds, and shorebirds), fish, and mussels. The amount and diversity of migratory bird, wildlife, mussel, and fish habitat in the study area has been reduced due to continued river-borne sedimentation from the Mississippi River leading to reduced depth and flow through the backwater channels. Figure 1 below shows the Gilead Slough project area outlined in green.

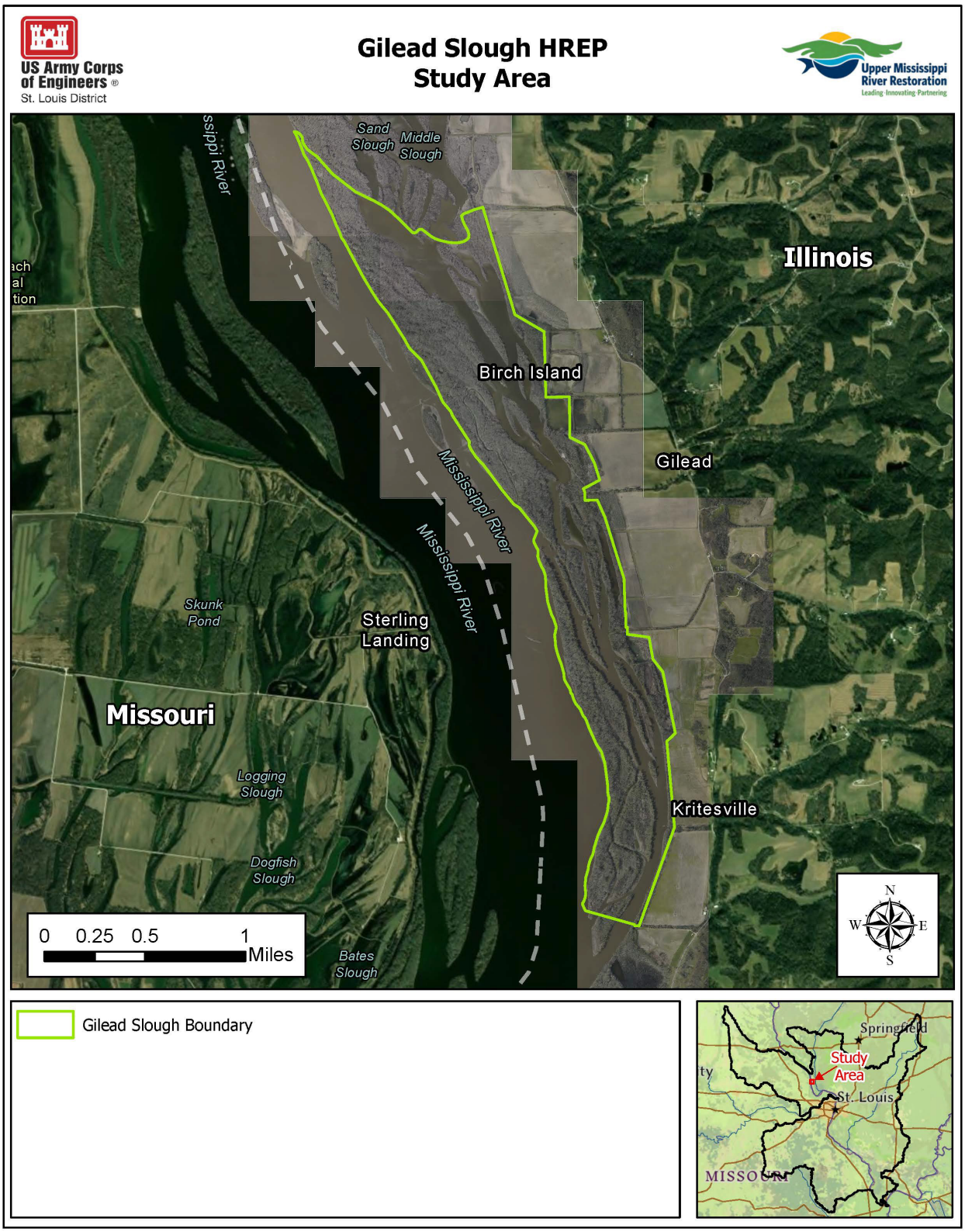


**Figure 1 Gilead Slough Vicinity Map**

## 1.2 Historical Information

Prior to the construction of L&D 25 at Winfield, MO, the area of Reds Landing and Gilead Slough were utilized for forestry logging and agricultural fields in the late 1800's to early 1900's. During the early 1900's, the Mississippi River near Reds Landing & Gilead had been dramatically altered due to historically constructed river training structures. The structures were constructed as part of the USACE authority to provide a safe and dependable navigation channel. They were constructed to manage flow within the main channel for navigational purposes to reduce dredging needs. River training structures have had a significant impact on the topography in the project area, especially those constructed and modified between 1928 -1960. Historic structures were never removed by the USACE, but may have degraded over time as result of air, scour, or ice. Many are likely to remain relatively intact beneath the sediment.

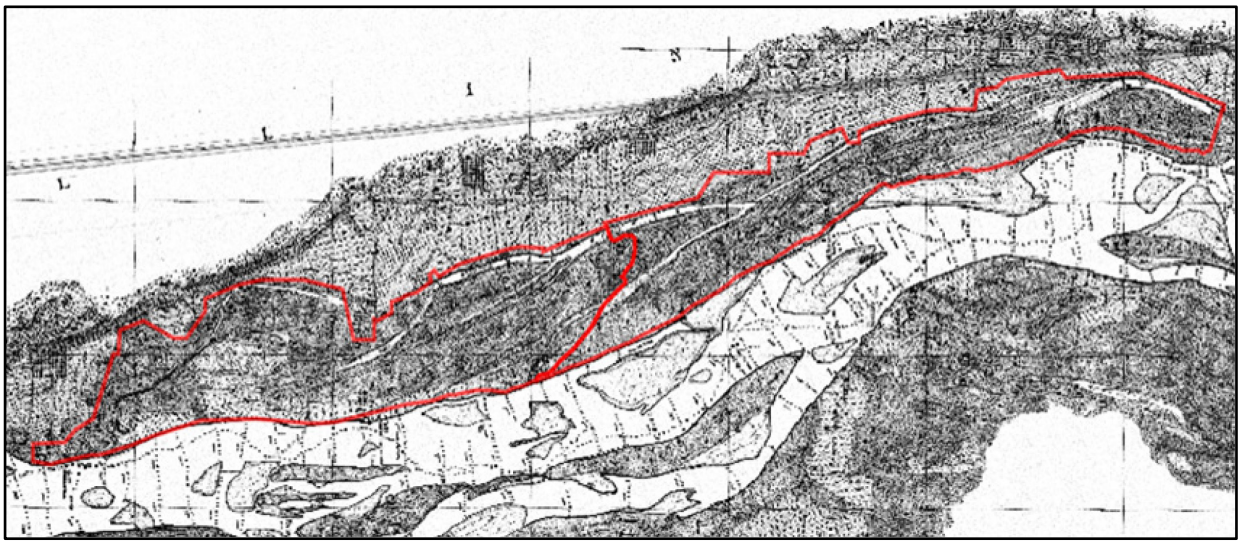

**Figure 2 Historical 1980 Survey of Reds Landing and Gilead Slough**

The area now consists of a patchwork of habitat types including sloughs, backwater lakes, bottomland forest, and remnant agricultural fields. The USACE purchased this area for the Upper Mississippi River navigation system, and portions were leased back to the private sector. One such area was Gilead Slough, which was subsequently managed primarily as a hunting and fishing club, known as the Gilead Club. During operation, club members constructed dikes and installed water control structures to manipulate water levels for moist soil management and waterfowl production during the hunting season. The flood of 1993 destroyed most of the infrastructure used by the Gilead Club and led to the Club terminating its long-standing lease with the USACE. Due to this area adjoining Reds Landing to the north, Gilead Slough was offered by the USACE to IDNR for management. Today, the old Gilead Club levees and infrastructure provide the water level control for the adjacent Reds Landing. However, the degraded condition of these systems prevents proper water level management for ideal fish and waterfowl habitat. In fact, on the northern end of the site, the silt load coming in during floods has filled many of the old sloughs and backwaters with sediment. Alterations to the floodplain have resulted

from the water control structures left behind from the days of Gilead Club's management. The HREP's goals include improving water management to improve wetland quality, waterfowl habitats, fish access, and restoring diversified forest acreage.

**Figure 3 Historical 1940 Aerial of Gilead Slough**

### 1.3 Dredging Operations

Through the enactment of a series of Rivers and Harbors Acts, WRDAs, and Public Laws, the District maintains the navigation channels on the Mississippi River (Upper and Middle), Kaskaskia River, Illinois River, and the Southeast Missouri Port. A District Dredging Master Plan was created in 2014 to document dredging frequency and status of the navigation channel. Starting in 2021, USACE began to coordinate dredging efforts with partners, including USFWS, IDNR, and Missouri Department of Conservation.

The District conducts regular dredging in Pool 25 within the main channel adjacent to the project reach. Records show that the most recent dredging event near Gilead Slough (RM 250.5) occurred in 2020 with a quantity of 114,126 cubic yards. Dredge material was placed throughout the main channel and along the right descending bankside away from the dike tips. Figure 4 shows the dredging efforts near Gilead Slough within the past 10 years (2003-2023). Dredging events are depicted in green, and the preferred placement area is shown in red. The state boundary line is shown with a gray dashed line.

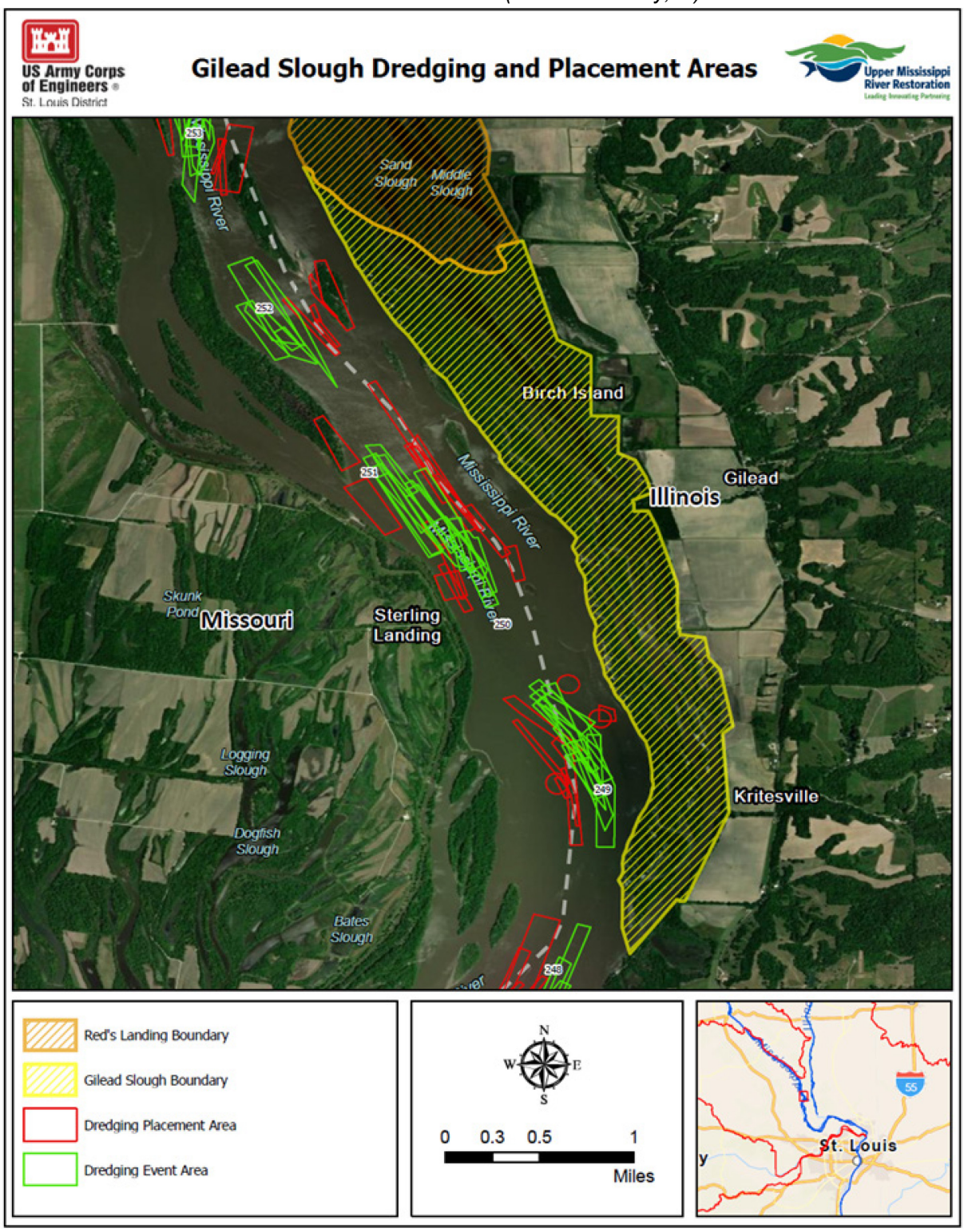


**Figure 4 Dredge Operations at Gilead Slough**

## 1.4 Project Purpose and Need

The USACE proposes to rehabilitate and enhance Gilead Slough through construction of measures which will increase floodplain forest community diversity,

restore function of flowing side channels, increase emergent wetland habitat, and improve the overall structure and function of Gilead Slough. The purpose of the study is to restore and improve the quality within diversified areas of backwater, floodplain forest, and wetland ecosystem resources.

Gilead Slough is passively managed with backwaters from L&D 25 operations and Pool 25 water control management. At times, flow overtops the overflow spillway and in some cases the retention berm at the boundary between Reds Landing and Gilead Slough. The spillway and berm have degraded over time with frequent overtopping conditions during higher flow conditions. The upper portion of Gilead Slough contains backwaters with low flow and velocities during normal flow conditions; thereby allowing sedimentation to occur; reducing depths within the upper backwaters.

The lower portion of Gilead has a small river side channel connection, which allows flow into the lower backwaters, but also sediments from the river. Upland drainage inflow from nearby creeks or agricultural ditches bring additional sediments into these backwater areas. Some of these sediments are beneficial to mussel and fish habitats, however, can create locations with lack of flow or depth diversity.

Sediment routinely builds up within the backwater areas and side channels after large flood events or during low flow situations. The rate at which sediment deposition occurs depends heavily on the duration and velocity of flow at specific time periods, especially during flood events. Due to lack of data and no sediment gauge stations located within Pool 25 to provide accurate data, sediment rates within the project area had to be devised through an alternative measure to determine the deposition rate. To determine an amount of sediment deposition within the side channel and backwater areas, a comparison of bathymetric terrain data was obtained through past hydrographic surveys. Using the recent bathymetric survey data from 2023 and comparing it to bathymetric survey data from 2012 within side channels of the project area, a difference in elevation data could be determined and the sediment rate could be approximated. After comparing these two side channel terrains, the approximated sediment deposition rate ranges from 1.8 inches to 2.9 inches per year. The value mentioned could be highly variable due to limited data over the past decades and characteristic changes within these side channels. It should also be noted that: bathymetric surveys are simply snapshots in time; hydrographic surveys have limited coverage within side channels and backwater areas; comparison terrain data was limited to only two surveys; and comparing two converted surveys can introduce statistical errors. The average daily sediment load of the Mississippi River at Hannibal, Missouri, is about 70,000 tons (USACE, 2001).

### 1.5 Gauge Information

The project area is located between two USACE St. Louis District flow gauges, Lock & Dam 24 (Tailwater), Clarksville, MO, and Lock & Dam 25 (Pool), Winfield, MO. Mosier Landing, located at RM 260.3, is located near the midpoint hinge of Pool 25, and has a stage-flow gauge. There are no major flow inputs from other minor rivers or creeks to make considerable impact to the studied project area.

The navigation pools in the St. Louis District are maintained based upon hinge point limits. As the flows increase and the upper limit of the hinge point is approached, the pool level is lowered to compensate until the flows start decreasing or max drawdown is reached. As the flows decrease and the lower limit of the hinge point is approached, the pool level is raised to compensate until the flows start increasing. The lower limit at the hinge point is defined by the lowest river level allowable for a safe and dependable navigation channel and in coordination with dredging efforts. The upper limit is defined by the highest river level that can be maintained by the dam because the land above this limit isn't owned by the U.S. government, and thus is not authorized to be inundated by the project

Figure 5 shows the percent exceedance using gauge data from 1970 to present for Lock & Dam 24 (L&D 24) and Mosier Landing gauges. Historical data was used to represent current hydrologic conditions since it includes the effects of all major infrastructure and reservoirs on the rivers. Figure 6 shows the maximum, minimum, and average stage hydrograph at Mosier Landing from 1970 to 2023. Table 1 Average Monthly Discharges (2009 - 2023) shows the average monthly discharge between 2009 - 2023 for L&D 24 tailwater and Mosier Landing. On average low stages occur between the months of August to February.

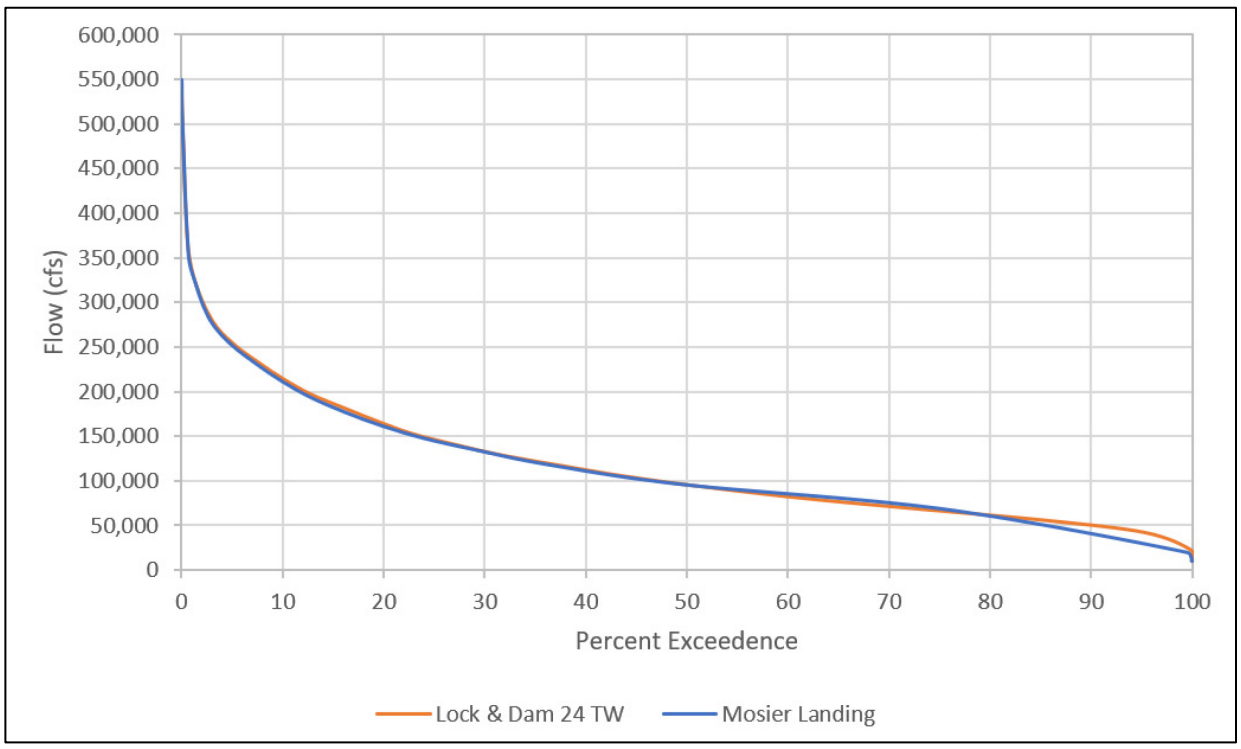


**Figure 5 Duration of Exceedance for Lock and Dam 24 Tailwater and Mosier Landing Gauges (1970 – Present)**

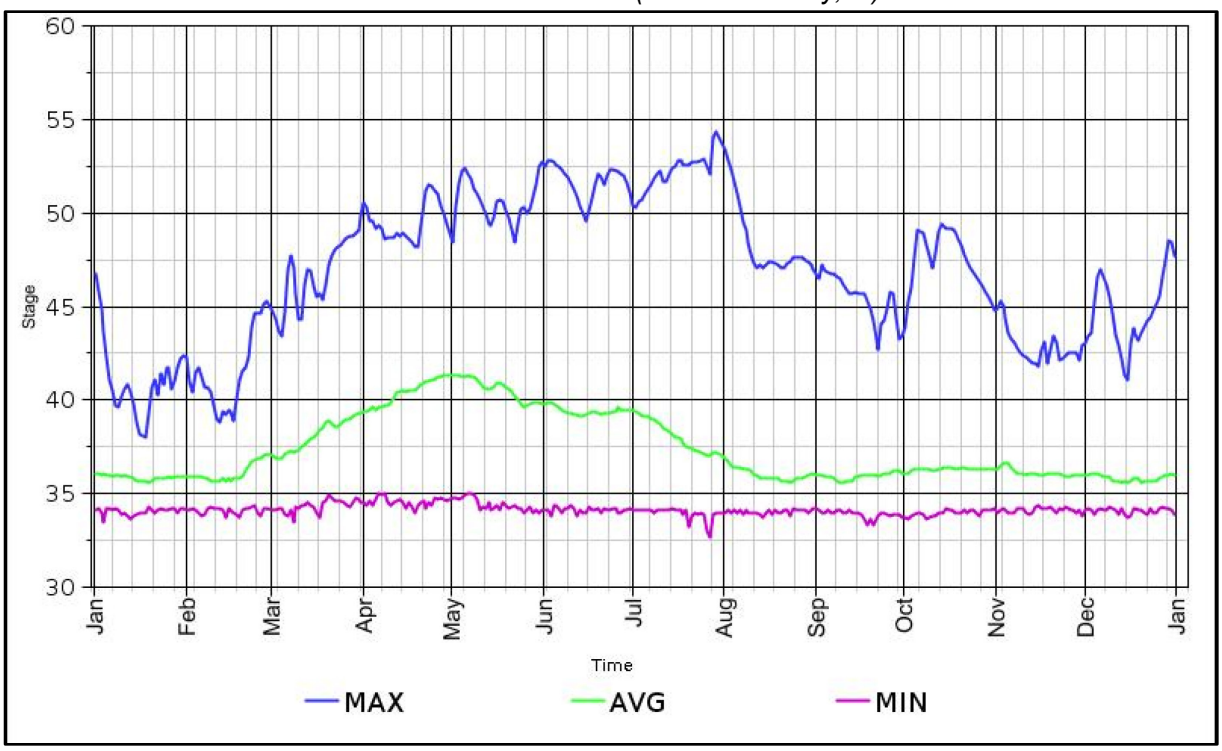


**Figure 6 Comparative Stage Hydrograph for Mosier Landing (1970 - Present)**

**Table 1 Average Monthly Discharges (2009 - 2023)**

| Month | L&D 24 Tailwater 2009 – 2023 Average Discharge (cfs) | Mosier Landing 2009 – 2023 Average Discharge (cfs) |
|---|---|---|
| January | 85,699 | 98,855 |
| February | 89,503 | 99,267 |
| March | 143,589 | 145,902 |
| April | 173,652 | 181,988 |
| May | 191,002 | 196,356 |
| June | 178,431 | 184,641 |
| July | 153,501 | 156,901 |
| August | 96,826 | 99,899 |
| September | 98,053 | 101,858 |
| October | 119,231 | 124,125 |
| November | 104,789 | 111,658 |
| December | 91,316 | 99,825 |

## 2 HEC-RAS 2D MODELING

The Hydraulic Engineering Center River Analysis System (HEC-RAS) version 6.3.1 was used to construct a 2D numerical model of the Reds Landing and Gilead Slough study area. The geometry from HEC-RAS was created from imported ArcGIS shapefiles. These shapefiles were used to establish the location of bank lines, river centerline, islands, river miles, and several river training structures.

The HEC-RAS model starts near the Mosier Landing gauge (RM 260.3), approximately five miles upstream of Reds Landing (RM 252.5 to RM 255.5) and extends downstream to L&D Pool 25 (RM 242.0). The extent of model was limited by a series of levees along the Missouri right descending bank (Elsberry, Kings Lake, Sandy Slough) and the Illinois river bluff along North Mississippi River Road (Figure 7). The limits of the HEC-RAS 2D model are shown in magenta in Figure 8. The following sub-sections detail how the model was developed and how it was used to evaluate project alternatives.

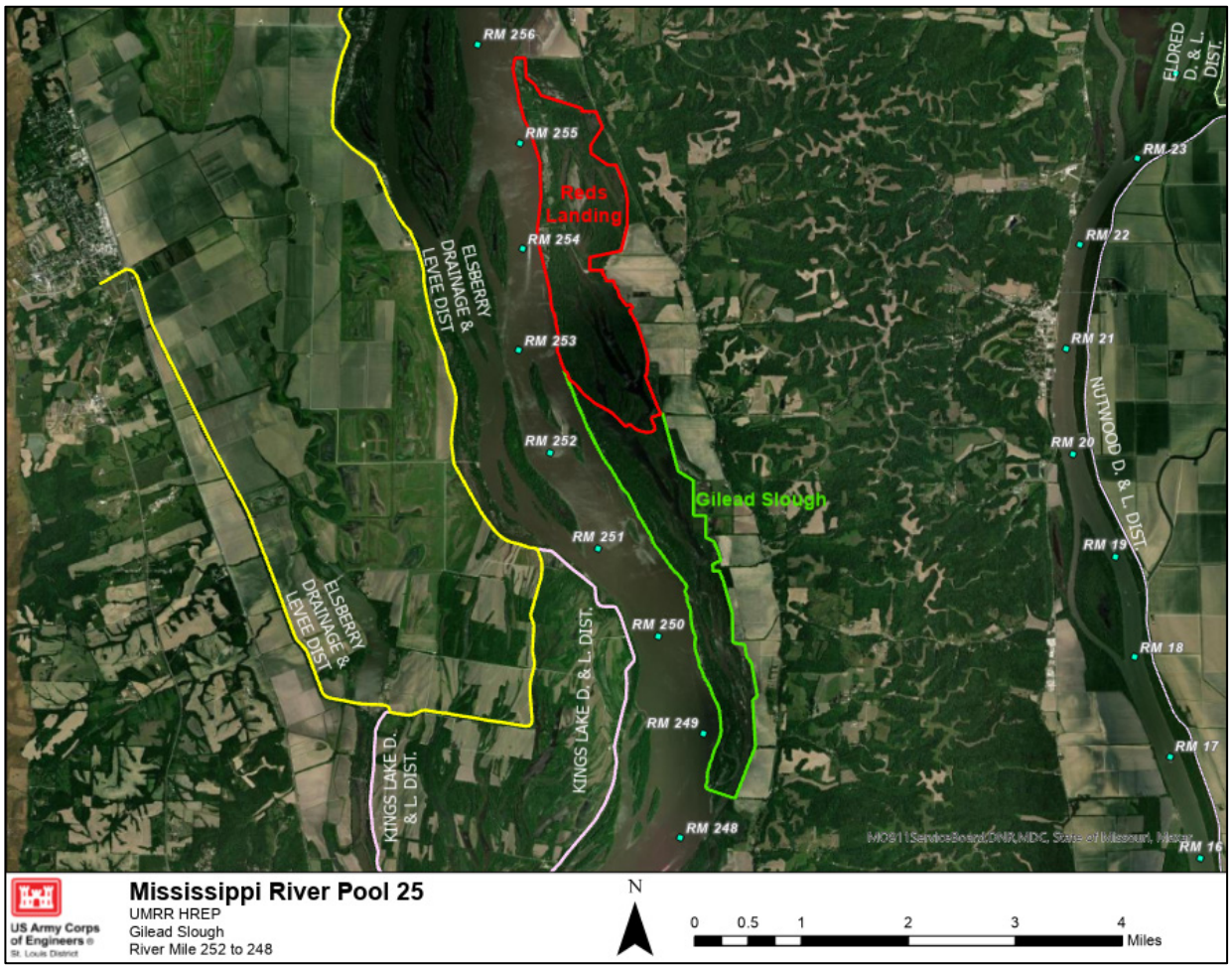


**Figure 7 Gilead Slough Neighboring Levee Districts**

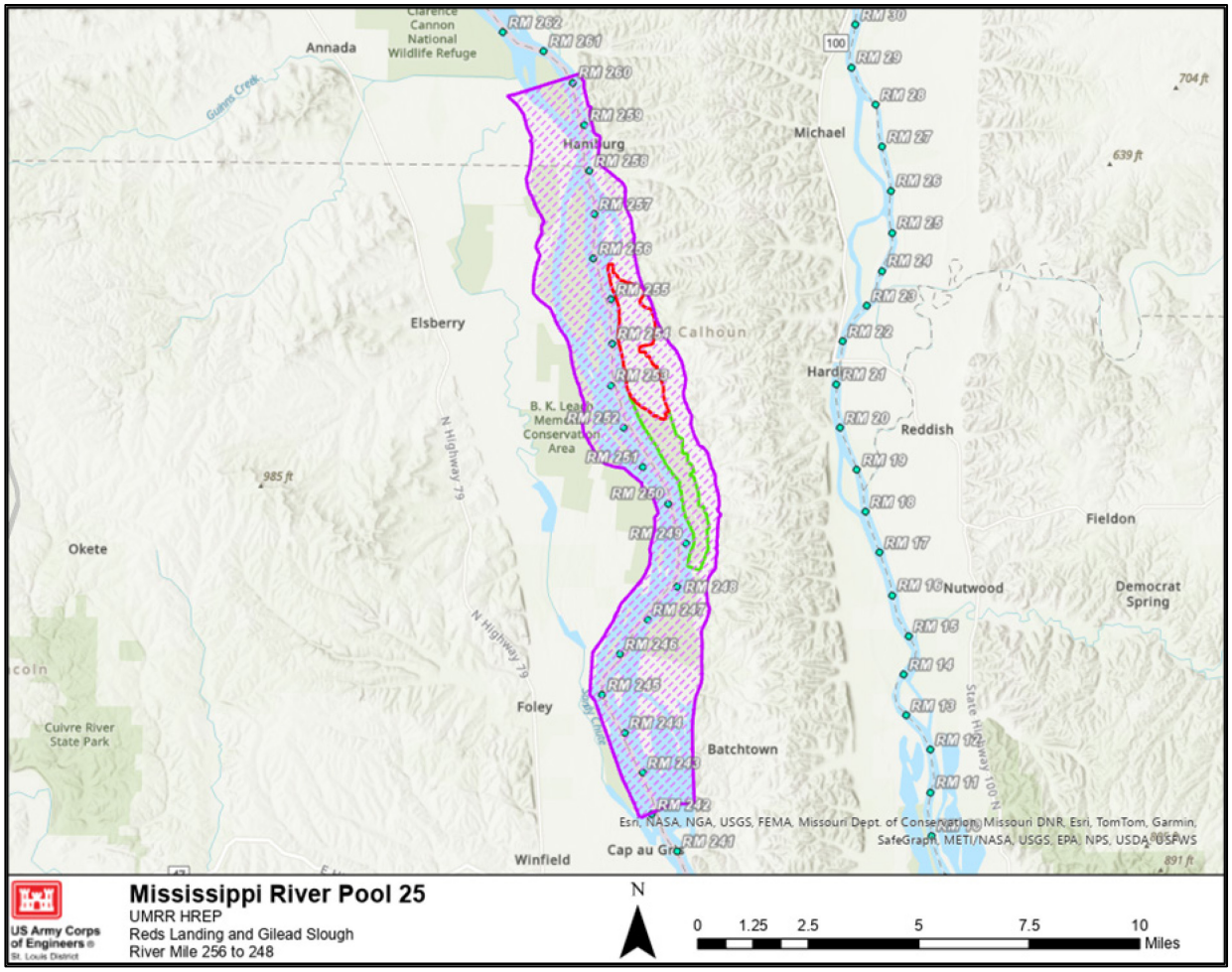


**Figure 8 HEC-RAS Model Limits**

## 2.1 Model Geometry

### 2.1.1 Terrains

The existing conditions terrain compiles a combination of LiDAR ground elevation topography and various bathymetric surveys collected by USGS and USACE (Table 2, Table 3). The USGS topographic and bathymetric elevation data from survey date 2016 was used as the base layer for the model terrain. All elevation data integrated into the terrain was converted to the North American Vertical Datum of 1988 (feet) and reprojected into North American Datum of 1983 State Plane MO East (US survey feet) coordinate system. These separate data sources were layered and merged using feathering and terrain painting functionality in programs, ArcGIS Pro v3.1.0 and Global Mapper Pro v23.0. Due to the lack of bathymetric data in the backwater pools of Reds Landing, a site visit was conducted in February 2024 to collect depths within the ponds. Ponds were then set at the estimated depths according to the site visit points. Project features represented in terrains include islands, side channels, dredged backwaters, levees, ridgelines, and river training structures (existing, altered, and new). These features were added to the existing terrain by further manipulation in Global Mapper Pro and/or by altering roughness values in the HEC-RAS model.

**Table 2 Elevation Data Sources**

| Source | Survey Date | Coordinate System | Vertical Datum |
|---|---|---|---|
| USACE Aerial LiDAR (Reds/Gilead) | 2023 | NAD 1983 UTM Zone 15N (m) | NAVD88 (ft) |
| USGS Aerial LiDAR (Pool 25) | 2016 | NAD 1983 UTM Zone 15N (m) | NAVD88 (ft) |
| USGS Bathymetry (Pool 25) | 2016 | NAD 1983 UTM Zone 15N (m) | NAVD88 (ft) |

**Table 3 USACE Bathymetric Surveys**

| RM Coverage | Survey | Date | Type |
|---|---|---|---|
| RM 241-273 | Pool 25 Comprehensive Main Channel | 2016 | Single Beam & Multi Beam Sonar |
| RM 258-262 | Main Channel | 7/31/2020 | Multi Beam Sonar |
| RM 245-247 | Hausgen Island | 5/9/2023 | Multi Beam Sonar |
| RM 269-273 | Clarksville & Carroll Islands | 5/17/2023 | Single Beam & Multi Beam Sonar |
| RM 248-256 | Red's Landing & Gilead Slough | 8/15/2023 | Single Beam & Multi Beam Sonar |
| RM 242-247 | Hausgen Island | 5/31/2024 | Single Beam |
| RM 272-273 | Clarksville Island | 5/31/2024 | Single Beam |

Figure 9 below shows the extent of surveys for Pool 25 that comprise the terrain. Surveys are highlighted in blue with darker blue indicating the layering order.

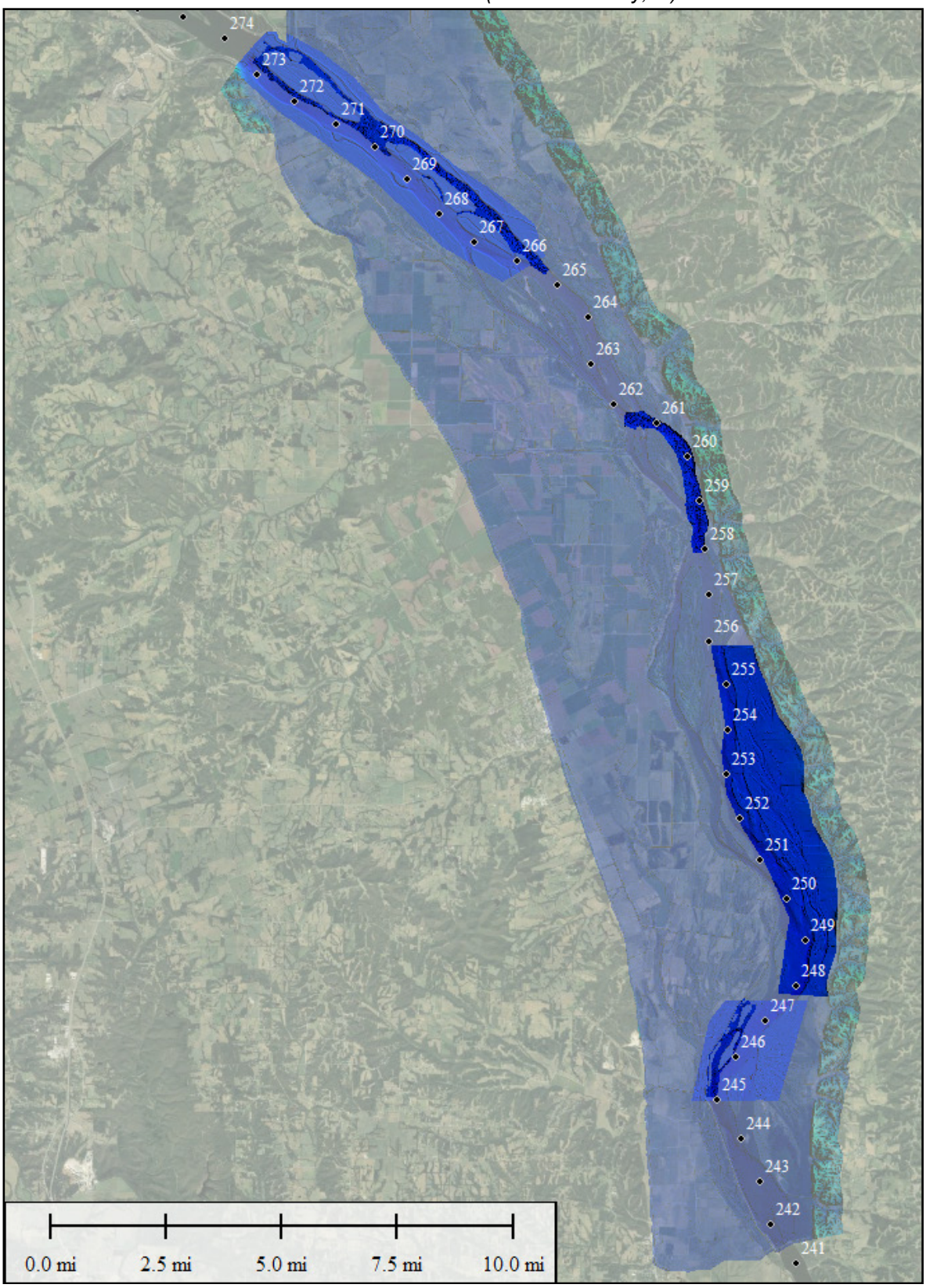


**Figure 9 Pool 25 terrain extents**

### 2.1.2 Mesh Development

The HEC-RAS 2D numerical modeling was setup with a 2D flow area covered with individual computation cells making up a model mesh network. Each individual cell element was spaced every 100 feet by 100 feet. These cells allow volumetric computations to be performed on an individual cell by cell basis. Breaklines were established to further refine the model into smaller mesh areas with cell spacing at a minimum of 10 feet and maximum of 100 feet. Breaklines were used to establish the river centerline so the mesh would align perpendicularly to flow. Breaklines were also added to topographic / bathymetric features along riverbanks, levees, island, and other river training structures throughout the 2D modeled area. These breaklines were enforced into the mesh area. The model mesh was then edited to ensure each computation cell element did not exceed 8 sides to allow for faster model analysis run times. After model simulations run through multiple iterations, the data output provides calculated water surface elevations (WSEs), velocities, flow depths, etc. at each cell location for the entire modeled 2D mesh flow area. The next figure shows a typical 2D flow area mesh created from the topographic, bathymetric, cell elements, and breaklines for the existing and proposed conditions.

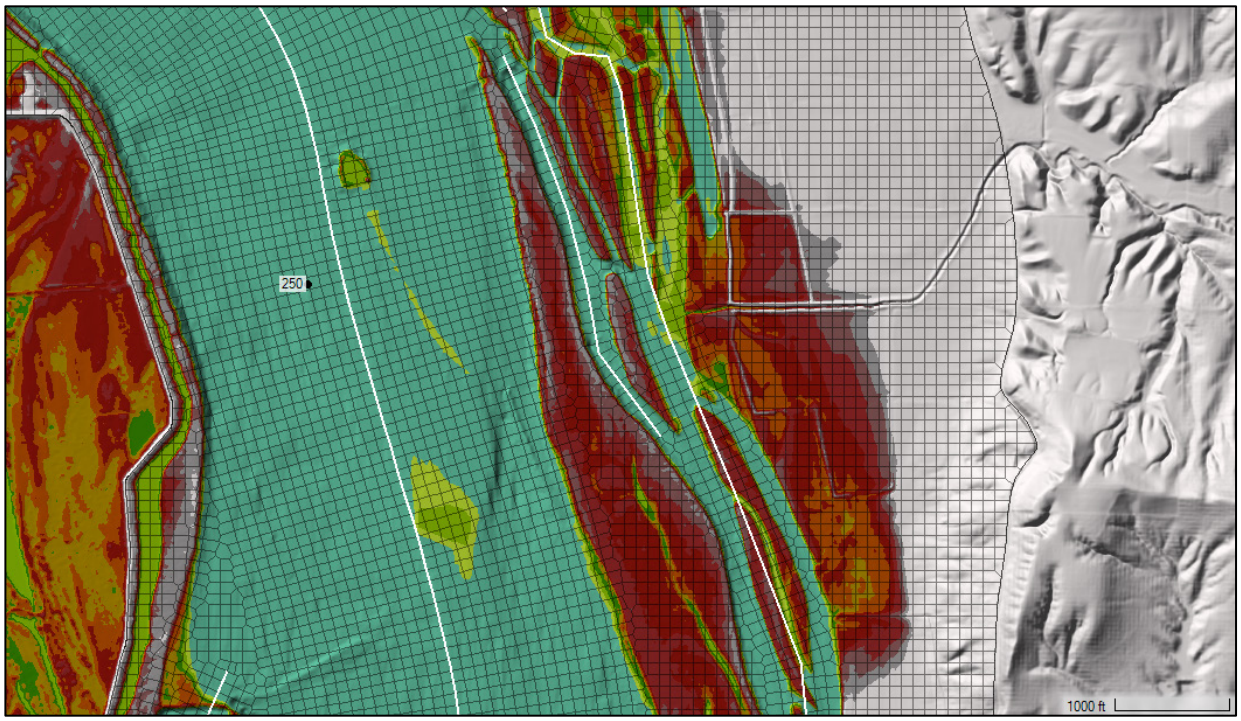


**Figure 10 Existing Model Mesh Development**

### 2.1.3 Model Features

Existing features were setup, adjusted, or assumed within the existing model to provide representative conditions that were not identified, surveyed, or provided during data collection. Features included backwaters, scour structures, dikes, and other river training structures. These features were modeled by modifying the raster terrain layer in Global Mapper Pro using terrain painting and feathering

functionalities. Backwater channel elevations were lowered to assumed targeted channel invert elevations in areas where bathymetric survey data could not be obtained and collected during low pool shallow water environments. River training structure features, such as dikes, were placed into the surface at their respective existing locations and adjusted accordingly to their terrain locations. The materials used to construct the dikes consisted of stone grade A. Table 4 and Figure 11 show a list of River Training Structure Inventory.

**Table 4 River Training Structure Inventory Gilead Slough ( RM2 256 – 248)**

| Structure Name | Dike ID | River Mile | Descending Bank Side | Stone Tons |
|---|---|---|---|---|
| Chevron 248.1L | 248.1L | 248.1 | Left | - |
| Dike 248.15L | 248.10L | 248.1 | Left | 17,300 |
| Dike 248.1L | 248.10L | 248.1 | Left | 17,300 |
| Dike 248.4R | 248.40R | 248.4 | Right | - |
| Dike 248.5R | 248.50R | 248.5 | Right | - |
| Dike 248.6R | 248.60R | 248.6 | Right | - |
| Dike 248.7R | 248.70R | 248.7 | Right | - |
| Dike 248.8R | 248.80R | 248.8 | Right | - |
| Dike 248.9R | 248.90R | 248.9 | Right | - |
| Dike 249.2R | 249.20R | 249.2 | Right | - |
| Dike 249.3R | 249.30R | 249.3 | Right | 33,275 |
| Dike 249.4R | 249.40R | 249.4 | Right | 7,785 |
| Chevron 250.08L | 250.08L | 250.08 | Left | 8,148 |
| Dike 250.2L | 250.20L | 250.2 | Left | - |
| Dike 250.5L | 250.50L | 250.50 | Left | 9,001 |
| Dike 250.8L | 250.80L | 250.8 | Left | 22,505 |
| Dike 251.1L | 251.10L | 251.1 | Left | 13,247 |

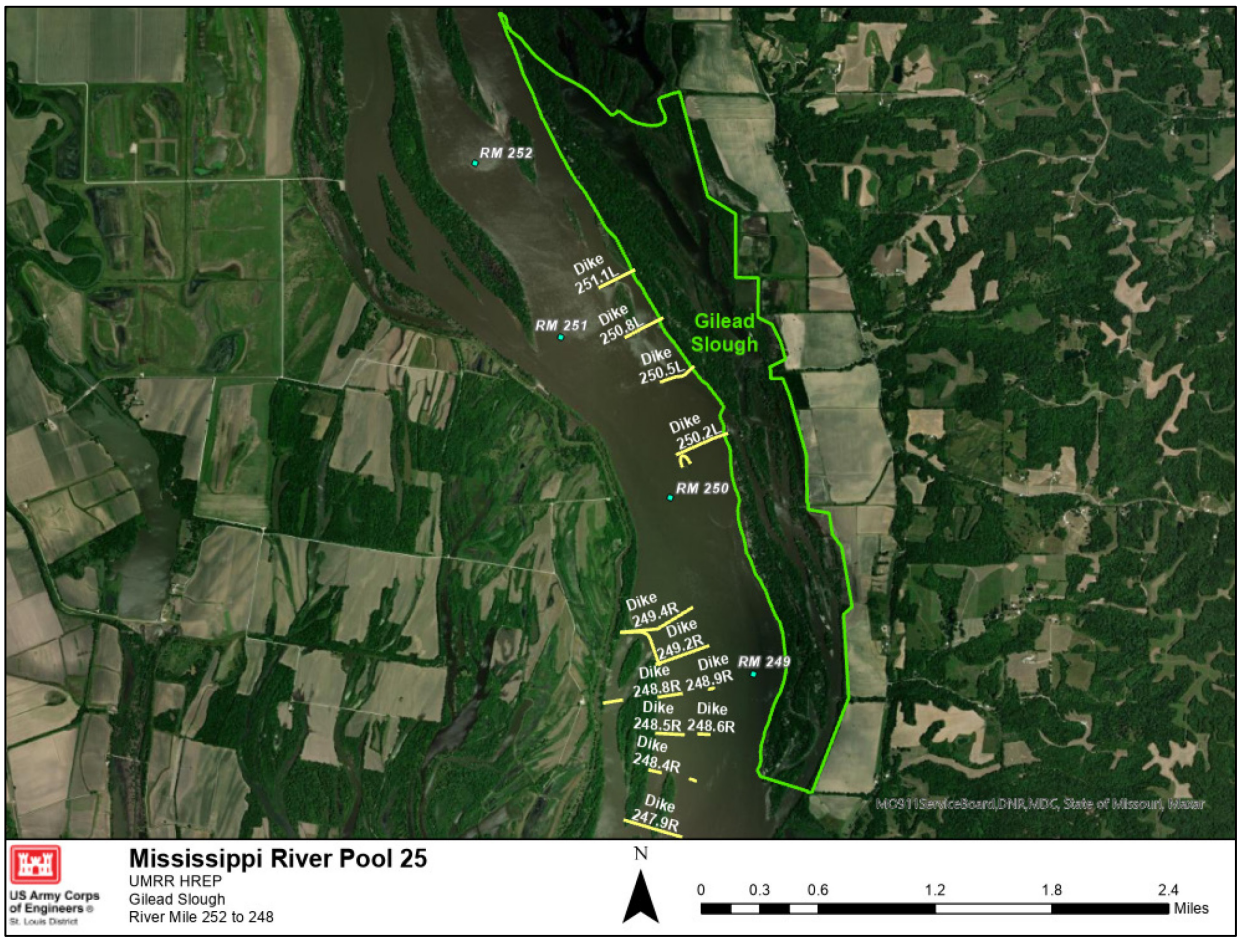


**Figure 11 River Traraining Structures - Gilead Slough (RM 252- 248)**

## 2.2 Model Calibration

### 2.2.1 Boundary Conditions

Upstream and downstream boundary conditions were initially setup and used for calibration. The upstream boundary condition was set at L&D 24 tailwater, and flow information was taken from the "Upper Mississippi River System Flow Frequency Study" (USACE, 2004) for larger flow models. Gauge information was taken from Mosier Landing in calibrating lower frequency flow events for each studied low flow condition. The downstream boundary condition was set at L&D Pool 25 (RM 242) for corresponding stage elevation for each studied flow condition. An energy grade slope of 0.001178 ft/ft was measured along the thalweg of the channel at the downstream boundary condition as a basis to set the flow distribution for model simulations. The boundary conditions allow 2D HEC-RAS to calculate starting and ending flow distributions across these terrain sections through each simulation analysis. The next few tables show average monthly discharges and relevant design data.

An interpolated value for the datum conversion was used. The NGVD29 to NAVD88 conversion at Mosier Landing was noted as -0.46 and the NGVD29 to NAVD88 conversion at L&D 25 Pool was noted as -0.40. An assumed conversion factor of -0.4

was used to convert elevation data from NGVD29 to NAVD88. For calculation purposes, this conversion factor remained constant throughout the model extents.

**Table 5 Relevant Design Data**

| Relevant Design Data | Current Discharge from Water Control (cfs) | Discharge from Flow Frequency Study (2004) (cfs) | RM 260.30 Mosier Landing Elevation (ft NGVD 88) | RM 241.49 L&D 25 Upper Pool Elevation (ft NGVD 88) | Daily Percent Exceedance |
|---|---|---|---|---|---|
| Existing Channel Bottom | - | - | 408.1 | 412.7 | - |
| L&D 25 Minimum Pool | 10,000 | - | 433.80 | 429.3 | 99.99 % |
| ADCP Survey 7/28/2023 | 15,110 | - | 433.91 | 431.5 | 99.75 % |
| L&D 25 Normal Pool | 20,000 | - | 433.95 | 433.6 | 99.31 % |
| 2-year (50% AEP) | - | 210,000 | 441.2 | 434.0 | 10.19 % |
| L&D 25 Overflow Dike | 211,800 | - | - | 434.1 | 9.91 % |
| 5-year (20% AEP) | - | 269,000 | 444.4 | 437.2 | 3.59 % |
| 10-year (10% AEP) | - | 310,000 | 446.1 | 439.4 | 1.72 % |
| 100-year (1% AEP) | - | 443,000 | 450.3 | 445.2 | 0.28 % |
| Levee Crown | - | - | 451.7 | 445.3 | - |

* Discharge in cubic feet per second (cfs)
** Elevation conversion from NGVD29 to NAVD88 assumed to be -0.4 ft

**Table 6 Water Surface Elevation (WSE) based on the Flow Frequency Study**

| River Mile | 50% AEP 2-year | 20% AEP 5-year | 10% AEP 10-year | 1% AEP 100-year |
|---|---|---|---|---|
| 260.30 | 441.3 | 444.5 | 446.2 | 450.4 |
| 260.17 | 441.2 | 444.4 | 446.2 | 450.4 |
| 259.18 | 440.8 | 444.0 | 445.8 | 450.0 |
| 258.00 | 440.3 | 443.5 | 445.3 | 449.6 |
| 257.57 | 440.1 | 443.3 | 445.2 | 449.4 |
| 256.40 | 439.6 | 442.8 | 444.7 | 449.0 |
| 255.26 | 439.1 | 442.3 | 444.3 | 448.6 |
| 254.18 | 438.6 | 441.8 | 443.9 | 448.3 |
| 253.21 | 438.1 | 441.4 | 443.5 | 447.9 |
| 252.19 | 437.7 | 441.0 | 443.1 | 447.6 |
| 251.22 | 437.3 | 440.6 | 442.7 | 447.2 |
| 250.00 | 436.8 | 440.0 | 442.3 | 446.9 |
| 249.50 | 436.7 | 439.8 | 442.1 | 446.8 |
| 248.22 | 436.2 | 439.3 | 441.6 | 446.4 |
| 247.09 | 435.9 | 438.8 | 441.2 | 446.1 |
| 246.00 | 435.5 | 438.4 | 440.8 | 445.8 |
| 245.39 | 435.3 | 438.1 | 440.6 | 445.7 |
| 244.03 | 434.9 | 437.7 | 440.1 | 445.4 |
| 243.22 | 434.6 | 437.5 | 439.9 | 445.4 |
| 242.02 | 434.2 | 437.3 | 439.6 | 445.3 |
| 241.49 | 434.0 | 437.2 | 439.4 | 445.2 |

*Elevation conversion from NGVD29 to NAVD88 assumed to be -0.4 ft

### 2.2.1 Initial Conditions

The model was set to run from 00:00 to 24:00 hour to calibrate the model within a 24-hour period to allow for model stabilization. The model was set with a ramp-up time of 12 hours and set at 1-minute computational time step intervals for stabilization and calibration. The model warm-up period consists of 1-hour intervals starting from zero flow to the first flow value in the hydrograph, then maintaining that flow during the simulation. Data output intervals were set to 15-minute intervals.

### 2.2.2 Roughness Values

Manning's "n" roughness values were established and assigned according to 2019 National Land Cover Database (NLCD) land cover designations for model analysis. The next table shows the Manning's "n" values for various land cover types. Each Manning's "n" value was reviewed and adjusted accordingly during calibration. The adjusted calibrated Manning's "n" values can be found in the third column of the table.

**Table 7 Manning's "n" Values by Land Cover (NLCD)**

| Land Cover Region Description | NLCD Range Manning's "n" Values | Calibrated Manning's "n" Values |
|---|---|---|
| Open Water | 0.025 - 0.05 | 0.025 |
| Developed, Open Space | 0.03 - 0.05 | 0.03 |
| Developed, Low Density | 0.06 - 0.12 | 0.06 |
| Developed, Medium Density | 0.08 - 0.16 | 0.08 |
| Developed, High Density | 0.12 - 0.20 | 0.12 |
| Barren Land | 0.023 - 0.030 | 0.025 |
| Grassland/Herbaceous | 0.025 - 0.05 | 0.03 |
| Shrub/Scrub | 0.07 - 0.16 | 0.07 |
| Mixed Forest | 0.08 - 0.20 | 0.08 |
| Undeveloped, Deciduous Forest | 0.10 - 0.20 | 0.10 |
| Undeveloped, Evergreen Forest | 0.08 - 0.16 | 0.10 |
| Agricultural, Cultivated Crops | 0.020 - 0.05 | 0.03 |
| Agricultural, Pasture/Hay | 0.025 - 0.05 | 0.035 |
| Wetlands, Forested (Woody) | 0.045 - 0.15 | 0.04 |
| Wetlands, Non-Forested (Emergent Herbaceous) | 0.05 - 0.085 | 0.045 |

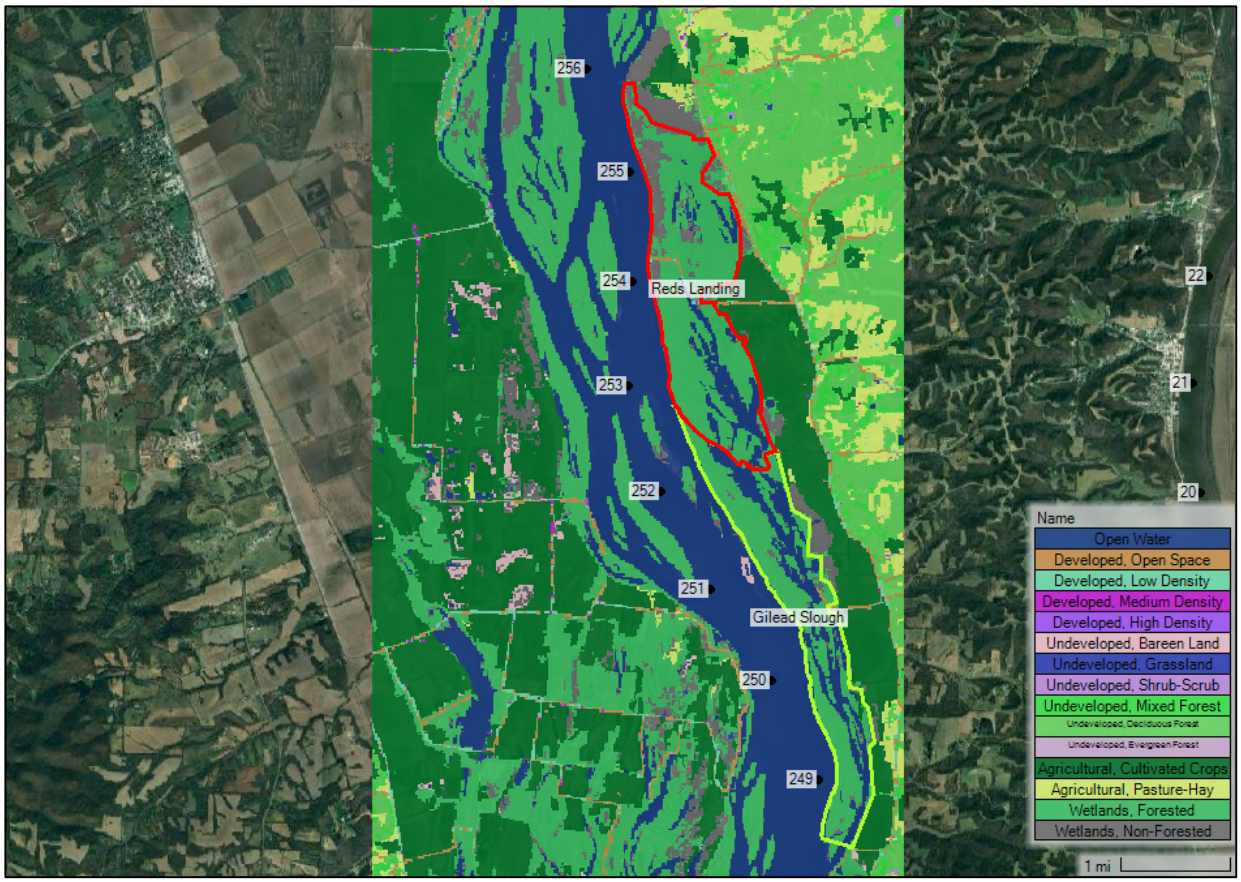


**Figure 12 Land Cover Regions from 2019 NLCD**

## 2.3 Calibration Results

### 2.3.1 MVS Flow Frequency Study (2003)

The water surface elevations within the lower portion of Pool 25, from the hinge-point near Mosier Landing to the Pool at L&D 25 were calibrated to the 1% annual chance exceedance (ACE) or the 100-year flood. Table 8 and Figure 13 compare the WSE values from the Flow Frequency Study, FEMA FIRM Flood Data, and the HEC-RAS 2D model. Cross sections were determined using sections that overlapped on the FEMA database and the USACE database. The model was also calibrated to water surface elevations for flow frequency events of 2-year (50%), 5-year (20%), and 10-year (10%) event (Table 9, Figure 14).

**Table 8 HEC-RAS Calibration Results**

| River Mile | 100-Year (1% ACE) WSE MVS Flow Frequency Study (ft) | 100-Year (1% ACE) WSE FEMA FIRM Flood Data (ft) | 100-Year (1% ACE) WSE HEC-RAS 2D Model (ft) |
|---|---|---|---|
| RM 242.02 | 445.30 | 445.50 | 445.30 |
| RM 244.03 | 445.40 | 445.60 | 445.69 |
| RM 246.00 | 445.80 | 445.90 | 446.06 |
| RM 248.22 | 446.40 | 446.50 | 446.62 |
| RM 250.00 | 446.90 | 447.00 | 447.07 |
| RM 252.19 | 447.60 | 447.70 | 447.63 |
| RM 255.26 | 448.60 | 448.70 | 448.44 |
| RM 258.00 | 449.60 | 449.70 | 449.28 |
| RM 260.17 | 450.40 | 450.50 | 450.01 |

* Elevation conversion from NGVD29 to NAVD88 assumed to be -0.4 ft

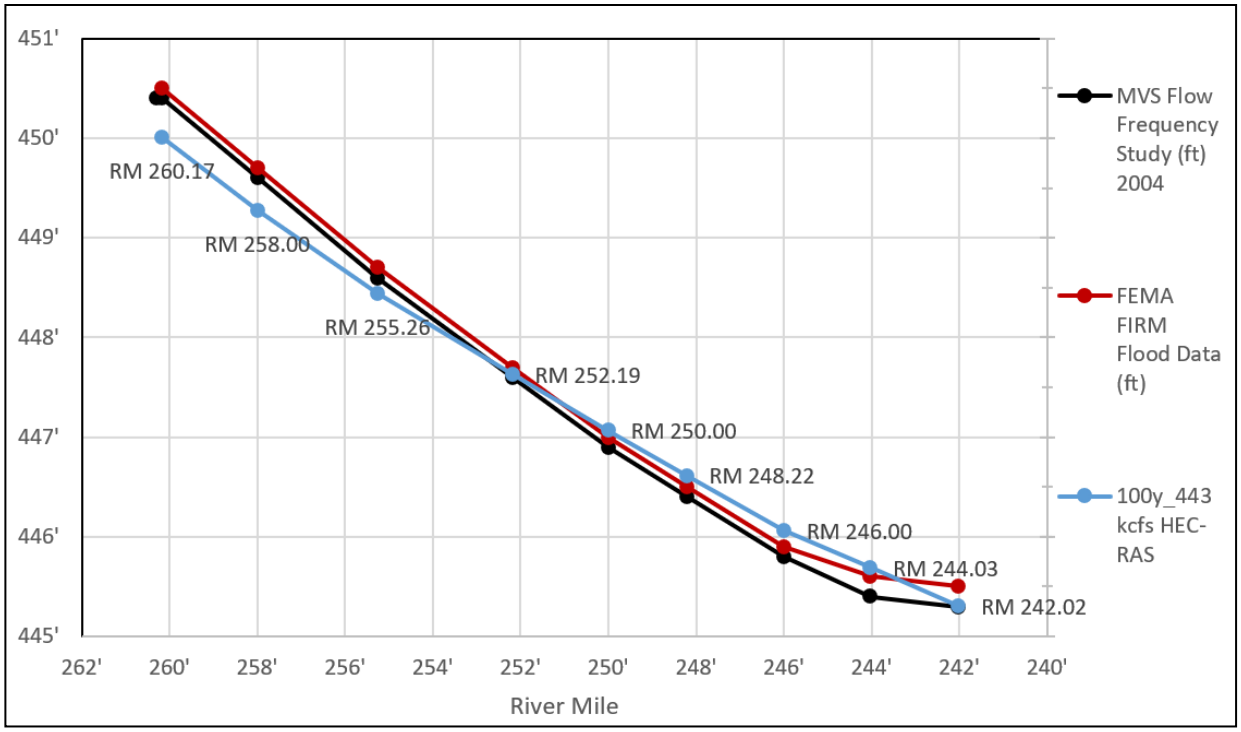


**Figure 13 100-year HEC-RAS Calibration**

**Table 9 MVS Flow Frequency Study – HEC-RAS Calibration**

| River Mile | **1% AEP** (100-year) 443,000 cfs MVS Flow Frequency Study 2004 (ft) | **1% AEP** (100-year) 443,000 cfs HEC-RAS 2D Model (ft) | **10% AEP** (10-year) 310,000 cfs MVS Flow Frequency Study 2004 (ft) | **10% AEP** (10-year) 310,000 cfs HEC-RAS 2D Model (ft) | **20% AEP** (5-year) 269,000 cfs MVS Flow Frequency Study 2004 (ft) | **20% AEP** (5-year) 269,000 cfs HEC-RAS 2D Model (ft) | **50% AEP** (2-year) 210,000 cfs MVS Flow Frequency Study 2004 (ft) | **50% AEP** (2-year) 210,000 cfs HEC-RAS 2D Model (ft) |
|---|---|---|---|---|---|---|---|---|
| 242.02 | 445.30 | 445.30 | 439.60 | 439.60 | 437.30 | 437.30 | 434.20 | 434.20 |
| 244.03 | 445.40 | 445.69 | 440.10 | 440.10 | 437.70 | 437.86 | 434.90 | 435.01 |
| 246.00 | 445.80 | 446.06 | 440.80 | 440.64 | 438.40 | 438.54 | 435.50 | 435.66 |
| 248.22 | 446.40 | 446.62 | 441.60 | 441.32 | 439.30 | 439.32 | 436.20 | 436.41 |
| 250.00 | 446.90 | 447.07 | 442.30 | 441.83 | 440.00 | 439.88 | 436.80 | 437.06 |
| 252.19 | 447.60 | 447.63 | 443.10 | 442.46 | 441.00 | 440.47 | 437.70 | 437.58 |
| 255.26 | 448.60 | 448.44 | 444.30 | 443.49 | 442.30 | 441.64 | 439.10 | 438.98 |
| 258.00 | 449.60 | 449.28 | 445.30 | 444.49 | 443.50 | 442.80 | 440.30 | 439.99 |
| 260.17 | 450.40 | 450.01 | 446.20 | 445.21 | 444.40 | 443.53 | 441.20 | 440.98 |
| 260.30 | 450.40 | - | 446.20 | - | 444.50 | - | 441.30 | - |

* WSE shown in NAVD88, -0.4 ft (converted from NVGD29)

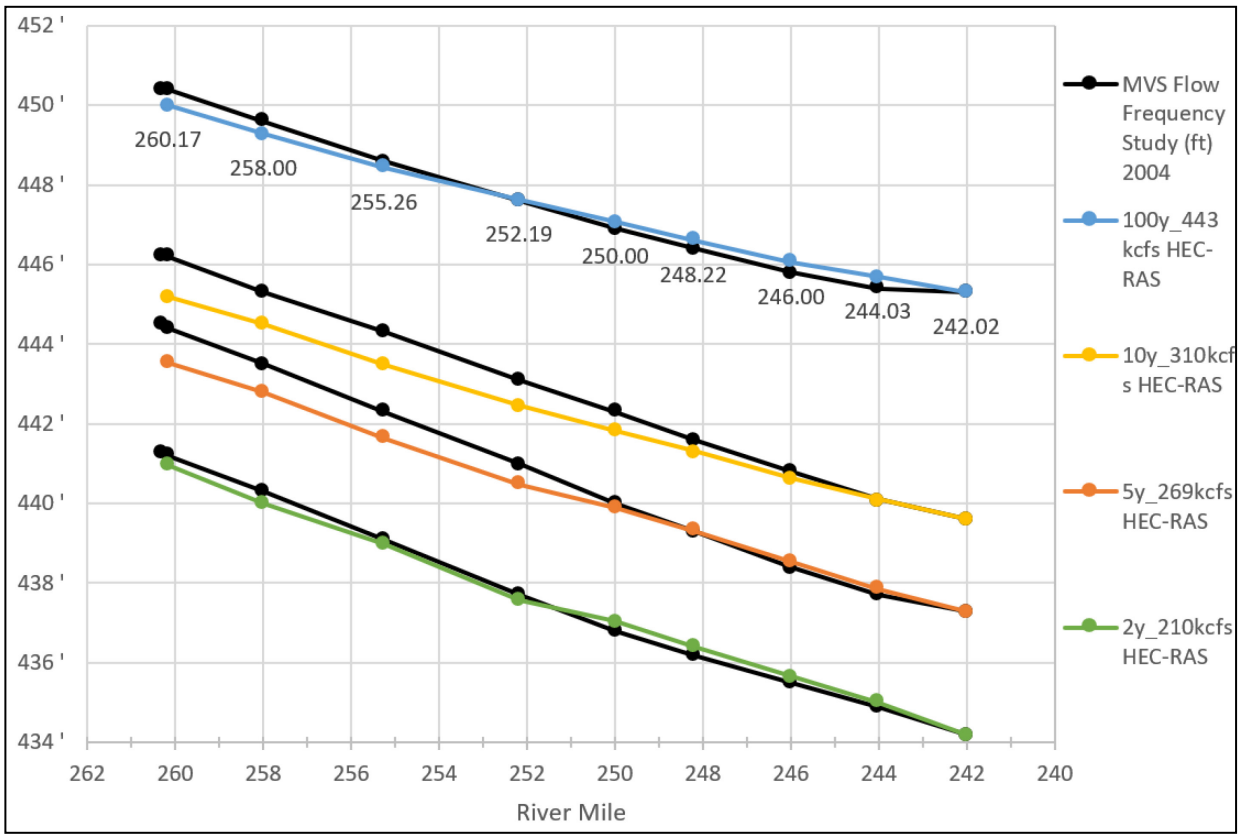


**Figure 14 MVS Flow Frequency Study – HEC-RAS Calibration**

### 2.3.2 Acoustic Doppler Current Profiler (15,110 cfs, 2023)

During a low flow event, the velocity was calibrated to acoustic doppler current profiler (ADCP) survey date obtained on 7/28/2023 with a corresponding average flow (15,110 cfs) during the 12-hour survey collection window. Depth-averaged velocities span from 0 ft/s to 2.5 ft/s within the main channel and 0 ft/s to 1.5 ft/s within the backwaters. The flow data was obtained from USACE's Mosier Landing gauge on the same day as the ADCP survey. The hydraulic model velocity results were compared to the 2023 ADCP velocity data using the similar flow event. The ADCP collection is depicted with velocity arrows and the hydraulic model velocity shading results shown underneath. Figure 15 shows the velocity calibration results for Reds Landing.

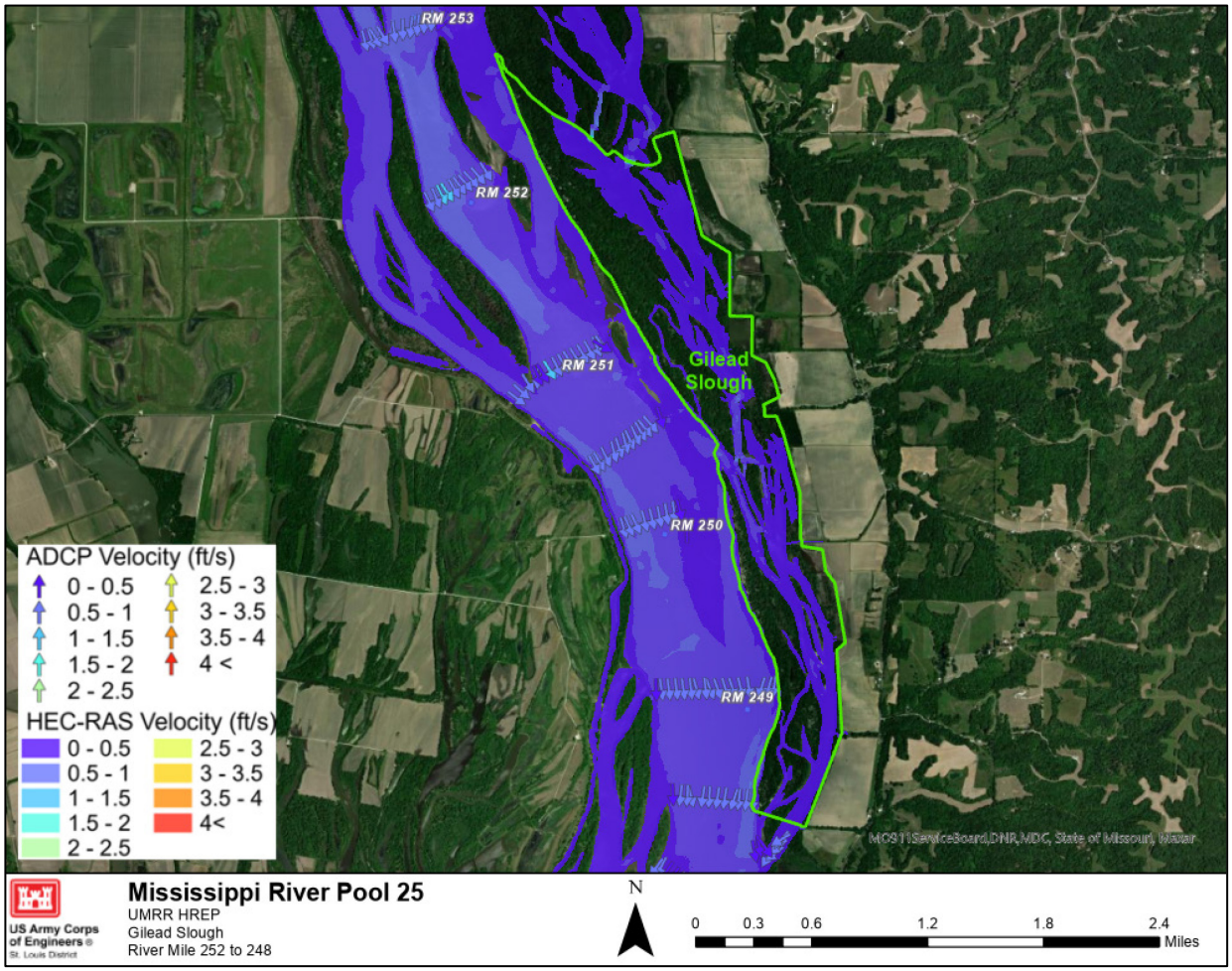


**Figure 15 ADCP Calibration – Gilead Slough**

After the model was calibrated, other low-flow scenarios were tested using L&D 24 TW discharges and Mosier gage readings provided from USACE St. Louis District Water Control. The same mesh, manning's "n" values, boundary locations, and cross sections were used for these runs. Monthly average discharges along with select pool discharges were pulled from USACE records between the years 2009 to 2023. The normal pool, average pool, ADCP flow, average monthly minimum, average

monthly median, and average monthly maximum were calculated; and these events were run within the HEC-RAS program. The WSEs for these conditions are shown in Table 10 for each existing HEC-RAS flow condition. The results were deemed acceptable by the hydraulic engineer given the different parameters and therefore the model was calibrated.

**Table 10 Low Flow Model Scenarios**

| River Mile | Discharge* Normal Pool 7/28/2023 20,000 cfs | Discharge* Moderate Pool 55,000 cfs | Discharge* ADCP 7/28/2023 15,110 cfs | Discharge* 2009-2023 Monthly Average Min 95,000 cfs | Discharge* 2009-2023 Monthly Average Med 120,000 cfs | Discharge* 2009-2023 Monthly Average Max 175,000 cfs |
|---|---|---|---|---|---|---|
| RM 242.02 | 433.60 | 434.00 | 433.96 | 434.00 | 434.05 | 434.10 |
| RM 244.03 | 433.61 | 434.01 | 433.92 | 434.04 | 434.16 | 434.60 |
| RM 246.00 | 433.62 | 434.12 | 433.97 | 434.34 | 434.59 | 435.17 |
| RM 248.22 | 433.63 | 434.19 | 433.97 | 434.54 | 434.90 | 435.78 |
| RM 250.00 | 433.64 | 434.26 | 433.98 | 434.74 | 435.19 | 436.28 |
| RM 252.19 | 433.65 | 434.34 | 433.99 | 434.96 | 435.50 | 436.72 |
| RM 255.26 | 433.69 | 434.57 | 434.01 | 435.36 | 436.99 | 437.97 |
| RM 258.00 | 433.73 | 434.77 | 434.01 | 435.78 | 437.36 | 438.86 |
| RM 260.17 | 433.75 | 434.96 | 434.04 | 436.45 | 437.97 | 439.83 |

* WSE shown in NAVD88, -0.4 ft (converted from NVGD29)

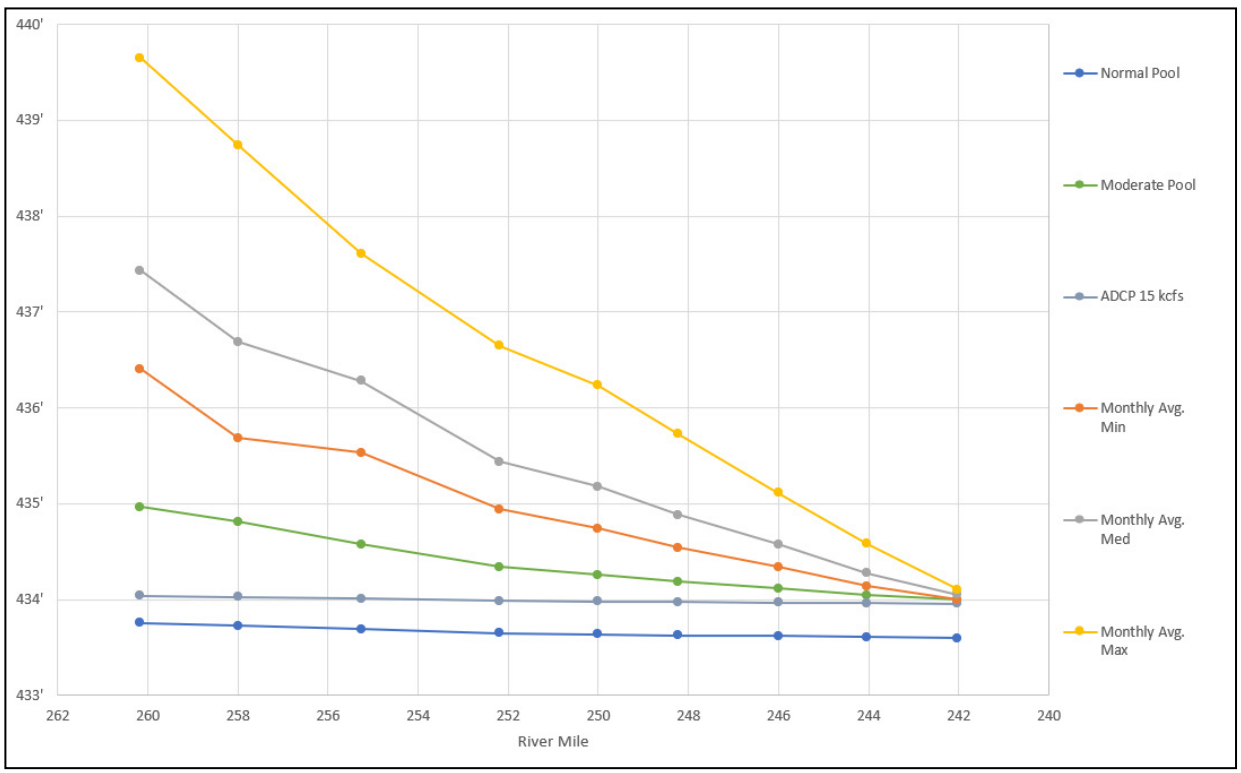


**Figure 16 Low Flow Model Scenerios**

# 3 ALTERNATIVE ANALYSIS

Four design alternatives were developed by the PDT for the study area. The design alternatives (FWOP, Minimum Habitat Benefit, Intermediate Habitat Benefit, and Maximum Habitat Benefit) consist with or without the project features detailed within the following subsections. This section summarizes the corresponding project features contained within each design alternative of the study area. The design alternatives were then analyzed at the flow conditions shown in Table 11 for each habitat benefit alternative and corresponding selected project features within each alternative. The flow conditions selected represent significant targets for proposed features modeled within each habitat benefit alternative.

**Table 11 Modeled Flow Conditions**

| Flow Condition | L&D 25 Pool Flow (CFS) |
|---|---|
| Moderate Pool | 95,000 |
| Avg. Median Pool | 120,000 |
| Avg. Maximum Pool | 175,000 |
| 50% AEP (2-year) | 210,000 |
| 20% AEP (5-year) | 269,000 |
| 1% AEP (100-year) | 443,000 |

The moderate pool was selected to represent a low flow condition within Pool 25. The average median pool will be used to help analyze habitat features representing a typical flow condition. The average maximum pool represents a higher flow, but below significant flood events as a check on habitat features within the model. The 50% AEP was used to closely represent the OHWM, a benchmark set by the PDT. The 20% AEP was utilized to analyze a low-level flood event with project features. Finally, the 1% AEP will be used to analyze the tentatively selected plan (TSP) for a No-Rise Analysis as required when constructing projects within FEMA designated waterways. A summary of the alternative analysis can be found at the end of this section. The TSP and No-Rise Analysis discussion can be found in Section 4.1 “Proposed Design”.

## 3.1 Project Features

The features chosen for analysis include dredging, shoreline protection with gradual slope revetment (GSR), scour structures, barbs, hard points, sediment deflection dike, island creation, moist soil units, bank protection, vegetative activities, and other natured-based features. Each of the project features were placed into three design alternatives: minimum habitat benefit, intermediate habitat benefit, and maximum habitat benefit. A No Action, Future Without Project (FWOP) was also analyzed with no project features nor improvements. Features contained within each alternative are shown in Table 12. Specifics of each feature will be discussed in the following sections.

**Table 12 Project Features**

| **Feature(s)** | **No Action** FWOP | Minimum Habitat Benefit | Intermediate Habitat Benefit | Maximum Habitat Benefit |
|---|---|---|---|---|
| Dredging Channels / Connections / Deep Pockets | - | X | X | X |
| Barbs | - | X | X | X |
| Scour Structures (Chevrons) | - | X | X | X |
| Backwater Excavation for Emergent Vegetation | - | X | X | X |
| Island Creation | - | - | X | X |
| Shoreline Protection with GSR | - | X | X | X |
| Hard Points | - | - | X | X |
| Bank Protection (Internal) | - | - | X | X |
| Substrate Diversity | - | - | X | X |
| Moist Soil Unit with Overflow | - | - | X | - |
| Moist Soil Unit with Pump | - | - | - | X |
| Sediment Deflection Dike | - | - | - | X |
| River Connection starting at Upper Gilead | - | - | - | X |

### 3.1.1 Dredging

The project's objective is to restore the backwater habitats of Gilead Slough by connecting the river side channel with backwater channels and sloughs. Increased sedimentation has been observed in the backwater reaches, primarily within the middle and upper reaches of Gilead. The implementation of dredging will re-establish regular depths and deep pockets for overwintering fish and initiating connecting flow paths, with the hope of inducing natural scouring to "open up" the channel during larger flow events over time. Without intervention, the backwater channels will eventually become cut off from the main river, degrading the aquatic habitat.

Design criteria for dredging were taken from the NESP Environmental Design Toolkit. The Toolkit outlines basic parameters for constructability and design elements for consideration. These include location of dredge material disposal, water quality monitoring, material type, adjacent banks, and river connectivity. It is suggested that a short segment of high ground should be placed near the upper reaches of a dredged channel to minimize sedimentation of the channel. High ground is being maintained naturally along the Mississippi River shoreline up to the 20% AEP flood event within upper Gilead.

There are two main forms of dredging discussed in the Toolkit: mechanical dredging and hydraulic dredging. Mechanical dredging involves an excavator or similar machine, either based on a barge or driven on land to remove material. Hydraulic

dredging utilizes water pressure to agitate material and then apply suction to transport it though a pipe to a disposal site.

Mechanical dredging has a lower mobilization component when compared to hydraulic dredging. Mechanical dredging can be fairly precise and shape channel bank lines to design specifications. Due to this precision, less turbidity is created during the process which helps meet water quality standards. Mechanical dredging works well in stiff clays and stump fields with the materials removed containing higher solids content. A concern with mechanical dredging is a lower production rate which makes it less cost effective for large-scale operations.

Hydraulic dredging boasts a higher production rate with sands and silts. It has a higher mobilization cost, lower precision, and high turbidity. Materials that are removed contain a higher water content, so more space is required for placement areas. This method is not as suitable for stiffer clays and stump fields. Due to these considerations, mechanical dredging has been listed as the preferred method of dredging on this project.

Dredge centerlines were determined to maximize flow into the backwaters of Gilead. Deep pockets ranging an additional 0-5 feet were introduced within the dredge paths to promote bathymetric diversity and provide overwintering habitat. Figure 17 below shows the dredge centerlines highlighted in shades of blue. Dredge centerlines were broken down into primary (dark blue), secondary (teal), and tertiary (light blue/white), and decrease in channel width and priority.

The Minimum and Intermediate Habitat Benefit alternatives consisted of the same dredge paths. The Maximum Habitat Benefit included an additional river connection near the northern portion of Gilead Slough (orange). Environmental Pool Management regions were added to all alternatives within the shallower, more narrow sections of Gilead and are highlighted in yellow in the figure below.

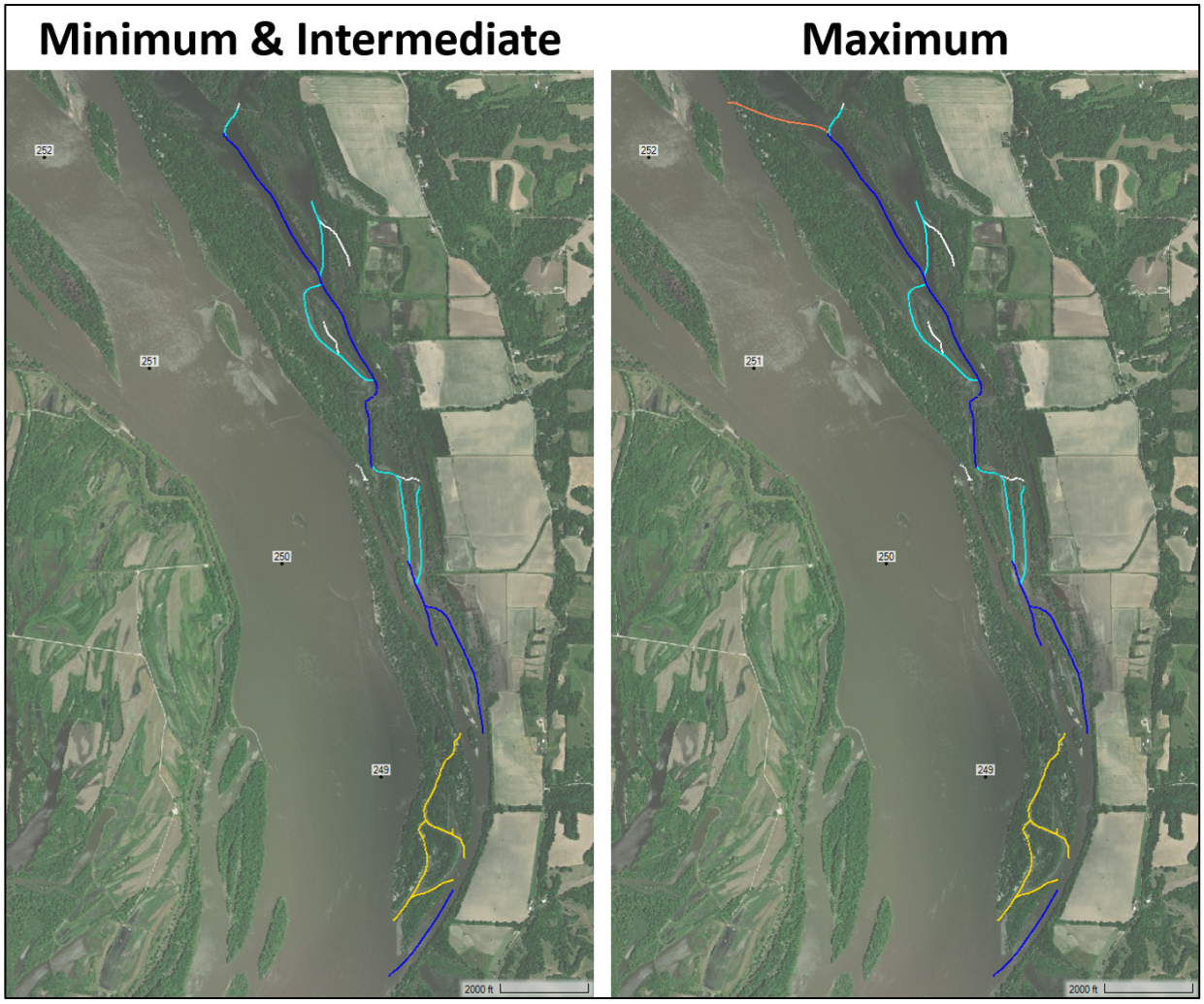


**Figure 17 Dredge Centerlines**

### 3.1.2 Gradual Slope Revetment (GSR)

For proposed habitat, the utilization of bank stabilization with gradual slope revetment (GSR) will be placed to stabilize the left descending banklines along the Mississippi River in areas of shoreline erosional concerns. Typical slope revetment involves placing rock along the shoreline to armor the slope. GSR takes that method further by extending the shoreline into the channel at a shallow slope with revetment. Extra material from dredging and excavation activities could be utilized in construction of the bankline overlain with rock revetment. This helps utilize extra excavated material, enhances the stability of the bankline slope, and provides voids within the revetment for aquatic habitat. The shoreline protection with GSR will also be built up to the 50% AEP flow event to help assist in sediment deflection with Gilead Slough during significant flow events. cross section of the GSR modeled for this project is shown below in Figure 18.

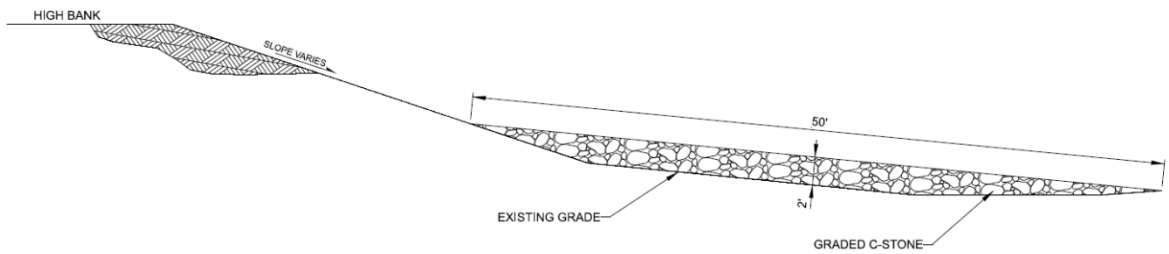


**Figure 18 Gradual Slope Revetment Cross Section**

### 3.1.3 Barbs

Barbs are river training structures (RTS) that help redistribute or redirect watercourse energy to achieve various flow patterns and velocity results. Barbs are typically angled upstream to create diverse flow patterns with results that include scouring or deepening a channel for navigation purposes, enhancing bankline stabilization, managing sediment distribution, or increasing habitat by inducing bathymetric diversity. Barbs should be keyed or tied into the existing bankline to avoid flanking or bypassing of the river, which may pose detrimental results. For this project, there are seven barbs located within the middle backwater reaches of Gilead Slough to aid in flow conditions and habitat diversity. The Minimum and Intermediate model results were similar, while the Maximum showed an increase in the side channel velocity due to the river connection.

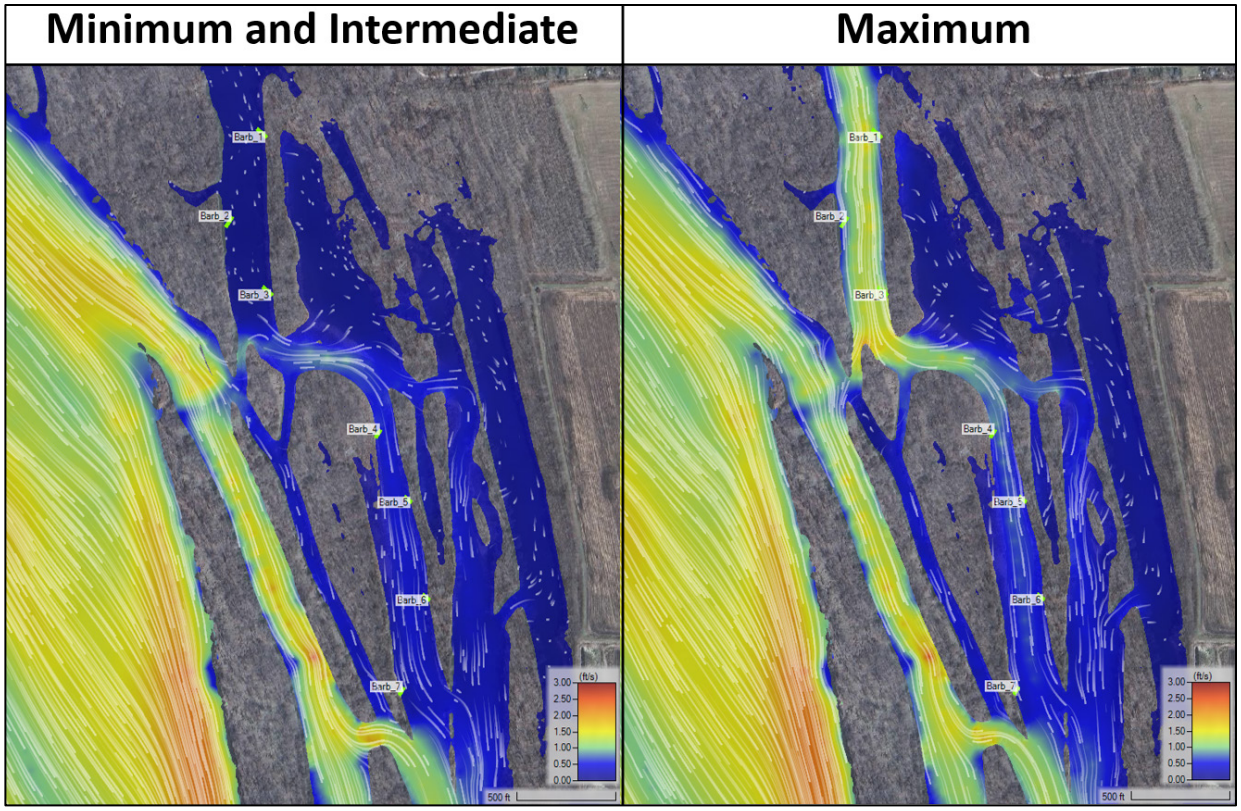


**Figure 19 Gilead Barb Placement. Velocity at 120 kcfs.**

### 3.1.4 Scour Structures (Chevrons)

Scour Structures are river training structures (RTS) utilized to redistribute or redirect the watercourse energy to achieve various flow patterns and velocity with the focus to induce scour results. Scour structures aid in flow diversity, managing sediment distribution, and increasing habitat depths by inducing bathymetric diversity. Chevrons will be placed within the middle to lower reaches of Gilead Slough below the side channel connection exploiting better flow conditions.

Chevrons were modeled with a crest elevation of 435 feet and side 2H:1V side slopes. This is roughly 2 feet below the 210 kcfs water surface elevation and just below the 120 kcfs water surface elevation.

Figure 20 shows the impact chevrons have on the velocity in the lower portion of Gilead Slough when the 120 kcfs flow was applied. The red highlighted point has a velocity of 1.485 ft/s (Existing), 1.615 ft/s (Minimum and Intermediate), and 1.653 ft/s (Maximum). Overall, the chevrons increased downstream velocity for each alternative. The maximum increased more due to the river connection feature.

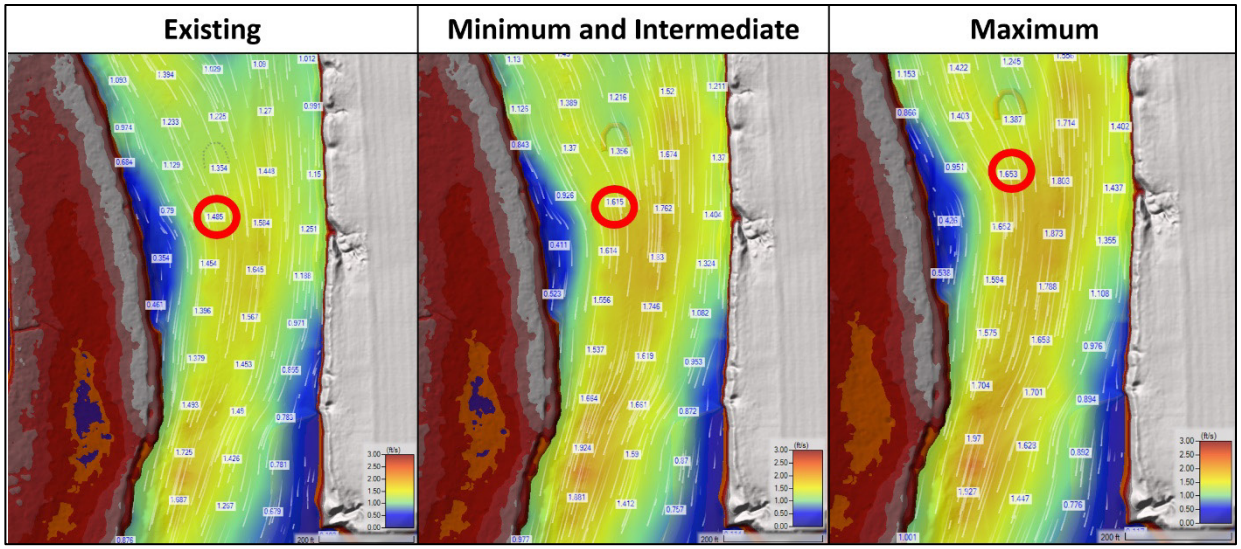


**Figure 20 Scour Structures Lower Gilead**

### 3.1.5 Hard Points

Hard Points are smaller river training structures (RTS) that extend perpendicular to the bankline and protect the bankline from erosion. It has been observed that hard points create aggradation (accumulation of material) on the upstream portion and degradation (removal of material) on the downstream portion.

The hard points for this project will follow a geometry of a 1V:10H slope, feet from the bankline to a hinge elevation of 436 feet, determined by the OHWM (50% AEP), and then follow a 1V:5H slope down to the existing channel elevation. Five alternating hard points will be located downstream of the existing river connection along steep banklines (Figure 22).

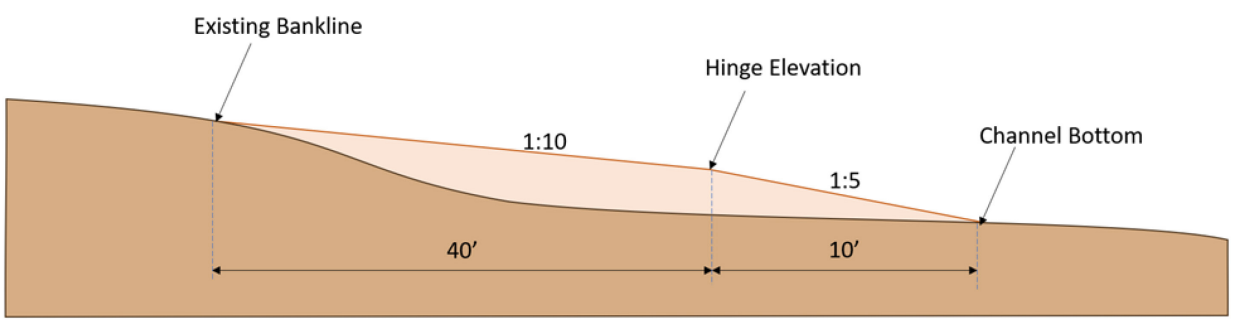


**Figure 21 Example Hard Point Profile**

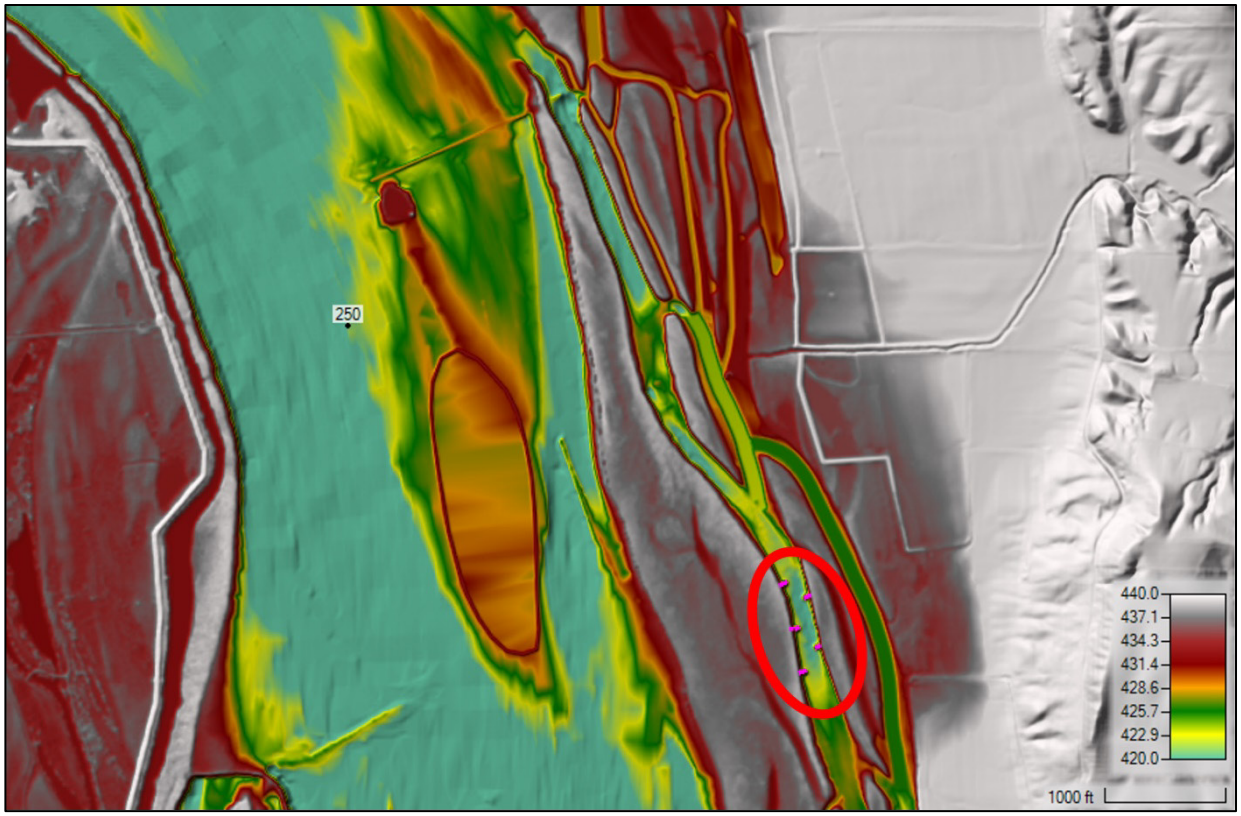


**Figure 22 Hard Point Locations**

### 3.1.6 Bank Protection

For the proposed project, bank protection will be utilized to stabilize various problematic banklines or near vertical slopes along the backwater reaches of Gilead Slough.

Typical slope revetment involves placing rock along the shoreline to armor the slope; however, revetment does not need to be deployed in areas with low or stagnate flow conditions similar to what is seen in the proposed placement area. This measure will enhance the stability of the bankline slopes and help re-establish a more natural bankline allowing for vegetation to take root. A typical section of bank protection for this project is shown below in Figure 23.

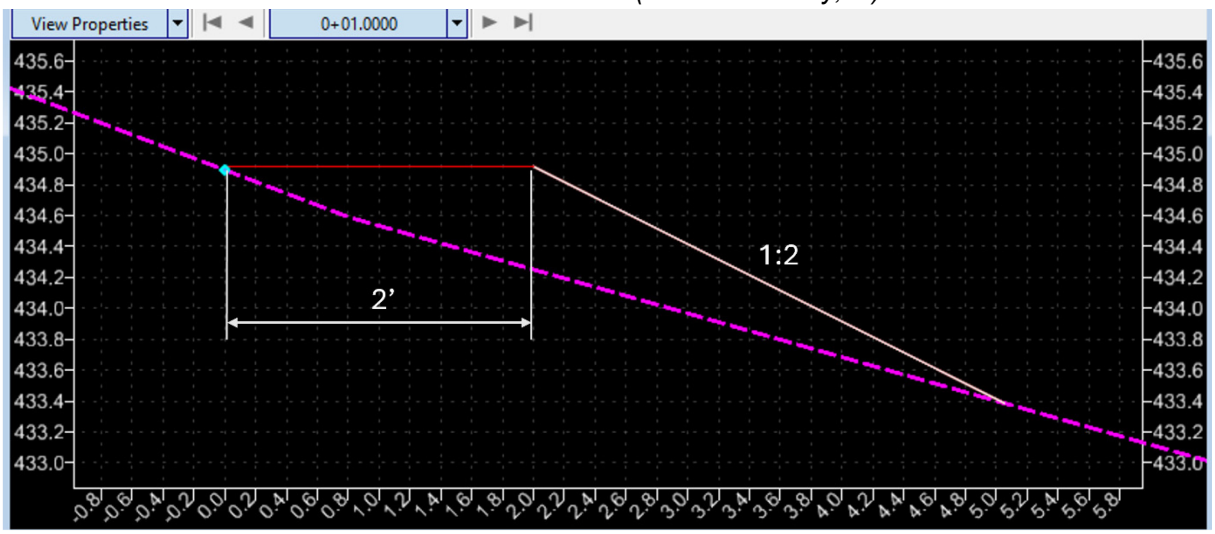


**Figure 23 Bank Protection Typical Section**

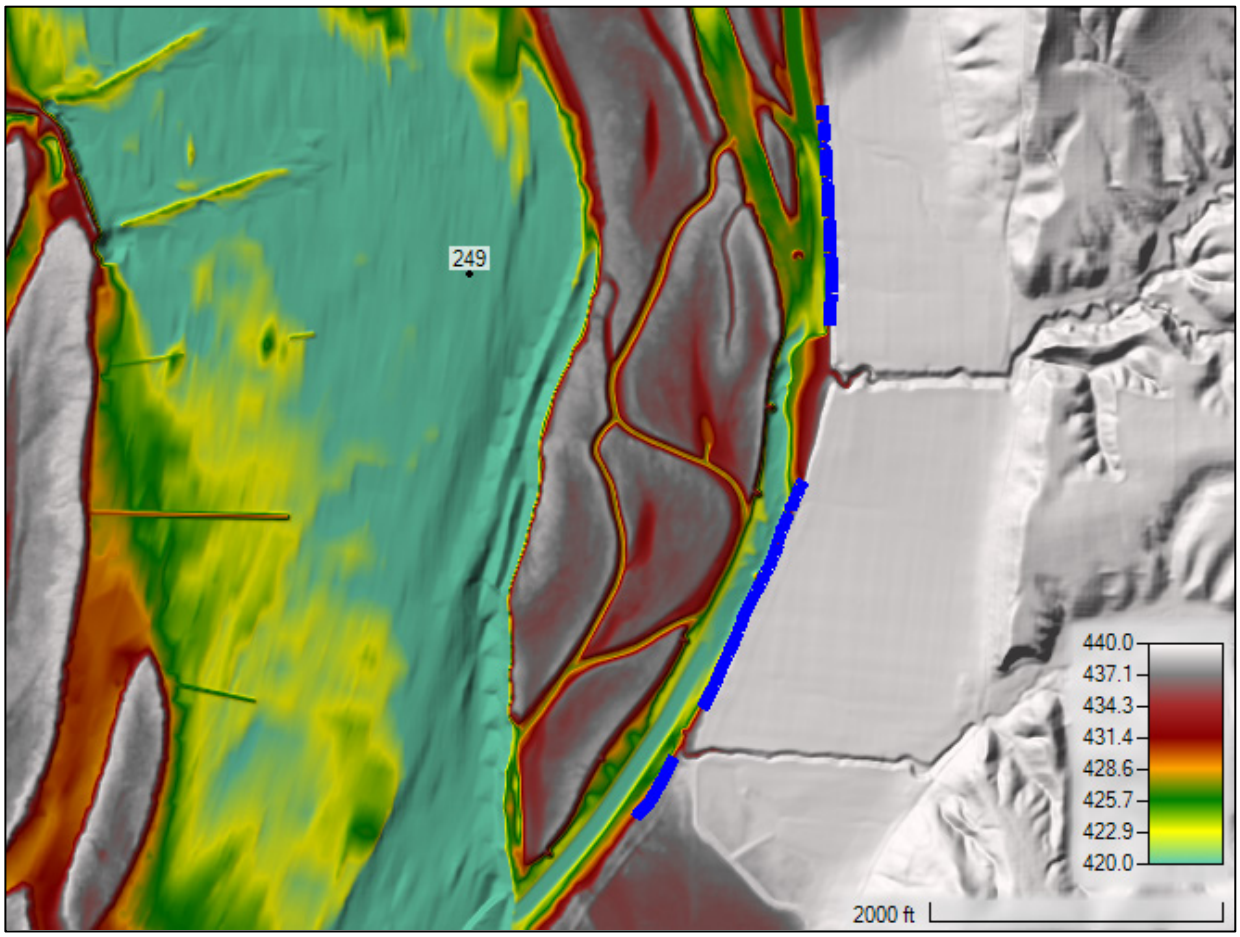


**Figure 24 Bank Protection Locations**

### 3.1.7 Side Channel River Connection with Sediment Deflection Dike

The inclusion of a side channel river connection starting in the upper reaches of Gilead Slough was considered by the PDT for analysis. The river connection

comprised of an excavated channel and sediment deflection dike. The river connection side channel would be excavated to length of 2000 feet with a bottom width of approximately 40 feet and have 4H:4V side slopes.

A sediment deflection dike would be constructed as a curved “hook” downstream at the entrance of the river connection up to the elevation of the surrounding terrestrial terrain and deflect sediments around and away from the entrance of the side channel during flow events less than 210 kcfs. The sediment deflection dike would be constructed in out of material onsite and heavily armored with rock revetment and keyed into the adjacent terrain. The dike would be approximately 250 feet long, with a crown width of approximately 10 feet, and have 1H:2V side slopes.

The concept creates a new river connection to promote additional flow into Gilead Slough and slightly increase flow velocities to flush out sediments naturally within the backwater channels during larger flow events above 210 kcfs. The sediment deflection dike would continually act as a shield to deter sediments from depositing within Gilead’s backwaters.

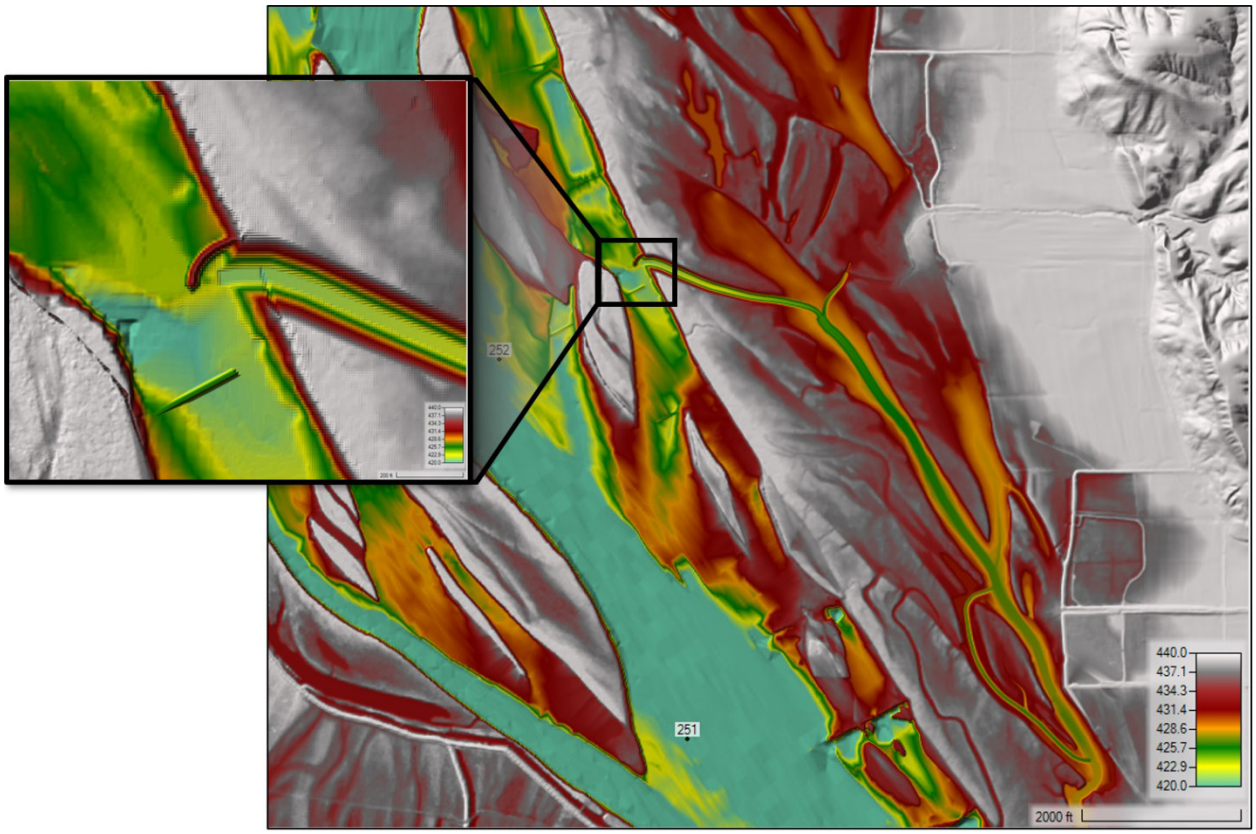


**Figure 25 River Connection at Gilead and Sediment Deflection Dike**

### 3.1.8 Island Creation

Island Creation was deemed to be necessary with the amount of excavation and dredging occurring within this project. The leftover earthwork that could not be utilized elsewhere within the project boundary would be placed within the Mississippi River’s

main channel away from the main sailing line while maintaining an appropriate navigational width of 300 feet. The island would be located along the left descending channel between RM 249.5 to 250.0 and range between 25-30 acres within a shallow portion of the river. The creation of an island or sandbar would aid in creating additional terrestrial habitats unique for turtles, birds, and other terrestrial species.

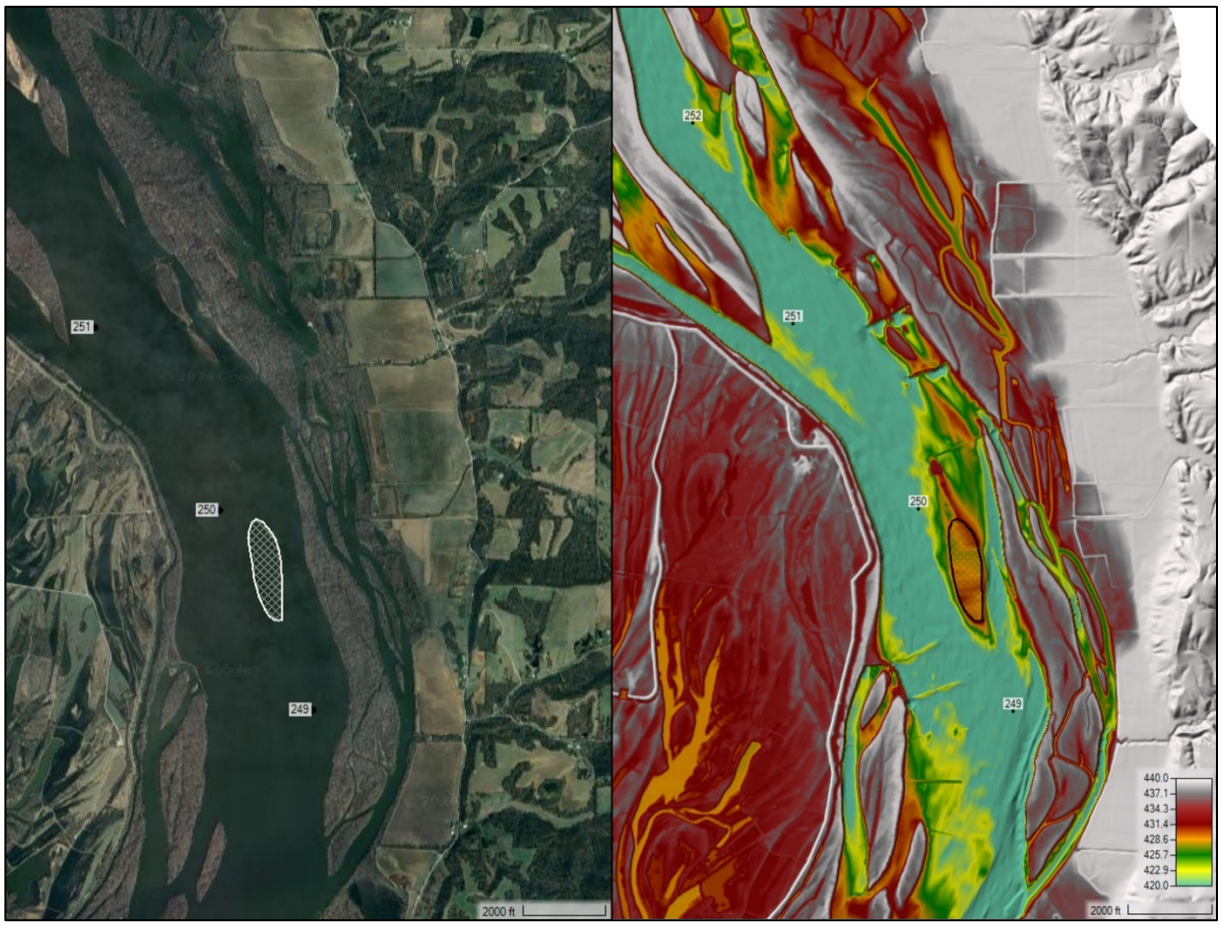


**Figure 26 Proposed Island Creation**

### 3.1.9 Moist Soil Units

Three Moist Soil Units (MSUs) are proposed for Gilead. MSUs consist of excavated channels, paths, berms, pumps, and water control structures. The excavated areas will be gradually sloped to allow for positive drainage towards specified drainage points or water control structures. Figure 27 MSU Locations below shows the locations of the MSU areas. Water control structures are located on the northern MSU (blue) and the southern MSU (green) and are highlighted in red.

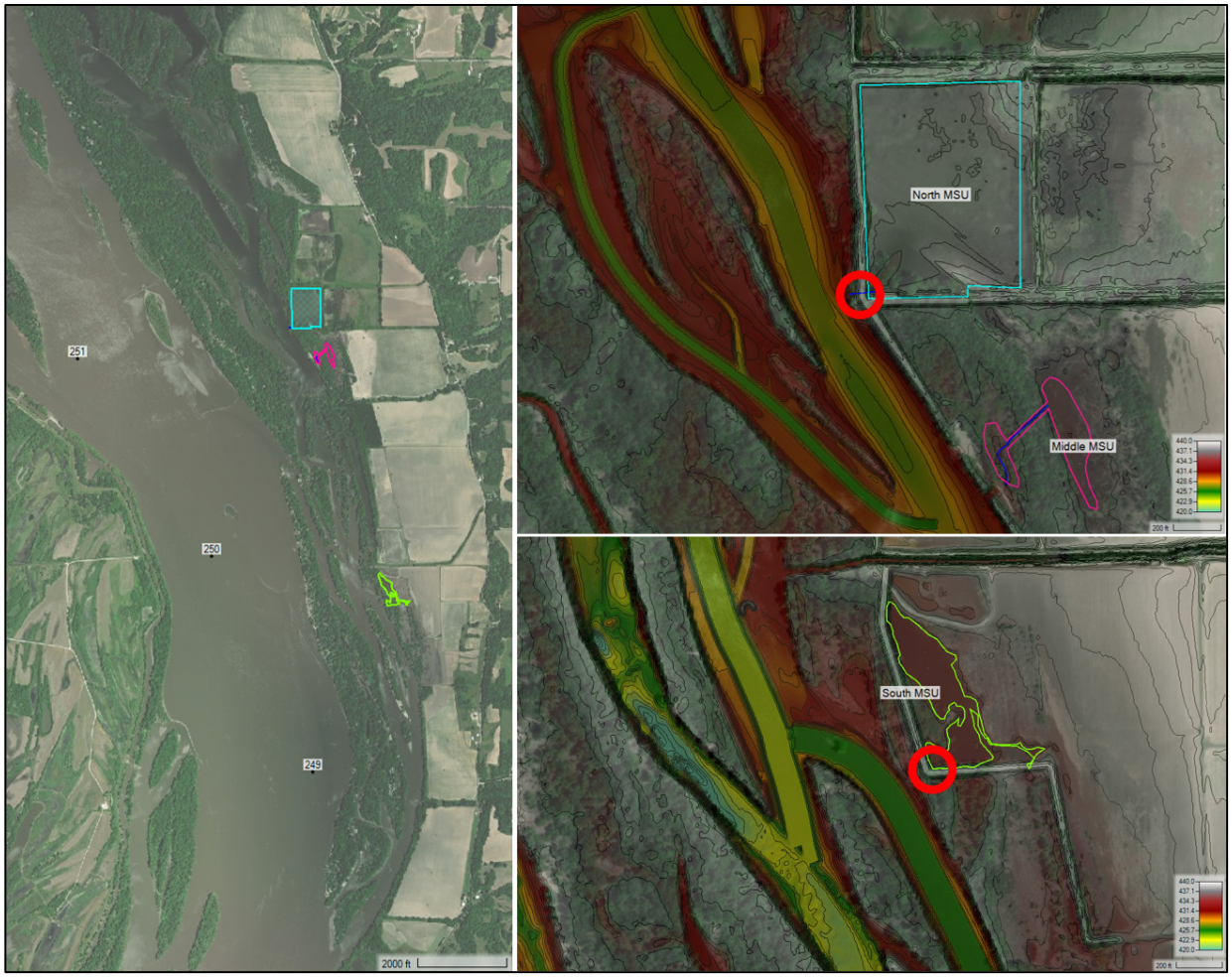


**Figure 27 MSU Locations**

## 3.2 Proposed Design Alternatives

Three Alternatives were modeled for the Gilead Slough HREP. The models included various features mentioned in the previous sections. Each alternative had adjustments within the terrains, altered to reflect the corresponding features included within each alternative. Then specified flows were run through the hydraulic model, HEC-RAS, and compared the existing conditions without project features with the proposed conditions with project features for alternative analysis. The alternatives studied are the Minimum Habitat Benefit, Intermediate Habitat Benefit, and the Maximum Habitat Benefit. The following sections summarize the results from each alternative analyzed.

## 3.3 No Action – Future Without Project (FWOP)

There are no features, so no additional modeling was needed for the "No Action – Future without Project" model. The "existing conditions" model shown in Section 2.3 would be most representative for hydraulic analysis.

**Table 13 FWOP**

| Feature(s) | **No Action** FWOP | Minimum Habitat Benefit | Intermediate Habitat Benefit | Maximum Habitat Benefit |
|---|---|---|---|---|
| Dredging Channels / Connections / Deep Pockets | - | X | X | X |
| Barbs | - | X | X | X |
| Scour Structures (Chevrons) | - | X | X | X |
| Backwater Excavation for Emergent Vegetation | - | X | X | X |
| Island Creation | - | X | X | X |
| Shoreline Protection with GSR | - | - | X | X |
| Hard Points | - | - | X | X |
| Bank Protection (Internal) | - | - | X | X |
| Substrate Diversity | - | - | X | X |
| Moist Soil Unit with Overflow | - | - | X | - |
| Moist Soil Unit with Pump | - | - | - | X |
| Sediment Deflection Dike | - | - | - | X |
| River Connection starting at Upper Gilead | - | - | - | X |

Without project implementation, sedimentation may continue within Gilead Slough and cause backwater regions to close off from the main channel due to natural erosion received from farmland cultivation, upland drainage ditches, backwater shorelines, and large flood events depositing out material as velocities and water levels fall and normalize. The secondary and tertiary side channels may become cut off from the main channel due to debris blockage and sedimentation over time. Degraded conditions of these backwater habitats would prevent proper water level depths ideal for fish habitat and accessibility, waterfowl habitat, wetland quality, and diversified forest acreage. Without action, the conditions in the area would be similar to existing conditions in the future with backwater (low flow area) aquatic habitats within the study area continuing to degrade due to loss of flow, depth diversity, and possible loss of side channel.

Navigation along the main channel will continue to have adverse effects and impacts on important side channel and backwaters habitats within Pool 25 of the Mississippi River. Navigation induced shoreline erosion would continue degrading shorelines and aquatic habitats. If an alternative plan is not selected, habitats within the study area

would be impacted even further with sediments and lose connectivity.

Without the Gilead Slough HREP, it is assumed the existing conditions of the region would remain the same, with the potential to become more extreme as the climate continues to change. Side channel and backwater habitats may become shallow, dry, or cut off from the main river and species located in those areas would suffer. The backwater (low flow area) aquatic habitat within the study area would continue to degrade due to loss of flow, depth diversity, and loss of connection. The aquatic habitat would convert into low-quality habitats with terrestrial area overrun with invasive vegetative species or one that allows for only a few species such as willow and cottonwood to establish.

### 3.4 Minimum Habitat Benefit

The Minimum Habitat Benefit alternative will feature the following measures highlighted and listed below in Table 14 for the Gilead Slough HREP.

**Table 14 Minimum Habitat Benefit**

| **Feature(s)** | **No Action** FWOP | Minimum Habitat Benefit | Intermediate Habitat Benefit | Maximum Habitat Benefit |
|---|---|---|---|---|
| Dredging Channels / Connections / Deep Pockets | - | X | X | X |
| Barbs | - | X | X | X |
| Scour Structures (Chevrons) | - | X | X | X |
| Backwater Excavation for Emergent Vegetation | - | X | X | X |
| Island Creation | - | X | X | X |
| Shoreline Protection with GSR | - | - | X | X |
| Hard Points | - | - | X | X |
| Bank Protection (Internal) | - | - | X | X |
| Substrate Diversity | - | - | X | X |
| Moist Soil Unit with Overflow | - | - | X | - |
| Moist Soil Unit with Pump | - | - | - | X |
| Sediment Deflection Dike | - | - | - | X |
| River Connection starting at Upper Gilead | - | - | - | X |

The objective of dredging channels to widen and deepen the existing side channel and backwater sloughs within Gilead to improve flows and connectivity for aquatic habitats within the Mississippi River. The additional depth will assist providing deep pockets for overwintering fish, will extend the amount of time the backwater channels are submerged and allow for additional connectivity of aquatic system. Scour structures and barbs will allow improved flow conditions in transporting sediments

downstream. Within the lower reaches of Gilead backwater areas will be excavated on higher terrestrial ground to allow for emergent vegetation with environmental pool management (EPM). Also, extra excavated and dredge material will be utilized for island creation, as discussed previously within Section 3.

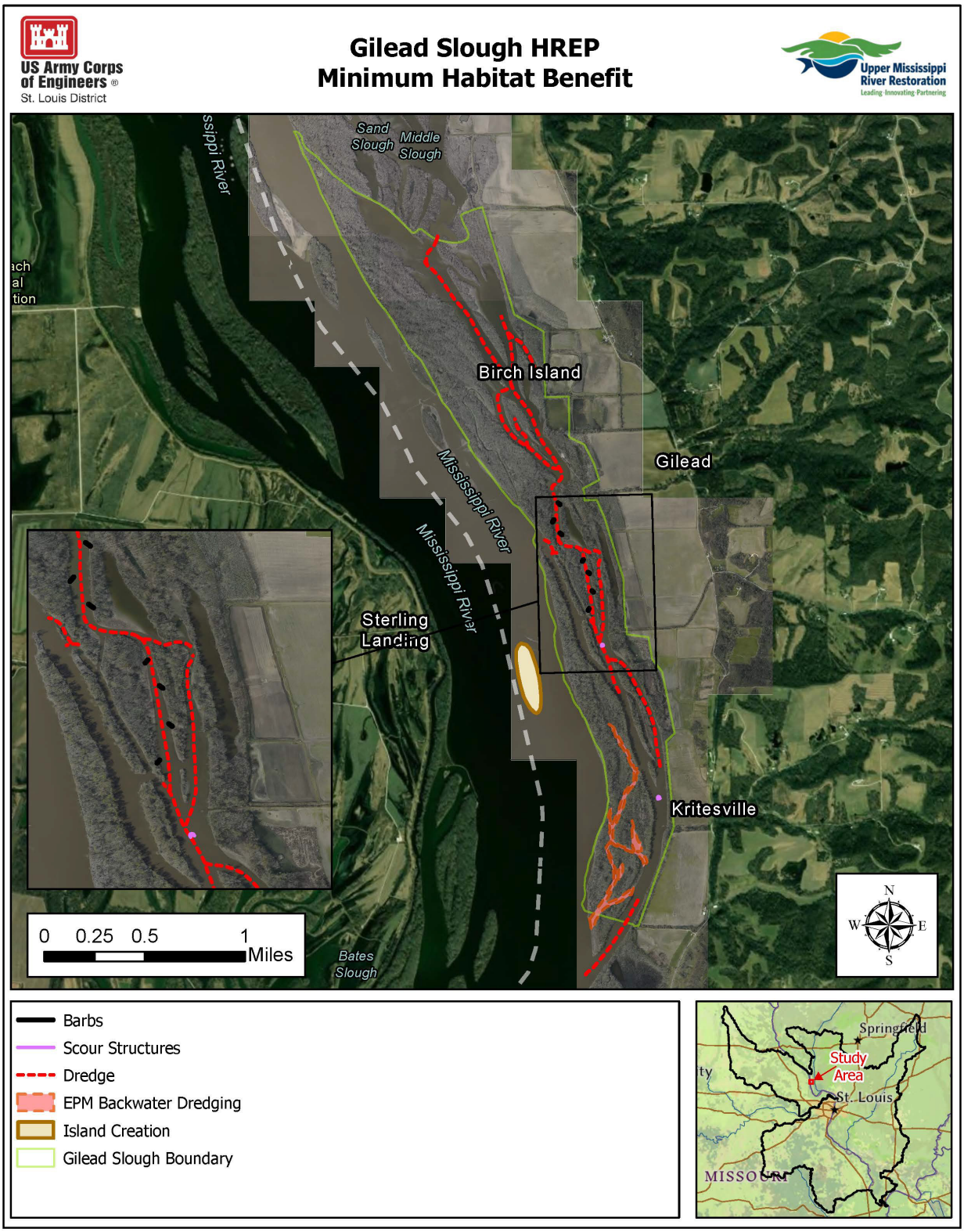


**Figure 28 Minimum Habitat Benefit**

### 3.5 Intermediate Habitat Benefit

The Intermediate Habitat Benefit alternative will feature the following measures highlighted and listed below in Table 15 for the Gilead Slough HREP.

**Table 15 Intermediate Habitat Benefit**

| **Feature(s)** | **No Action** FWOP | Minimum Habitat Benefit | Intermediate Habitat Benefit | Maximum Habitat Benefit |
|---|---|---|---|---|
| Dredging Channels / Connections / Deep Pockets | - | X | X | X |
| Barbs | - | X | X | X |
| Scour Structures (Chevrons) | - | X | X | X |
| Backwater Excavation for Emergent Vegetation | - | X | X | X |
| Island Creation | - | X | X | X |
| Shoreline Protection with GSR | - | - | X | X |
| Hard Points | - | - | X | X |
| Bank Protection (Internal) | - | - | X | X |
| Substrate Diversity | - | - | X | X |
| Moist Soil Unit with Overflow | - | - | X | - |
| Moist Soil Unit with Pump | - | - | - | X |
| Sediment Deflection Dike | - | - | - | X |
| River Connection starting at Upper Gilead | - | - | - | X |

Areas impacted by navigational shoreline erosion will be re-established with shoreline protection with GSR and armored with rock. Hard Points will provide bank protection, direct water during lower flow events, and direct scouring away from the bank line within the side channel. Substrate diversity will be an ancillary benefit with the previous features planned within this alternative. Two moist soil units (MSU) will be passively managed by the sponsor with stoplogs and overflows. These MSUs will be constructed north and south of the Gilead boat ramp along the Illinois bankline within the property boundary. Both MSUs will provide habitat benefits for waterfowl and amphibian species. This alternative will also include all the features previously discussed in within the Minimum Habitat Benefit.

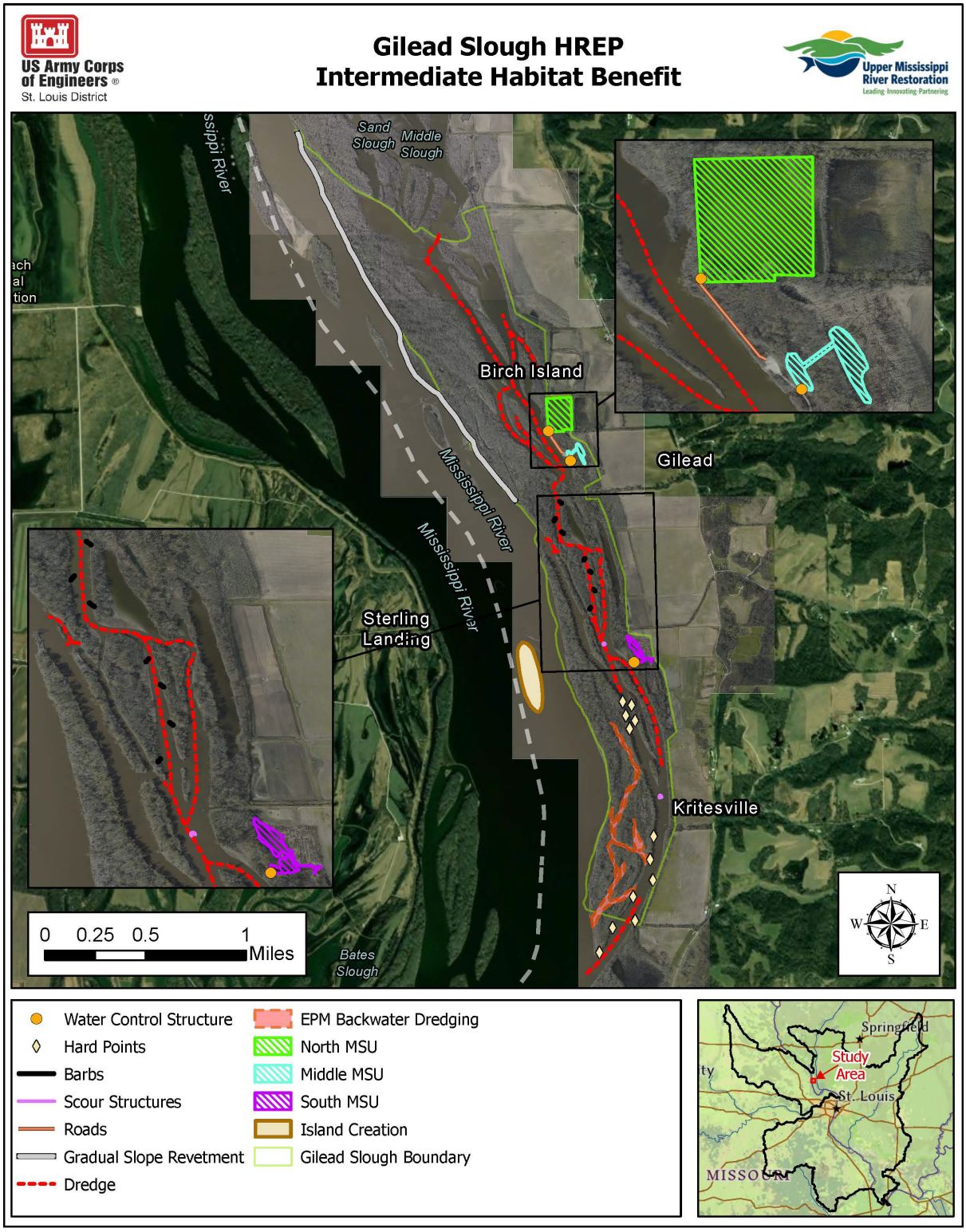


**Figure 29 Intermediate Habitat Benefit**

### 3.6 Maximum Habitat Benefit

The Maximum Habitat Benefit alternative will feature the following measures highlighted and listed below in Table 16 for the Gilead Slough HREP.

**Table 16 Maximum Habitat Benefit**

| **Feature(s)** | **No Action** FWOP | Minimum Habitat Benefit | Intermediate Habitat Benefit | Maximum Habitat Benefit |
|---|---|---|---|---|
| Dredging Channels / Connections / Deep Pockets | - | X | X | X |
| Barbs | - | X | X | X |
| Scour Structures (Chevrons) | - | X | X | X |
| Backwater Excavation for Emergent Vegetation | - | X | X | X |
| Island Creation | - | X | X | X |
| Shoreline Protection with GSR | - | - | X | X |
| Hard Points | - | - | X | X |
| Bank Protection (Internal) | - | - | X | X |
| Substrate Diversity | - | - | X | X |
| Moist Soil Unit with Overflow | - | - | X | - |
| Moist Soil Unit with Pump | - | - | - | X |
| Sediment Deflection Dike | - | - | - | X |
| River Connection starting at Upper Gilead | - | - | - | X |

With the Moist Soil Units in this alternative a more active management approach will be operated by the sponsor to operate a pump to fill the northern MSU. The southern MSU will still be operated passively with an overflow and stoplogs. Again, both MSUs will provide many beneficial qualities for the species that occupy these locations. This alternative provides a new excavated River Connection channel starting at upper Gilead. With this arrangement, Gilead Slough would function more like a side channel habitat rather than a backwater habitat. It will provide flow through the entire project reaches. A Sediment Deflection Dike will be constructed at the entrance of the proposed river connection channel to divert sediments as previously discussed within Section 3. The Maximum Habitat alternative creates a significant change to the current site conditions and would be the most intrusive, however beneficial, to the existing environment. This alternative will also include all the features previously discussed in within the Minimum and Intermediate Habitat Benefit.

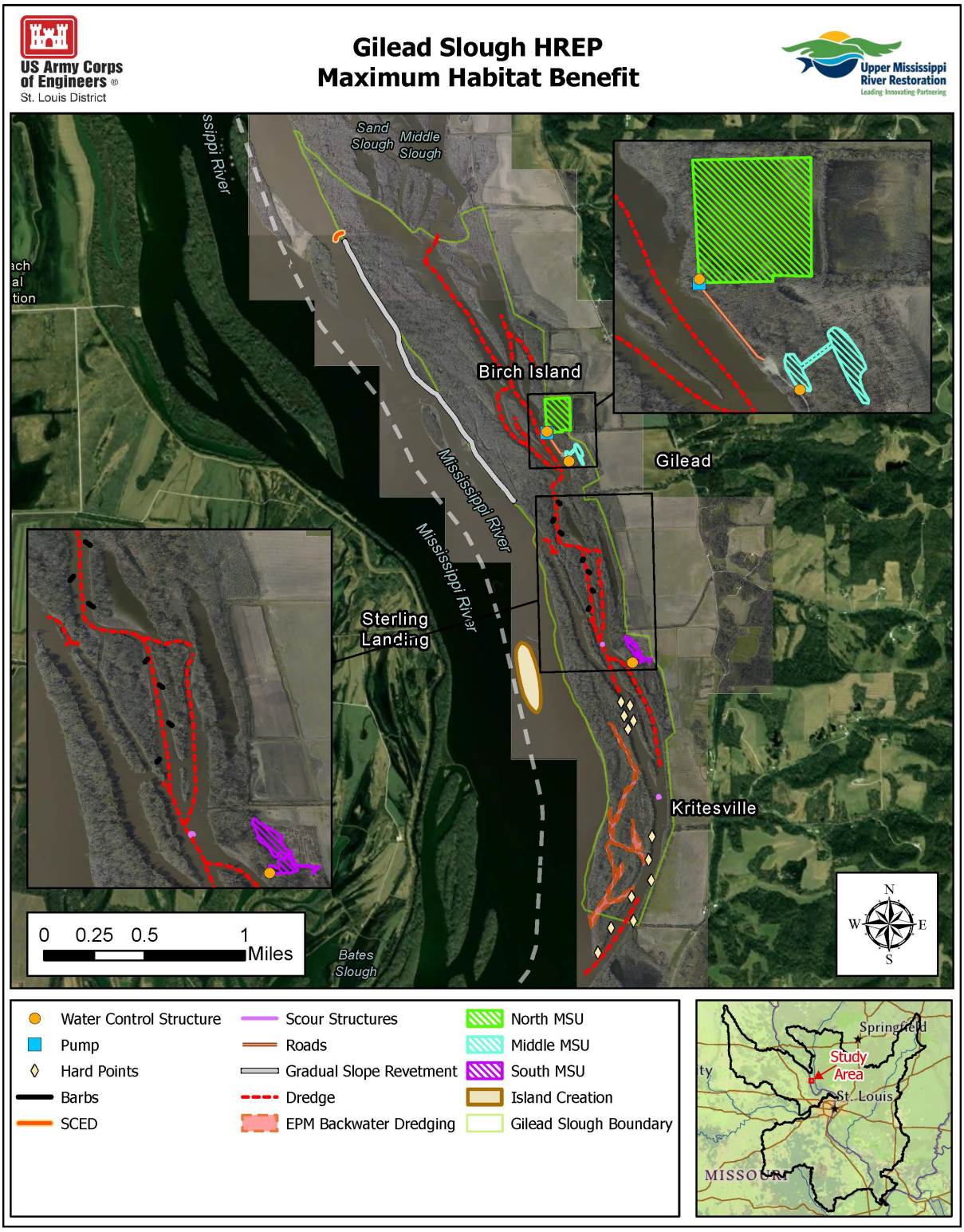


**Figure 30 Maximum Habitat Benefit**

# 4 PROPOSED DESIGN

## 4.1 Tentatively Selected Plan (TSP)

The Tentatively Selected Plan was determined to be Alternative 2 – Intermediate Habitat Benefit. The PDT saw this alternative as the most beneficial habitat enhancements for the aquatic species inhabiting the project area. All features were retained within this alternative and placed to produce the best hydraulic function. Figure 31 below shows the existing terrain for Gilead Slough.

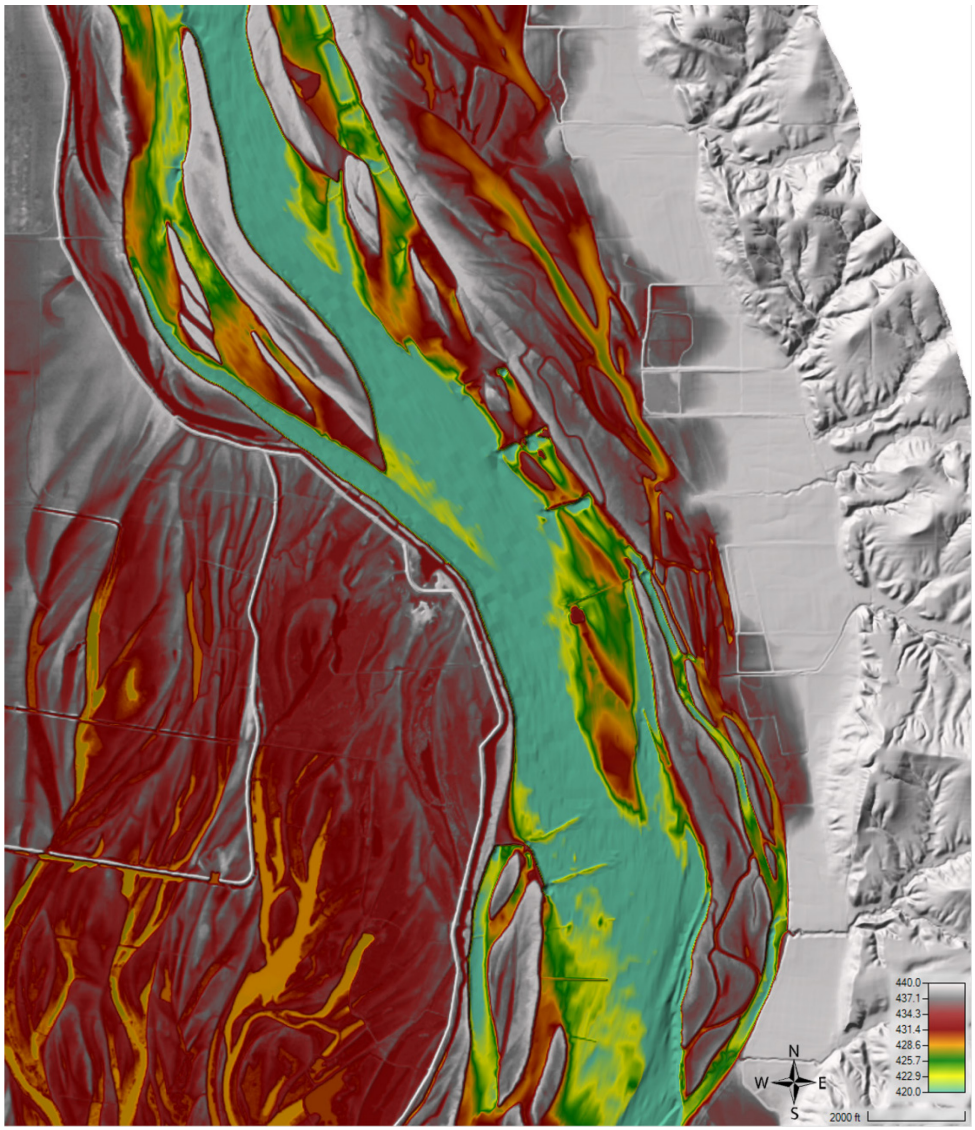


**Figure 31 Gilead Slough Exisiting Conditions**

The TSP will include the features of dredging and excavation of backwater channels and connections, shoreline protection with GSR, scour structures, barbs, hard points, island creation, moist soil units, and other nature-based features. All these features provided the best habitat benefits for the Gilead Slough HREP. Figure 32 shows the TSP terrain for Gilead Slough.

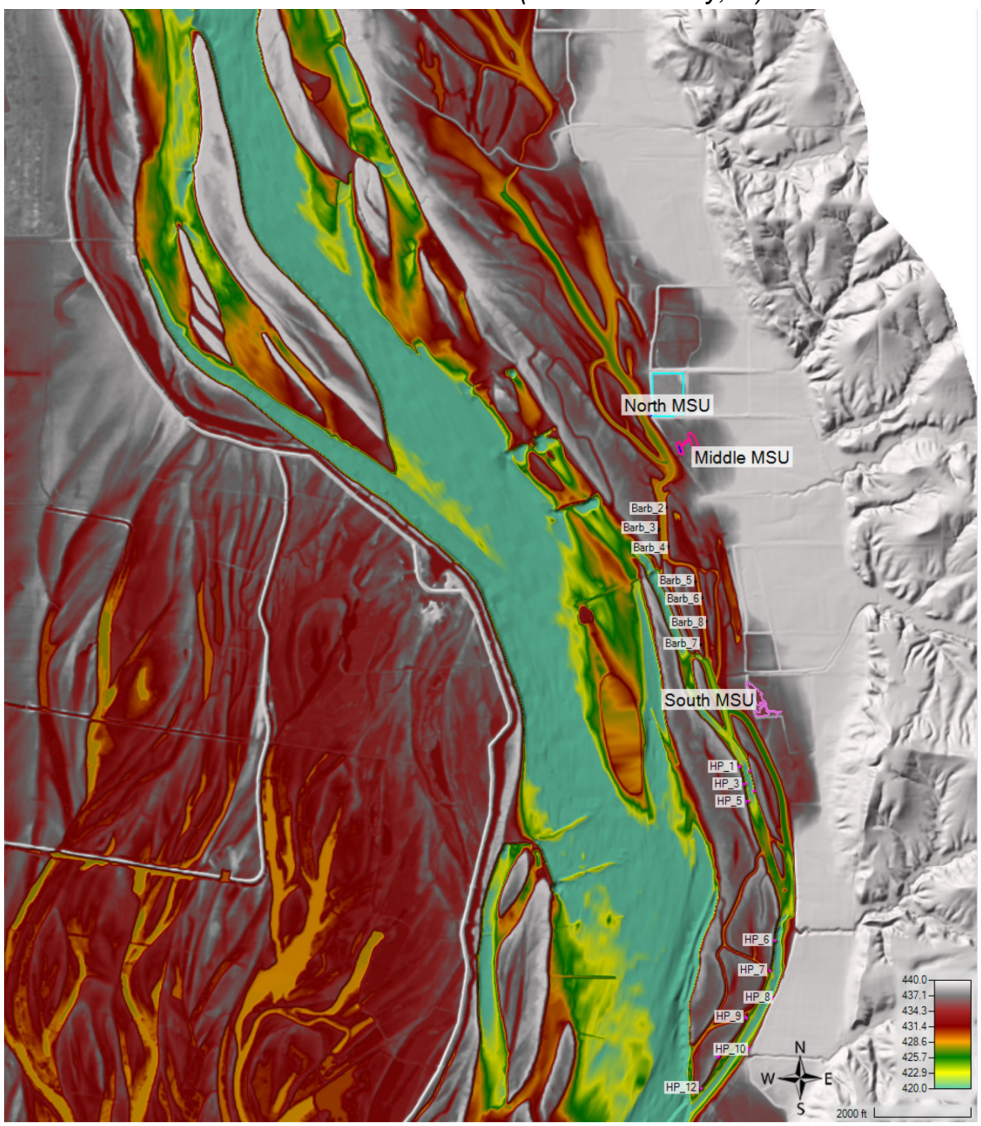


**Figure 32 Gilead Slough TSP Terrain**

The final velocities were analyzed for various flows. The Average Median flow (120 kcfs) was used to analyze habitat features, the 50% AEP (210kcfs) represents the OHWM, and the 5-year (269 kcfs) represents a higher flow yet below the 1% AEP. Figure 33, Figure 34, and Figure 35 below show a comparison between the existing and the TSP project areas within the project bounds. Areas where structures such as barbs, hard points, and scour structures are located helped aid favorable flow conditions for habitat diversity.

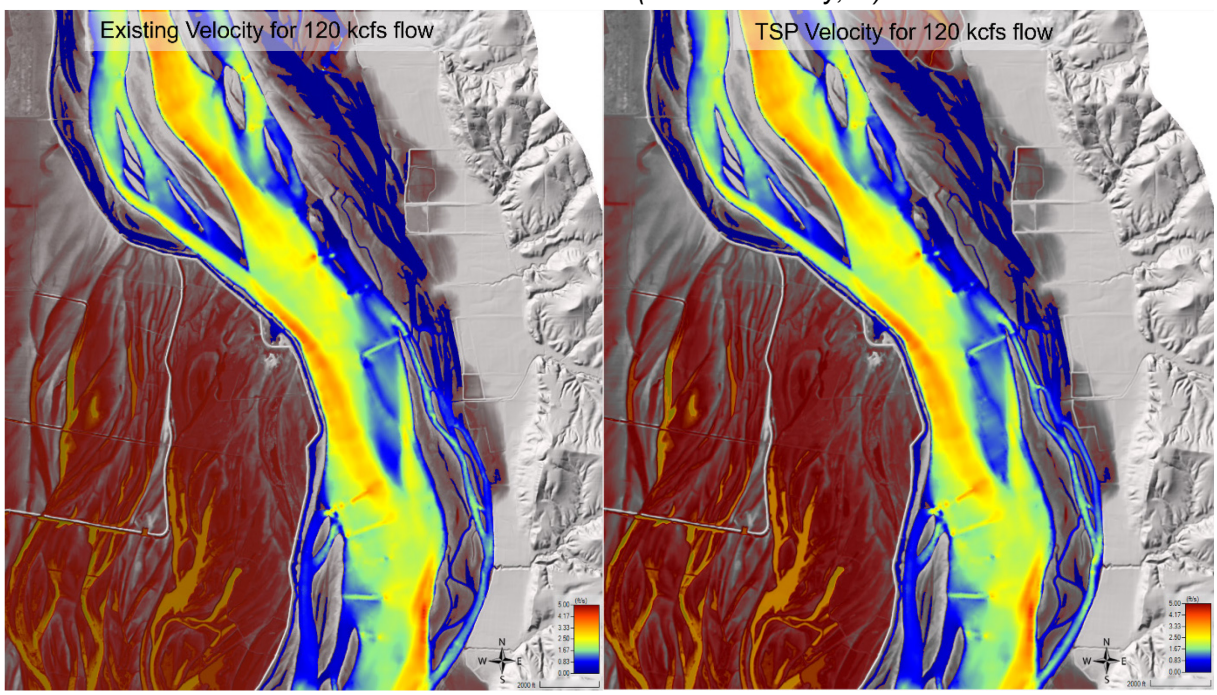


**Figure 33 Velocity – Existing vs TSP Average Median Flow**

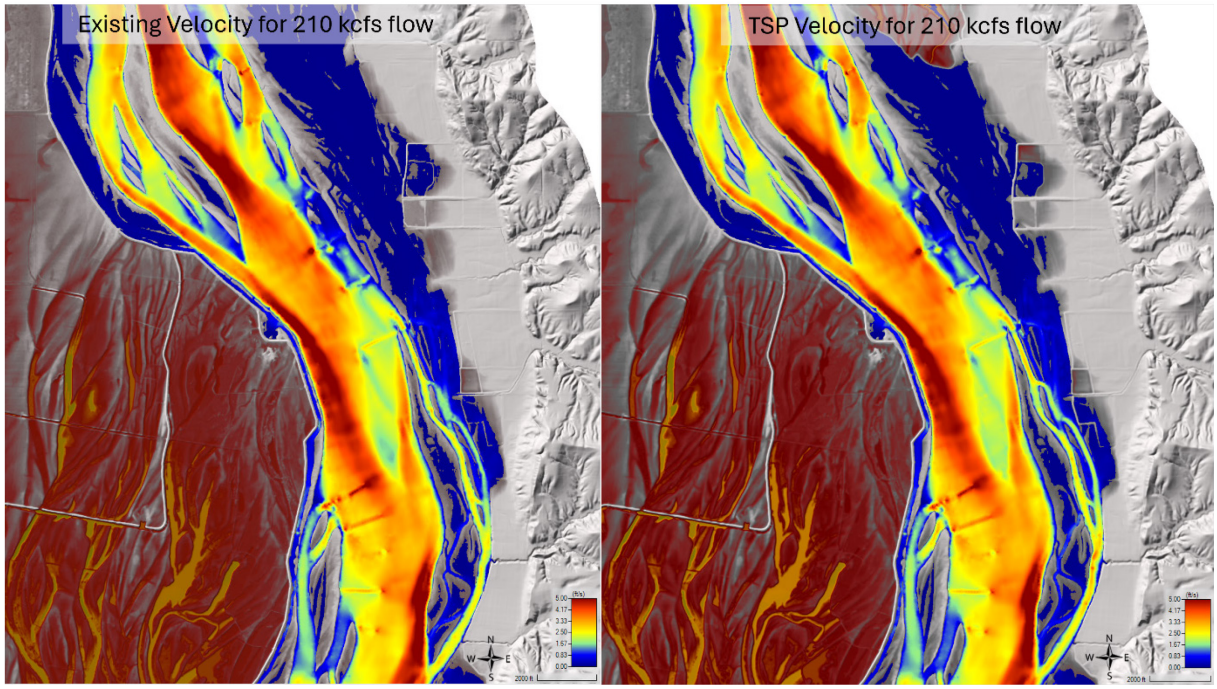


**Figure 34 Velocity – Existing vs TSP 50% AEP**

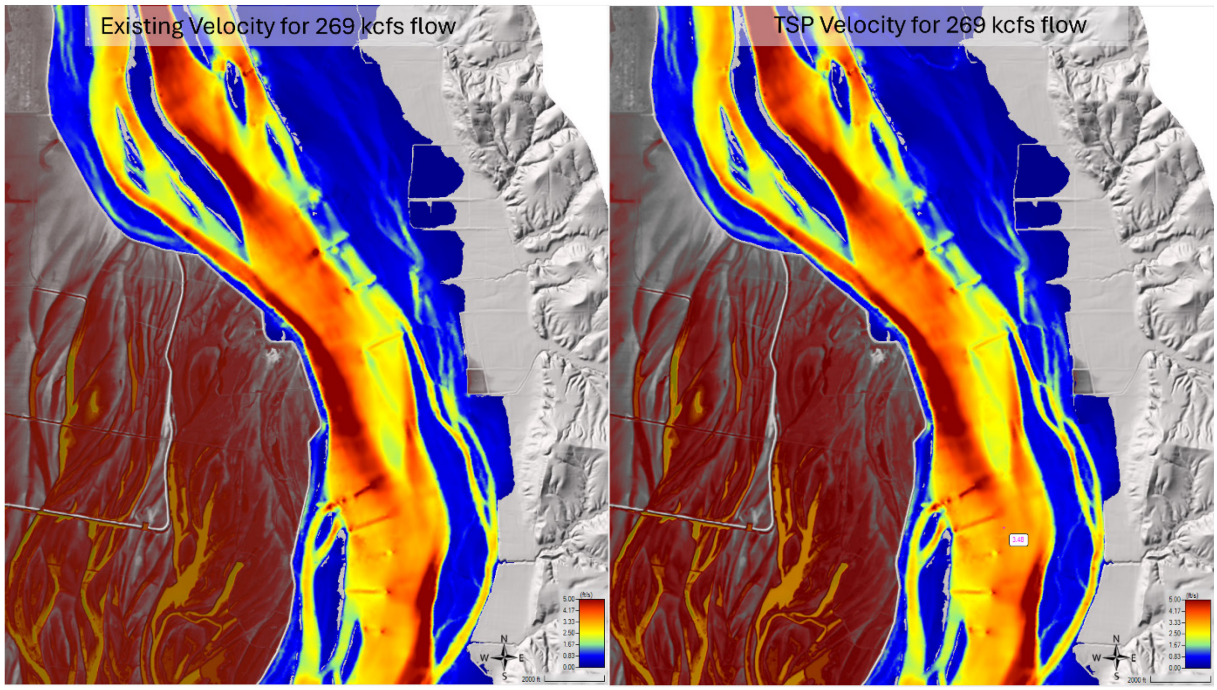


**Figure 35 Velocity – Existing vs TSP 20% AEP**

Although this model is not a mobile bed model, depths were analyzed. Figure 36, Figure 37, and Figure 38 below show a comparison between the existing and the TSP project areas within project bounds. Dredging paths through the backwater channels were modeled which showed adequate depths needed for overwintering habitats and will allow additional connection for aquatic systems.

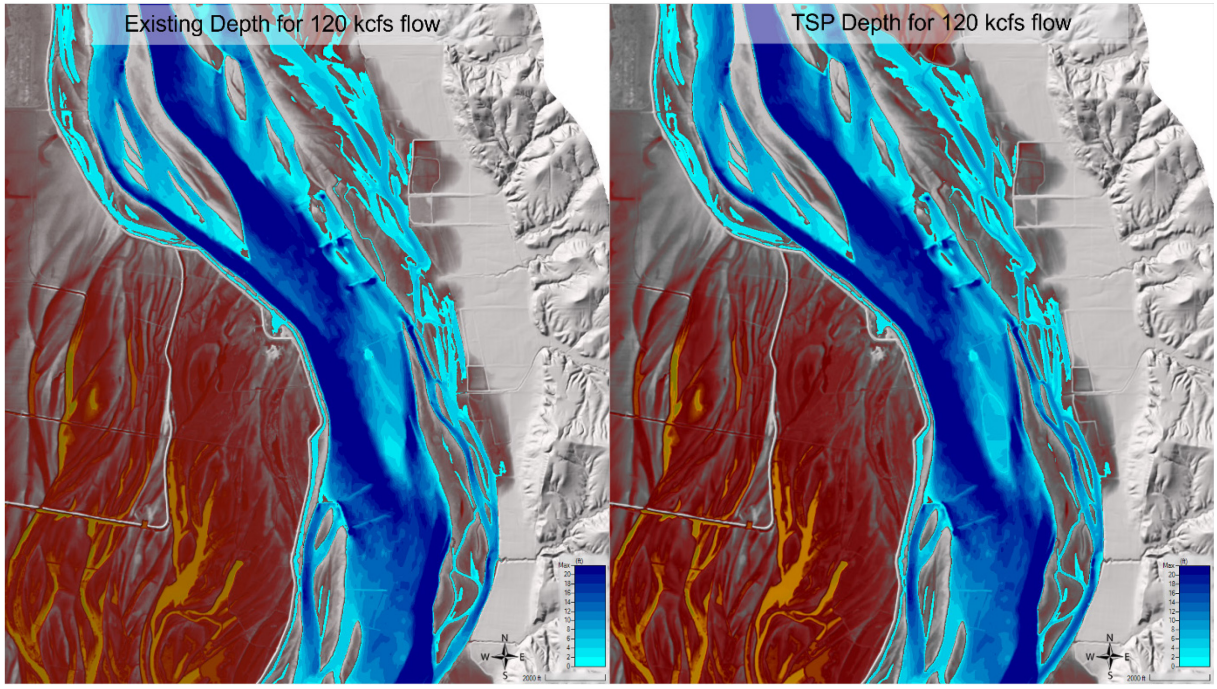


**Figure 36 Depth – Existing vs TSP Average Median Flow**

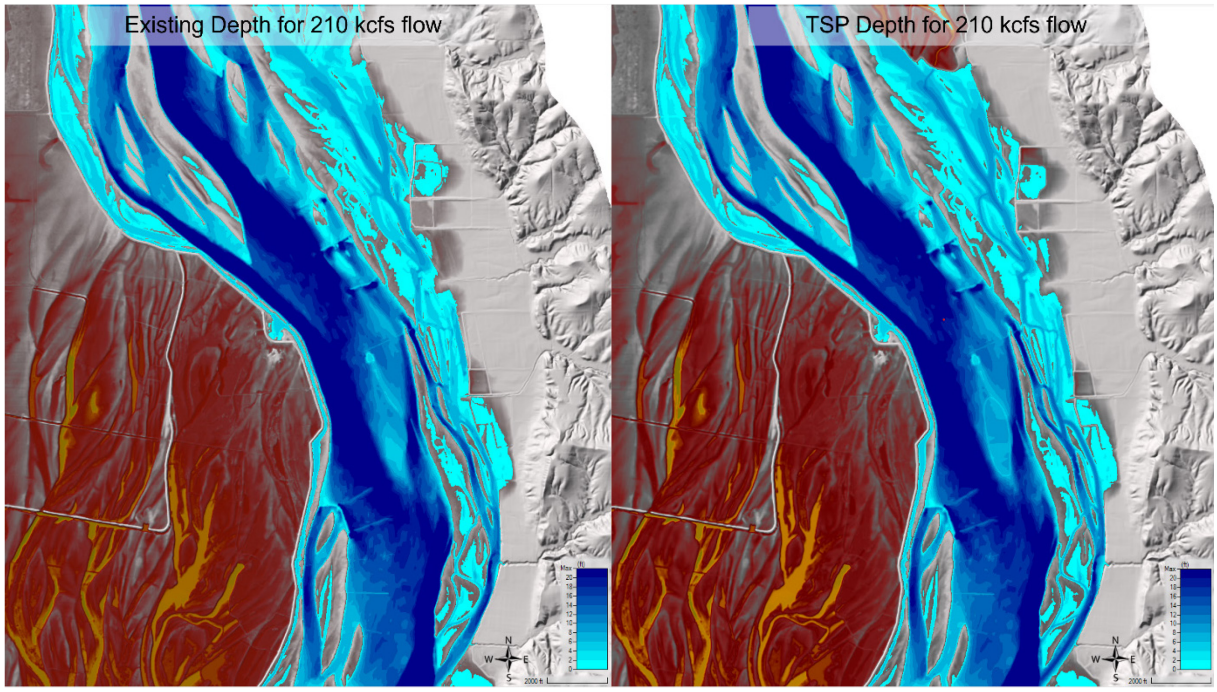


**Figure 37 Depth – Existing vs TSP 50% AEP**

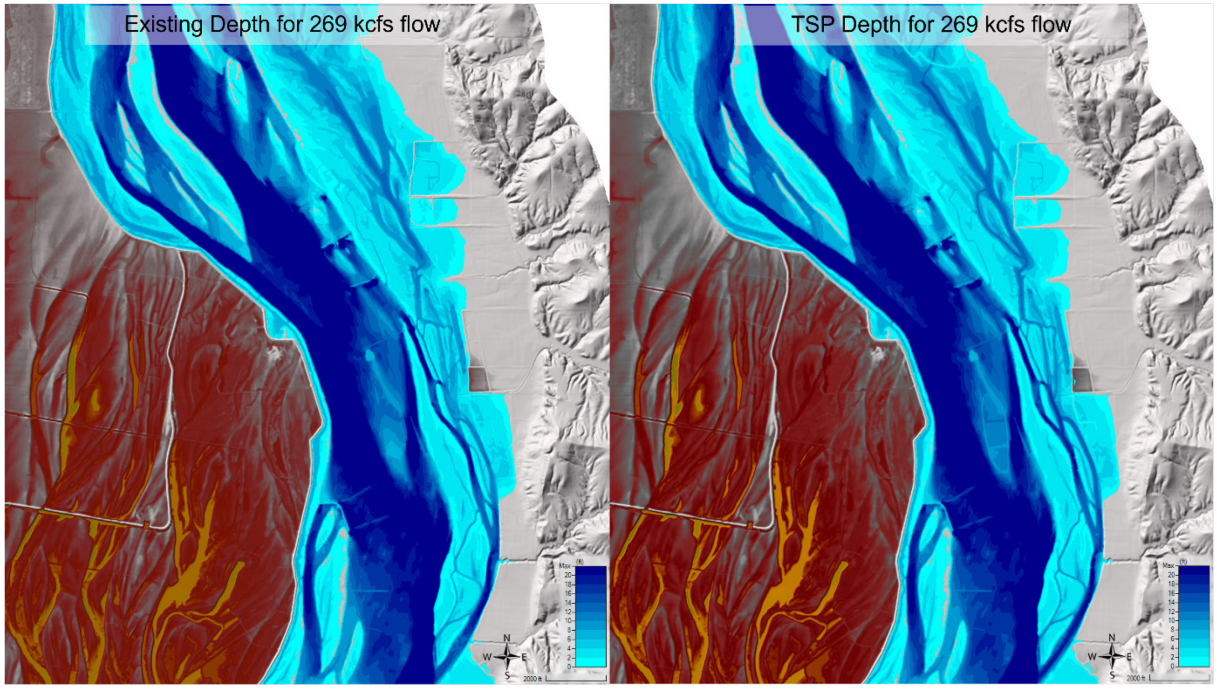


**Figure 38 – Existing vs TSP 20% AEP**

### 4.2 No-Rise Analysis

For any project in the FEMA regulatory floodway, a 'no-rise' determination must be made to ensure adverse flooding along neighboring structures will not be impacted by the project. Figure 39 below shows that the project lies within the regulatory

floodway zone AE. There is no evidence of damaging floods impacting the site of the project.

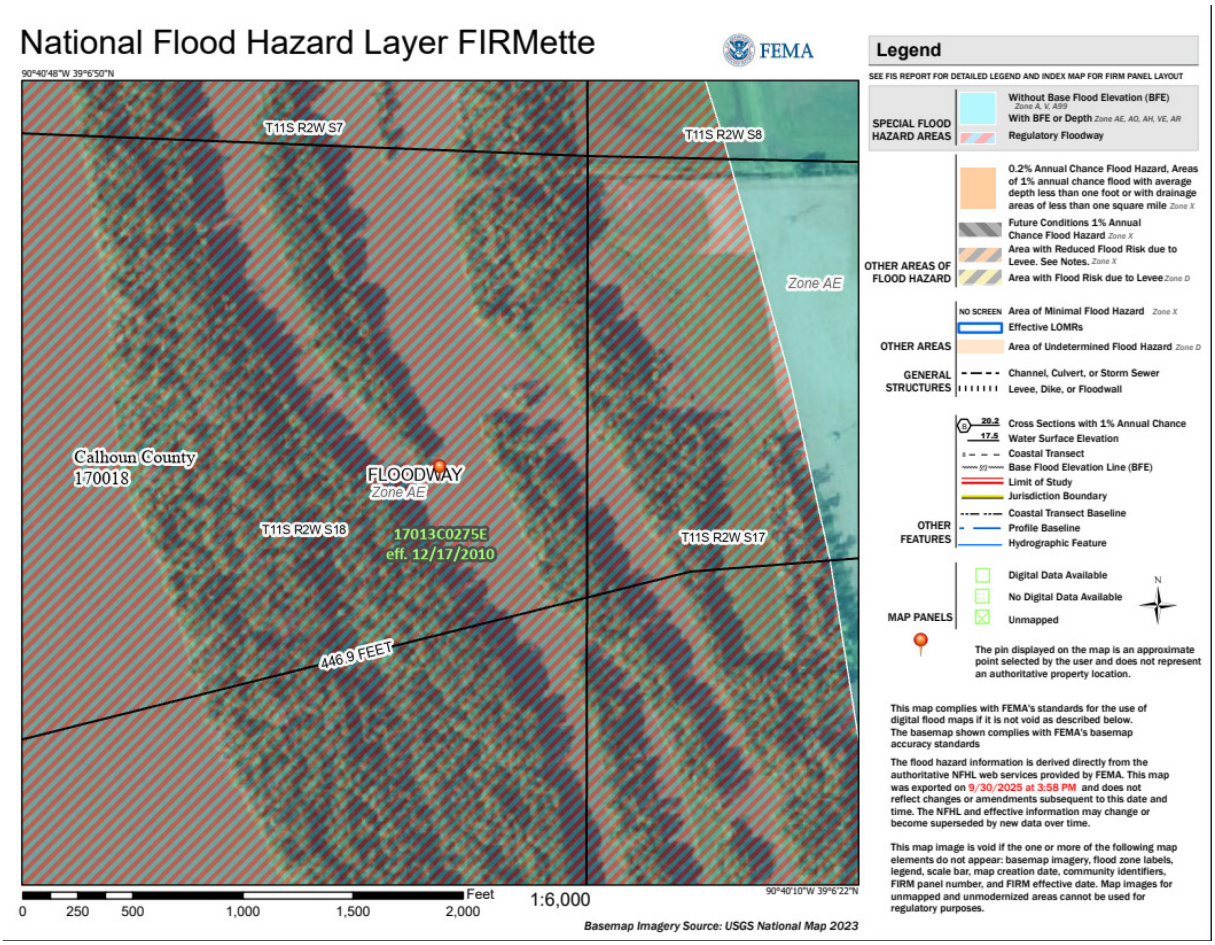


**Figure 39 FEMA National Flood Hazard FIRMette zone AE**

Illinois state guidelines dictate that in rural areas such as the project site, proposed features may not cause more than 0.5 ft of rise in water surface elevation under a 1% AEP (Illinois Department of Natural Resources, 2014). The cross sections used during calibration were used for the no rise comparison through the stretch. All water surface elevations for the cross sections were less than the maximum allowable rise. The 1% AEP was used for this comparison. Further investigation of 'no rise' will be conducted in the design phase of this project.

**Table 17. No RIse Analysis - 1% AEP**

| River Mile | 1% AEP WSE ft Existing | 1% AEP WSE ft TSP | No Rise ft |
|---|---|---|---|
| 260.17 | 449.81 | 449.74 | -0.07 |
| 258.00 | 449.31 | 449.30 | -0.01 |
| **255.26** | 448.44 | 448.43 | **-0.01** |
| 252.19 | 447.62 | 447.61 | -0.01 |
| 250.00 | 447.03 | 447.03 | -0.01 |

| River Mile | 1% AEP WSE ft Existing | 1% AEP WSE ft TSP | No Rise ft |
|---|---|---|---|
| 248.22 | 446.56 | 446.55 | 0.00 |
| 246.00 | 445.99 | 445.99 | -0.01 |
| 244.03 | 445.60 | 445.60 | -0.01 |
| 242.02 | 445.20 | 445.20 | -0.07 |

An additional comparison for the 2 year, 210 kcfs flow event was analyzed. Most water surface elevations for the cross sections were less than the maximum allowable rise.

**Table 18. No Rise Analysis - OHWM**

| River Mile | 210 kcfs OHWM WSE ft Existing | 210 kcfs OHWM WSE ft TSP | No Rise ft |
|---|---|---|---|
| 260.17 | 440.79 | 440.67 | -0.12 |
| 258.00 | 440.02 | 440.03 | 0.01 |
| **255.26** | 438.99 | 438.99 | **0.00** |
| 252.19 | 437.63 | 437.78 | 0.15 |
| 250.00 | 437.08 | 437.08 | 0.00 |
| 248.22 | 436.43 | 436.44 | 0.01 |
| 246.00 | 435.67 | 435.67 | 0.00 |
| 244.03 | 434.82 | 434.82 | 0.00 |
| 242.02 | 434.20 | 434.20 | 0.00 |

Since most cross-section's water surface elevations were less than the maximum allowable rise, from a preliminary standpoint, the 'no rise' check was complete. Further investigation and refinement will be completed in the design portion of this project.

### 4.3 Impacts to Navigation

The project area was analyzed for potential impacts to the 9ft deep and 300ft wide navigation channel authorized for the Mississippi River in the St. Louis District. Impacts to the channel could be, but are not limited to, unexpected changes in the existing channel alignment and an increased need for dredging in the channel. Looking at multiple flow events, the same cross sections that were used for section 4.2 were checked for impacts. Those checks included looking at the flow and velocity differences in the main channel between existing and proposed conditions. Model results indicate that surrounding levee systems in the area contain the water through the 1% AEP event. No impact can be expected for flow events where water is contained. Hydraulic changes are localized around the project area mainly within backwater channels, thus changes to navigation are not expected. Velocities through the project are minimal (through backwater channel access), thus, water surface elevations are not impacted by the project. These points were further validated by the model, as changes to flow and velocities at each of the cross sections were negligible (no noticeable change to flows).

# 5 CONCLUSIONS

In summary, a HEC-RAS model was used to develop alternatives and evaluate the TSP for the Gilead Slough. The calibration and validation effort yielded WSEs within 1.14' of gage data at Mosier Landing, Illinois for all modeled events. Results of this hydraulic model were then used to develop the project alternatives and evaluate their effect on the surrounding area. Preliminary modeling of the TSP does not show negative impacts to navigation or a significant WSE rise (consistent with IDNR no-rise standards). Guidance related to a potential takings analysis has not been received. Once received, the guidance will need to be applied to the project.

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