Grand River Ecosystem Restoration Study

Final Integrated Feasibility Report and Environmental Assessment

Lower Grand River Sub-Basin, Missouri

October 2020

US Army Corps
of Engineers ®
Kansas City District

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Acronyms and Abbreviations

AAHU............Average Annual Habitat Unit
ACEP-WRE ...Agricultural Conservation Easement Program - Wetlands Reserve Easements
ACHP ....Advisory Council on Historic Preservation
AFG ....Aquatic Fountain Grove
ALC ....Aquatic Locust Creek
APE ....Area of Potential Effect
AYC ....Aquatic Yellow Creek
BMP...............Best Management Practice
CDT ....Central Daylight Time
CE/ICA...........Cost Effectiveness/Incremental Cost Analysis
CEM...............Conceptual Ecological Model
Corps .............U.S. Army Corps of Engineers
CWA ....Clean Water Act
DU ....Ducks Unlimited
EPA ...............U.S. Environmental Protection Agency
EQ ....Environmental Quality
ESA ....Endangered Species Act
Fountain Grove CA ... Fountain Grove Conservation Area
FR/EA ....Feasibility Report/Environmental Assessment
FWOP............Future without Project
FWP...............Future with Project
H&H ....Hydrology and Hydraulics
HSI.................Habitat Suitability Index
HUC...............Hydrologic Unit Code
HWY ....Highway
LERRD ....Lands, easements, right of ways, relocations and disposals
LPSTP ....Longitudinal Peak Stone Toe Protection
MDC ....Missouri Department of Conservation
MoDNR..........Missouri Department of Natural Resources
MoDOT ....Missouri Department of Transportation
NAAQS ....National Ambient Air Quality Standards
NAWMP .... North American Waterfowl Management Plan
NEPA .... National Environmental Policy Act
NER .... National Ecosystem Restoration
NHPA............ National Historic Preservation Act
NPS .... National Park Service
NRCS .... U.S. Department of Agriculture – Natural Resources Conservation Service
NRI................ National Rivers Inventory
NWR .... National Wildlife Refuge
OMRRR .... Operation, Maintenance, Rehabilitation, Replacement, and Repair
PA .... Programmatic Agreement
RED .... Regional Economic Development
RFFA .... Reasonably Foreseeable Future Action
SHPO............ State Historic Preservation Office
TFG............... Terrestrial Fountain Grove
TLC .... Terrestrial Locust Creek
TMDL............ Total Maximum Daily Load
TSP............... Tentatively Selected Plan
TYC............... Terrestrial Yellow Creek
USACE.......... U.S. Army Corps of Engineers
USFWS......... U.S. Fish and Wildlife Service
USGS............ U.S. Geological Survey
WRP .... Wetland Reserve Program
WRDA........... Water Resources Development Act

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers partnered with the Missouri Department of Conservation (MDC) and the Missouri Department of Natural Resources (MoDNR), the non-federal cost-share sponsors, on the Grand River Feasibility Study. The Missouri Department of Transportation (MoDOT), U.S. Fish and Wildlife Service (USFWS), USDA – Natural Resources Conservation Service (NRCS), U.S. Environmental Protection Agency (EPA), and U.S. Geological Survey (USGS) are study partners.

The feasibility study was authorized by resolution of the Committee on Environment and Public Works of the United States Senate during the 108th Congress 2nd Session on June 23, 2004. The authorization stated:

> *That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Grand River and Tributaries, Missouri and Iowa, published as House Document 241, 89th Congress, First Session, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, municipal and industrial water supply, recreation, fish and wildlife conservation, or environmental restoration in the Grand River Basin, Iowa and Missouri.*

The Grand River watershed drains 7,900 square miles in north central Missouri and southern Iowa, making it the largest Missouri watershed north of the Missouri River. Hundreds of miles of channels within the Grand River watershed were straightened in the early 1900s to facilitate agricultural development, causing progressive instability of the watershed, loss of high value habitat, and continually threatened infrastructure. Flood frequency and intensity have increased in recent years. The watershed historically contained diverse complexes of river/stream channel and oxbow habitats, floodplain forest and woodland, bottomland prairie, and terrace prairie and savanna that supported rich animal communities and provided many important ecological functions. Since the mid-1800s, thousands of acres of tallgrass prairie, wetland, and bottomland hardwood habitat have been lost. Over 300 miles of natural stream corridor were channelized, adversely impacting thousands of linear feet of riparian and aquatic habitat. Sediment deposition, erosion, and habitat degradation have increased in intensity, which are now serious problems.

The scope of the study focused on achieving National Ecosystem Restoration (NER) benefits in accordance with Engineer Regulation (ER) 1165-2-501 because funding was provided through the USACE ecosystem restoration business line. Parts of the Lower Grand River sub-basin, one of three sub-basins within the Grand River watershed, have experienced the most ecosystem degradation and have the greatest restoration potential (Figure ES-1). The study scope focused on the Lower Grand River sub-basin in recognition of the significance of the ecological resources within the sub-basin, in particular a wetland complex of over 24,000 acres of state and federal lands including Pershing State Park, Fountain Grove Conservation Area (CA), Swan Lake National Wildlife Refuge (NWR), Yellow Creek CA, thousands of acres of NRCS conservation easement lands, and other private lands managed for conservation purposes.

The study area lies is in the heart of what is known as the "Golden Triangle" by bird experts and waterfowl hunters because of its significance to migratory waterfowl and other bird species. The Golden Triangle lies near the border of the Central and Mississippi waterfowl flyways. Evidence of the significance of resources in the study area include its designation as an area of greatest continental significance to North American ducks, geese, and swan in the North American Waterfowl Management Plan, designation as an Important Bird Area by the Audubon Society, it is a focus area watershed in the NRCS Mississippi River Basin Healthy Watersheds Initiative, has received over $100 million in NRCS wetland easement investment, and contains a National River Inventory-listed segment of Locust Creek. The study area contains habitat supporting federally-listed bat species and is home to bald eagles. The institutional, public, and technical significance of the ecological resources within the study area is well established.

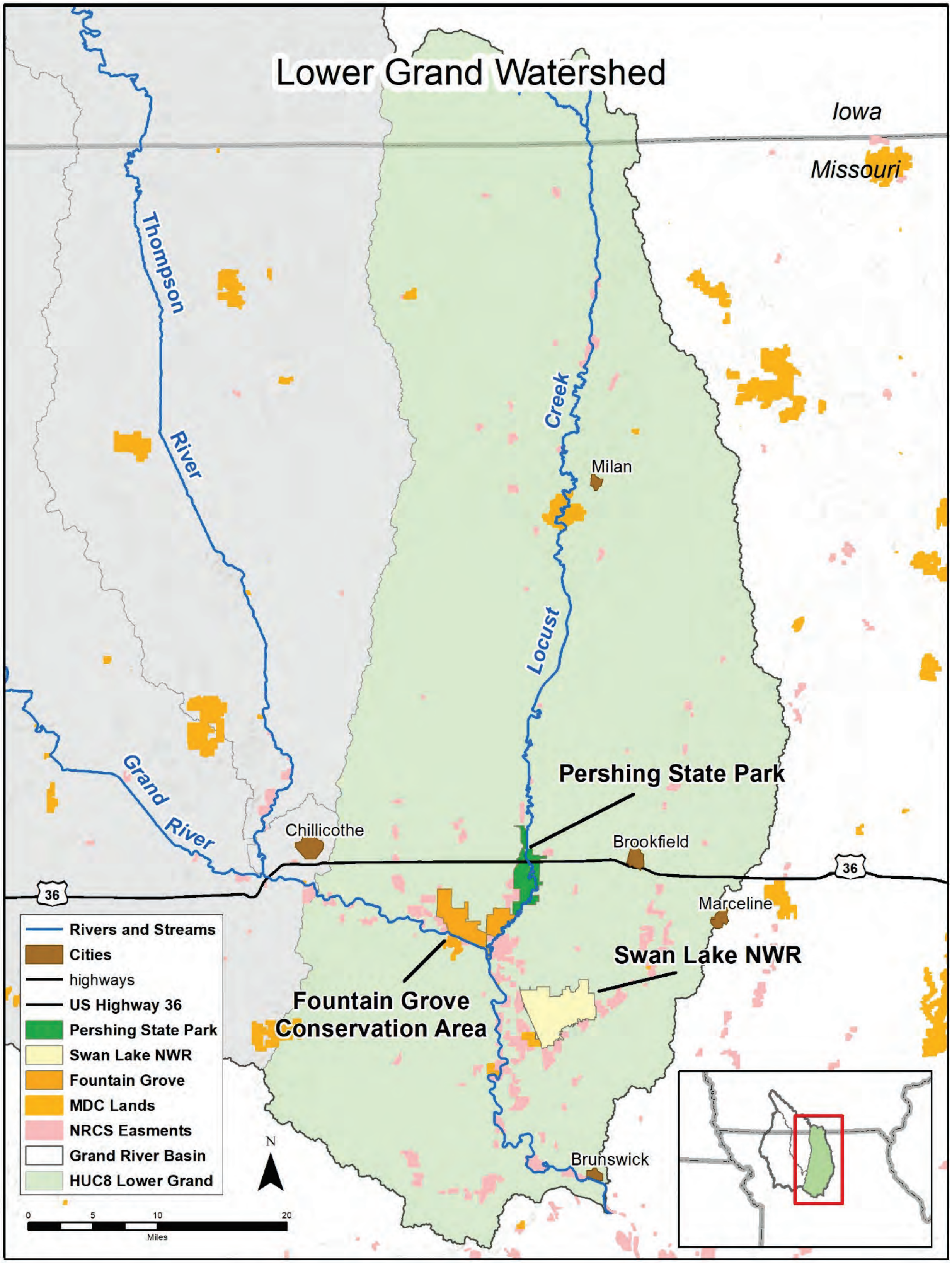

Figure ES-1. Lower Grand River Sub-basin.

PLAN FORMULATION

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. The USACE objective in ecosystem restoration planning is to contribute to NER. Contributions to NER are increases in the net quantity or quality of desired ecosystem resources.

Goals and Objectives - Goals were items that the study team aimed to achieve through the planning process. Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the identified opportunities.

The following study goals were identified with the study partners:

1. Identify a recommended plan that maximizes ecosystem benefits (given costs) and capitalizes on opportunities to provide holistic solutions to the benefit of watershed stakeholders.
2. Investigate problems and develop solutions for excessive sedimentation affecting Locust Creek, Pershing State Park, Fountain Grove CA and Yellow Creek CA, and nearby public and private conservation lands.
3. Evaluate the feasibility of a comprehensive suite of measures to address identified problems and improve aquatic and wetland habitat in the Lower Grand River sub-basin including measures to improve connectivity and flow conveyance, reduce sedimentation, increase stream meander, and alleviate the impacts of excessive large woody debris transport and accumulation.
4. Identify potential improvements to the hydraulic and sediment carrying functionality of Locust Creek from its headwater to its confluence with the Grand River, including solutions to the diversion of flow from Locust Creek to Higgins Ditch in the vicinity of Pershing State Park.
5. Identify measures to improve wetland, wet prairie, riparian, and in-stream aquatic habitats in the Lower Grand River sub-basin "Golden Triangle" area.
6. Build upon recent public engagement and partnership efforts in the Lower Grand River sub-basin to provide awareness and understanding, solicit input, and generate support from local partners.

Project goals were identified based on problems, needs, and opportunities present in the study area. Two broad project goals were used to guide the formulation of alternatives. Goal #2 will be achieved to the maximum extent practicable and so long as it is consistent with Goal #1.

- **Goal #1**: Increase quality and quantity of bottomland forest, in-stream aquatic habitat, wet prairie, and other wetlands in the Lower Grand River watershed for at least the next 50-years.
- **Goal #2**: Realize additional benefits to critical infrastructure, agriculture, water quality, recreation, and/or flood risk reduction in association with wetland and aquatic habitat improvement within the Lower Grand River Basin for at least the next 50 years

The planning objectives were developed for each geographic area that was a focus of formulation. The planning objectives for each area were used to evaluate and screen alternatives:

Locust Creek Study Area

- Improve hydraulic conveyance in Locust Creek while maintaining floodplain connectivity
- Reduce floodplain sediment deposition leading to habitat degradation
- Reduce accumulation of large woody debris

Fountain Grove Study Area

- Increase wetland habitat form and function on East, West, and South Fountain Grove CA.
- Improve resiliency of Fountain Grove CA wetlands units.
- Reduce sedimentation on Fountain Grove CA over the project life.

Yellow Creek Study Area

- Reduce backwater effects at the lower Grand River/Yellow Creek confluence that are driving degradation of nearby bottomland hardwoods, wetlands, agricultural lands, and Swan Lake NWR.
- Reduce sedimentation effects along Yellow Creek degrading nearby bottomland hardwoods and wetlands.

Formulation of Measures - Measures are the building blocks of alternatives. The identified environmental restoration measures consist of one or more actions or features in a particular location that are intended to solve specific problems or help meet the identified planning objectives. The management measures considered for alternatives development included: bank stabilization, sediment and woody debris catchment, grade control structures/engineered rock riffles, water control structures, earthwork for habitat restoration or flow conveyance, native species plantings, stream restoration and channel realignment, dredging, levee modification or construction, and reservoirs/dams.

Alternatives Development - Alternative plans (i.e. alternatives) are a set of one or more management measures functioning together to address one or more planning objectives. Alternatives were developed and evaluated for Locust Creek, Fountain Grove, and Yellow Creek study areas separately. The technical team worked to combine the management measures identified into an initial array of alternatives for each study area. Formulating the initial array was an iterative process that resulted in the identification of 26 alternative plans for Locust Creek, over 50 alternative plans for Fountain Grove, and 13 alternative plans for Yellow Creek. The evaluation of the initial array of alternatives, resulted in the screening (i.e. removal from further consideration) of 17 Locust Creek alternatives, 10 Fountain Grove alternatives, and 11 Yellow Creek alternatives.

Table ES-1 summarizes the final array of Locust Creek alternatives. Table ES-2 summarizes the final array of Fountain Grove alternatives. Table ES-3 summarizes the final array of Yellow Creek alternatives.

Table ES-1. Locust Creek Alternatives – Summary of Final Array.

Alternative	Cost Effective?	Best Buy?	Description
Locust Creek – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Locust Creek – Alternative 3	Yes	No	Construct a large sediment detention basin to the east of Locust Creek to remove logs and sediment and gets water back into Locust Creek via the Muddy Creek confluence south of highway (HWY) 36. Measures include a diversion berm, excavation of a pilot channel, log capture, levee notches, levee raise and construction around the detention basin, exit culverts, dredging a portion of Muddy and Locust creeks, small levee modifications and habitat mounds.
Locust Creek – Alternative 3.5	No	No	Same as Alternative 3, with the addition of excavating a new stream connection from Higgins Ditch to Locust Creek.
Locust Creek – Alternative 15	Yes	Yes	Same as Alternative 3, with the addition of grade control on Higgins Ditch to prevent head-cutting and further reduce sediment.
Locust Creek – Alternative 15.5	Yes	Yes	Same as Alternative 15, with the addition of excavating a new stream connection from Higgins Ditch to Locust Creek.
Locust Creek – Alternative 18	Yes	No	Same as Alternative 3; however, the sediment detention basin would be smaller in size.
Locust Creek – Alternative 18.5	No	No	Smaller sediment detention basin with no flow split, minimal dredge, filling of avulsions along Locust Creek, and improved connection from Higgins Ditch to Locust Creek.

Table ES-2. Fountain Grove Summary of Final Array Alternatives.

Alternative	Cost Effective?	Best Buy?	Description
Fountain Grove – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Fountain Grove – Alternative 2	Yes	No	This alternatives includes armoring of the streambank adjacent to Pool 3 Water Control Structure (WCS) 3.
Fountain Grove – Alternative 3	Yes	Yes	Combines Alternative 2 with increasing the size of the Pool 1 WCS 1.
Fountain Grove – Alternative 5	Yes	No	Includes both water control structure modifications from FC 3 with a new levee on the west side of the area, excavation of a water conveyance channel, removal of an old railroad berm, enhanced micro-topography, and excavating a connection to the pump station.
Fountain Grove – Alternative 6	Yes	No	Alternative 5 with the addition of modification to the Pool 2/3 Levee to shift it closer to the new pump station and an additional levee within Pool 3 to the south of the drainage ditch. This will allow for independent filling and drainage of all three major pools on Fountain Grove CA.
Fountain Grove – Alternative 7	No	No	A levee setback on the east side of Fountain Grove CA.
Fountain Grove – Alternative 8	No	No	Includes the levee setback from Alternative 7 as well as a raise in the perimeter of Che-Ru Lake by two feet and a pipe to move water from Goose Pond Lake into Che-Ru Lake.
Fountain Grove – Alternative 8.5	No	No	Includes the levee setback from Alternative 7 as well as reworking the existing pools and micro-topography in east Fountain Grove CA to reduce infrastructure and facilitate better management of habitat.
Fountain Grove – Alternative 9	No	No	Alternative 8 plus reworking the existing pools and micro-topography in east Fountain Grove CA to reduce infrastructure and facilitate better management.
Fountain Grove – Alternative 10	No	No	Adds two electric groundwater pumps on south Fountain Grove CA. The groundwater pumps would allow more effective management of this portion of the site.
Fountain Grove – Alternatives 11 through 41			40 additional combinations of alternative FG2, 3, 5, 6, 7, 8, 8.5, 9, and 10.

Table ES-3. Summary of Yellow Creek Final Array Alternatives.

Alternative	Cost Effective?	Best Buy?	Description
Yellow Creek – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Yellow Creek – Alternative 11	Yes	Yes	Levee setback D on Swan Lake NWR along with stabilizing an existing levee on Swan Lake NWR, and removal of some internal infrastructure.

EVALUATION AND COMPARISON OF ALTERNATIVE PLANS

USACE guidance requires that the ecosystem related benefits of proposed alternatives be subjected to detailed economic analysis, allowing an explicit comparison of the costs and benefits associated with the alternatives. USACE ecosystem restoration projects calculate the value and benefits of restored habitat using established habitat assessment methodologies. Comparing the alternatives in this manner facilitates the determination of the most cost-effective restoration alternative that meets restoration goals.

Alternatives were evaluated using the four criteria established in the Principles and Guidelines (U.S. Water Resources Council 1983): effectiveness, completeness, efficiency, and acceptability.

In collaboration with the study technical team, four general habitat types were identified for the focus of the habitat evaluation: wet prairie, emergent wetland, bottomland forest, and aquatic riverine habitat. These habitat types were selected because they are significant resources in the study areas that are representative of the habitat types being degraded. The USFWS's Habitat Evaluation Procedure methodology was used to assess the quality and quantity of existing and future habitats in the study areas. In general, this procedure assigns Habitat Suitability Index (HSI) scores to model variables, which assess the quality or suitability of a habitat relative to a species ability to access food, secure shelter, and reproduce. Hydrology and hydraulics (H&H) and sediment modeling outputs such as depth of floodplain sedimentation, inundation extent, duration, and depth were used in combination with the best professional judgment of the technical team to evaluate and forecast future quality of habitat variables over time. Alternatives included in the final array went through habitat evaluation and quantification modeling and were evaluated through cost effectiveness/incremental cost analysis (CE/ICA). Incremental costs and benefits for all proposed alternatives were compared in the USACE CE/ICA program to identify the cost effective and best-buy plans. "Cost effective" means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money. Those most efficient plans are called "Best Buys". They provide the greatest increase in output for the least increase in cost.

Effectiveness is the extent to which an alternative plan alleviates specified problems and achieves opportunities. This is demonstrated by how well each alternative plan meets the planning objectives. Efficiency is "the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment." Cost effectiveness analysis answers the question: "Does the alternative plan accomplish the objectives for the least cost?" Habitat quantification and evaluation determined the average annual habitat units (AAHUs) for each habitat type resulting from each alternative plan. CE/ICA was used to identify the most efficient alternative plans. Alternatives identified as "best buy" plans are compared in Tables ES-4, ES-5, and ES-6.

Acceptability is the workability of a plan with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and policies. All of the alternatives in the final array must be in accordance with Federal law and policy. All alternatives in the Fountain Grove and Yellow Creek final arrays are considered acceptable. For the Locust Creek final array, those alternatives that include a new connection between Higgins Ditch and Locust Creek (LC 3.5 and LC15.5) are not considered acceptable because they would transfer flood risk from existing private property to other private property.

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. The study team has not identified any additional investments, or actions, needed by others to realize the benefits identified within the Locust Creek or Fountain Grove final arrays, therefore, all alternatives are considered complete USACE plans. However, all of the measures included within YC11 would occur on the Swan Lake NWR, owned and managed by the USFWS. Therefore, because YC11 requires action and investments by another Federal agency, it is not technically a complete USACE plan. No other plans remain within the final array that achieve USACE planning objectives while meeting planning constraints. USFWS has been a study partner from the initiation of the project and assisted with development and evaluation of measures.

Achievement of Opportunities –

All alternatives reverse the trend of degradation of aquatic habitat, bottomland forests, wetland and wet prairie within the sub-basin, to varying degrees. All alternatives would benefit infrastructure, agriculture, water quality, and recreation. Locust Creek alternatives that include a sediment detention basin would result in beneficial impacts to infrastructure in the study area. HWY 36 bridge crossing at Locust Creek has repeatedly been the location of extensive log jams. Diverting logs into the sediment detention basin upstream of HWY 36 should prevent further impacts to the bridge structures at HWY 36. The Locust Creek best buy plans result in a reduction in the 100-year water surface elevation for a large portion of the Locust Creek study area; however, some localized increases also occur. The Locust Creek final array of alternatives reduce floodplain sediment deposition below HWY 36 by as much as 61 percent. This reduction in sediment load would also improve water quality through a reduction in nutrient loading. All the alternatives maintain or improve connectivity amongst habitats by providing habitat benefits on NRCS lands, which are permanent easements and critical areas for providing habitat connectivity between the public areas of Pershing State Park, Fountain Grove CA, Yellow Creek CA, and Swan Lake NWR.

Table ES-4. Locust Creek Best Buy Alternative Comparison.

Alternative	LC1 (FWOP) Best Buy	LC15 Best Buy - NER	LC15.5 Best Buy
Construction		$31,370,532	$38,212,387
Real Estate		$12,973,673	$13,885,829
Preconstruction Engineering and Design		$4,705,580	$5,731,858
Supervisor and Administration		$1,882,231	$2,292,743
Contingency		$10,696,661	$12,983,346
Total Capital Costs		$61,628,677	$73,106,163
Interest During Construction		$1,888,591	$2,158,800
Total Investment Costs		$63,517,268	$75,264,963
Interest & Amortization Factor	0.0379	0.0379	0.0379
Annualized Costs		$2,410,359	$2,856,161
Annual OMRR&R		$100,000	$100,000
Total Annual Costs	$30,000	$2,510,359	$2,956,161
Total Average Annual Habitat units - Wet Prairie	204	334	345
Total Average Annual Habitat units - Wetlands	1,535	1,688	1,718
Total Average Annual Habitat units - Forest	3,386	4,030	4,079
Total Average Annual Habitat units - Aquatic	154	199	197
Total Average Annual Habitat Units- All Habitats	5,279	6,250	6,339
Net AAHU		971	1,059
Incremental Cost		$2,480,359	$445,802
Incremental AAHU		971	88
Incremental Cost/ Incremental AAHU		$2,553	$5,089

Note: Price level date of May 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

Table ES-5. Fountain Grove Best Buy Alternative Comparison.

Alternative	Alternative FG1 (FWOP) Best Buy	Alternative FG3 Best Buy	Alternative FG35 Best Buy	Alternative FG36 Best Buy	Alternative FG37 Best Buy	Alternative FG37.5 Best Buy - NER	Alternative FG38 Best Buy
Construction		$1,076,865	$13,195,546	$15,243,549	$17,235,157	$18,597,388	$20,588,996
Real Estate		$4,631	$3,418,518	$3,889,362	$4,375,643	$5,603,696	$6,089,977
Preconstruction Engineering and Design		$161,529	$1,979,332	$2,286,532	$2,585,274	$2,789,608	$3,088,349
Supervisory and Administration		$64,611	$791,733	$914,613	$1,034,109	$1,115,843	$1,235,340
Contingency		$364,842	$4,390,818	$4,488,209	$5,839,271	$6,225,786	$6,892,510
Total Capital Costs		$1,672,478	$23,775,947	$26,822,265	$31,069,454	$34,332,321	$37,895,172
Interest During Construction		$32,417	$642,614	$726,734	$834,778	$964,102	$1,058,991
Total Investment Costs		$1,704,895	$24,418,561	$27,548,999	$31,904,232	$35,296,423	$38,954,163
Interest & Amortization Factor	0.0379	0.0379	0.0379	0.0379	0.0379	0.0379	0.0379
Annualized Costs		$64,698	$926,638	$1,045,432	$1,210,705	$1,339,432	$1,478,236
Annual OMRR&R	$95,000	$92,500	$94,500	$89,500	$89,000	$88,500	$88,000
Total Annual Costs	**$95,000**	**$157,198**	**$1,021,138**	**$1,134,932**	**$1,299,705**	**$1,427,932**	**$1,566,236**
Total AAHU Wetlands	1,377	1,466	1,937	1,969	2,008	2,033	2,045
Total AAHU Forest	1,529	1,694	1,985	2,012	2,012	2,013	2,013
Total Average Annual Habitat Units- All Habitats	2,907	3,160	3,922	3,981	4,021	4,046	4,058
Net AAHU		**254**	**1,016**	**1,074**	**1,114**	**1,140**	**1,152**
Incremental Cost		$62,198	$863,940	$113,794	$164,773	$128,227	$138,304
Incremental AAHU		254	762	59	40	26	12
Incremental Cost/AAHU		$245	$1,134	$1,935	$4,171	$4,951	$11,430

Note: Price level date of June 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

Table ES-6. Yellow Creek Best Buy Alternative Comparison.

Alternative	Alternative YC1 (FWOP) Best Buy	Alternative YC11 Best Buy - NER
Construction		$3,893,598
Real Estate		$2,246,156
Preconstruction Engineering and Design		$641,905
Supervisor and Administration		$256,762
Contingency		$968,038
Total Capital Costs		$8,006,459
Interest During Construction		$275,700
Total Investment Costs		$8,282,159
Interest & Amortization Factor	0.0379	0.0379
Annualized Costs		$314,292
Annual OMRR&R	$100,000	$75,000
Total Annual Costs	**$100,000**	**$389,292**
Total Average Annual Habitat units: Forest	88	77
Total Average Annual Habitat units: Wetlands	4,721	4,803
Total Average Annual Habitat units: Wet Prairie	4,579	4,850
Total Average Annual Habitat Units- All Habitats	9,388	9,730
Net AAHU		**342**
Incremental Cost		$289,292
Incremental AAHU		342
Incremental Cost/ Incremental AAHU		$845

Note: Price level date of May 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

Risk and Uncertainty Analysis - Risks and uncertainty are associated with the forecasted ecosystem benefits of the Recommend Plan. There is uncertainty associated with where and how much woody debris deposits in the Locust Creek floodplain, if and when future channel avulsions may occur, and the actual long-term sediment loads within the watershed. Each of these sources of uncertainty represent a risk to achieving the forecasted ecosystem benefits. Some of this uncertainty was reduced by inclusion of upstream bank stabilization and sediment reduction techniques. The remaining risk and uncertainty of project performance was evaluated to assess the reliability of ecological success and support the development of the OMRR&R manual. The Monitoring and Adaptive Management Plan (MAMP) was completed in consultation with the non-Federal sponsors to include estimated costs of adaptive management measures, based on the outcomes of the ecological success monitoring. The Recommended Plan is a structural project designed primarily to reduce sedimentation and woody debris inputs from upstream sources. Long-term non-Federal Sponsor OMRR&R activities will likely be needed to maintain project performance even after ecological success determinations have been made and the 10-year cost-shared monitoring and AM period has expired. The non-Federal sponsors will be required to conduct their OMRR&R responsibilities in accordance with the project's OMRR&R manual.

SELECTION OF THE RECOMMENDED PLAN

Federal planning for water resources development was conducted in accordance with the Principles and Guidelines adopted by the U.S. Water Resources Council.

> *"For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost effective and justified to achieve the desired level of output. This plan shall be identified as the National Ecosystem Restoration (NER) Plan."*

Locust Creek Study Area – The NER Plan and the recommended plan for the Locust Creek study area is LC 15.25, which is LC15 with the addition of upstream bank stabilization projects (approximately 316 or similar cost-effective methods for sediment reduction) to achieve a 14% reduction in quantified risk. LC15 was the most effective plan at achieving the Locust Creek planning objectives of improving hydraulic connectivity while maintaining floodplain connectivity, reducing sediment deposition on the floodplain, reducing the potential for log jams, and increasing habitat quantity and quality within the study area. The addition of upstream bank stabilization actions would enhance the effectiveness of LC15 at achieving planning objectives by further increasing sediment reduction and reducing the potential for log jams. This alternative would realize opportunities in the upper portion of the sub-basin to improve water quality, protect critical infrastructure, and farmland. LC 15 is the most efficient alternative plan at creating ecosystem benefits for its project cost. It is a complete plan and is considered an acceptable plan.

Fountain Grove Study Area – The NER Plan and the recommended plan for the Fountain Grove study area is FG37.5. It was the most effective plan at achieving the Fountain Grove planning objectives of maximizing natural ecosystem form and function through management capability, providing operational ability to drain water efficiently from the site, limiting sediment deposition on the site, and increasing the quality and quantity of emergent wetlands and bottomland hardwoods. FG 37.5 is the most efficient alternative plan at creating ecosystem benefits for its project cost. It is a complete plan and is considered an acceptable plan. In selecting FG37.5, the team is "buying up" from FG37. The additional AAHUs realized from selecting FG37.5 occur on East Fountain Grove CA. East Fountain Grove CA is significant and the selection of FG37.5 justified because:

- It achieves planning objectives to a larger degree than FG37.
- East Fountain Grove CA habitats have been the least degraded and represent the best and most reliable habitat within Fountain Grove CA and the surrounding matrix of public and private lands.
- The core habitat at East Fountain Grove CA provide stopover habitat for over 227 migratory bird species.
- East Fountain Grove CA wetland units have a high probability of providing annual resources for wildlife because the likelihood of this area being impacted by flood events during the entire year is lower compared to West and South Fountain Grove CA.
- Measures within East Fountain Grove CA would also result in reduction of overall infrastructure, reducing maintenance costs from an annual and long-term perspective. Larger pools and fewer units would limit total habitat berms needing to be maintained as well as fewer structures to repair and requiring annual maintenance. This reduction would also reduce disturbance to wildlife during water manipulations as the berm network is reduced, thereby increasing habitat quality.
- Improvements on East Fountain Grove CA would more fully take advantage of the opportunity to provide benefits for recreation. Existing design does not allow for diverse hunting styles (i.e. use of boats and other small craft), thus limiting overall use to individuals who are capable of walking long distances. By adding features that emulate meander scrolls and sloughs the habitat diversity would be enhanced, while at the same time offering new access opportunities for boats through the wetland units. This kind of access and use currently does not exist on East Fountain Grove CA.
- East Fountain Grove CA contains bottomland forest that may provide maternity and/or foraging habitat for the Federally-endangered Indiana bat and northern long-eared bat.

Yellow Creek Study Area – The NER Plan and the recommended plan for the Yellow Creek study area is YC11. It was the only effective plan at achieving the Yellow Creek planning objectives of reducing the impacts of inundation and sedimentation within the Yellow Creek/Grand River confluence and increasing habitat quantity and quality within the study area. YC11 is the most efficient alternative plan at creating ecosystem benefits for its project cost. Implementation of YC11 requires action and investment by the

USFWS, therefore, it is not a complete USACE plan; however, no other alternatives within the final array were reasonable. It is considered an acceptable plan.

Environmental Consequences

In compliance with NEPA, the anticipated environmental consequences were evaluated for the No Action and FWP alternatives. This assessment was limited to resources potentially affected by the plan alternatives. Table ES-7 summarizes the anticipated environmental consequences.

Table ES-7. Summary of Impacts.

Resource Topic	No Action Alternative	FWP Alternatives
Priority Habitats	Short and long-term direct adverse impacts	Long-term beneficial impacts
Hydrology, Hydraulics, and Sedimentation	No impacts	Short- and long-term beneficial impacts
Water Quality	Long-term adverse impacts	Short- term minor adverse impacts Long-term beneficial impacts
Fish and Wildlife	Short- and long-term adverse impacts	Short-term negligible to minor adverse impacts Long-term beneficial impacts
Threatened and Endangered Species	Long-term adverse impacts	No impacts
Invasive Species	Long-term adverse impacts	Long-term beneficial impacts
Floodplains	Long-term adverse impacts	Long-term beneficial impacts
Geology and Soils	Long-term adverse impacts	Long-term beneficial impacts
Prime and Unique Farmlands	No impacts	Long-term minor adverse and beneficial impacts
Socioeconomics	No impacts	Short-term beneficial impacts
Environmental Justice	No impacts	No impacts
Land Use	No impacts	Long-term minor change to land use
Flood Risk	No impacts	Long-term beneficial and adverse location-dependent impacts
Infrastructure	Long-term adverse impacts	Long-term beneficial impacts
Cultural Resources	No impacts	No adverse impacts are anticipated. However, the location of all project areas is not known at this time. Any impacts would be addressed by stipulations in a cultural resources programmatic agreement.
Recreation	No impacts	Short-term minor adverse and long-term beneficial impacts
HTRW	No impacts	No impacts. Potential for long-term beneficial

Recommended Plan

The recommended plan is composed of actions within the three focus study areas: Locust Creek, Fountain Grove, and Yellow Creek (Figure ES-2). During development of the recommended plan it was determined that the U.S. Fish and Wildlife Service (USFWS) could implement the recommended restoration measures for the Yellow Creek study area, all of which are within the Swan Lake National Wildlife Refuge (NWR) managed by USFWS, under their existing authorities. For this reason, the Yellow Creek study area measures are part of the overall NER Plan, but the Corps is not seeking authorization or funding for these measures. They are listed below to describe the entirety of the federal restoration activities within the NER plan. The subset of the NER plan (all measures of the NER minus the USFWS measures) represents the “Corps Plan”. The full NER plan, with all measures including measures on the USFWS lands, represents the “Federal Plan”. MoDNR would be the non-federal sponsor for the Locust Creek element of the project and MDC would be the non-federal sponsor for the Fountain Grove element of the project.

The Locust Creek recommended plan would benefit approximately 432 acres of aquatic riverine, 8,852 acres of bottomland hardmast forest, 1,493 acres of wet prairie, and 2,975 acres of emergent wetland in the Locust Creek study area, resulting in a net gain of 971.5 AAHUs. Plan features include a diversion berm across the Locust Creek floodplain and extending into the Locust Creek channel upstream of Pershing State Park. The floodplain portion of the berm would serve to prevent the progression/formation of additional avulsions that might divert water and bypass the sediment detention basin. The in-channel portion of the berm would serve to divert flows into the sediment basin while also allowing water to continue downstream on Locust Creek and Higgins Ditch. This portion of the berm would be designed to allow for fish and aquatic organism passage. Construction of the sediment detention basin would require raising/construction of a perimeter levee around the sediment detention basin. Two spillways were included in the levee raise to allow water to overtop in a controlled manner. A pilot/diversion channel would be excavated in the sediment detention basin to convey sediment and logs into the basin.

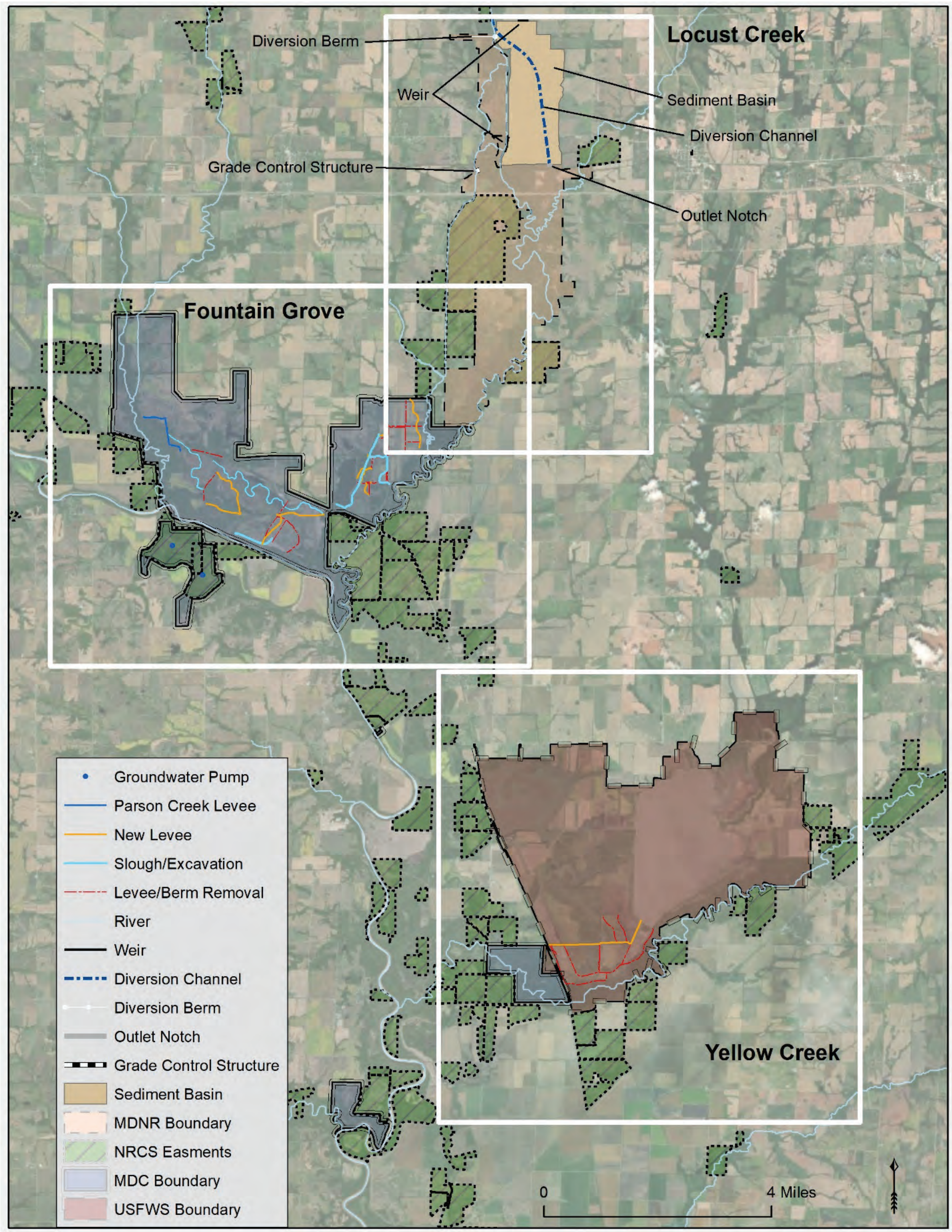

Figure ES-2. Overview of Features of the Recommended Plan.

Training levees would be constructed on either side of the channel. A portion of the existing levee on the east bank of Locust Creek would be notched to allow flow into the sediment detention basin. In addition, several existing levees within the sediment detention basin would be notched to allow for the movement of water, sediment, and logs in the basin. Water would exit the sediment detention basin through a 1,500-foot spillway located on the south side of the sediment detention basin.

The Locust Creek recommended plan also includes up to four grade control structures. Two may be located on Locust Creek, one would likely be constructed along Higgins Ditch, and one on Muddy Creek upstream of its connection with the sediment detention basin to prevent head-cutting. Approximately 23,500 feet of Muddy and Locust creeks would be dredged to provide channel dimensions sufficient to accommodate the historic bankfull flow and provide appropriate slope. Dredge material would be used to perform small levee modifications and habitat enhancements. Dredged material would be spoiled along a portion of Locust Creek to create an avulsion spoil berm. The partial removal of the levee separating the east and west sides of the Locust Creek floodplain south of HWY36 would help restore floodplain connectivity between Higgins Ditch and the Locust Creek channel.

Bank stabilization measures would be implemented in the Locust Creek watershed upstream of the sediment detention basin. It is estimated that the non-federal sponsor would implement approximately 316 bank stabilization projects or similar cost-effective sediment reduction methods to achieve a 14% reduction in quantified risk associated with uncertainties in forecasted sediment loading. Projects may be implemented in the following HUC-10 watersheds: Watkins Creek-Locust Creek (excluding the portion in Iowa); East Locust Creek; West Locust Creek; and Locust Creek.

The Fountain Grove recommended plan would benefit approximately 320 acres of aquatic riverine, 3,917 acres of bottomland hardwood forest, and 2,825 acres of emergent wetland in the Fountain Grove study area resulting in a net gain of 1,139.8 AAHUs. Plan features a suite of actions to enhance wetlands through increased natural ecosystem form and function, improved habitat development, and improved water management. The bank of the channel downstream of the Pool 3 Levee WCS, referred to as Jackson’s Ditch, would be armored to prevent erosion on the neighboring property. The existing Pool 3 WCS would be set back from Jackson’s Ditch. This measure allows for opening the gates at Pool 3 Levee WCS to increase the drainage rate from Fountain Grove CA pools without eroding adjacent property. The Pool 1 WCS #1 would be replaced with two 96-inch PVC pipes with two sluice gates. The culverts are used to drain Pool 1 to Pool 2. A new levee would be constructed, running north/south, on the west side of Fountain Grove CA where Parsons Creek flows are entering the area under existing conditions. The levee would prevent smaller flows from entering Fountain Grove CA and focus Parsons Creek flows towards a controlled overtopping point into a conveyance channel. The Pool 1/2 levee would be realigned to facilitate flooding of current un-manageable habitat. The Pool 2/3 levee would be re-aligned, an additional levee would be constructed within Pool 3, and a channel would be added to fill Pool 3 allowing for independent water control of all three major pools on Fountain Grove CA. The levee on the east side of Fountain Grove CA would be set back to increase flood resiliency.

A conveyance channel would be excavated through Fountain Grove CA to effectively move Parsons Creek flows through the area during high flow events. Outside of high flow events, the feature serves as a water distribution channel and provides aquatic/edge habitat for wetland species. A portion of the Chillicothe-Brunswick rail berm would be removed.

Micro-topography on the site would be enhanced through the creation of sloughs and habitat mounds. Spoil from drainage channel excavation would be used to form the habitat mounds. Earthwork would be performed to modify the existing pool design on the east side of Fountain Grove CA. The intent would be to provide more naturally shaped wetland pools, which is consistent with modern wetland management practices. The redesign of the pools on the east side would allow for the removal of some water control structures in that area, creating more natural conditions, and allowing for more efficient management.

An additional drainage ditch would be constructed from the proposed Parsons Creek levee to the vicinity of the Fountain Grove CA pump station. This feature would allow for more efficient drainage of Pool 1 when desired. Two electric groundwater pumps would be installed on South Fountain Grove CA to facilitate wetlands development and more reliable hydrology.

The recommended plan for Yellow Creek is alternative YC11. The main feature of the plan is the setback of a levee on Swan Lake NWR (Figure ES-5). The plan would include levee removal, removing three existing culverts, raising a portion of existing levee, constructing a portion of new setback levee, and addition of two 3-foot diameter concrete culverts with flap gates.

Lands, easements, right of ways, relocations and disposals (LERRD) - TThe non-federal sponsor is required to provide any lands, easements, right of ways, relocations and disposals (LERRD) necessary for project construction and Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRRR). Any LERRDs determined to be integral to the project will be credited to the project. Approximately 24 parcels of varying size of public and private ownership lie within the Locust Creek recommended plan footprint and are required in fee. This includes 9 parcels in private ownership totaling 1,394 acres. The remaining parcels are in public ownership by MoDNR. Flowage easements would be required on an additional 14 parcels totaling 206 acres. Bank protection easements totaling 18 acres were assumed for feasibility level cost estimating of the upstream bank stabilization project. The Locust Creek recommended plan real estate values based on October 2019 price levels for the affected lands total approximately $5,276,440. Total Locust Creek LERRDs costs after factoring in contingency, administration, and relocation costs are $8,041,000 based on October 2020 price levels. Real estate needed for the Fountain Grove recommended plan includes 259 acres of fee, 2 acres of bank protection easement, 1,754 acres of temporary construction easement, and 2 acres of utility line easement. Only the bank protection and utility line easements affect privately-owned parcels (three private parcels in total). The Fountain Grove recommended plan real estate values based on October 2019 price levels for the affected lands total approximately $1,590,680. Total Fountain Grove LERRDs costs after factoring in contingency, administration, and relocation costs are $3,595,000 based on October 2020 price levels. More detailed information can be found in Appendix E, Real Estate Plan.

Total Estimated Project Cost -

Based on October 2020 price levels, the estimated USACE Project first cost is estimated at $121,347,000. Total project cost including escalation to the midpoint of construction for the USACE project is estimated to be $140,081,000.

The total project first cost for the Locust Creek element using October 2020 price levels is $87,075,000, which includes cost-shared monitoring costs of $798,000 and adaptive management costs of $2,475,000. In accordance with the cost share provisions in Section 103(c) of the WRDA of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the Locust Creek element first cost is estimated at $56,598,750 (65 percent), and the non-federal share is estimated at $30,476,250 (35 percent), which includes the value of lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas estimated to be $8,041,000. The MoDNR is responsible for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project after construction, with costs currently estimated at $8,071,095 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $586,726 over the 50-year planning horizon.The total first project cost for the Fountain Grove element using October 2020 price levels is $34,272,000, which includes cost-shared monitoring costs of $158,000 and adaptive management costs of $360,000. In accordance with the cost share provisions in Section 103(c) of the WRDA of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the Fountain Grove element first cost is estimated at $22,276,800 federal (65 percent), and the non-federal share is estimated at $11,995,200 (35 percent), which includes the value of lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas estimated to be $3,595,000. The MDC is responsible for OMRR&R of the project after construction, with costs currently estimated at

$861,383 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $131,083 over the 50-year planning horizon.The LERRD cost estimates were prepared by the Kansas City District Real Estate Office.

Table ES-8. Total Project Cost Estimate for the Recommended Plan.

USACE Account	Measure	Locust Creek Cost Estimate	Fountain Grove Cost Estimate
1	Lands & Damages	$7,469,000	$2,194,000
2	Relocations	$572,000	$1,401,000
6	Fish & Wildlife Facilities (Adaptive Management)	$2,475,000	$360,000
9	Channels & Canals	$60,705,000	$23,986,000
30	Planning, Engineering, & Design	$10,638,000	$4,235,000
31	Construction Management	$5,216,000	$2,096,000
	Sub-Total	$87,075,000	$34,272,000
	Total Estimated First Project Cost*		$121,347,000

1.0 Introduction

This Integrated Feasibility Report and Environmental Assessment (FR/EA) presents the results of the *Grand River and Tributaries, Missouri and Iowa Feasibility Study*. The FR/EA integrates plan formulation with documentation of environmental effects, potential alternatives for ecosystem restoration within the Grand River basin, outlines the process used for selecting the recommended alternative, and concludes with recommendations for project implementation. It also documents compliance with the National Environmental Policy Act (NEPA) of 1969, and includes input from the non-federal study sponsors, natural resource agencies, and the public.

1.1 Study Authority

The feasibility study was authorized by resolution of the Committee on Environment and Public Works of the United States Senate during the 108th Congress 2nd Session on June 23, 2004. The authorization stated:

> *That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Grand River and Tributaries, Missouri and Iowa, published as House Document 241, 89th Congress, First Session, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of flood damage reduction, municipal and industrial water supply, recreation, fish and wildlife conservation, or environmental restoration in the Grand River Basin, Iowa and Missouri.*

1.2 Study Area and Scope of Study

The Grand River Basin drains 7,900 square miles in southern Iowa and north central Missouri, making it the largest Missouri watershed north of the Missouri River (Figure 1-1). The Grand River basin includes three Hydrologic Unit Code (HUC)-8 sub-basins: the Upper Grand, the Thompson (also referred to as the middle), and the Lower Grand (Figures 1-2 and 1-3). HUCs are a hydrology-based classification system applied to watersheds throughout the nation. Throughout this report, “watershed” will refer to the entire Grand River basin, and “sub-basin” will refer to the HUC-8 level. The Grand River has been highly altered along its 226-mile length. Hundreds of miles of channels within the Grand River watershed were straightened in the early 1900s to facilitate agricultural development, causing progressive instability of the watershed, loss of high value habitat, and continually threatened infrastructure. Flood frequency and intensity have increased in recent years. The watershed historically contained diverse complexes of river/stream channel and oxbow habitats (a U-shaped lake formed when a wide meander of a stream or river is cut off, creating a free-standing body of water), floodplain forest and woodland, bottomland prairie, and terrace prairie and savanna that supported rich animal communities and provided many important ecological functions (Heitmeyer et al. 2011). Since the mid-1800s, thousands of acres of tallgrass prairie, wetland, and bottomland hardwood habitat have been lost. Over 300 miles of natural stream corridor were channelized, adversely impacting thousands of linear feet of riparian (the area associated with the banks of streams or other watercourse) and aquatic habitat. Habitat degradation, erosion, and sediment deposition have increased in intensity, which are now serious problems.

The scope of the study focused on achieving National Ecosystem Restoration (NER) benefits in accordance with Engineer Regulation (ER) 1165-2-501 because funding was provided through the U.S. Army Corps of Engineers (USACE) ecosystem restoration business line. The authorized study area includes the entire Grand River watershed. Parts of the Lower Grand River sub-basin have experienced the most ecosystem degradation and have the greatest restoration potential (Figure 1-4). In coordination with the study sponsors, the scope focused on the Lower Grand River sub-basin in recognition of the significance of the ecological resources within the sub-basin. Actions are needed throughout the Lower Grand River sub-basin to reverse the trend of ecosystem degradation.

Figure 1-1. Grand River Watershed.

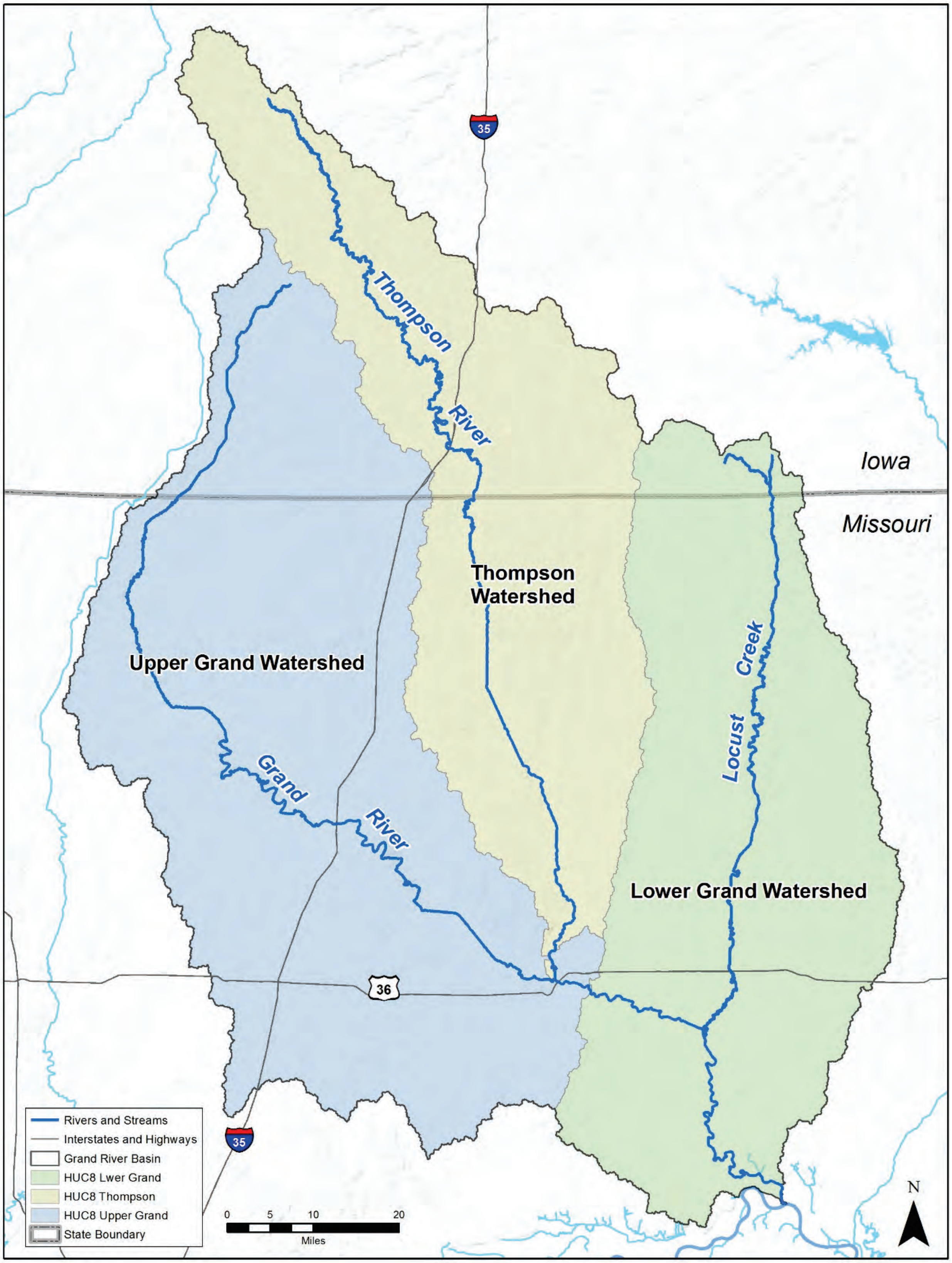

Figure 1-2. Grand River Sub-Basins

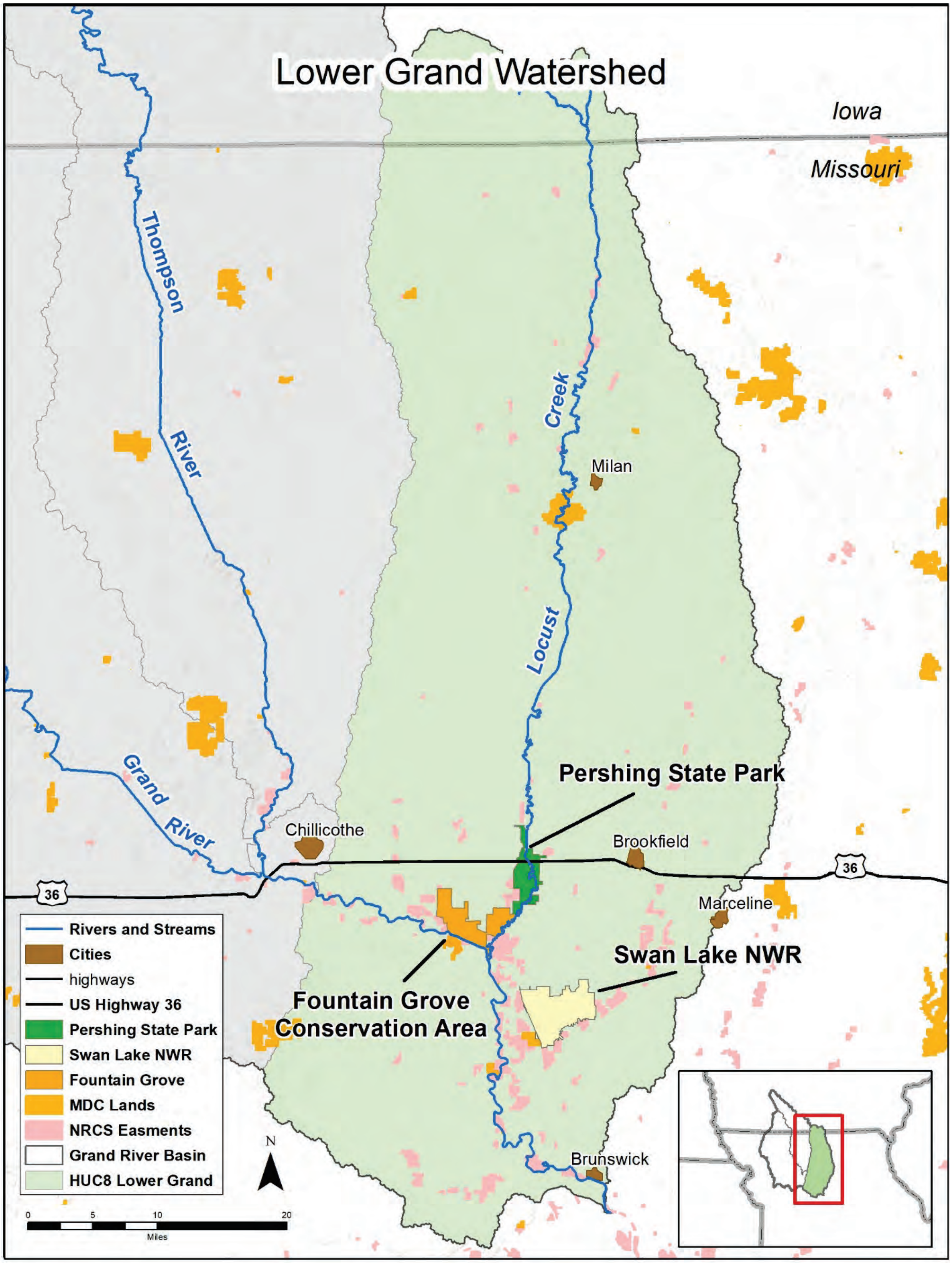

Figure 1-3. Lower Grand River Sub-basin

1.3 Study Sponsors and Partners

The Missouri Department of Conservation (MDC) and the Missouri Department of Natural Resources (MoDNR) are the cost-share sponsors and signatories to the Feasibility Cost Share Agreement. The Environmental Protection Agency (EPA), Missouri Department of Transportation (MoDOT), U.S. Fish and Wildlife Service (USFWS), U.S. Department of Agriculture – Natural Resources Conservation Service (NRCS), and U.S. Geological Survey (USGS) are study partners.

1.4 Federal Interest and Resource Significance

The study seeks to identify a plan that contributes to the NER objective by increasing the net quantity and/or quality of desired ecosystem resources. There is a Federal Interest in contributing to NER within the Grand River Basin. The focused study area is in the heart of the area known as the "Golden Triangle" to bird experts and waterfowl hunters because of its importance to migratory waterfowl and other bird species. The Golden Triangle lies near the border of the Central and Mississippi waterfowl flyways and includes a wetland complex of over 24,000 acres of state and federal lands including the USFWS Swan Lake National Wildlife Refuge (NWR) (10,795 acres), 14,000 acres of privately owned NRCS conservation easement properties, and thousands of acres of privately held lands managed for waterfowl, wildlife, and agriculture. The wetlands and associated uplands provide vital habitat for migrating waterfowl, shorebirds, and many other wetland-dependent species, and were previously some of the best wetland habitat in the Midwest.

The criteria for determining the significance of resources are published in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (United States Water Resources Council, 1983), Resource Significance Protocol for Environmental Project Planning, (IWR Report 97-R-4, July 1997) and in USACE planning guidance such as the Planning Guidance Notebook (Engineer Regulation 1105-2-100). The consideration of significant resources is central to plan formulation and evaluation for any type of water resources development project. Significance of resources are derived from institutional, public, and technical recognition of the ecological, cultural and aesthetic attributes of resources within the study area. As per the USACE Planning Guidance Notebook:

- **Institutional recognition** of an environmental resource means its importance is acknowledged in the laws, plans, and policies of public agencies, tribes, or private groups.
- **Public recognition** means some segment of the general public considers the environmental resource to be important.
- **Technical recognition** of a resource is based upon scientific or technical knowledge or judgment of critical resource characteristics that establish its significance.

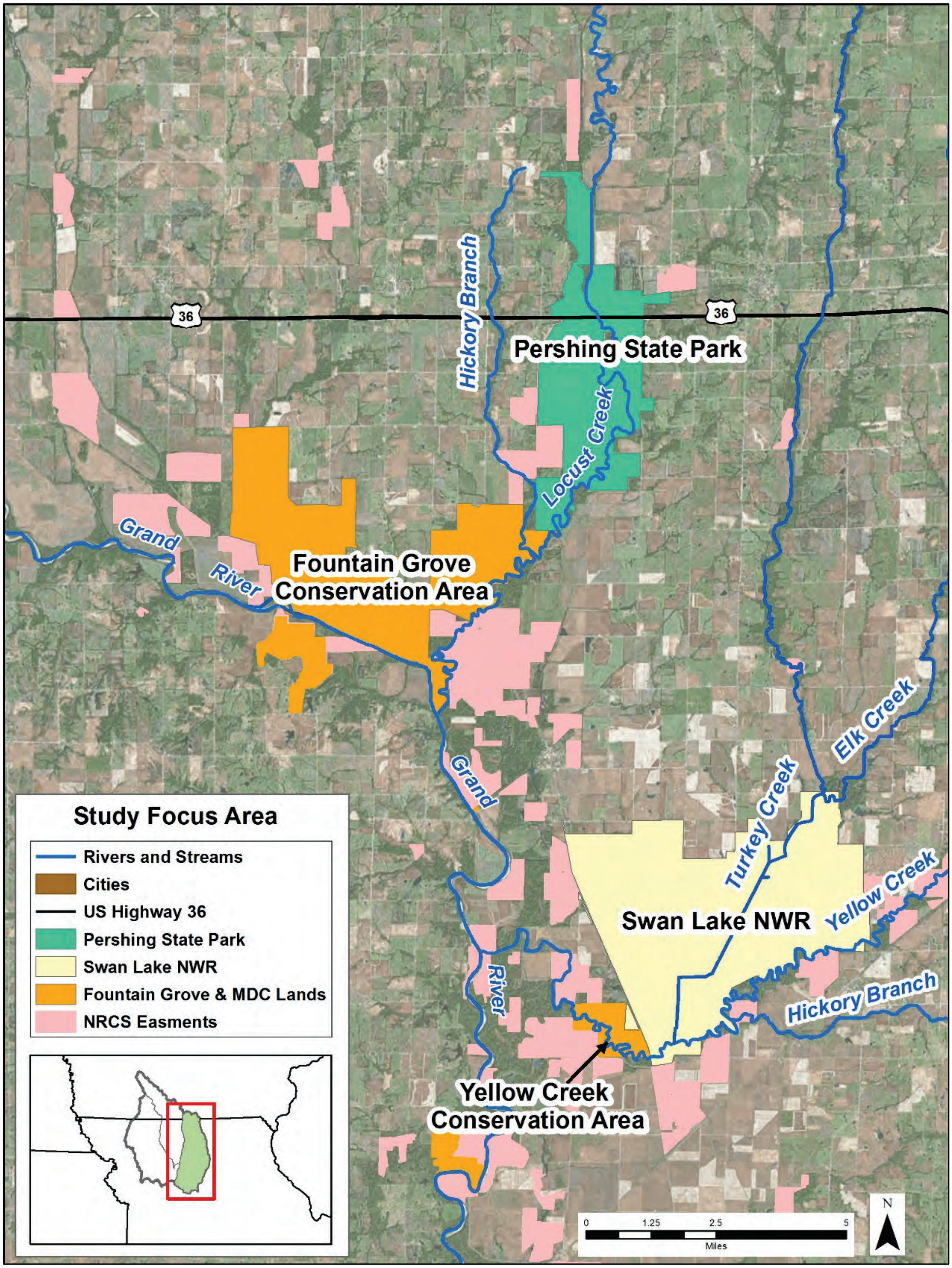

Figure 1-4. Focused Study Area.

1.4.1 Institutional significance

Federal law and executive orders establish National policy on the protection, restoration, conservation, and management of environmental resources. The institutional significance of wildlife resources is demonstrated by the multitude of legislative acts that exist to manage and conserve the resource. Pivotal among these are the following:

- Migratory Bird Treaty Act of 1918 (16 United States Code (USC) 703-712)
- Migratory Bird Conservation Act of 1929, as amended (16 USC 715-715d, 715e, 715f-715r)
- Fish and Wildlife Coordination Act of 1934, as amended (16 USC 661-667e)
- NEPA of 1969, as amended (42 USC 4321 et seq.)
- Endangered Species Act of 1973 (16 USC 1531 et seq.)
- Fish and Wildlife Conservation Act of 1980 (16 USC 2901-2911)
- North American Wetlands Conservation Act of 1989 (16 USC Code 4401-4412)
- Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds, dated January 10, 2001

Fish and wildlife resources are critical elements of the Grand River ecosystem, important indicators of the health of aquatic habitats, and highly regarded by the public for their aesthetic, recreational, and commercial value. A substantial Federal investment exists within the Lower Grand River sub-basin. Specific examples of institutional recognition of the significance of the resources in the Grand River watershed include the following:

- The Grand River watershed falls within the Central Rivers area of greatest continental significance to North American ducks, geese, and swan included in the 2012 revision to the North American Waterfowl Management Plan (NAWMP) (NAWMP Committee 2012).
- The area was designated as an Important Bird Area by the Audubon Society.
- The USFWS Swan Lake NWR is located within the focused study area.
- The Lower Grand River sub-basin was identified as a focus area watershed within the NRCS Mississippi River Basin Healthy Watersheds Initiative. Focus area watersheds are HUC8 sub-basins where modeling has shown a significant contribution of nutrients to the Mississippi River basin. The Lower Grand River sub-basin ranks in the top 10% for phosphorous contribution and top 20% for nitrogen contribution of over 800 sub-basins evaluated (Robertson et al 2009).
- The NRCS has invested over $100 million in federal wetlands easement within the Lower Grand River sub-basin, with $56 million of that investment occurring within the focused study area (approximately 14,000 easement acres).
- The segment of Locust Creek from U.S. Highway (HWY) 36 to the Grand River in the focused study area is listed on the Nationwide Rivers Inventory (NRI) maintained by the National Park Service (NPS). NRI segments are potential candidates for inclusion in the National Wild and Scenic River System. The free-flowing river segments listed on the NRI are believed to possess one or more “outstandingly remarkable” natural or cultural values judged to be of more than local or regional significance. The NRI designation states “Locust Creek Natural Area represents the last remnant landform types in northern Missouri of an active meandering river system and associated oxbow sloughs, swamps, and rich floodplain forests; one of the last unchannelized, undisturbed landform features in northern Missouri; high recreation potential, especially in and near Pershing State Park; historic covered bridge; one of the best examples of aquatic community types in the region.” The segment’s outstandingly remarkable values include fish, historic, recreational, scenic, and wildlife. An additional segment of Locust Creek upstream of the focused study area is also listed on the NRI.

- The focused study area falls within the summer range of the Indiana bat and northern long-eared bat. The Indiana bat has been listed as endangered and the northern long-eared bat as threatened under the Endangered Species Act of 1973, as amended. The draft Recovery Plan for the Indiana bat identifies conservation and management of summer habitat as a needed action (USFWS 2007). The Federal listing of these bat species demonstrates that they are recognized by Federal law as highly significant.
- Bald eagles, protected under the Bald and Golden Eagle Protection Act, have been nesting successfully in the study area for over 10 years. Golden eagles, although uncommon, are also known to visit the area.
- There are two Missouri Natural Areas, a notable state designation, in the study area. They are the Locust Creek Natural Area (within Pershing State Park) and Yellow Creek Natural Area (within Yellow Creek Conservation Area). The designation recognizes the “best of the best” examples of a specific community type, feature or landscape and is nominated and decided on by a panel of Missouri’s best ecologists from multiple state, federal and nongovernmental environmental agencies.
- MDC designated the Grand River Conservation Opportunity Area within the focused study area.
- Within the Lower Grand River sub-basin, MDC Fisheries Division designated the Lower Locust Creek as a Missouri Aquatic Conservation Opportunity Area and the Locust Creek/Yellow Creek watershed as a Priority Watershed.

1.4.2 Public significance

Significance based on public recognition means that some segment of the general public recognizes the importance of an environmental resource. Public recognition is evidenced by people engaged in activities that reflect an interest in or concern for a particular resource. Such activities may involve membership in an organization, financial contributions to resource-related efforts, provision of volunteer labor, and correspondence regarding the importance of a resource. Specific examples that demonstrate the public significance of the Lower Grand River sub-basin include:

- Ducks Unlimited (DU) is a national not-for-profit with a mission to conserve, restore, and manage wetlands and associated habitats for North America’s waterfowl. Recent and historic investment by DU in the study area and in Missouri demonstrate the ecosystem’s public significance. DU partnered with private donors, MDC, and the USFWS to receive a $1 million North American Wetlands Conservation Act grant for a large conservation project at Swan Lake NWR. Historically, DU has conserved 115,522 acres in Missouri and invested $18.5 million.
- Twenty-seven Missouri Stream Teams in the Lower Grand River sub-basin contributed 872 volunteer hours from 2013-2016 performing stream clean-up and other stream enhancement projects.
- Pershing State Park has had 369,383 visitors from 2010 through 2016.
- Fountain Grove Conservation Area (Fountain Grove CA) had over 3,200 hunter trips in each fiscal year from 2014-2016. The use of the study area for waterfowl hunters demonstrates that this segment of the public recognizes the resource’s significance.
- Swan Lake NWR has held 227 refuge programs from fiscal year 2010 through 2016 that attracted 13,801 participants. In addition, an average of 2,465 total volunteer hours have been spent at the refuge over the same time period.

1.4.3 Technical significance

USACE uses scarcity, representativeness, status and trends, connectivity, and biodiversity to assess technical significance. Each category is discussed below.

1. Scarcity

Scarcity is a measure of a resource's relative abundance within a specified geographic range. The State of Missouri has lost approximately 87 percent of its wetland area (Dahl 1990). Pershing State Park features the largest complex of natural bottomland wetlands remaining in northern Missouri. The problems discussed in Section 1.6 represent threats to this already scarce resource. Wet bottomland forest and wet prairie, both habitats found in the study area, are considered vulnerable and critically impaired habitats at the state level. The wet prairie at Pershing State Park includes a reproducing population of the state-listed endangered prairie massasauga rattlesnake. A stable/semi-stable population of this species also occurs at Swan Lake NWR. Other rare species found in the study area include:

- The state-ranked imperiled flat floater (a freshwater mussel species) has only been found in the regionat Pershing State Park and Swan Lake NWR.
- An extensive stand of Ostrich Fern, a state-ranked imperiled species, occurs in Pershing State Park adjacent to Locust Creek.
- The state-endangered American bittern is found in the study area and relies on marshes, wet meadows, and sloughs.
- The study area falls within the heart of Indiana bat maternity habitat with the highest concentrations/numbers of bats and maternity colonies of this Federal endangered species.

Additionally, the unchannelized portion of Locust Creek from Pershing State Park to the confluence with the Grand River represents one of the last active meandering unchannelized stream segments in northern Missouri.

2. Representativeness

Representativeness is a measure of an environmental resource's ability to exemplify the natural habitat or ecosystems of a specified geographic range. Pershing State Park includes the largest remaining representation of an active meandering river system retaining its associated bottomland forests, prairies, swamps, marshes, oxbow sloughs, and ponds in northern Missouri. The rich and diverse fauna in the unchannelized reach of Locust Creek exemplify what was likely present throughout northern Missouri before most streams were extensively channelized (Winston et al. 1998).

3. Status and Trends

Excessive sedimentation and altered hydrology threaten the bottomland forest, wet prairie, and other wetland habitat types within the focused study area. Habitat degradation includes loss of hardwood trees and replacement of mast-producing oak species with less-desirable species that provide less value to wildlife. Heitmeyer et al (2011) summarized data comparing the species composition of floodplain forest in the Lower Grand River region between 2010 and a forecasted pre-settlement composition. Composition of pin oak and pecan declined (pin oak – 50 percent to 20 percent, pecan – 20 percent to 15 percent); while more flood-tolerant species such as silver maple and green ash had increased (silver maple – trace amounts to 20 percent, green ash – less than 5 percent to 15 percent). The Cordgrass Bottoms Natural Area located at Pershing State Park was delisted because flooding and sedimentation altered its species composition from cordgrass to invasive reed canary grass with woody vegetation encroachment. In-stream impacts to aquatic habitat include channels filling with sand and silt and loss of pool habitat and coarse substrate (Pitchford and Kearns 1994). Loss of quality pool habitat is a serious factor affecting stream fish populations throughout the Grand River Basin (Pitchford and Kerns 1994).

4. Biodiversity

Biodiversity is a measure of the variety of distinct species and the genetic variability within them and encompasses the variety and interaction of habitat types and ecosystem processes extending over a given region. Bird diversity within Pershing State Park and surrounding areas is exceptionally high for the region. Notable records include Yellow-throated warbler, Cerulean warbler, and high species counts of other warblers, brown creepers and the largest number of golden-crowned kinglets ever recorded in the spring for Missouri. As composition of bottomland forest continues to change over time due to habitat degradation, bird diversity may decline.

The riparian forest community throughout the focused study area is used during the summer by the federally endangered Indiana bat and federally threatened northern long-eared bat.

Fish sampled from Locust Creek in Pershing State Park were regionally outstanding, with samples ranking third, fourth, and seventh in species richness out of 65 samples from the Prairie-Upper Missouri Aquatic Faunal Division (Winston et al 1998). The loss of Locust Creek flows to Higgins Ditch impacts the fish community. Densities of live and fresh-dead mussels were 10 times higher in the lower section of Locust Creek within Pershing State Park compared to the channelized reaches upstream of the park (Winston et al. 1998).

5. Connectivity

Connectivity measures the potential for movement and dispersal of species throughout a given area or ecosystem. Connectivity is essentially the opposite of fragmentation, and it is considered in the context of an entire landscape or watershed. The focused study area contains a large amount of existing publicly owned wetlands. Approximately 24,000 acres of public land exists in the detailed study area (Pershing State Park – 5,400 acres; Fountain Grove CA – 7,959 acres; Yellow Creek Conservation Area [Yellow Creek CA] – 593 acres; and Swan Lake NWR – 10,795 acres). Thousands of acres of NRCS easement lands are located in the Lower Grand River sub-basin, primarily in the ACEP-WRE. The lower Locust Creek and Grand River complex of publicly owned wetlands provides unparalleled connectivity of represented habitat types in the region.

1.5 Purpose and Need

The overall purpose of the study is to identify a plan by which USACE, MoDNR, MDC, and USFWS will achieve ecosystem restoration benefits within the Lower Grand River sub-basin. Specifically, to reverse the trend of degradation of wetland, aquatic, and floodplain habitats within the areas of Pershing State Park, Fountain Grove CA, Swan Lake NWR, Yellow Creek CA, and surrounding public and private lands. The need for the plan is demonstrated by the discussion of problems that follows in Section 1.6.

1.6 Problems and Opportunities

The following problem statement was developed by the study team, sponsors, and partners:

> *The Grand River watershed has experienced degradation of aquatic habitat, bottomland forest habitat, wet prairie habitat, and other wetlands due to the combined effects of widespread stream channelization, upstream degradation (i.e. head-cuts, streambank failure, excessive large woody debris transport and accumulation), excessive downstream sediment aggradation, altered hydrology and hydraulics, channel piracy, land management, and infrastructure development.*

The following problems were identified through review of existing studies within the basin and discussions with technical experts.

1.6.1 Stream Channelization, Soil Erosion, and Sediment Loading

Following the Civil War, human settlement in the watershed increased and native vegetative communities were converted to agricultural crop land through the early 1900s, including expansion into floodplain areas (Heitmeyer et al. 2011). By 1915, stream channelization (the act of widening, deepening, and straightening streams to increase their capacity to contain flows) was common in many reaches of the Grand River watershed and much of the early channelization occurred in the upstream part of the watershed (Pitchford and Kearns 1994). Agricultural uses such as cropland and/or pasture now make up over 90 percent of the watershed (Heitmeyer et al. 2011). Stream channelization and conversion to agriculture have increased sediment loading in streams. Primary symptoms of these effects include head-cutting (i.e. degradation of the stream bed in a concentrated area), log jams, avulsions or pirating (i.e. the diversion of stream flow out of an established channel and into a new permanent course), stream bank erosion and failure, and channel bed/floodplain aggradation (buildup of sediments in the stream bed or on the floodplain) resulting in the loss of native aquatic and floodplain habitats. These problems are most pronounced in the Lower Grand River sub-basin. The resource conditions on Locust Creek in the vicinity of Pershing State Park and Fountain Grove CA are particular problem areas.

Locust Creek was about 123 miles long prior to channelization (HDR 2013). Only 51 miles remain un-channelized, while 23 miles have been eliminated (HDR 2013). Aquatic habitat was directly lost from channelization, and the subsequent channel aggradation has filled important -pool-run habitats (i.e. reaches of a stream that alternate from relatively shallow to deeper waters), further degrading aquatic habitat. Pershing State Park includes a portion of unchannelized Locust Creek, diverse remnant areas of floodplain forest and woodland and the largest remaining tract of bottomland prairie in the sub-basin. Channel oxbows (historic meanders that have been cut off from the present channel) of Locust Creek are also present in the park. Locust Creek converts from a straightened, channelized configuration into a meandering, un-channelized stream just north of HWY 36 in Pershing State Park. This configuration has resulted in numerous log jams within Pershing State Park for over 25 years. While log jams cause additional sedimentation and aggradation once formed, these log jams are a symptom of aggradation and sedimentation of coarse and fine bed materials in Locust Creek and other nearby drainages (Figure 1-5). Excessive sediment loading causing Locust Creek to aggrade and become a perched channel has also contributed to formation of log jams in the Pershing State Park area. This situation contributed to numerous erosive floodplain avulsion channels that have diverted Locust Creek flow into the near-by Higgins Ditch (a man-made drainage ditch), which has worsened the hydrologic condition in the vicinity. Locust Creek is now 8 to 9 feet higher than Higgins Ditch as a result of sediment aggradation, a primary cause of avulsions and the diversion of flow to Higgins Ditch. Recent data indicates that Higgins Ditch is now capturing over 90% of Locust Creek flows. In addition to channel aggradation, floodplain aggradation is occurring along Locust Creek. Within Pershing State Park, loss of flow, wetland filling, vegetation damages, and vegetative community changes have occurred as a result of the aggradation. Many acres of high quality bottomland hardwood forest, wet prairie, emergent marshes, riparian communities, and other wetlands have become covered and filled in with several feet of sediment. There has been substantial mortality of bottomland hardwood trees.

The first waterfowl/wetland management area acquired and developed by the MDC was Fountain Grove CA. It consists of 7,959 acres that are managed to provide diverse wetland habitat, including marshes, bottomland forests, grain fields, oxbow lakes, and sloughs. Fountain Grove CA has experienced loss of important micro-topography and diversity within its wetland areas due to similar floodplain sedimentation from Parsons Creek. Prolonged inundation and floodplain aggradation have contributed to the loss of floodplain forest species at Fountain Grove CA, as well as at Yellow Creek CA, located downstream near Swan Lake NWR. Private lands enrolled in NRCS conservation easements and area private lands managed for waterfowl and other species are experiencing similar effects.

Figure 1-5. Excessive floodplain sediment deposition (left) and log jams (right) within Pershing State Park.

1.6.2 Altered Flow Conveyance

Over 50 organized drainage and levee districts were formed in the basin in the early 1900s (Heitmeyer et al. 2011; Pitchford and Kearns 1994). These districts have historically constructed levees, ditches, channelization, and substantial water-control structures that altered hydrology in the watershed. Many townships and private organizations formed small organizations and supported projects in the early 1900s. The collective effect of these uncoordinated drainage and levee projects within the Grand River watershed was to intensify and accelerate water and sediment discharge and cause more regular and prolonged overbank and backwater flooding from the Grand River (Heitmeyer et al. 2011). Alteration of floodplain lands has also restricted the movement of organisms, plants, and organic matter both laterally between the channel and the floodplain, upstream into tributaries, and the longitudinal movement of organisms between floodplain habitats.

1.6.3 Loss of Aquatic Habitat, Riparian Communities, Wetlands, and Floodplain Habitats

As stated previously, widespread streambank channelization and conversion of native vegetative communities to agriculture over the past 150 years have resulted in direct losses of native habitats and communities with resultant declines in fish and wildlife populations that used those habitats. The excessive sediment loading that has occurred as a result of the combined effects of channelization and land management practices has further degraded and reduced the extent of in-stream aquatic habitat, in particular pool-run habitat, as well as bottomland hardwoods, floodplain forest, woodland, and wet prairie habitats due to stream and floodplain aggradation.

1.6.3.1 Bottomland Hardwoods

Bottomland forest has been severely damaged throughout Pershing State Park (Figure 1-6). More than 248 acres of dead/dying trees exist along Locust Creek throughout the southern end of Pershing State Park and more than 30 acres of bottomland forest/riparian forest around the Locust Creek Covered Bridge have been heavily degraded. Numerous other timbered areas of Pershing State Park have received large amounts of sedimentation. Bottomland hardmast sapling recruitment is not regularly occurring at Fountain Grove CA and Yellow Creek CA. As described previously, Heitmeyer et al (2011) described the change in species composition of floodplain forest from pin oak and pecan (hardmast) to more flood-tolerant species such as silver maple and green ash (softmast).

1.6.3.2 Wet Prairie and Other Wetlands

Pershing State Park has experienced long-term degradation over much of its wet prairie including loss of one of the last and largest wet prairies in the State of Missouri (Figure 1-7). Emergent marshes have been filled in from floodplain deposition. Native wetland and wet prairie species are being quickly replaced by reed canary grass. Reed canary grass is a major threat to marshes and natural wetlands because of its hardiness, aggressive nature and rapid growth. It is of particular concern because of the difficulty of selective control. All ephemeral pools and oxbows within Pershing State Park are threatened by sedimentation. Sediment deposition from Parsons Creek has caused Fountain Grove CA to lose much of its micro-topography, which has reduced the diversity of vegetation and wetland community types. Historically, patches of wet prairie were common on slightly higher ground at Yellow Creek CA. Altered hydrology within the watershed, stream channelization, channel incision, siltation, and floodplain constriction have degraded the bottomland woodland community and eliminated the prairie elements at Yellow Creek CA (MDC 2017). Habitat on private lands within the area are experiencing similar degradation.

Figure 1-6. Healthy pin oak forest (left) and degraded forest with dying pin oaks (right).

Figure 1-7. Cordgrass Bottoms Natural Area at Pershing State Park in 1979 (left) and in 2013 (right) after degradation.

1.6.3.3 In-channel Aquatic Habitat

Water levels in Locust Creek are no longer at historically typical levels/flows within Pershing State Park due to the avulsion of water into Higgin's Ditch. Within the park, this is 9.39 miles of Locust Creek (49,601 ft) that will continue to be de-watered by the pirating of flows to Higgins Ditch. This results in Locust Creek having little to no flow most of the year and severely degraded aquatic habitat. High sediment loads in Yellow Creek are causing channel aggradation and some areas of the creek bed are becoming higher than surrounding floodplain areas (USFWS 2016). It is likely that channel avulsions with potential to negatively affect Swan Lake NWR will occur in the future.

1.6.4 Water Quantity and Quality

Decades of land management practices have resulted in extensive soil erosion and compaction, which limits water infiltration of soil and percolation. Combined with extensive stream channelization, the hydrograph of the basin resembles an "urban" run-off pattern, where runoff moves more rapidly through the system to the downstream portion of the watershed. The NRCS has been implementing the PL-566 program in the watershed, which has built several hundred 5-10-acre watershed structures on public and private lands to contribute towards reducing flood pulses (Heitmeyer et al. 2011). The NRCS is also in the planning process for construction of a new reservoir on East Locust Creek.

Water quality monitoring in the Lower Grand River sub-basin indicates there are elevated E. coli levels, high suspended solids, high nutrients (nitrogen and phosphorus), and low dissolved oxygen in some streams (MoDNR 2016). These water quality impairments can affect the designated beneficial uses of the streams. Identifying opportunities to improve water quality in conjunction with wetland and aquatic habitat is expected to be considered as an incidental project benefit.

1.6.5 Damaging Floods

As early as 1932, the USACE had identified the increased frequency and severity of flooding as a problem in the Lower Grand River sub-basin (USACE 1932). This problem was attributed to the combined effects of widespread stream channelization and levee construction. The funnel shape of the basin directs discharge to the narrow floodplain along the lower Grand River. The Grand River watershed has experienced frequent damaging floods, the 1947 flood event caused approximately $22,600,000 of damages in unadjusted dollars (USACE 1963). After 1915, flooding that exceeded 24 feet (flood stage) at Chillicothe, Missouri was exceeded (with intervals of 30 days or more between crests) 87 times through 1962. Since the 1960s, there has been an increased frequency of 0.5 to 2-year recurrence interval flood events (Heitmeyer et al. 2011). Most of the study area experienced the flood of record in 2019.

1.6.6 Opportunities

The study team has identified the following opportunities:

- Reverse the trend of degradation of aquatic habitat, bottomland forests, wetland and wet prairie habitat within the Lower Grand River sub-basin.
- Provide benefits to infrastructure, agriculture, water quality, recreation, and flood risk reduction in association with wetland and aquatic habitat improvement within the Lower Grand River sub-basin
- Maintain or improve connectivity of floodplain habitat types within the focused study area

1.7 Relationship to Other Federal Activities

The Grand River study team has collaborated with Federal agencies that have an interest in or jurisdiction over resources within the study area. The team has developed a Federal plan that capitalizes on the multiple Federal programs at work in the Lower Grand River sub-basin in order to find synergistic results from future implementation. Although certain measures considered in plan formulation may be outside the USACE scope of action, other Federal agencies will have an opportunity to act for ecosystem benefits in concert with the USACE recommended plan. Several relevant programs are mentioned here; however, Section 5.19.2 provides a more comprehensive discussion of such programs.

1.7.1 USACE Regulatory Program

The USACE is responsible for protecting the public interest in waters of the United States including rivers, streams, lakes, and wetlands. This is accomplished through a Department of the Army permit program. Under this program, USACE authorizes most activities involving work in waters of the United States. Section 404 of the Clean Water Act regulates the discharge of dredged or fill material in all waters of the United States. This includes work such as site development fills, causeways or road fills, dams and dikes, artificial islands, bank stabilization, levees, fish attractors, mechanized clearing of wetlands, and certain types of excavation activities. USACE issued 14 permits between 1995 and 2014 for log-jam removal projects in and around Pershing State Park. Plan formulation for this study considers the need for a more efficient process of dealing with log jams and their removal to prevent harm to important habitats including wetlands, wet prairie, and bottomland forest.

1.7.2 NRCS Conservation Easements and Working Lands Programs

The NRCS has made a substantial investment in the Lower Grand River sub-basin through its conservation easements and working lands programs. Over 27,000 acres within the sub-basin are enrolled in NRCS conservation easements, approximately 14,000 of which are in the focused study area. These easement lands serve a critical conservation purpose within the focused study area, as they provide habitat connectivity between the three main publicly owned areas: Pershing State Park, Fountain Grove CA, and Swan Lake NWR. As a result, these easement lands present an opportunity in the overall formulation of alternative plans to solve the problems within the sub-basin. These programs are described in more detail in Section 5.19.2.

1.7.3 USFWS Swan Lake NWR

Swan Lake NWR is managed as “a refuge and breeding ground for migratory birds and other wildlife” (Executive Order 7563, dated February 27, 1937). The purposes of the refuge are:

- To act as a refuge and breeding ground for migratory birds and other wildlife
- For use as an inviolate sanctuary, or for any other management purpose, for migratory birds
- To carry out the national migratory bird management program

Since establishment of the refuge, the primary emphasis on waterfowl species has changed from ducks to the eastern prairie population of Canada geese. Canada geese were first observed on the refuge in the early 1940s, and numbers increased gradually to peak populations of 150,000 to 200,000 annually during the early 1970s. Today, Canada geese are commonly seen on the refuge but not in the large concentrations that they were in years past. Currently, the refuge is managed for migratory birds including waterfowl, geese, and shorebirds. It also provides natural habitat for many neo-tropical migrating species of birds. Swan Lake NWR is designated as an Important Birding Area for Missouri.

2.0 Existing Conditions and Affected Environment

The Lower Grand River sub-basin is the general study area for identification of management measures and alternative plans to address the identified problems contributing to ecosystem degradation. The Lower Grand sub-basin (Figure 1-3) extends downstream of Chillicothe, MO to the confluence with the Missouri River near Brunswick, MO and includes drainage areas from significant tributaries such as Locust Creek, Muddy Creek, Hickory Branch, Parsons Creek, Little Parsons Creek, and Yellow Creek. The sub-basin drains approximately 2,360 square miles and is characterized by extensive stream channelization and levee construction. Three focused study areas were identified: Locust Creek Study Area, which includes MoDNR's Pershing State Park; Fountain Grove Study Area, which includes MDC's Fountain Grove CA; and Yellow Creek Study Area, which includes MDC's Yellow Creek CA and the USFWS Swan Lake NWR. Each study area also includes adjoining private lands. Note that through the rest of the document, "Fountain Grove" refers to the broader Fountain Grove Study Area and "Fountain Grove CA" refers to the MDC-owned conservation area. This chapter describes the existing conditions at these three focused study areas. It also describes the affected environment, which includes the environmental resources (i.e. physical, natural, social, and economic) that may be affected by the alternative plans.

2.1 Priority Habitat Types

The primary habitat types assessed for ecosystem degradation and potential restoration lift include wet prairie, emergent wetland, bottomland forest, and aquatic riverine.

2.1.1 Wet Prairie

Wet prairies are densely vegetated grassland habitats with shorter hydroperiods than emergent wetlands (Figure 2-1). This natural community is characterized by having a seasonally high water table with standing water present during much of the winter and spring and generally lacks standing water as summer progresses (July through October) in most years (8-10 years) (Weaver 1960, Nelson 2010). These habitats may occur in depressions less than 1 foot from the surrounding floodplain habitats and can also occur on flats that are inundated by adjacent streams. Fire and the seasonal spring wetness keep these communities from becoming forested habitats. Sedimentation can be detrimental due to covering the existing seed bank, nutrient enrichment, changing the hydrology and elevations of where these habitats occur. Although the dominant plants of wet prairies, such as prairie cordgrass, can handle multiple fluctuations between flooding and drying, these plants are more sensitive to longer duration floods that may occur further into the summer months (approximately 30 continuous days, July-October). By this time plants are generally greater than 2 feet tall and are more likely to survive if leaves can stay above the flood waters. The repeated occurrence of long duration summer floods is detrimental to this community and would result in a community shift and possibly begin to reflect an emergent marsh (more than 4 out of 10 years). If sediment deposition is associated with continued flooding, this community may transition the other way and turn into monocultures of invasive communities like reed canary grass (Kercher et al. 2007) or forested communities over time (Johnston 2003). Characteristic and dominant plant species include: prairie cordgrass (*Spartina pectinata*), bluejoint (*Calamagrostis canadensis*), smartweeds (*Persicaria amphibia* and other *Persicaria* spp.), sedges (*Carex hyalinolepis* and other *Carex* spp.), swamp milkweed (*Asclepias incarnata*), asters (*Symphyotrichum praealtum* and other *Symphyotrichum* spp.), false aster (*Boltonia asteroides*), sawtooth sunflower (*Helianthus grosseserratus*), ironweed (*Vernonia fasciculata*), southern blue flag (*Iris virginica* var. *shrevei*), water parsley (*Sium suave*), rice cutgrass (*Leersia oryzoides*), tickseed sunflower (*Bidens aristosa*), false indigo (*Amorpha fruticosa*), and buttonbush (*Cephalanthus occidentalis*).

2.1.2 Emergent Wetland

The flood pulse concept acknowledges that the timing, duration, and the rate of rise and fall of water across floodplain habitats is important and often helps reset succession (Junk et al 1989, Sparks et al

1990). Emergent wetlands and marshes are vegetated habitats with semi-permanent hydroperiods (Figure 2-2). These often occur in basins in-between 1-4 feet in depth of the adjacent floodplain topography.

Figure 2-1. Example of Wet Prairie Habitat (located west of Swan Lake NWR).

Figure 2-2. Example of Emergent Wetland Habitat (located in Yellow Creek Conservation Area).

These habitats often occupy former oxbows and sloughs, are in depressions within bottomland prairies, and along the edge of deeper oxbow lakes (Nelson 2010). Emergent wetland and marsh habitat represents a transition between open water and bottomland wet prairies or bottomland forest. Water levels fluctuate seasonally based upon frequency of floods, floodplain connectivity, precipitation, and duration of evapotranspiration. While these habitats can persist with inundated conditions for years, more frequent drought conditions (5 out of 10 years) are necessary for the emergent plants to germinate in warm, shallow water (approximately 2-6 inches) (Eldridge 1990, Van der Valk 2005). Characteristic and dominant plant species include: river bulrush (*Bolboschoenus fluviatilis*), great bulrush (*Schoenoplectus tabernaemontani*), bur-reed (*Sparganium eurycarpum*), cattails (*Typha latifolia*, *T. angustifolia*), sedges (*Carex hyalinolepis* and other *Carex* spp.), smartweeds (*Persicaria amphibia* and other *Persicaria* (Polygonum) species), duckweeds (*Lemna minor*, *L. trisulca*), giant reed (*Phragmites australis* subsp. *americanus*-native type, *P. australis* subsp. *australis*-exotic, invasive type), water parsley (*Sium suave*). These are the species characteristic of more permanent, deeper waters of a wetland. Many other species are also common and abundant at lower water depths.

2.1.3 Floodplain Forest Habitat

This typically includes riverfront forest, bottomland hardmast forest, and mixed forest species, all of which are present in the study areas, and important to a natural, healthy bottomland forest. However, due to the primary problems of land conversion, increased inundation, and sediment deposition in the study areas, the general trend has been a gradual conversion from bottomland hardmast forest species to softmast species more representative of a riverfront forest community. This has resulted in improvements to forest components and variables for species that prefer softmast tree species for growth, survival, and reproduction; but have also resulted in detriments to species that require hardmast trees, primarily as an acorn food source. From a project level perspective, this has resulted in the loss or conversion to riverfront forest of approximately 5,000 acres of bottomland hardmast forest within the study areas over the past 20 years.

- **Bottomland Hardmast Forest** are an important transitional habitat between wet prairies and riverfront forest (Figure 2-3). Not only have these habitats diminished, but the stand structure is quite different than it was historically by becoming denser than the historical woodland/savanna setting would have been (Hanberry et al. 2014). Periodic fire during periods of drought, would have helped maintain this community over time (Nelson 2010). Like wet prairies, this habitat can handle frequent floods that occur in the spring and within 12-20% of the growing season (Nelson 2010). Many of these species can withstand various durations of flooding but are more likely to survive if they are partially inundated rather than becoming completely inundated (Hosner 1960, Kabrick et al 2012). Generally, these habitats would dry out sooner than emergent marshes as summer progresses (April through November) most years (8-10 years). This relation to hydrology is linked to soil characteristics and fluvial landforms. Bottomland hardmast communities are often found on slightly higher elevations, floodplain ridges, or terraces (Hupp and Osterkamp 1985, Hodges 1997, Stanturf et al. 2001, Wall and Darwin 1999). Bottomland hardmast seedlings are sensitive to prolonged periods of inundation. Alterations in today's landscape can complicate floodplain hydrology and its effects on natural communities. For example, overtopped levees can retain floodwater several weeks longer than unleveed areas, contributing to higher tree mortality within these leveed forests (Howard 2012). Unfortunately, defining the exact flood tolerances for specific species is difficult to delineate (Burke et al. 2003, Kabrick et al. 2012, King and Grant 1996, Krzywicka et al. 2017). July through November represents the time period immediately following the establishment season, where bottomland hardmast tree seeds would most likely drown if inundated for an extended length of time. Realizing there are a lot of contributing factors, 14 days is the estimated length of time that a seedling could be continuously inundated before it dies. If the sustained inundation is less than 0.5 feet, seedlings are more likely to survive. Median conditions (2 year flood event) can be used

Figure 2-3. Example of Bottomland Hardmast Forest Habitat (located in Yellow Creek Conservation Area).

as an estimate of typical inundation. Characteristic and dominant plant species include: bur oak (*Quercus macrocarpa*), pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), shellbark hickory (*Carya laciniosa*), pecan (*Carya illinoensis*), green ash (*Fraxinus pennsylvanica*), sugarberry (*Celtis laevigata*) slippery elm (*Ulmus rubra*), false nettle (*Boehmeria cylindrica*), goldenglow (*Rudbeckia laciniata*), yellow ironweed (*Verbesina alternifolia*), late goldenrod (*Solidago gigantea*), sedges (*Carex* spp), and wood reed grass (*Cinna arundinacea*).

- **Riverfront Forests** generally occur along the edge of rivers and streams along the natural levee (Figure 2-4). These habitats provide multiple services to the stream, as well as important terrestrial habitat along the stream corridor (Weaver 1960, Nelson 2010). These often occur in habitats that are seasonally saturated for 1 to 2 months throughout the spring or early summer (Huffman and Forsythe, 1981), however, these habitats generally dry out sooner than emergent wetlands as summer progresses (June through October) most years (8-10 years). Often times these locations can be delineated by fluvial landforms. For example, willows, cottonwoods, and other early successional species often occur on depositional areas to form riverfront forests (Hupp and Osterkamp 1985, Hodges 1997, Corenblit et al. 2009). Although soil moisture is important, flooding is not necessary for the survival and growth of these communities. In fact, many species can withstand flooding less than 5 days and are more likely to survive partial inundation rather than complete inundation (Anderson and Pezeshki 2000, Hosner 1960). Riparian tree seedlings are sensitive to prolonged periods of inundation (Dollar et al. 1992, Hall 1993, Burke et al 2003). However, pinpointing exact flood tolerance conditions by species is challenging (Kabrick et al 2012). July through September, which represents the time period immediately following germination, is when riparian tree seedlings would be most likely to drown. The estimated length of time that a seedling could be continuously inundated before it dies is estimated at 35 days. If the sustained inundation is less than 0.5 feet, seedlings are more likely to survive. Median conditions (2 year) can be used as an estimate of typical inundation. Characteristic and dominant plant species include: silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), black willow (*Salix nigra*), sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), river birch (*Betula nigra*), box elder (*Acer negundo*), bur oak (*Quercus macrocarpa*), shellbark hickory (*Carya laciniosa*), wood nettle (*Laportea canadensis*), brown-eyed susan (*Rudbeckia triloba*), late goldenrod (*Solidago gigantea*), and asters (*Symphyotrichum* spp).

Figure 2-4. Example of Riverfront Forest Habitat (located at Locust Creek).

2.1.4 Aquatic Riverine Habitat

The study area is in the Prairie Faunal Region of Missouri. This region includes most of the state north of the Missouri River, plus a wedge-shaped area south of the Missouri River along the Kansas state line. This region is mostly flat with rolling plains that are drained by several rivers located in the lower elevations. These rivers typically occupy broad, flat valleys that slope gradually into the surrounding uplands. Originally, most of these streams meandered in S-shaped courses and often formed oxbow lakes and sloughs as they shifted their beds. Most of these streams, however, have been channelized and are now straight with a nearly uniform depth. Examples of this channelization can be seen in the Higgins Ditch and upper Locust Creek reaches within the Locust Creek study area. The stream bottoms in the

Prairie Region are typically silt, sand, or gravel, and the water is generally turbid due to clay and silt particles suspended in the water. Stream flow and other water conditions such as current, depth, dissolved oxygen and water temperatures can vary over the course of a year. Aquatic riverine habitat within the Locust Creek study area consisted of Locust Creek, Higgins Ditch, Old Locust Creek, Muddy Creek, Hickory Branch, and the Grand River (Figure 2-5). Aquatic riverine habitat in the Fountain Grove study area included Little Parsons Creek, Parsons Creek, Locust Creek, and the Grand River. Habitat within the Yellow Creek study area included Yellow Creek, Elk Creek, Turkey Creek, Tough Branch, Hickory Branch, and Grand River.

Figure 2-5. Example of Aquatic Riverine Habitat (Confluence of Muddy and Old Locust Creek).

2.2 Locust Creek

The Locust Creek Study Area includes Locust Creek, Pershing State Park, private lands under NRCS conservation easement, and private lands. Locust Creek originates in southern Iowa and flows south about

100 miles through north central Missouri until it enters the Grand River. It is channelized over most of its length, with the notable exception being an unchannelized reach flowing 18.6 miles from the northern part of Pershing State Park to its confluence with the Grand River. Most of this reach of Locust Creek (from HWY 36 to the Grand River) is listed on the NRI for the outstandingly remarkable values of fish, historic, recreational, scenic, and wildlife.

Locust Creek flows through Pershing State Park, where it crosses under HWY 36, in Linn County (Figure 2-6). The first land tracts acquired for Pershing State Park were made in 1937 to protect areas along the Locust Creek floodplain that were frequented by General John J. Pershing as a boy. The park includes one of the largest remnant native wetland environments in Missouri, with nearly 3,000 contiguous acres of forested wetlands, sloughs, marshes, shrub swamps and at 800 acres, one of Missouri's two remaining large wet prairies. Abandoned channel oxbows of Locust Creek are present in the park. As a state park, the area was gradually developed to enhance public camping, hiking trails, vehicular access, day use facilities, and picnic shelters. Habitat management on the park was largely related to protection and interpretation of the natural resources along Locust Creek. Certain small water-control structures have been constructed in the park to allow seasonal water management of some wetland restoration areas. Prescribed fire has been the consistent management tool used to maintain wet prairie at Pershing State Park.

2.2.1 Hydrology, Hydraulics, and Sedimentation

Substantial aggradation and log jams contributed to the creation of a perched channel along Locust Creek near HWY 36. Multiple channel avulsions (i.e. pirate channels) formed upstream of HWY 36 and diverted water from Locust Creek to Higgins Ditch, an agricultural drainage channel (Figure 2-6). Over time, Higgins Ditch degraded and widened to the point where it now conveys most Locust Creek flows. When initially excavated, Higgins Ditch stopped south of HWY 36. By 2010, Higgins Ditch had extended itself south and by 2015 conveyed most all of the Locust Creek flows. High flows from Higgins Ditch overbank into Hickory Branch. Higgins Ditch now conveys more than 90% of the flow previously in the Locust Creek channel (Table 2-1). Flow originating in Locust Creek spills into the floodplain in multiple locations upstream and downstream of the main avulsion, commonly called the pirate channel. During moderate and higher flows, all four bridge openings under HWY 36 convey flow (Higgins Ditch, Locust Creek, Locust Creek Overflow, and Muddy Creek). The highest daily flow on Locust Creek at Linneus between October 1966 and September 2016 was 29,794 cfs (peak hourly 30,306 cfs), which is just higher than the flow with a 1% annual exceedance probability (29,500 cfs).

The other noteworthy stream in the vicinity of Pershing State Park is Muddy Creek. Muddy Creek is a tributary to Locust Creek draining approximately 28 square miles to the east, before joining Locust Creek south of HWY 36 in Pershing State Park.

Measured bed sediment samples indicate that the bed of both Higgins Ditch and Locust Creek are predominantly medium and coarse sand. Some of the downstream cross sections in Higgins Ditch contained larger percentages of fines. A flow-load rating curve for the upstream end of Locust Creek was developed from suspended sediment measurements at the USGS gage near Linneus, MO from 2011 to 2017 for flows greater than 100 cfs (Figure 2-7). The black line shown on Figure 2-7 represents the amount of suspended sediment (measured in tons per day) for a given flow (measured in cubic feet per second (cfs)) at that location. Prolonged and frequent inundation within Pershing State Park has impacted existing habitats through sediment deposition. Figure 2-8 shows the magnitude of deposition at Pershing State Park.

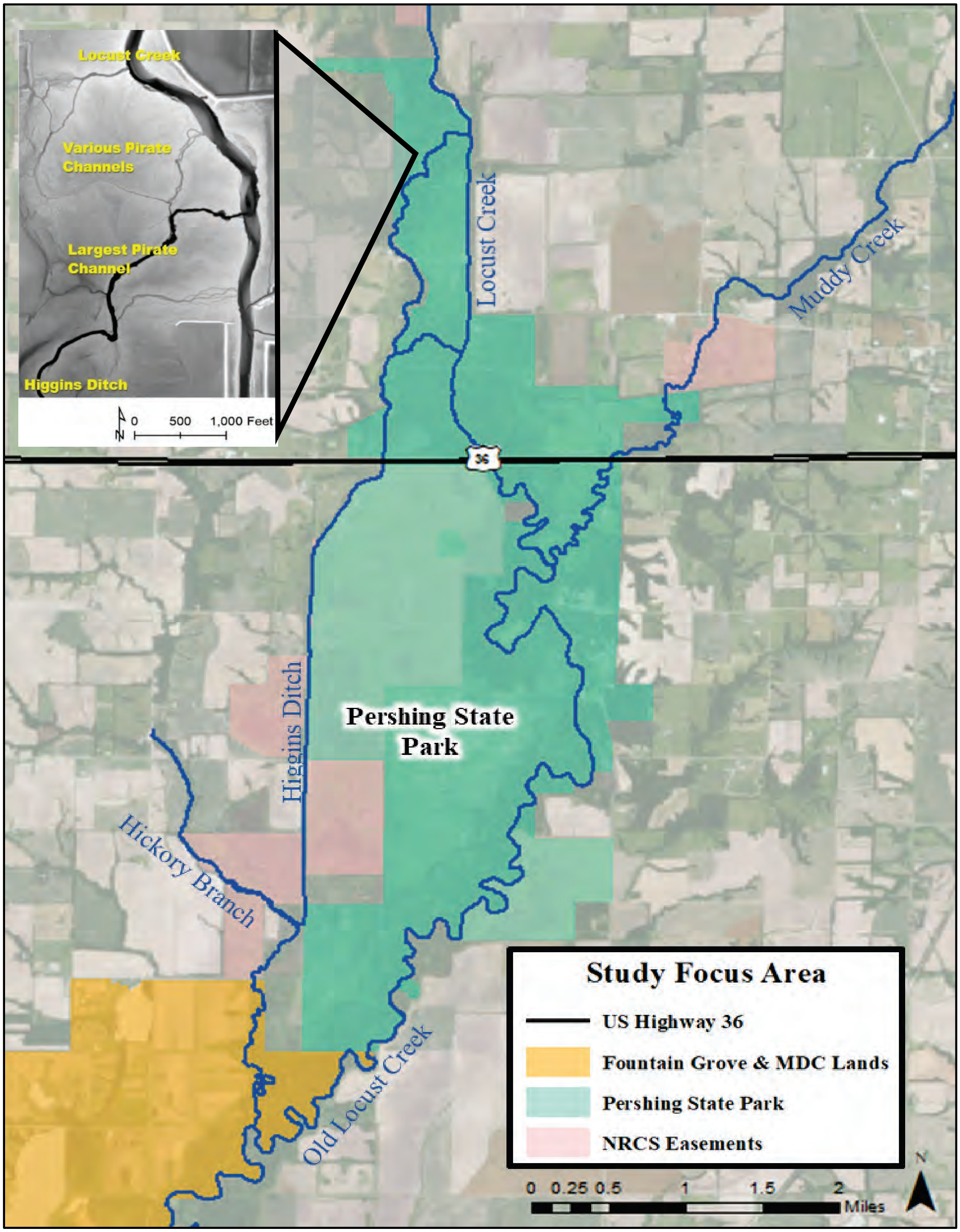

Figure 2-6. Pershing State Park and Stream Locations.

Table 2-1. Flow Split under Highway 36- Existing Conditions.

Linneus	Higgins Ditch Opening	Locust Creek Opening	Muddy Creek Opening
50	49.5	0.5	0
200	185	15	0
1,000	881	119	0
2,500	2,163	306	20
5,500	4,700	509	288
7,300	6,268	556	419
9,150	7,400	580	460
14,500	13,170	645	669
18,200	16,745	683	740
22,800	21,170	728	840
26,200	24,397	773	942
29,500	27,532	815	1,025

Note: Flows are measured in cubic feet per second (CFS).

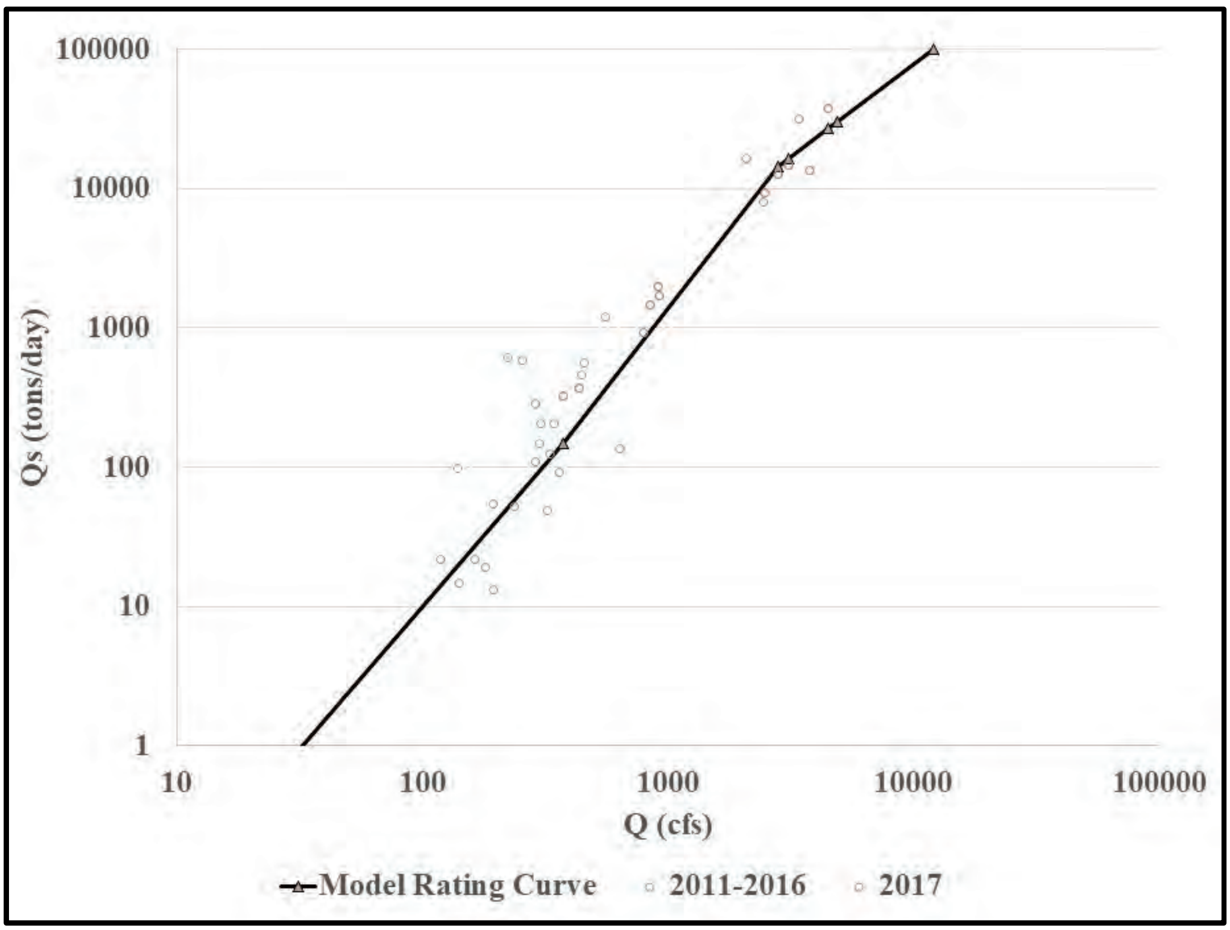

Figure 2-7. Model Rating Curve at Upstream End of Locust Creek (Higgins Ditch RS 26.456).

Figure 2-8. Example of sediment deposition in the Locust Creek floodplain.

2.2.2 Habitat

Study area boundaries were delineated based on 1) extent of hydrology and hydraulics (H&H) and sediment modeling capabilities, 2) location of existing habitats targeted for restoration, and 3) the extent of inundation, sedimentation, and habitat change from proposed restoration measures. Each study area was then divided into discreet terrestrial habitat tracts based on existing natural barriers (e.g. current baseflow), existing man-made barriers (e.g. levees, highways), similarity in impact extent and intensity (e.g. sedimentation), and similarity in potential restoration measures (e.g. sediment detention basin, stream channel realignment, levee modifications). Existing land use/cover was then identified within each habitat tract. A similar process was used to identify aquatic habitat tracts. The following list identifies the terrestrial and aquatic habitat tracts for the Locust Creek focused study area. Terrestrial habitat tracts are displayed in Figure 2-9 and aquatic habitat tracts in Figure 2-10. Existing land use/cover for the area is displayed in Figures 2-11 and acreages are shown in Tables 2-2 and 2-3.

Terrestrial Locust Creek (TLC) Tracts:

- TLC1 – North of proposed diversion berm
- TLC2 – Higgins Ditch from proposed diversion to HWY 36
- TLC3 – Proposed Sediment Detention Basin Area
- TLC4 – Higgins Ditch from HWY 36 to below Hickory Branch
- TLC5 – Zell tract Area from HWY 36 to below Hickory Branch
- TLC6 – Locust Creek from HWY 36 to below Hickory Branch
- TLC7 – Locust Creek from Hickory Branch to Confluence with Hickory Branch
- TLC8 – Locust Creek from Hickory Branch Confluence to Grand River

Aquatic Locust Creek (ALC) Tracts:

- ALC1 – Upper Boundary of Locust Creek to existing avulsion to Higgins Ditch
- ALC2 – Higgins Ditch, Avulsion to Footbridge
- ALC3 – Locust Creek, Avulsion to HWY 36
- ALC4 – Proposed Sediment Detention Basin Area
- ALC5 – Higgins Ditch, Footbridge to Hickory Branch
- ALC6 – Locust Creek, HWY 36 to Muddy Creek
- ALC7 – Upper Boundary of Muddy Creek to Confluence with Locust Creek
- ALC8 – Upper Boundary of Hickory Branch to Confluence with Higgins Ditch

- ALC9 – Hickory Branch, from confluence with Higgins Ditch to Locust Creek
- ALC10 – Locust Creek, Confluence with Muddy Creek to Hickory Branch
- ALC11 – Locust Creek, Confluence with Hickory Branch to Grand River
- ALC12 – Proposed Higgins Ditch to Locust Creek Connector

Table 2-2. Existing conditions acreages within the Locust Creek study area by aquatic tract.

Aquatic Tract	Acres
ALC1	84
ALC2	12
ALC3	27
ALC4	0
ALC5	51
ALC6	12
ALC7	10
ALC8	35
ALC9	19
ALC10	72
ALC11	71
ALC12	0
TOTAL	**393**

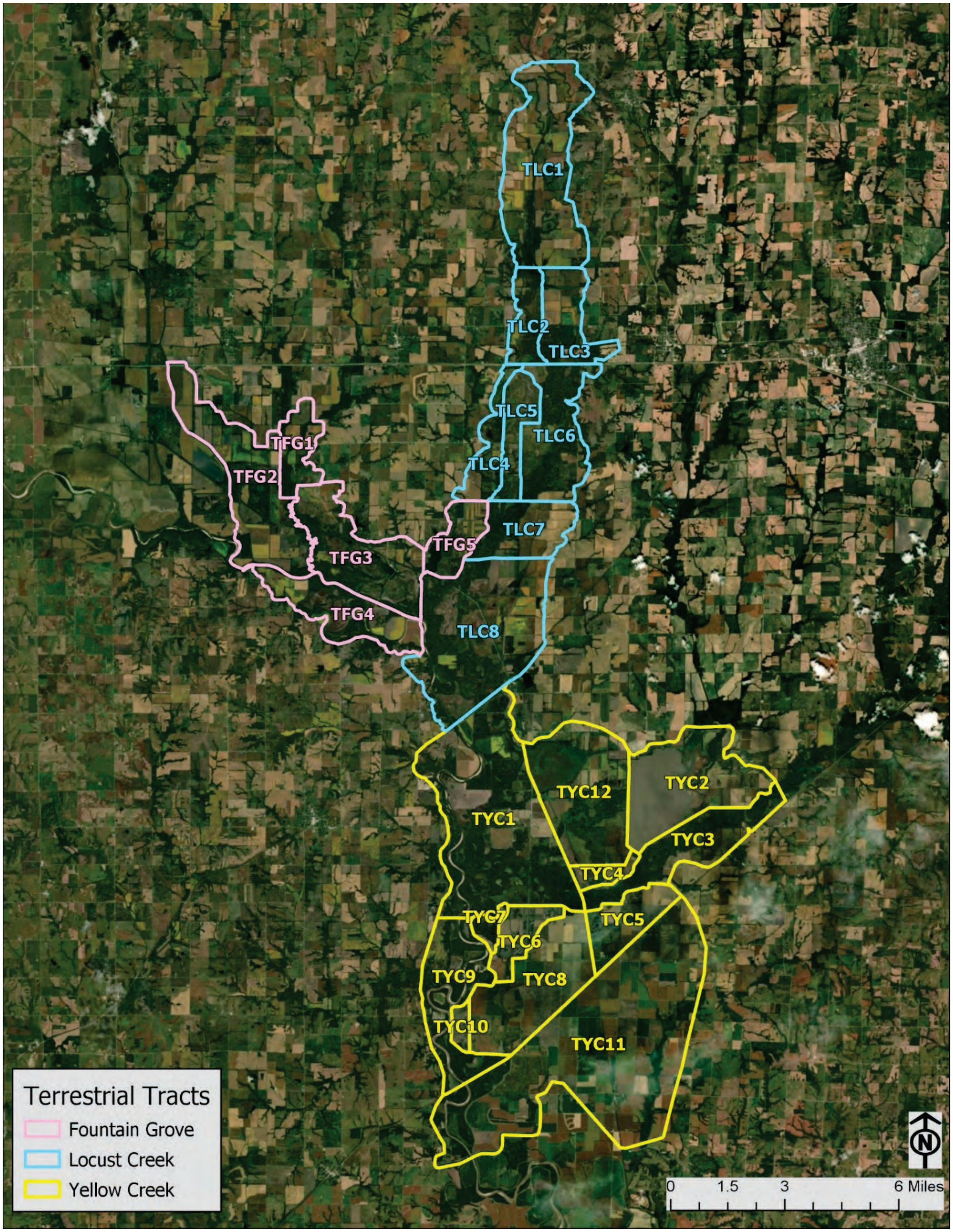

Figure 2-9. Terrestrial Habitat Tracts Delineated for the Three Focus Study Areas.

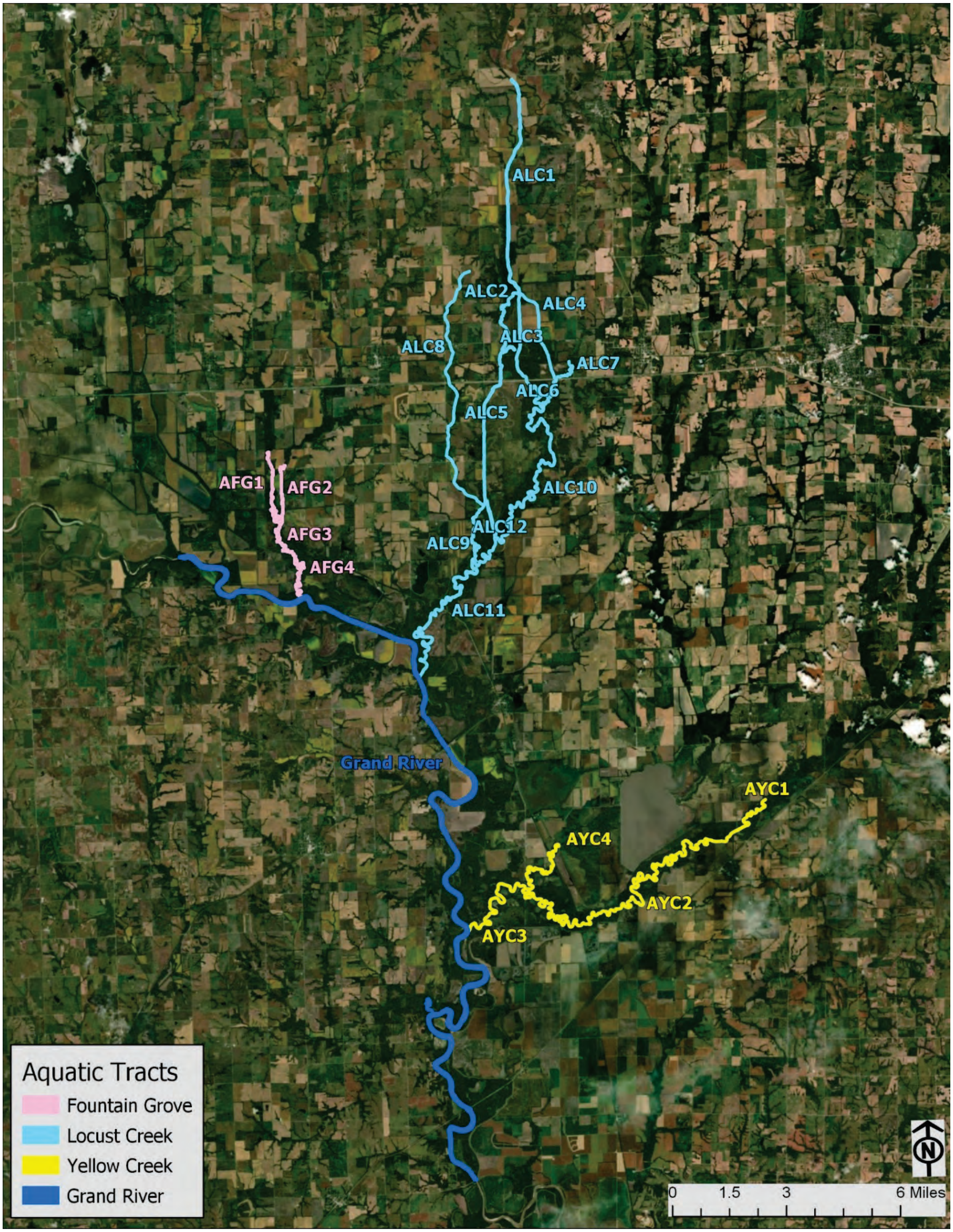

Figure 2-10. Aquatic Habitat Tracts Delineated for the Three Focus Study Areas.

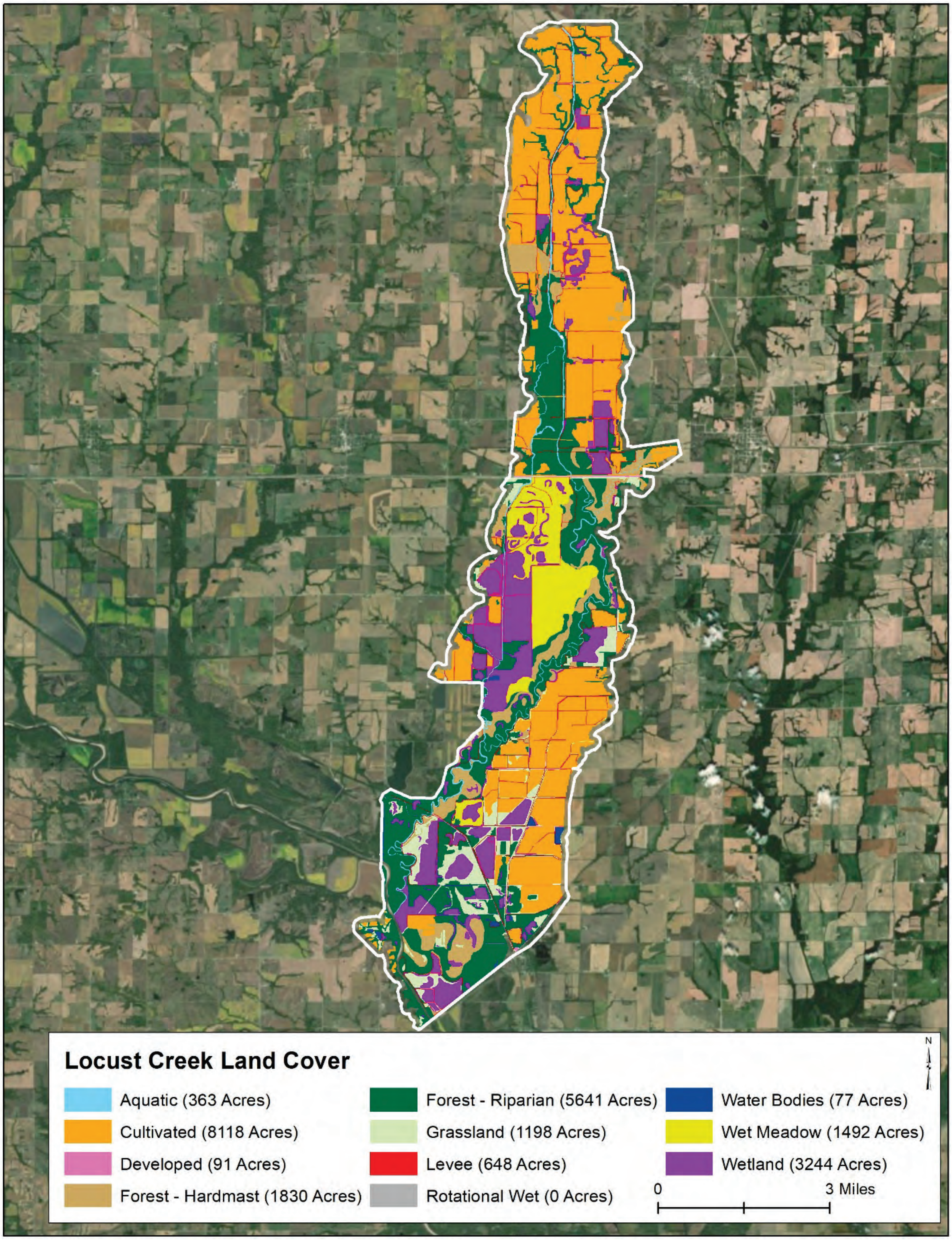

Figure 2-11. Existing Conditions for Locust Creek Terrestrial and Aquatic Tracts

Table 2-3. Existing conditions acreages within the focused study areas by terrestrial tract.

Study Area	Study Area / Tract (acres)	Cultivated	Developed / Barren	Forest (Riparian / Hardmast)	Grassland	Levee	Water Bodies	Wet Prairie	Emergent Wetland	Aquatic	TOTAL
Locust Creek	TLC1	3,739	15	402 / 626	0	172	0	0	291	77	**5,322**
Locust Creek	TLC2	245	7	11 / 767	3	12	0	0	0	67	**1,112**
Locust Creek	TLC3	1,027	7	135 / 349	3	76	2	0	0	4	**1,859**
Locust Creek	TLC4	262	4	81 / 111	67	55	0	8	433	40	**1,060**
Locust Creek	TLC5	0	0	2 / 96	1	28	10	557	733	0	**1,427**
Locust Creek	TLC6	247	18	471 /1,011	158	44	0	803	190	73	**3,014**
Locust Creek	TLC7	1,139	3	157 / 397	62	80	0	44	155	49	**2,086**
Locust Creek	TLC8	1,463	36	573 / 2,284	905	182	65	81	1,188	53	**6,830**
Locust Creek	**TOTAL**	**8,123**	**91**	**5,642 / 1,830**	**1,198**	**649**	**77**	**1,493**	**3,245**	**363**	**22,709**
Fountain Grove	TFG1	271	3	63 / 244	136	48	0	0	186	47	**998**
Fountain Grove	TFG2	2,066	17	124 / 950	892	130	59	0	363	79	**4,681**
Fountain Grove	TFG3	293	11	102 / 1,223	165	92	8	0	1,747	90	**3,730**
Fountain Grove	TFG4	850	0	417 / 605	291	75	16	0	109	104	**2,468**
Fountain Grove	TFG5	52	1	153 / 36	234	64	254	0	420	0	**1,213**
Fountain Grove	**TOTAL**	**3,533**	**32**	**858 / 3,058**	**1,718**	**409**	**337**	**0**	**2,825**	**320**	**13,090**
Yellow Creek	TYC1	1,741	56	861 / 3,867	660	117	191	148	1,219	399	**9,259**
Yellow Creek	TYC2	423	14	26 / 307	871	20	2,343	16	419	0	**4,439**
Yellow Creek	TYC3	361	6	981 / 967	136	46	0	0	275	102	**2,873**
Yellow Creek	TYC4	0	0	18 / 92	11	16	4	34	375	0	**551**
Yellow Creek	TYC5	755	20	0 / 153	156	6	0	0	662	0	**1,751**
Yellow Creek	TYC6	618	5	0 / 80	85	6	7	0	409	0	**1,208**
Yellow Creek	TYC7	20	0	26 / 232	34	6	16	0	47	0	**382**
Yellow Creek	TYC8	3,716	46	0 / 172	304	6	64	0	165	0	**4,472**
Yellow Creek	TYC9	229	14	24 / 1,830	363	21	48	0	249	369	**3,148**
Yellow Creek	TYC10	307	0	0 / 13	14	5	0	0	8	0	**346**
Yellow Creek	TYC11	10,065	300	378 / 1,510	476	15	13	0	709	110	**13,577**
Yellow Creek	TYC12	820	17	0 / 721	315	64	49	0	2,948	6	**4,940**
Yellow Creek	**TOTAL**	**19,054**	**479**	**2,315 / 9,943**	**3,424**	**328**	**2,735**	**197**	**7,484**	**986**	**46,946**

Note: Fountain Grove emergent wetland acres include permanent and rotational wetland cells.

2.3 Fountain Grove

The Fountain Grove Study Area includes Fountain Grove CA, as well as substantial acreage of private lands enrolled in NRCS conservation easement programs, and existing private lands. Fountain Grove CA is in Linn and Livingston counties, approximately 5 miles south of HWY 36 on Route W. The area includes 7,959 acres of wetlands, forest, woodland, old fields, grasslands, open land, streams, ponds, and lakes. The initial purchase by MDC was 3,433 acres in 1947-1948, using Pittman-Robertson Wildlife Restoration funds to provide habitat for migratory waterfowl and duck hunting opportunities for the public. Since the initial purchase, there have been three additions to Fountain Grove CA. From 1948-1975, 2,405 acres were purchased using general MDC revenue (license sales) to enhance wetland habitats and to provide opportunity for management of Canada geese migrating from west of Hudson Bay known as the Eastern Prairie Population. From 1978-1992, 1,315 acres were purchased using general MDC revenue (including Design and Conservation sales tax) to carry out planned wetland development on East Fountain Grove CA and acquire key inholdings to enhance additional Eastern Prairie Population Canada goose management. In 2015, 752 acres were purchased using general MDC revenue for additional floodplain expansion and wetland and upland species management.

Fountain Grove CA was the first waterfowl area developed by MDC. Following the initial purchase, 2,000 acres were developed into three wetland pools (Pools 1, 2, and 3) (Figure 2-12). These three wetland pools were filled by rainfall until 1960 when a diesel-powered pump was installed on the Grand River to provide a reliable water supply for wetland management. In 1963, wetland objectives were shifted from duck management to Canada goose management. This shift in focus was due to a declining duck population throughout the flyway and the establishment of a major wintering population of Eastern Prairie Population Canada geese on Fountain Grove CA and Swan Lake NWR. The primary goal during this time was to provide Canada goose habitat. During 1962-1976, Fountain Grove CA emphasized land acquisition and intensifying the permittee farming program to meet the Canada goose food requirements associated with the growing goose population. At the end of 1976, Fountain Grove CA was 6,200 acres. In 1983, Fountain Grove CA was the first wildlife area in Missouri to develop an area plan. The plan established a broader and multi-disciplined management style that focused on the importance of wetland diversity. During this time, Fountain Grove CA was reclassified as a wetland area, instead of a waterfowl area. The management emphasis was to identify and provide quality wetland habitat for migratory and resident wildlife resources as well as providing wetland recreational opportunities to the public. During this time, Canada goose management objectives were maintained, and wetland development priorities were made, such as the East Fountain Grove CA development to provide an additional 1,100 acres of wetland units, West Fountain Grove CA development to provide an additional 570 acres of wetland units, and improvements in the existing wetlands to increase management capabilities of nearly 2,100 acres.

From 1984-1988 there was a dramatic change in Canada goose distribution and composition on Fountain Grove CA, Swan Lake NWR, and the Swan Lake zone. These changes included delayed migrations, declining numbers of Canada geese on Fountain Grove CA/Swan Lake NWR, and greater winter dispersal throughout Missouri. Population composition shifted from Eastern Prairie Population Canada geese, which predominated up to this time to more Giant Canada geese (resident and migrants) and Richardson Canada geese (Tall Grass Prairie Population). The East Fountain Grove CA development was completed in late 1989. This added 1,300 acres of diverse, manageable wetlands and Che-Ru Lake. Che-Ru Lake's main function is to serve as a water supply to flood the wetland units in the East Fountaing Grove CA complex. At that time, the East Fountain Grove CA complex consisted of eight unique wetland units comprised of emergent marsh, moist soil, food plots, and agricultural fields. Che-Ru Lake opened for fishing in the spring of 1990.

Currently at Fountain Grove CA, the East Fountain Grove CA complex is managed for a wide range of wetland-dependent wildlife by using a variety of moist soil management techniques and planting small- and large-grain crops, where feasible. East Fountain Grove CA has some flood protection and generally is paramount in providing predictable resources on an annual basis for many species of migratory wildlife.

Management in Pools 1, 2, and 3, and the Parsons Creek complex on West Fountain Grove CA consists of bottomland forest, moist soil, shrub-scrub and emergent marsh. These habitats provide a broad range of wetland-dependent species, including waterfowl, secretive marsh birds, shorebirds, fish, and wetland mammals.

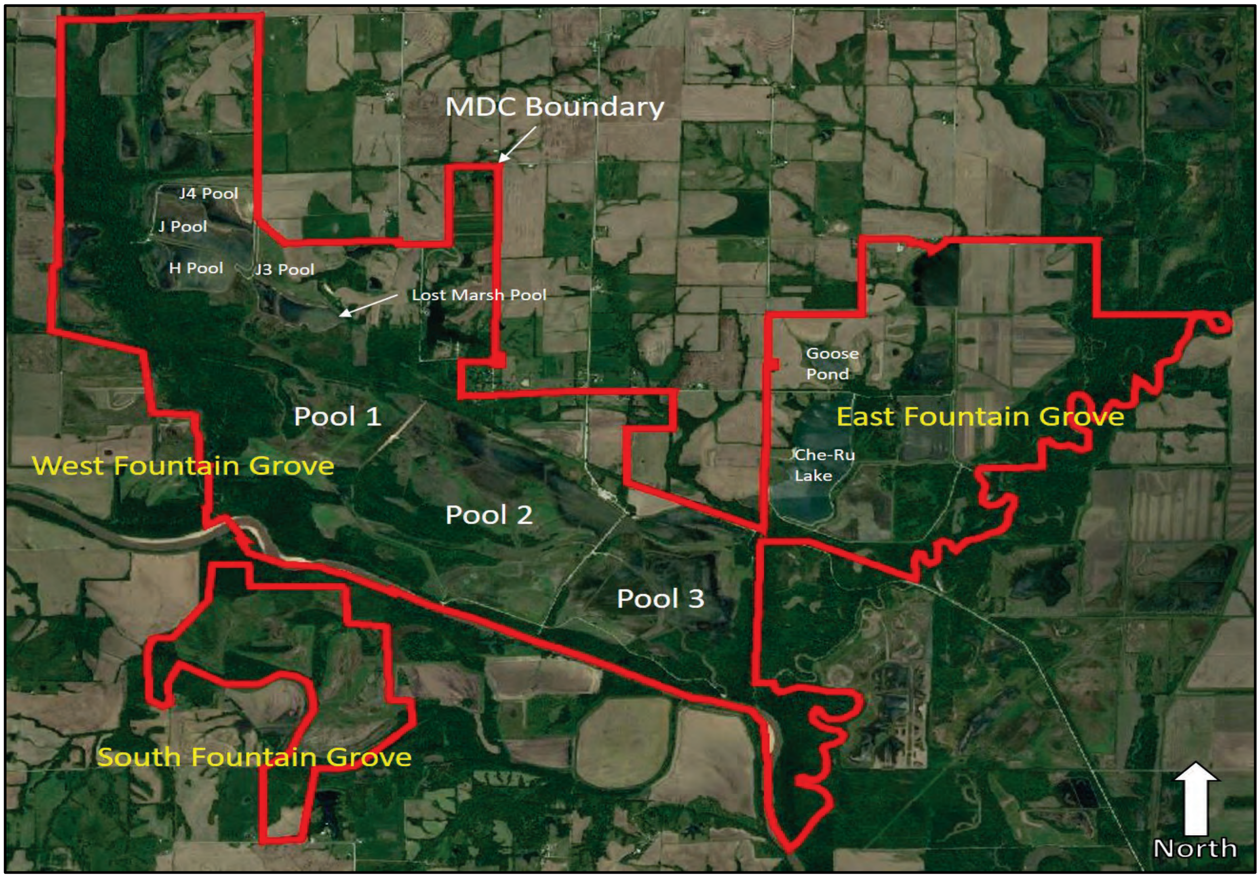

Figure 2-12. Fountain Grove Conservation Area.

2.3.1 Hydrology, Hydraulics, and Sedimentation

Parsons Creek is a Grand River tributary located west of Fountain Grove CA. The entire watershed drains approximately 102 square miles and frequently experiences backwater effects as a result of Grand River flooding. Little Parsons Creek is a Parsons Creek tributary draining approximately 13 square miles. At the Parsons Creek and Little Parsons Creek confluence, Parsons Creek drains approximately 85 square miles. The Parsons Creek and Little Parsons Creek confluence is located just upstream of Fountain Grove CA where the west floodplain contains several agricultural levees. Additionally, the Parsons Creek channel near the Grand River conveys approximately 500 cfs within bank. As a result, the majority of Parsons Creek and Little Parsons Creek flows travel through the Fountain Grove CA where the floodwaters are primarily drained through Fountain Grove CA outlet structures. The outlet structures are limited by Grand River stages. Flow-load rating curves for the Grand River near Fountain Grove CA and for Hickory Branch were developed from suspended sediment measurements (Figure 2-13).

Hickory Branch is a Locust Creek tributary and drains an area of approximately 9.6 square miles west of Locust Creek. The Locust Creek – Hickory Branch confluence is located east of Fountain Grove CA. Higgins Ditch meets Hickory Branch north of Belt Road and east of Crow Drive south of HWY 36.

Fountain Grove CA is heavily managed with a system of levees and water control structures to maximize moist-soil wetlands, bottomland hardwood forests, as well as oxbows and sloughs. Currently, the site lacks the ability to fill or drain the main pools independently. Pools are filled or drained using gravity. The existing water control infrastructure is undersized to effectively move water off the site, which leads to increased flooding durations and sediment deposition. This results in a loss of habitat and micro-topography. The site has also seen an increase in sediment coming from the Parsons Creek and Little Parsons Creek watershed. The recent evolution of the Hickory Branch and Locust Creek system has led to additional erosion to the East Fountain Grove CA levee and is compromising the future ability for that levee to limit habitat impacts from flooding and massive sedimentation. The existing pool configuration does not make provisions for allowing controlled backwater flow into the area to reduce infrastructure damage during large flood events. The East Fountaing Grove CA complex is currently configured in a grid formation with a multitude of small cross levees, dotted with water control structures. This layout is typical of the state of practice for wetland creation when Fountain Grove CA was created. East Fountain Grove CA is managed by integrating farming practices as a periodic soil disturbance tool along with seasonal water level manipulation. The farming lease specifies that part of the agricultural crop is to be left for the incoming fall migratory waterfowl. Because the levee reduces flooding this area provides excellent habitat when most of the surrounding area is under water. It has not endured damaging sedimentation and continues to provide excellent conditions for many migratory and local species dependent upon a healthy floodplain. The portion of Fountain Grove on the southern side of the Grand River has been limited in providing reliable and high-quality wetland resources because of the disconnect with the river and variance in soils. Although the current shallow pools may be temporarily flooded in the spring or summer, this is driven solely by opportunistic flooding from precipitation or large backwater flood events. The units in this portion of the site are designed to be shallow and have slightly lighter soils and therefore dry up prior to the arrival of fall migratory birds, leading to less available habitat.

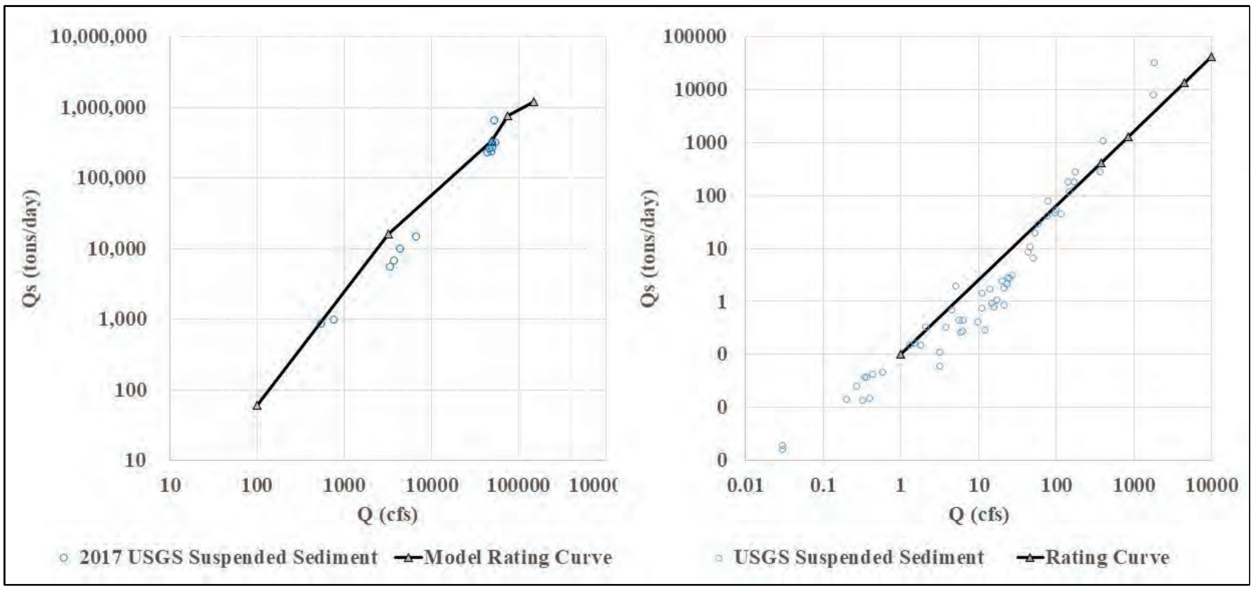

Figure 2-13. Model Rating Curve for Grand River at Fountain Grove and Hickory Branch. *Fountain Grove is shown on left, and Hickory Branch on the right.*

2.3.2 Habitat

The following list identifies the terrestrial and aquatic habitat tracts for the Fountain Grove Study Area. Existing land use/cover for the area is displayed in Figures 2-14 and acreages are shown in Table 2-3.

Terrestrial Fountain Grove (TFG) Tracts:

- TFG1 – Parsons / Little Parsons Creek Area
- TFG2 – West side of Parsons Creek Area

- TFG3 – West side Fountain Grove CA
- TFG4 – South side Fountain Grove CA
- TFG5 – East side Fountain Grove CA

Aquatic Fountain Grove (AFG) Tracts:

- AFG1 – Little Parsons Creek to Parsons Creek
- AFG2 – Parsons Creek to Little Parsons Creek
- AFG3 – Middle Parsons Creek
- AFG4 – Lower Parsons Creek to Grand River

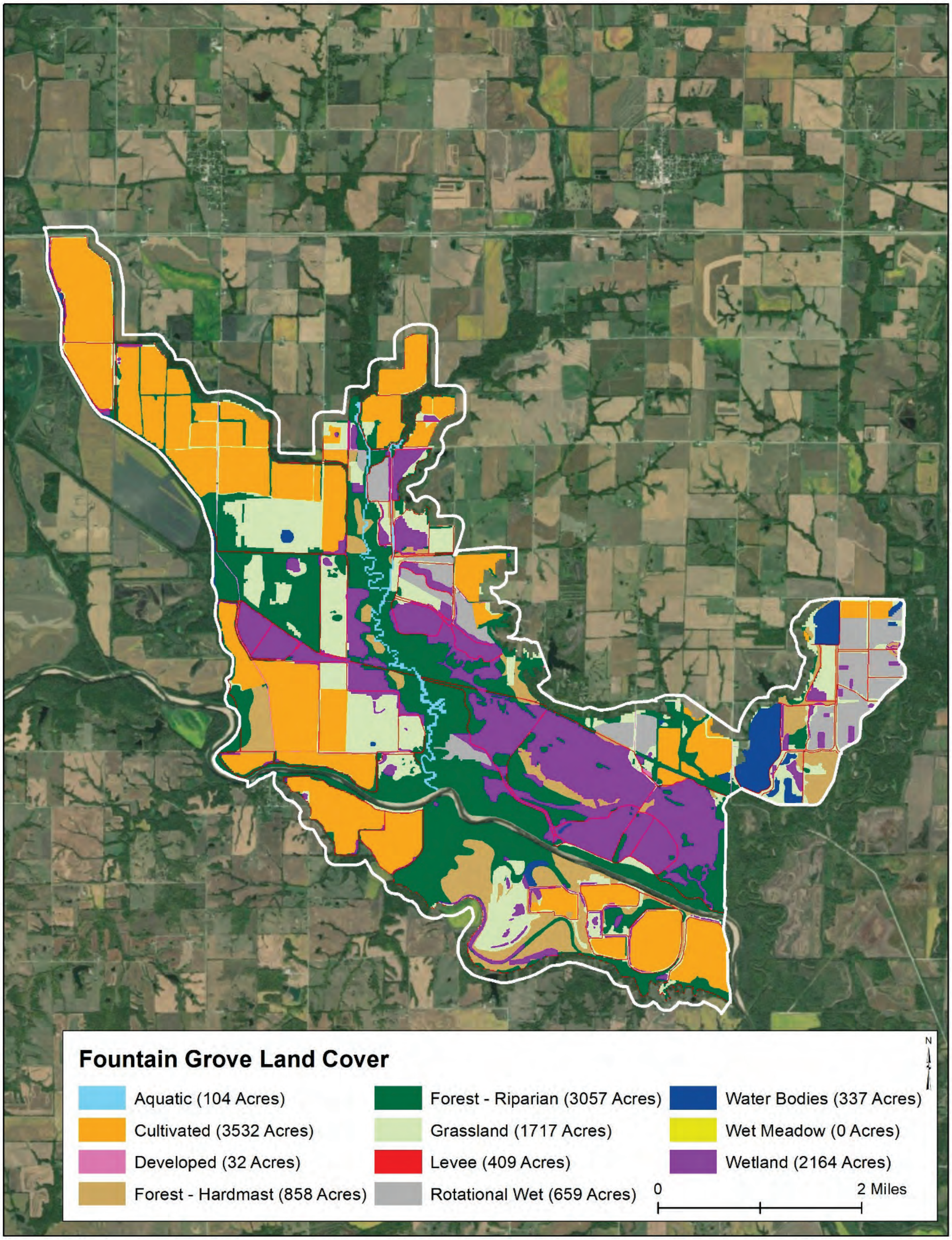

Figure 2-14. Existing Conditions Fountain Grove Terrestrial and Aquatic Tracts.

2.4 Yellow Creek

Yellow Creek CA is in Chariton County, approximately 5.5 miles south of Sumner, MO. Yellow Creek CA includes 618 acres (474 acres is designated a Natural Area) of predominantly bottomland forest and several small oxbows and slough meanders. The eastern boundary of Yellow Creek CA is shared with Swan Lake NWR. This area provides a vital riparian buffer for Yellow Creek, Elk Creek, and backwater Grand River flows. Yellow Creek CA was purchased in 1988 in order to protect the wet mesic bottomland forest and the un-channelized portion of Yellow Creek. This tract of bottomland forest is the largest block of bottomland hardwood forest remaining in northwest Missouri. Many species of neo-tropical warblers rely on this tract for migratory and nesting habitat. This area is beneficial for prothonotary warblers, wood ducks, hooded mergansers, and other migratory wildlife.

Swan Lake NWR is in Chariton County, Missouri (Figure 2-15). The Refuge is in close proximity to the towns of Mendon and Sumner, Missouri. The confluence of the Grand River and Yellow Creek lies just southwest of the Refuge boundary, 27 miles upstream of where the Grand River meets the Missouri River. Swan Lake NWR encompasses over 11,000 acres of the Grand River floodplain in north central Missouri. This area is a combination of bottomland forest, prairie, and wetlands. Over 7,000 acres of wetland habitat can be found on the refuge. Swan Lake NWR was established by President Franklin D. Roosevelt through Executive Order in 1937. In 1938, work was done to create a system of levees to impound the waters of Turkey Creek, Elk Creek, and Tough Branch Creek creating what are today known as Silver Lake and Swan Lake Marsh along with numerous other wetland habitats. Silver Lake, which serves as the Refuge’s main supply of water for wetland management is the larger of the two at 2,387 acres. Swan Lake Marsh is the smaller of the two, at 918 acres. Swan Lake NWR also includes the 1,000-acre Yellow Creek Research Natural Area, located along the southern border. This area was established in 1973 as part of a nation-wide network of reserved areas under ownership of various federal agencies. The purpose of this area is to let natural processes dominate without any human intervention, to preserve a wide variety of North American ecosystems and habitats.

2.4.1 Hydrology, Hydraulics, and Sedimentation

Yellow Creek is a Grand River tributary located south of Sumner, MO near Yellow Creek CA and Swan Lake NWR. The channel is fairly sinuous downstream of Rothville, MO and drains approximately 560 square miles from the confluence with the Grand River. West of the Chillicothe and Brunswick Railroad, Yellow Creek is confined by levees including Swan Lake NWR exterior levees and Garden of Eden Section 1. East of the railroad, Yellow Creek is open to the floodplain but is often impacted by Grand River flows.

No rating curves were developed for Yellow Creek; however, the area is experiencing similar impacts as described previously for Locust Creek and Fountain Grove including degradation of bottomland hardwood forest. USFWS (2011) states the average volume of Silver Lake has decreased by about 25 percent from 1983 to the publication of that report, which was attributed to the accumulation of sediments carried by Turkey Creek and Elk Creek.

2.4.2 Habitat

The following list identifies the terrestrial and aquatic habitat tracts for the Yellow Creek focused study area. Existing land use/cover for the area is displayed in Figures 2-16 and acreages are shown in Table 2-3.

Terrestrial Yellow Creek (TYC) Tracts:

- TYC1 – Northwest Area along Grand River
- TYC2 – Silver Lake Area
- TYC3 – Northeast Yellow Creek Area

- TYC4 – Levee / Railroad Setback Area below Swan Lake
- TYC5 – South side of Yellow Creek below Swan / Silver Lake
- TYC6 – Large Levee Setback Area
- TYC7 – Small Levee Setback Area
- TYC8 – Area below Levee Setbacks and North of Railroad
- TYC9 – Area West of Levee Setbacks along Grand River
- TYC10 – Small Levee Setback Area 2
- TYC11 – Area below Levee Setbacks and South of Railroad
- TYC12 – Swan Lake Area

Aquatic Yellow Creek (AYC) Tracts:

- AYC1 – Upper Yellow Creek
- AYC2 – Middle Yellow Creek
- AYC3 – Lower Yellow Creek
- AYC4 – Elk CreekA

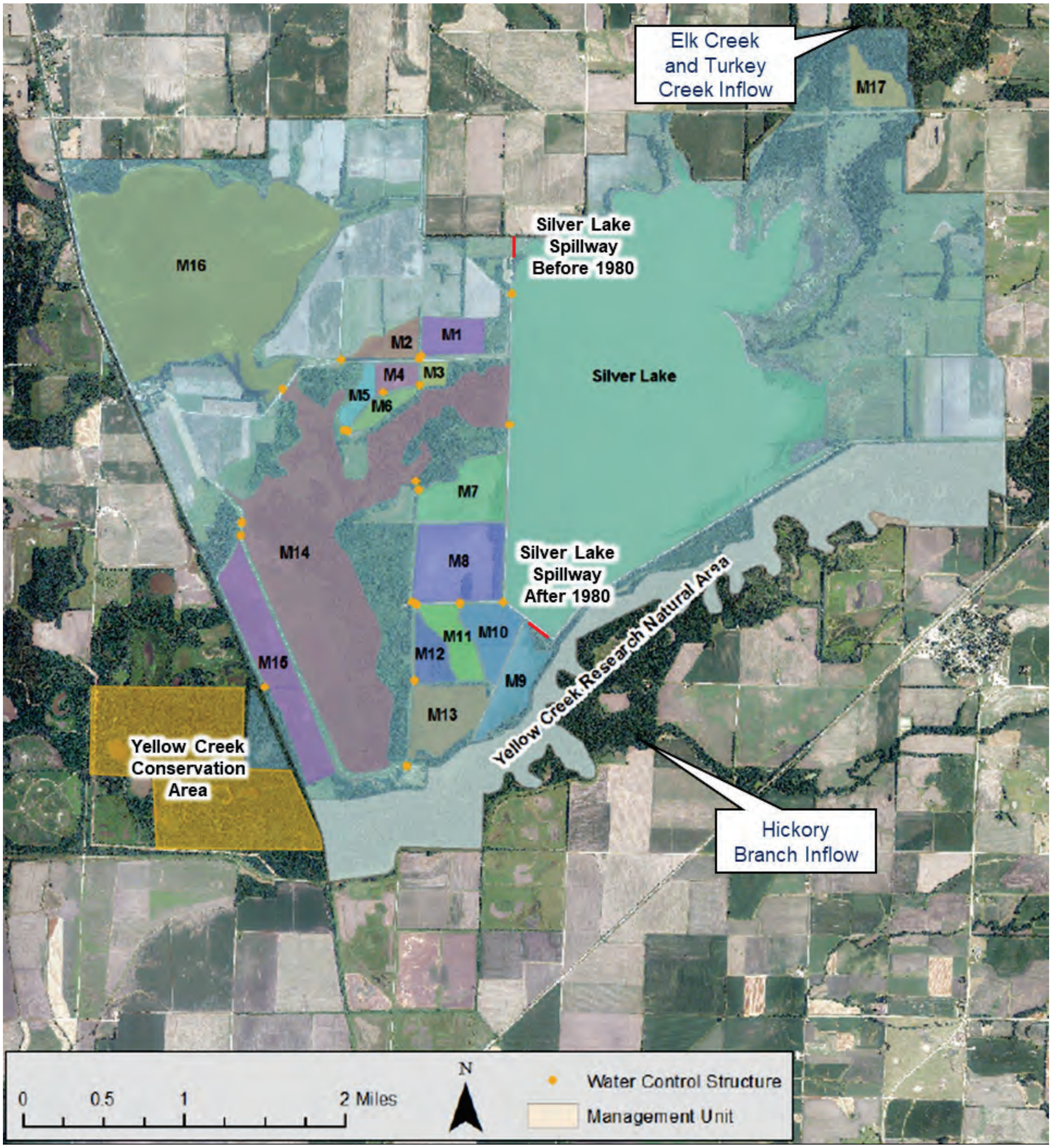

Figure 2-15. Swan Lake National Wildlife Refuge Management Units *(Adapted from USFWS 2016).*

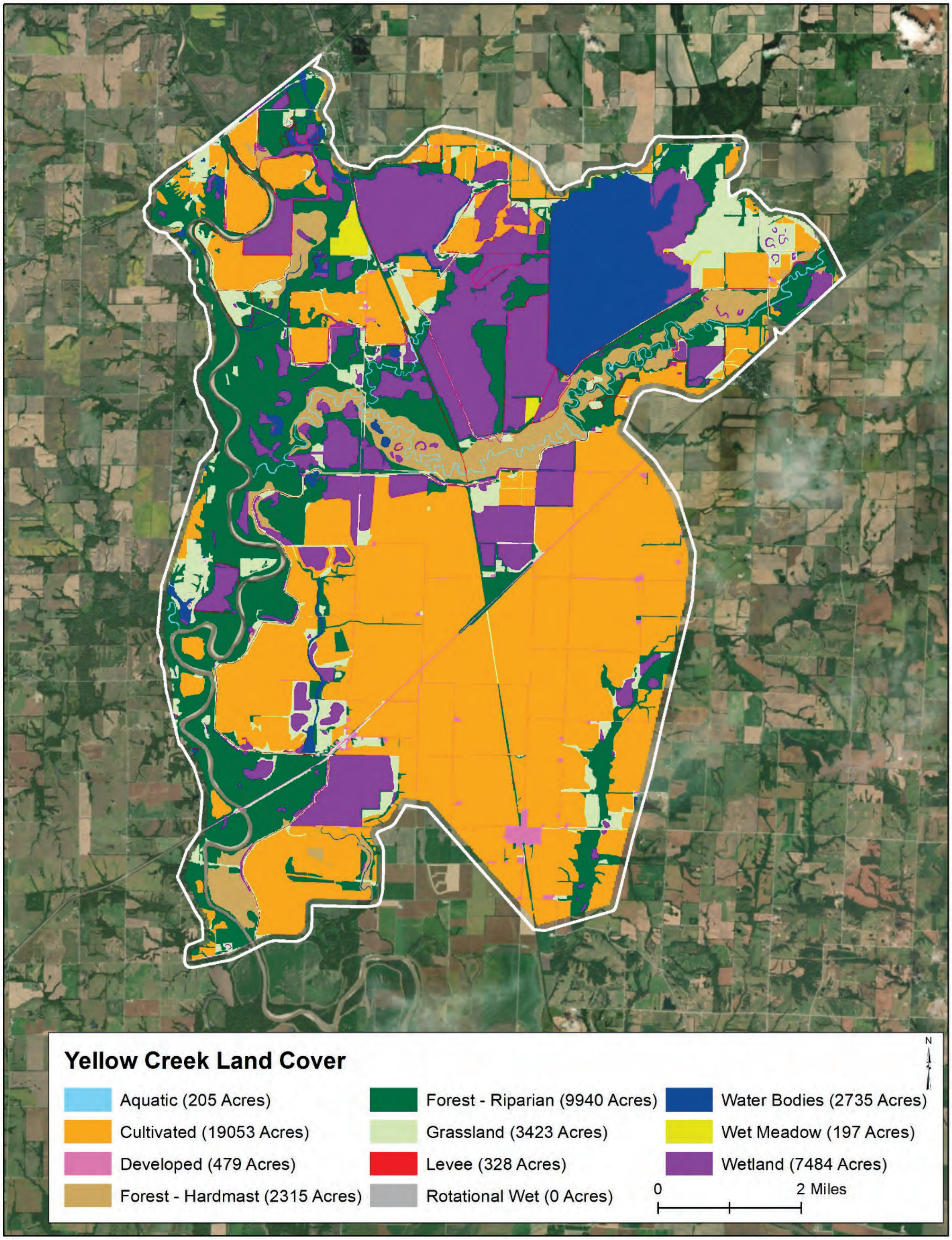

Figure 2-16. Existing Conditions for Yellow Creek Terrestrial Habitat Tracts.

2.5 Affected Environment

In addition to the three primary focus areas described, this section describes other environmental resources within the study area with a potential to be affected by the alternatives.

2.5.1 Air Quality

Emissions from construction activities under the proposed action would affect air quality in the immediate study area. Air quality is defined by ambient air concentrations of specific pollutants that the EPA has determined to be of concern for the health and welfare of the general public and the environment. The primary pollutants of concern, called criteria pollutants, include carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, suspended particulate matter less than or equal to 10 microns in diameter, fine particulate matter less than or equal to 2.5 microns in diameter, and lead. Under the CAA, the EPA has established National Ambient Air Quality Standards (NAAQS) (40 CFR §50) for these pollutants. Areas that are and historically have been in compliance with the NAAQS are designated as attainment areas. Areas that violate a federal air quality standard are designated as nonattainment areas. Areas that have transitioned from nonattainment to attainment are designated as maintenance areas and are required to adhere to maintenance plans to ensure continued attainment. The NAAQS represent the maximum levels of background pollution that are considered safe, including an adequate margin of safety, to protect public health and welfare. Short-term standards (1-, 3-, 8-, and 24-hour periods) are established for pollutants contributing to chronic health effects. The study area is in attainment for all NAAQS criteria pollutants.

Emissions associated with the alternatives would be short-term, occurring during construction activities. No permanent new sources of emissions including greenhouse gasses that would contribute to climate change are associated with the alternatives. Because the study area is currently in attainment and it is not anticipated that any alternatives would result in exceedance of the NAAQS, air quality was dismissed from detailed evaluation in Chapter 5.

2.5.2 Water Quality

Section 305(b) of the Clean Water Act (CWA) requires each state to develop a water quality monitoring program and periodically report the status of its water quality. Water quality status is described in terms of the suitability of the water for its “designated uses” (e.g. drinking water, fishing, swimming, aquatic life). Section 303(d) of the CWA requires identification of “impaired waters” (i.e. those that do not meet applicable water quality standards) and Total Maximum Daily Loads (TMDLs) be determined for these waters. TMDLs establish the maximum amount of a contaminant that a water body can assimilate and still meet the water quality standards.

Several streams within the Lower Grand River watershed are impaired or have TMDLs. The whole body contact recreation use is impaired for the Grand River, Locust Creek, Medicine Creek, and Little Medicine Creek due to Escherichia coli (E. coli) attributed to rural non-point source pollution (MoDNR 2018a). The Grand River is designated Category A for whole body contact recreation use, which means it has swimming areas which are open to and fully accessible by the public (MoDNR 2010a). Locust Creek, Medicine Creek, and Little Medicine Creek are designated Category B for whole body contact recreation use, meaning the streams have places deep enough for total immersion (i.e. swimming), but may be on private lands or inaccessible to the public (MoDNR 2010b). In addition, the East Fork Locust Creek whole body contact recreation and aquatic life uses are impaired for E. coli and dissolved oxygen, respectively.

West Fork Locust Creek has a TMDL that addresses total suspended solids, total nitrogen, and total phosphorus, which had been present at elevated levels (EPA 2010). East Fork Medicine Creek has a TMDL for sediment (EPA 2006). Recently, a TMDL for Medicine Creek and Little Medicine Creek covering pathogens was submitted to the EPA for approval (MoDNR 2019).

2.5.3 Fish and Wildlife Resources

The wide variety of habitat types present in the study area including rivers/streams, floodplain lakes, wetlands, prairie, woodland, and forest communities allow for a diversity of fish and wildlife species. The area supports resident, seasonal, and migratory populations. This section describes the main groups of fish and wildlife occurring within the study area.

2.5.3.1 Amphibians and Reptiles

A variety of salamanders, toads, turtles, lizards, frogs, and snakes inhabit the study area. Amphibians are associated with permanent, seasonal, and ephemeral wetlands within the study area. Heitmeyer et al (2011) identified 15 amphibian species common in the Lower Grand River sub-basin. Mengel (2010) documented ten amphibian species during sampling of 50 NRCS sites within the Lower Grand River sub-basin. Leopard frogs, northern cricket frogs (*Acris crepitans*), and American bullfrog (*Lithobates catesbeianus*) were the most common species sampled. Central newts (*Notophthalmus viridescens*), considered rare and unlikely to occur in the area, were documented in the area. Heitmeyer et al (2011) listed seven turtles and 25 snakes and lizards common in the Lower Grand River sub-basin. Most notable are populations of the state-listed endangered western massasauga rattlesnake known to occur at Pershing State Park and Swan Lake NWR.

2.5.3.2 Birds

The Lower Grand River sub-basin is in the heart of what is known as the “Golden Triangle” of Missouri because of the presence and importance of the area to migratory waterfowl and other bird species. It lies near the border of the Central and Mississippi waterfowl flyways. The wetlands and associated uplands in the study area provide vital habitat for migrating waterfowl, shorebirds, and many other wetland dependent species. The study area has been designated an Important Bird Area by the Audubon Society for its importance as a migration stopover site and breeding site for wetland birds. The area provides grassland bird habitat and riparian woodlands for arboreal (i.e. tree) nesting species including bald eagle (*Haliaeetus leucocephalus*), rookeries of great blue herons (*Ardea herodias*), red-headed woodpecker (*Melanerpes erythrocephalus*), Acadian flycatcher (*Empidonax virescens*), prothonotary warbler (*Protonotaria citrea*), and wood thrush (*Hylocichla mustelina*). American bitterns (*Botaurus lentiginosus*) are common during migration and least bitterns (*Ixobrychus exilis*) have been observed to nest in the area. Pied-billed grebes (*Podilymbus podiceps*) and red-shouldered hawks (*Buteo lineatus*) also nest in the area including on the Swan Lake NWR. Additional wetland birds observed include common moorhen (*Gallinula chloropus*), dispersing individuals of interior least tern (*Sterna antillarum*), marsh wren (*Cistothorus palustris*), and sora rail (*Porzana carolina*). During migration and winter, the area regularly supports large concentrations of waterfowl, and substantial numbers and diversity of shorebird species.

Other breeding species in the area include Bell’s vireo (*Vireo bellii*), black-billed cuckoo (*Coccyzus erythropthalmus*), black-crowned night-heron (*Nycticorax nycticorax*), blue-winged warbler (*Vermivora cyanoptera*), cerulean warbler (*Setophaga cerulean*), dickcissel (*Spiza Americana*), field sparrow (*Spizella pusilla*), Henslow’s sparrow (*Ammodramus henslowii*), Kentucky warbler (*Oporornis formosus*), peregrine falcon (*Falco peregrinus*), Swainson’s hawk (*Buteo swainsoni*), upland sandpiper (*Bartramia longicauda*), willow flycatcher (*Empidonax traillii*), and worm eating warbler (*Helmitheros vermivorum*). Wintering species include fox sparrow (*Passerella iliaca*), rusty blackbird (*Euphagus carolinus*), and short-eared owl (*Asio flammeus*). Year-round species include loggerhead shrike (*Lanius ludovicianus*) and northern flicker (*Colaptes auratus*).

2.5.3.3 Mammals

White-tailed deer (*Odocoileus virginianus*) are common in the study area and popular for hunting. Other common medium-sized mammals using the study area include opossum (*Didelphis virginiana*), eastern cottontail rabbit (*Sylvilagus floridanus*), beaver (*Castor canadensis*), woodchuck (*Marmota momax*), muskrat (*Ondatra zibethicus*), fox squirrel (*Sciurus niger*), eastern gray squirrel (*Sciurus carolinensis*), southern flying squirrel (*Glaucomys volans*), coyote (*Canis latrans*), river otter (*Lontra canadensis*), bobcat *(Lynx rufus*), striped skunk (*Mephitis mephitis*), mink (*Mustela vison*), racoon (*Procyon lotor*), badger (*Taxidea taxus*), gray fox (*Urocyon cinereoargenteus*), and red fox (*Vulpes vulpes*). Small mammals present in the area include Elliot's short-tailed shrew (*Blarina hylophaga*), eastern mole (*Scalopus aquaticus*), prairie vole (*Microtus ochrogaster*), woodland vole (*Microtus pinetorum*), deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), and southern bog lemming (*Synaptomys cooperi*). Nine bat species are known to occur in the study area including three federally listed species that are discussed further in Section 2.8.

2.5.3.4 Fish and Mussels

Sixty-one fish species including 55 native species have been documented in the Grand River watershed (Galat et al. 2005). Major fishes in the watershed include shortnose gar (*Lepisosteus platostomus*), bigmouth shiner (*Notropis dorsalis*), red shiner (*Cyprinella lutrensis*), creek chub (*Semotilus atromaculatus*), sand shiner (*Notropis stramineus*), central stoneroller (*Campostoma anomalum*), fathead minnow (*Pimephales promelas*), bluntnose minnow (*Pimephales notatus*), common carp (*Cyprinus carpio*), river carpsucker (*Carpiodes carpio*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and Johnny darter (*Etheostoma nigrum*). The fish community in Locust Creek is typical of a prairie fish community dominated by cyprinids (i.e. the minnow family) that can tolerate widely fluctuating environmental conditions (MDC 1994). Thirty-seven fish species have been documented in the Locust Creek basin (MDC 1994). Notable species that have been collected include stonecat (*Noturus flavus*) and trout-perch (*Percopsis omiscomaycus*), species typically intolerant of degraded water quality. The Locust Creek fish community is characterized by an abundance of tolerant and omnivorous fishes, resulting from the extensive degradation of fish habitat in the Locust Creek basin (MDC 1994). The fish community composition and distribution within the Locust Creek basin is influenced by stream channelization. The sampled sites with highest overall fish community diversity and highest sunfish diversity were in unchannelized stream reaches (MDC 1994). Fish samples from Pershing State Park were regionally outstanding in species richness compared to other streams in the basin including channelized reaches of Locust Creek (Winston et al 1998). A 2007 fisheries survey of Silver Lake at Swan Lake NWR found 15 species including white crappie (*Pomoxis annularis*), freshwater drum (*Aplodinotus grunniens*), flathead catfish, and shortnose gar. Flood events dramatically affect the number and composition of the Silver Lake fishery (USFWS 2011).

Past mussel surveys of Locust Creek have documented between 10 and 12 species (Cotton 2012, Winston et al 1998) including the flat floater (*Anodonta suborbiculat*a), a state imperiled species. Densities of live and fresh-dead mussels were up to 10 times higher in the lower section of Pershing State Park compared to the upper section of the park and the channelized reaches above the park (Winston et al 1998). Eleven mussel species have been documented at Swan Lake NWR, including the flat floater (USFWS 2011).

2.5.3.5 State-Listed Species and Species of Concern

The Missouri Natural Heritage Database identifies 55 species within Linn, Livingston, and Chariton counties Missouri, the location of the focused study area, that are ranked by the state as critically imperiled, imperiled, vulnerable, or state-listed endangered (Table 2-4). The list includes the bald eagle, which is also protected under the Bald and Golden Eagle Protection Act. Bald eagles are commonly found in fall and winter in the study area and occasionally occur year-round. Approximately 60 percent of the state species of concern in Table 2-2 have been documented in the study area.

Table 2-4. State-Listed Species and Species of Concern Potentially in Focused Study Area.

Common Name	Scientific Name	State Rank	State Status	Federal Status
American Badger	*Taxidea taxus*	Vulnerable		
American Bittern	*Botaurus lentiginosus*	Critically imperiled	Endangered	
An Umbrella Sedge	*Cyperus flavicomus*	Critically imperiled		
Auriculate False Foxglove	Agalinis auriculata	Vulnerable		
Austin Springfly	*Hydroperla fugitans*	Vulnerable		
Bald Eagle	*Haliaeetus leucocephalus*	Vulnerable		
Barn Owl	Tyto alba	Vulnerable		
Bellow Beaked Sedge	Carex albicans var. australis	Critically imperiled		
Brassy Minnow	*Hybognathus hankinsoni*	Vulnerable		
Cerulean Warbler	*Setophaga cerulea*	Imperiled		
Chestnut-sided Warbler	*Setophaga pensylvanica*	Unrankable		
Common Gallinule	*Gallinula galeata*	Imperiled		
Dwarf Chinquapin Oak	*Quercus prinoides*	Vulnerable		
Eastern Tiger Salamander	*Ambystoma tigrinum*	Vulnerable		
Flat Floater	*Utterbackiana suborbiculata*	Imperiled		
Flathead Chub	*Platygobio gracilis*	Critically imperiled	Endangered	
Franklin's Ground Squirrel	*Poliocitellus franklinii*	Imperiled		
Ghost Shiner	*Notropis buchanani*	Imperiled		
Giant Stone	*Attaneuria ruralis*	Vulnerable		
Gray Myotis	*Myotis grisescens*	Vulnerable	Endangered	Endangered
Great Egret	*Ardea alba*	Vulnerable		
Grizzly Grasshopper	*Melanoplus punctulatus griseus*	Unrankable		
Indiana Myotis	*Myotis sodalis*	Critically imperiled	Endangered	Endangered
Interior Least Tern	*Sterna antillarum athalassos*	Critically imperiled	Endangered	Endangered
Lake Sturgeon	*Acipenser fulvescens*	Critically imperiled	Endangered	
Least Bittern	*Ixobrychus exilis*	Vulnerable		
Least Flycatcher	*Empidonax minimus*	Unrankable		
Least Weasel	*Mustela nivalis*	Vulnerable		
Little Brown Myotis	*Myotis lucifugus*	Imperiled		
Loesel's Twayblade	*Liparis loeselii*	Imperiled		
Long-eared Owl	Asio otus	Unrankable		
Long-tailed Weasel	*Mustela frenata*	Vulnerable		
Marsh Wren	*Cistothorus palustris*	Vulnerable		
Meadow-sweet	*Spiraea alba var. alba*	Critically imperiled		
Northern Crawfish Frog	*Lithobates areolatus circulosus*	Vulnerable		
Northern Harrier	*Circus hudsonius*	Imperiled	Endangered	
Northern Long-eared Myotis	*Myotis septentrionalis*	Critically imperiled	Endangered	Threatened

Common Name	Scientific Name	State Rank	State Status	Federal Status
Northern Rein Orchid	*Platanthera flava var. herbiola*	Imperiled		
Ostrich Fern	*Matteuccia struthiopteris var. pensylvanica*	Imperiled		
Pallid Sturgeon	*Scaphirhynchus albus*	Critically imperiled	Endangered	Endangered
Plains Minnow	*Hybognathus placitus*	Imperiled		
Prairie Massasauga	*Sistrurus tergeminus tergeminus*	Critically imperiled	Endangered	
Regal Fritillary	*Speyeria idalia*	Vulnerable		
Rose Turtlehead	*Chelone obliqua*	Imperiled		
Slightly-musical Conehead Katydid	*Neoconocephalus exiliscanorus*	Vulnerable		
Sora	*Porzana carolina*	Imperiled		
Sturgeon Chub	*Macrhybopsis gelida*	Vulnerable		
Toad Rush	*Juncus bufonius var. bufonius*	Critically imperiled		
Tri-colored Bat	*Perimyotis subflavus*	Imperiled		
Trout-perch	*Percopsis omiscomaycus*	Critically imperiled		
Trumpeter Swan	Cygnus buccinator	Critically imperiled		
Virginia Rail	*Rallus limicola*	Imperiled		
Western Silvery Minnow	*Hybognathus argyritis*	Imperiled		
Wood Frog	*Lithobates sylvaticus*	Vulnerable		
Yellow Rail	*Coturnicops noveboracensis*	Unrankable		

2.5.4 Federally Threatened and Endangered Species

Section 7 of the Endangered Species Act (ESA) (16 USC 1531 et seq.) requires federal agencies to ensure that any actions authorized, funded, or carried out by the agency do not jeopardize the continued existence of a federally listed threatened or endangered species, or result in the destruction or adverse modification of the designated critical habitat of a federally listed species. An official species list was obtained from the USFWS Information, Planning, and Conservation system for the project. Four Federally listed species were identified with potential to occur in the study area: gray bat (*Myotis grisescens*), Indiana bat (*Myotis sodalis*), Northern long-eared bat (*Myotis septentrionalis*), and pallid sturgeon (*Scaphirhynchus albus*). These species are discussed in the following sections. No critical habitat is found in the study area.

2.5.4.1 Gray Bat

The gray bat was federally listed as endangered in 1979 due to declining populations. The range of the gray bat is geographically limited to the limestone karst areas of the southeastern United States. This species primarily occurs in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee although few gray bats also occur in northwestern Florida, western Georgia, southeastern Kansas, southern Indiana, southwestern Illinois, northeastern Oklahoma, northeastern Mississippi, western Virginia, and western North Carolina. The gray bat is identifiable by its uniform grayish-brown fur which is dark gray following their molt and then lightens to a rusty brown in the summer. This species is most easily identified and distinguished from other closely related bat species by its wings that attach to the ankle and not the base of the toes. The gray bat also has a distinct notch on the inside curve of each claw (MDC 2019b).

Gray bats occupy caves in limestone karst regions within its range during both the summer and the winter. In the winter, these bats hibernate in deep, vertical cold caves or mines that trap large volumes of cold air

(USFWS 2019a). Hibernacula for this species often have multiple entrances and maintain temperatures between 5 and 9°C (41 and 48.2°F) with a range of 1 to 4°C (33.8 to 39.2°F) being more preferable. During the summer, females roost in warmer caves ranging in temperature from 14 to 25°C (57.2 to 77°F) with proximity to water where they can forage (USFWS 2006). Gray bats mate in the fall when males and females arrive at the hibernacula. Female gray bats begin hibernating in early fall following copulation, store the sperm through the winter and become pregnant in spring after emerging from hibernation. Male gray bats remain active after the females enter hibernation until early November, when they also begin to hibernate. Females give birth to one pup in late May or early June after a 64-day gestation period and form large maternity colonies in caves with domed ceilings. Gray bats are dependent on aquatic insects, in particular mayflies, caddisflies, and stoneflies and use water features and forested riparian corridors for foraging and travel. Due to this foraging need, maternity colonies are usually within proximity to prime feeding areas near large reservoirs or rivers (USFWS 2006).

Human disturbance, habitat loss and degradation, cave commercialization, and improper gating continue to threaten the gray bat. The continued spread of white-nose syndrome also poses a threat to this species, as is the case with many bats. The gray bat is vulnerable to disturbance due to their narrow habitat requirements and high density of cave occupancy. Disturbance during hibernation reduces energy stores and disturbance during the roosting period startles mothers which could cause potential harm to the pups. Caves within the gray bat range have been flooded from reservoir creation which forces the bats out in search of another suitable cave which may be difficult. Commercialization of caves also forces bats out and alters the conditions that make it suitable habitat for gray bats (USFWS 2019a).

2.5.4.2 Northern Long-Eared Bat

The northern long-eared bat was listed as a threatened species under ESA in 2015 (80 FR 17974). This small bat species occurs across much of the eastern and north central United States, encompassing 37 states and all Canadian provinces from the Atlantic coast west to the southern Northwest Territories and eastern British Columbia. During the summer months, the northern long-eared bat roosts underneath bark or in cavities of a variety of tree species, both live and dead, and may roost individually or in colonies. Summer roosting sites may also include caves, mines, or human-made structures, such as barns, other buildings, utility poles, window shutters, and bat houses (80 FR 17974). During the winter, the northern long-eared bat inhabits large caves or mines known as hibernacula (Caceres and Pybus 1997). Foraging habitat consists of forested areas or forested edges along rivers and lakes. Northern long-eared bats feed at dusk preying on moths, leafhoppers, caddisflies, and beetles while in flight or by gleaning insects from vegetation (USFWS 2019b).

The northern long-eared bat was placed on the Endangered Species List due to severe impacts of white-nose syndrome, a fungal disease that has caused massive population declines in some portions of the species range (81 FR 1901). Other threats include habitat fragmentation, destruction, and modification from logging, oil/gas/mineral development, and wind energy development. Disturbances of hibernacula caused by recreational caving activities have also been documented as a potential threat to the northern long-eared bat (78 FR 61046). In January 2016 the USFWS published a Final 4(d) Rule which provides an exemption from incidental take restrictions for northern long-eared bats occurring in areas not yet affected by white-nose syndrome (81 FR 1901).

The study area falls within the range of the northern long-eared bat. The entire state of Missouri is within the white-nose syndrome zone per the Final 4(d) Rule. Thus, individuals in the area are subject to full protection under ESA. Some of the counties adjacent to the Missouri River in Missouri have known hibernacula infected with white-nose syndrome. Efforts to identify and record hibernacula and maternity roost trees for the northern long-eared bat are ongoing (USFWS 2019b).

2.5.4.3 Indiana Bat

The Indiana bat (*Myotis sodalis*) is listed as an endangered species under the ESA. This species was listed as in danger of extinction in 1967 and was grandfathered in under the ESA in 1973 (USFWS 2007). The range of the Indiana bat spans most of the eastern half of the United States, but the population is largely concentrated in southern Indiana. The Indiana bat is similar in size to the northern-long eared bat and has many of the same habitat requirements. However, the Indiana bat requires hibernacula with cooler temperatures than those used by the northern long-eared bat. The Indiana bat is more selective with roosting sites, showing preference for trees that are dying or dead, and has been found to select trees by size, species, and surrounding canopy cover (USFWS 2007). Like the northern long-eared bat, foraging habitat for the Indiana bat consists of forested areas or forested edges along rivers and lakes. Indiana bats feed while in flight on a variety of flying insects along rivers, lakes, and uplands. This species consumes up to half of its body weight in insects daily (USFWS 2019c).

Hibernating population estimates for the Indiana bat in Missouri show a downward trend from an estimated 399,000 in 1965 to 65,104 in 2005. As of 2006, 20 Indiana bat maternity colonies had been recorded in Missouri, some of which are in Chariton County. Maternity colonies or scattering groups of adults and juveniles are annually found in Pershing State Park. Threats to this species include loss or alteration of cave and forest habitats and human disturbance of hibernating individuals (USFWS 2007).

2.5.4.4 Pallid Sturgeon

Pallid sturgeon are large, long-lived benthic (i.e. bottom dwelling) fish that inhabit rivers of the Missouri and Mississippi River basins. They have physical features adapted to life in turbid fast-flowing rivers such as a flattened shovel-shaped snout; a long, slender, and completely armored body; fleshy barbels; and a protrusible mouth (i.e. capable of being extended and withdrawn from its natural position) that supplement their small eyes in detecting and capturing food. The pallid sturgeon was listed as endangered under the ESA on September 6, 1990 (55 Federal Regulation 36641–36647). A recent revision of the species recovery plan notes that the species status has improved and is currently stable as a result of artificial propagation and stocking efforts under the Pallid Sturgeon Conservation Augmentation Program (USFWS 2014; Steffensen et al. 2013). However, the population remains neither self-sustaining nor viable and if stocking were to cease, pallid sturgeon would face local extirpation in several reaches of the Missouri River (USFWS 2014). Sampling on the Grand River has been limited as the majority of pallid sturgeon monitoring and sampling efforts occur on the Missouri and Mississippi rivers. However, six pallid sturgeon captures were recorded in the Grand River in 2018 and 2019. In addition, three angler-caught records of pallid sturgeon in the Grand River were confirmed by MDC. Winders and Steffensen (2014) developed population estimates for a reach of the Missouri River downstream of Kansas City, Missouri. The annual population estimates of pallid sturgeon varied from 6.1 to 11.1 fish/river kilometer (rkm), of which known hatchery-origin pallid sturgeon (5.5 to 10.2 fish/rkm) were much more abundant than those of wild origin (0.6 to 0.9 fish/rkm) (Winders and Steffensen 2014).

Pallid sturgeon are long-lived, with females reaching sexual maturity later than males (Keenlyne and Jenkins 1993). However, the age at first reproduction can vary between hatchery-reared and wild fish, depending on local conditions (USFWS 2014). The estimated age at first reproduction of wild fish is about 15 to 20 years for females and approximately 5 to 7 years for males (Keenlyne and Jenkins 1993). Minimum age-at-sexual maturity for known-aged hatchery-reared fish was age-9 for females and age-7 for males (Steffensen et al. 2012). Pallid sturgeon generally spawn from late April through May in the lower Missouri River (DeLonay et al. 2016). Reproductively ready pallid sturgeon indicate consistent patterns of upstream migration before spawning. Migration patterns can differ between males and females; where male patterns are less regular. Migrating pallid sturgeon in Missouri selected shallow places in the channel, and velocities on the low end of the distribution, which indicates selection of migration pathways that optimize energy expenditure (DeLonay et al. 2016).

Fertilization to hatching, the embryo life stage, lasts 5-8 days depending on water temperature (DeLonay et al. 2016). Most of what is known about habitat requirements for embryos is extrapolated from laboratory studies. Naturally spawned pallid sturgeon eggs become adhesive 1 to 3 minutes after fertilization (Dettlaff et al. 1993) and presumably fall through the water column to affix to solid substrate such as rock (DeLonay et al. 2016). The relative importance of turbidity for the deposition, fertilization, and hatch of pallid sturgeon embryos is unknown (DeLonay et al. 2016). It is also unknown if predation is a threat to pallid sturgeon embryos (DeLonay et al. 2016). Spawning has not been documented in the Grand River.

A free embryo is a developing fish that no longer resides within the egg membrane. This life stage lasts 8 to 12 days post-hatch and covers the period from hatch until the larval fish begins feeding (DeLonay et al. 2016). Studies to date indicate: (1) pallid sturgeon free embryos drift and disperse downstream at a rate slightly less than mean water column velocity; (2) downstream drift and dispersal occur during day and night; (3) duration of the free embryo drift period depends on water temperature and rate of development; and (4) free embryos will drift and disperse several hundred kilometers during development into exogenously (i.e. external) feeding larvae, with total drift distance a function of water temperature, development rate, and velocity conditions in the river channel. Drifting free embryos use up their yolk sac and develop swimming ability, after which they “settle” into environments conducive to feeding, growth, and survival. The larval life stage is a developing fish without a yolk, feeding exogenously (i.e., it has consumed its yolk sac and must now feed externally). The period of transition from endogenous (growing or produced by growth from deep tissue) to exogenous feeding is considered critical because the larvae must find sufficient food or it will starve. Larval pallid sturgeon have been reported to consume the larvae and pupae of Dipterans (mainly from the family Chironomidae (i.e., midges) and Ephemeroptera nymphs (i.e., mayflies); DeLonay et al. 2016).

The juvenile life stage consists of sexually immature fish and lasts until the fish enter their first reproductive cycle. Diet composition plays a large role in the growth of juvenile pallid sturgeon to adult (Grohs et al. 2009), with chironomids (Order: Diptera) and mayflies (Order: Ephemeroptera) serving as important components of the early juvenile diet (Sechler 2010; Sechler et al. 2013). Pallid sturgeon diets shift from macroinvertebrates to fish as they grow. Of the food eaten by juvenile pallid sturgeon between 350 and 500 mm fork length, 57 percent was fish, whereas fish made up 90 percent of the diets of juvenile pallid sturgeons longer than 500 mm fork length (Gerrity et al. 2006; Grohs et al. 2009). Isotope analyses of pectoral spines support gut analyses and indicate that the diet shift of juvenile pallid sturgeon from invertebrates to fish likely occurs at or before 500 mm fork length–well before pallid sturgeon reach reproductive maturity (French 2010). Limited prey sources increase mortality and may suppress growth in surviving juveniles (Deng et al. 2003; DeLonay et al. 2009). No clear relationship has been documented between abiotic factors (e.g., water temperature) and pallid sturgeon recruitment, but early diet and growth are hypothesized to affect recruitment into adult spawning populations (DeLonay et al. 2009; Sechler 2010).

2.5.4.5 Topeka Shiner

This small prairie minnow was once common in many prairie streams of the Great Plains. It prefers perennial pools of small to medium-sized streams and nearby headwaters and is often found in oxbow lake environments in the northern portions of its range. This fish is somewhat tolerant of high temperatures and low dissolved oxygen, which helps it to survive in isolated pools during extreme droughts. The Topeka shiner is a schooling species often found associated with other cyprinid fishes such as redfin, sand, common and red shiners and central stonerollers. They live approximately three years. Male Topeka shiners develop bright orange-red fins during the reproduction period. They spawn in green sunfish and orangespotted sunfish nests during the early summer, taking advantage of that silt-free area which is protected by the parent sunfish. Because of the impacts to and loss of functioning headwater streams, as well as continuing degradation in many historically suitable waterbodies, the species is almost extirpated from the northern half of Missouri. The species is not known to occur in the study area, and therefore would not be affected; however, the MDC is implementing their Ten Year Strategic Plan for Topeka Shiner Recovery. Conservation elements defined within this plan include specific recovery actions such as population reintroductions within the upper Grand River Basin.

2.5.5 Invasive Species

EO 13112 directs federal agencies not to authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species. Invasive species are defined as alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Alien species means any species, including its seeds, eggs, spores, or other biological material capable of propagating that species that is not native to an ecosystem. A native species is one that historically or currently occurs in an ecosystem, other than as a result of introduction. Numerous invasive plant and animal species have the potential to occur in the study area. Known invasive species in the focused study areas include reed canary grass, Sericea lespedeza, Sesbania, garlic mustard, Johnson grass, and purple loosestrife (USFWS 2011, MDC 2017, 2019).

Reed canary grass (*Phalaris arundinacea*) is a cool-season perennial wetland grass that spreads via a dense rhizome system into clumps or colonies. This species is native to Europe, Asia, and North America. The introduced Eurasian ecotype is invasive, but the native varieties are not. Occurs in wet to dry habitats with best growth on fertile and moist or wet soils, including marshes, wet prairies, wet meadows, fens, stream banks, and swales. It has been planted widely for forage and for erosion control. This grass is one of the first to sprout in spring, and it forms a thick rhizome system that dominates the subsurface soil. This species is statewide in Missouri.

Sericea lespedeza (*Lespedeza cuneata*) is a warm-season, perennial legume with herbaceous to somewhat woody stems, and many leafy branches. It tolerates both droughts and floods. While it prefers full sun, it can survive in partial shade, allowing it to invade a wide range of habitats and climates. It is commonly found in open woodlands, thickets, fields, prairies, disturbed open ground, gravel bars, borders of ponds and swamps, meadows, and especially along roadsides. Native to Asia and widely introduced, it is now found in every county in Missouri.

Sesbania (coffeeweed) (*Sesbania herbacea*) is an annual herb of the legume family that typically grows to a height of 3–10 feet. Sesbania prefers wet, highly disturbed habitats and sandy sites. It occurs in low sandy fields, sand bars of streams, alluvial ground along sloughs and borders of oxbow lakes, and along roadsides, railroads, in disturbed urban sites, and agricultural areas. It may become a troublesome species in wetland communities that are managed for waterfowl. It is statewide.

Garlic mustard (*Alliaria petiolata*) occurs most frequently in upland and floodplain forests, savannas, and along roadsides. It invades shaded areas, especially disturbed sites, and open woodland. It is capable of growing in dense shade and occasionally occurs in areas receiving full sun. It prefers soils with an abundance of calcium and does not do well in acidic substrates. It is found in Linn County, Missouri.

Johnson grass (*Sorghum halepense*) is a tall, coarse, perennial grass that grows in dense clumps or nearly solid stands. It occurs in crop fields, pastures, abandoned fields, rights-of-way, and forest edges and along stream banks. It thrives in open, disturbed, rich bottom ground, particularly in cultivated fields. Native to the Mediterranean, this grass now occurs in warm-temperate regions worldwide, including the tropical Americas, and is common in the southern United States. It is statewide in Missouri and found heavily in major river bottoms.

Purple loosestrife (*Lythrum salicaria*) is a perennial herb with a strongly developed taproot and showy spikes of rose-purple flowers. Purple loosestrife occurs in wet habitats, such as freshwater marshes, fens, sedge meadows, and wet prairies, but also in roadside ditches, on river- and stream banks and at the edges of lakes and reservoirs. It thrives in moist soil in full sun but can survive in half shade. This invasive plant is especially harmful in wetland habitats, which it quickly takes over by outcompeting native species. It is considered to potentially be statewide in Missouri.

2.5.6 Floodplains

EO 11988 directs federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. ER 1165-2-26 documents USACE policy for compliance with EO 11988. ER 1165-2-26 states it is the policy of USACE to formulate projects which, to the extent possible, avoid or minimize adverse impacts associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no applicable alternative. The base floodplain is defined as the one percent chance floodplain. The three focused study areas of Locust Creek, Fountain Grove, and Yellow Creek are located within the base floodplain.

2.5.7 Geology and Soils

The study area falls within the Grand River Hills and Missouri River Alluvial Plain ecological subsections (Nigh and Schroeder 2002). The geology, soils, and topography of the Lower Grand River sub-basin reflects the historic glacial-derived geomorphology of the region and subsequent reworking of landscapes by fluvial (i.e. river) dynamics (Heitmeyer et al 2011). The upland terraces are blanketed with Pleistocene loess that overlies glacial till deposited by Pre-Illinoisan ice sheets (Nigh and Schroeder 2002). Loess is loosely compacted deposits of windblown sediment; whereas till is sediment deposited by melting glaciers or ice sheets. The geology of the area consists of alternating deposits of shale, limestone, coal, and small amounts of sandstone that dip gently northwest (Nigh and Schreoder 2002, Heitmeyer et al 2011). Bedrock is > 30 feet below the surface and alluvial fill (deposits left by flowing streams or rivers) contains Pleistocene gravels, sands, and silts (Heitmeyer et al 2011). Most of the landscape is gently rolling plains with a relief of 80-150 feet, with valleys cut shallowly into the till and loess (Nigh and Schroeder 2002). Along some of the major streams where the loess and glacial till have been cut into, the bedrock is exposed. Water infiltration through the subsurface is limited by these sequences of geologic strata. No sinkholes or caves have been documented in the study area. Groundwater quality is poor and no high yield potable bedrock aquifers are available. Wells that terminate in the glacial till above bedrock are low yielding. Few springs have been documented. Water movement in the basin is predominantly through the surface streams. Generally, the streams are silty and carry high suspended loads, due in part to the highly erodible soils in the upper terraces. The silty channels naturally have low gradients and have extremely meandering courses with reasonably stable banks; however, many long stretches have been channelized and leveed, which has affected bank stabilization and contributes to erosion. At the end of channelized areas, flooding is increased, and the silty sediments are deposited on the floodplain.

Soils in the study area are mostly alluvium derived from a mixture of loess and glacial till eroded from upland terraces adjacent to floodplains (Heitmeyer et al 2011). Soils near streams/river typically have coarser texture and are moderately to well-drained. Soils in floodplain depressions and swamps contain mostly clay surfaces and are poorly drained. Broad transition areas are transitional in texture and drainage (Heitmeyer et al 2011). Loess silt loam soils cover most of the Grand River Hills, with most of the soils having silt loam surfaces with silty clay loam or silty clay subsoils, and very low sand content (Heitmeyer et al 2011).

2.5.8 Prime and Unique Farmlands

Prime farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, oilseed crops, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion [7 U.S.C. 4201 (c)(1)(A)]. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. The Farmland Protection Policy Act (PL 97-98; 7 U.S.C. 4201 et seq.) was passed by Congress with the stated purpose of minimizing the unnecessary and irreversible conversion of farmland to nonagricultural uses by Federal programs.

Within the area of habitat evaluation, approximately 8.7% of acres are classified as prime farmland (7,783 acres), 1.2% (1,107 acres) are farmlands of statewide importance, and 22.2% (19,806 acres) would qualify as prime farmland if the areas were drained.

2.5.9 Socioeconomics

The three focus areas are in a 4-county region, which includes Carroll, Chariton, Linn and Livingston counties in north central Missouri. The region is located approximately 75 miles northeast of Kansas City and 65 miles northwest of Columbia, Missouri. This section describes the population, population density, employment and income for this 4-county region. Additional demographic information on race, ethnicity, and poverty is provided in Section 2.14, Environmental Justice.

2.5.9.1 Population

In 2017, population in the 4-county region was 43,768 (U.S. Census Bureau, 2018). The region is rural and sparsely populated, with approximately 16.9 persons per square mile (compared to 88.4 across the state of Missouri as a whole). Table 2-5 summarizes the population, population changes since 2010, and the population density by county, for the 4-county region, and for the state. Three of the four counties in the region have experienced population decreases between 2010 and 2017, the exception is Livingston County, which has experienced relatively constant population during this time period.

Livingston is the most populated county in the region with a population of 15,025. Much of the population resides in the town of Chillicothe, Missouri (9,668 residents) in the middle of the County, located just west of the Locust Creek and Fountain Grove study areas on HWY 36. The Fountain Grove focus area is in the eastern portion of Livingston County. The southern portion of the Fountain Grove is also located in Livingston County.

Linn County, just east of Livingston County, is the second-most populated county in the region, with 12,248 residents. Locust Creek originates in southern Iowa and flows south about 100 miles through north central Missouri through Linn County to its confluence with the Grand River. Pershing State Park lies along Locust Creek in Linn County at HWY 36. The town of Brookfield, Missouri lies about 8 miles to the east of Pershing State Park in Linn County.

South of Linn County, Yellow Creek lies in Chariton County and confluences with Grand River at the border of Chariton and Carroll County. The Grand River south of Yellow Creek forms the border between Chariton and Carroll counties. Carrollton, Missouri is the largest city and county seat in Carroll County, southwest of Yellow Creek. Salisbury, Missouri is the largest city in Chariton County, located to the southeast of the focus areas.

Table 2-5. Population, Trends, and Population Density

County/Region	Population (2017)	Population Change (2010-2017)	Population Density
Carroll County	8,909	-6.1%	12.8
Chariton County	7,586	-3.6%	10.1
Linn County	12,248	-4.5%	19.9
Livingston County	15,025	0.4%	28.2
4-County Region	43,768	-3.0%	16.9
Missouri	6,075,300	2.6%	88.4

Sources: U.S. Census Bureau, 2018; U.S. Department of Labor, Bureau of Labor Statistics, 2019.

2.5.9.2 Employment and Income

In the 4-county region, the largest employing industry and sectors are education, healthcare and social assistance (22.5%); manufacturing (12.7%); and retail trade (12.4%) (Table 2-6). Farming and agricultural activities are prevalent in the region, accounting for 6.8 percent of the employment. Tourism sectors, including retail trade and arts, entertainment, recreation, accommodations and food and beverage establishments, together account for 19.3 percent of employment in the 4-county region.

Table 2-6. Employment by Industry in the 4-County Region, 2017.

Industry	Total/Percent
Total Employment (civilians over 17 years)	18,982
Agriculture, forestry, fishing and hunting, and mining	6.8%
Construction	7.5%
Manufacturing	12.7%
Wholesale trade	2.4%
Retail trade	12.4%
Transport, warehousing, and utilities	5.5%
Information	3.0%
Finance and ins, and real estate	4.6%
Professional, management, administrative, and waste management	4.3%
Education, health care, and social assistance	22.4%
Arts, entertainment, recreation, accommodations, and food beverage	6.9%
Other services, except public admin	4.9%
Public administration	6.6%

Source: U.S. Census Bureau, 2018.

Median household income rages from $41,652 in Linn county to $45,929 in Livingston County, lower than median household income across the state in 2017 ($51,542) (Table 2-7). The region is experiencing low unemployment rates, ranging from 2.5% in Livingston County to 4.7% in Linn County. Unemployment rates are consistent with or slightly lower than the state's unemployment rate, the exception is Linn County, where the unemployment rate is 1.5% higher than the unemployment rate for the state.

Table 2-7. Income, Employment, and Employment Rates.

County/Region	Median Household Income (2017)	Employment (2017)	Unemployment Rate (2018)
Carroll County	$43,583	3,700	3.1%
Chariton County	$43,186	3,129	2.8%
Linn County	$41,652	5,516	4.7%
Livingston County	$45,929	6,637	2.5%
4-County Region	NA	18,982	3.2%
Missouri	$51,542	2,867,393	3.2%

Sources: U.S. Census Bureau, 2018; U.S. Department of Labor, Bureau of Labor Statistics, 2019.

2.5.10 Environmental Justice

Executive Order 12898, issued in 1994, directs federal agencies to incorporate environmental justice (EJ) as part of their mission by identifying and addressing the effects of programs, policies, and activities on minority and low-income populations. The fundamental principles of Executive Order 12898 are as follows:

- Ensure full and fair participation by potentially affected communities in the decision-making process.
- Prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority or low-income populations.
- Avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and low-income populations.

- Encourage meaningful community representation in the NEPA process through the use of effective public participation strategies and special efforts to reach out to minority and low-income populations.
- Identify mitigation measures that address the needs of the affected low-income and minority populations.

An environmental justice assessment requires an analysis of whether minority and low-income populations (i.e., "populations of concern") would be disproportionately adversely affected by a proposed federal action. Of primary concern is whether adverse impacts fall disproportionately on minority and/or low-income members of the community compared to the larger community and, if so, whether they meet the threshold of "disproportionately high and adverse." If disproportionately high and adverse effects are evident, then EPA guidance advises that it should initiate consideration of alternatives and mitigation actions in coordination with extensive community outreach efforts (EPA, 1998).

Areas can be determined to have a high proportion of minority residents if either (1) 50 percent or more of the population identifies themselves as a minority; or (2) there is a significantly greater minority population than the reference area (EPA, 1998). Individuals are considered to be of a minority if they are identified as a race other than Non-Hispanic White Alone. Low-income populations are defined as those individuals living below the poverty line, as defined by the U.S. Census Bureau. According to the U.S. Census Bureau, a poverty area consists of 20 percent of the population living below the poverty level, while an extreme poverty area includes 40% of the population living below the poverty level (U.S. Census Bureau, 2016). Thus, block groups with more than 20 percent of their families living below the poverty level were identified as a potential environmental justice poverty area.

Table 2-8 summarizes the percentage of the population that identifies as a minority as well as the percent of the population living below the poverty level. This 4-county region has a much lower proportion of minority populations (3.7%-6.0%) when compared with the state (20.2%). Livingston County has the largest portion of minority populations, accounting for 6% of the population in the County. The minorities in this region include people who identify as African American and Hispanic.

The proportion of the populations that live below the poverty level ranges from 14.2% in Chariton County to 18.4% in Carroll County. Although 3 of the 4 counties have higher proportions of poverty populations than the poverty populations across the state of Missouri (14.6%).

Over 98 percent of the population in the 4-county region speaks only English (U.S. Census Bureau, 2018).

Table 2-8. Race and Ethnicity and Poverty Characteristics, 2017.

County/Region	Population	Percent of the Population that Identifies as Minority*	Population Living Below the Poverty
Carroll County	8,909	4.0%	18.4%
Chariton County	7,586	4.2%	14.2%
Linn County	12,248	3.7%	16.5%
Livingston County	15,025	6.0%	17.9%
4-County Region	43,768	4.6%	17.0%
Missouri	6,075,300	20.2%	14.6%

Sources: U.S. Census Bureau, 2018.
*Note: Minority populations include populations that include all races and ethnicities other than white alone (non-Hispanic).

2.5.11 Land Use

Dominant land use in the study area is cropland (37.1%), followed by riparian forest (22.5%) and wetland (15.6%) (Figure 2-17). Land use within the broader Lower Grand River sub-basin is dominated by grassland/pasture (50%), cropland (15%), and forest (15%) (MoDNR 2016). The northern part of the sub-basin is primarily dominated by pasture, while the southern part is dominated more by row crop agriculture due to the less steep terrain (MoDNR 2016).

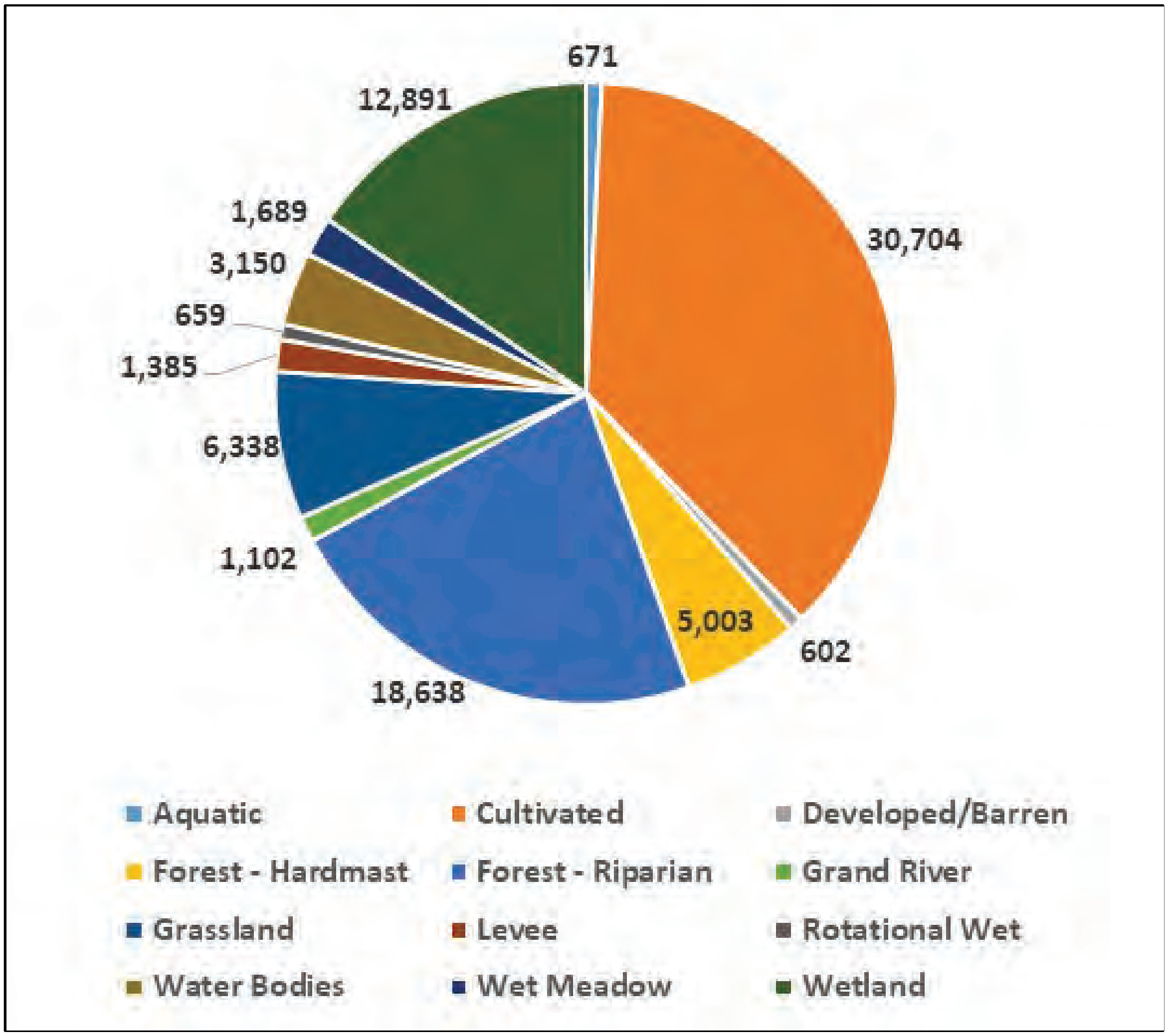

Figure 2-17. Land Use Composition.

2.5.12 Flood Risk

2.5.12.1 Flood History

Several significant flooding events have occurred in the watershed and inundated Fountain Grove CA, Pershing State Park, and Yellow Creek CA. Historic floods that affected the study area include:

- **Floods Prior to 1909 –** Widespread systematic stream-gaging by the USGS was not present across much of the Grand River basin until the late 1920's. Floods of record without stage and discharge information include 1844, 1866, 1883, and 1903.
- **1909 Flood –** The flood of 1909 resulted from a four-day rain event around 4-7 July 1909 that produced an average of 7.26 inches upstream of Chillicothe, MO and a maximum of 11.23 inches in Bethany, MO. One month of heavy rainfall preceded the event resulting in saturated antecedent

moisture conditions. The flood produced a stage of 33.6 feet on the Grand River at Chillicothe, MO. High water mark estimates indicate stages of 39.3 feet and 36.7 feet and approximate discharge of 70,000 cfs and 150,000 cfs at Gallatin, MO and Sumner, MO respectively (USACE 1963). Locust Creek at Linneus, MO peaked at 18,000 cfs (Searcy 1955).

- **1929 Flood –** The 1929 event occurred May 29 through June 3 with rainfall over most of the basin. The 6-day average precipitation above Chillicothe, MO was 4.65 inches with a maximum precipitation of 7.76 inches at Bethany, MO. The event occurred after the completion of channel modification projections throughout the basin including 24 miles of new channel excavated in 1920 near Linneus, MO and an additional 8 miles of channel excavated downstream from the station on Locust Creek at Milan, MO (Searcy 1955). Stages of 37.4 and 35.3 with peak discharges of 56,800 cfs and 110,000 cfs were recorded at Gallatin and Sumner, respectively (USACE 1963).
- **1947 Flood –** The 1947 event consisted of two storm periods, 4-7 June and 17-23 June, and produced stages and discharges exceeding several previous maximum records throughout the Grand River basin, including 1909 measurements. Records indicate the event was widespread, producing similar stage results throughout the tributaries in the basin. Frequent and heavy rainfall occurred throughout the last half of May and June and produced an average rainfall across northern Missouri of approximately 12 inches, 7.08 inches above typical rainfall amounts. The Lathrop station recorded a maximum monthly rainfall of 23.60 inches (USACE 1963).
- **Great Flood of 1993 –** The 1993 event was characterized by above average precipitation from fall of 1992 into the spring of 1993. Some areas recorded twice the normal amount of precipitation for the fall and winter months which resulted in saturated soil conditions and higher than normal streamflows in spring. Magnitude and timing of intense thunderstorms in early and mid-July, coupled with wet antecedent conditions were the primary causes of severe flooding to the Missouri River and tributaries from Rulo to St. Louis. Total rainfall within the basin varied from 19 inches in Mount Ayr, IA to 22.6 inches in Bethany, MO (USACE 1994). The Grand River entered flood stage by July 1. The 1993 event set record stages for several locations within the Grand River basin including Pattonsburg, Gallatin, Chillicothe, Sumner, and Brunswick. Garden of Eden Section 1 faced record flooding in 1993, with river levels nearly to the top of the levee. Garden of Eden Section 2 and Garden of Eden Section 3 overtopped during the 1993 event.
- **2007 to 2010 Floods –**The Grand River had several out of bank events (bankfull flows estimated at 27,000 cfs) during this period. The frequency and magnitude of the flooding contributed to substantial sediment deposition near the Yellow Creek and Grand River confluence that prevented recruitment of hardmast forests in the area. Whitham Drainage District overtopped in 2008 with no damages. Garden of Eden Section 1 overtopped in 2007 and overtopped and breached in 2008. Garden of Eden Section 2 did not overtop in 2007 and 2008 but withstood 100% loadings in both events. Garden of Eden Section 3 overtopped and breached in 2007 and 2008.
- **2017 Flood –** The 2017 Event occurred between 25 March and 08 April of 2017. Rain fell across northern Missouri and southern Iowa between 25 March and 06 April. The Grand River at Sumner, MO peaked on 07 April at 90,100 cfs and Locust Creek peaked at 11,700 cfs on 05 April according to USGS. The observed hydrograph at the Sumner gage depicts a multi-peak event with the first peak reaching 27,000 cfs on 31 March 2019 16:00 Central Daylight Time (CDT). The event was characterized by several small amounts of precipitation over a 13-day period. Over the two-week period, 4 to 6 inches of widespread rain fell across the entire Grand River Basin. The rain was centered at the Iowa-Missouri border near Redding and Bedford, Iowa where a total of 7.3 inches fell. At least five precipitation events occurred over the 13-day period with the highest intensity rainfall occurring on 29 March 2017 and 30 March 2017, corresponding to the initial peak of the Grand River hydrograph at Sumner, MO.

- **2018 Flood –** The 2018 Event occurred between 04 October and 15 October of 2018 with majority of the rainfall falling between 05 and 11 October. The Grand River at Sumner, MO peaked on 11 October at 78,500 cfs and Locust Creek peaked at 9,720 cfs on 08 October according to USGS. The observed hydrograph at the Sumner gage depicts a single-peak event reaching 78,500 cfs on 11 October 2018 19:45 CDT. The event was characterized by several precipitation events over a 6-day period. Over the 6-day period, 6 to 8 inches of widespread rain fell across the entire Grand River Basin. The rain was centered in the southeast portion of the basin northeast of Kingston, Missouri where a total of 11.4 inches fell. At least five precipitation events occurred over the 6 day period with the largest volume of rainfall occurring on 07 October 2018 and 09 October 2019, corresponding to the initial peak of the Grand River hydrograph at Sumner, MO. Damages for the 2018 event were widespread impacting Fountain Grove CA, Pershing State Park, and Swan Lake NWR.
- **2019 Flood –** The May 2019 event was characterized by wet antecedent moisture conditions throughout fall and winter in addition to extensive rainfall throughout the Grand River basin. 15 to 20 inches of precipitation was documented within the Grand River Basin for the month of May. The ground was largely saturated due to a wet winter and spring rains. Wet antecedent moisture conditions coupled with significant amounts of precipitation contributed to flooding along the Grand River. In the Grand River Basin, the maximum precipitation totals, ranging between 18 and 21 inches, were primarily centered in the Lower Grand watershed and impacted Locust Creek and Yellow Creek. The drainage area upstream of the Locust Creek gage near Linneus received a basin average precipitation of 16.38 inches while areas upstream of Yellow Creek at Rothville received a basin average of 14.84 inches. Table 2-9 displays the preliminary USGS recorded peak stage and flow measurements for various Grand River Basin gages during the May 2019 event. In many locations throughout the Grand River Basin, the 2019 flood may be considered the flood of record. The resulting water volumes inflicted damages across the study area.

Table 2-9. Peak Stage and Flows during 2019 Flood Event.

Gage	Peak Stage (ft)	Peak Flow (cfs)	Time (CDT)
Grand River near Chillicothe, MO	38.18	---	---
Grand River near Fountain Grove CA	38.50	100,000	31May2019 08:30
Grand River near Sumner, MO	41.48	135,000	30May2019 06:45
Grand River Auxiliary Gage below Sumner, MO	40.07	---	---
Locust Creek near Linneus, MO	26.63	35,400	29May2019 16:15

2.5.12.2 Levees

Locust Creek is largely characterized by levee construction and stream channelization. Levee construction occurred in the 1940's and 1950's and is extensive north of the confluence with the Grand River and HWY 36 past Linneus, MO. Partial stream channelization of Locust Creek occurred in the late 1800's and early 1900's and stopped upstream of HWY 36.

The Grand River has nonfederal levees on both the left and right banks throughout the study area. Downstream of Sumner, six levee systems built by local interests on the Grand River are enrolled in USACE PL-84-99 non-federal levee program, including three Garden of Eden Levee Systems, Big Bend, Dewitt, and Brunswick. A federally constructed levee called L-246 is also present further downstream along the Grand and Missouri Rivers. The Garden of Eden system, Section 1 is located adjacent to the Yellow Creek CA and Swan Lake NWR along Yellow Creek and the Grand River. In total, all three Garden of Eden Levee sections consist of 23.7 miles of earthen levee protecting three separable leveed areas with a total protected area of approximately 17,000 acres, of which 16,000 is in agricultural production. According to the National Levee Database, the total population of the three leveed areas is 21 people during the day, and 45 at night, with an estimated annual agricultural production of $8.8 million and 102 structures valued at $21 million (2015 price levels). Garden of Eden Section 1 contains 93% of this structure value, and 63% of the average annual agricultural production, with an estimated overtopping frequency of 5.4% annual chance exceedance (1 in 18 years). Portions of the Garden of Eden levee system overtopped and breached in 1993, 2007, and 2008 and were subsequently repaired by USACE. All three of the Garden of Eden levee sections breached again during the 2019 flood event.

2.5.13 Infrastructure

Transportation infrastructure within the study area primarily includes U.S., state, and county highways and roads, and railroads (Figure 2-18). U.S. HWY 36 runs east/west through the study area, passing through the northern portion of Pershing State Park. HWY 36 has bridge crossings at Muddy Creek, Locust Creek floodplain, Locust Creek, and Higgins Ditch. Log jams are a frequent occurrence at the Locust Creek/HWY 36 bridge crossing. Primary north/south routes include Missouri HWY 5 and Missouri HWY 139. The BNSF Railway Company, Inc. owns and operates two active rail lines that cross the study area running northeast/southwest crossing the study area north and south of Swan Lake NWR. An old rail line that is no longer active crosses through Fountain Grove CA and a part of Swan Lake NWR. The rail line paralleling HWY 36 is also no longer active.

There are no airports listed in the Federal Aviation Administration's National Plan of Integrated Airport Systems within 10 miles of any proposed project features. As a result, the guidance in FAA Advisory Circular 150/5200-33 to address aircraft-wildlife strikes is not applicable.

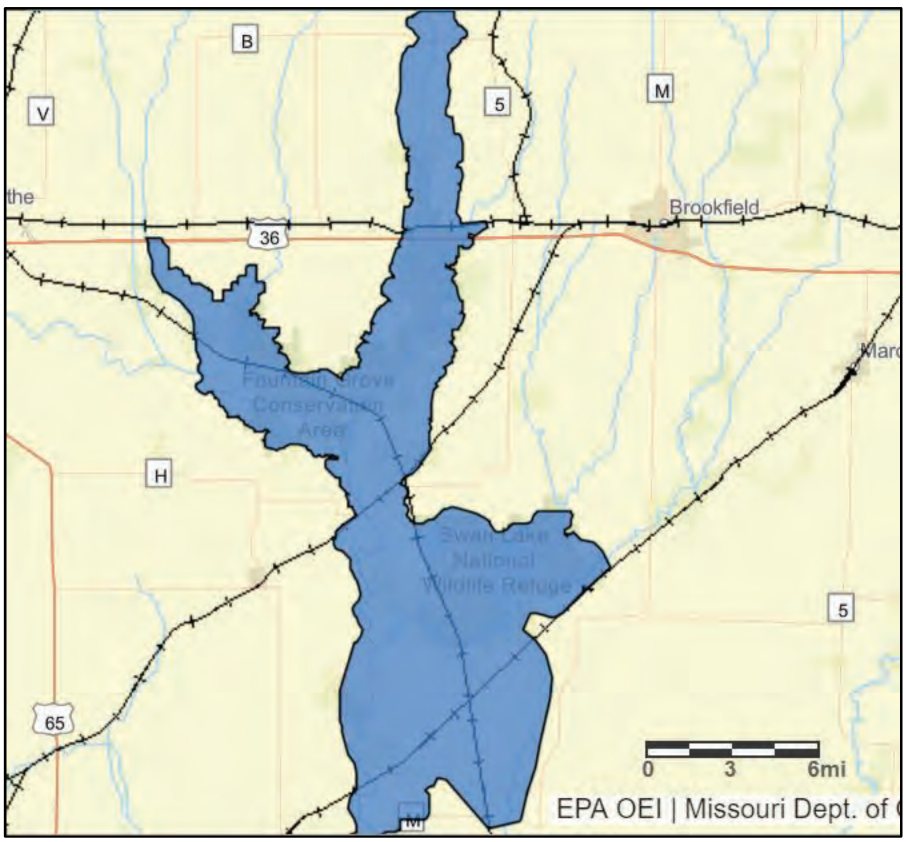

Figure 2-18. Transportation Infrastructure in Study Area.

2.5.14 Cultural Resources

Cultural resources include archaeological sites, buildings, structures, objects, historic landscapes and districts, sacred sites, properties of traditional religious and cultural importance, and traditional cultural properties. In accordance with Section 106 of the National Historic Preservation Act (NHPA) of 1966 (as amended) and its implementing regulations at 36 CFR § 800, USACE must consider potential effects of this project on historic properties, which are cultural resource sites listed on or eligible for inclusion on the National Register of Historic Places (NRHP). In addition, USACE must provide the State Historic Preservation Officers (SHPO), federally recognized Native American Tribes (Tribes), the Advisory Council on Historic Preservation (ACHP), and other interested parties the opportunity to comment on its determination of effects to historic properties.

Consultation with SHPO, ACHP, and Tribes was initiated by letter in January 2019 with information on the alternatives and an invitation to participate in the development of a Programmatic Agreement (PA) for compliance with Section 106 of the NHPA. The ACHP declined to participate in a letter dated June 29, 2019. SHPO informed USACE they wish to participate in the PA in a letter dated March 1, 2019. A public notice posted on December 13, 2019 for 30 days received no public comment or request for participation in the PA process. All correspondence received to date from SHPO, ACHP, and Tribes is included in Appendix N.

No tribes are currently located within or adjacent to the Grand River basin study area. However, sixteen tribes with ancestral ties to the area were invited to consult and participate in the PA including the Ho-Chunk Nation, Iowa Tribe of Kansas and Nebraska, Kaw Nation, Kickapoo Tribe of Kansas, Miami Tribe of Oklahoma, Omaha Tribe, Osage Nation, Otoe-Missouria Tribe, Pawnee Nation, Ponca Tribe of Nebraska, Ponca Tribe of Oklahoma, Prairie Band Potawatomie Nation, Sac and Fox Nation of Missouri in Kansas and Nebraska, Sac and Fox Nation of Oklahoma, Sac and Fox Tribe of the Mississippi, and the Winnebago Tribe. No tribes have expressed concerns with the study. To date, four tribes, the Iowa Tribe of Kansas and Nebraska, Kaw Nation, Osage Nation, and Otoe-Missouri have indicated they wanted to participate in the PA. The Winnebago Tribe has declined to participate.

Ten properties listed on the NRHP are in the study area, four of which are near the focused study areas (Figure 2-19). The Locust Creek Covered Bridge State Historic Site is located closest to any study area (Figure 2-20). A background review of the study area was undertaken using archeological files from the MoDNR Archaeological viewer (on-line) and files supplied by the Missouri State Historic Preservation Office, and records at the USACE Kansas City District office. The review found that portions of the study area have been previously inventoried for archeological sites (Figure 2-21). Fountain Grove CA has been surveyed most extensively of the three study areas.

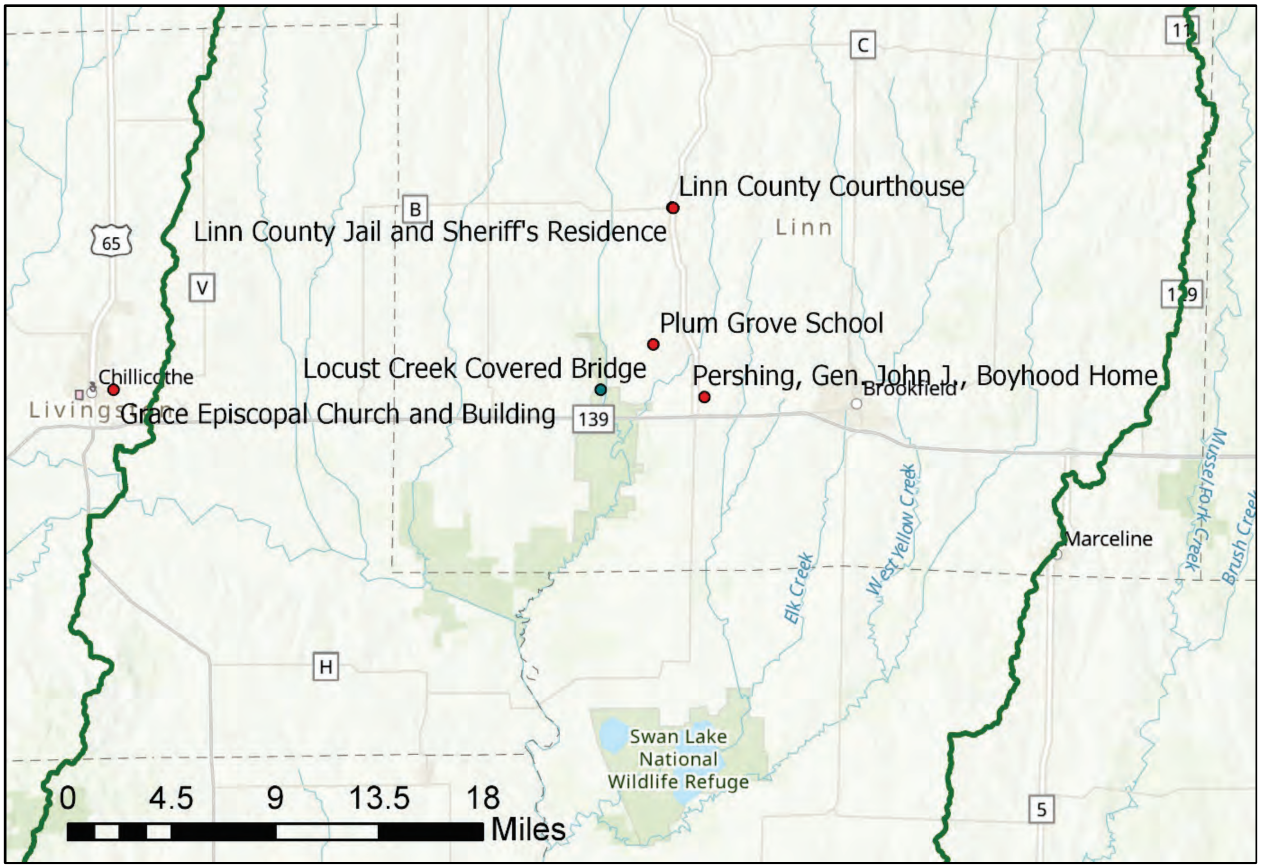

Figure 2-19. NRHP Properties in Vicinity of the Focused Study Area.

Figure 2-20. Locust Creek Covered Bridge. *Photo from NRHP nomination (1970), view to northwest.*

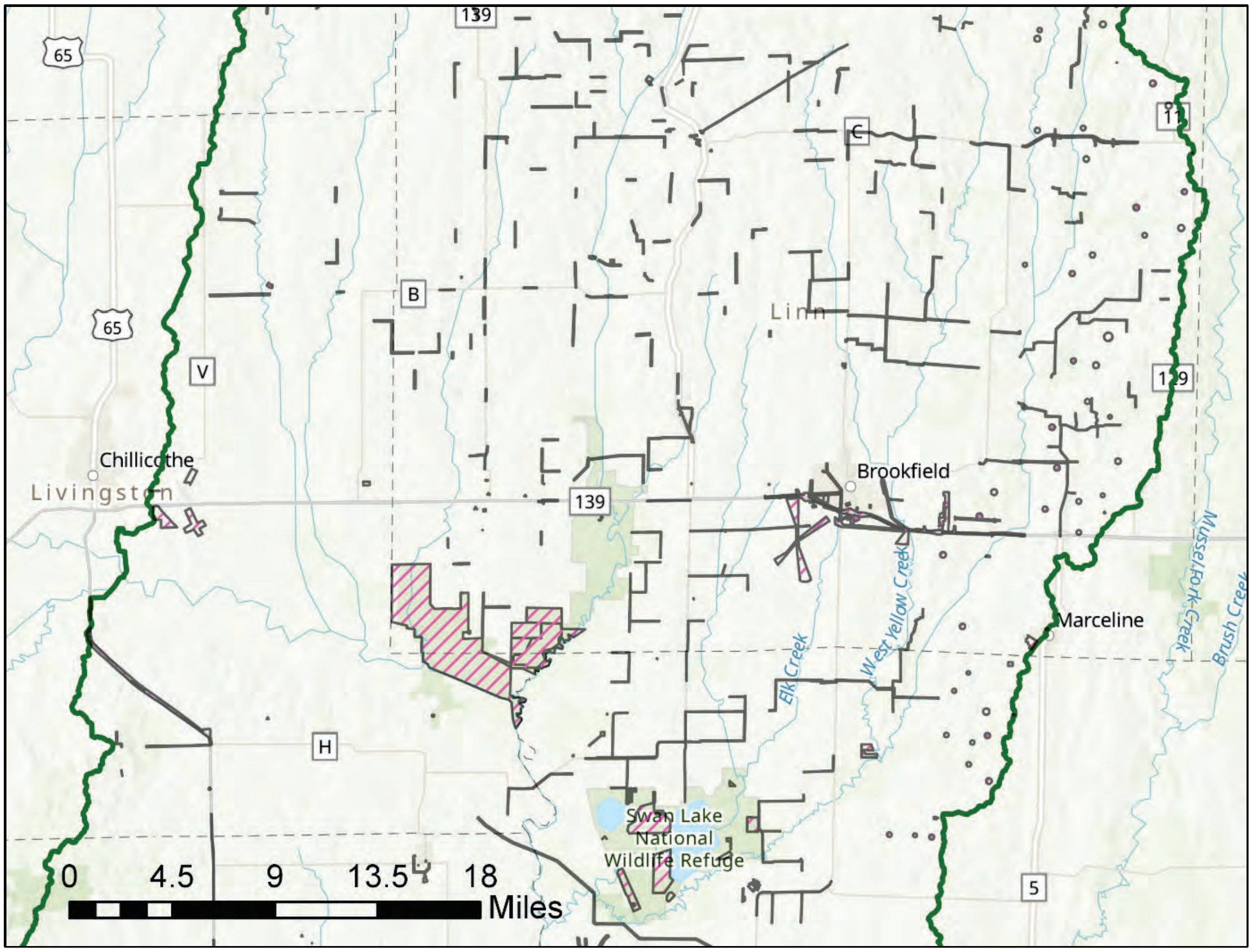

Figure 2-21. Previous Survey Areas (pink hatch and gray line) in the Study Area.

2.5.15 Recreation

Abundant outdoor recreational opportunities exist in the study area due largely to the rural nature of the watershed and the concentration and amount of public and private conservation areas (for example, NRCS Wetland Reserve Program locations). Recreational opportunities include birding, camping, fishing, hiking, hunting, and boating. This section describes the recreation and conservation areas within the study area.

2.5.15.1 Locust Creek

Pershing State Park was gradually developed to enhance public camping, hiking trails, vehicular access, day use facilities, and picnic shelters. Habitat management on the park was largely related to protection and interpretation of the natural resources along Locust Creek.

Locust Creek and four small lakes provide abundant fishing resources for anglers. Aquatic recreation in Locust Creek is generally limited to some fishing (especially for catfish). Where floatable water exists in the middle and lower Locust Creek, small boats and canoes can be launched from public lands (HDR 2013). Pershing State Park includes a campground with electric and basic campsites. In 2017, Pershing State Park had over 55,000 visitors, including 5,500 overnight visitors (MoDNR 2018b).

2.5.15.2 Fountain Grove

The diverse habitats at Fountain Grove CA provide an abundance of recreational activities, include fishing, bird watching, hunting, trapping, camping, and hiking. Wetland pools and upland habitat draw a broad suite of wetland-dependent species throughout the year. Abundant waterfowl populations during spring and fall migrations draw wildlife viewers and hunters to the area. Waterfowl hunting on Fountain Grove CA provides a large-scale experience with a diversity of hunting opportunities. Deer hunting is also popular on Fountain Grove CA. The area includes some limited access to river fishing although ample opportunities exist for fishing in ponds and lakes, some of which are periodically stocked with channel catfish (MDC 2018).

2.5.15.3 Yellow Creek

Swan Lake NWR is open from March through October. There are three entrances including the main entrance, north entrance and the west entrance. Swan Lake NWR is open to goose hunting during the goose season, which is usually mid-November through the end of February. Annual visitation was estimated at approximately 25,000 in 2008, which was obtained through estimates derived from traffic counters at the three entrances (USFWS 2011). The largest segment of visitors to Swan Lake NWR come to view wildlife, followed by fishing, education, and hunting activities (USFWS 2011).

2.5.16 Hazardous, Toxic, and Radioactive Waste

No sites of concern regarding hazardous, toxic, and radioactive waste (HTRW) were identified within the study area based on a review of the NEPAssist tool and MoDNR’s ESTART web map. NEPAssist includes data on the following:

- Hazardous waste – information contained in the Resource Conservation and Recovery Act Information including an inventory on all generators, transporters, treaters, storers, and disposers of hazardous waste that are required to provide information about their activities.
- Toxic releases – information from the Toxics Release Inventory containing information on toxic chemical releases and waste management activities reported annually by certain industries as well as federal facilities.
- Superfund – sites included in the Superfund Enterprise Management System, which are those falling under the Comprehensive Environmental Response, Compensation, and Liability Act (otherwise known as CERCLA or Superfund). CERCLA provides a Federal “Superfund” to locate, investigate, and clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment.
- Brownfields – Data from the Assessment, Cleanup and Redevelopment Exchange System, which captures grantee reported data on environmental activities and accomplishments (assessment, cleanup, and redevelopment), funding, job training, and details on cooperative partners and leveraging efforts for the Brownfields program.
- Radiation Information Database – contains information about facilities that are regulated by EPA for radiation and radioactivity.

MoDNR’s ESTART web map includes data on:

- Hazardous substance investigations and clean-up sites (i.e. Superfund sites, Federal Facilities sites, Resource Conservation and Recovery Act Corrective Action sites, Brownfields/Voluntary Cleanup Program sites, Brownfield Assessments)
- Regulated Petroleum and Hazardous Substance Storage Tank Facilities – only two closed facilities, one on Fountain Grove CA and one on Swan Lake NWR were identified.

2.5.17 Aesthetics

As described in previously related sections, the dominant setting and land use of the study area is rural, agricultural lands and a variety of natural areas consisting of diverse habitats primarily associated with streams/rivers and associated floodplain areas. The actions comprising the alternatives evaluated would not substantially change the dominant aesthetics of the area. Localized changes from agricultural land to natural habitat areas may occur under some alternatives considered. Other than short-term disturbances to ground cover during construction activities, any effects to aesthetics in the area would be negligible; therefore, this resource was eliminated from further evaluation.

3.0 Future without Project Condition

This section provides a description of the future without project (FWOP) conditions within the study area and described how the FWOP is used in the comparison and evaluation of alternative plans.

3.1 "With and Without" Comparisons

The U.S. Water Resources Council's *Principles and Guidelines* provide the instructions and rules for Federal water resources planning. One requirement is to evaluate the effects of alternative plans based on a comparison of the most likely future conditions with and without those plans in place. To make this type of comparison, descriptions (often called forecasts) must be developed for two different future conditions: the FWOP condition and the future with project (FWP) condition. Note that the project referred to in FWP context is any one of the alternative plans that have been considered in the study. The FWOP condition describes what is assumed to be in place if none of the study's alternative plans are implemented. The FWOP condition is the same as the alternative of "no action" that is required to be considered by the Federal regulations implementing NEPA. The FWP condition describes what is expected to occur as a result of implementing each alternative plan being considered. The differences between the FWOP and the FWP condition are the effects (benefits) of the project.

3.2 Planning Horizon

The planning horizon encompasses the planning study period, construction period, economic analysis period, and the effective life of the project. The timeframe used when forecasting future with and without project conditions while considering impacts of alternative plans is called the period of economic analysis. It may also be referred to as simply the period of analysis. It is the period of time over which scientists think extending the analysis of the plan impacts is important. This time period is frequently confused with the planning horizon, which is a longer and more encompassing concept. Figure 3-1 shows that the period of analysis is part of the planning horizon.

A 50-year period of analysis was used to assess effects of the project. The period of analysis was estimated as 2022 to 2072 because 2022 is the estimated beginning of construction. The actual year of start of construction may differ. Incremental periods of 10 and 25 years were used in evaluating FWOP conditions to capture the predicted degradation of study areas due to inundation and sedimentation effects. The incremental periods were also used to evaluate FWP conditions to capture the predicted restoration or reduction in degradation with implementation of alternative plans. Within each habitat model, the same four time stamps (0, 10, 25, and 50 years) were used to assess habitat change over the period of analysis. Year 0 represents existing conditions, prior to construction; Years 10, 25 and 50 represent 10, 25 and 50 years into the future from Year 0 under FWOP (no implementation) or FWP (initiation of construction).

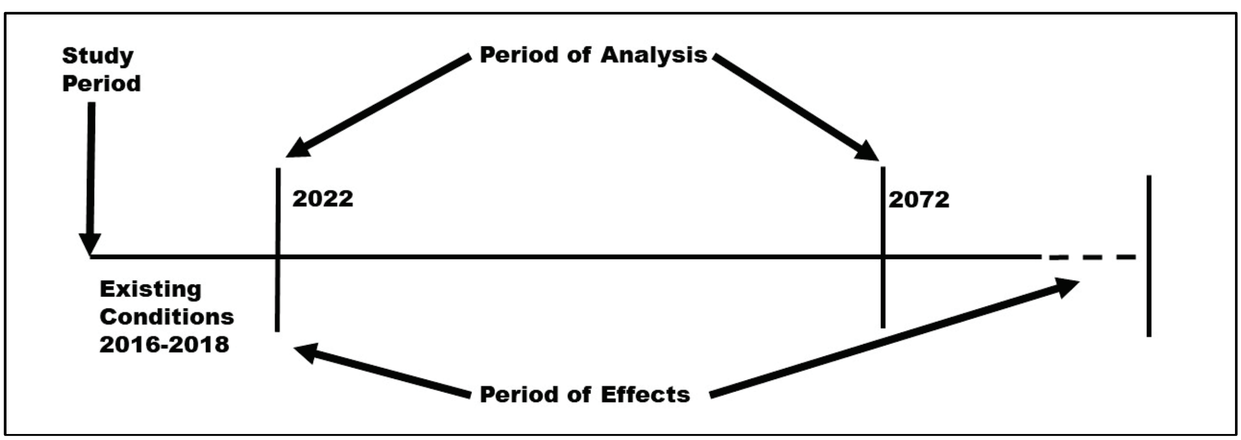

Figure 3-1. Grand River Planning Horizon.

3.3 Habitat Evaluation and Quantification

In collaboration with the technical team (see Section 4.2), four general habitat types were identified for the focus of the habitat evaluation: wet prairie, emergent wetland, bottomland forest, and aquatic riverine habitat. These habitat types were selected because they are significant resources in the study areas that are representative of the habitat types being degraded.

The USFWS's Habitat Evaluation Procedure methodology was used with all modeling to assess the quality and quantity of existing and future habitats in the study areas. In general, the Habitat Evaluation Procedure assigns Habitat Suitability Index (HSI) scores to model variables, which assess the quality or suitability of a habitat relative to a species ability to access food, secure shelter, and reproduce. H&H and sediment modeling outputs such as sedimentation depth, inundation extent, duration, and depth were used to evaluate and forecast future quality of habitat variables over time. Final HSI quality scores from 0.0 to 1.0 were used with habitat acreages to obtain habitat units (HUs), which measured the overall value of each habitat type. Cumulative average annual habitat units (AAHUs) and Net AAHUs were calculated and compared under FWOP and future with project (FWP) conditions to determine if a given alternative resulted in habitat lift or impairment over the 50-year period of analysis. The time intervals or stamps included Year 0 (existing, baseline conditions), Year 10 (for habitat types that reach sustainability quickly such as wetlands), Year 25 (for habitats with mid- to long-term growth characteristics), and Year 50 (for habitats that reach maturity after long periods of time such as old growth riparian corridors). Existing conditions were informed by existing data, previous field investigations and best professional judgment depending on the variables in each species HSI. FWOP and FWP conditions were informed by sediment and H&H modeling output as well as best professional judgment from technical team members. The suite of species HSI models listed in Table 3-1 were identified for use in the focused study areas with review and approval by the technical team and USACE Ecosystem Center of Expertise.

Table 3-1. Habitat Models Used in Evaluation.

Habitat Type	Habitat Model	Notes
Wet Prairie	Marsh Wren HSI	Locust Creek study area contains most of the wet prairie habitat. A small amount is present in the Yellow Creek area. No current or future wet prairie habitat was identified in the Fountain Grove study area.
Bottomland Forest	Gray Squirrel HSI	Habitat type is present in all focus study areas. The model was selected because it has variables that allow assessment of bottomland forests with emphasis on hardmast tree species.
Emergent Wetland	Dabbling Duck Migration Model	Habitat type is present in all project areas. Applicable to managed wetland acres in Fountain Grove CA and USFWS Swan and Silver Lake area. Supplemental information including topography (slope), soil type, and inundation frequency helped inform these models.
Aquatic Riverine	Qualitative Habitat Evaluation Index (QHEI)	The Locust Creek area used this habitat model to assess changes in aquatic riverine conditions. The model focuses on base flow conditions, channel morphology, riparian connectivity, and in stream habitat.

3.4 General Key Assumptions

The following assumptions were applicable to all the focus study areas:

- The projection of FWOP conditions assumes no habitat restoration measures would occur in the study areas and the processes of erosion, inundation, and sedimentation would continue to degrade habitat and change the area in a manner similar to past effects. Habitat throughout the project area will continue to degrade and convert to monotypic invasive species, softmast tree varieties, and other lower quality habitats. The patterns of inundation and deposition will change over time.
- H&H modeling and subsequently the sediment analysis assumed that the 2-year flood event was most representative of flood events leading to habitat degradation.

- Agriculture will continue to be the dominant land use within the Lower Grand River sub-basin. A trend toward increased amounts of land enrolled in conservation easements would likely continue within the focused study areas (Figure 3-2).
- Upstream sediment inputs will remain constant (i.e. flow/sediment relationships remain the same) over the 50-year period of analysis.
- Other organizations including state and federal agencies will continue to work within the watershed (e.g. NRCS easements, PL-566 Program).
- Private levees will remain in existing alignments and at existing heights.
- Floodplain sediment deposition in wet prairie and emergent wetlands affects those habitats as follows (based on best professional judgment and scientific literature review):
    - 0-0.5 feet of sediment = normal, no impact to habitat
    - 0.5-1 feet of sediment = some seed burial, loss of habitat quality
    - 1-1.67 feet of sediment = loss of habitat quality, some habitat conversion
    - 1.67-4 feet of sediment = additional loss of habitat quality, additional habitat conversion
    - 4+ feet of sediment = total loss of wetland habitat and conversion to terrestrial and riparian
- Floodplain sediment deposition in bottomland hardmast forest affects that habitat as follows (based on best professional judgment and scientific literature review):
    - 0-0.5 feet of sediment = normal, no impact to habitat
    - 0.5-1 feet of sediment = some seed burial, decreased recruitment, persistence
    - 1-1.67 feet of sediment = total seed burial, minimal recruitment, some persistence
    - 1.67-4 feet of sediment = no recruitment, long-term trend to riparian species
    - 4+ feet of sediment = no recruitment, long-term trend to riparian species

3.5 Locust Creek

This section describes the key assumptions specific to the Locust Creek focus study area. It also describes the anticipated FWOP condition.

3.5.1 Key Assumptions

- Future avulsions and log jams within the Locust Creek study area are likely but predicting where and when they may occur is difficult. The FWOP condition assumes the existing avulsion that diverts approximately 90-100% of Locust Creek flow to Higgins Ditch will remain in place.
- Higgins Ditch will continue to widen and degrade until it reaches a stable stream configuration. It is anticipated that Higgins Ditch would remain straight and channelized over the next 50 years because existing infrastructure and levees are assumed to be maintained.
- Locust Creek will continue to narrow and aggrade in adjustment to Muddy Creek flow and sediment loads but will remain low quality habitat for the majority of the period of analysis.

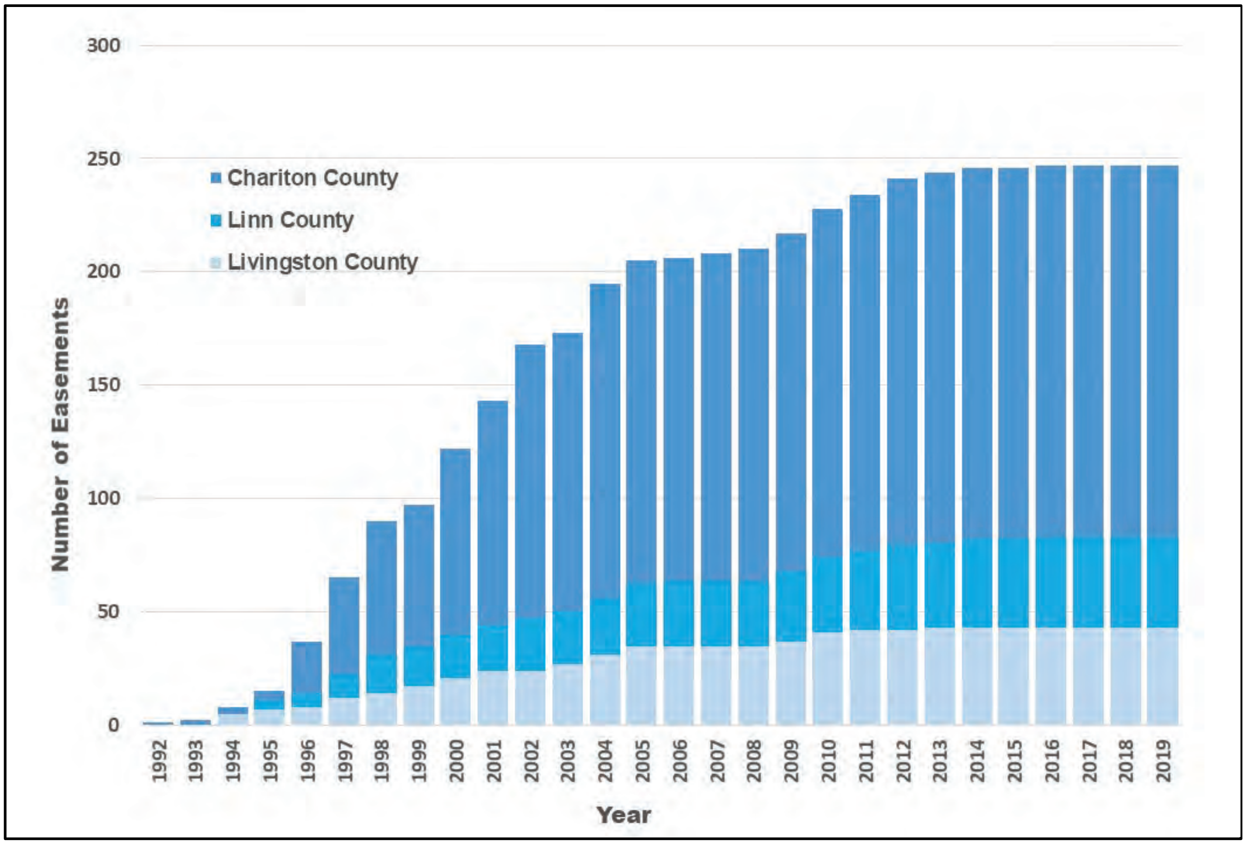

Figure 3-2. Trend in Wetland Reserve Program Easements, 1992 to 2019.

- Hickory Branch will continue to widen and deepen with headcuts that will provide additional sediment and logs to lower Locust Creek.
- The water table on the east side of Locust Creek will remain low or continue to drop resulting in continued negative impacts to existing wet prairie habitat.

3.5.2 Habitat Evaluation

Table 3-1 provides the modeled average sediment deposition amount in each Locust Creek terrestrial habitat tract by the end of 10, 25, and 50 years. Some habitat tracts were subdivided because the sediment behavior is significantly different within the tract. Figure 3-3 shows the average sediment deposition at the end of 50 years of simulation. The thresholds plotted in Figure 3-3 equate to habitat impairment thresholds. Floodplain deposition begins to affect forest productivity at 0.5 feet of depth over 50 years. Habitat degradation begins at 1.67 feet over 50 years. One foot of sediment deposition was viewed as a sustainable target. As seen in Figure 3-3, floodplain deposition well exceeds the recommended target for much of the region under the FWOP condition.

Based on degradation trends over the past 20 years and the results of sediment analysis, it can be expected that existing stands of bottomland hardmast forest within all of the study areas will continue to be impacted by inundation events and sedimentation under FWOP conditions. These impacts will reduce or eliminate hardmast recruitment and create conditions conducive for softmast riverfront forest species. As existing old growth hardmast trees die-off and seed sources are removed, only sporadic hardmast tree cover can be expected to remain in the study areas in the next 50 years.

Table 3-1. Floodplain Sediment Average Deposition by Habitat Tract under the FWOP.

Habitat Area	Area of Deposition (ac)	10 Years	25 Years	50 Years
LC1	3,864	0.06	0.15	0.30
LC3	1,035	0.06	0.16	0.32
LC2	713	0.34	0.86	1.71
LC6w	1,165	0.18	0.45	0.89
LC6e	497	0.06	0.15	0.31
LC4	686	0.94	2.36	4.72
LC5	1,345	0.58	1.45	2.90
LC7e	851	0.01	0.03	0.07
LC7w	443	1.06	2.65	5.30
LC7s	276	0.12	0.31	0.62
FG5n	3	0.77	1.93	3.87
FG5s	8	0.34	0.85	1.70
LC8n	1,393	0.12	0.31	0.62
LC8s	4,950	0.08	0.21	0.41

Note: Average Deposition at 10, 25, and 50 years in feet.

Existing emergent wetland and wet prairie habitats located south of HWY 36 in the Locust Creek study area will continue to receive excessive sediment, resulting in degradation and loss of many wetland features, similar to what has been observed in Pershing State Park. In high sedimentation areas shown on Figure 3-3, complete loss and conversion of wetland and wet prairie habitat is very likely. Under the FWOP, most of the existing quality habitat will convert to softmast riverfront species within the 50-year period of analysis.

The potential effects to aquatic riverine habitat were only assessed in the Locust Creek study area. The FWOP condition for the various aquatic tracts/reaches is highly dependent upon the existing quality of a given reach (i.e., channelized, constricted by levees, have adequate base flows) and the potential for future changes due to log jams, aggradation, and de-watering through avulsions. Due to the inability to accurately predict where or when the next log jam or avulsion might occur, future new avulsions were considered, but not modeled. In general, aquatic habitat quality varied over the 12 reaches that were assessed in the Locust Creek study area. Under the FWOP condition, some reaches remained relatively stable (i.e., ALC1, ALC5, ALC7); other reaches showed gradual increases in quality or initial decreases followed by increases as reach width, sinuosity, and depth evolved with changed flows (i.e., ALC2, ALC10); and many reaches had decreasing value over time due to degradation (i.e., ALC8, ALC9, ALC11) or had no habitat due to a lack of base flows (i.e., ALC3, ALC6).

Tables 3-2 and 3-3 summarize the average annual habitat units with the terrestrial and aquatic Locust Creek habitat tracts under the FWOP condition. Detailed information on H&H, sediment, and ecosystem modeling can be found in Appendices A, C, and D respectively.

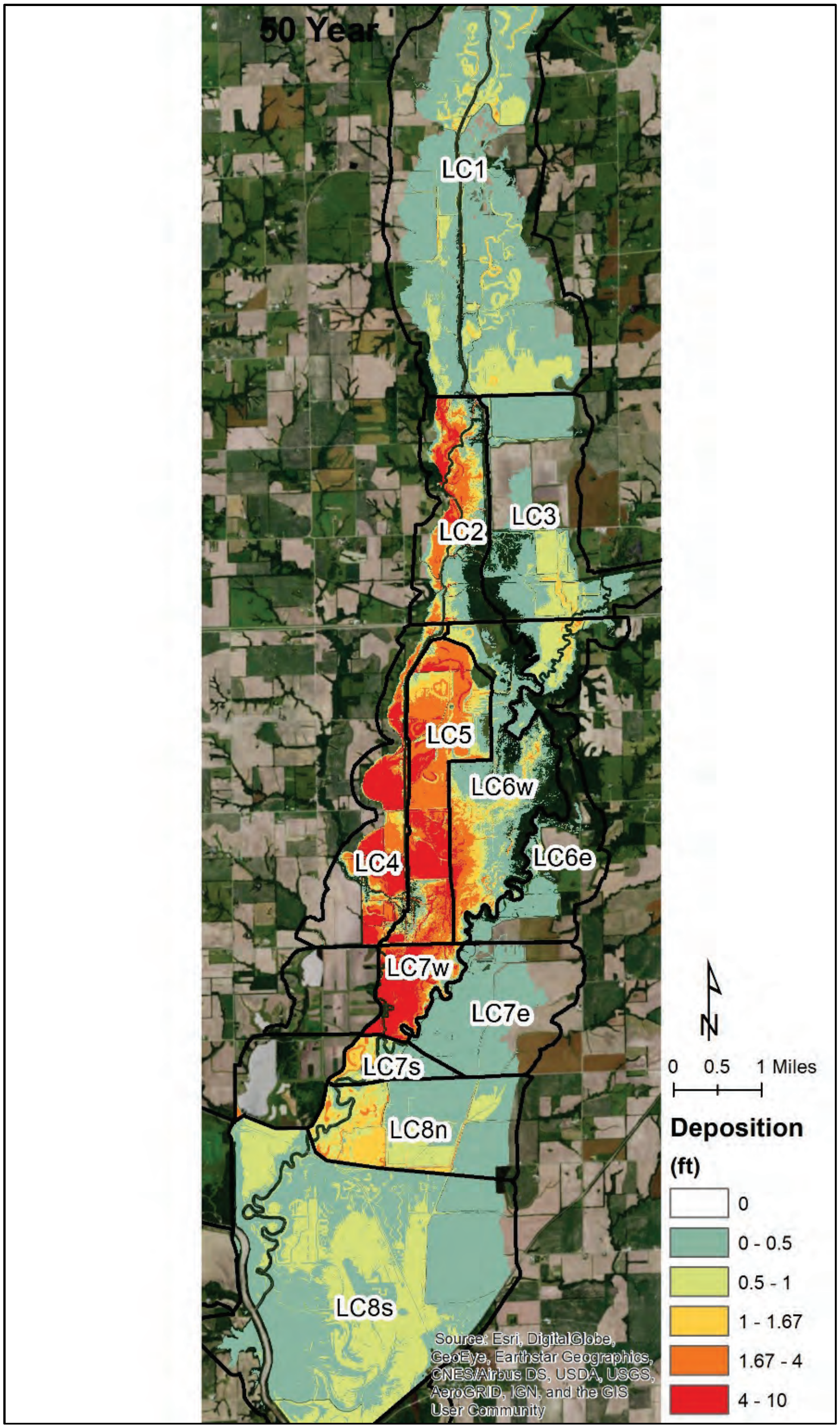

Figure 3-3. Modeled Floodplain Sediment Deposition over 50 years under FWOP*. Esri was source of basemap. Habitat tracts and deposition estimates were developed by USACE.*

Table 3-2. Average Annual Habitat Units by Locust Creek Terrestrial Habitat Tract under FWOP.

Tract	Wet Prairie Acres	Wet Prairie AAHUs	Emergent Wetland Acres	Emergent Wetland AAHUs	Bottomland Forest Acres	Bottomland Forest AAHUs
TLC1	0.0	0.0	290.7	147.1	1,028.4	560.9
TLC2	0.0	0.0	0.0	0.0	778.0	151.4
TLC3	0.0	0.0	6,736.0	134.7	483.9	251.0
TLC4	30.5	0.6	8,051.3	161.0	191.5	62.9
TLC5	2,310.4	46.2	11,666.8	233.3	97.7	12.7
TLC6	6,917.3	138.3	5,999.0	120.0	1,481.9	720.0
TLC7	164.0	3.3	2,379.4	47.6	553.9	215.7
TLC8	783.6	15.7	34,557.7	691.2	2,856.9	1,411.3
Totals:	10,205.8	204.1	69,680.9	1,534.9	7,472.2	3,385.9

Table 3-3. Average Annual Habitat Units by Locust Creek Aquatic Habitat Tract under FWOP.

Habitat Tract	Acres	AAHUs
ALC1	1,200.3	24.0
ALC2	363.8	7.3
ALC3	0.0	0.0
ALC4	0.0	0.0
ALC5	643.0	12.9
ALC6	0.0	0.0
ALC7	432.3	8.6
ALC8	705.6	14.1
ALC9	429.4	8.6
ALC10	1,660.0	33.2
ALC11	2,251.0	45.0
ALC12	0.0	0.0
Totals	7,685.4	153.7

3.6 Fountain Grove

This section describes the key assumptions specific to the Fountain Grove study area. It also describes the anticipated FWOP condition.

3.6.1 Key Assumptions

- Sediment will continue to deposit within Fountain Grove at a similar rate as to that observed in the past.
- Parsons Creek will likely avulse into the West Fountain Grove CA pools creating substantial operations and maintenance (O&M) costs and further degrading managed wetland habitat.
- The East Fountain Grove CA levee will breach within the next 25 years resulting in additional O&M costs and degraded managed wetland habitat.
- Existing private levees outside of Fountain Grove CA will be maintained over the period of analysis.

- Average drain time (i.e. the number of days it takes to remove excess flood water from the managed wetlands to a normal operating condition) was assumed to be representative of effects at Fountain Grove CA.

3.6.2 Habitat Evaluation

Figure 3-4 illustrates the forecasted drainage time at Fountain Grove CA for the FWOP and Figure 3-5 shows forecasted sediment deposition on the area, both of which were key in habitat evaluation. Managed wetland cells within Fountain Grove CA will continue to experience substantial degradation from Parsons Creek and Grand River sedimentation. However, due to the managed nature of wetland habitat at Fountain Grove CA, it is anticipated that the wetlands cells will remain, but will gradually decrease in habitat quality and quantity over time. As the ability to manage the system decreases, the ability to provide natural wetland form, function, and benefits for native plant and animal species also decreases. At some point, the degradation may become so substantial that it is no longer feasible to manage the area as a wetland system. MDC could have to reconsider the operational effectiveness of Fountain Grove CA's ability to continue to provide for benefits to migratory waterfowl. Table 3-4 summarizes the average annual habitat units with the terrestrial Fountain Grove habitat tracts under the FWOP condition. Aquatic tracts were not evaluated for Fountain Grove.

Table 3-4. Average Annual Habitat Units by Fountain Grove Terrestrial Habitat Tract under the Future without Project Condition.

Tract	Emergent Wetland Acres	Emergent Wetland AAHUs	Bottomland Forest Acres	Bottomland Forest AAHUs
TFG1	186.4	74.9	307.4	105.2
TFG2	362.8	155.3	1,074.0	316.2
TFG3	1,746.7	875.9	1,324.3	291.2
TFG4	108.9	42.0	1,022.8	670.1
TFG5	420.0	229.0	188.1	146.6
Totals:	2,824.8	1,377.1	3916.6	1,529.3

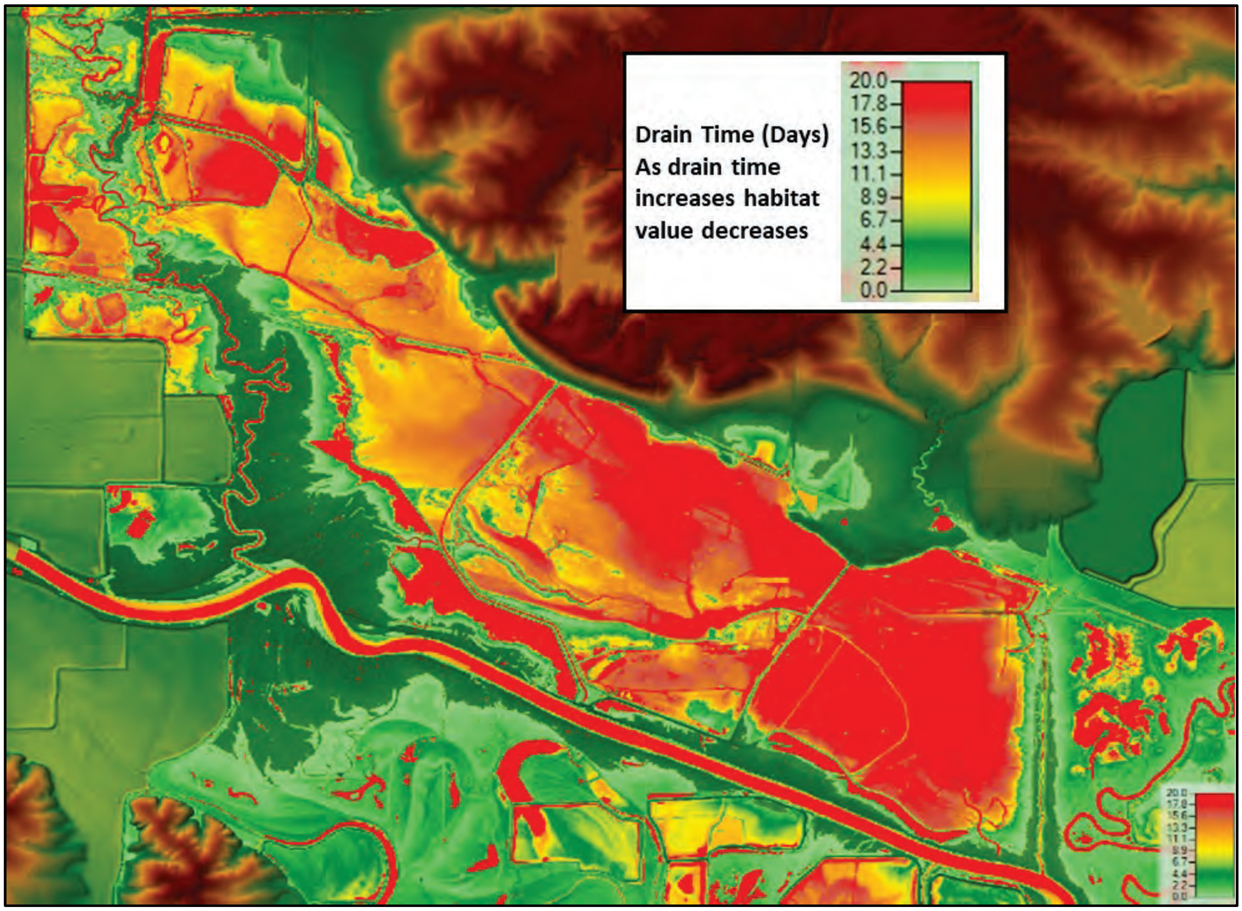

Figure 3-4. Modeled Drainage Time at Fountain Grove Conservation Area under FWOP Condition.

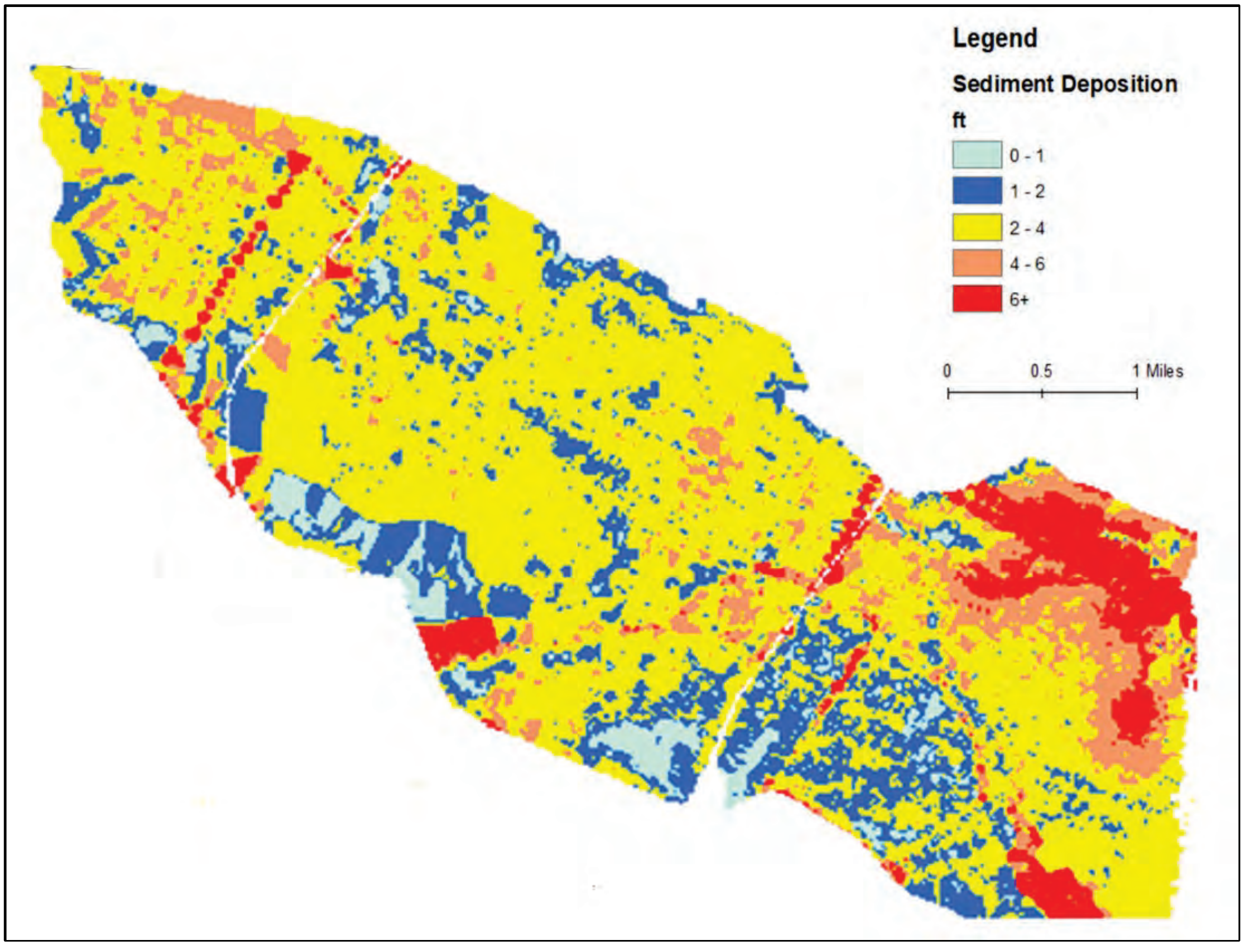

Figure 3-5. Forecasted Sediment Deposition at Fountain Grove Conservation Area under FWOP Condition.

3.7 Yellow Creek

This section describes the key assumptions specific to the Yellow Creek focus study area. It also describes the anticipated FWOP condition.

3.7.1 Key Assumptions

- It is assumed that private levees will remain in their existing alignment and height including current Swan Lake NWR levees.
- Under the FWOP condition, no levee set-back would occur over the period of analysis.
- Swan Lake NWR will continue to manage property to the best of their abilities within their budgetary constraints. However, flows from Yellow Creek will likely continue to impact NWR infrastructure and roads into the future, including degradation of high-quality pin oak flats.
- Floodplain inundation in wet prairie and emergent wetlands affects those habitats as follows (based on best professional judgment and scientific literature review)
  - 0 days (at 0-foot depth) = Bad (wetlands are not receiving water)
  - 0-32 days (at 0-0.5-foot depth) = Fair (receiving some water, but less than 0.5 ft)
  - 0-7 days (above 0.5-foot depth) = Good (receiving more than 0.5 feet of water)
  - 7-14 days (above 0.5-foot depth) = Good (receiving more than 0.5 feet of water)
  - 14-32 days (above 0.5-foot depth) = Good (receiving more than 0.5 feet of water)

- Floodplain inundation in bottomland hardmast forests affects that habitat as follows (based on best professional judgment and scientific literature review)
  - o 0 days (at 0-foot depth) = Good (normal, no impact to recruitment)
  - o 0-32 days (at 0-0.5-foot depth) = Good (< 0.5 foot depth so duration is not critical)
  - o 0-7 days (> 0.5-foot depth) = Fair (> 0.5 foot depth, but < 14 days, minor impact)
  - o 7-14 days (> 0.5-foot depth) = Fair (> 0.5 foot depth, but < 14 days, minor impact)
  - o 14-32 days (> 0.5-foot depth) = Bad (total recruitment failure)

3.7.2 Habitat Evaluation

Existing stands of bottomland hardmast forest within all of the study area will continue to be impacted by inundation events and sedimentation under FWOP conditions. Wetland and wet prairie habitat within the Yellow Creek study area will be impacted from inundation and sedimentation into the future resulting in a gradual reduction in habitat quality over time. Table 3-5 summarizes the average annual habitat units with the terrestrial Yellow Creek habitat tracts under the FWOP condition. Aquatic tracts were not evaluated for Yellow Creek.

Table 3-5. Average Annual Habitat Units by Yellow Creek Terrestrial Habitat Tract under FWOP.

Tract	Wet Prairie Acres	Wet Prairie AAHUs	Emergent Wetland Acres	Emergent Wetland AAHUs	Bottomland Forest Acres	Bottomland Forest AAHUs
TYC1	147.8	47.2	1,219.0	617.4	4,728.1	1,598.6
TYC2	15.5	13.1	419.1	293.8	333.3	126.9
TYC3	0.0	0.0	275.4	127.8	1,947.5	1,068.3
TYC4	33.8	28.1	375.1	263.0	110.1	36.4
TYC5	0.0	0.0	661.5	412.9	152.7	96.2
TYC6	0.0	0.0	408.7	243.1	79.8	5.9
TYC7	0.0	0.0	47.0	27.8	258.2	118.8
TYC8	0.0	0.0	165.4	81.7	171.7	7.1
TYC9	0.0	0.0	249.1	135.7	1,854.7	473.1
TYC10	0.0	0.0	7.6	0.9	12.7	0.3
TYC11	0.0	0.0	708.8	449.9	1,888.8	819.3
TYC12	0.0	0.0	2,947.9	2,067.0	720.7	227.7
Totals:	197.1	88.4	7,484.6	4,721.0	12,258.3	4,578.6

4.0 Formulation and Evaluation of Alternative Plans

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. USACE guidance for planning studies requires the systematic formulation of alternative plans that contribute to the federal objective. The terms “plan”, “alternative”, and “alternative plan” all mean the same thing in the context of this report. The USACE objective in ecosystem restoration planning is to contribute to NER. Contributions to NER are increases in the net quantity and/or quality of desired ecosystem resources. To ensure that sound decisions are made with respect to development of alternatives and ultimately with respect to plan selection, the plan formulation process requires a systematic approach to the formulation, comparison, and selection of plans. This chapter presents the results of the plan formulation process.

4.1 Plan Formulation Process

The study team followed the USACE’s Six-Step Plan Formulation Process to develop, evaluate, and compare the array of potential alternatives that could solve the identified problems. The following six steps were undertaken and are described elsewhere as indicated:

1. Specify problems and opportunities relevant to the study area. Identify planning constraints and establish planning objectives (Chapters 1 and 4).
2. Inventory and forecast conditions. Identify and document existing and FWOP conditions (Chapters 2 and 3).
3. Formulate alternative plans. Develop alternatives comprising differing sets of measures to address the identified problems and planning objectives for ecosystem restoration (Chapter 4). Separate public input in this process was sought through a public involvement program (Chapter 7).
4. Evaluate alternative plans. Evaluate each of the ecosystem restoration alternatives derived from Step 3 for overall effectiveness, efficiency, completeness, and acceptability (Chapters 4 and 5).
5. Compare alternative plans. Compare each of the ecosystem restoration alternatives in terms of cost effectiveness (Chapters 4) and other considerations. Cost effectiveness and incremental cost analysis (CE/ICA) modeling was used to prioritize and rank ecosystem restoration alternatives.
6. Select recommended plan. Based on the information and results from the previous steps, select recommended plan for ecosystem restoration (Chapter 4 and 6). Prepare documentation to justify the plan selection.

The study area was divided into three geographic areas for plan formulation: Locust Creek, Fountain Grove, and Yellow Creek. This approach was taken because different solutions are needed to address the identified problems in each area. For example, Fountain Grove CA is an intensively managed area with existing infrastructure and as a result the types of measures that would be combined to address the problem at this geographic area are different from other locations in the study area.

4.2 Study Technical Team

At the beginning of the study, a technical team was convened that included approximately fifty representatives from MoDNR, MDC, MoDOT, USFWS, NRCS, USACE, EPA, and USGS. The technical team comprised expertise in wetland science, aquatic ecosystems, fisheries, wildlife, land management, sediment, hydrology and hydraulics, soil science, water resources engineering, civil engineering, real estate, natural resources planning, water quality, and economics. The team met bi-weekly or weekly during the entire plan formulation process. The knowledge and expertise of the technical team represented the best professional judgment regarding the resources, problems, and potential solutions in the study area. The technical team informed the development of goals, objectives, constraints, identification of management measures, development of alternative plans, ecosystem benefits evaluation, and comparison of alternative plans.

4.3 Planning Goals and Objectives

Study goals were items the study team (i.e. USACE, local sponsors, and partners) aimed to achieve through the planning process. Project goals were items that the formulated plans aim to achieve. Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the identified opportunities.

4.3.1 Study Goals

The following study goals were identified with the study partners:

1. Identify a recommended plan that maximizes ecosystem benefits (given costs) and capitalizes on opportunities to provide holistic solutions to the benefit of watershed stakeholders.
2. Investigate problems and develop solutions for excessive sedimentation affecting Locust Creek, Pershing State Park, Fountain Grove CA, Yellow Creek CA, and nearby public and private conservation lands.
3. Evaluate the feasibility of a comprehensive suite of measures to address identified problems and improve aquatic and wetland habitat in the Lower Grand River watershed including measures to improve connectivity and flow conveyance, reduce sedimentation, increase stream meander, and alleviate the impacts of excessive large woody debris transport and accumulation.
4. Identify potential improvements to the hydraulic and sediment carrying functionality of Locust Creek from its headwater to its confluence with the Grand River, including solutions to the diversion of flow from Locust Creek to Higgins Ditch in the vicinity of Pershing State Park.
5. Identify measures to improve wetland, wet prairie, riparian, and in-stream aquatic habitats in the Lower Grand River watershed "Golden Triangle" area.
6. Build on recent public engagement and partnership efforts in the Lower Grand River watershed to provide awareness and understanding, solicit input, and generate support from local partners.

4.3.2 Project Goals

Project goals were identified based on problems, needs, and opportunities present in the study area. Two broad project goals were used to guide the formulation of alternatives. Goal #2 will be achieved to the maximum extent practicable and so long as it is consistent with Goal #1.

- **Goal #1**: Increase quality and quantity of bottomland forest, in-stream aquatic habitat, wet prairie, and other wetlands in the Lower Grand River watershed for at least the next 50 years.
- **Goal #2**: Realize additional benefits to critical infrastructure, agriculture, water quality, recreation, and/or flood risk reduction in association with wetland and aquatic habitat improvement within the Lower Grand River Basin for at least the next 50 years.

4.3.3 Planning Objectives

The planning objectives were developed for each geographic area that was a focus of formulation. The planning objectives for each site were used to evaluate and screen alternatives.

4.3.3.1 Locust Creek

- Improve hydraulic conveyance in Locust Creek while maintaining floodplain connectivity.
  - Metric: Flow path and inundation extent
    - Ideal: Restore baseflow to Locust Creek while allowing floodplain inundation on key habitats (approximately 5,000-6,000 cfs bankfull capacity).
    - Acceptable: Occasional flow in Locust Creek with limited floodplain inundation on key habitats.

- Reduce floodplain sediment deposition leading to habitat degradation.
  - Metric: Sediment deposition over 50 years in wet prairie and emergent wetland habitat
    - 0.0-0.5 feet = normal, no habitat impact
    - 0.5-1 feet = loss of habitat quality/seed burial
    - 1.0-1.67 feet = loss of habitat quality/habitat conversion
    - 1.67-4.0 feet = additional loss of habitat quality/additional habitat conversion
    - ≥ 4.0 feet = total loss of wetland habitat/conversion to terrestrial and riparian habitats
  - Metric: Sediment deposition over 50 years in bottomland hardmast habitat
    - 0.0-0.5 feet = normal, no habitat impact
    - 0.5-1.0 feet = some seed burial, decreased recruitment, persistence
    - 1.0-1.67 feet = total seed burial, minimal recruitment, some persistence
    - 1.67-4.0 feet = no recruitment, long-term trend to riparian species
    - ≥ 4.0 feet = no recruitment, long-term trend to riparian species
- Reduce accumulation of large woody debris
  - Metric: Qualitative assessment of high-risk locations for woody debris accumulation and increased potential for stream channel avulsions and impacts to habitats or private property.
    - Acceptable: reduced potential for avulsions and negative effects to habitats and private property relative to the FWOP condition.
    - Unacceptable – no measurable change or increased potential for avulsions and negative effects to habitats and private property relative to the FWOP condition.

4.3.3.2 Fountain Grove

- Increase wetland habitat form and function on East, West, and South Fountain Grove CA:
  - Metric: habitat units
- Improve resiliency of Fountain Grove CA wetlands units:
  - Metric average drain time by pool for west side after Grand River recedes:
    - 0-4 days = Ideal, no negative habitat impacts
    - 4-8 days = Good, minor habitat impacts
    - 8-12 days = Acceptable, minor to moderate negative habitat impacts
    - 12-16 days = Negative, moderate to severe habitat impacts
    - >16 days = Unacceptable, negative habitat impacts
  - Metric: protection from flooding on east side for study period
    - Acceptable, site unlikely to experience major unpredictable flooding, only minor flooding with ability to rebound readily
    - Unacceptable, site vulnerable to catastrophic headwater Locust Creek flooding
  - Metric: independent fill and drain ability for pools on west side
    - Ideal, all pools able to fill and drain independently

    - Acceptable, all pools able to fill or drain independently
    - Unacceptable, no pools able to fill and drain independently
- Reduce sedimentation on Fountain Grove CA over the project life
  - Metric: Sediment deposition over 50 years on West Fountain Grove CA
    - 0-1 feet = Ideal, normal, no impact to habitat
    - 1-2 feet = Good, some seed burial loss of habitat quality, some habitat conversion
    - 4-6 feet = Negative, additional loss of habitat quality, additional habitat conversion
    - 6+ feet = Unacceptable, total loss of wetland habitat and conversion to terrestrial and riparian

4.3.3.3 Yellow Creek

- Reduce backwater effects at the lower Grand River/Yellow Creek confluence that are driving degradation of nearby bottomland hardwoods, wetlands, agricultural lands, and Swan Lake NWR
  - Wet Prairie and Emergent Wetlands Metric: Duration and Depth of Inundation
    - 0 days (at 0 foot depth) = Bad; wetlands are not receiving water
    - 0-32 days (at 0-0.5 foot depth) = Fair; wetlands receiving some water
    - 0-7 days (above 0.5 foot depth) = Good; wetlands receiving adequate water
    - 7-14 days (above 0.5 foot depth) = Good; wetlands receiving adequate water
    - 14-32 days (above 0.5 foot depth) = Good; wetlands receiving adequate water
  - Bottomland Hardmast Forest Metric: Duration and Depth of Inundation
    - 0 days (at 0 foot depth) = Good; normal, no impact to recruitment
    - 0-32 days (at 0-0.5 foot depth) = Good; below 0.5 feet depth, duration is not critical
    - 0-7 days (above 0.5 foot depth) = Fair; above 0.5 feet depth, but below 14 days, minor impact
    - 7-14 days (above 0.5 foot depth) = Fair; above 0.5 feet depth, but below 14 days, minor impact
    - 14-32 days (above 0.5 foot depth) = Bad; total recruitment failure
- Reduce sedimentation effects along Yellow Creek degrading nearby bottomland hardwoods and wetlands
  - Metric: Sediment deposition over 50 years in bottomland hardmast habitat:
    - 0-0.5 feet = normal, no impact to habitat
    - 0.5-1 feet = some seed burial, decreased recruitment, persistence
    - 1-1.67 feet = total seed burial, minimal recruitment, some persistence
    - 1.67-4 feet = no recruitment, long-term trend to riparian species
    - 4+ feet = no recruitment, long-term trend to riparian species
  - Metric: Sediment deposition over 50 years in wetland habitat:
    - 0-0.5 feet = normal, no impact to habitat

- 0.5-1 feet = some seed burial, loss of habitat quality
- 1-1.67 feet = loss of habitat quality, some habitat conversion
- 1.67-4 feet = additional loss of habitat quality, additional habitat conversion
- 4+ feet = total loss of wetland habitat and conversion to terrestrial and riparian.

4.4 Planning Constraints and Considerations

4.4.1 Constraints

Constraints are significant barriers or restrictions that limit the extent of the planning process. Plans are formulated to meet the planning objectives and to avoid violating the constraints. Two constraints were identified for this study:

- Alternative plans should not increase flood risk on private landowners without the ability to feasibly mitigate the impacts.
- Alternative plans should not increase the risk to bridges, roads, and other infrastructure or maintenance needs compared to what would be expected under the FWOP.

4.4.2 Considerations

Considerations are those issues or matters that should be taken into account during the planning process, but do not necessarily limit the extent of the process as do constraints. Considerations taken into account during plan formulation for the study included:

- Seek to maintain or enhance habitats of importance (e.g. the existing remnant wet prairie adjacent to Locust Creek) at Pershing State park (Figure 4-1)

4.5 Conceptual Ecological Model

Conceptual ecological models (CEMs) are graphical depictions of an ecosystem that are used to communicate the important components of the system and their relationships. They are a representation of the current scientific understanding of how the system works. The Grand River CEM depicts the drivers, ecological stressors, ecological effects and attributes of relevance to the scope of the study (Figure 4-2). Drivers represent the natural or anthropogenic factors leading to ecosystem alteration (i.e. sources of stress). Drivers cause ecological stressors, which adversely affect the ecosystem condition in the study area. Attributes serve as key indicators of success towards ecosystem benefits through assessment of related performance measures. The CEM was developed by the PDT in cooperation with a technical team that included representatives from MoDNR, MDC, MoDOT, NRCS, USFWS, USGS, and USFWS. Measures identified for plan formulation should address one or more stressors identified in the CEM.

4.6 Formulation of Measures

Measures are the building blocks of alternatives. The management measures identified consist of activities or features that can be implemented at specific locations to solve specific problems or address one or more planning objectives. Measures were initially developed at a plan formulation workshop held in June 2017. Participants at the workshop assessed each measure and identified the focused study area where the measure may be applicable. The following management measures were identified during the plan formulation process. Measures that could be effective at addressing the identified problems but are not within the scope of actions that USACE could implement are discussed in Section 5.19. Those actions are within the scope of activities that could be undertaken by the study partners.

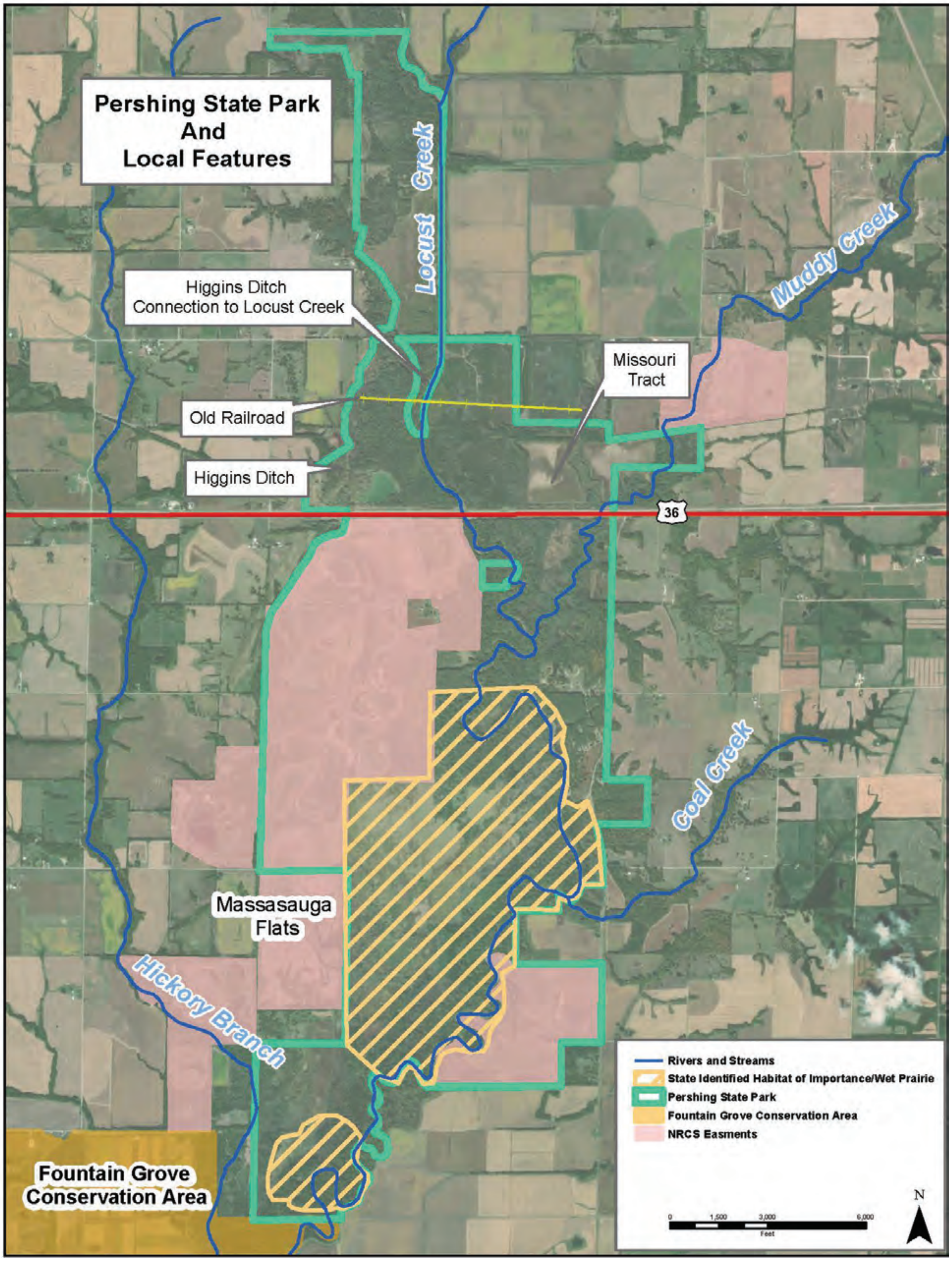

Figure 4-1. Key Features of Pershing State Park.

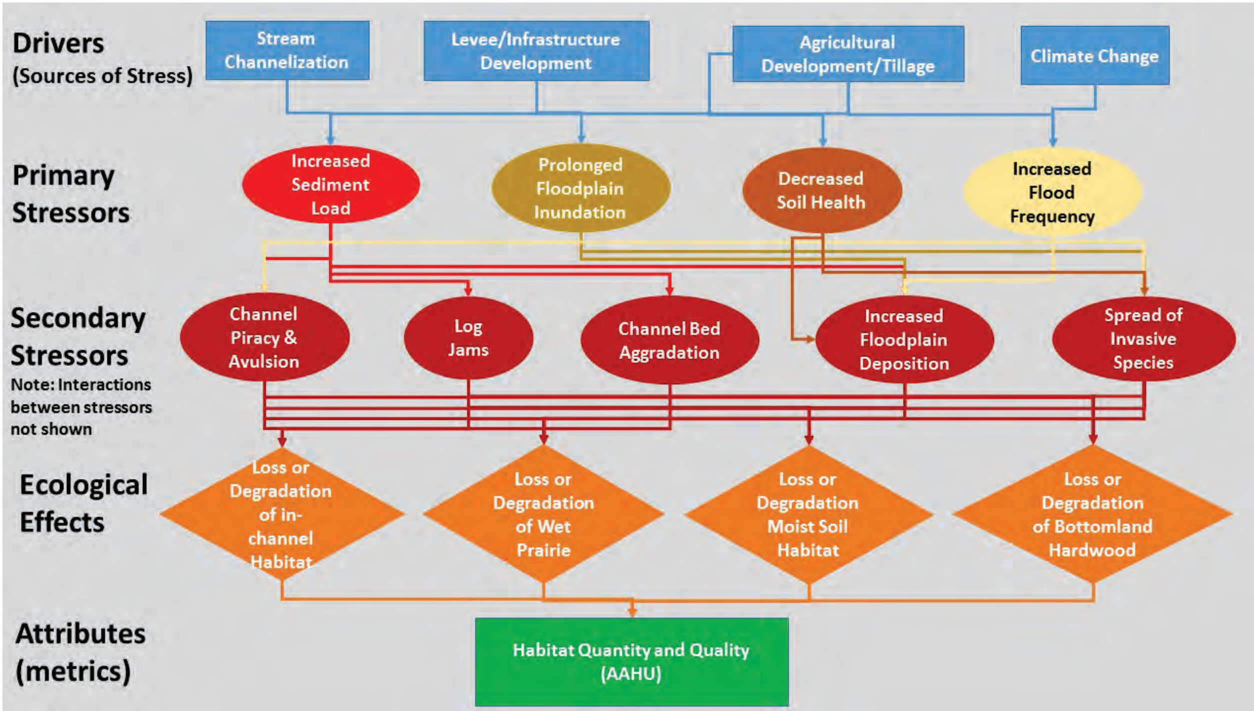

Figure 4-2. Grand River Conceptual Ecological Model.

4.6.1 Bank stabilization

Bank stabilization projects were considered as a measure primarily in the upper watershed, upstream of HWY 36 on Locust Creek and its tributaries as a means of reducing sediment load downstream. However, the measure was also considered for strategic locations at Fountain Grove and Locust Creek to address localized problems. One or more techniques are implemented at a location to halt erosion of a streambank. The most appropriate and effective technique(s) depends on a variety of factors determined by the hydrologic and hydraulic conditions at the point of interest. Factors include the nature of the erosion problem (e.g. gullying, stream flow scour, slope failure, etc.), hydraulic characteristics (i.e. velocities and boundary shear stress), and the spatial extent of the problem. Bank stabilization techniques typically fall into one of two categories: conventional hard protection or soil bioengineering. Conventional hard protection incorporates rock or stone to either armor the eroding bank, prevent erosion of the bank by deflecting the current away from the bank, or reducing the erosive capability within the channel. Longitudinal peak stone toe protection (LPSTP), revetments, bendway weirs, and baffle/tiebacks are examples of conventional hard protection techniques. Soil bioengineering techniques are often considered “soft fixes” because they incorporate vegetative material. Examples include branch packing, brush layering, brush mattress, dormant post-plantings, live cribwalls, live fascines, live post, live stakes, root wads, tree or log revetments, and vegetated geogrids. Bank stabilization projects typically incorporate multiple techniques.

Bank stabilization projects typically involve re-sloping the upper bank. It is typically desired to limit the use of rock to the toe of the bank using LPSTP. Soil bioengineering techniques can then be incorporated into the LPSTP and the upper bank revegetated with native species.

4.6.2 Sediment and Woody Debris Catchment

This measure consists of capturing and controlling the distribution of sediment and woody debris (e.g. tree logs). It could include in-stream sediment retention (e.g. debris rack or trap) or from floodwaters in the floodplain. Capturing sediment and woody debris can be accomplished in floodplains where levees do not exist or have been breached or removed. Controlling sediment and woody debris distribution is important in maximizing capture through controlled movement of floodwater. Access (e.g. roads) is required to clear out the trapped sediment and woody debris as necessary. Specific variations of this measure that were considered include:

- In-stream sediment retention with removal
- Log-jam removal using currently employed techniques
- Log interception above Linneus, MO
- Log interception above HWY 36
- Sediment removal structure
- Sediment detention basin

4.6.3 Grade Control Structures/Engineered Rock Riffles

This measure consists of preventing the progression of stream bed erosion (head cutting) with channel grade control structures such as an engineered rock riffles (i.e. Newbury riffle or structure). The measure reduces channel bank erosion, gully erosion, the loss of farmland soils, and helps prevent damages and loss to bridges, culverts and pipeline crossings. Grade control was considered within the upper watershed north of HWY 36, but also in strategic locations within the Locust Creek/Pershing State Park study area, such as on Higgins Ditch.

4.6.4 Water Control Structures

Water control structures are used to convey water, control the direction or rate of flow of water, or maintain a desired water surface elevation. Examples include culverts, weirs, flap gates, and pumps.

4.6.5 Earthwork for Habitat Restoration or Flow Conveyance

Earthwork includes the movement of dirt by mechanical means for the purpose of creating micro-topography or other features (e.g. berms) intended to benefit the restoration of targeted habitat types. It could also include excavation of flow conveyance channels for the purposes of directing water for habitat management. Berms are similar to levees but smaller in size and not generally constructed for the purpose of flood protection. This measure is applicable at the Locust Creek and Fountain Grove study areas. Micro-topography is small variations in ground surface elevations. Such features are important to maintain a diversity of wetland vegetation and different species have different tolerance for length of being inundated. There are several old railroad berms in the study areas, and removal of portions of these to facilitate flow conveyance or other habitat purposes is included under this measure.

4.6.6 Native Species Plantings

This measure includes soil preparation and planting with native seeds or saplings to restore desired terrestrial habitat types.

4.6.7 Stream Restoration and Channel Realignment

The stream restoration measure consists of creating or restoring stream functions, either partially or fully, on degraded or channelized streams. Functional results of stream restoration are reduced or eliminated bank and bed erosion, improved stream habitat, and water quality improvements. Channel realignment consists of creating or restoring a natural stream alignment on channelized reaches of stream channels back into a more sinuous plan form. Bank reconstruction and bioengineering is often associated with channel re-alignment. Specific variations of this measure that were considered include:

- Connecting Higgins Ditch to Locust Creek
- Realign and improve Higgins Ditch
- Filling Higgins Ditch to facilitate restoring flow to Locust Creek

- Redirecting Locust Creek flows that are being diverted to Higgins Ditch into Muddy Creek

4.6.8 Dredging

Dredging is the removal of sediments and debris from the bottom of streams or rivers. It is carried out by mechanical means using a hydraulic dredge. The dredged material must be disposed of in some other location. Different variations of this measure were considered for use on Locust Creek or associated tributaries.

4.6.9 Levee modification or construction

Levee modification includes raising or lowering an existing levee, setting back a levee, or notching/breeching a levee. Levee construction means building new sections of levee. A levee raise includes adding material to an existing levee to increase its height, which also increases its total footprint. This is done to increase the level of protection for the area inside the levee. Levee setbacks consist of relocating large sections of levee adjacent to a stream to allow floodwater inundation, sediment deposition, potential reduced peak flood and flow and related damages, wetland development, water quality and groundwater recharge. A levee setback relocates the levee in the same vicinity to continue providing flood protection to adjacent property that otherwise would not be protected. A levee notch/breech consists of removing small section(s) of levee adjacent to a stream or river to allow floodwater inundation, sediment deposition, potential reduced peak flows and related damages, woody debris deposition, and wetland development. Some variation of this management measure is applicable at all three focused study areas. Within the Locust Creek area, this measure may include construction of levees to prevent Locust Creek flows from diverting to Higgins Ditch, or raising or lowering existing levees to more efficiently manage flood flows. Variations of this measure include constructing a levee to separate Higgins Ditch from Locust Creek and filling openings in a natural levee that occurs between Locust Creek and Higgins Ditch. At Fountain Grove CA this measure would be considered for keeping floodwaters carrying sediment off the site. At Yellow Creek, levee setbacks are considered to alleviate prolonged inundation that prevents regeneration of bottomland hardwood tree species.

4.6.10 Reservoir/Dams

A dam is defined as an artificial barrier, constructed for the purpose of storage, control, or diversion of water which is (1) twenty-five feet or more in height or (2) has an impounding capacity at maximum water stage elevation not in excess of fifteen acre-feet (ER 1110-2-1156). This measure was also considered to a smaller degree on streams throughout the upper watershed to create a series of miniature dams for sediment reduction.

4.7 Alternative Plan Development

Alternative plans (i.e. alternatives) are a set of one or more management measures functioning together to address one or more planning objectives. Alternatives were developed and evaluated for Locust Creek, Fountain Grove, and Yellow Creek separately. This approach to alternatives development was taken because:

1. Each focused study area is in a different sub-watershed (i.e. HUC 10) and is positioned at a different location within the larger Locust Creek sub-basin (HUC 8).
2. Due to their location in the watershed, each area experiences the problems differently and as a result the extent or progression of ecosystem degradation varies by area. For example, the Locust Creek area is located furthest upstream in the sub-basin of the three areas. The symptoms of the problems at Locust Creek have included avulsions, log jams, and excessive sediment deposition. In the Yellow Creek area, located furthest downstream in the sub-basin, avulsions have yet to occur, however it is possible they may occur in the future. The Yellow Creek area also experiences much more influence of the Grand River due to its location at the confluence of the Grand River and Yellow Creek.

3. The main public land area in each study area is owned by a different resource agency and therefore have different management objectives.
4. The key habitats differ by study area and as a result so do the planning objectives for each area.
5. Each area represents a separately justifiable plan that could result in ecosystem benefits without being dependent on acting in the other areas.

As part of formulating the initial array of alternative plans for each study area, measures that would be dependent on the implementation of another measure were grouped together. The following sections summarize the initial and final array of alternatives for each geographic area, including how the initial array of alternatives were screened (i.e. determining alternative plans to remove from further consideration).

4.7.1 Initial Array of Alternatives and Screening

The technical team worked to combine the management measure identified into an initial array of alternatives for each study area. This formulation involved identifying specific locations within each study area where a measure could be applied. Formulating the initial array was an iterative process that resulted in the identification of 26 alternative plans for Locust Creek, over 50 alternative plans for Fountain Grove, and 13 alternative plans for Yellow Creek.

The initial array of alternatives was evaluated using the four criteria established in the Principles and Guidelines (U.S. Water Resources Council 1983): effectiveness, completeness, efficiency, and acceptability.

- **Effectiveness** is the extent to which an alternative plan alleviates specified problems and achieves opportunities.
- **Completeness** is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.
- **Efficiency** is "the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment." Cost effectiveness analysis answers the question: "Does the alternative plan accomplish the objectives for the least cost?"
- **Acceptability** is the workability of a plan with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and policies.

Consistent with a risk-informed planning approach and in consideration of the number of alternatives formulated, the initial array was screened based on the best professional judgment of the technical team rather than through quantification of the evaluation criteria for every alternative.

Table 4-1 through 4-3 summarize the initial array alternative plans that were screened from further consideration. The alternative plans that remained were carried forward to the final array and are discussed in the next section. Appendix G, Plan Formulation and CE/ICA, provides more detailed descriptions of all of the alternatives considered during the plan formulation process.

Table 4-1. Locust Creek Alternatives Screened from Further Consideration.

Alternative	Description	Reason for Screening
Locust Creek – Alternative 1	Construct a structural barrier to block Higgins Ditch flows from diverting into Hickory Branch in the lower portion of Pershing State Park. Excavate a new channel that connects Higgins Ditch to Locust Creek across Pershing State Park.	Alternative is not effective at reducing sedimentation or addressing large woody debris.
Locust Creek – Alternative 2	Construct a new meandering channel on the floodplain to the west of Locust Creek and south of HWY 36 that would capture Higgins Ditch flows. Connect the southern end of the new stream channel to Locust Creek. Spoil from excavation would be used to partially fill Higgins Ditch and to build habitat berms in the vicinity. The lower portion of Locust Creek would be dredged to improve flow capacity of that channel.	Alternative is not effective at reducing sedimentation or addressing large woody debris. Construction would result in unacceptable impacts to Locust Creek aquatic habitat.
Locust Creek – Alternative 2.2	Create meandering channel on the low ground on west side of the floodplain south of HWY 36 to slow down water and create a more natural evolving aquatic system.	Alternative is not effective at reducing sedimentation or addressing large woody debris.
Locust Creek – Alternative 3.1	Large Muddy Creek sediment detention basin with full capacity channel	Less effective and efficient than similar alternative (LC3).
Locust Creek – Alternative 4 and 4.1	Construct a levee or berm beginning north of HWY 36 and likely extending south to the wet prairie area in Pershing State Park for the purpose of blocking Locust Creek flows from diverting into Higgins Ditch. The existing Locust Creek channel would be dredged to partially or fully restore its flow conveyance capacity. LC 4 included a partial dredge of Locust Creek and LC 4.1 included a full dredge of Locust Creek.	Alternative is not effective at reducing sedimentation or addressing large woody debris. Unacceptable amount of risk and uncertainty regarding achieving desired outcomes. Potential for unacceptable adverse impacts to existing habitat as a result of construction.
Locust Creek – Alternative 5	This alternative was the same as Alternative 4, except that the dredging of Locust Creek would be limited to a pilot channel with the assumption that once flow is restored to the stream, it would self-scour the channel to restore flow capacity.	Alternative is not effective at reducing sedimentation or addressing large woody debris.. Potential for unacceptable adverse impacts to existing habitat.
Locust Creek – Alternative 6	Fill in Higgins Ditch	Not effective at reducing sediment deposition or improving habitat.
Locust Creek – Alternative 7	Construct a sediment detention basin east of Locust Creek and north of HWY 36. A deflection berm would be constructed to divert flows into the basin. A meandering channel would be excavated through the detention basin that would connect to Muddy Creek. Additional excavation and dredging would be performed as necessary to ensure flows could be restored to Locust Creek. A meandering channel would be constructed on the west floodplain and Higgins Ditch partially filled similar to that described for Alternative 2.	The addition of a meandering channel along Higgins Ditch would not likely provide additional habitat benefits beyond alternatives that include the east side sediment detention basin and restoring flows to Locust Creek therefore would not be cost effective
Locust Creek – Alternative 8	Construct a levee or berm beginning north of HWY 36 and likely extending south to the wet prairie area in Pershing State Park for the purpose of blocking Locust Creek flows from diverting into Higgins Ditch. Use the existing Dobbins Notch as access to a sediment and log capture area and to route flows back to Locust Creek via Muddy Creek. Dredge Locust Creek and Muddy Creek as necessary to ensure flow conveyance can be restored.	Alternative is not effective at reducing sedimentation or addressing large woody debris. It's technical feasibility depends on the remaining capacity at Dobbins Notch.
Locust Creek – Alternative 9	Construct a reservoir at Linneus, MO.	Would not be effective at increasing habitat. Unacceptable level of habitat impacts..

Alternative	Description	Reason for Screening
Locust Creek – Alternative 10	This alternative combines a small sediment and log detention basin (compared to that under Alternative 3) with upstream actions to reduce sediment load (e.g. bank stabilization).	Not considered cost effective.
Locust Creek – Alternative 11	Dredging of Locust Creek below the Muddy Creek confluence to remove the 'slug' of sediment that has accumulated in this area to improve the slope and sediment conveyance. Spoil would be used to create sheet-flow berms along the west bank to fill avulsions and reduce likelihood of a pirate channel developing. Remaining spoil used to create habitat features. Includes modifications to connect Higgins Ditch and Locust Creek.	Alternative is not effective at reducing sedimentation or addressing large woody debris
Locust Creek – Alternative 12	Same as LC 3, with the addition of upstream bank stabilization projects of a magnitude to achieve a 25% reduction in sediment loading.	Not as effective or efficient as other similar alternatives.
Locust Creek – Alternative 13	Use Zell Tract on Pershing State Park as a sediment detention basin.	Not as effective or efficient as other similar alternatives.
Locust Creek – Alternative 14	Pump water from Higgins Ditch to the wet prairie on Pershing State Park	Alternative is not effective at reducing sedimentation or addressing large woody debris.
Locust Creek – Alternative 15.1	Constructs a floodplain weir north of HWY 36 across the entire floodplain to allow the full floodplain north of the area to retain sediment.	Unacceptable risk to HWY 36 infrastructure if the structure were to fail. Potential to be classified as a dam, which would significantly increase cost and analysis required.
Locust Creek – Alternative 16	Create sediment trap on Higgins Ditch	Alternative is not effective at reducing sedimentation or addressing large woody debris.
Locust Creek – Alternative 17	Construct a full floodplain sediment detention basin at HWY 36.	Unacceptable risk to HWY 36 infrastructure if the structure were to fail. Potential to be classified as a dam, which would significantly increase cost and analysis required.
Locust Creek – Alternative 19	Remove all levees to the east of Locust Creek above HWY 36, acquire all property and allow flows to go where they want.	Very high uncertainty as to effectiveness in achieving objectives, costs would be exorbitant, potential to have unacceptable adverse impacts to existing habitats.

Table 4-2. Fountain Grove Alternatives Screened from Further Consideration.

Alternative	Description	Reason for Screening
Fountain Grove – Alternative 4	Combines both the WCS modifications from Alternative 3 and adds creation of a levee from north to south on the west side of Fountain Grove CA where Parsons Creek flows currently enter the site and removal of the levee around H pool. The new levee would prevent flows lower than the 1.2 year reoccurrence interval from entering Fountain Grove CA and focus Parsons Creek flows at a controlled overtopping point in a drainage ditch. The drainage ditch would be designed to effectively move Parsons Creek flows off site as efficiently as possible. Part of the Chillicothe-Brunswick rail berm would be removed to allow construction of the drainage ditch. The drainage ditch would also allow for movement of water during non-flood events and have boat lanes and spoil berms for enhancing wildlife features. Additional excavation to the new pump station near the Grand River to the south would allow for more efficient draining of Pool 1.	Maintaining the H pool levee decreases habitat benefits while incurring additional cost. Therefore it was not effective or efficient.
All Combinations using Alternative 4		Same as above

Table 4-3. Yellow Creek Alternatives Screened from Further Consideration.

Alternative	Description	Reason for Screening
Yellow Creek – Alternative 2	Garden of Eden levee setback in the northwest corner of the unit (Setback A).	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 3	Combines the levee setback from Alternative 2 (Setback A) with an additional levee setback further downstream (Setback B).	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 4	Garden of Eden levee setback in the northwest corner of the unit (Setback C), however, a larger setback then in Alternative 2 combined with an additional levee setback further downstream (Setback B).	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 5	Combines the Garden of Eden levee setback from Alternative 2 (Setback A) with a setback of the levee on the southern portion of the USFWS Swan Lake NWR (Setback D). An existing levee on Swan Lake NWR would be stabilized, some pools and current internal infrastructure would be removed.	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 6	Combines levee setbacks A, B, and D.	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 7	Combines levee setbacks B, C, and D.	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 8	Combines levee setbacks A and D with the removal or breaching of an old railroad berm adjacent to the USFWS Swan Lake NWR.	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 9	Combines levee setbacks A, B, and D with the removal or breaching of an old railroad berm adjacent to the USFWS Swan Lake NWR.	Increases downstream flood risk, which violates planning constraints.

Alternative	Description	Reason for Screening
Yellow Creek – Alternative 10	Combines levee setbacks B, C, and D with the removal or breaching of an old railroad berm adjacent to the USFWS Swan Lake NWR.	Increases downstream flood risk, which violates planning constraints.
Yellow Creek – Alternative 12	Removal or breaching of an old railroad berm adjacent to the USFWS Swan Lake NWR.	Does not provide any reduction in inundation time therefore is not effective.
Yellow Creek – Alternative 13	Levee setback D combined with removal or breaching of an old railroad berm adjacent to the USFWS Swan Lake NWR.	Does not provide any additional reduction in inundation time compared to YC 10, only incurs additional cost. Therefore not effective.

4.7.2 Final Array of Alternatives

Tables 4-4 through 4-6 summarize the final array of alternatives for each focused study area. NEPA regulations require that the No Action alternative always be considered, and therefore it is included within the final array for each focused study area. The No Action alternative means there would be no federal actions taken in the focused study areas for the purpose of ecosystem restoration. Within the USACE planning process, the future condition expected to occur from taking no action is represented by the FWOP.

The alternatives within each final array were evaluated through CE/ICA. Tables 4-4 through 4-6 identify whether or not each plan was determined to be cost effective and/or a best buy plan. CE/ICA analysis is explained in Section 4.8.

Table 4-4. Locust Creek Alternatives – Summary of Final Array.

Alternative	Cost Effective?	Best Buy?	Description
Locust Creek – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Locust Creek – Alternative 3	Yes	No	Construct a large sediment detention basin to the east of Locust Creek to remove logs and sediment and gets water back into Locust Creek via the Muddy Creek confluence south of HWY 36. Measures include a diversion berm, excavation of a pilot channel, log capture, levee notches, levee raise and construction around the detention basin, exit culverts, dredging a portion of Muddy and Locust creeks, small levee modifications and habitat mounds.
Locust Creek – Alternative 3.5	No	No	Same as Alternative 3, with the addition of excavating a new stream connection from Higgins Ditch to Locust Creek.
Locust Creek – Alternative 15	Yes	Yes	Same as Alternative 3, with the addition of grade control on Higgins Ditch to prevent head-cutting. Two versions of this alternative were simulated in the hydraulic model (Appendix B) and labeled as 15.1 and 15.2. They differed on the elevation of the grade control structure.
Locust Creek – Alternative 15.5	Yes	Yes	Same as Alternative 15, with the addition of excavating a new stream connection from Higgins Ditch to Locust Creek.
Locust Creek – Alternative 18	Yes	No	Same as Alternative 3; however, the sediment detention basin would be smaller in size. Hydraulic model simulation for LC10 (Appendix B) was used as representative of LC18.
Locust Creek – Alternative 18.5	No	No	Smaller sediment detention basin with no flow split, minimal dredge, filling of avulsions along Locust Creek, and improved connection from Higgins Ditch to Locust Creek

Table 4-5. Fountain Grove Summary of Final Array Alternatives.

Alternative	Cost Effective?	Best Buy?	Description
Fountain Grove – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Fountain Grove – Alternative 2	Yes	No	This alternatives includes armoring of the streambank adjacent to Pool 3 Water Control Structure (WCS) 3.
Fountain Grove – Alternative 3	Yes	Yes	Combines Alternative 2 with increasing the size of the Pool 1 WCS 1.
Fountain Grove – Alternative 5	Yes	No	Includes both water control structure modifications from FC 3 with a new levee on the west side of the area, excavation of a water conveyance channel, removal of an old railroad berm, enhanced micro-topography, and excavating a connection to the pump station.
Fountain Grove – Alternative 6	Yes	No	Alternative 5 with the addition of modification to the Pool 2/3 Levee to shift it closer to the new pump station and an additional levee within Pool 3 to the south of the drainage ditch. This will allow for independent filling and drainage of all three major pools on Fountain Grove CA.
Fountain Grove – Alternative 7	No	No	A levee setback on the east side of Fountain Grove CA.
Fountain Grove – Alternative 8	No	No	Includes the levee setback from Alternative 7 as well as a raise in the perimeter of Che-Ru Lake by two feet and a pipe to move water from Goose Pond Lake into Che-Ru Lake.
Fountain Grove – Alternative 8.5	No	No	Includes the levee setback from Alternative 7 as well as reworking the existing pools and micro-topography in east Fountain Grove CA to reduce infrastructure and facilitate better management of habitat.
Fountain Grove – Alternative 9	No	No	Alternative 8 with the addition of reworking the existing pools and micro-topography in east Fountain Grove CA to reduce infrastructure and facilitate better management of habitat.
Fountain Grove – Alternative 10	No	No	Adds two electric groundwater pumps on south Fountain Grove CA. The groundwater pumps would allow more effective management of this portion of the site.
Fountain Grove – Alternative 11	No	No	Alternative 2 + Alternative 7
Fountain Grove – Alternative 12	No	No	Alternative 2 + Alternative 8
Fountain Grove – Alternative 12.5	No	No	Alternative 2 + Alternative 8.5
Fountain Grove – Alternative 13	No	No	Alternative 2 + Alternative 9
Fountain Grove – Alternative 14	No	No	Alternative 2 + Alternative 10
Fountain Grove – Alternative 15	No	No	Alternative 2+Alternative 7+Alternative 10
Fountain Grove – Alternative 16	No	No	Alternative 2+Alternative 8+Alternative 10
Fountain Grove – Alternative 16.5	No	No	Alternative 2+Alternative 8.5+Alternative 10
Fountain Grove – Alternative 17	No	No	Alternative 2+Alternative 9+Alternative 10
Fountain Grove – Alternative 18	Yes	No	Alternative 3+Alternative 7
Fountain Grove – Alternative 19	Yes	No	Alternative 3+Alternative 8
Fountain Grove – Alternative 19.5	No	No	Alternative 3+Alternative 8.5
Fountain Grove – Alternative 20	No	No	Alternative 3+Alternative 9
Fountain Grove – Alternative 21	Yes	No	Alternative 3+Alternative 10

Alternative	Cost Effective?	Best Buy?	Description
Fountain Grove – Alternative 22	Yes	No	Alternative 3+Alternative 7+Alternative 10
Fountain Grove – Alternative 23	Yes	No	Alternative 3+Alternative 8+Alternative 10
Fountain Grove – Alternative 23.5	Yes	No	Alternative 3+Alternative 8.5+Alternative 10
Fountain Grove – Alternative 24	Yes	No	Alternative 3+Alternative 9+Alternative 10
Fountain Grove – Alternative 25	Yes	No	Alternative 5+Alternative 7
Fountain Grove – Alternative 26	No	No	Alternative 5+Alternative 8
Fountain Grove – Alternative 26.5	No	No	Alternative 5+Alternative 8.5
Fountain Grove – Alternative 27	No	No	Alternative 5+Alternative 9
Fountain Grove – Alternative 28	Yes	No	Alternative 5+Alternative 10
Fountain Grove – Alternative 29	Yes	No	Alternative 5+Alternative 7+Alternative 10
Fountain Grove – Alternative 30	No	No	Alternative 5+Alternative 8+Alternative 10
Fountain Grove – Alternative 30.5	No	No	Alternative 5+Alternative 8.5+Alternative 10
Fountain Grove – Alternative 31	No	No	Alternative 5+Alternative 9+Alternative 10
Fountain Grove – Alternative 32	Yes	No	Alternative 6+Alternative 7
Fountain Grove – Alternative 33	Yes	No	Alternative 6+Alternative 8
Fountain Grove – Alternative 33.5	No	No	Alternative 6+Alternative 8.5
Fountain Grove – Alternative 34	No	No	Alternative 6+Alternative 9
Fountain Grove – Alternative 35	Yes	Yes	Alternative 6+Alternative 10
Fountain Grove – Alternative 36	Yes	Yes	Alternative 6+Alternative 7+Alternative 10
Fountain Grove – Alternative 37	Yes	Yes	Alternative 6+Alternative 8+Alternative 10
Fountain Grove – Alternative 37.5	Yes	Yes	Alternative 6+Alternative 8.5+Alternative 10
Fountain Grove – Alternative 38	Yes	Yes	Alternative 6+Alternative 9+Alternative 10
Fountain Grove – Alternative 39	No	No	Alternative 7+Alternative 10
Fountain Grove – Alternative 40	No	No	Alternative 8+Alternative 10
Fountain Grove – Alternative 40.5	No	No	Alternative 8.5+Alternative 10
Fountain Grove – Alternative 41	No	No	Alternative 9+Alternative 10

Table 4-6. Summary of Yellow Creek Final Array Alternatives.

Alternative	Cost Effective?	Best Buy?	Description
Yellow Creek – Alternative 1	Yes	Yes	Future Without Project Condition/No Action alternative.
Yellow Creek – Alternative 11	Yes	Yes	Levee setback D on Swan Lake NWR along with stabilizing an existing levee on Swan Lake NWR, and removal of some internal infrastructure.

4.8 Evaluation and Comparison of Alternative Plans

USACE guidance requires that the ecosystem related benefits of proposed alternatives be subjected to detailed economic analysis, allowing an explicit comparison of the costs and benefits associated with the alternatives. Consequently, it is necessary that the environmental benefits of the alternatives be based on some quantifiable unit of value. Since restoration value is difficult to monetize, instead of calculating benefits in monetary terms, USACE ecosystem restoration projects calculate the value and benefits of restored habitat using established habitat assessment methodologies. Comparing the alternatives in this manner facilitates the determination of the most cost-effective restoration alternative that meets restoration goals.

4.8.1 Habitat Evaluation and Quantification

In collaboration with the technical team, four general habitat types were identified for the focus of the ecosystem evaluation: wet prairie, emergent wetland, bottomland forest, and aquatic riverine habitat. These habitat types were selected because they are significant resources in the study areas that are representative of the habitat types being degraded. The approach to habitat evaluation was described in Section 3.3 and is described in detail in Appendix D. The habitat evaluations were informed by the results of H&H and sediment modeling, which are described in detail in Appendices A, B, and C.

4.8.2 Efficiency: Cost Effectiveness and Incremental Cost Analysis

Efficiency is “the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation’s environment.” The alternative plans included in the final array were evaluated on the basis of CE/ICA as required by ER 1105-2-100, Planning Guidance Notebook. CE/ICA are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative restoration plan’s output cannot be produced more cost effectively by another alternative. “Cost effective” means that, for a given level of non-monetary output, no other plan costs less, and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a “best” level of output within the limits of both the sponsor’s and the Corps’ capabilities. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. Those most efficient plans are called “Best Buys”. They provide the greatest increase in output for the least increases in cost. They have the lowest incremental costs per unit of output. In most analyses, there will be a series of Best Buy plans, in which the relationship between the quantity of outputs and the unit cost is evident. As the scale of Best Buy plans increases (in terms of output produced), average costs per unit of output and incremental costs per unit of output will increase as well. Usually, the incremental analysis by itself will not point to the selection of any single plan. The results of the incremental analysis must be synthesized with other decision-making criteria (for example, significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, reasonableness of costs) to help the planning team select and recommend a particular plan.

Figure 4-3 and 4-4 show the results of the CE/ICA analyses for Locust Creek. Table 4-7 summarizes the costs (measured in dollars) and benefits (measured in AAHUs) for the Locust Creek “Best Buy” alternatives. Figure 4-5 and 4-6 show the results of the CE/ICA analyses for Fountain Grove. Table 4-8 summarizes the costs (measured in dollars) and benefits (measured in AAHUs) for the Fountain Grove “Best Buy” alternatives. CE/ICA results are not presented for Yellow Creek because the final array included only the No Action alternative and one FWP alternative. Table 4-9 summarizes the costs and benefits of the Yellow Creek “Best Buy” alternatives.

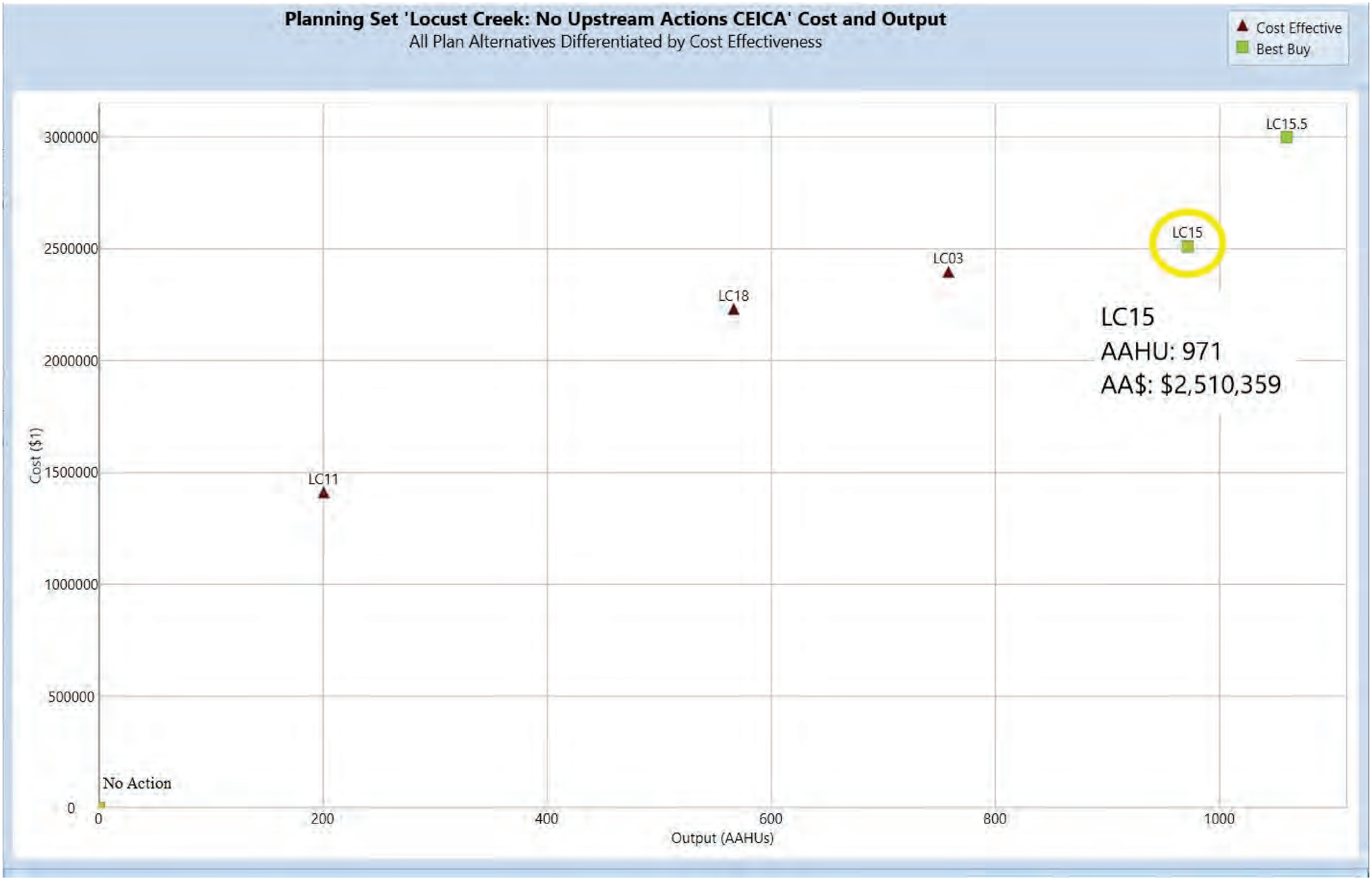

Figure 4-3. Annualized Costs versus Habitat Outputs for the Locust Creek Final Array of Alternatives.

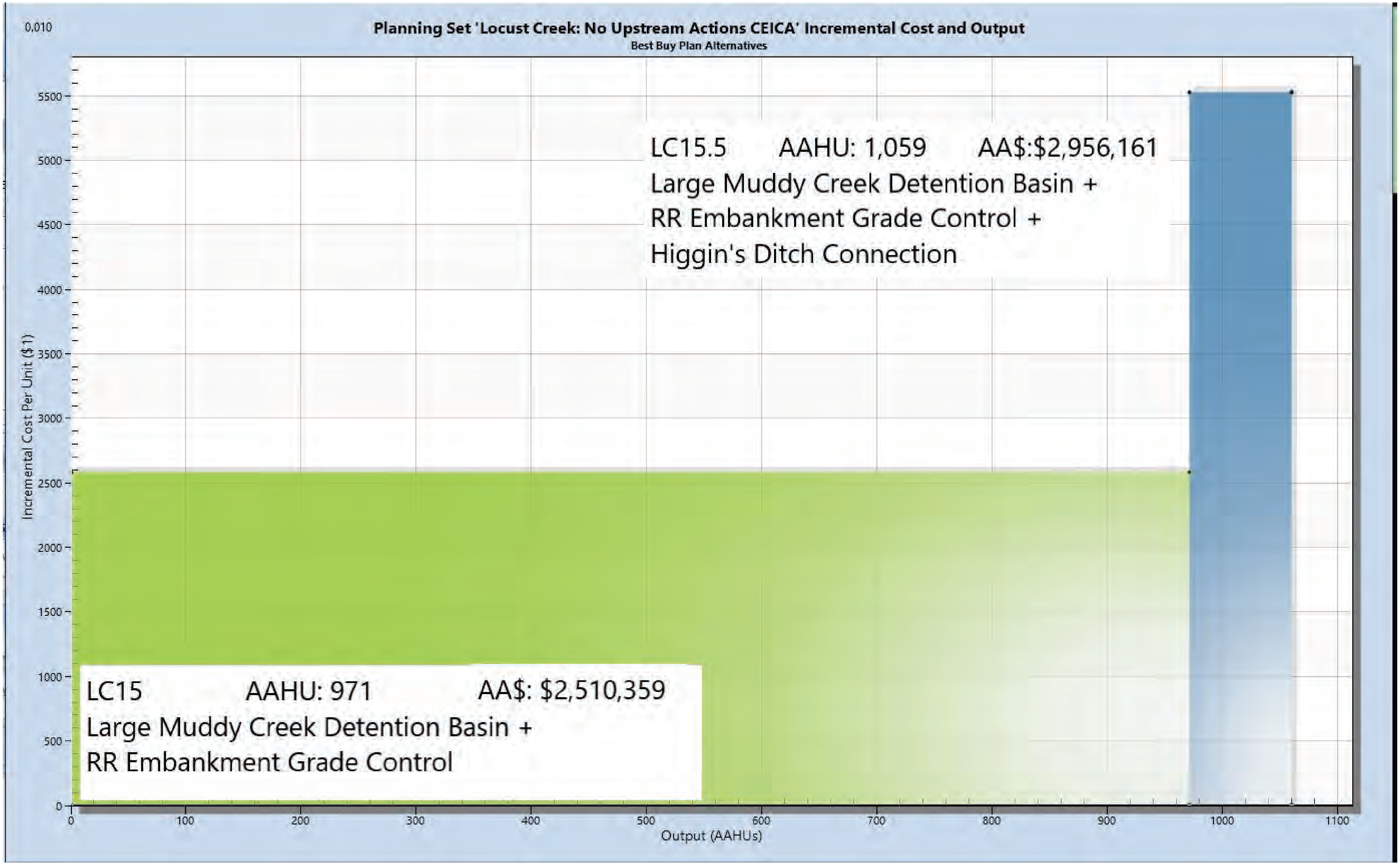

Figure 4-4. Locust Creek Incremental Cost Analysis Results.

Table 4-7. Locust Creek Best Buy Alternative Comparison.

Alternative	LC1 (FWOP) Best Buy	LC15 Best Buy - NER	LC15.5 Best Buy
Construction		$31,370,532	$38,212,387
Real Estate		$12,973,673	$13,885,829
Preconstruction Engineering and Design		$4,705,580	$5,731,858
Supervisor and Administration		$1,882,231	$2,292,743
Contingency		$10,696,661	$12,983,346
Total Capital Costs		$61,628,677	$73,106,163
Interest During Construction		$1,888,591	$2,158,800
Total Investment Costs		$63,517,268	$75,264,963
Interest & Amortization Factor	0.0379	0.0379	0.0379
Annualized Costs		$2,410,359	$2,856,161
Annual OMRR&R		$100,000	$100,000
Total Annual Costs	$30,000	$2,510,359	$2,956,161
Total Average Annual Habitat units - Wet Prairie	204	334	345
Total Average Annual Habitat units - Wetlands	1,535	1,688	1,718
Total Average Annual Habitat units - Forest	3,386	4,030	4,079
Total Average Annual Habitat units - Aquatic	154	199	197
Total Average Annual Habitat Units- All Habitats	5,279	6,250	6,339
Net AAHU		971	1,059
Incremental Cost		$2,480,359	$445,802
Incremental AAHU		971	88
Incremental Cost/ Incremental AAHU		$2,553	$5,089

Note: Price level date of May 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

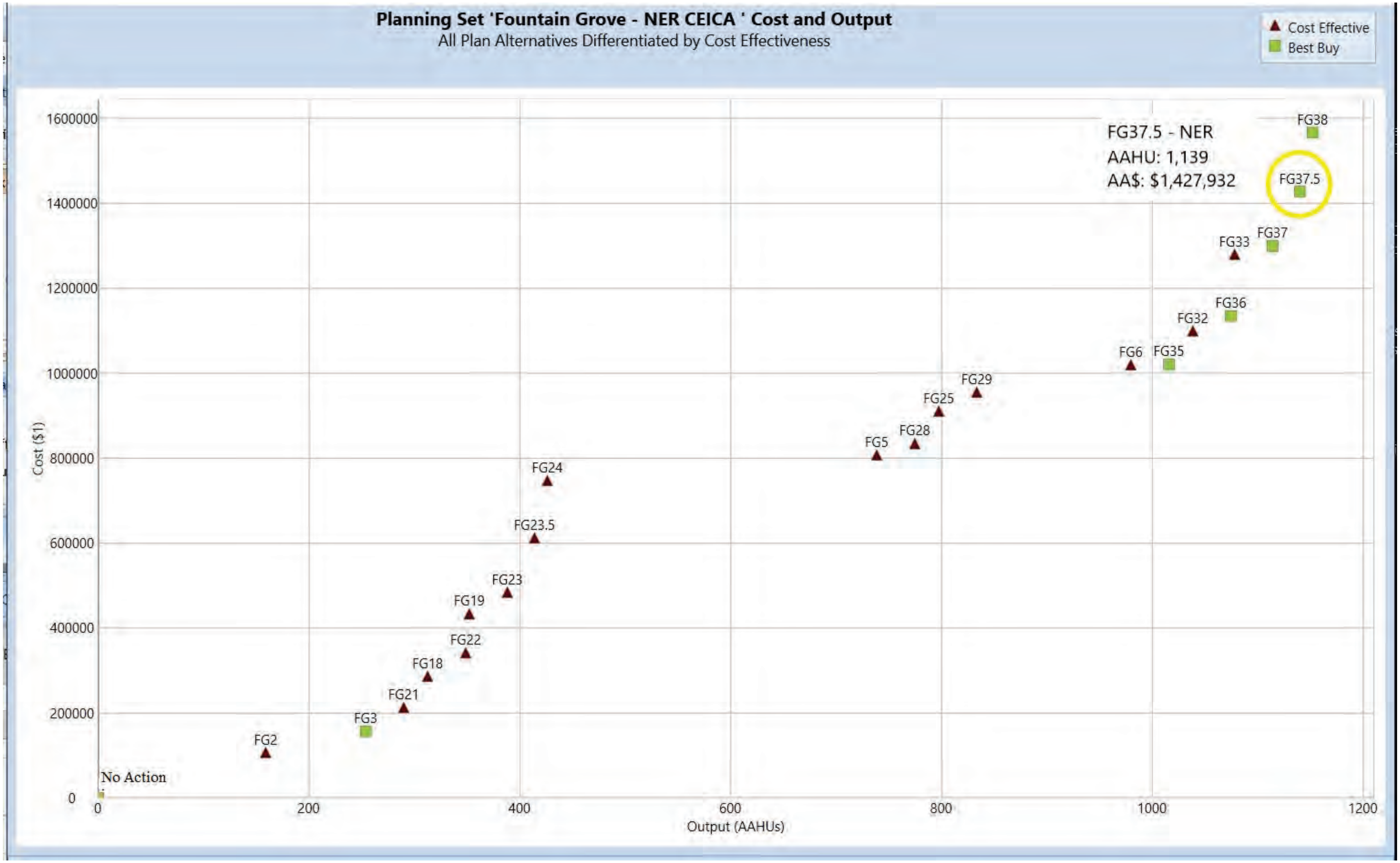

Figure 4-5. Annualized Costs versus Habitat Outputs for the Fountain Grove Final Array of Alternatives.

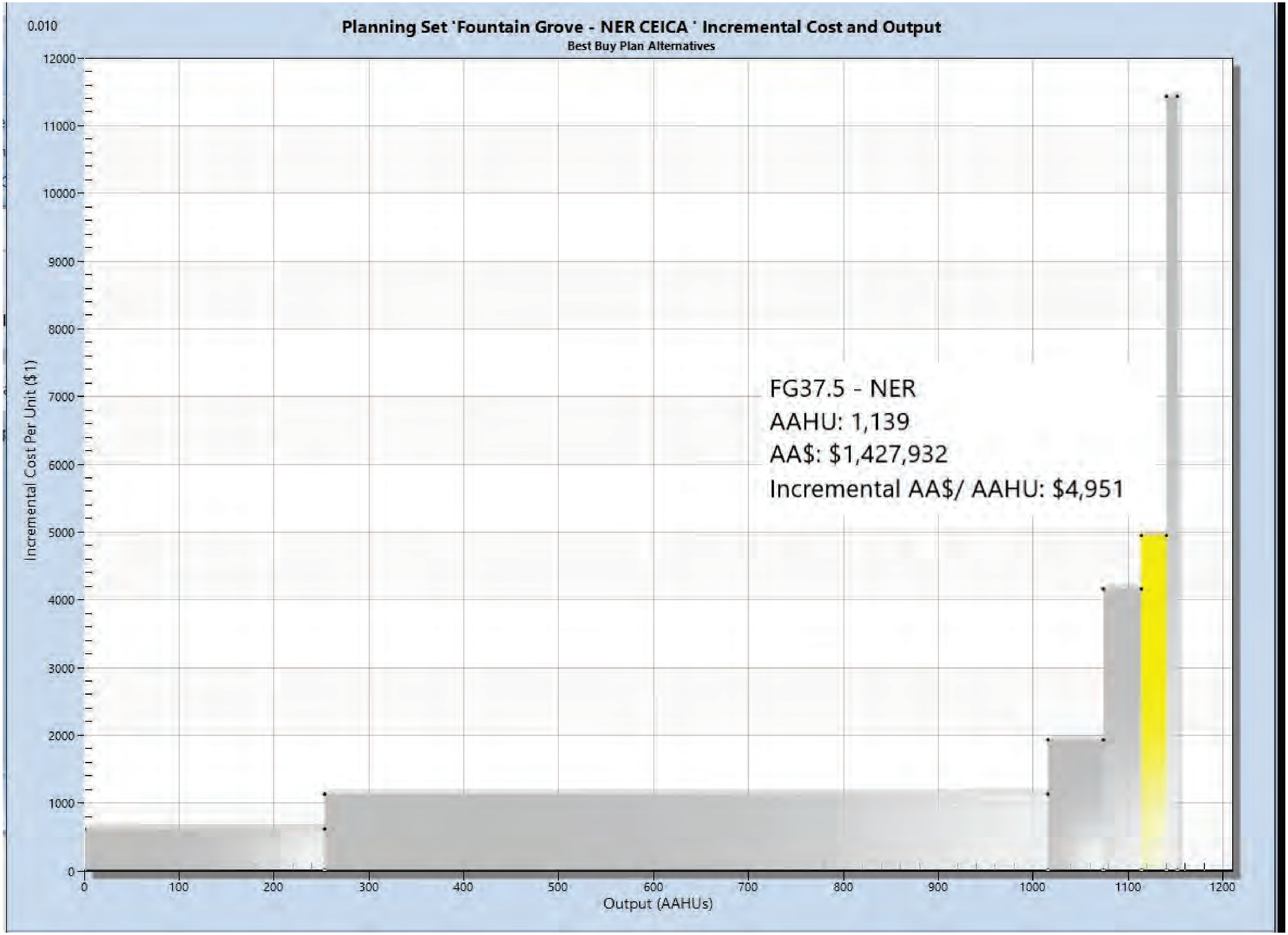

Figure 4-6. Fountain Grove Incremental Cost Analysis Results.

Table 4-8. Fountain Grove Best Buy Alternative Comparison.

Alternative	Alternative FG1 (FWOP) Best Buy	Alternative FG3 Best Buy	Alternative FG35 Best Buy	Alternative FG36 Best Buy	Alternative FG37 Best Buy	Alternative FG37.5 Best Buy - NER	Alternative FG38 Best Buy
Construction		$1,076,865	$13,195,546	$15,243,549	$17,235,157	$18,597,388	$20,588,996
Real Estate		$4,631	$3,418,518	$3,889,362	$4,375,643	$5,603,696	$6,089,977
Preconstruction Engineering and Design		$161,529	$1,979,332	$2,286,532	$2,585,274	$2,789,608	$3,088,349
Supervisory and Administration		$64,611	$791,733	$914,613	$1,034,109	$1,115,843	$1,235,340
Contingency		$364,842	$4,390,818	$4,488,209	$5,839,271	$6,225,786	$6,892,510
Total Capital Costs		$1,672,478	$23,775,947	$26,822,265	$31,069,454	$34,332,321	$37,895,172
Interest During Construction		$32,417	$642,614	$726,734	$834,778	$964,102	$1,058,991
Total Investment Costs		$1,704,895	$24,418,561	$27,548,999	$31,904,232	$35,296,423	$38,954,163
Interest & Amortization Factor	0.0379	0.0379	0.0379	0.0379	0.0379	0.0379	0.0379
Annualized Costs		$64,698	$926,638	$1,045,432	$1,210,705	$1,339,432	$1,478,236
Annual OMRR&R	$95,000	$92,500	$94,500	$89,500	$89,000	$88,500	$88,000
Total Annual Costs	**$95,000**	**$157,198**	**$1,021,138**	**$1,134,932**	**$1,299,705**	**$1,427,932**	**$1,566,236**
Total AAHU Wetlands	1,377	1,466	1,937	1,969	2,008	2,033	2,045
Total AAHU Forest	1,529	1,694	1,985	2,012	2,012	2,013	2,013
Total Average Annual Habitat Units- All Habitats	2,907	3,160	3,922	3,981	4,021	4,046	4,058
Net AAHU		**254**	**1,016**	**1,074**	**1,114**	**1,140**	**1,152**
Incremental Cost		$62,198	$863,940	$113,794	$164,773	$128,227	$138,304
Incremental AAHU		254	762	59	40	26	12
Incremental Cost/AAHU		$245	$1,134	$1,935	$4,171	$4,951	$11,430

Note: Price level date of June 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

Table 4-9. Yellow Creek Best Buy Alternative Comparison.

Alternative	Alternative YC1 (FWOP) Best Buy	Alternative YC11 Best Buy - NER
Construction		$3,893,598
Real Estate		$2,246,156
Preconstruction Engineering and Design		$641,905
Supervisor and Administration		$256,762
Contingency		$968,038
Total Capital Costs		$8,006,459
Interest During Construction		$275,700
Total Investment Costs		$8,282,159
Interest & Amortization Factor	0.0379	0.0379
Annualized Costs		$314,292
Annual OMRR&R	$100,000	$75,000
Total Annual Costs	**$100,000**	**$389,292**
Total Average Annual Habitat units: Forest	4579	4850
Total Average Annual Habitat units: Wetlands	4,721	4,803
Total Average Annual Habitat units: Wet Prairie	88	77
Total Average Annual Habitat Units- All Habitats	9,388	9,730
Net AAHU		**342**
Incremental Cost		$289,292
Incremental AAHU		342
Incremental Cost/ Incremental AAHU		$845

Note: Price level date of May 2019, 50-year period of analysis, FY19 Discount Rate applied at 2.875%

4.8.3 Effectiveness

Effectiveness is the extent to which an alternative plan alleviates specified problems and achieves opportunities. This is demonstrated by how well each alternative plan meets the planning objectives. This section discusses the alternative plans relative to their effectiveness at achieving the planning objectives for each focused study area.

4.8.3.1 Locust Creek

Objective 1: Improve hydraulic conveyance in Locust Creek while maintaining floodplain connectivity

All the Locust Creek final array alternatives include measures designed to improve hydraulic conveyance within the Locust Creek study area. Alternatives LC3, LC15, LC18, and LC18.5 improve hydraulic conveyance in Locust Creek through Pershing State Park by restoring a connection and channel slope necessary to accommodate restoration of flows to that stream. Alternatives LC3.5 and LC15.5 include the same measures to improve hydraulic connectivity in Locust Creek but also include a connection from Higgins Ditch to Locust Creek that would improve hydraulic connectivity of Higgins Ditch. Alternatives that include the Higgins Ditch to Locust Creek connection would result in more overall improvement to hydraulic conveyance, however, it is possible these alternatives would not maintain floodplain connectivity on the west side of the study area to the same degree as alternatives without the Higgins Ditch connector.

Objective 2: Reduce floodplain sediment deposition leading to habitat degradation

Table 4-10 shows the forecasted reduction in sediment deposition on the floodplain for LC3, LC15, and LC18 by percentage. LC15 reaches a 61% reduction in floodplain sediment deposition compared to the FWOP; the highest reduction among alternatives for which detailed sediment modeling was conducted.

Table 4-10. Floodplain Sediment Deposition Reduction below Highway 36.

Alternative	Floodplain Deposition below HWY36 along Higgins Ditch and Locust Creek (CY)	% Reduction from FWOP
LC1	20,548,551	NA
LC3	14,400,807	37%
LC15	8,083,089	61%
LC18	16,776,198	18%

Objective 3: Reduce accumulation of large woody debris

All alternatives that include a sediment detention basin (LC3, LC3.5, LC15, LC15.5, LC 18, and LC18.5) are also intended to capture logs and therefore would be anticipated to be effective at meeting this objective.

Objective 4: Increase quality and quantity of wet prairie, emergent wetlands, bottomland forest, and aquatic riverine habitat within the Locust Creek study area

Based on the amount of sediment retention and associated downstream habitat benefits, alternatives that include the Large Sediment Basin and Railroad Berm (LC15 and LC15.5) provide the most benefits. Configurations of the Large Sediment Basin only (LC3, LC3.5) provide more benefits than the Small Sediment Basin with Flows to Higgins Ditch (LC18, LC18.5). Additional local terrestrial floodplain benefits within the Hickory Branch/Higgins Ditch confluence area and aquatic riverine habitat benefits for ALC5 can be seen for alternatives that also include the connection channel (LC3.5, LC15.5, and LC18.5). However, due to increased flood risk potential, alternatives that include a channel connector also include increased mitigation costs to purchase private lands with increased flooding due to the project.

For bottomland hardmast forest species under the various FWP conditions, it is likely that long-term survival and persistence will only be achieved with alternatives that include the Large Sediment Detention Basin and Railroad Berm. Even under this alternative there will be continued effects to hardmast species (i.e., seed burial, decreased recruitment), but older more mature trees are expected to survive and provide a seed source for areas where sediment has been reduced to a point allowing some seed survival and recruitment. Alternatives that provide less sediment reduction will likely result in increased loss of hardmast species, especially in tracts TLC4, TLC5, TLC6, TLC7, and TLC8. Existing land use and habitat for alternatives that include a sediment detention basin will likely result in conversion of existing row crop agricultural fields to riparian tree species over the 50-year period of analysis. These habitat conversions have been included in the habitat modeling for alternatives where applicable.

For emergent wetland habitat, FWP conditions under alternative 15.5 with the large sediment detention basin and the channel connector measure provide the most benefits. Like hardmast forest habitat, existing wetlands in the study area will continue to receive excess sediment, but at levels that do not result in total loss of habitat and conversion to riparian forests. For highly affected tracts (TLC4, TLC5, TLC7 and TLC8) it appears that 0.5 to 4 feet of sediment is likely over the 50-year period of analysis. This will result in a gradual decline in existing habitat quality but allow most wetlands to remain on the landscape.

For existing wet prairie habitat, located primarily in tracts TLC5 and TLC6, alternatives that remove sediment and restore historic base flow routes (i.e., send water to the east into old Locust Creek) would provide the most benefits. Within the study area, wet prairie habitat has been lost primary from excess sediment deposition, which changes the hydrologic conditions, allows for invasion by woody plant species, or completely buries existing habitat. Alternatives that restore base flows and associated overbank events to old Locust Creek could restore historic hydrologic conditions with substantial reduction in sediment deposition, which would mimic conditions that allowed for a thriving wet prairie.. Dredging of old Locust Creek and the addition of swales that reduce potential future avulsion potential and provide preferred sheet flow paths to the wet prairie areas would result in improved hydrologic connectivity. For Alternatives that do not address issues with both sediment and hydrologic conditions, long-term persistence of wet prairie habitat is unlikely within the study area (i.e., LC1, LC3, and LC18).

For the reaches of aquatic riverine habitat within the study area, ALC1 remained in relatively poor habitat quality over all alternatives due to existing levee constrictions and channelization. For ALC2 and ALC5, alternatives that move water to the east and return base flows to old Locust Creek would result in de-watering this reach resulting in HSI scores of 0.0 under FWP conditions. ALC3 and ALC6 would remain de-watered under all alternatives. ALC4, new sediment detention basin, would result in new aquatic habitat from conversion of existing agricultural row crops. Therefore, aquatic quality would increase under all FWP alternatives that include the sediment basin. ALC7 would be impacted by alternatives with dredging actions but would increase over time to pre-construction values; alternatives that keep water in Higgins Ditch would result in values equal to FWOP projections in this reach. ALC8 will remain relatively the same under all FWP alternatives. ALC9 would receive the most benefits from alternatives that move water to the east and into old Locust Creek, thus restoring base flow conditions to this reach (i.e., only from Hickory Branch); and alternatives that include a connector, which provides more channel capacity. ALC10 would remain in relatively poor quality under alternatives that do not restore historic base flows but would improve slightly as the reach evolves with Muddy Creek only flows. Alternatives that restore historic base flows (i.e., move water to the east) would result in drastically improved HSI scores over 50 years. For ALC11, it is anticipated that this reach will decline over time under all alternatives as it receives all sediment from all study area reaches. ALC12 is the new Higgins Ditch/Locust Creek channel connector and will result in average aquatic habitat for LC18.5 that includes this measure and has base flows routed to the west.

4.8.3.2 Fountain Grove

Objective 1: Increase wetland form and function on East, West, and South Fountain Grove CA.

Improvements in FWP management capability and flexibility translate to an increased ability to provide naturally functioning wetland pools for high value littoral habitat, which is the most critical natural variable for migrating waterfowl and shorebirds. For West Fountain Grove CA, providing independent utility at Pools 1 – 3, improving water management infrastructure, and restoring micro-topography were critical measures for maximizing management capability. Within East Fountain Grove CA, the primary objective is to maintain valuable natural wetland form and function by avoiding protective levee failure and associated damaging sedimentation. The measure of setting back the levee would allow more flood space for Locust Creek. Addition of a controlled entry point for extreme flood water would help to prevent levee failure and control entry of sediment. The implementation of these measures would help maintain other habitat enhancements such as micro-topography work, water supply modifications, and infrastructure changes. In combination, these measures would improve the ability to preserve natural wetland form and function and overall wetland habitat quality. For South Fountain Grove CA, the addition of a reliable water source would improve both habitat quality and quantity, resulting in increased AAHUs. All the measures formulated were intended to provide increased natural ecosystem form and function through improved management capability. However, another aspect to assessing the viability of an alternative is the degree to which the combination of measures addresses habitat restoration, improvement, and creation in all three areas of Fountain Grove CA (i.e. East, West, and South).

For emergent wetlands at Fountain Grove CA, no changes relative to the FWOP condition were seen for tracts TFG1 and TFG2. For West Fountain Grove CA tract TFG3, alternatives FG5 and FG6 provided the greatest improvement in habitat quality relative to the FWOP condition and alternatives that had fewer restoration measures. For South Fountain Grove CA, alternative FG10 included the installation of groundwater pumps, which provided positive lift versus the FWOP condition. East Fountain Grove CA results indicated that alternative FG8.5 (levee setback with micro-topography work) provided the greatest overall increase in HSI scores from 0.67 to 0.81 over the 50-year period of analysis. Among the Best Buy alternatives, FG38 resulted in the most wetland AAHUs (2,045), followed by FG37.5 (2,033), FG37 (2,008), FG 36 (1,969), and FG35 (1,937). There was then a drop to the next highest alternative, which was FG3 at 1,466 wetland AAHUs. The range of wetland AAHUs separating the top five Best Buy plans was only 108 wetland AAHUs.

For bottomland forest areas, a gradual decrease in habitat quality is expected under the FWOP as existing hardmast species are replaced with riparian species. For the Parsons Creek north and west areas, tracts TFG1 and TFG2, none of the proposed restoration measures and alternatives are expected to improve FWP conditions. Tracts TFG3, TFG4, and TFG5 represent West, East, and South Fountain Grove CA tracts, respectively. For TFG3, alternative combinations that included FG5 and FG6 provided the most benefits, while other alternatives were relatively similar to the FWOP condition. For TFG4, South Fountain Grove CA, no changes relative to the FWOP condition are anticipated because the proposed improvements are targeted towards wetland habitat. For TFG5, East Fountain Grove CA, some minor HSI improvements were identified with alternatives that avoid catastrophic levee failure and associated future sedimentation of forested areas. Among the Best Buy alternatives, FG38 and FG37.5 resulted in the most forest AAHUs (2,013), followed by FG37 and FG36 (2,012), and FG35 (1,985). There was then a drop to the next highest alternative, which was FG3 at 1,694 forest AAHUs. The range of forest AAHUs separating the top five Best Buy plans was only 28 forest AAHUs.

Overall, FG38 resulted in the most total AAHUs for all habitats (4,058) followed by FG37.5 (4,046), FG37 (4,021), FG36 (3,981), and FG35 (3,922). The spread in total AAHUs for the top five Best Buy alternatives was relatively small at 136 AAHUs. This indicates that all five top Best Buy alternatives were relatively effective at increasing wetland form and function (as indicated by AAHUs) over the 50-year period of analysis. However, this planning objective also takes into account whether the increase in wetland form and function occurs on all three areas of Fountain Grove CA (East, West, and South). FG36, FG37, FG37.5, and FG38 include measures that increase AAHUs at all three areas of Fountain Grove CA. FG35 addresses only West and South Fountain Grove CA, but not East Fountain Grove CA. Therefore, FG35 is not considered as effective at meeting this planning objective as FG36, FG37, FG37.5, or FG38.

Objective 2: Improve resiliency of Fountain Grove CA wetland units.

Average drain time of the 2-year flood event from West Fountain Grove CA pools 1-3 was assessed using an H&H model (Appendix B). Drain-time differences were modeled for proposed measures that were likely to affect drain time at the site and results are summarized in Table 4-11. Drain times were started when the first exterior discharge culvert was activated (i.e., 2-year flooding and backwater effects no longer influenced drain times). Results indicated significant improvements to average drain time with FG2 (reduction from 15.9 to 7.8 days), with minor additional decreases in average drain time under alternatives FG3, FG4, FG5, and FG6 (ranging from 7.8 to 7.0 days). H&H modeling indicates that alternative FG6 and its combinations performed best at achieving this objective. It is important to note that additional drainage benefits for measures (FG3, FG4, FG5, and FG6), such as micro-topography, were established and quantified using professional judgment from stakeholders. All of the Best Buy alternatives identified in Table 4-8 were combinations of FG6; therefore, they all are similarly effective at meeting this objective.

Objective 3: Reduce sedimentation on Fountain Grove CA over the project life.

Reductions in sediment deposition at Fountain Grove CA were based on reductions in drain time; therefore, the alternatives that were most effective at reducing drain time were also the most effective at limiting sediment deposition and meeting this objective (i.e. FG6 and its combinations). Appendix C provides more detail on the drain time and sediment assessment for Fountain Grove alternatives.

4.8.3.3 Yellow Creek

Objective 1: Reduce backwater effects at the lower Grand River/Yellow Creek confluence that are driving degradation of nearby bottomland hardwoods, wetlands, agricultural lands, and Swan Lake NWR

H&H modeling was performed to determine if inundation in Yellow Creek habitat tracts was reduced under YC11 versus the FWOP/No Action (YC1). Inundation times was representative of sedimentation effects and impacts to bottomland hardmast regeneration. Based on inundation mapping (Appendix B), conditions improve under YC11 when compared to YC1; therefore, YC11 meets this objective. Alternative YC11 provided a total of 9,730.1 cumulative AAHUs, which is a net increase in 342.3 AAHUs over the FWOP/No Action condition (YC1).

Objective 2: Reduce sedimentation effects along Yellow Creek degrading nearby bottomland hardwoods and wetlands

Inundation times were considered representative of sedimentation effects and impacts to bottomland hardmast regeneration. Based on inundation mapping (Appendix B), conditions improve under YC11 when compared to YC1; therefore, YC11 meets this objective.

4.8.4 Acceptability

Acceptability is the workability of a plan with respect to acceptance by state and local entities and the public, and compatibility with existing laws, regulations, and policies. All the alternatives in the final array must be in accordance with Federal law and policy. All alternatives in the Fountain Grove and Yellow Creek final arrays are considered acceptable. For the Locust Creek final array, those alternatives that include a new connection between Higgins Ditch and Locust Creek (LC 3.5 and LC15.5) are not considered acceptable because they would transfer flood risk from existing private property to other existing private property.

4.8.5 Completeness

Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. The study team has not identified any additional investments, or actions, needed by others to realize the benefits identified within the Locust Creek or Fountain Grove final arrays, therefore, all alternatives are considered complete USACE plans. However, all the measures included within YC11 would occur on the Swan Lake NWR, owned and managed by the USFWS. Therefore, because YC11 requires action and investments by another Federal agency, it is not technically a complete USACE plan. No other plans remain within the final array that achieve USACE planning objectives while meeting planning constraints. USFWS has been a partner in the study team from the initiation of the project and assisted with development and evaluation of measures.

4.8.6 Four Principles and Guidelines Accounts

The U.S. Water Resources Council Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies provides the requirements for Federal agencies to conduct water resources planning studies. This regulation provides the overall direction by which USACE Civil Works projects are formulated, evaluated and selected for implementation. The P&G specifies the use of four accounts to facilitate evaluation of alternative plans: NED, EQ, OSE, and RED. Based on the four accounts, the USACE developed ER 1105-2-100, Planning Guidance Notebook, to provide detailed implementation guidance to planners specific to the nature of type of Corps water resource planning studies. Specific guidance on Ecosystem Restoration can be found in Appendix E of the Planning Guidance Notebook, in ER 1165-2-501, Civil Works Ecosystem Restoration Policy, and in ER 1165-2-502, Ecosystem Restoration - Supporting Policy Information.

The Grand River Ecosystem Restoration Study can be considered generally under the EQ account of the P&G, but more specifically, as a single purpose Ecosystem Restoration study under ER 1105-2-100, Appendix E, Section 5, with the intent of identifying a National Ecosystem Restoration (NER) plan that reasonably maximizes ecosystem restoration benefits and can be justified on the basis of project acceptability, completeness, efficiency, and effectiveness. As a single purpose Ecosystem Restoration Study, all Grand River alternatives provide net contributions that increase ecosystem value (NER outputs). The net increase in AAHUs for the final array of proposed actions are summarized in Table 4-7, 4-8, and 4-9, as well as described in detail in Appendix D. Potential impacts to cultural resources are not fully known at this time because the entire study area has not been surveyed. Should cultural resources be discovered, avoidance or mitigation and consultation with the SHPO and applicable Native American Tribes would occur in accordance with a programmatic agreement that has been developed for this study. Aesthetics are expected to be enhanced by all alternatives because they reduce sedimentation and increase natural ecosystem form and function. Potential temporary adverse effects could result from construction activities (e.g., land disturbance, emissions, tree clearing), but construction best management practices (BMPs) will be strictly adhered to, such that any and all adverse effects are temporary and minimal.

A qualitative assessment of the other three P&G accounts was conducted by the PDT and determined that the ecosystem restoration benefits associated with implementation of the NER plan would be beneficial and in agreement with the purpose and intent of the accounts. Although National Economic Development (NED) and Regional Economic Development (RED) economic benefits were not quantified, benefits would be anticipated from all proposed ecosystem restoration alternatives, primarily for economies that rely on high quality natural resources and systems, such as camping, hunting, bird watching, hiking and other outdoor and recreational type activities. Short-term local and regional economic benefits would also occur from construction-related spending. Reduced flooding, erosion, sedimentation and log jams would also provide long-term economic benefits to transportation and agricultural by reducing direct impacts, increasing long-term reliability and sustainability, and reducing annual O&M costs. Overall, it is anticipated that minor NED and moderate RED benefits would occur with implementation of the NER plan. Other Social Effects (OSE) would be positive through improved water quality conditions within and downstream of the project areas; improved aesthetics, outdoor experiences, and recreational opportunities on public and private lands; and decreased transportation-related delays, detours and loss of time for local residents.

4.8.7 Achievement of Opportunities and Constraints

Opportunities – All alternatives reverse the trend of degradation of aquatic habitat, bottomland forests, wetland and wet prairie within the sub-basin, to varying degrees. As discussed under the Environmental Quality and Other Social Effects accounts, all alternatives would benefit infrastructure, agriculture, water quality, and recreation. Flood risk reduction is location dependent and discussed in more detail in Section 5.13.2. All the alternatives also improve future conditions by accounting for habitat benefits on NRCS lands, which are permanent easements and critical areas for providing habitat connectivity between the public areas of Pershing State Park, Fountain Grove CA, Yellow Creek CA, and Swan Lake NWR.

Constraints - It is not anticipated that any of the alternatives violate the study constraints. Although alternatives LC 3.5 and LC15.5 transfer flood risk between private property parcels, it is likely this impact could be mitigated through acquisition of those properties, which is why these alternatives were not screened from the final array; whereas, numerous Yellow Creek alternatives were screened for violating the increased flood risk constraint.

4.9 Risk and Uncertainty Analysis

Following the evaluation of the final array of alternatives, a risk and uncertainty analysis was completed. A potential risk identified was related to the reliability of claiming habitat benefits on private lands over the 50-year period of analysis (Appendix D Attachment E). This risk was not present in the Fountain Grove study area because benefits are occurring on MDC-owned lands. The benefits in the Yellow Creek study area occur on USFWS property or on the river side of two large levees, land which is not suitable for development into another land use and are not being counted as part of the Corps plan. A review of habitat benefits forecasted in the Locust Creek study area showed that of the 2,669 acres benefited, only 277 acres are private lands with no conservation easements. These acres are along the floodway or on the riverside of a levee, are situated adjacent to a state park and a conservation area, and are inundated multiple times a year in a region that has a trend towards conservation. Therefore, the risk of land conversion and not realizing habitat benefits on private lands was considered minimal. If this risk was realized it would not impact the decision-making for any study area. Any additional risk and uncertainty for the alternatives at Fountain Grove and Yellow Creek were minimal and able to be managed through adaptive management or operations and maintenance actions.

The risk and uncertainty for performance of the recommended plan for Locust Creek was increased due to the high sediment loads in this watershed. This risk was recognized from the beginning of the study which is why sediment sampling was completed. The largest remaining risk for the Locust Creek alternative plans is that actual long-term sediment loads could be higher than projected and, in turn, the habitat benefits for the area would not be as high as projected.

As explained in Appendix C, the sediment rating curve which was the basis for habitat assessment for Locust Creek was based on 37 flow/load measurements from 2011 to 2017 then calibrated with nine months of data so the cumulative incoming sediment load during the calibration period matched the sum of USGS-computed daily sediment loads over that time period. Furthermore, modeling assumed that the next 50 years is a repeat of the previous 50 years of daily flows. Due to the limited sampling period and the hydrologic uncertainty of which flows will occur over the next 50 years, the actual volume of sediment entering the modeled reach at Linneus (and the sediment basin and downstream habitats) could be higher or lower than estimated. The risk that the sediment loads are higher than expected was addressed by combining uncertainty in the rating curve with hydrologic uncertainty to create a composite standard deviation. This analysis resulted in a distribution of cumulative sediment load for 100 different rating curves (Figure 4-7). One standard deviation away from the calibrated result is presented as a reasonable range of uncertainty. The quantified risk, defined as one standard deviation of the sediment load uncertainty as documented in Appendix C, is 350,251,082 cubic feet of sediment.

The study team considered different measures that could be used to “buy down” the risk and uncertainty associated with forecasting future sediment loads and their influence on the trapping efficiency and lifespan of a sediment detention basin. Risk and uncertainty reduction measures considered included implementing bank stabilization measures in the upper watershed, dredging out the sediment detention basin as part of O&M, expanding the basin, or raising the perimeter sediment detention basin levee. Dredging the basin as part of O&M was determined to be cost prohibitive. Expanding the basin and/or raising the perimeter levee would trigger dam safety requirements and potentially would require additional land acquisition, which was not considered cost effective. Table 4-11 illustrates the amount of sediment reduction and percent of quantified risk that could be achieved from various levels of upstream banks stabilization projects. This assumed small bank stabilization sites of approximately 250 feet in length with 12-foot high banks. Costs were estimated based on similar projects MoDNR has completed for stabilization, since it is assumed, they would complete this action as part of their work in kind. Twenty- two constructed stabilization projects were assessed. Each site measures approximately 0.05 acres on average resulting in a real estate acquisition cost of $92.40 per project ($77 plus a 20% contingency amount that includes all possible acquisition scenarios). The total real estate acquisition cost is estimated at $23,400 for all sites (approximately 18 acres). Combined construction and real estate acquisition costs for the sites averaged $21,400 per project. A 27% contingency amount was added to the combined costs, to include all possible construction as well as real estate acquisition scenarios. The resulting estimated cost per bank stabilization project is $27,200. If 316 projects are built, the total combined construction and real estate cost for all bank stabilization projects is estimated to be approximately $8,595,200.

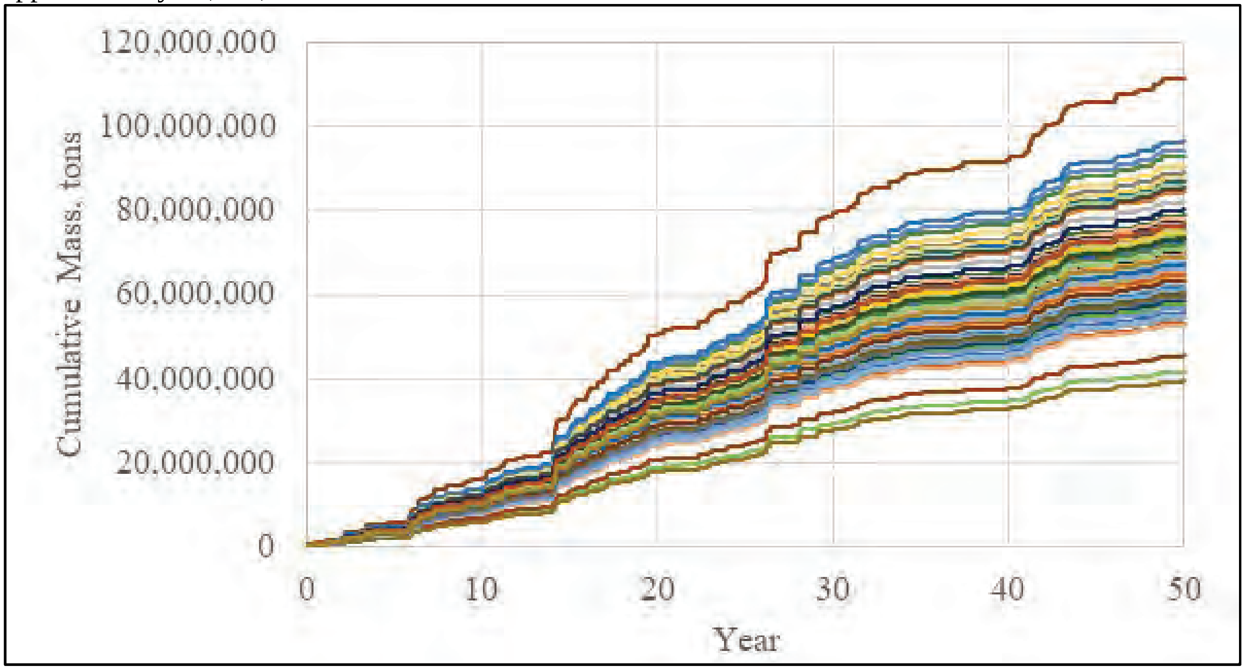

Figure 4-7. Cumulative incoming sediment load using 100 different rating curves.

Table 4-11. Floodplain Sediment Deposition Reduction below Highway 36

Risk-based Alternatives	# Small Sites	Cubic Feet Reduction	% of Quantified Risk	Total Estimated Cost	Estimated Net AAHUs
LC15.05	95	15,000,000	4%	$2,584,000	25.7
LC15.15	190	30,000,000	9%	$5,168,000	51.3
LC15.25	316	50,000,000	14%	$8,595,200	85.3
LC15.35	721	114,000,000	33%	$19,611,200	194.7
LC15.45	1264	200,000,000	57%	$34,380,800	315.6
LC15.55	1738	275,000,000	79%	$47,273,600	418.0
LC15.65	2212	350,000,000	100%	$60,166,400	511.9

Note: Table illustrates percent reduction for modeled units.

4.10 Selection of the Recommended Plan

Federal planning for water resources development was conducted in accordance with the Principles and Guidelines adopted by the U.S. Water Resources Council.

> *"For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost effective and justified to achieve the desired level of output. This plan shall be identified as the National Ecosystem Restoration (NER) Plan."*

4.10.1 Locust Creek Study Area

The NER Plan and the recommended plan for the Locust Creek study area is LC 15.25, which is LC15 with the addition of upstream bank stabilization projects to achieve a 14% reduction in quantified risk. LC15.25 was the most effective plan at achieving the Locust Creek planning objectives of improving hydraulic connectivity while maintaining floodplain connectivity, reducing sediment deposition on the floodplain, reducing the potential for log jams, and increasing habitat quantity and quality within the study area. LC15.25 is the most efficient alternative plan at creating ecosystem benefits for its project cost. It is a complete plan and is considered an acceptable plan.

The risk of habitat loss or the need for costly dredging of the sediment detention basin is higher in later years of the project life if sediment loads increase over time, are consistently much greater than what was originally modeled, or are much higher with extreme flood events. Implementation of different increments of upper basin erosion control actions helps identify the various levels of risk that could be reduced from a long-term project sustainability perspective. The increments to buy-down this risk for Alternative LC15.25 and the associated sediment detention basin were discussed with the study team and the cost-share sponsor (Table 4-11). Each increment was assessed by not only how much risk it would buy down, but also how implementable they would be based on existing sponsor resources. Due to limited funding, equipment and manpower, the team agreed that targeting a 50,000,000 cubic feet reduction would be the most implementable over the project life. This increment of upper basin actions would also be able to be completed prior to when potential sediment trapping efficiency or capacity issues could occur within the LC15.25 sediment basin due to higher than expected long-term sediment loads.

It is also likely that within the upper basin of Locust Creek, other resource agencies, their projects, and site specific erosion control actions would be implemented over the next 50 years to further buy down downstream sedimentation risk, ensure downstream habitat benefits, restore upper basin habitat values, reduce losses to productive agricultural lands, improve water quality in the basin, and ensure longevity of the LC15.25 sediment detention basin (see Section 5.19.2). Synergy between multiple resource agencies, the public, and Federal entities will be required to address the long-term sedimentation issues within the Grand River watershed. The implementation of up to 316 upper basin erosion control sites or similar cost-effective methods for sediment reduction was identified as the most appropriate to support long-term effectiveness and efficiency of LC15.25 by buying down risk associated with future sediment loads. Appendix C3 documents the risk and uncertainty analysis that led to the selection of this number of bank stabilization projects. It is also anticipated that this initial suite or increment of erosion control sites will help pave the way for additional restoration within the upper basin by others, help identify the most appropriate and effective mechanisms for erosion control, and most importantly begin to address the source for lower basin problems. Therefore, Alternative LC15.25 with up to 316 upper basin erosion control sites or similar cost-effective methods for sediment reduction was selected as the recommended plan for Locust Creek. The addition of upstream bank stabilization actions would enhance the effectiveness of LC15.25 at achieving planning objectives by further increasing sediment reduction and reducing the potential for log jams. This alternative would realize opportunities in the upper portion of the sub-basin to improve water quality, protect critical infrastructure, and farmland.

4.10.2 Fountain Grove Study Area

Total average annual costs of the best buy alternatives ranged from $95,000 to $1,566,236, with net benefits ranging from 254 AAHU to 1,152 AAHU. The average annual benefits and costs of the best buy Fountain Grove alternatives resulted in incremental cost per incremental AAHU being as inexpensive as $245 to as expensive as $11,430.

FG3 significantly reduces the drainage time on West Fountain Grove CA compared to FG1. This results in a reduction in sediment deposition and loss of micro-topography, as well as limiting negative habitat impacts from extended flood inundation. However, FG3 does not prevent sedimentation from Parson's Creek or provide the ability to independently fill or drain all pools. As a result, FG3 net 254 AAHUs, which is substantially less than the other best buy alternatives. FG3 only produces benefits on West Fountain Grove CA. As a result, FG3 does not achieve the Fountain Grove planning objectives as well as the other best buy alternatives.

FG35 is a combination of sub-area alternatives FG6 on West Fountain Grove CA, and FG10 on South Fountain Grove CA. This alternative adds features to reduce the flooding and sediment inputs from Parson's Creek more effectively reducing habitat impacts. This alternative also realigns levees and restores microtopography on West Fountain Grove CA to improve the resiliency of the internal levees and provide independent fill or drain for all pools. The groundwater pumps associated with FG10 would allow for more productive management of South Fountain Grove CA. With a net AAHU of 1,016 and a total average annual cost of $1,021,138, alternative FG35 generates an additional 762 AAHU above FG3. Each of these 762 additional AAHUs obtained from implementing FG35 costs $1,134. However, FG35 does not benefit East Fountain Grove CA and as a result does not achieve the planning objectives to the same extent as FG36, FG37, FG37.5, or FG38. FG35 cannot be determined to reasonably maximize ecosystem benefits at Fountain Grove CA compared to other best buy alternatives because of the lack of benefits to East Fountain Grove CA. East Fountain Grove CA is significant because:

- East Fountain Grove CA habitats have been the least degraded and represent the best and most reliable habitat within Fountain Grove CA and the surrounding matrix of public and private lands.
- The core habitat at East Fountain Grove CA provides stopover habitat for over 227 migratory bird species.
- East Fountain Grove CA wetland units have a high probability of providing annual resources for wildlife because the likelihood of this area being impacted by flood events during the entire year is lower compared to West and South Fountain Grove CA. As a result, East Fountain Grove CA is critical to the resilience of the entire site and providing resources to waterfowl and migratory birds.
- East Fountain Grove CA contains bottomland forest that may provide maternity and/or foraging habitat for the Federally-endangered Indiana bat and northern long-eared bat.

FG36 is a combination of the fully restored West Fountain Grove CA with modified pool design and restored micro-topography to reduce sediment impacts and provide independent fill and drain for all pools (FG6); the addition of groundwater pumps for improved habitat on South Fountain Grove CA (FG10) and adds a levee setback to prevent failure of the primary levee on East Fountain Grove CA (FG7). It is assumed under the FWOP condition that this levee will continue to be negatively impacted and eventually fail, resulting in the degradation of existing wetland habitat on East Fountain Grove CA. Total annual cost for FG36 is $1,134,932, with net AAHUs of 1,074. FG36 provides 59 additional AAHUs (all wetland AAHUs on East Fountain Grove CA) above FG35, with each of the additional AAHUs costing $1,935. FG36 does provide ecosystem benefits to all three areas of Fountain Grove CA; however, the benefits to East Fountain Grove CA are the lowest of the best buy alternatives that include measures in that area.

FG37 is a combination of the fully restored West Fountain Grove CA with modified pool design and restored micro-topography to reduce sediment impacts and provide independent fill and drain for all pools (FG6); the addition of groundwater pumps for improved habitat on South Fountain Grove CA (FG10), the East Fountain Grove CA levee setback, and includes a raise of the Che Ru Lake perimeter on East Fountain Grove CA (FG8). FG 37 has a total annual cost of $1,299,705 with a net AAHU 1,114. This alternative provides 40 incremental AAHUs above FG36 for an additional incremental cost per AAHU of $4,171. While the raise of Che Ru lake does increase wetland form and function on East Fountain Grove CA, it does not reasonably maximize it on that area. In addition, the installation of a water pipeline that is associated with the Che Ru Lake improvements under FG37 has a greater potential of affecting cultural resources than other measures considered on East Fountain Grove CA.

Alternative FG37.5 is a combination of the fully restored West Fountain Grove CA with modified pool design and restored micro-topography to reduce sediment impacts and provide independent fill and drain for all pools (FG6); the addition of groundwater pumps for improved habitat on South FG (FG10); the East Fountain Grove CA levee setback, and modified pool design and restoration of microtopography on East Fountain Grove CA. FG37.5 provides 1,140 AAHUs at a total average annual cost of $1,427,932. The incremental benefits of FG37.5 is an additional 26 AAHUs over FG37 at an incremental cost per AAHU of $4,951. This alternative restores a more-natural habitat form and function to all portions of Fountain Grove (East, West and South). The modified pool design with a water movement channel would allow for independent fill or drain of all pools on Fountain Grove CA. Reduced infrastructure from the modified pool design would result in additional resiliency for the entire site. Larger pools and fewer units on East Fountain Grove CA would limit the total number of levees needing to be maintained as well as fewer structures to repair and require annual maintenance. This reduction of infrastructure in East Fountain Grove CA would also reduce instances of disturbance to wildlife during water manipulations as the levee network is reduced, thereby increasing the quality of habitat. Minimizing infrastructure where possible, repositioning access along the periphery of the refuge, and using the existing topography is a justified investment to maintain the habitat quality, while at the same time reducing long-term management and maintenance costs for this critical area of Fountain Grove CA. The instability of the Higgins Ditch-Hickory Branch confluence and the additional flows to the waterways from the avulsions of Locust Creek currently threaten the East Fountain Grove CA levee and the habitat it protects. Additional renovations accommodate this changing hydrology and reduce the potential for future habitat degradation resulting from large flood events. The levee setback and ability to backfill the East Fountain Grove CA pools during major floods is critical to protecting the federal investment. The installation of wells on the southern portion of the site would greatly increase the timing and duration of flooding of these wetlands, thereby benefiting the quality of habitat and regularity that a range of wetland species could utilize these resources within and across years.For these reasons, the PDT determined that FG37.5 reasonably maximizes ecosystem benefits in the Fountain Grove study are and that the incremental cost of $4,951 per 26 incremental AAHUs is worth the economic investment. FG37.5 is a cost-effective best buy plan that reasonably maximizes habitat output and best meets the planning objectives. Therefore FG37.5 this is the NER plan as well as the Recommended Plan.

FG38 includes the fully restored West Fountain Grove CA with modified pool design and restored micro-topography (FG6); the addition of groundwater pumps on South Fountain Grove CA (FG10); the East Fountain Grove CA levee setback and modified pool design and microtopography, as well as the raise to the perimeter of Che Ru Lake (FG9). While this plan restores more natural form and function to East, West and South Fountain Grove; the additional cost related to the benefits of adding the Che Ru Lake raise are not justified. FG38 provides 12 additional AAHUs over FG37.5 at a cost of $11,430 for each unit. The incremental cost per AAHU of FG38 are more than double the incremental cost per AAHU of FG37.5. The PDT determined the economic investment associated with FG38 was not justified when compared to FG37.5, which reasonably maximizes ecosystem benefits and also achieves the planning objectives.

4.10.3 Yellow Creek Study Area

The NER Plan and the recommended plan for the Yellow Creek study area is YC11. It was the only effective plan at achieving the Yellow Creek planning objectives of reducing the impacts of inundation and sedimentation within the Yellow Creek/Grand River confluence and increasing habitat quantity and quality within the study area. YC11 is the most efficient alternative plan at creating ecosystem benefits for its project cost. Implementation of YC11 requires action and investment by the USFWS, therefore, it is not a complete USACE plan; however, no other alternatives within the final array were reasonable. It is considered an acceptable plan.

The recommended plan is a Federal Plan that is comprised of a USACE plan (LC15.25 and FG37.5) and a plan to be implemented by USFWS (YC11). The details of the recommended plan and implementation responsibilities for the Federal Plan are described further in Section 6.0.

4.10.4 Combined Recommended Plan

The NER Plan and recommended plan for the Lower Grand River sub-basin consists of the combined NER plans for the Locust Creek study area, Fountain Grove study area, and Yellow Creek study area. Although each study area plan has been evaluated and justified individually; substantial ancillary benefits to the watershed and habitat connectivity can be achieved with a combined plan. In addition, a combined plan best addresses the extensive Federal interest documented for the study area.

A combined plan benefits almost 40,000 acres of wet prairie, emergent wetland, bottomland forest, and aquatic riverine habitats, of which about 24,000 acres occur on state and Federal lands that are considered the most representative of these natural systems in the region. The study area lies near the border of the Central and Mississippi waterfowl flyways, is designated as an area of greatest continental significance to North American ducks, geese, and swan in the North American Waterfowl Management Plan, is an Important Bird Area by the Audubon Society, is a focus area watershed in the NRCS Mississippi River Basin Healthy Watersheds Initiative, has received over $100 million in NRCS wetland easement investment, and contains a NRI-listed segment of Locust Creek, as well as the Swan Lake NWR. The study area contains habitat supporting federally-listed bat species and is home to bald eagles. The future without project forecast demonstrates substantial degradation to these habitats would occur, undermining the existing Federal investment in the study area.

The NRCS has made a significant investment in restoration efforts in the study area. NRCS has approximately 205 easements (typically 30-year or permanent easements) comprising approximately 27,600 acres enrolled in conservation easement programs within the Lower Grand River sub-basin. The NRCS Working Lands Programs are implemented via contracts and have a shorter time horizon than conservation easements. In Fiscal Year 2017, 171 contracts were initiated in the Lower Grand River sub-basin comprises 28,243 acres with payments in excess of $1.8 million.

The lower Locust Creek and Grand River complex of publicly owned wetlands provides unparalleled connectivity of represented habitat types in the region, which is threatened by the on-going degradation in the area. The combined plan would improve future conditions by accounting for habitat benefits on NRCS easements, which are permanent easements and critical areas for providing habitat connectivity between the public areas of Pershing State Park, Fountain Grove CA, Yellow Creek CA, and Swan Lake NWR. A combined plan is consistent with taking a watershed perspective to ecosystem restoration. A combined plan would best capitalize on the NRCS investment in the Lower Grand River sub-basin, which was strategic in providing connectivity between the three premier public areas.

The study area falls within the heart of Indiana bat maternity habitat in Missouri with the highest concentrations and numbers of bats and maternity colonies of this Federal endangered species. The draft Recovery Plan for the Indiana bat identifies conservation and management of summer habitat as a needed action (USFWS 2007). The combined plan would have a net increase of almost 1,400 AAHUs of bottomland forest directly benefiting listed bat species.

For these reasons and in consideration of the Federal interest within the study area, a combined plan is the recommended plan. Construction of the three project areas can be completed independently and in any given order to realize habitat benefits, as none depend on the other. However, as Fountain Grove study area and Locust Creek study area would have separate cost-share sponsors and Swan Lake NWR would be the responsibility of the USFWS, other factors will be important to consider. Prioritization of construction should be dependent on sponsor availability of funds and land ownership (some areas require more land acquisition prior to construction).

5.0 Environmental Consequences

This chapter describes the anticipated impacts to the environment from implementation of the FWP alternatives included in the final array for each study area. Impacts associated with the No Action alternative, which serves as the baseline for comparison, are also described. Impacts associated with upstream bank stabilization projects are discussed generally based on past implementation of similar projects by USACE and the State of Missouri. As stated previously, specific locations for the upstream bank stabilization projects have not yet been identified. The FWP alternative impacts are typically discussed collectively, with any notable differences between alternatives highlighted.

The potential impacts are described using the following terms:

- Beneficial: A positive change in the condition or appearance of the resource or a change that moves the resource toward a desired condition.
- Adverse: A change that moves the resource away from a desired condition or detracts from its appearance or condition.
- Direct: An effect on a resource by an action at the same place and time. For example, soil compaction from construction traffic is a direct impact on soils.
- Indirect: An effect from an action that occurs later or perhaps at a different place and often to a different resource, but is still reasonably foreseeable.
- Short-term: impacts generally occur during construction or for a limited time thereafter, generally less than two years, by the end of which the resources recover their pre-construction conditions.
- Long-term: impacts last beyond the construction period, and the resources may not regain their preconstruction conditions for a longer period of time.

5.1 Priority Habitat Types

5.1.1 No Action Alternative

Under the no action alternative, all priority habitats would experience degradation due to the continued effects of prolonged inundation, sediment deposition, log jams, and other problems previously described for the study area. Sections 3.5, 3.6, and 3.7 described the FWOP condition of priority habitat types associated with taking no action. The priority habitat types would experience adverse short and long-term direct impacts under the No Action Alternative.

5.1.2 FWP Alternatives

All the FWP alternatives were formulated to benefit the ecosystem and priority habitat in the study areas. All the FWP alternatives for Locust Creek, Fountain Grove, and Yellow Creek study areas would result in net increases in AAHUs for the priority habitat types, which represents beneficial direct impacts (see Section 4.8 and Appendix D for detailed discussion on the habitat evaluation).

Locust Creek from HWY 36 to the Grand River is listed on the NRI for outstandingly remarkable values including fish, historic, recreational, scenic, and wildlife. Under Section 5(d)(1) of the Wild and Scenic Rivers Act, federal agencies must seek to avoid or mitigate actions that would adversely affect NRI river segments. In accordance with the CEQ's "*Procedures for Interagency Consultation to Avoid or Mitigate Adverse Effects on Rivers in the Nationwide Inventory*", potential impacts to this NRI reach of Locust Creek have been evaluated. None of the Locust Creek FWP alternatives would result in the destruction or alteration of all or part of the free-flowing nature of this segment of Locust Creek. Under the existing condition, over 90% of Locust Creek flows are being diverted to Higgins Ditch as a result of channel avulsions. The FWP alternatives would restore flow to Locust Creek, benefiting its free-flowing nature. Dredging of the Locust Creek channel would be necessary to restore a sustainable channel geometry and slope that has been altered by past and ongoing sedimentation. The dredging would be a one-time occurrence and long-term operations and maintenance of the dredged reach is not anticipated. The need for bank stabilization in this reach following dredging would be determined during PED. Dredging this portion of Muddy and Locust creeks would not be anticipated to cause any erosion problems. The extent of required dredging would be refined during PED and it is possible the amount of dredging may be reduced. Restoring flow to Locust Creek without dredging a portion of the creek would likely cause adverse impacts to surrounding habitats. No visual, audible, or other sensory intrusions that would be out of character with the Locust Creek setting would be introduced. Water quality is anticipated to improve within Locust Creek because of sediment load reductions, discussed in Section 5.3. Property acquisition necessary for ecosystem restoration would occur adjacent to this Locust Creek segment. The existing condition of Locust Creek is greatly altered from the time of its listing on the NRI. The FWP alternatives are not anticipated to result in any impacts that would preclude the stream segment's eligibility for inclusion in the National Wild and Scenic Rivers System. The FWP alternatives would be beneficial to its eligibility because of anticipated stream restoration benefits.

Although not quantified in the habitat evaluation, upstream bank stabilization projects included with certain Locust Creek FWP alternatives would provide localized benefits to priority habitat types from either prevention of further loss of the habitat to streambank erosion or from establishment of these habitat types in the riparian area following stabilization of the bank.

5.2 Hydrology, Hydraulics, and Sedimentation

5.2.1 No Action Alternative

No actions would be taken to restore hydraulics in the study area under this alternative. Altered hydraulics would continue to contribute to degradation of habitat. Additional channel avulsions would likely occur, causing adverse direct habitat impacts. Hydrology is expected to be the same as the existing condition. Habitat-degrading sedimentation rates are forecasted to continue over the 50-year period of analysis under this alternative.

5.2.2 FWP Alternatives

FWP alternatives would modify hydrology and/or hydraulics in the three study areas for the benefit of aquatic and terrestrial habitats. Restoration measures under all FWP alternatives are expected to benefit aquatic ecosystem function as demonstrated by the habitat evaluation results for aquatic habitat tracts Locust Creek alternatives LC3.5 (Large Sediment Basin Plus Connection Channel), LC15.5 (Large Sediment Basin, Higgins Ditch Grade Control, Plus Connection Channel), and LC18.5 (Small Sediment Basin with Flows to Higgins Ditch Plus Connection Channel) would have the largest changes to hydrology and hydraulics because they would include measures to both restore flow north of HWY 36 that is being diverted to Higgins Ditch back to Locust Creek and connect Higgins Ditch to Locust Creek in the southern portion of the study area. LC 3 (Large Sediment Basin Only), LC15 (Large Sediment Basin and Higgins Ditch Grade Control), LC 15.25(Large Sediment Basin, Higgins Ditch Grade Control, and Upper Basin Bank Stabilization), and LC18 (Small Sediment Basin with Flows to Higgins Ditch) would have the next largest changes to hydrology and hydraulics because they would restore flow to Locust Creek north of HWY 36 but would not include the downstream Higgins Ditch connection. LC 15.25 would have the largest reduction in sediment loads because it combines the large sediment detention basin with bank stabilization projects in the upper watershed. Alternatives LC 3, LC3.5, LC15, and LC15.5 would also result in large reductions in sediment because they include the larger sediment detention basin. Alternatives LC 18 and LC18.5 would have smaller reductions in sedimentation because of a smaller sediment detention basin. Although there are numerous Fountain Grove alternatives, they are all different variations of measures designed to improve the hydrology within Fountain Grove CA. Appendix B describes the hydraulic modeling results specific to those Fountain Grove alternatives that were modeled. Appendix D describes how potential changes from hydrology, hydraulics, and sedimentation for each Fountain Grove and Yellow Creek alternative was evaluated in terms of effects to quality and quantity of priority habitats. These changes are considered beneficial impacts to hydrology and hydraulics within all three study areas. All FWP alternatives would have beneficial impacts to sedimentation by reducing the forecasted amount of floodplain deposition in the study areas. More detailed information on hydrology and hydraulics can be found in Appendix A and B. Sediment analysis is included in Appendix C; however detailed sediment analysis was not performed for the Fountain Grove and Yellow Creek study areas.

5.3 Water Quality

5.3.1 No Action Alternative

No change from existing conditions would be anticipated under the No Action alternative. Those water bodies currently on the 303(d) impaired water body list would likely remain listed into the future. Excessive erosion and sedimentation would be expected to continue and would represent a long-term adverse impact to water quality.

5.3.2 FWP Alternatives

Locust Creek FWP alternatives that include a sediment detention basin and/or upstream bank stabilization projects would result in beneficial impacts to water quality from a reduction in sediment load. Primary pollutants resulting in impaired water bodies in the study area are E. coli, suspended sediment, total nitrogen, and total phosphorous. It would be expected that a reduction in suspended sediment would also result in a decrease in nutrient levels. For alternatives that include a sediment detention basin but do not include upstream bank stabilization, these benefits would occur downstream of HWY 36 in Locust Creek. Locust Creek contributes a relatively small portion of the total sediment in the Grand River; therefore, the any water quality impacts in the Grand River would be negligible. For alternatives that include upstream bank stabilization, benefits would be anticipated in the upper portions of the watershed. Fountain Grove FWP alternatives that include bank armoring on Jackson’s Ditch may result in short-term minor adverse impacts from construction activities. YC11 (Levee Setback on Swan Lake NWR) does not involve work within water bodies and therefore is not anticipated to result in any impacts to water quality. None of the FWP alternatives would be anticipated to cause an impairment of any designated use or cause exceedance of a water quality standard. A 404(b)(1) assessment has been completed and MoDNR has issued a 401 water quality certification for the recommended plan (Appendix K).

Project features such as the diversion berm, stream dredging, grade control, and bank stabilization projects would require in-channel construction activities. Direct impacts on water quality would be minor, short-term, and adverse during construction from increased turbidity and potential for sediment or other construction-related pollutant to enter the water body. BMPs would be implemented to minimize the incidental fallback of material into the waterway and to minimize the introduction of fuel, petroleum products, or other deleterious material from entering the waterway. Such measures could include the use of erosion control fences; storing equipment, solid waste, and petroleum products above the ordinary high water mark and away from areas prone to runoff; and requiring that all equipment be clean and free of leaks. To prevent fill from reaching water sources by wind or runoff, fill would be covered, stabilized or mulched, and silt fences would be used as required. Other measures to minimize adverse effects would include using clean rock fill with minimal fines, stabilizing the earthen material with rock, using appropriate construction equipment, minimizing the amount of time that equipment would be in the stream channel, and not placing fill in the stream during unusual high water events.

5.4 Fish and Wildlife Resources

5.4.1 No Action Alternative

As described previously, habitats on which fish and wildlife depend would continue to experience degradation under the No Action alternative. As a result, fish and wildlife populations would be expected to experience adverse short and long-term adverse impacts. The severity of the impact would vary by species and depend on the affected habitat type.

5.4.2 FWP Alternatives

All FWP alternatives would result in beneficial long-term impacts to fish and wildlife resulting from an increase in the quantity and quality of habitat. Net increase in AAHUs modeled for habitat evaluation and quantification is considered representative for the effects of alternatives on fish and wildlife populations (Appendix D; Table 15). All FWP alternatives include construction of features that would result in ground disturbance and/or tree clearing. Fish and wildlife within proximity to project features would experience short-term direct adverse impacts from construction activities and/or short-term indirect adverse impacts from construction-related noise or disturbance. These impacts are anticipated to be negligible to minor. Appendix I includes the Final Fish and Wildlife Coordination Act Report prepared by the USFWS in coordination with the state natural resource agencies. It describes agency views on the effects of the project to fish and wildlife resources in the study area.

5.5 Federal Threatened and Endangered Species

5.5.1 No Action Alternative

Under the no action alternative, bottomland forest in the study area would continue to be degraded. A general decline in quality of bottomland forest would be anticipated. Over the long-term this may result in adverse impacts to the Federally-listed bat species that rely on this habitat type in the study area.

5.5.2 FWP Alternatives

Pallid sturgeon would not likely be adversely affected by any of the FWP alternatives. Pallid sturgeon have been recently captured in the Grand River. Pallid sturgeon are well known to travel long distances. MDC has indicated non-wadeable, mid-sized, Missouri River tributaries in Missouri are currently understudied. The USFWS indicated this situation limits understanding of the potential presence and use of pallid sturgeon in the study area. In-stream construction activities would not occur in the Grand River; therefore, direct impacts to pallid sturgeon are unlikely. Pallid sturgeon are adapted to the naturally-turbid waters of the Missouri and Mississippi Rivers. Suspended sediment reductions or turbidity changes in the Grand River would be negligible because the contribution of sediment load from Parsons Creek and Locust Creek to the Grand River is relatively small. As a result and due to the low numbers of pallid sturgeon captured in the Grand River, no indirect adverse impacts are likely from any FWP alternative. Following consultation with the USFWS, it was determined that the recommended plan may affect, but would not likely adversely affect pallid sturgeon (Appendix J).

All three of the Federally-listed bat species are known to occur in one or more of the study areas. Tree clearing would be necessary to construct certain project features under the FWP alternatives. Approximately 247 acres of tree clearing is estimated for construction of the recommended plan. The majority of tree clearing (approximately 86 acres) would be associated with constructing the avulsion spoil berm that is a component of all Locust Creek final array alternatives. The bats roost in forest and woodland habitats. Amounts of required tree clearing would be refined during the design phase of the project. Any opportunity to avoid or minimize tree clearing would be considered during design. Any necessary tree clearing would be restricted to the non-active period of November 1 to March 31 to avoid any impacts to bat species. Long-term beneficial impacts to bat species would be expected from an increase in bottomland forest AAHUs over the 50-year period of analysis. LC3 (Large Sediment Basin Only) and LC3.5 (Large Sediment Basin Plus Connection Channel) would result in the largest net increase in bottomland forest AAHUs in the Locust Creek study area. YC11 (Swan Lake NWR Levee Setback) results in a net increase of 271 AAHUs of bottomland forest in the Yellow Creek study area. Fountain Grove final array alternatives ranged from zero to 489 net increase in bottomland forest AAHUs. FG10 (installation of groundwater pumps on South Fountain Grove CA) resulted in no increase. FG6 and all its combinations resulted in the largest increase in bottomland forest AAHUs. Appendix D includes the full discussion of the habitat quantification and evaluation. The USFWS provided a list of conservation measures to implement to ensure minimization of impacts to federally listed bats (see

Section 6.6). Appendix J includes the Biological Assessment that was the basis for consultation with USFWS regarding the proposed action. USACE determined that the recommended plan may affect but would not likely adversely affect federally listed bats. USFWS concurred with that determination (Appendix J).

Topeka shiner would not be impacted by any FWP alternatives because it does not currently occur in the study area. For implementation of any alternative that includes upstream bank stabilization project, USACE would coordinate the locations of those projects with USFWS to ensure no impacts occur to future Topeka shiner reintroduction sites.

5.6 Invasive Species

5.6.1 No Action Alternative

Under the no action alternative, it is anticipated invasive species would continue to be problematic within the study area as documented for the existing conditions. Alterations within the watershed are considered to be facilitating the spread of invasive species within the study areas.

5.6.2 FWP Alternatives

All FWP alternatives seek to restore ecosystem structure and function for native species and habitats. It is anticipated native species should be able to better compete with existing invasive species and make the ecosystem less susceptible to future invasions. During construction, best management practices would be implemented to reduce invasion while construction areas are being disturbed. All previously used construction equipment would be required to be cleaned prior to being brought onto construction sites. Construction contracts would stipulate that contractors are required to ensure that all equipment is free from soil residuals, egg deposits from plant pests, noxious weeds, plant seeds, and aquatic nuisance species prior to its use. Native vegetation would be used to re-vegetate any disturbed areas to prevent the establishment of invasive species.

5.7 Floodplains

5.7.1 No Action Alternative

Long-term adverse impacts to the floodplain would occur under the No Action alternative. The floodplain would be expected to continue to degrade as sedimentation fills in the area at an excessive rate. As the floodplain fills, less space will be available to floodwater and degradation can be expected to progress into adjacent and downstream areas.

5.7.2 FWP Alternatives

FWP alternatives are designed and implemented in compliance with USACE regulations on implementation of Executive Order 11988, on Floodplain Management (ER 1165-2-26). The ER states USACE policy is to avoid or minimize adverse impacts associated with use of the base floodplain and avoid inducing development in the base floodplain unless there is no practicable alternative. Project features under the FWP alternatives must occur within the base floodplain and there are no practicable alternatives to achieve the planning objectives that would not occur in the base floodplain. Actions under the FWP alternatives would benefit floodplains by reducing future floodplain deposition that reduces floodplain capacity. None of the FWP alternatives would be expected to induce development in the floodplain.

5.8 Geology and Soils

5.8.1 No Action Alternative

Under the No Action alternative, existing rates of soil erosion in the study area would be anticipated to continue. This level of erosion would be anticipated to continue to allow for high levels of floodplain sediment deposition. As a result, continued long-term adverse impacts to geology and soils would be anticipated.

5.8.2 FWP Alternatives

No long-term impacts to geology are anticipated. For soils, the FWP alternatives would have beneficial impacts through the proposed project features. An increase in AAHUs of priority habitats would increase soil organic matter and soil fertility. Bank stabilization projects would directly affect floodplain soils by stabilizing and re-sloping banks providing opportunities for soils to accumulate among the in-stream structures. Sediment basins would also directly affect floodplain soils by depositing of fine material over time. Spoil from dredging of Muddy and Locust creeks would be used to create habitat enhancement areas in coordination with state natural resource staff on Pershing State Park. Spoil would also be placed along the riparian area of Locust Creek to plug avulsion channels. Excess material would be disposed of off-site. Earthwork activities associated with levee construction/modification or micro-topography work at Fountain Grove CA would disturb existing soils. Long-term beneficial impacts to soils within the study areas would be anticipated.

5.9 Prime and Unique Farmlands

5.9.1 No Action Alternative

No impacts to prime and unique farmlands would occur under the No Action alternative.

5.9.2 FWP Alternatives

Fountain Grove and Yellow Creek FWP alternatives would have no impacts to prime and unique farmlands as project features are located on existing conservation area or on the Swan Lake NWR. Locust Creek FWP alternatives that include the large sediment detention basin would have minor impacts to prime farmland. Most of the large sediment detention basin is not considered prime farmland; however, minor portions would be considered prime farmland if drained. Conversion of these areas to a sediment detention basin would be considered a long-term minor adverse impact. The small sediment detention basin has less impacts to prime farmland. Locust Creek FWP alternatives would likely result in long-term beneficial impact to prime and unique farmlands in the study area by reducing the extent of inundation on the floodplain. Upper watershed bank stabilization projects would benefit any prime and unique farmlands at those project locations by preventing further loss to streambank erosion. USACE coordinated with the USDA-NRCS regarding proposed conversion of prime farmlands in accordance with the Farmland Protection Policy Act. This coordination included completion of a Farmland Conversion Impact Rating (Form AD-1006) with assistance from USDA-NRCS. Coordination with USDA-NRCS including the final Form AD-1006 can be found in Appendix H.

5.10 Socioeconomics

5.10.1 No Action Alternative

In the absence of any project measures, the socioeconomic characteristics of the study area would remain the same. Recently, the study area has been experiencing a slight decline in population, which would be expected to continue into the future. Employment prospects and industry mix are unlikely to vary substantially into the future.

5.10.2 FWP Alternatives

Effects of measures in the study areas would be similar to those of the No Action alternative. The areas affected under all FWP alternatives are rural in nature and sparsely populated. Alternatives with measures that require more substantial construction activities such as levee modification, dredging, bank stabilization, etc. could cause short-term disruptions to roadway traffic during the construction period. Given the area’s rural nature and sparse population, as well as the relatively short duration of the construction period, the impacts to the local population would be negligible. Local industries, employment, or population would likely not suffer adverse effects from the alternatives. Modest, regional benefits may be experienced as a result of temporary jobs and income from project construction in the area, representing a short-term beneficial impact.

5.11 Environmental Justice

5.11.1 No Action Alternative

There would be no environmental justice impacts under the No Action alternative because no restoration measures would be implemented.

5.11.2 FWP Alternatives

The 4-county study area has minimal environmental justice populations, and in fact, the area has much smaller proportions of the population that identify as minority when compared to the state proportions. There is a greater proportion of the population living below the poverty level in 3 of the 4 study area counties when compared to populations in the state; however, the differences are small and the percentages living below the poverty level fall below the U.S. Census threshold for a "poverty area" of 20%. In addition, implementation of any of the FWP alternatives would not result in disproportionate and adverse impacts to environmental justice communities.

5.12 Land Use

5.12.1 No Action Alternative

No changes to existing land use within the study area would be expected under the No Action Alternative.

5.12.2 FWP Alternatives

The FWP alternatives that would result in land use changes are Locust Creek alternatives that include a large or small sediment detention basin. The larger sediment detention basin (LC3, LC3.5, LC15, and LC15.5) would require acquisition of approximately 1,835 acres of land that is primarily in agricultural use when not flooded. These areas would transition to a conservation/natural resources use under these alternatives. The smaller sediment detention basin included in LC18 and LC18.5 would require approximately half as much land acquisition of a similar type. Another 206 acres of predominantly agricultural land would be placed under flowage easements due to induced flooding associated with the Locust Creek alternatives. As was previously described, the study area and the watershed are predominately comprised of agricultural land use. This represents a less than 5% change in the amount of cultivated land existing in the focused study area; and would be a much smaller percentage when considered at the sub-basin scale. As a result, this is considered a minor long-term impact. The change to a natural area is not inconsistent with the setting or other uses within the study area; therefore, the change would not be considered adverse.

5.13 Flood Risk

5.13.1 No Action Alternative

Long-term adverse impacts to the flood risk would occur under the No Action alternative. The floodplain would be expected to continue to degrade as sedimentation fills in the area at an excessive rate. As the floodplain fills, less space will be available to floodwater and degradation can be expected to progress into adjacent and downstream areas. Futher discussion of the FWOP is included in Appendix B2..

5.13.2 FWP Alternatives

Changes in flood risk for the Locust Creek study area were assessed by simulating 100-year constant flows for the No Action alternative and LC15. Refinements to the recommended plan were made following its identification as the tentatively selected plan and publication of the draft report. The flood risk analysis for the recommended plan was updated to account for the refinements. Results were evaluated to identify if 100-year inundation extents or water surface elevations increased on private properties not proposed for acquisition as part of the recommended plan. Appendix B2 includes a detailed discussion of the flood risk analysis for the recommended plan . Most of the Locust Creek study area has some existing level of flood risk. Figure 5-1 shows the extent of 100-year event inundation occurring under the FWOP condition compared to the recommended plan. Yellow areas on Figure 5-1 are locations inundated under the recommended plan that modeling indicates would not be under the FWOP. Most of the increased inundation extent is contained within Pershing State Park or the proposed sediment detention basin. There is a relatively small area of private land on the west side of the study area north of HWY 36 and on the east side of the study area south of HWY 36 that would experience increased inundation (Figure 5-1). Prior to the diversion of the majority of Locust Creek flows to Higgins Ditch, the areas on the east side of the study area showing increased inundation likely experienced some level of inundation during high flows historically (Burns and McDonnell 2000). The FWOP condition assumes that Locust Creek flow continues to be diverted to Higgins Ditch.

In addition to inundation extents, changes in water surface elevations (i.e. depth of inundation) were evaluated. Refinements to the recommended plan determined that the sediment detention basin discharge would need to increase from 1,500 cfs to 4,000 cfs at Year 10 post-construction. Therefore, water surface elevation changes were assessed for Year 0 and Year 10 (Figures 5-2 and 5-3). The recommended plan largely did not contribute to an increase in water surface elevation upstream of Pershing State Park and downstream of Hickory Branch. Flood risk benefits (i.e. reductions in water surface elevation for the 100-year event) at Year 0 were observed upstream of Pershing State Park and south of Dexter Road. Increases in water surface elevation occurred within the proposed sediment detention basin as would be expected. USACE would mitigate impacts from increased water surface elevations on private properties by acquiring flowage easements from the affected landowners (Appendix E, Real Estate Plan). The proposed Higgins Ditch grade control structure increases water surface elevation immediately upstream and these impacts extend to private properties. Additional increases in water surface elevation were largely located on public property except on portions of the Locust Creek left bank where a rise of 2-4 feet is anticipated. This impact results from restoring flow to Locust Creek and the east side of the floodplain. As stated previously, this area has likely experienced similar impacts historically before channel avulsions diverted Locust Creek flow to Higgins Ditch. Modeling indicates there would be induced flooding on 10 adjacent private parcels, totaling 206 acres, as a result of the recommended plan representing localized long-term adverse impacts. The affected private parcels are agricultural lands. The recommended plan would also result in beneficial impacts to flood risk for properties between Pershing State Park and Dexter Road resulting from anticipated reductions in water surface elevations for the 100-year event. LC3.5 (Large Sediment Basin Plus Connection Channel), LC15.5 (Large Sediment Basin, Higgins Ditch Grade Control, Plus Connection Channel), and LC18.5 (Small Sediment Basin with Flows to Higgins Ditch Plus Connection Channel) would be anticipated to transfer flood risk impacts from construction of the Higgins Ditch to Locust Creek downstream connector; however, the 100-year flood risk impacts were not hydraulically modeled. Available information indicates the connector may transfer flood risk from an existing private parcel to other private property downstream.

Changes in flood risk for the Fountain Grove study area were assessed by simulating 100-year constant flows for the No Action alternative and the recommended plan. Modeling was performed for the Fountain Grove alternatives that included measures that were believed to have potential to affect water surface elevations outside of Fountain Grove CA. A majority of the Fountain Grove study area does not show an increase in water surface elevation resulting from the Fountain Grove recommended plan. One isolated area near Jackson’s Ditch showed increases in water surface elevation ranging between 0.005 and 0.01 feet (Appendix B). Therefore, negligible flood risk impacts are anticipated from Fountain Grove recommended plan. The East Fountain Grove CA levee setback included in FG7, 8, 8.5, and all their combinations was not considered to have potential to affect water surface elevations because the existing levee would be left in place.

Changes in water surface elevations within the Yellow Creek study area were assessed by simulating the June 2008 flood event. This analysis indicated that the Yellow Creek recommended plan (YC11) did not result in changes to water surface elevations in the Yellow Creek study area; indicating flood risk would not change.

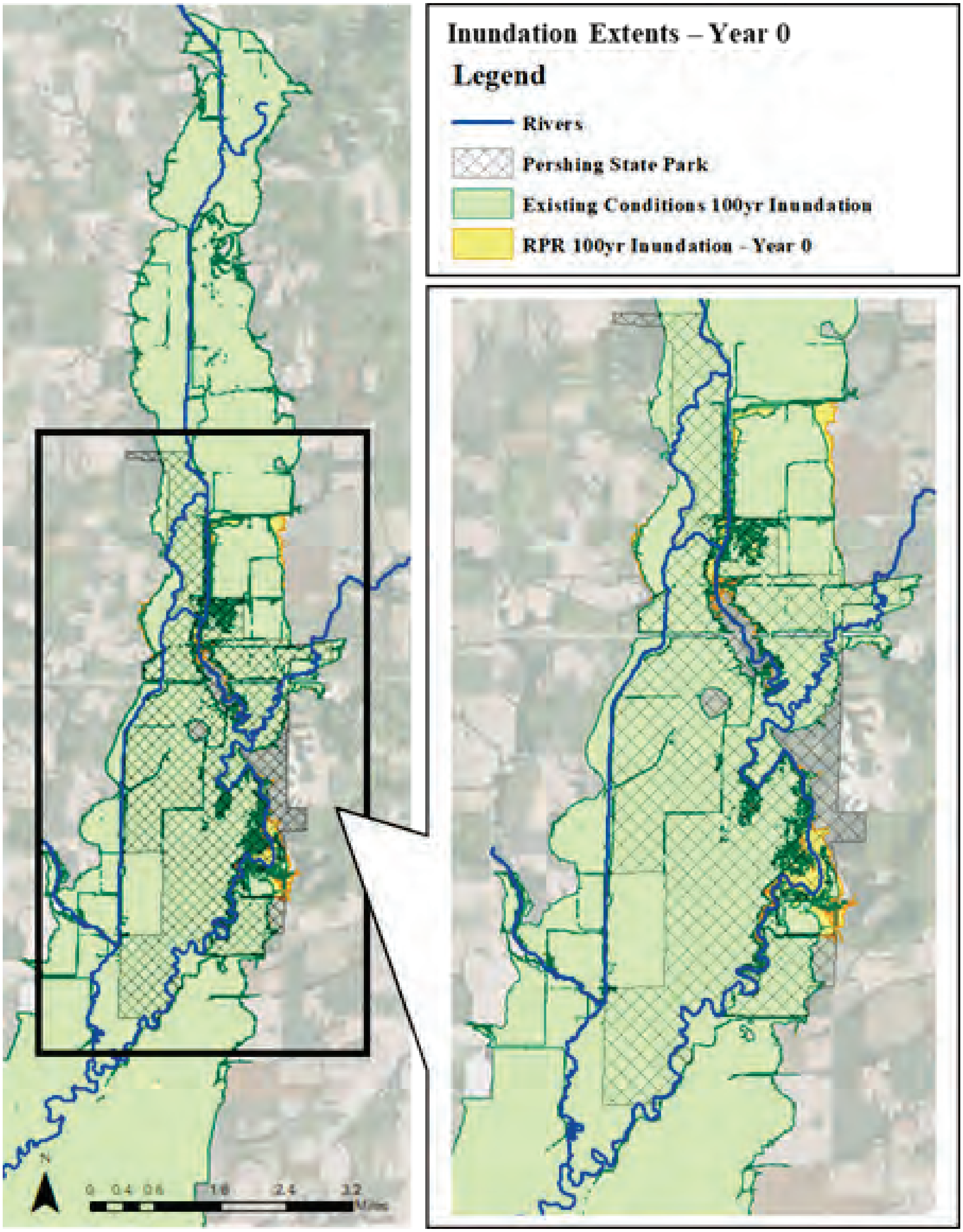

Figure 5-1. 100-year inundation extent for Locust Creek Recommended Plan.

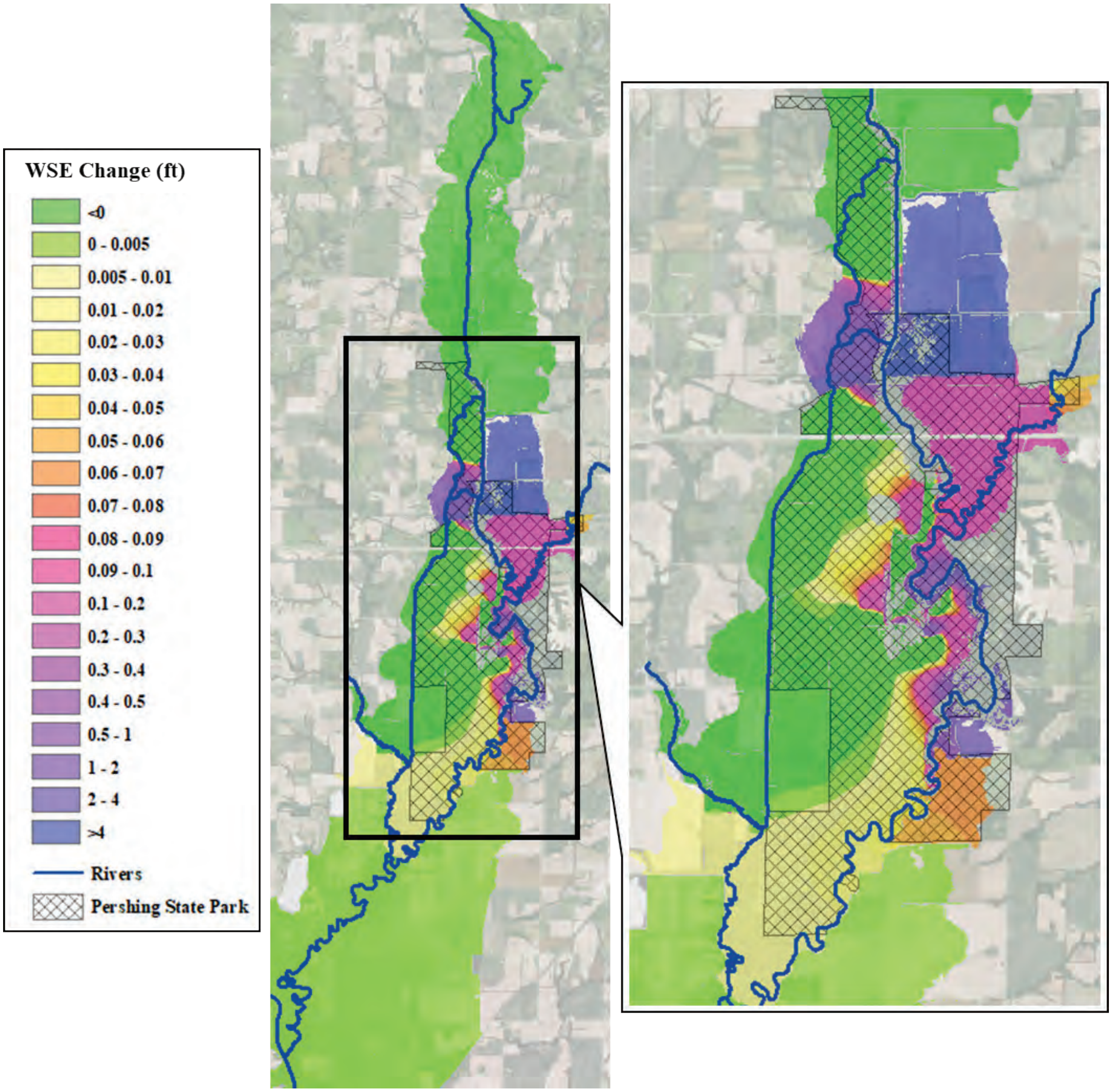

Figure 5-2. 100-year water surface elevation changes for Year 0 of Locust Creek Recommended Plan

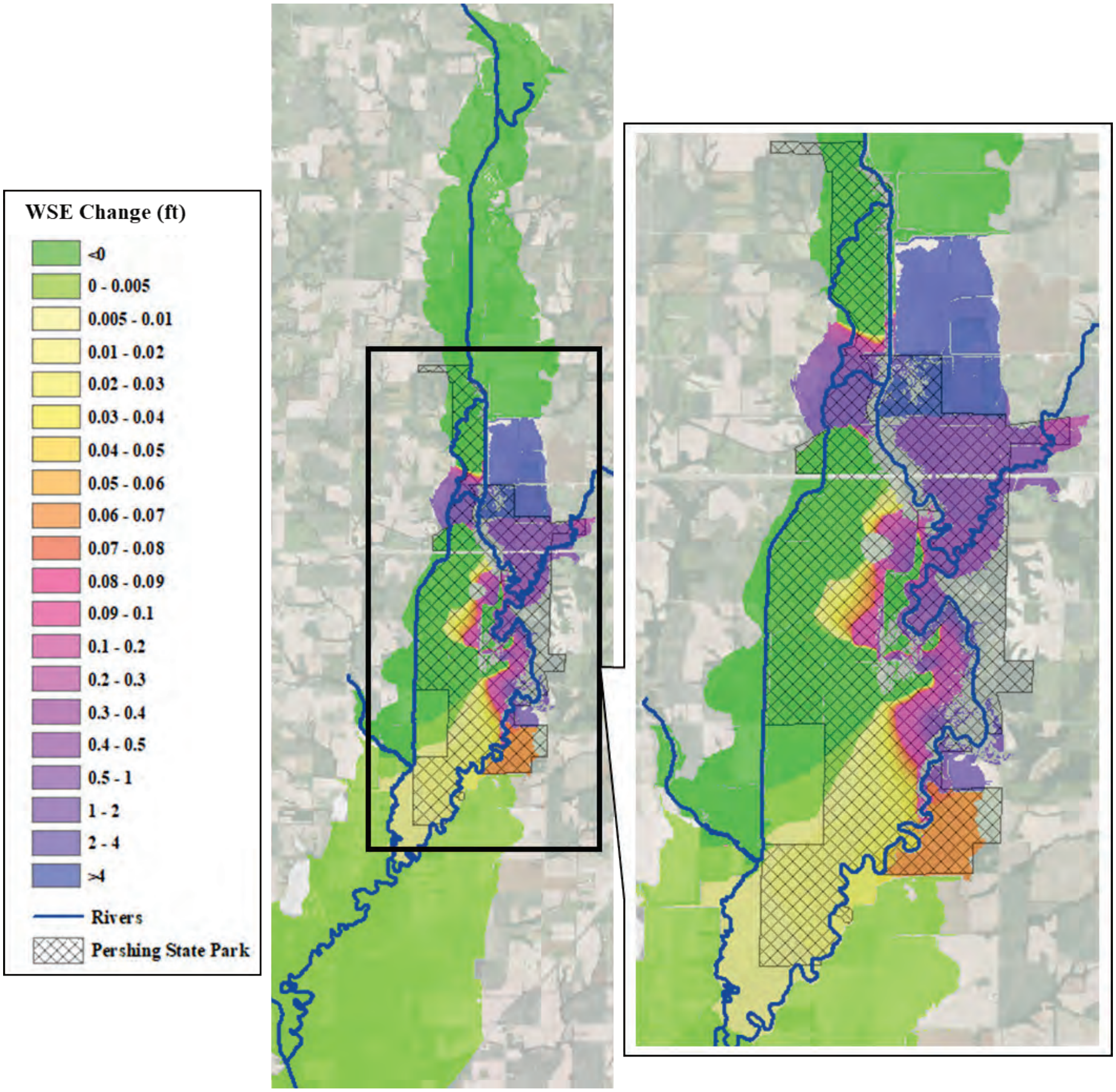

Figure 5-3. 100-year water surface elevation changes for Year 10 of Locust Creek Recommended Plan

5.14 Infrastructure

5.14.1 No Action Alternative

Under the No Action alternative, impacts to infrastructure would be expected to continue as they occur under the existing condition. These impacts are largely to bridges resulting from log jams and erosion.

5.14.2 All FWP Alternatives

Locust Creek alternatives that include a sediment detention basin (i.e. LC3, LC3.5, LC15, LC15.5, LC18, and LC18.5) would result in beneficial impacts to infrastructure in the study area. HWY 36 bridge crossing at Locust Creek have repeatedly been the location of extensive log jams. Diverting logs into the sediment detention basin upstream of HWY 36 should prevent further impacts to the bridge structures at HWY 36. In addition, implementation of upstream bank stabilization projects as part of the Locust Creek recommended plan (LC15.25) would potentially benefit infrastructure to the degree that these areas were located in proximity to bridges being affected by streambank erosion. No impacts to active rail lines within the study area are anticipated under any alternatives.

5.15 Cultural Resources

USACE prepared a Programmatic Agreement (PA) to fulfil its responsibilities under the NHPA. The PA approach to Section 106 compliance is applicable because 1) the exact location of upstream bank stabilization projects is not known at this time and 2) there is potential for future flood events and sedimentation to cause changes in the final design and footprint of recommended plan components during pre-construction engineering and design. USACE invited the Missouri SHPO, ACHP, federally recognized Native American Tribes, and other interested parties to participate in the development of the PA. The executed PA and associated correspondence is included in Appendix N. This section focuses impacts discussion on the recommended plan for each study area; however, impacts for any FWP alternative would be anticipated to be similar to that described for the recommended plan and any alternative would be implemented under the PA.

5.15.1 No Action Alternative

Under the No Action alternative, there would be no federal actions for ecosystem restoration taken and therefore, there would be no associated impacts to cultural resources. Cultural resources on USACE-permitted areas on state and private land would continue to be managed in accordance to Federal laws and Army regulations.

5.15.2 Recommended Plan

A proposed area of potential effect (APE) was defined for the three focused study areas included in the recommended plan, as well as the upper HUC10 sub-watersheds where bank stabilization projects may occur (Figure 5-2 and 5-3). A background review of the area was completed as described previously. The background findings for each of the project areas follows. None of the NRHP properties discussed in Section 2.19 are located within the APE.

5.15.2.1 Locust Creek

The northern part of the Locust Creek APE (north of HWY 36) has been surveyed by only one linear utility survey (Figure 5-2), which located no cultural resources. No cultural resource sites are recorded in the northern part. South of HWY 36, three cultural resources sites (sites), including the remnants of a historic mill, have been identified near the proposed dredging locations along Muddy Creek and none have been evaluated for eligibility to the NRHP.

Higgins Ditch is an artificial ditch that is located along the western edge of the Locust Creek APE. Oral history tells that the ditch was dug with mules and skids by local farmers, hoping to improve drainage.

The ditch is over 50 years old but no longer retains integrity due to erosion and incision through various flood events.

The implementation of ground-disturbing activities associated with the recommended plan at Locust Creek have the potential to impact cultural resources that might be eligible for listing on the NRHP. In accordance with the PA, areas that are to be disturbed will undergo background review and, if necessary, survey to inventory the area for cultural resources. If cultural resources are found that are eligible for the NRHP through consultation with the SHPO, federally recognized Native American Tribes, and other interested parties, efforts would be made to avoid the cultural resource or otherwise minimize impacts to the site. If avoidance is not possible, mitigation measures would be developed in consultation with SHPO and Native American Tribes. All consultations and investigations would be conducted in compliance to the PA.

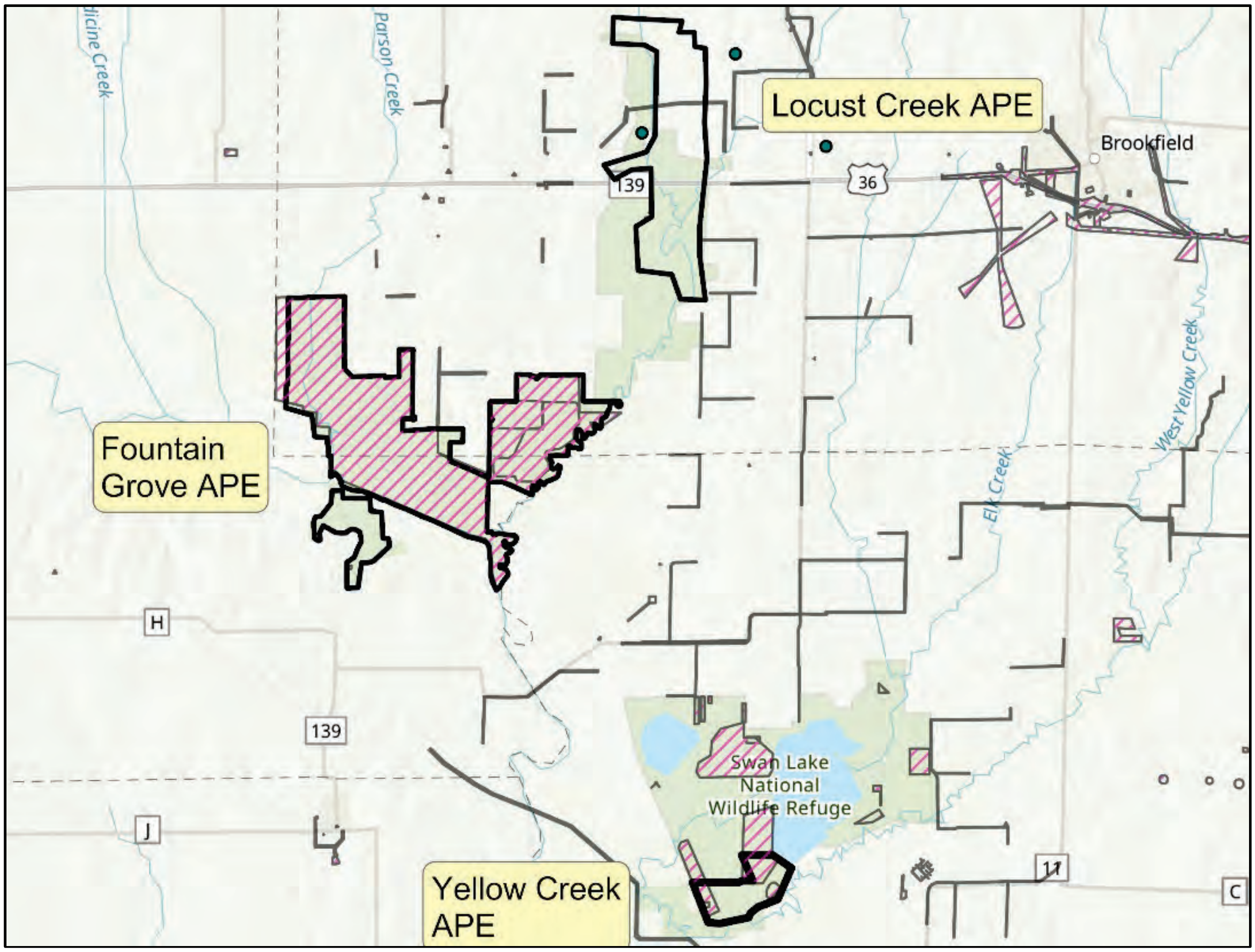

Figure 5-4. Locust Creek, Fountain Grove, and Yellow Creek Cultural Resource Surveys. *Previous cultural resources surveys (pink hatched and gray lines) in and around the subject APEs.*

5.15.2.2 Fountain Grove

Several large surveys have covered most of the Fountain Grove APE (Figure 5-2) except for the southwestern, discontinuous area. Forty archeology sites, both historic and prehistoric in nature, were identified on the higher ground. Five sites were recommended for testing for NRHP eligibility: three prehistoric artifact scatters; one multicomponent historic and prehistoric artifact scatter; and one multicomponent historic cemetery and prehistoric artifact scatter sites. The remainder of the sites were recommended ineligible for the NRHP.

The sites identified have been found to be limited to the higher ground and so should not be impacted by proposed activities. As plans are developed the past archeological surveys will be evaluated to determine if the methods employed were adequate to identify archeological sites. If additional investigations are warranted, they will be conducted in accordance with stipulations outlined in the PA. If cultural resources are found that are eligible for the NRHP through consultation with the SHPO, federally recognized Native American Tribes, and other interested parties, efforts would be made to avoid the cultural resource or otherwise minimize impacts to the site. If avoidance is not possible, mitigation measures would be developed in consultation with SHPO and Native American Tribes. All consultations and investigations would be conducted in compliance to the PA.

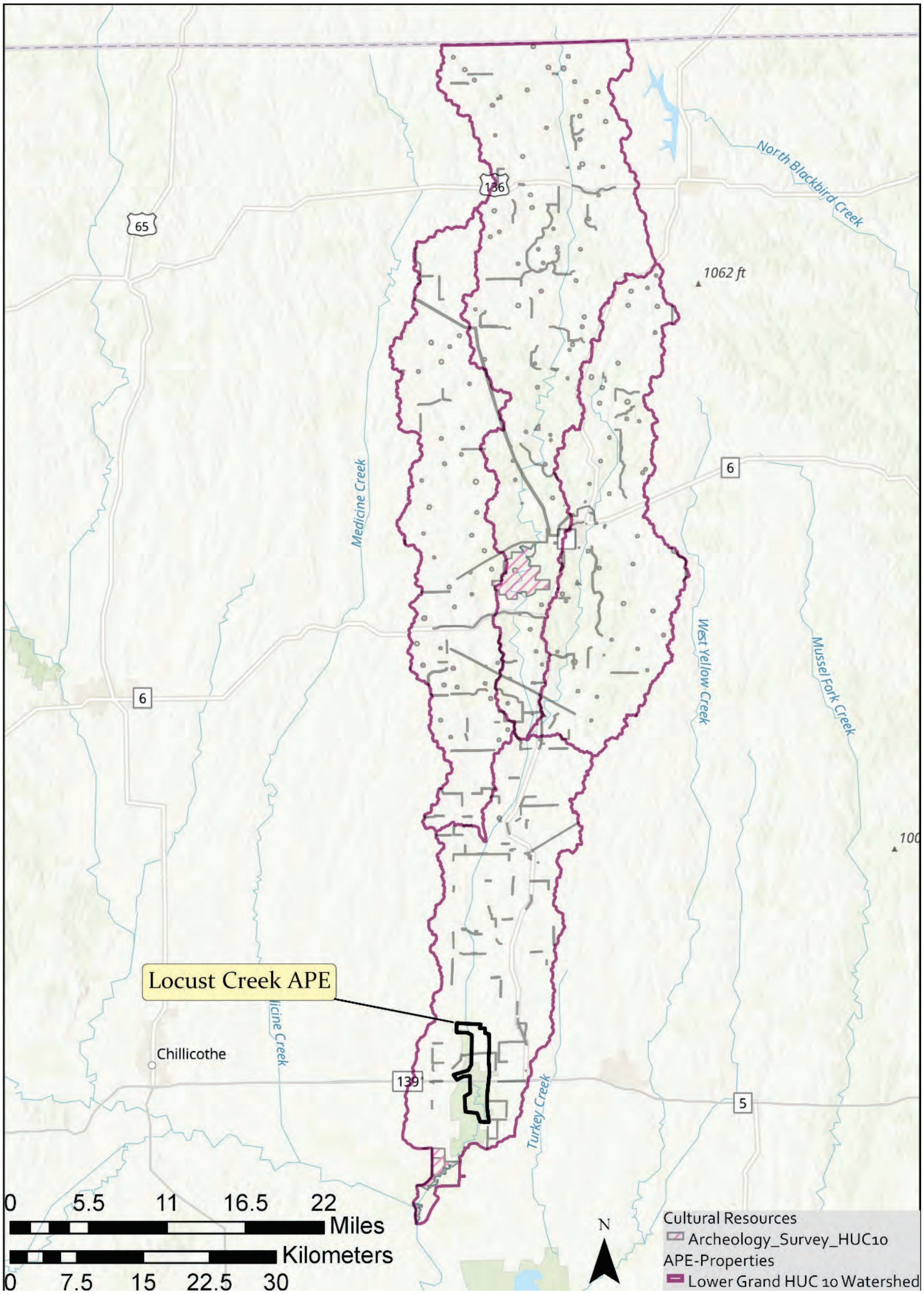

Figure 5-5. HUC 10 watershed cultural resources surveys. *Historic cultural resource surveys, shown in pink hatched polygons and gray lines. The small gray dots are small sample survey areas for a large watershed survey.*

5.15.2.3 Yellow Creek

Approximately 30-40% of the Yellow Creek APE has been surveyed (Figure 5-2). Two archeology sites have been identified; one was recommended as not eligible for the NRHP and the other, a deeply buried site, was recommended to be eligible.

The Yellow Creek area has been partially surveyed with cultural resource sites identified. As such, the implementation of ground-disturbing activities associated with the recommended plan at this location has the potential to impact cultural resources that might be eligible for listing on the NRHP. In accordance with the PA, areas that are to be disturbed will undergo background review and, if necessary, survey to inventory the area for cultural resources. If cultural resources are found that are eligible for the NRHP through consultation with the SHPO, federally recognized Native American Tribes, and other interested parties, efforts would be made to avoid the cultural resource or otherwise minimize impacts to the site. If avoidance is not possible, mitigation measures would be developed in consultation with SHPO and Native American Tribes. All consultations and investigations would be conducted in compliance to the PA

5.15.2.4 Upper Watershed

An estimated 300 small streambank stabilization projects are proposed within four HUC-10s in the upper watershed of Locust Creek. A number of cultural resource surveys have been performed in the watershed but most were quite limited in scope (Figure 5-3). The locations of the bank stabilization projects are not known and Section 106 compliance work would be performed under the conditions of the PA now being developed. Past archeological surveys will be evaluated to determine if the methods employed were adequate to identify archeological sites. If additional investigations are warranted, they will be conducted in accordance with stipulations outlined in the PA. If cultural resources are found that are eligible for the NRHP through consultation with the SHPO, federally recognized Native American Tribes, and other interested parties, efforts would be made to avoid the cultural resource or otherwise minimize impacts to the site. If avoidance is not possible, mitigation measures would be developed in consultation with SHPO and Native American Tribes. All consultations and investigations would be conducted in compliance to the PA.

5.16 Recreation

5.16.1 No Action Alternative

The recreation resources in the study area, Yellow Creek, Pershing State Park and Fountain Grove CA, would continue to provide habitat that supports fish and wildlife that are desired by sportsmen. The habitat throughout this portion of the watershed, however, would not improve and would be anticipated to degrade over time under the No Action alternative. The southern portion of Fountain Grove CA would continue to be underutilized, limiting its value to sportsmen. Recreation opportunities in the study area would likely degrade and be notably reduced in the absence of any project actions.

5.16.2 FWP Alternatives

FWP alternatives for all three study areas include improvements to the habitat and would be expected to benefit fish and wildlife populations in those area. This should in turn improve recreational experiences for sportsmen. Although no new recreation facilities would be created, the quality of fishing and hunting experiences would improve with the increased opportunities for fishing and hunting. Bird watchers and nature enthusiasts would also benefit from the improved habitats and increased abundance of wildlife with an increase in flora and fauna in the area. Improved wetland habitat on South Fountain Grove CA would increase recreational opportunity at that site. Short-term minor adverse impacts to recreation would occur due to disruption from construction activities (e.g. temporary closure of areas during construction or noise disturbance to recreators from nearby construction activities). Beneficial long-term impacts to recreation would be anticipated for all FWP alternatives.

5.17 Hazardous, Toxic, and Radioactive Waste

5.17.1 No Action Alternative

No HTRW related impacts would occur under the No Action Alternative.

5.17.2 All FWP Alternatives

Review of Federal and state databases containing information on the location of HTRW areas or sites within the study area did not identify known locations or areas of concern. The potential to encounter HTRW during construction activities is considered low. If HTRW was to be identified or discovered within lands necessary for implementation of the TSP, it would be the non-federal sponsor's responsibility to clean up/remediate for the HTRW. As a result, any impacts associated with HTRW in the study area would be beneficial.

5.18 Summary of Environmental Consequences

Table 5-1 summarizes the impacts associated with the No Action and FWP alternatives.

Table 5-1. Summary of Impacts.

Resource Topic	No Action Alternative	FWP Alternatives
Priority Habitats	Short and long-term direct adverse impacts	Long-term beneficial impacts
Hydrology, Hydraulics, and Sedimentation	No impacts	Short- and long-term beneficial impacts
Water Quality	Long-term adverse Impacts	Short- term minor adverse impacts Long-term beneficial impacts
Fish and Wildlife	Short- and long-term adverse impacts	Short-term negligible to minor adverse impacts Long-term beneficial impacts
Threatened and Endangered Species	Long-term adverse impacts	No impacts
Invasive Species	Long-term adverse impacts	Long-term beneficial impacts
Floodplains	Long-term adverse impacts	Long-term beneficial impacts
Geology and Soils	Long-term adverse impacts	Long-term beneficial impacts
Prime and Unique Farmlands	No impacts	Long-term minor adverse and beneficial impacts
Socioeconomics	No impacts	Short-term beneficial impacts
Environmental Justice	No impacts	No impacts
Land Use	No impacts	Long-term minor change to land use
Flood Risk	No impacts	Long-term beneficial and adverse location-dependent impacts
Infrastructure	Long-term adverse impacts	Long-term beneficial impacts
Cultural Resources	No impacts	No adverse impacts are anticipated. However, the location of all project areas is not known at this time. Any impacts would be addressed by stipulations in a cultural resources programmatic agreement.
Recreation	No impacts	Short-term minor adverse and long-term beneficial impacts
HTRW	No impacts	No impacts. Potential for long-term beneficial

5.19 Cumulative Effects

The CEQ regulations for implementing NEPA require the assessment of cumulative impacts in the decision-making process. This section describes the methods for identification of cumulative actions and presents the results of the cumulative impact analysis. CEQ defines a cumulative impact as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions” (40 CFR § 1508.7).

5.19.1 Cumulative Effects Methodology

The cumulative action identification and analysis methods are based on the policy guidance and methodology originally developed by CEQ (1997) and an analysis of current case law. Cumulative impacts were determined by adding the impacts of the alternatives being considered with other past, present, and reasonably foreseeable future actions. A process based on four primary steps was employed to assess the cumulative impacts of the alternatives.

Step 1: Identify Potentially Affected Resources

In this step, each resource adversely affected by the alternatives is identified. If there is no impact to a resource, by definition there is no cumulative impact and that resource was not included in the cumulative impacts assessment.

Step 2: Establish Boundaries (Geographic and Temporal)

In identifying past, present, and reasonably foreseeable actions to consider in the cumulative impact analysis, affected resource-specific spatial and temporal boundaries were identified. The spatial boundary is where impacts to the affected resource could occur from the proposed alternatives and therefore where past, present, and reasonably foreseeable future actions could contribute to cumulative impacts to the affected resource. This boundary is defined by the affected resource.

The temporal boundary describes how far into the past and forward into the future actions should be considered in the impact analysis. The temporal boundary is guided by CEQ guidance on considering past action and a rule of reason for identifying future actions.

For each resource topic, the geographic and temporal boundaries were identified. For all resource topics, the consideration of past actions is reflected in the existing condition. A future temporal boundary of 50 years from the baseline condition was used consistent with the period of analysis identified for evaluation of plan benefits; however, the impacts are based on their likelihood of occurring and whether they can be reasonably predicted.

Step 3: Identify the Cumulative Action Scenario

In this step, past, present, and reasonably foreseeable future actions (RFFAs) to be included in the impact analysis for each specific affected resource were identified. These actions fall within the spatial and temporal boundaries established in Step 2. Table 5-2 summarizes the cumulative impacts scenario considered for each resource identified for evaluation.

Step 4: Analyze Cumulative Impacts

For each resource, the actions identified in Step 3 are analyzed in combination with the impacts of the alternatives being evaluated. This analysis describes the overall cumulative impact related to each resource and the contribution to this cumulative impact of alternatives being evaluated.

5.19.2 Past, Present, and Reasonably Foreseeable Future Actions

Establishment of Fountain Grove CA, Pershing State Park, Swan Lake NWR, and Yellow Creek CA were past actions influential on the study area. Other important past actions within the study area were described in Section 1.6, Problems and Opportunities. They include widespread stream channelization, conversion of riparian areas to agricultural use, construction of levees, development of transportation corridors, as well as log jams and channel avulsions. Other past actions have included investment by the NRCS in the study area through conservation easement programs and working lands programs.

Notable present and ongoing actions include damages sustained during the 2019 flood event. NRCS continues to invest within the Lower Grand River sub-basin through its numerous conservation programs. The following sections describe the reasonably foreseeable future actions (RFFAs) identified and considered in the cumulative effects analysis.

5.19.2.1 East Locust Creek Reservoir

This Reasonably Foreseeable Future Action is a proposed 2,352-acre water supply reservoir that would be located north of Milan, Missouri. The project is estimated at $110 million project cost and over 90% of property acquisition has been completed. The economic impact of the reservoir is estimated to range from $1.25 to $9.8 million annually over 50 years (North Central Missouri Regional Water Commission 2017).

5.19.2.2 Garden of Eden Levee System Rehab/Repair

During the 2019 Flood event, the Garden of Eden levee system sustained breaches on all three sections. This levee is enrolled in the USACE PL84-99 Program, which allows for federal funding to assist with levee rehab and repair of non-Federal levees. In-place repairs has been recommended for Garden of Eden sections 1 and 2. It is assumed for the cumulative effects analysis that these levee sections will be repaired to their existing alignments.

5.19.2.3 MoDNR Soil and Water Conservation Practices

The MoDNR funds and administers the state-funded Soil and Water Conservation Program that consists of offices in each county that offer voluntary conservation practices to agricultural landowners. Many of these practices have the potential to further reduce sediment loading beyond what is forecasted for the recommended plan.

Sheet, Rill and Gully Erosion Best Management Practices – Sheet, rill and gully erosion is the unwanted removal of soil from the land surface through incised channels by the action of rainfall and runoff. Protecting the soil from runoff stops excessive erosion and can assist with reducing sediment loading in the upper watershed. Practices that can be used to address sheet, rill and gully erosion include:

- **Permanent Vegetative Cover Establishment -** Establish a permanent vegetative cover to stabilize soil on land that is experiencing significant erosion.
- **Permanent Vegetative Cover Improvement -** Improve plant health and diversity by introducing legumes into established grass communities to protect soil on land that is experiencing significant erosion.
- **Terrace System -** Reduce the erosive force of water by placing terraced embankments to slow water runoff and increase water absorption on crop land that is experiencing significant erosion.
- **Terrace System with Tile -** Reduce erosion with the placement of embankments on slopes to reduce the slope length and use underground piping to more quickly remove erosive water to a stable outlet from tracts that have experienced significant erosion.
- **Diversion -** Control erosion and reduce or prevent pollution of land, water or air from agricultural nonpoint sources by directing rainwater to less sloping areas of the landscape and allowing it to dissipate or run off at a lower velocity, which encourages infiltration into the soil.
- **Permanent Vegetative Cover (Critical Area) -** Establish a permanent vegetative cover on small critical areas such as gullies and steep banks to reduce erosion.
- **No-Till System -** A no-till system avoids disturbing the soil with tools like chisel plows, field cultivators, disks, and plows. This practice is an incentive payment to encourage farmers to use conservation no-till to reduce erosion on land that is experiencing significant erosion.
- **Water Impoundment Reservoir -** Control erosion by constructing ponds to catch sediment and prevent it from leaving fields on land that is experiencing significant active erosion.

- **Sediment Retention Erosion or Water Control Structure -** Temporarily retain water to control the release of runoff water and settle out the soil particles and nutrients. This practice is applicable to areas on farms where runoff of substantial amounts of sediment or runoff containing pesticides or fertilizers constitutes a significant pollution hazard.
- **Grassed (Sod) Waterway -** Prevent or reduce existing erosion and pollution of water or land from agricultural nonpoint sources by using sod-forming grasses to protect soil within waterways to efficiently transport rainfall.
- **Contour Buffer Strips -** Reduce erosion by establishing strips of permanent vegetative cover between crops, around hill slopes, and alternated downhill slopes.
- **Cover Crops -** A crop of legumes, winter killed species, grasses and/or certified cereal grains, when planted for purposes of benefiting soil and/or other crops, but is not intended for harvest for feed or sale. Benefits of cover crops include soil quality improvements, erosion control, fertility improvements, suppressing weeds, and insect control.
- **Contour Strip Cropping -** Reduce erosion and water pollution by implementing crop and vegetation rotations through systematic arrangements of equal-width strips across fields.

Grazing Management – Grazing management is used in pastureland where non-woody, permanent vegetative cover is established. These practices are designed to promote economically and environmentally sound agricultural land management on pastureland by demonstrating the best use of soil and water resources using rotational grazing. One result is the reduction or prevention of soil erosion. Grazing management BMPs consist of a wide range of state and federally approved and cost share funded practices. Practices include:

- **Permanent Vegetative Cover Enhancement -** Improve the vegetative cover on pastures by introducing legumes into the grass base using no-till technology. Improving the plant community health protects the soil by reducing erosion and preventing water pollution.
- **Grazing System Water Development -** Develop water sources (ponds, springs or wells) for livestock watering that are generally strategically located to help efficiently manage grazing resources (water and grasses).
- **Grazing System Water Distribution -** Develop water distribution, including pipeline and watering tanks/troughs, for grazing areas. By providing water distribution to individual grazing areas, livestock can more effectively use the resource. A planned grazing system includes water availability in each grazing area.
- **Grazing System Fence -** A planned rotational grazing system allows time for vegetation to rest and recover before being grazed again. Fencing is used to allow livestock access to a small area to be grazed.
- **Grazing System Lime -** Manage the pH of soil for optimum fertility. This is an important factor in how effectively plants can take in soil nutrients. Lime is the most cost-effective method to manage soil pH.
- **Grazing System Seed -** Interseed legumes in an established grass pasture grazing system to improve plant health and diversity and protect soil from erosion.
- **Prescribed Grazing -** Managing the harvest of vegetation with grazing and/or browsing animals with the intent to achieve specific ecological, economic, and management objectives.

Sensitive Area Management –Sensitive areas are areas of agricultural land where current management has impacted erosion, surface water and ground water such as streams, sinkholes and springs. These practices are designed for the protection of water quality through: buffers collecting and filtering out sediment and other nutrients, herbicides and pesticides that could run off of crop fields; the exclusion of livestock, which prevents high nutrient and E. coli content while protecting the streambank from soil degradation at the same time; the protection of sinkholes and karst areas, which provide direct access to shallow groundwater, to protect drinking water aquifers and underground ecology. The following practices are included:

- **Streambank Stabilization -** Uses large stones or anchored cedar trees as mechanical protection of highly eroded stream banks to provide a stable area to establish grasses or other vegetation to protect the soil and water resource from erosion losses and contamination.
- **Field Border -** Establish permanent grass buffers along the edges of crop fields to trap pesticide and fertilizer runoff. This practice reduces soil loss and improves water quality by preventing excess sediment and nutrients from entering streams.
- **Riparian Forest Buffer -** Protect soil and shallow groundwater from contamination by sediments, chemicals, nutrients, pesticides or organic matter and protect stream banks from erosion by planting woody species along the stream course and protecting the buffer area from trampling and grazing.
- **Filter Strip -** Establish permanent grass filter strips below crop, hay and grazing land; and to prevent sediments, chemicals or nutrients from entering sensitive areas or water bodies.
- **Stream Protection -** Exclude livestock from stream corridors to allow revegetation with grasses and trees on the streambank. This also provides a filter to trap sediments, chemicals and nutrients.

Woodland Management –Woodland erosion is caused by the removal of soil or vegetation through livestock trampling or improper tree harvesting. These practices address concerns regarding soil erosion and water quality, by exclusion of livestock and by developing timber harvest plans. Specific practices include:

- **Timber Harvest Plan -** This practice provides financial assistance for the proper design and construction of logging roads and stream crossings for timber harvest operations.
- **Forest Plantation -** Protect the soil and encourage the conversion of marginal soils to less intensive use by planting trees and shrubs and excluding livestock.
- **Livestock Exclusion -** Install exclusion fence around existing ponds, woodlands, sinkholes, streams, or sensitive areas where vegetation, soil condition, and water quality are in need of protection from livestock.
- **Restoration of Skid Trails, Logging Roads, Stream Crossings and Log Landings -** Correct and control gully erosion resulting from improperly constructed logging roads and stream crossings following timber harvest.

5.19.2.4 USDA-NRCS Conservation Easement Programs

NRCS has approximately 205 easements (typically 30-year or permanent easements) comprising approximately 27,600 acres enrolled in conservation easement programs within the Lower Grand River sub-basin. The relevant programs that are likely to receive continued investment from NRCS within the sub-basin are:

- **Agricultural Conservation Easement Program -Wetlands Reserve Easements (ACEP-WRE)**: This program helps landowners, land trusts, and other entities protect, restore, and enhance wetlands, grasslands, and working farms and ranches through conservation easements. The WRP and the Emergency Wetlands Reserve Program were merged into ACEP-WRE in the 2014 Farm Bill.
- **Emergency Watershed Protection - Floodplain Easements:** These easements restore, protect, maintain, and enhance the functions of the floodplain; conserve fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal

disaster assistance; and safeguard lives and property from floods, drought, and the products of erosion.

5.19.2.5 USDA-NRCS Working Lands Programs

The NRCS Working Lands Programs are implemented via contracts and have a shorter time horizon than conservation easements. In Fiscal Year 2017, 171 contracts were initiated in the Lower Grand River sub-basin comprises 28,243 acres with payments in excess of $1.8 million. Programs include:

- **Environmental Quality Incentives Program:** Provides financial and technical assistance to agricultural and forestry producers to deliver improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation, and improved or created wildlife habitat.
- **Conservation Stewardship Program:** The largest conservation program in the United States. Provides technical and financial assistance to help producers enhance natural resources and their business operations.
- **Regional Conservation Partnership Program (RCPP):** This program offers opportunities for the NRCS, conservation partners and agricultural producers to work together to harness innovation, expand the conservation mission and demonstrate the value and efficacy of voluntary, private lands conservation.

5.19.2.6 USDA-NRCS Watershed Protection and Flood Prevention Program

The Watershed Protection and Flood Prevention Act (Public Law 83-566) authorizes the Secretary of Agriculture to provide technical and financial assistance to entities of state and local governments and tribes (project sponsors) for planning and installing watershed projects. The USDA agency responsible for program management is the NRCS. The Watershed Protection and Flood Prevention Program helps units of federal, state, local and tribal government protect and restore watersheds up to 250,000 acres.

This program provides for cooperation between the Federal government and the states and their political subdivisions to work together to prevent erosion; floodwater and sediment damage; to further the conservation development, use and disposal of water; and to further the conservation and proper use of land in authorized watersheds. Approximately 72 projects have been constructed under this program in the East Locust Creek sub-watershed within the Lower Grand River sub-basin (HDR 2013).

5.19.2.7 EPA Section 319 Non-Point Source Grant Program

The mission of the EPA is to protect human health and the environment. EPA administers regulatory and voluntary grant programs under the Clean Water Act that contribute to mitigation, recovery, and restoration on the landscape/watershed scale. The Section 319 Non-Point Source Grant Program provides grant money to states and Tribes to support nonpoint source control projects. A wide variety of support is provided under this program including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, watershed planning, and implementation of best management practices and monitoring. Specific project actions include:

- Total Maximum Daily Load establishment and monitoring
- Best Management Practice design and implementation
- Wetland restoration/protection
- Nutrient runoff management
- Water quality assessment and monitoring
- Stormwater discharge control
- Vegetation management
- Erosion control
- Streambank stabilization

Table 5-2. Cumulative Effects Scenario for Evaluated Resources.

Impact Topic	Spatial Boundary	Past Actions	Present or Ongoing Action	Reasonably Foreseeable Future Actions
Water Quality	HUC-10 watersheds: Watkins Creek-Locust Creek (excluding the portion in Iowa); East Locust Creek; West Locust Creek; and Locust Creek	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices
Fish and Wildlife	Lower Grand River sub-basin	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices
Prime and Unique Farmlands	HUC-10 watersheds: Watkins Creek-Locust Creek (excluding the portion in Iowa); East Locust Creek; West Locust Creek; and Locust Creek	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices

Impact Topic	Spatial Boundary	Past Actions	Present or Ongoing Action	Reasonably Foreseeable Future Actions
Land Use	HUC-10 watersheds: Watkins Creek-Locust Creek (excluding the portion in Iowa); East Locust Creek; West Locust Creek; and Locust Creek	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices
Flood Risk	Lower Grand River sub-basin	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices
Cultural Resources	APE described in Section 5.	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices

Impact Topic	Spatial Boundary	Past Actions	Present or Ongoing Action	Reasonably Foreseeable Future Actions
Recreation	Lower Grand River sub-basin	Establishment of Public Lands Bank Stabilization and Channelization Floodplain Animal Pasturing/Grazing Floodplain Development Crop Production Transportation and Utility Corridor Development NRCS Easement Programs NRCS Technical and Financial Assistance Programs	2019 Flood Event NRCS Easement Programs NRCS Technical and Financial Assistance Programs	East Locust Creek Reservoir Levee Rehab/Repair NRCS Conservation Easement Programs NRCS Working Lands Programs EPA Section 319 Program Soil and Water Conservation Practices

5.19.3 Cumulative Effects by Resource

5.19.3.1 Water Quality

The degradation of water quality resulting from past and present animal pasturing/grazing, crop production, and transportation corridor development throughout the study area is deemed to be substantial. This is evidenced by several streams in the study area being listed on the 303(d) list of impaired waterbodies or having TMDLs. RFFAs such as NRCS conservation easement programs, NRCS working lands programs, soil and water conservation practices, and the EPA Section 319 program are anticipated to contribute beneficial impacts that would improve water quality over the long-term. Construction of the East Locust Creek reservoir would be expected to have a small reduction in sediment loads downstream, representing a potential beneficial impact to water quality. The short-term minor adverse impacts contributed by the alternatives would represent little or no incremental increase in adverse water quality degradation. The alternatives would contribute long-term beneficial impacts that would likely be synergistic to the RFFAs. The impacts of the alternatives when combined with other present and RFFAs would likely result in overall beneficial cumulative impacts in the sub-basin.

5.19.3.2 Fish and Wildlife

Fish and wildlife populations have been beneficially and adversely impacted by past actions. Establishment of public lands such as Fountain Grove CA, Pershing State Park, Yellow Creek CA, and Swan Lake NWR has contributed substantial benefits to fish and wildlife. Likewise, the past and present investment by the NRCS in conservation easements and other programs have substantially benefited fish and wildlife. In portions of the sub-basin, fish and wildlife would have been adversely impacted by conversion of land to animal pasturing/grazing, crop production, floodplain development for urban land uses, and transportation corridor development. Reasonably foreseeable activities such as NRCS conservation easement programs, NRCS working lands programs, soil and water conservation practices, and the EPA Section 319 program are anticipated to contribute beneficial impacts that would improve fish and wildlife populations overall the long-term. The short-term minor adverse impacts contributed by the alternatives would represent little or no incremental increase in adverse fish and wildlife cumulative effects. The alternatives would contribute long-term beneficial impacts that would likely be synergistic to the RFFAs. The impacts of the alternatives when combined with other present and RFFAs would likely result in overall beneficial cumulative impacts to fish and wildlife populations in the sub-basin.

5.19.3.3 Prime and Unique Farmlands

Past and present animal pasturing/grazing and crop production have substantially benefited prime and unique farmlands in the area. Past conversion likely occurred through minor development for urban land uses and transportation corridor development. Reasonably foreseeable activities such as NRCS conservation easement programs, NRCS working lands programs, soil and water conservation practices, and the EPA Section 319 program are anticipated to contribute beneficial impacts to prime and unique farmlands. Although these areas are taken out of crop production, they are not permanently converted to other uses. The short-term minor adverse impacts contributed by the alternatives would represent little or no incremental increase in adverse cumulative impacts to prime and unique farmlands. The impacts of the alternatives when combined with other present and RFFAs would likely result in overall negligible cumulative impacts to prime and unique farmlands.

5.19.3.4 Land Use

Past and present actions have been consistent with the predominant land use composition in the Lower Grand River sub-basin for the last century. Agricultural uses predominate through the past conversion of land to animal pasturing/grazing and crop production. Urban and transportation-related land use have increased over time with increases in population. The focused study area includes a notable amount of public lands. The region’s economy has undergone extensive change in the past 30 to 45 years as a result of agricultural consolidation and restructuring, and to a lesser extent due to the evolution of corporate farms and vertically integrated agricultural production systems (Green Hills Regional Planning Commission 2012). However, agricultural enterprises continue as a predominant land use within the region. The long-term minor change in land use from agricultural to conservation land would represent a minor change to land use within the sub-basin and would not be inconsistent with the current land use composition. No cumulative impacts to land use are anticipated.

5.19.3.5 Flood Risk

Past actions such as levee construction and stream channelization contributed beneficial impacts to floor risk within the sub-basin. Present actions such as the levee breaches at the Garden of Eden levee system as well as elsewhere in the sub-basin have temporarily adversely impacted flood risk. RFFAs would be anticipated to restore the level of flood protection and flood risk that existed prior to the 2019 food event. The alternatives contribute both beneficial and adverse impacts to flood risk in the study area, however, adverse impacts can be mitigated. As a result, overall cumulative effects to flood risk would likely be beneficial.

5.19.3.6 Cultural Resources

Past actions generally involve ground-disturbing activities that would have pre-dated federal laws regarding cultural resources. As a result, past impacts on cultural resources within the sub-basin have likely been substantial. Although the alternatives have potential to impact cultural resources in the study area, implementation of the TSP following the PA would serve to avoid or mitigate impacts to cultural resources that are found within project footprints. Identified RFFAs would also be implemented in accordance with federal law on preservation of historic resources. As a result, the alternatives would likely represent a negligible increment to any cumulative impacts to cultural resources in the sub-basin.

5.19.3.7 Recreation

Past actions in the sub-basin such as the establishment of public lands have substantially benefited recreation opportunities. RFFAs such as construction of the East Locust Creek Reservoir would be expected to expand recreation opportunities in the sub-basin. The alternatives contribute short-term adverse impacts to recreation through disruptions during construction. Long-term recreation impacts from the alternatives are beneficial and would contribute to overall beneficial cumulative impacts.

5.20 Climate Change

A climate change analysis was conducted following guidance in Engineering Construction Bulletin 2016-25 and ETL 1110-2-3 regarding non-stationarity detection. The detailed climate change analysis is provided in Appendix A. The climate change analysis indicated Grand River watersheds are vulnerable to the impacts of climate change on ecosystem restoration relative to the other 202 HUC-4 watersheds in the Continental United States. A qualitative analysis indicates overall flows will increase in the Grand River Basin. Changing flow conditions in the Grand River Basin could have negative effects on the proposed project and the surrounding ecosystems.

Historic discharge data at three of the long term USGS gages in the Grand River Basin indicate statistically significant trends of increasing average annual discharge, annual peak streamflow, and identifications of nonstationarities for the period of available data (1922 to 2016 and 1928 to 2016). Further analysis and a reduction of the period of record to 1948 to 2016 resulted in no detection of statistically significant trends or nonstationarities. Reducing the period of record results in an increase in uncertainty, but the natural variability in the data should still be captured in the 68-year period of reduced data. The increase in the uncertainty of flows will then be accounted for during design of the TSP.

Potential channel modifications on Locust Creek should be relatively resilient to gradual changes in flow regime such as increased annual flows. Initial designs for channel capacity can be based on the historic record as the relatively erodible channel should adjust itself to gradual changes in flow. Diversion structures may need to be designed with appropriate factors of safety to withstand more frequent overtopping. An increased average annual flow may result in increased sediment and large woody debris loads, so sediment detention basins may fill more rapidly than initially anticipated. These issues should be addressed during design by either increasing factors of safety or increasing anticipated O&M costs.

Alternatives under consideration for Fountain Grove are most likely to be vulnerable to increases in average annual discharges as well as to longer more severe droughts and larger more extensive storms. Water control structures designed to effectively fill and drain wetland pools and to drain the site after floods may become less effective over time if the frequency and magnitude of large events increases with time. Longer and more severe droughts may impact the ability to supply water to the managed wetland areas. These issues may lead to a lessoning of habitat benefits in the future. In addition, features such as training structures designed to overtop in larger events may require more frequent maintenance resulting in higher O&M costs. These issues should be addressed during design by either increasing factors of safety or increased anticipated O&M costs.

Potential impacts from increasing average annual flows for the Yellow Creek area would most likely impact actions relating to levee setbacks or modifications to structures relating to water management on the Swan Lake NWR.

5.21 Environmental Compliance

Table 5-3 summarizes the status of USACE compliance with Federal environment laws relevant to implementation of the recommended plan.

Table 5-3. Environmental Compliance Status for the Recommended Plan.

Federal Policies	Compliance Status
Archeological Resources Protection Act, 16 U.S.C. 470, et seq.	Compliant
Clean Air Act, as amended, 42 U.S. C. 7401-7671g, et seq.	Compliant
Clean Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq.	Compliant
Coastal Zone Management Act, 16 U.S.C. 1451, et seq.	Not Applicable
Endangered Species Act, 16 U.S.C. 1531, et seq.	Compliant
Environmental Justice (Executive Order 12898)	Compliant
Estuary Protection Act, 16 U.S.C. 1221, et seq.	Not Applicable
Farmland Protection Policy Act, 7 U.S.C. 4201, et. seq.	Compliant
Federal Water Project Recreation Act, 16 U.S.C. 4601-12, et seq.	Compliant
Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq.	Compliant
Floodplain Management (Executive Order 11988)	Compliant
Invasive Species (Executive Order 13122)	Compliant
Land and Water Conservation Fund Act, 16 U.S.C. 4601-4, et seq.	Not Applicable
Marine Protection Research and Sanctuary Act, 33 U.S.C. 1401, et seq.	Not Applicable
National Environmental Policy Act, 42 U.S.C. 4321, et seq.	Compliant
National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470a, et seq.	Compliant
Protection & Enhancement of the Cultural Environment (Executive Order 11593)	Compliant
Protection of Wetlands (Executive Order 11990)	Compliant
Rivers and Harbors Act, 33 U.S.C. 403, et seq.	Not Applicable

Federal Policies	Compliance Status
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq.	Not Applicable
Wild and Scenic River Act, 16 U.S.C. 1271, et seq.	Compliant

Notes: Compliant. Having met all requirements of the statute for the current stage of planning (either preauthorization or post authorization).

In-Progress. Statute is applicable to the proposal. Coordination/compliance is being conducted and would be completed during the feasibility phase.

Not applicable. No requirements for the statute required.

5.22 Fish and Wildlife Coordination Act Recommendations

The following recommendations were contained in the USFWS Final Fish and Wildlife Coordination Act Report submitted to USACE for the Grand River Ecosystem Restoration Feasibility Study. In accordance with FWCA, USACE has provided its responses to these recommendations here.

General Recommendations:

- Use the overarching Principles and Requirements for Federal Investments in Water Resources" while completing the Grand River Feasibility Study.
  - USACE Response: Although the Principles and Requirements referenced have not been approved for replacement of the Principles and Guidelines for Water Resources Studies, the Grand River feasibility study was conducted consistent with their intent, in particular, using a watershed approach to identifying the problems and formulating alternative plans to address the identified problems.
- Investigate additional project partnerships to help leverage more comprehensive efforts to supplement the proposed project and potentially enhance viable conservation and funding opportunities to address the basin-wide problems of sedimentation and flooding and help to protect, rehabilitate, and restore adjacent habitats within the Grand River Basin.
  - USACE Response: The USACE anticipates continued coordination with existing project sponsors, stakeholders, partners, and landowners to address the basin-wide problems of sedimentation and flooding that continue to negatively impact the basin. As the project moves into the design phase, incorporation of approximately 316 stream bank stabilization projects or similar cost-effective methods for sediment reduction in the upper basin of Locust Creek will be identified, further assessed and designed for incorporation of various potential erosion and sedimentation remediation measures. It is anticipated that remediation measures such as soil bioengineering, rip-rap stabilization, native plantings, and other similar techniques would be incorporated at each site based on specific site needs, constraints, and objectives.
- Review the MDC Ten Year Strategic Plan for Topeka Shiner Recovery and consider how project measures may help address conservation elements defined within this plan to help recover this endangered species.
  - USACE Response: As the project moves into design phase, USACE is committed to continued coordination with USFWS to ensure project activities do not impact potential future Topeka Shiner recovery and reintroduction efforts in the watershed.
- Seek soil and water conservation practices and water quality improvement opportunities throughout the Grand River Basin to best help reduce environmental impacts to soil and water resources, reduce impacts to economic and public infrastructure, and lessen ongoing impacts to stream and floodplain habitats.
  - USACE Response: Many of the proposed Locust Creek, Fountain Grove, Yellow Creek, and upper basin restoration features were developed with the primary goal of reducing soil erosion, floodplain sedimentation, and instream aggradation for the improvement of existing wildlife habitats. Incorporation of these types of restoration features should also provide

secondary benefits to instream water quality through reduced turbidity, as well as agricultural, recreation and other floodplain uses that benefit from stable riverbanks and decreased floodplain erosion.

- Maximize project potential to reduce flood duration and/or sedimentation rates to improve habitat viability as frequent and prolonged inundation of terrestrial habitats which continue to threaten plant and animal health and diversity impacting the resulting ecosystem services associated with these environments.
  - USACE Response: Through future design and construction phases and with further development of the project Adaptive Management Plan, the proposed project features will be developed to maximize project goals and objectives of reducing flood duration, sedimentation rates, aggradation, and woody debris inputs. Additional LIDAR, aerial photography, hydrologic, hydraulic, woody debris, and sediment modeling will be utilized along with the latest technology to further develop proposed restoration measures as identified in the feasibility report.
- Work with the USFWS and the MDC to develop native vegetation planting list for those areas planned for riparian plantings to maximize habitat benefits for wildlife species such as imperiled bats and pollinator species.
  - USACE Response: During the design phase, USACE will coordinate with USFWS and MDC to develop native vegetation planting lists for the projects.
- Continue to investigate the most sustainable, long-term solutions, especially given continued sedimentation and changing precipitation and river stages. Solutions would likely involve additional work upstream of the project focal areas where sediments and trees originate.
  - USACE Response: In the design phase, approximately 316 stream bank stabilization or similar cost-effective projects will be identified and designed for incorporation of erosion and sedimentation remediation measures. It is anticipated that remediation measures such as soil bioengineering, rip-rap stabilization, native plantings, and other similar techniques would be incorporated at each site based on specific site needs, constraints, and objectives. The primary goal of these projects, along with coordination of other similar resource agency floodplain actions, would be to address and reduce future inputs of sediment and woody debris that are impacting downstream resources.
- Investigate designs including streambank benching and adequate geomorphic calculations during project and riparian restoration design phases.
  - USACE Response: A Monitoring and Adaptive Management Plan has been developed for the project, which will incorporate new LIDAR, aerial photography, hydraulic cross-section monitoring, habitat assessments, and estimates of upstream sediment loading. This monitoring information will be used in the design, construction, and Adaptive Management phases to further develop proposed restoration features, including potential modification such as streambank benching, where appropriate.
- Reference hydrologic and geomorphology studies/literature such as Rosgen et al. (2006).
  - USACE Response: Along with current feasibility study hydrologic, hydraulic, and sediment modeling/data, the use and reference of other geomorphic studies, literature, and practices will continue to occur during the project design, construction, monitoring and AM phases to modify and further develop proposed project restoration measures as appropriate.
- Conduct post-project monitoring per the USACE October 19, 2017 memorandum regarding Water Resources Development Act of 2016 implementation guidance for completion of ecosystem restoration projects.
  - USACE Response: A Monitoring and Adaptive Management Plan has been developed for the recommended plan in collaboration with MDC and MoDNR. This plan should be considered

as a living document that will be further refined and developed, along with proposed restoration features, during the design and construction phases of the project.

- Ideally, project alternatives should be flexible and function over a variety of future conditions.
  - USACE Response: It is anticipated that future flooding, aggradation, sedimentation, logjams, and/or avulsions could result in changed future conditions that may result in the need to modify current restoration plans. During the design and construction phases, there is opportunity to modify currently proposed restoration measures/alternatives as appropriate to address any future changed conditions. During the 10-year AM phase there is also opportunity to modify existing project features to increase performance. During the Operation & Maintenance (O&M) phase of the project the local project Sponsors have the ability to also existing project features as needed to ensure long-term performance and sustainability.
- Given the many unknowns in the Grand River Basin, project designs should account for future dynamic sediment and water patterns to provide the greatest long-term habitat gains.
  - USACE Response: It is anticipated that future flooding, aggradation, sedimentation, logjams, and/or avulsions could result in changed future conditions that may result in the need to modify current restoration plans. As part of the proposed Monitoring and Adaptive Management Plan framework, future data will be collected to identify any potential change in future conditions. This information will be used to modify, refine, and develop proposed project measures/alternatives so that they continue to maximize the project goals and objectives, and account for any potential change in future basin or project specific conditions.
- Assess the potential impacts to project actions resulting from climate change, flooding, changes in precipitation, landscape level changes, or addition of major infrastructure.
  - USACE Response: A Monitoring and Adaptive Management Plan has been developed for the project, which will be considered as a living document that utilizes the latest LIDAR, aerial photography, hydraulic cross-section monitoring, habitat assessments, and sediment loading data. This information will be used in the design, construction, and Adaptive Management phases to further asses changed conditions and develop proposed restoration features as appropriate. It is also anticipated that the Kansas City District USACE will be involved with any future major infrastructure or landscape level changes in the basin that could impact the Grand River Ecosystem Restoration project; with coordination to identify synergistic restoration opportunities in the basin and avoidance/minimization of any potential adverse impacts to the project.
- Include AM activities which promote development of unique habitat diversity elements (e.g., connectivity to back channels, sloughs, nursery environments).
  - USACE Response: A Monitoring and Adaptive Management Plan has been developed for the recommended plan in collaboration with MDC and MoDNR. Continued habitat assessment, as coordinated with the project Sponsors, is included in the Monitoring and AM phases to assess habitat quality and quantity within the project areas. This data can be used to help identify additional or modified restoration measures in the AM and O&M phases to help maximize ecosystem benefits.
- Collaborate with MDC, MDNR, and USFWS to develop an appropriate suite of biological monitoring metrics to effectively identify and evaluate the baseline habitat quality as well as evaluate the biological response resulting from project actions. Future habitat evaluations should also be designed specific to focus species to draw comparisons with the approved HEP models used in the Study.
  - USACE Response: A Monitoring and Adaptive Management Plan has been developed for the recommended plan in collaboration with MDC and MoDNR. Aquatic and terrestrial habitat assessment methods and protocol have been developed with MDC and MoDNR and are

described in the AM plan to assess habitat quality and quantity, long-term sedimentation/erosion, changes in hydrology/hydraulics within the project areas. This data can be used with baseline HEP results to assess changes in current/future habitat conditions, changes in future biological responses, and identification of potential restoration modifications.

Locust Creek Recommendations:

- The Study reflects conditions circa 2019-2020. All design work and AM efforts should be based upon adequate understanding of actual site conditions in the future.
    - USACE Response: The design phase will consider any updates needed to reflect current and/or future conditions. A Monitoring and Adaptive Management Plan has been developed for the project, which will be considered as a living document that utilizes new LIDAR, aerial photography, hydraulic cross-section monitoring, habitat assessments, and sediment loading data.
- Search for reaches within Locust Creek exhibiting stable channel conditions to investigate and evaluate those areas regarding reference information for the appropriate stream type to calibrate hydrologic calculations/modeling and dimensions for the development of stable channel/meander geometry.
    - USACE Response: The feasibility study hydrologic and hydraulic cross sections and those identified in the AM plan will continue to be used to document existing and future channel conditions. This data along with Sponsor knowledge of historical channel conditions will be used to identify appropriate channel/meander geometry and dimensions during the design, construction and AM phases.
- Measure bedload transport upstream, within, and downstream of all project locations for comparison and potential AM information needs.
    - USACE Response: Hydraulic cross sections used in the feasibility study and as outlined in the Monitoring and AM Plan will continue to be used in subsequent project phases to assess change in channel morphology. Suspended sediment levels would be collected at the Linneus United States Geological Survey (USGS) gage during project monitoring phase. Sondes would be established at key locations to measure turbidity within study areas. Permanent monitoring stakes (rebar or similar item) would be used at locations to assess long-term riverbank erosion and floodplain sediment deposition.
- Perform a longitudinal profile within a variety of locations throughout Locust Creek to establish baseline streambed data for future comparisons.
    - USACE Response: Hydraulic cross sections used in the feasibility study and as outlined in the Monitoring and AM Plan will continue to be used in subsequent project phases to assess changes in channel morphology, aggradation, degradation, erosion, and sedimentation. The compilation of these cross sections can provide a longitudinal profile of existing and potential future changes in streambed and channel morphology.
- Establish permanent cross sections to monitor channel evolution and response to activity.
    - USACE Response: Hydraulic cross sections used in the feasibility study and as outlined in the Monitoring and AM Plan will continue to be used in the Monitoring phase of the project to assess changes in channel morphology, aggradation, degradation, erosion, and sedimentation. Depending on project needs and funding availability, additional cross section monitoring may be continued in the AM and O&M phases of the project.
- Consider designs to reduce the amounts of sediment prior to confluence of Higgins Ditch/Locust Creek.

  - USACE Response: As part of the upper basin study area, prior to the confluence of Higgins Ditch/Locust Creek, approximately 316 stream bank stabilization or similar cost-effective projects will be identified and designed for incorporation of erosion and sedimentation remediation measures. It is anticipated that remediation measures such as soil bioengineering, rip-rap stabilization, native plantings, and other similar techniques would be incorporated at each site based on specific site needs, constraints, and objectives. The primary goal of these projects, along with coordination of other similar resource agency floodplain actions, would be to address and reduce future inputs of sediment and woody debris that are impacting downstream resources.
- Consider designs to reduce the volume of flow down Higgins Ditch to improve depth of flow/efficiency in Locust Creek.
  - USACE Response: As outline in the feasibility report, a diversion berm and grade control structure would be constructed across the Locust Creek floodplain and extended into the active channel of Locust Creek within Pershing State Park. The instream portion of the berm will divert flows into the sediment basin while also allowing flows to continue into Locust Creek and Higgins Ditch. Preliminary berm designs will allow it to be overtopped when the Locust Creek gage at Linneus is 4,000 cfs and final designs would allow fish and aquatic organism passage. It is anticipated that under future project conditions, the grade control structure and flow diversion into the sediment detention basin are expected to reduce further enlargement of Higgins Ditch, resulting in gradual deposition and a smaller channel over time.
- Ensure future design calculations and components consider potential impacts to Study elements upon proposed construction and operation of the East Locust Creek Reservoir.
  - USACE Response: It is anticipated that the Kansas City District USACE will be involved with any future major infrastructure or landscape level changes in the basin that could impact the Grand River Ecosystem Restoration project. Coordination with applicable entities would be conducted to identify synergistic restoration opportunities in the basin and avoidance/minimization of any potential adverse impacts to the Grand River Ecosystem Restoration project. Hydrologic, hydraulic, and sediment modeling would be conducted to assess potential changed future conditions in the basin with the construction and operation of the East Locust Creek Reservoir.
- Establish large woody debris collection/storage location which may eventually be incorporated into bio-engineering streambank stabilization designs. Build in long-term management of woody debris to minimize losses of native habitats.
  - USACE Response: If project monitoring identifies woody debris issues, manual log removal and mulching AM measures would be considered based on the distance from access roads and on-the-ground conditions. If needed, notching of interior sediment detention basin levees/berms could be used as an AM measure to help promote the movement of flows/logs/sediment to other areas of the basin. Mounding of sediment/debris and creation of low spots (i.e., sediment/log traps) could be used to promote accumulation in desired areas of the sediment detention basin. Bank-packing and placement of woody material into existing avulsions would also be considered depending on the location where the woody debris accumulation occurs.
- Consider working with cooperating landowners upstream to increase the riparian corridor widths. Riparian corridors are known to significantly reduce erosional forces from flooding. Riparian vegetation acts as roughness elements which promote sediment and debris capture (the situation within Locust Creek).
  - USACE Response: As part of the upper basin study area, approximately 316 stream bank stabilization or similar cost-effecitve projects will be identified and designed for

incorporation of erosion and sedimentation remediation measures. Within these project areas, it is likely that native plantings would be considered to increase riparian corridor widths. Remediation measures such as soil bioengineering, rip-rap stabilization, native plantings, and other similar techniques would be incorporated at each site based on specific site needs, constraints, and objectives.

- A large fraction of streambank stabilization projects were mentioned to include conventional methods using rock or stone along eroding streambanks. This type of material is atypical within a majority of northern streams. A comparative impact analysis is recommended to assess the physical and biological responses within these habitats relative to impacts on native species.
    - USACE Response: Remediation measures such as soil bioengineering, rip-rap stabilization, native plantings, and other similar techniques would likely be incorporated based on specific site needs, constraints, and objectives. Habitat, hydrologic, hydraulic, and sediment modeling, similar to those conducted in the feasibility study, would be conducted on a site-by-site basis to identify potential costs, benefits, and impacts.

Fountain Grove CA Recommendations:

- Complete the plan features in such a way to maximize resource fish and wildlife benefits given the level of deterioration within the study area.
- USACE Response: The Kansas City District USACE has been and will continue to be in close coordination with the Missouri Department of Conservation (MDC) for development of all restoration plan features within the Fountain Grove CA. The primary objectives for the project area are to increase quality and quantity of emergent wetlands and bottomland forest, maximize management for optimal habitat conditions, increase operational capability, and limit sediment deposition.
- Work with MDC and USFWS to develop a quantitative biological functional assessment tool to accurately provide a baseline wetland species inventory for future quantitative comparisons to evaluate improvements following project completion.
- USACE Response: The Kansas City District USACE is committed to continued collaboration with MDC, USFWS, and all project partners. The District recently certified a new wetland species assessment tool called the Kansas Floristic Quality Assessment (FQA) Model, which could potentially serve as a means to quantitatively assess biological functionality of wetlands in Fountain Grove and other project areas. The model is based on calculation of a Coefficient of Conservatism relative to the wetland species present. The model would require the use of plants specific to Missouri. Our Engineering, Research and Development Center (ERDC) is in the process of developing a nationwide FQA model that considers species specific to each state.

Yellow Creek Recommendations:

- Consider ancillary flood control and ecological benefits from a variety of levee setbacks over the full range of flows to best understand implications of various alternatives.
    - USACE Response: The Kansas City District USACE has baseline data from habitat, sediment, and hydrologic studies of the Yellow Creek study area that can be used with future USFWS endeavors..

6.0 Recommended Plan.

The recommended plan is composed of actions within the three focus study areas: Locust Creek, Fountain Grove, and Yellow Creek (Figure 6-1). During development of the recommended plan it was determined that the U.S. Fish and Wildlife Service (USFWS) could implement the recommended restoration measures for the Yellow Creek study area, all of which are within the Swan Lake National Wildlife Refuge (NWR) managed by USFWS, under their existing authorities. For this reason, the Yellow Creek study area measures are part of the overall NER Plan, but the Corps is not seeking authorization or funding for these measures. They are listed below to describe the entirety of the federal restoration activities within the NER plan. The subset of the NER plan (all measures of the NER minus the USFWS measures) represents the “Corps Plan”. The full NER plan, with all measures including measures on the USFWS lands, represents the “Federal Plan”. MoDNR would be the non-federal sponsor for the Locust Creek element of the project and MDC would be the non-federal sponsor for the Fountain Grove element of the project.Estimated construction quantities are in Appendix F. Engineering plates for the features comprising the recommended plan are in Appendix M.

6.1 USACE Plan Components

6.1.1 Locust Creek/Pershing State Park

The recommended plan for Locust Creek is alternative LC15.25 which would benefit approximately 432 acres of aquatic riverine, 8,852 acres of bottomland hardmast forest, 1,493 acres of wet prairie, and 2,975 acres of emergent wetland in the Locust Creek study area, resulting in a net gain of 971.5 AAHUs. . The dominant features of the plan are a large sediment detention basin to reduce sediment deposition on significant habitat within and around Pershing State Park, and dredging portions of Locust and Muddy creeks to restore flow conveyance (Figure 6-2). A more detailed description of the plan features follows:

- **Land Acquisition –** Approximately 1,394 acres of existing private land would be acquired to allow for construction of the sediment detention basin. Section 6.4 and Appendix E discuss the real estate requirements of the recommended plan in more detail.
- **Diversion berm –** A diversion berm would be constructed across the Locust Creek floodplain and extending into the Locust Creek channel on Pershing State Park. The floodplain portion of the berm would serve to prevent the progression/formation of additional avulsions that might divert water and bypass the sediment detention basin. The in-channel portion of the berm would serve to divert flows into the sediment basin while also allowing water to continue downstream on Locust Creek and Higgins Ditch. This portion of the berm would be designed to allow for fish and aquatic organism passage. The floodplain portion of the berm would be approximately 1.5 feet tall compared to the lowest point in the floodplain. The diversion structure in the channel was designed such that the structure overtops when Locust Creek at Linneus reaches a flow of 4,000 cfs (approximately between 95% AEP (1/1.05 year) and 90% AEP (1/1.11 year) frequency events), corresponding to a flow of 2,900 cfs just upstream of the diversion channel and structure. At higher flows, it is anticipated that Higgins Ditch and the existing Locust Creek channel would convey flow. The diversion berm would be comprised of two structures: the structure that would cross the existing Locust Creek channel and the structure that would cross the floodplain to the west of the existing Locust Creek channel (Figure 6-3).
- **Sediment Detention Basin Perimeter Levee, Spillways, and Drainage–** This measure includes the raise/construction of a perimeter levee around the sediment detention basin (Figure 6-3). Average levee height was assumed to be approximately 6-feet tall relative to the surrounding terrain. Two spillways were included in the levee raise to allow water to overtop in a controlled manner. The west spillway is intended to allow large flows to travel into Locust Creek, through the main avulsion, and into Higgins Ditch, preventing potential damages and channel erosion in Locust Creek and Muddy Creek. The north spillway allows ponded water on the north side of the

basin to spill into the basin in a controlled manner. The spillway dimensions were identified through an iterative process where the dimensions were adjusted until a constant 100-year inflow on Locust Creek at Linneus did not overtop the basin perimeter except at the spillways. The iterative process for sizing the spillways was used in conjunction with the other measures. Additionally, a drainage channel with a flap gate located north of the northern basin perimeter was included as part of this measure. The drainage channel serves to drain private property north of the basin to Locust Creek. The drainage channel was sized by examining existing drainage features used to drain the same area and applying similar sizes to the channel dimensions. Material for constructing the perimeter levee would come from excavation for other plan features. Both spillways would be armored with rock.

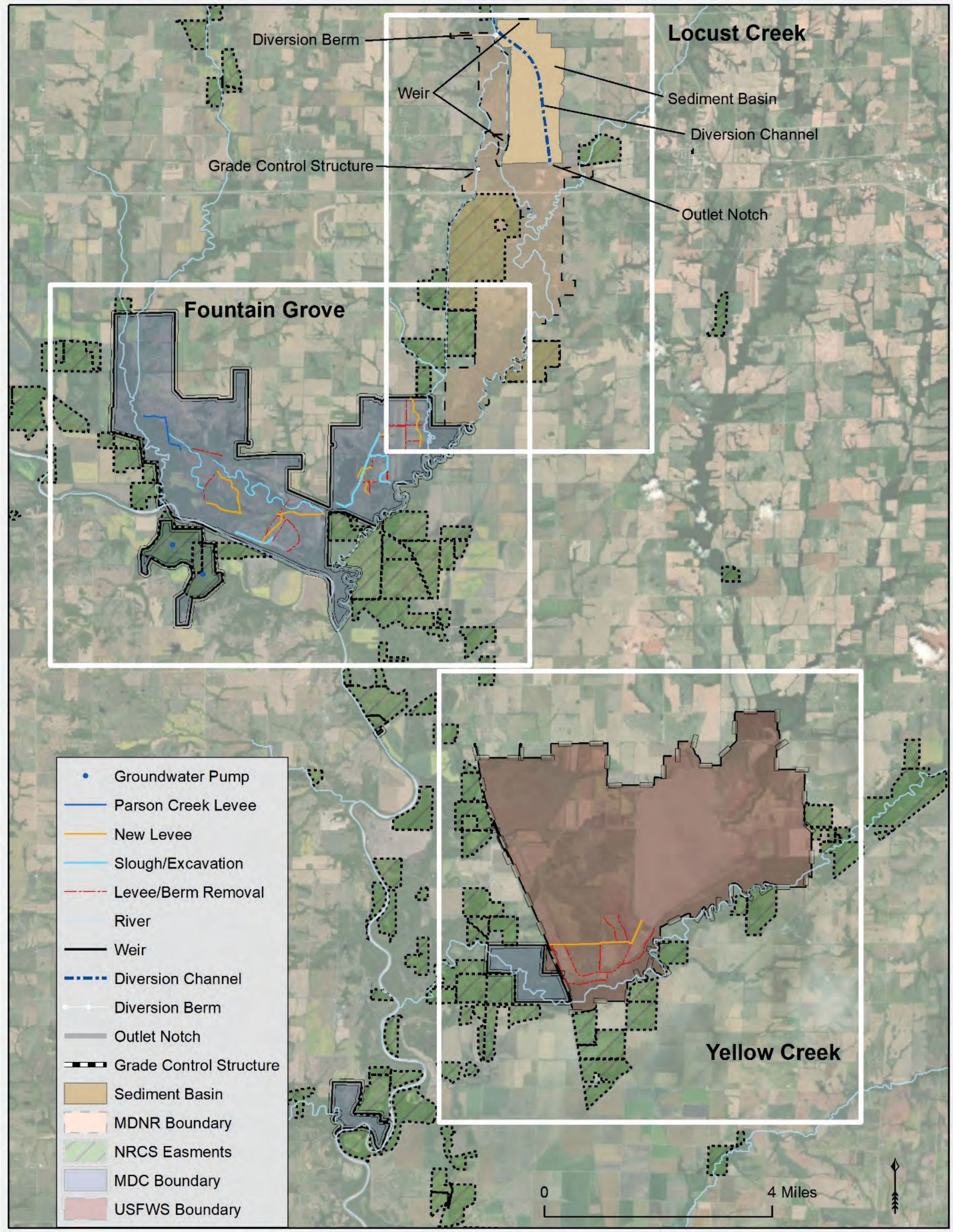

Figure 6-1. Overview of Features Included in the Recommended Federal Plan.

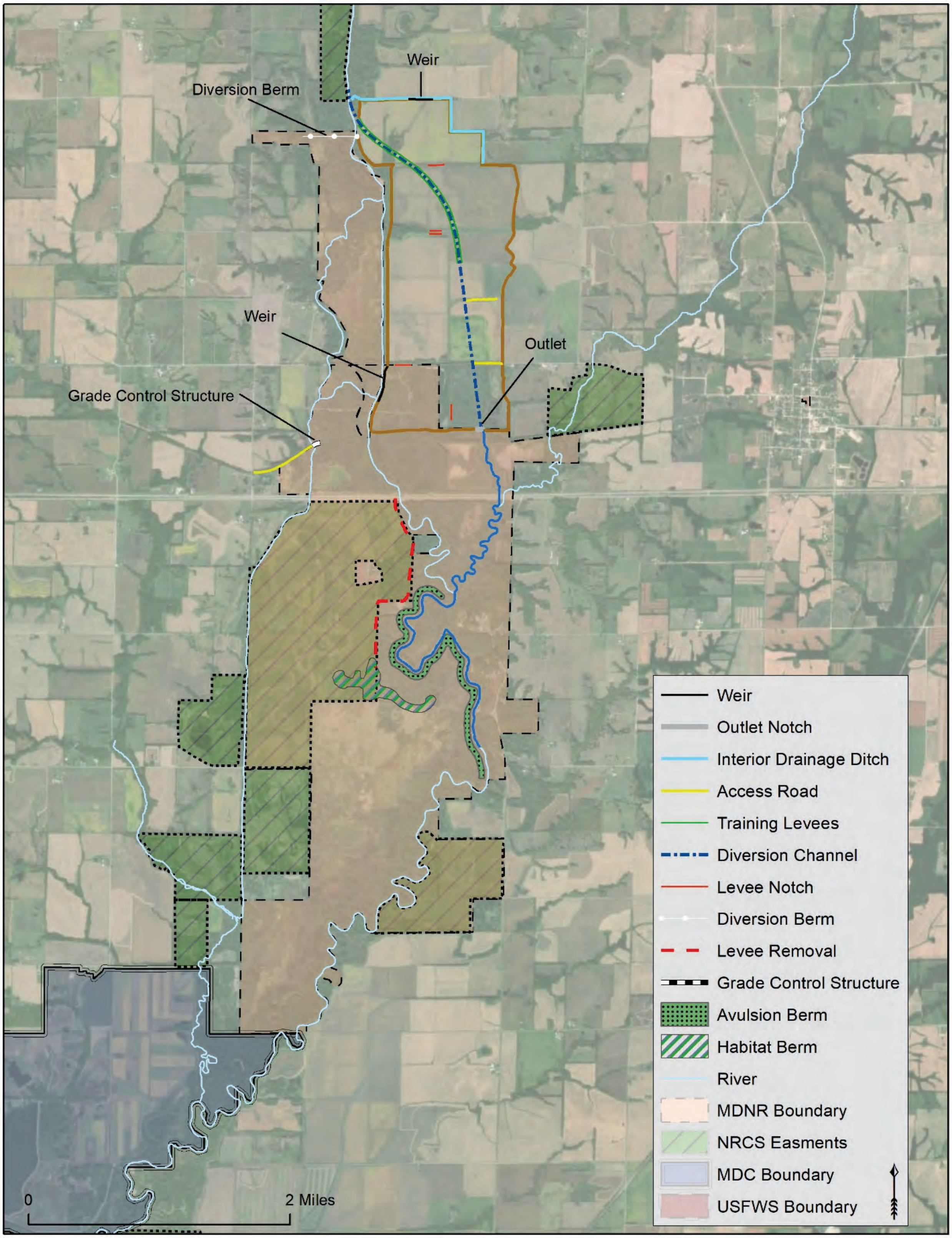

Figure 6-2. Locust Creek Recommended Plan Features.

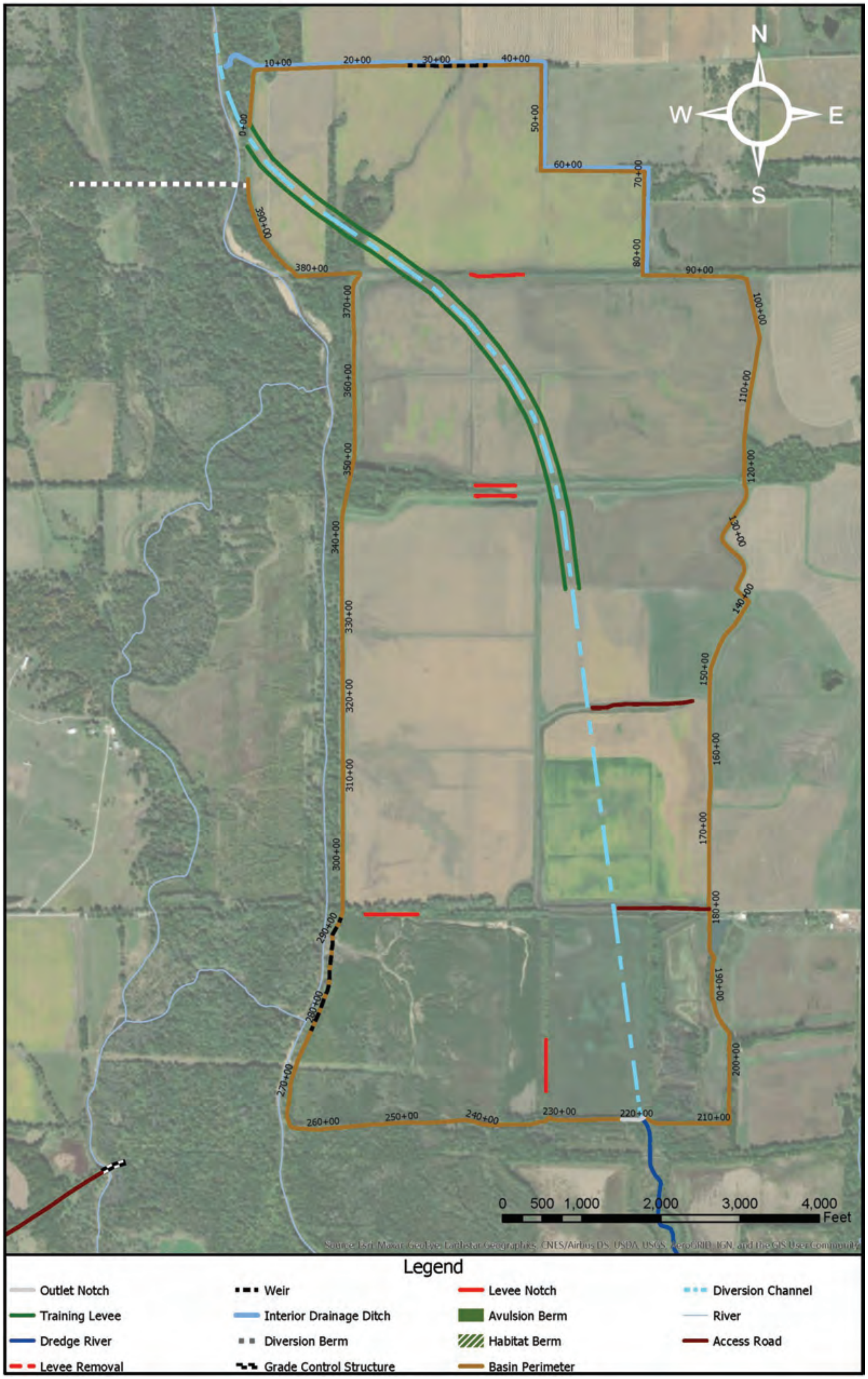

Figure 6-3. Locust Creek Recommended Plan Features Located Upstream of Highway 36.

- **Pilot/Diversion Channel and Training Levees–** A pilot/diversion channel into the sediment detention basin would be excavated to convey sediment and logs away from the diversion berm and reduce the risk of plugging the mouth of the diversion (Figure 6-3). The upstream section of the diversion channel includes a wide width (90-foot bottom width) to allow logs to pass through the sediment basin inlet without initiating a log jam. Two training levees are also included on each side of the channel to concentrate flow, increase depths in the channel, and increase velocities to prevent sedimentation and log jams from forming at the basin entrance. The two training levees are approximately 6 feet higher than the surrounding ground. Suitable material from the diversion channel excavation would be used to construct the training levees and sediment detention basin perimeter levee.
- **Levee Notches –** A portion of the existing levee on the east bank of Locust Creek would be notched to allow flow into the sediment detention basin (Figure 6-3). In addition, several existing levees within the sediment detention basin would be notched to promote meandering of the diversion channel within the basin and facilitate sediment deposition. Material from the levee notches would be used to construct the sediment detention basin perimeter levee.
- **Access Roads –**Access roads would be required to allow for removal of logs and other operations and maintenance. Some of the access roads were incorporated into the basin perimeter and training levees.
- **Exit notch –** Water would exit the sediment detention basin through a levee notch located on the south side of the sediment detention basin (Figure 6-3). The notch is sized to promote backwater and sedimentation within the sediment detention basin. The existing conditions Locust Creek channel capacity downstream of HWY 36 is approximately 2,000 cfs. The notch discharge is intended to increase flows in the Locust Creek channel via Muddy Creek to simulate overbank flows and increase water availability for wet prairie habitat. The notch is designed such that the downstream Locust Creek channel would convey the 99% AEP flows for both Muddy Creek (~400 cfs) and Locust Creek (~2,000 cfs). Because the Locust Creek channel between the avulsions and Muddy Creek passes some water, a flow of 1,500 cfs was used as the notch design discharge for contributions from Locust Creek between Year 0 and Year 10. At Year 10, an increase in discharge to 4,000 cfs is needed to ensure the basin is functional for the full 50-year period. The dimensions of the levee notch will be determined during design to obtain the specified discharges.
- **Grade Control –** Four grade control structures would be constructed as part of the plan. Two would be located on Locust Creek, one north of the pilot/diversion channel and one south of the diversion berm. Another grade control structure would be constructed along Higgins Ditch to limit sediment deposition on the west side of the Locust Creek floodplain below HWY 36. The Higgins Ditch grade control and associated upstream/downstream bank stabilization would require approximately 15,000 CY of fill. The upstream and downstream bank stabilization would affect approximately 750 feet of streambank to prevent flanking. The fourth grade control structure would be required on Muddy Creek upstream of its connection with the sediment detention basin to prevent head-cutting.
- **Dredge –** Approximately 23,500 feet of Muddy and Locust creeks would be dredged to provide channel dimensions sufficient to accommodate the historic bankfull flow and provide appropriate slope (Figure 6-4). This also ensures that sediment currently in those stream channels is not activated and deposited in sensitive habitat areas once the sediment detention basin becomes operational. Dredge material would be used to perform small levee modifications and habitat enhancements. This dredging would be a one-time occurrence and no long-term O&M of the dredged portion of Muddy and Locust creeks is anticipated. The need for and the methods of bank stabilization within the dredged reach would be determined during PED.

- **Avulsion Spoil Berm/Habitat Enhancements-** Dredged material would be spoiled along a portion of Locust Creek (Figure 6-4) to create an avulsion spoil berm. The avulsion spoil berm was developed from state sponsor recommendations based on prior experience in Pershing State Park. The recommendations included a berm offset 100-feet from the stream, 1-foot in height vertical slope, 200-feet wide, with a landside side slope of 10H:1V. The 100-foot offset was included to allow additional room for future stream meandering due to the formation of log jams within the system. An average height of 1-foot was used to establish the top elevation of the avulsion spoil berm. The berm would be intended to protect against future avulsions of Locust Creek to Higgins Ditch. It would require approximately 22,600 cubic yards. The material for the berm would come from the dredging of Muddy/Locust Creek. Dredged material would also be used to construct a habitat enhancement area comprising approximately 83,200 cy of material. Portions of the habitat feature may be constructed if limited material is available, but new material is not planned to be excavated solely for the purpose of habitat berm construction. The habitat feature would tie in to previously constructed habitat features at Pershing State Park. The spoil area would be planted to native species to provide habitat enhancements for massasauga rattlesnakes.
- **Downgrade of Existing Pershing State Park Levee** – This measure includes the partial removal of a levee separating the east and west sides of the Locust Creek floodplain south of HWY36. The removal of the levee serves to help restore floodplain connectivity between Higgins Ditch and the Locust Creek channel. Conceptual design assumes the levee would be lowered approximately 4 feet to match the floodplain elevations east of the levee.
- **Log Jam Removal** – It is likely that log jams may occur within the study area prior to initiation of construction. Log jams present in the vicinity of the diversion berm and entrance to the sediment detention basin would need to be removed as part of construction of plan features. In addition, log jams present downstream of the confluence of Muddy Creek and Locust Creek would likewise be removed as part of construction of the plan and to facilitate the required dredging in that stream reach. Log jam removal may occur as part of ongoing operations and maintenance of the project. Any log jam removal occurring prior to construction of the recommended plan would fall under the scope of the Letter of Permission process that is being coordinated between MoDNR/Pershing State Park and USACE Regulatory. Should log jam removal occur during PED or prior to construction, the method of removal should consider its effect on the recommended plan features. For example, in-channel treatment where silt and woody debris is redeposited along the inside meander bends of the existing channel should be avoided in Locust Creek downstream of its confluence with Muddy Creek because it would further reduce flow conveyance in that reach, which the dredging under the recommended plan is intended to restore.
- **Upper watershed bank stabilization –** Bank stabilization measures would be implemented in the Locust Creek watershed upstream of the sediment detention basin. It is estimated that approximately 316 bank stabilization or similar cost-effective projects would be implemented to achieve a 14% reduction in quantified risk associated with uncertainties in forecasted sediment loading (Appendix C3). The projects would emphasize the use of soil bioengineering techniques; however, hard stabilization such as rock rip-rap would likely be incorporated. It is anticipated that these upstream measures would ensure/extend the lifespan of the sediment detention basin, as well as address the larger instabilities in the system that contribute to high sediment loading. Projects may be implemented in the following HUC-10 watersheds (Figure 6-5): Watkins Creek-Locust Creek (excluding the portion in Iowa); East Locust Creek; West Locust Creek; and Locust Creek.

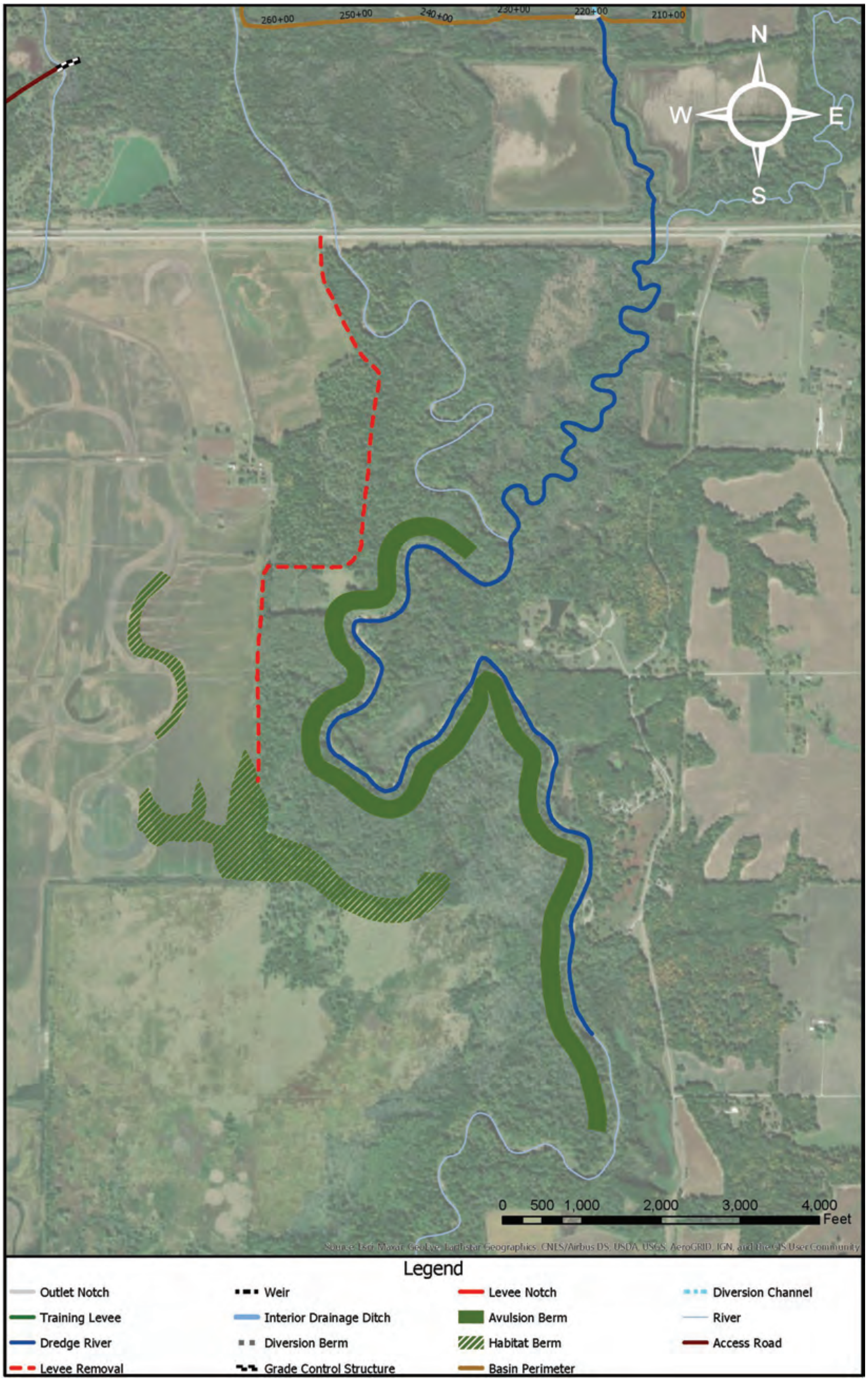

Figure 6-4. Locust Creek Recommended Plan Features Located Downstream of Highway 36.

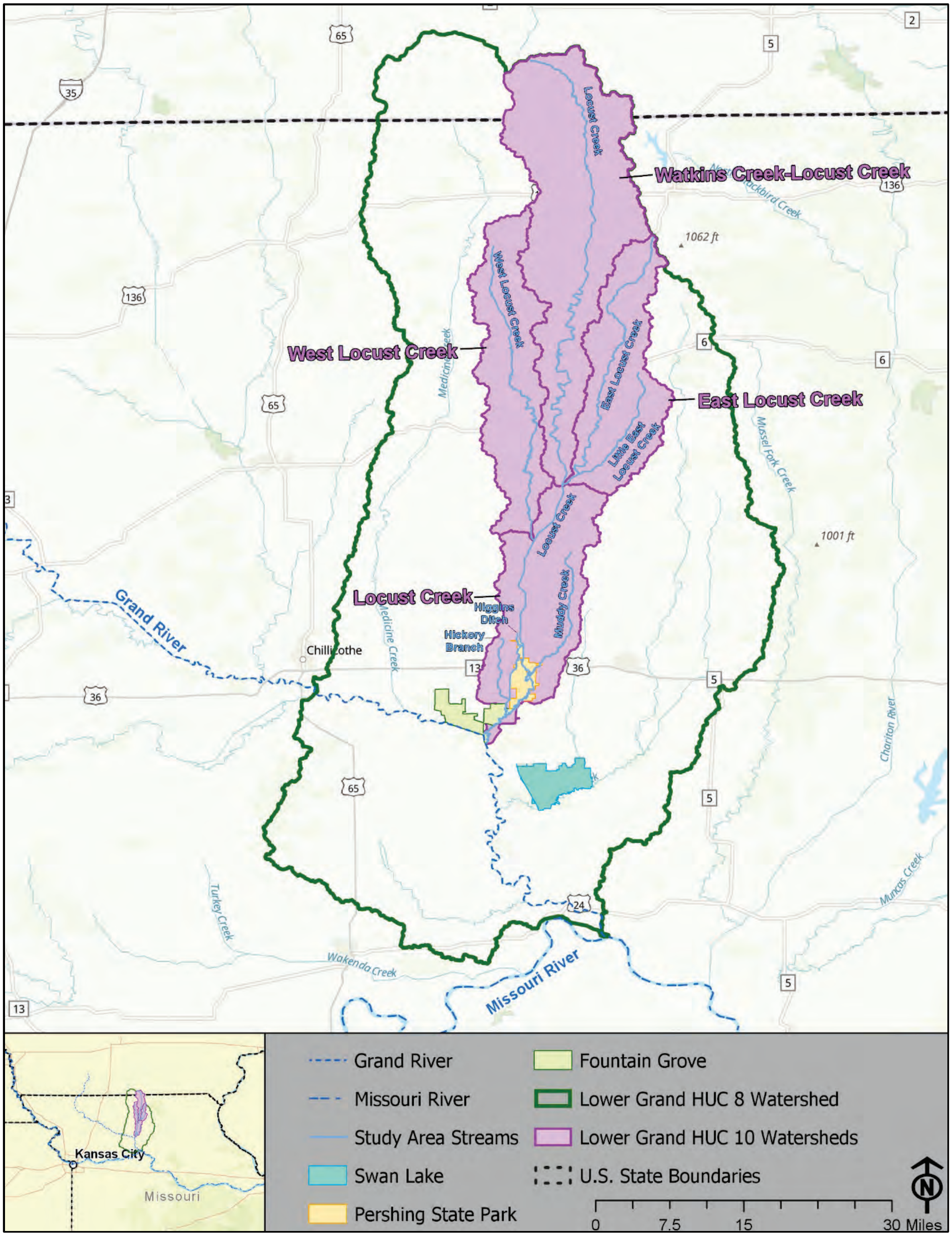

Figure 6-5. HUC 10 watersheds for upstream bank stabilization projects.

6.1.2 Fountain Grove

The recommended plan for Fountain Grove is alternative FG37.5 which would benefit approximately 320 acres of aquatic riverine, 3,917 acres of bottomland hardwood forest, and 2,825 acres of emergent wetland in the Fountain Grove study area resulting in a net gain of 1,139.8 AAHUs.. The plan features a suite of actions to enhance wetlands through increased natural ecosystem form and function, improved habitat development and improved water management (Figure 6-6). The main features of the plan include:

- **Bank armoring and outlet relocation** – The bank of the channel downstream of the Pool 3 Levee WCS, referred to as Jackson's Ditch, would be armored to prevent erosion on the neighboring property. This measure allows for opening the gates at Pool 3 Levee WCS to increase the drainage rate from Fountain Grove CA pools. Additionally, the structure would be relocated to the new levee just upstream of the existing location to alter the direction of flow into the ditch.
- **Water Control Structures** – The Pool 1 WCS #1 would be replaced with two 96-inch PVC pipes with two sluice gates. The culverts are used to drain Pool 1 to Pool 2. The proposed pipe dimensions would be further refined during design.
- **Levee construction/modification** – A new levee would be constructed, running north/south, on the west side of Fountain Grove CA where Parson Creek flows are entering the area under existing conditions. The levee would reduce the frequency of smaller Parson Creek flows from entering Fountain Grove CA. The levees within the pools would be reconfigured to generally follow the elevation contours and allow for independent water control for most pools. The levees would be broader than typical levee cross sections (10-foot crest width and 3H:1V side slopes) with more gradual side slopes to improve flood resiliency when the levees overtop during large flood events. A portion of the perimeter levee on East Fountain Grove CA would be set back to increase flood resiliency by providing extra space for backwater flooding along Hickory Branch.
- **Sloughs** – Sloughs would be excavated through Fountain Grove CA to effectively convey Parson Creek flows through the area during moderate to high flow events. Outside of moderate to high flow events, the features serve as water distribution channels and provide aquatic/edge habitat for wetland species.
- **Berm removal** – a portion of the abandoned Chillicothe-Brunswick rail berm would be removed. This would improve sheet-flow and distribution of shallow water across the area.
- **West Side micro-topography restoration** – Micro-topography on the site would be enhanced through the creation of additional sloughs and habitat mounds. Spoil from the main slough excavation and existing levees would be used to form the habitat mounds.
- **East Side micro-topography restoration** – earthwork would be performed to modify the existing pool design on the east side of Fountain Grove CA. The intent would be to provide more naturally shaped wetland pools, which is consistent with modern wetland management practices. The redesign of the pools on the east side would allow for the removal of some water control structures in that area, creating more natural conditions, and allowing for more efficient management.
- **South Fountain Grove CA groundwater pumps** – Two electric groundwater pumps would be installed on South Fountain Grove CA to facilitate wetlands development and more reliable hydrology.

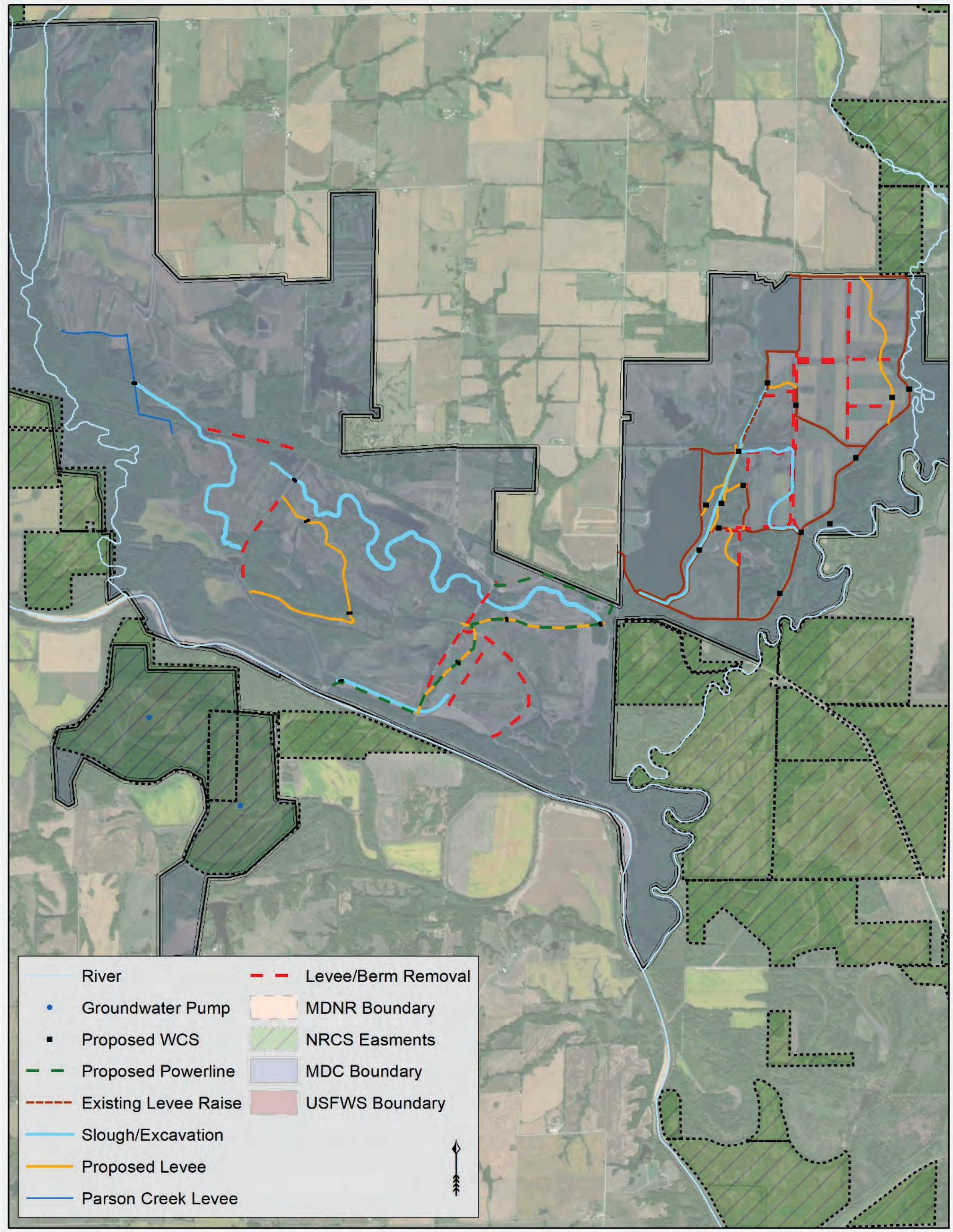

Figure 6-6. Fountain Grove Recommended Plan Features.

6.2 USFWS Plan Components– Yellow Creek

The recommended plan for Yellow Creek is alternative YC11. The main feature of the plan is the setback of a levee on Swan Lake NWR (Figure 6-7). The plan would include levee removal, removing three existing culverts, raising a portion of existing levee, constructing a portion of new setback levee, and addition of two 3-foot diameter concrete culverts with flap gates.

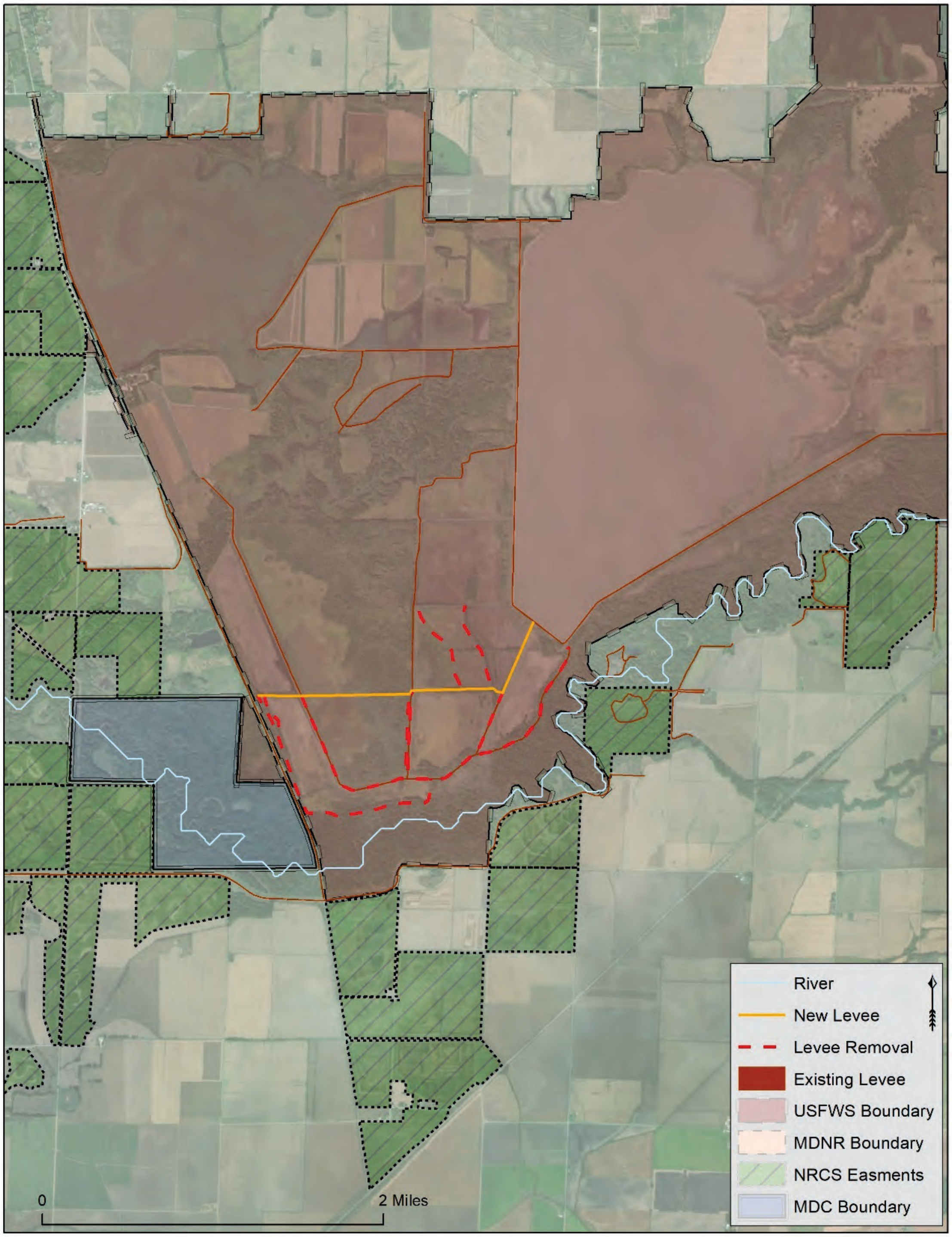

Figure 6-7. Recommended Plan Features on Swan Lake National Wildlife Refuge.

6.3 Operation, Maintenance, Rehabilitation, Replacement, and Repair

Operation, Maintenance, Rehabilitation, Replacement, and Repair (OMRRR) life cycle costs include oversight, management, monitoring, woody debris removal, clearing of drainage areas and sloughs, levee and spillway maintenance and inspection, riprap repair, earthwork, tree clearing, plantings, and additional rock placement for stabilization sites. The MoDNR is responsible for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the Locust Creek project including upper basin sites after construction, with costs currently estimated usgin October 2020 price levels at $8,071,095 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $586,726 over the 50-year planning horizon. The MDC is responsible for OMRR&R of the Fountain Grove project after construction, with costs currently estimated at $861,383 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $131,083 over the 50-year planning horizon.Additional details are provided in Appendix L.

6.4 Land, Easements, Rights of Way, Relocation, and Disposal

The non-federal sponsor is required to provide any lands, easements, right of ways, relocations and disposals (LERRD) necessary for project construction and Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRRR). Any LERRDs determined to be integral to the project will be credited to the project. Approximately 24 parcels of varying size of public and private ownership lie within the Locust Creek recommended plan footprint and are required in fee. This includes 9 parcels in private ownership totaling 1,394 acres. The remaining parcels are in public ownership by MoDNR. Flowage easements would be required on an additional 14 parcels totaling 206 acres. Bank protection easements totaling 18 acres were assumed for feasibility level cost estimating for the upstream bank stabilization project. The Locust Creek recommended plan real estate values based on October 2019 price levels for the affected lands total approximately $5,276,440. Total Locust Creek LERRDs costs after factoring in contingency, administration, and relocation costs are $8,041,000 based on October 2020 price levels. Real estate needed for the Fountain Grove recommended plan includes 259 acres of fee, 2 acres of bank protection easement, 1,754 acres of temporary construction easement, and 2 acres of utility line easement. Only the bank protection and utility line easements affect privately-owned parcels (three private parcels in total). The Fountain Grove recommended plan real estate values based on October 2019 price levels for the affected lands total approximately $1,590,680. Total Fountain Grove LERRDs costs after factoring in contingency, administration, and relocation costs are $3,595,000 based on October 2020 price level. More detailed information can be found in Appendix E, Real Estate Plan. Risk and Uncertainty of the Recommended Plan

6.5 Risk and Uncertainty of the Reccomended Plan

Risks and uncertainty are associated with the forecasted ecosystem benefits of the Recommend Plan. There is uncertainty associated with where and how much woody debris deposits in the Locust Creek floodplain, if and when future channel avulsions may occur, and the actual long-term sediment loads within the watershed. Each of these sources of uncertainty represent a risk to achieving the forecasted ecosystem benefits. Some of this uncertainty was reduced by inclusion of upstream bank stabilization and sediment reduction techniques as discussed in Section 4.9. The remaining risk and uncertainty of project performance was evaluated to assess the reliability of ecological success and support the development of the OMRR&R manual. The Monitoring and Adaptive Management Plan (MAMP) was completed in consultation with the non-Federal sponsors to include estimated costs of adaptive management measures, based on the outcomes of the ecological success monitoring. The Recommended Plan is a structural project designed primarily to reduce sedimentation and woody debris inputs from upstream sources. Long-term non-Federal Sponsor OMRR&R activities will likely be needed to maintain project performance even after ecological success determinations have been made and the 10-year cost-shared monitoring and AM period has expired. The non-Federal sponsors will be required to conduct their

OMRR&R responsibilities in accordance with the project's OMRR&R manual.Monitoring and Adaptive Management

USACE guidance requires monitoring and adaptive management of ecosystem restoration projects. Project monitoring is designed to gauge progress toward meeting the project objectives. Per Section 2039 of Water Resources Development Act (WRDA) 2007, monitoring for ecosystem restoration studies will be conducted to determine project success, and is defined as:

> *The systematic collection and analysis of data that provides information useful for assessment of project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits.*

The implementation guidance for Section 1161 of WRDA 2016, which amends Section 2039 of WRDA 2007, in the form of a CECW-P Memo dated 19 October 2017, requires that "the recommended project includes a plan for monitoring the success of the ecosystem restoration" and also requires that an adaptive management plan be developed for all ecosystem restoration projects. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which may include incomplete description and understanding of relevant ecosystem structure and function, imprecise relationships among project management actions and corresponding outcomes, engineering challenges in implementing project alternative and ambiguous management and decision-making processes.

A monitoring and adaptive management plan was developed with input from the study technical team (Appendix L). Details on monitoring targets, time of effect, frequency of monitoring, adaptive management triggers and responsibilities of monitoring and data collection are included in the Monitoring and Adaptive Management Plan. Per Section 1161 guidance, monitoring costs (not to exceed 10 years after project construction) were considered as part of project costs and developed for each considered alternative. Any monitoring conducted after 10 years would not be part of the total project cost and will be 100% non-Federal costs.

Foreseeable potential actions and total anticipated monitoring and potential adaptive management costs are estimated to be $2,475,000 for the Locust Creek element and $158,000 for the Fountain Grove element. A detailed monitoring and adaptive management plan and cost were not developed for the Yellow Creek element as USFWS will be responsible for implmementation and future management of that element of the plan through their existing authoirties.

6.6 Environmental Committments

The following environmental compliance activities would be required prior to or during construction of the recommended plan:

- CWA Section 401 Water Quality Certification Compliance – A Section 401 WQC has been obtained from MoDNR (Appendix K). The WQC includes conditions that should be referenced during PED and complied with during construction. There are special conditions regarding upstream bank stabilization projects that may require the need to obtain individual 401 WQCs for those projects if conditions apply.
- CWA Section 402 National Pollutant Discharge Elimination System – Construction of the recommended plan is anticipated to disturb greater than 1 acre and therefore it is anticipated an NPDES construction stormwater permit would be required. It would be the responsibility of the USACE contractor to obtain this permit. Likewise, proposed dredging activities may require an NPDES general permit for return water, which would be the responsibility of the contractor performing the dredging activities.
- Endangered Species Act – The USFWS provided the following conservation measures to be incorporated into plan activities to help reduce potential direct, indirect, and cumulative impacts

to federally listed bats (Zone 1 = actions within the State of Missouri excluding Zones 2 and 3; Zone 2 = actions within 5.0 miles (radius) of a known capture of a listed bat; Zone 3 = actions within 0.25 miles (radius) of a known roost tree or hibernacula):

1. All tree clearing resulting from the USACE action will occur during the inactive season from November 1 to March 31 unless negative presence/probable absence survey results were obtained for the action area through appropriate surveys approved by the USFWS.
2. USACE will require a habitat assessment if the project will occur in Zone 1 and includes more than 10 acres of tree clearing. If the results indicate that more than 10 acres of suitable roosting habitat will be cleared, USACE will require presence/probable absence surveys to determine if additional consultation is necessary or the project will not affect listed bats.
3. USACE will require a habitat assessment if the project will occur in Zone 2 and includes more than 5 acres of tree clearing. If the results indicate that more than 5 acres of suitable roosting habitat will be cleared, USACE will require presence/probable absence surveys to determine if additional consultation is necessary or the project will not affect listed bats.
4. If located in Zone 1, the project will not remove more than 10 acres of suitable roosting habitat during the inactive season.
5. If located in Zone 2, the project will not remove more than 5 acres of suitable roosting habitat during the inactive season.
6. The project and USACE action will not result in the removal of trees in Zone 3.
7. Tree clearing associated with the project and USACE action will not result in a cumulative loss of more than 5% of the baseline (2005) forested acreage.
8. If the project is located in a karst area and will involve construction methods that may cause deep ground disturbance, USACE will require a cave search be conducted to determine if any caves are present in the action area that would be considered suitable habitat for bats and/or are currently or formerly used by listed bats.
9. If the demolition of an existing building or structure will occur as a result of the project in Zones 2 or 3, USACE will require bat use surveys in collaboration with the USFWS. If during the course of demolition, bats of any species are discovered, then all work must cease and the USFWS must be immediately contacted. If the structure is safe to leave as is, then it will be left until after November 1, or until bats have stopped using the structure. If the structure is unsafe and poses a risk to human health and safety, USACE will request the assistance of the USFWS in determining reasonable measures to exclude the bats.

- NHPA Section 106 – Compliance with Section 106 has been achieved to date through the development of a PA. The signed PA is in Appendix N. Areas that are to be disturbed will undergo background review and, if necessary, survey to inventory the area for cultural resources. If cultural resources are found that are eligible for the NRHP through consultation with the SHPO, federally recognized Native American Tribes, and other interested parties, efforts would be made to avoid the cultural resource or otherwise minimize impacts to the site. If avoidance is not possible, mitigation measures would be developed in consultation with SHPO and Native American Tribes. All consultations and investigations would be conducted in compliance to the PA.

6.7 Estimated Project Costs

Based on October 2020 price levels, the estimated USACE Project first cost is estimated at $121,347,000. Total project cost including escalation to the midpoint of construction for the USACE project is estimated to be $140,081,000.

The total project first cost for the Locust Creek element using October 2020 price levels is $87,075,000, which includes cost-shared monitoring costs of $798,000 and adaptive management costs of $2,475,000. In accordance with the cost share provisions in Section 103(c) of the WRDA of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the Locust Creek element first cost is estimated at $56,598,750 (65 percent), and the non-federal share is estimated at $30,476,250 (35 percent), which includes the value of lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas estimated to be $8,041,000. The MoDNR is responsible for operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of the project after construction, with costs currently estimated at $8,071,095 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $586,726 over the 50-year planning horizon. The total first project cost for the Fountain Grove element using October 2020 price levels is $34,272,000, which includes cost-shared monitoring costs of $158,000 and adaptive management costs of $360,000. In accordance with the cost share provisions in Section 103(c) of the WRDA of 1986, as amended (33 U.S.C. 2213(c)), the federal share of the Fountain Grove element first cost is estimated at $22,276,800 federal (65 percent), and the non-federal share is estimated at $11,995,200 (35 percent), which includes the value of lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas estimated to be $3,595,000. The MDC is responsible for OMRR&R of the project after construction, with costs currently estimated at $861,383 over the 50-year planning horizon as well as all monitoring costs beyond the 10-year cost-shared period currently estimated at $131,083 over the 50-year planning horizon.The LERRD cost estimates were prepared by the Kansas City District Real Estate Office.

Table 6-1. Total First Project Cost Estimate for the Recommended Plan.

USACE Account	Measure	Locust Creek Cost Estimate	Fountain Grove Cost Estimate
1	Lands & Damages	$7,469,000	$2,194,000
2	Relocations	$572,000	$1,401,000
6	Fish & Wildlife Facilities (Adaptive Management)	$2,475,000	$360,000
9	Channels & Canals	$60,705,000	$23,986,000
30	Planning, Engineering, & Design	$10,638,000	$4,235,000
31	Construction Management	$5,216,000	$2,096,000
	Sub-Total	$87,075,000	$34,272,000
	Total Estimated First Project Cost*		$121,347,000

Table 6-2. Estimated Cost Shares Based on Total First Cost.

Location	Anticipated Cost-Share Sponsor	Total Cost	Non-Federal Sponsor Costs (35%)	Federal Costs (65%)
Locust Creek	Missouri Department of Natural Resources	$87,075,000	$30,476,250	$56,598,750
Fountain Grove	Missouri Department of Conservation	$34,272,000	$11,995,200	$22,276,800

6.8 Responsibilities

The project is expected to have two separate Project Partnership Agreements (PPAs) during implementation. MoDNR will be the non-federal sponsor for the Locust Creek element and MDC will be the non-federal sponsor for the Fountain Grove element. The Locust Creek and Fountain Grove project areas provide separate, self-sustainable and significant habitat benefits, can be implemented in differing timelines, and have no overlapping LERRD requirements. The Locust Creek site is owned and operated by MoDNR and the Fountain Grove site is owned and operated by MDC. The state agencies are distinct with separate foundation and function in state Constitution, state law and separate funding sources. Each organization has separate and distinct missions, facility ownership, capital improvement budgets, and operations and maintenance programs. Both agencies can fulfill the items of local cooperation without additional authority and have provided separate self-certifications, and understand that implmenetaion of both project sites will improve the habitat of the overall lower Grand River watershed.

6.8.1 USACE, Kansas City District

The USACE is responsible for project management and coordination with the MoDNR, MDC, USFWS, NRCS, and other affected agencies. The USACE will submit the feasibility report, program funds, finalize plans and specifications, complete all NEPA requirements, advertise and award a construction contract and perform construction contract supervision and administration.

6.8.2 Missouri Department of Natural Resources

The MoDNR is the non-Federal Project sponsor for the Locust Creek element. OMRRR for the Locust Creek project components is the responsibility of the MoDNR in accordance with Section 107(b) of WRDA 1992, Public Law 102-580. The USACE will further specify these functions in the Project Operation and Maintenance Manual, which will be provided prior to the Government turning the project, or a segment of the project, over to the sponsor. The MoDNR is responsible for acquiring the necessary real estate to construct the restoration features.

6.8.3 Missouri Department of Conservation

The MDC is the non-Federal Project sponsor for the Fountain Grove elment. OMRRR for the Fountain Grove project components is the responsibility of the MDC in accordance with Section 107(b) of WRDA 1992, Public Law 102-580. The USACE will further specify these functions in the Project Operation and Maintenance Manual, which will be provided prior to the Government turning the project, or a segment of the project, over to the sponsor. The MDC is responsible for acquiring the necessary real estate to construct the restoration features.

6.8.4 U.S. Fish and Wildlife Service

The USFWS administers Swan Lake NWR, and as a result, is responsible for work that would occur on their land. USFWS would be responsible for funding the construction of all features associated with the Yellow Creek plan because they all occur on Swan Lake NWR. USFWS would also bear responsibility for future O&M of those constructed project features, as well as, any monitoring and adaptive management associated with that portion of the plan.

6.9 Views of the USFWS and Non-Federal Sponsors

The USFWS, MDC, and MoDNR are supportive of the recommended plan. USFWS has provided a letter stating their support and intention to implement the USFWS portion of the recommended plan. Both non-federal sponsors, MDC and MoDNR, have provided letters of support and financial self-certification. All letters of support are in Appendix O.

7.0 Public Involvement

A public scoping process was held at the beginning of the study. Commencing with the release of this draft report, a public comment period will be opened during which USACE and the local sponsors will host public meetings. This section describes those components of public involvement in more detail.

7.1 Public Scoping

USACE held public scoping meetings to seek public and agency input into the scope of the study. The meetings were advertised through a USACE press release, notices in area newspapers, and via USACE, MoDNR, and MDC social media. Three open-house scoping meetings were held on September 12, 13 and 14, 2017 from 5:00-7:00pm, at:

- September 12, 2017, 5:00-7:00pm: Gen. John J. Pershing Boyhood Home State Historic Site, Memorial Museum and Leadership Archive Building, 900 Ausmus Street, Laclede, MO 64651
- September 13, 2017, 5:00-7:00pm: Keytesville Community Center, 301 West Bridge Street, Keytesville, MO 65261
- September 14, 2017, 5:00-7:00pm: Milan Community Center, 205 North Market Street, Milan, MO 63556

A thirty day comment period closed on October 14, 2017. USACE received 16 comment letters/emails. A total of 49 individuals signed in as attending the three public scoping meetings. The general topics expressed through the comments received included the following:

- General statements of support for the study
- Concerns about the impacts of log jams and flooding to agricultural lands
- Concerns about the impacts to bridges from streambank erosion
- Concerns about habitat degradation
- Suggestion to keep the bulk of flows in Higgins Ditch
- Suggestion to pursue a perpetual permit with USACE for log jam removal
- Suggestion to include a bank stabilization program in the Locust Creek, East Locust Creek, and West Locust Creek sub-watersheds as part of the plan
- Suggestion to include a voluntary flow easement or levee breach program in the Locust Creek, East Locust Creek, and West Locust Creek sub-watersheds as part of the plan
- Statement that the solution to the identified problems could be mutually beneficial to the ecosystem and agriculture
- Suggestion to make use of existing programs and BMPs available to landowners

7.2 Public Review and Comment on Draft Report

In accordance with USACE regulations for implementing NEPA and requirements for application for a 401 Water Quality Certification from the State of Missouri, the draft report was made available for public review and comment for a minimum of 30 days. A 43-day comment period commenced with the issuance of a joint public notice and publication of the report on USACE website (https://www.nwk.usace.army.mil/Media/Public-Notices/Planning-Public-Notices/) on October 8, 2019. The public and agency comment period concluded on November 20, 2019. The public and state/agency reviews were extended beyond the standard 30-day period due to overlap with regional crop harvesting and hunting seasons. Availability of the draft report was announced in a USACE press release and through USACE, MoDNR, and MDC social media. Three public meetings were held to present the findings of the draft report and solicit comments from the public. All substantive comments received were considered. All comments received and USACE responses to substantive comments are included in Appendix H.

8.0 District Engineer's Recommendation

Based on the conclusions of this study, after having given consideration to all significant aspects in the overall public interest, including environmental, social, and economic effects; and engineering feasibility; I recommend the implementation of the selected plan, which consists of actions in three focus study areas: Locust Creek, Fountain Grove, and Yellow Creek. The Locust Creek features include construction of a diversion berm, sediment detention basin, pilot/diversion channel, log capture features, four grade control structures, dredging of Locust and Muddy creeks, small levee modifications, habitat enhancements, and implementation of approximately 316 bank stabilization projects upstream of the sediment detention basin. The Fountain Grove features include a suite of infrastructure modifications and earthwork to enhance wetlands through increased natural ecosystem form and function, improved habitat development, and improved water management. The Yellow Creek features include a levee setback on Swan Lake NWR. I recommend this plan with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

Federal implementation of the recommended plan would be subject to the non-Federal sponsors agreeing to comply with Federal laws and policies, including but not limited to:

a. Provide 35 percent of total ecosystem restoration project costs as further specified below:

    1. Provide, during design, 35 percent of design costs in accordance with the terms of a design agreement entered into prior to the commencement of design work for the project;
    2. Provide all lands, easements, rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the federal government to be required or to be necessary for the construction, operation, and maintenance of the project, all in compliance with applicable provisions of the Uniform Relocation and Assistance and Real Property Acquisition Policies Act of 1970, as amended (42 U.S.C. 4601-4655) and the regulations contained in 49 C.F.R. Part 24; and
    3. Provide, during construction, any additional amounts necessary to make its total contribution equal to 35 percent of total project costs;

b. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

c. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

d. Not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal sponsor's obligations for the project unless the federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project;

e. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

f. For so long as the project remains authorized, operate, maintain, repair, rehabilitate and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purpose and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the Government;

g. Give the federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

h. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

i. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 USC 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation and maintenance of the project.

j. Assume, as between the federal government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project; and

k. Agree, as between the federal government and the non-federal sponsor, that the non-federal sponsor shall be considered the owner and operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

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

Date: 16 October 2020

William C. Hannan, Jr.
Colonel, Corps of Engineers
District Commander

9.0 Preparers and Technical Team Members

This chapter identifies the USACE team members responsible for preparation of the FR/EA and its appendices (Table 10-1), as well as the members of the study technical team, who contributed to all aspects of plan formulation and habitat evaluations (Table 10-2).

Table 10-1. Grand River Integrated Feasibility Study and Environmental Assessment Preparers.

Name	Education	Years of Experience/ Area of Expertise	Responsibilities
Holly Bender	Ph.D., Natural Resource Economics B.A. Political Science and Economics	20 years/NEPA compliance and natural resources planning	Lead on EA sections for socioeconomics, environmental justice, and recreation
Tracy Brown	B.S. Geography M.A. Geography	15 years/GIS and spatial analysis	GIS and spatial analysis technical lead
Katherine Carter	B.A. Economics	4 years/Economics Analysis of Flood Risk Management and Ecosystem Restoration	Lead economist and primary author of CE/ICA appendix
Diane Hassaballa	B.S.B.A. Business Ethics, Marketing, and Management	3 years/NEPA compliance and natural resources planning	Contributor to EA sections on socioeconomics, environmental justice, and recreation
Tim Meade	M.A. Archeology	30 years/North American Archaeology	Cultural Resources lead responsible for Section 106 compliance and preparation of the PA.
Kaely Megaro	B.A. Environmental Studies M.S. Planning	10 years of water resource planning and project management experience	Project manager/lead planner and primary author of plan formulation appendix
David Nagy	B.S.C.E. Civil Engineering M.S. Civil Engineering	6 years/railway engineering 5 years/bridge engineering 5 years/construction estimating 6 years/construction 3 years/city and state agreements 9 years/A/E agreements	Lead cost engineer and primary author of cost estimate appendix
Erin Reinkemeyer, E.I.T.	B.S. Civil Engineering	3 years/ Hydrology and Hydraulics	Technical lead and primary author of the H&H appendices
John Shelley	B.S. Civil Engineering Ph.D. Civil Engineering	12 years/ Fluvial geomorphology, sedimentation analysis, and river engineering	Technical lead and primary author of sediment analysis appendix
Michael Snyder	B.A. Biology M.S. Biological Sciences	20 years/NEPA compliance and natural resources planning	Primary author of EA, compilation of main report, biological assessment, and 404(b)(1) analysis.
Seth Thomas	B.S. Criminal Justice	4 years/Real Estate Management & Disposal and Civil Cost Share	Real estate lead and primary author of real estate plan
Jeff Tripe	B.A. Environmental Science / Biology M.S. Fisheries Biology	25 years / NEPA compliance, environmental planning	Technical lead and primary author for the habitat evaluation and quantification appendix

Table 10-2. Grand River Feasibility Study Technical Team Members.

Name	Education	Years of Experience/ Area of Expertise
Missouri Department of Conservation		
Paul Blanchard	B.S. Geological Sciences Ph.D. Geological Sciences	40 years/hydrology and fluvial geomorphology
Christopher Crabtree	B.S. Biology M.S. Biological Sciences	15 years/ecology and natural community management
Chris Freeman	B.S. Fisheries and Wildlife B.S. Plant Science	25 years/wildlife and wetland management
Thomas Huffmon	B.S. Wildlife Conservation and Management	12 years/Aquatic resources and fish management
Mike McClure	B. S. Wildlife Conservation & Management	32 years-Wetland management/restoration
Frank Nelson	B.A. Biology M.S. Fish and Wildlife Sciences	15 years wetland ecology and restoration
Doug Novinger	B.A. Biological Sciences M.S. Fisheries and Wildlife Ph.D. Zoology and Physiology	20 years/Aquatic resource conservation and research
Missouri Department of Natural Resources		
Charles DuCharme	B.S. Forestry B.S. Watershed Sciences M.S. GIS contd.	37 years/forestry, hydrology, GIS analysis, watershed science
Bryan Hopkins	B.A microbial ecology M.S, Environmental Microbiology	20 years in environmental fields with specialty in large river systems
John Horton	B.A. Environmental Geography M.S. Resource Planning	16 years in soil and wetland sciences, hydrology
Tim Rielly	B.S, Biology	25 years water quality monitoring, issues and restoration
Michael Weller	B.S. Civil Engineering	12 years/hydraulic modeling and water resources planning
Tom Woodward		38 years/facility management and resources protection
U.S. Army Corps of Engineers		
Glen M Bellew, PE	B.S Civil Engineering M.S Geotechnical Engineering	15 years/dam, levee, and geotechnical engineering for planning, design, construction, and operation.
Katherine Carter	B.A. Economics	4 years/Economics Analysis of Flood Risk Management and Ecosystem Restoration
Kara Hinshaw	B.A. Civil Engineering	1 year/Hydrology and Hydraulics
Ron Jansen PE	BS Civil Engineering	29 years pumps, piping, water / wastewater treatment, grading, flood control, general civil engineering.
Kaely Megaro	B.A. Environmental Studies M.S. Planning	10 years of water resource planning and project management experience
David Nagy	B.S.C.E. Civil Engineering M.S. Civil Engineering	6 years/railway engineering 5 years/bridge engineering 5 years/construction estimating 6 years/construction 3 years/city and state agreements 9 years/A/E agreements
Erin Reinkemeyer, E.I.T.	B.S. Civil Engineering	3 years/ Hydrology and Hydraulics

Name	Education	Years of Experience/ Area of Expertise
John Shelley	B.S. Civil Engineering Ph.D. Civil Engineering	12 years/ Fluvial geomorphology, sedimentation analysis, and river engineering
Michael Snyder	B.A. Biology M.S. Biological Sciences	20 years/NEPA compliance and natural resources planning
Seth Thomas	B.S. Criminal Justice	4 years/Real Estate Management & Disposal and Civil Cost Share
Jeffry A. Tripe	B.A. Environmental Science / Biology M.S. Fisheries Biology	25 years / NEPA compliance, environmental planning
U.S. Environmental Protection Agency		
Gabriel DuPree	B.S. Natural Resource Conservation Post-bacc, Environmental Policy & Management	14 years/Environmental compliance and water resources management
U.S. Fish and Wildlife Service		
Josh Eash	B.S. Geology	22 Years hydrologic assessments and water monitoring
Jane Ledwin	B.S. Biology-Geology M.A. Marine Science	25 years/NEPA, FWCA, ESA review and evaluations
Bryan Simmons	B.S. Biology M.S. Biology	17 years/Aquatic Ecology
James Stack	B.S. Environmental Science M.S. Aquatic Sciences and Environmental Informatics	3 Years/ Hydrology with the National Wildlife Refuge System

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