Memphis Metropolitan Area Stormwater

Cypress Creek

Ecosystem Restoration

Feasibility Study

With Integrated Environmental Assessment

Draft

December 2015

Executive Summary

This study examined aquatic ecosystem problems and opportunities in the Cypress Creek Watershed. Cypress Creek is a tributary of the Loosahatchie River which flows into the Mississippi River at Memphis, TN. Cypress Creek was channelized in the 1920's like most of the streams in the Lower Mississippi River Valley. The habitat in Cypress Creek is degraded and continues to get worse. This study recommends placing grade control weirs in Cypress Creek to restore aquatic habitat, stabilize the bed and banks, protect remaining riparian forests and allow some areas to revegetate, reestablish more natural hydrologic conditions, and provide some ancillary benefits to adjacent infrastructure. The Tentatively Selected Plan will cost approximately $14 million and will restore 90 acres of aquatic habitat.

I. INTRODUCTION 1
Authority 3
Prior Reports, Existing Water Projects, and Ongoing Programs 3
II. PROBLEMS AND OPPORTUNITIES [PURPOSE AND NEED] 7
Specific Problems and Opportunities 8
Aquatic Habitat Problems 8
Floodplain and Riparian Habitat Problems 8
Other Ancillary Problems 8
Aquatic Habitat Opportunities 9
Floodplain and Riparian Habitat Opportunities 9
Other Ancillary Opportunities 9
Planning Goal and Objectives 9
Planning Constraints 10
Public Scoping 10
III. INVENTORY AND FORECAST CONDITIONS 11
Existing Conditions [Affected Environment] 11
Fish and Wildlife 11
Land Use and Infrastructure 12
Other Environmental Resources 12
Socio Economic Considerations 13
Future Without Project Conditions 15
Fish and Wildlife 15
Land Use and Infrastructure 15
Other Environmental Resources 16
Socio Economic Considerations 16
IV. FORMULATE ALTERNATIVE PLANS 17
Management Measures 17
Screening of Measures 17
Formulation Strategy 18
Final Array of Plans 18
Alternative 1 No Action 18
Alternative 2 Grade Control Only 18
Alternative 3 Grade Control and Bench Cuts 19
Alternatives Eliminated From Detailed Analysis 20
Alternative 4 Grade Control and Meander Restoration 20
Alternative 5 Grade Control, Bench Cuts and Meander Restoration 20
Alternative 6 Recreation Features Added to Another Alternative 20
V. EVALUATE ALTERNATIVE PLANS 21
Alternative 1 No Action 21
Alternative 2 Grade Control Only 21
Fish and Wildlife 21
Land Use and Infrastructure 21
Other Environmental Resources 21
Socio Economic Considerations 21
Alternative 3 Grade Control and Bench Cuts 22
Fish and Wildlife 22
Land Use and Infrastructure 22
Other Environmental Resources 22
Socio Economic Considerations 22
VI. COMPARE ALTERNATIVE PLANS 23

Significance of the Alternatives 23
Technical Importance 23
Institutional Importance 25
Public Importance 25
P & G Criteria 26
CE/ICA Results 27
System of Accounts 28
Other Plan Information 29
VII. RECOMMENDED PLAN 30
National Significance of the Project 30
Implementation Plan 30
Real Estate 30
Weir Design 30
Construction Method 31
Funding and Construction Schedule 32
Operations, Maintenance, Repair, Rehabilitation and Replacement 32
Monitoring and Adaptive Management 32
Cost Sharing Requirements 33
Risk and Uncertainty 33
Environmental Disclosures 34
Floodplain Management 34
Hazardous, Toxic and Radioactive Waste (HTRW) 34
Environmental Justice 34
State and Federal Holdings 34
Wetlands 34
Endangered Species 35
Cultural Resources 35
Prime and Unique Farmland 35
Air Quality 35
Water Quality 35
Noise 35
Mitigation 36
Relationship of Plan to Environmental Laws and Regulations 36
Coordination 37
Cumulative Effects 37
Conclusion 37
VII. REFERENCES 38

List of Figures

Figure 1. Vicinity Map, Cypress Creek, Tennessee 2

Figure 2. Cypress Creek Watershed 6

Figure 3. Cypress Creek upstream of HWY 196 Bridge. The bridge abutments have created a hardpoint and the habitat is in good condition in this reach 14

Figure 4. Cypress Creek downstream of bridge 14

Figure 3. Alternative 2 Features 18

Figure 4. CE/ICA Results comparing average annual habitat units and average annual costs 19

Figure 5 Map of weir and bench cut locations for Alternative 3 19

Figure 8 Map of land cover in the Loosahatchie Watersehd 24

Figure 9. Comparison of alternatives using average annual cost and average annual habitat units. 27

Figure 10. Typical Design of a Grade Control Weir 31

Figure 11. Typical Design of Grade Control Weir 31

List of Tables

Table 1. Comparison of Significance of Alternatives 26

Table 2. Comparison of Alternatives using the P&G Criteria 26

Table 3. Comparison of Alternatives using CE/ICA 27

Table 4. System of Accounts Comparison 28

Table 5. Other Plan Information Comparison 29

Table 6 Cost Apportionment For the TSP escalated to 2020 (estimated first year of construction) 33

List of Appendices

Appendix A – Results of Habitat Suitability Models

Appendix B - Sampling and Assessment of the Habitat and Fish and Macroinvertebrate Communities at Cypress Creek, Shelby and Fayette County, Tennessee

Appendix C - Hydraulics and Hydrology

Appendix D – Cost Estimates

Appendix E – Real Estate Plan

Appendix F – Draft 404b1

Appendix G – Draft FONSI

I. INTRODUCTION

In 1996, Congress directed the U.S. Army Corps of Engineers to examine a large area around Memphis, TN and determine the need to address flooding, restore environmental resources and improve water quality in six major tributaries of the Mississippi River. The Memphis District first examined the flooding issues in the region and issued a report in 1999 that highlighted several areas it believed had federal interest in conducting flood risk management studies. The District continues to work with potential sponsors on these areas and on others where federal interest may develop as hydraulic and economic conditions continue to change.

In 2009, the Memphis District completed a second report that considered ecosystem restoration opportunities throughout the study area. Streams throughout the area were channelized starting in the 1920's. Habitat degradation is extensive and the rivers are unstable and unlikely to recover without intervention. The 2009 study found that over $120 million of projects on the mainstems of the Hatchie River, Loosahatchie River, Wolf River, Nonconnah Creek, Horn Lake Creek and the Cold Water River could provide over 14,000 habitat units, restore several thousand acres of bottomland hardwood forests, improve water quality, protect remaining wetlands, and generate many other benefits. The Memphis District worked with potential sponsors and resource agencies and determined the best way to achieve these benefits. The agencies decided to start with the tributaries of the major rivers and address the habitat, stability and water quality concerns there first. This approach will provide benefits to those tributaries and enhance the value of future restoration on the larger rivers providing a regional network of restored, connected habitat.

The first tributary chosen for this approach is Cypress Creek. Cypress Creek is a tributary of the Loosahatchie River located near Oakland, Fayette County, Tennessee (Figures 1 & 2). Channelization of Cypress Creek impacted aquatic, riparian and wetland habitat; and it is expected to continue degrading. This study will examine ways to restore aquatic, riparian and wetland habitat. Channelization has limited flooding and flood damage in the Cypress Creek watershed, and there is no federal interest in flood risk management activities.

Bottomland hardwood habitat once covered as much as 24.7 million acres throughout the Mississippi Alluvial Valley. This area has experienced an 80% decline over the last 200 years with the most rapid changes occurring within the last 70 years. Numerous reports have stated the scarcity and threats to bottomland hardwood habitat and the ecological benefits they provide. Bottomland hardwoods depend on healthy streams and functional floodplains. With the exception of the small isolated remnants, virtually all of the bottomland hardwoods within the region are degraded. Channelization has played a major role in this degradation. The Cypress Creek project could restore a remnant of the bottomland habitat that once existed in the watershed.

Like most of the tributaries of the Loosahatchie River, the entire length of Cypress Creek and its tributaries have been channelized. Many natural stream functions have been eliminated. These functions include but are not limited to providing habitat for freshwater mussels, crayfish, fish, amphibians, reptiles, mammals, and birds. Numerous scientific studies have documented population declines to all of these resources as a result of habitat loss (Benz and Collins 1997).

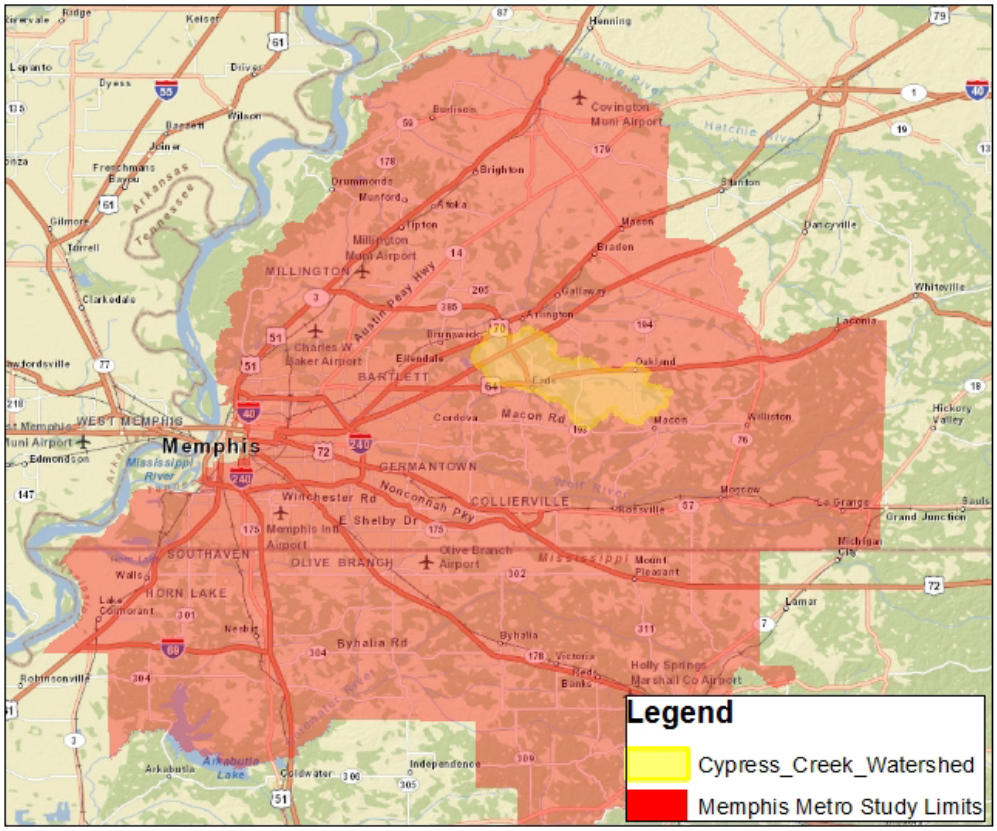

Figure 1. Vicinity Map, Cypress Creek, Tennessee

This project has the potential to restore connectivity between Cypress Creek and its floodplain. Restoring connectivity would provide numerous ecological benefits and interactions between the creek and its floodplain. This restored connection will provide valuable habitat for fish, amphibians, reptiles, mammals, and birds. Likewise, establishment of riparian vegetation would provide a connection between isolated patches of forested areas that occur within the floodplain.

The Loosahatchie River flows downstream to Meeman-Shelby Forest State Park and Wildlife Management Area, a 13,467-acre park with a bottomland hardwood forest of large oak, cypress, and tupelo. The park contains 2 lakes and miles of hiking trails. Deer and turkey are abundant, and there are at least 200 species of birds. A successful project on Cypress Creek would likely lead to other similar projects in the Loosahatchie River Watershed, eventually recreating a larger functional ecosystem and connecting the downstream area to the restored upstream reaches.

The Loosahatchie River is a tributary of the Mississippi River. Other studies have noted the importance of such tributaries on the health and function of the Mississippi. A majority of Lower Mississippi River tributaries have been altered to facilitate drainage (Benz & Collins 1997). Channelization has reduced or eliminated natural stream functions such as providing habitat for freshwater mussels, crayfish, fish, amphibians, reptiles, mammals, and birds. Habitat loss has caused population declines to all of these (Benz & Collins 1997). Channelization in tributary rivers has also altered geomorphology and changed sediment dynamics in the Mississippi River. Large rainfalls are quickly drained from the floodplain changing flood pulses (Baker et al. 2004) and reducing nutrient attenuation.

There are no federally listed species that are known to occur within the project area and no direct impacts or benefits to any federally listed species are anticipated. However, the study area is within the range of the federally listed northern long-eared bat and Indiana bat. Improved bank stability may prevent further loss of summer roosting and foraging habitat for these species. Over time, improved connectivity and ecosystem restoration in the area could restore more diverse and stable habitats. The naked sand darter (*Ammocrypta beani),* a state-listed fish species, is known from the Hatchie River to the north and the Wolf River to the south. There is potential for it in the Loosahatchie drainage, and it would benefit from a project. Restoring the area would benefit a wide array of additional species that are on the decline nationally such as freshwater mussels, amphibians, and neotropical migratory birds.

Authority

The United States House of Representatives Committee on Transportation and Infrastructure adopted a resolution on March 7, 1996.

Memphis Metro Area

> The Secretary of the Army review the report of the Chief of Engineers on the Wolf River and Tributaries, Tennessee and Mississippi, published as House Document Numbered 76, Eighty-fifth Congress, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at this time, with particular reference to the need for improvements for flood control, environmental restoration, water quality, and related purposes associated with storm water runoff and management in the metropolitan Memphis, Tennessee area and tributary basins including Shelby, Tipton, and Fayette Counties, Tennessee, and DeSoto and Marshall Counties, Mississippi. This area includes the Hatchie River, Loosahatchie River, Wolf River, Nonconnah Creek, Horn Lake Creek, and Coldwater River Basins. The review shall evaluate the effectiveness of existing Federal and non-Federal improvements, and determine the need for additional improvements to prevent flooding from storm water, to restore environmental resources, and to improve the quality of water entering the Mississippi River and its tributaries.

Prior Reports, Existing Water Projects, and Ongoing Programs

Channelization of Cypress Creek occurred sometime in the 1920s or before. Legal documents refer to the creek as a "canal" as early as 1923. The creek was used to describe property boundaries on deeds dated to 1904. Recent court cases have sought to clarify landownership given the change to Cypress Creek. The court has not been able to document who channelized Cypress Creek or when. No entity claims responsibility for it or maintains it for flood control or any other purpose.

1972 Wolf and Loosahatchie Rivers and Nonconnah Creek, Tennessee and Mississippi. Authorized a joint investigation by the Department of the Army and the Department of Agriculture. In this study, the Big Creek drainage basin was studied as part of a much larger study, which included the Wolf and Loosahatchie Rivers and Nonconnah Creek. Various alternative plans of improvement were investigated along Big Creek and Casper Creek in this study. None of the alternatives considered were determined to be economically feasible for USACE implementation.

Other entities performed clearing and snagging on Casper Creek and constructed a levee along Big Creek in the vicinity of the naval facilities.

1985 Land Treatment Plan, Wolf and Loosahatchie River Basins, Tennessee and Mississippi
The U.S. Department of Agriculture (USDA) and its agencies – Natural Resources and Conservation Service (NRCS), the Forest Service, and the Economic Research Service prepared this plan. The report addressed erosion control, water quality improvements, and environmental enhancement in the two river basins. The plan was approved, but not implemented.

1984 Mississippi Delta Headwaters Project
The Mississippi Delta Headwaters Project was authorized in 1984 to provide a means for the USACE and NRCS to work cooperatively and demonstrate various methods to reduce flooding and major sediment and erosion problems in areas of the Yazoo Basin in northwest Mississippi. Technical assistance was obtained by joint agency effort from the USDA Sedimentation Laboratory at Oxford, Mississippi, the United States Geological Survey and the Engineer Research Development Center in Vicksburg, Mississippi. Cypress Creek lies outside the authorized area for this program; however it is within the same region and has similar hydraulic, hydrologic and geotechnical conditions. The tools and techniques developed though this program are applicable to Cypress Creek. The Delta Headwaters Project generated a substantial amount of research on the engineering and ecological responses to grade control.

1999 Reconnaissance Report – Memphis Metro Area
This reconnaissance report examined the entire Memphis Metro authority area to determine if there was federal interest in addressing flood damages within the authorized area. The report identified several locations and those have been pursued as separate projects. The only one within the Loosahatchie drainage was Big Creek. The Millington and Vicinity study addressed it, but ended when the sponsor withdrew support.

2007 Oakland, TN Section 14
Channelization of Cypress Creek caused headcutting up the unnamed tributary. This headcutting was a threat to the city's sewer facilities. In 1996 the city asked for Corps assistance to provide protection for a force main leading to a lagoon located approximately 2,000 feet downstream of the lagoon and parallel to the unnamed tributary. USACE determined relocation of the main was the least cost alternative. The city relocated the force main in early 2002. The channel remained unstable and head cutting progressed upstream and threatened the lagoon system. In 2007, USACE completed a Section 14 Feasibility Study and determined there was a plan with Federal Interest. USACE placed rip rap along the sides and bottom of the channel in a reach approximately 130 feet long and located immediately downstream of the lagoon for protection against headcutting.

2007 Fisheries Report 08-05 Region I Stream Fisheries Report
The Tennessee Wildlife Resources Agency (TWRA) prepared this report and noted that quality habitat was not evident in the Loosahatchie. Watershed uses and siltation contributed to poor habitat conditions which would negatively impact spawning success and survival of young-of-year black bass. Eroding river banks increased woody debris in the river which may have provided temporary habitat structures. However due to the high silt load of the river, these areas were also excellent silt traps which provided poor spawning habitat for sport fishes.

2009 Memphis Metro Stormwater Reconnaissance Report
This report examined the entire Memphis Metro authority area to assess federal interest in ecosystem restoration. The study provided a conceptual plan for restoration of all of the rivers in the area. This current study is part of that overall plan.

2011 Fayette County Emergency Bridge Replacement
In December 2011, a 30 foot section of Belle Meade road washed out at a culvert crossing over a tributary to Cypress Creek. The road was closed for more than a month while County crews secured rights of way and replaced the culvert crossing. The road had sustained damage during heavy rains in summer 2011, but only temporary repairs were made at that time.

2013 WTRBA Constructed Weir on Oakland Branch
The West Tennessee River Basin Authority (WTRBA) constructed a grade control weir on Oakland Branch, a tributary to Cypress Creek. The work was necessary to stop streambank and streambed erosion and protect public and private infrastructure.

2015 Regional Conservation Partnership Program
USDA's Regional Conservation Partnership Program (RCPP) promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. RCPP encourages partners to join in efforts with producers to increase the restoration and sustainable use of soil, water, wildlife and related natural resources on regional or watershed scales. Through RCPP, NRCS and its partners help producers install and maintain conservation activities in selected project areas. Partners leverage RCPP funding in project areas and report on the benefits achieved. The Nature Conservancy in West Tennessee, leading a coalition of partners and resource agencies, has applied for an RCPP grant for the Cypress Creek watershed. The goal of this project is to measurably improve the water quality and ecological integrity of Cypress Creek watershed. The objectives include: implementing the NRCS soil health initiative and using engineered structures to control local stormwater runoff, sedimentation, and channel degradation.

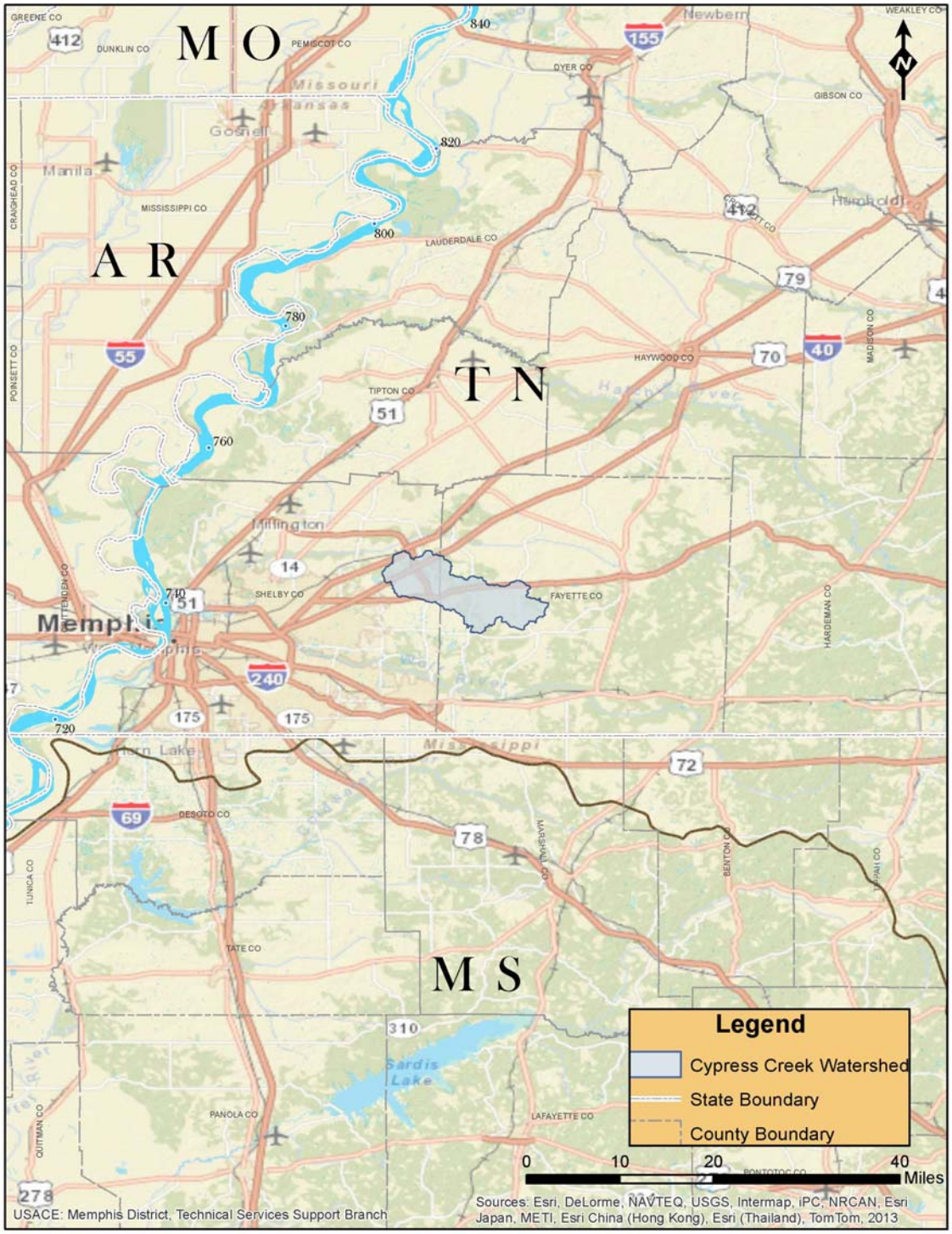

Figure 2. Cypress Creek Watershed

II. PROBLEMS AND OPPORTUNITIES [PURPOSE AND NEED]

Channelization is globally one of the major factors causing stream habitat loss and degradation, and is a serious threat to biodiversity of running water ecosystems (Muotka et al. 2002). Studies in the Czech Republic, Sweden, Poland, Switzerland, Australia and Japan have documented a wide range of problems including poor fish recruitment (Jurajda 1995), reduced fish abundance and diversity (Horlte and Lake 1983), problems retaining and decomposing coarse particulate matter (Lepori et al. 2005), degradation of riparian vegetation (Nakamura et al. 1997), floodplain habitat losses and changes in sedimentation patterns (Wyzga 2001), and even spider population collapses (Paetzold et al. 2008). Channelization devastates streams' primary productivity, faunal and floral community structures, hydrologic integrity and geomorphic condition.

In the U.S., channelization has been widely used to facilitate flood risk management and drain swamps and wetlands. A study in 1983 found that over 16,500 miles of streams in the U.S. had been channelized (Brookes et al. 1983). The impacts of channelization have been studied in Ohio (D'Ambrosio et al. 2014), Kentucky (Bukaveckas 2007), Missouri (Emerson 1971), Florida (Toth et al. 1995), California (Frissell 2002) and the Dakotas (Erikson et al. 1979) and results are similar to those mentioned above.

Most of the major streams in west Tennessee and Mississippi, in addition to their tributaries, have been channelized. These include the Obion, Forked Deer, Loosahatchie, and Wolf Rivers in western Tennessee, and the Cold Water, Tippah, Tallahatchie, Yocona, Skuna, and Yalobusha Rivers in Mississippi. Deforestation during the late 1800s and poor soil-conservation practices caused channels to fill with sediment in the early part of the 20th century. Channelization was widespread during the 1920s and 1930s. These projects reduced seasonal flooding and removed channel obstructions that created shallow swamps covering large areas of the floodplains (Shankman 1996).

Cypress Creek and its tributaries were channelized. Historically, project area streams were slow moving, meandering channels with dynamic habitat complexes, stable stream beds, and stable vegetated banks that provided fish and wildlife habitat. Now, there is little streambank vegetation to provide habitat, shade and nutrients. Water depth and dissolved oxygen levels are too low for many native species during the drier seasons. Land is eroding, streambanks are caving, and the bed of the creek is deepening especially around road crossings.

The fish habitat in Cypress Creek is poor and fish movement is limited. Floodplain and bottomland hardwood forest habitat, which are important for birds and mammals, have also declined. There are opportunities to stabilize the stream and restore habitat for a variety of fish and wildlife species. There may also be a recreational trail opportunity in the immediate project area as provided for in the Flood Control Act of 1944, as amended in the Water Resources Development Act of 1986.

Restoration of channelized rivers is occurring worldwide and studies show ecosystem processes, and structures can recover. Studies in Sweden and Kentucky show that restored streams are able to break down and store nutrients better than unrestored streams (Bukaveckas 2007, Lepori et al. 2005). Benthic invertebrates in Finland (Muotka et al. 2002), and macroinvertebrates in Japan (Nakano et al. 2008) responded well to restoration. Physical habitat and floral communities recovered to near pre-disturbance patterns in the Kissimmee River in Florida (Toth 1995). Studies in north Mississippi found fish abundance, richness and diversity improved with restoration (Shields

et al. 1995a, Shields et al. 1995b, Shields et al. 1998). Primary productivity, invertebrates, riparian vegetation, hydraulic processes and fish communities can recover from channelization.

In Goodwin Creek, northwest MS, rehabilitation increased pool habitat availability, overall physical heterogeneity, riparian vegetation, shade, and woody debris density. Fish response to rehabilitation measures was modest but distinct. Before rehabilitation cyprinids, which are generally tolerant of poor habitat, comprised 74% of the fish population and centrarchids, which are generally sensitive to poor habitat, comprised 11%. After rehabilitation the population shifted to 32% cyprinid and 55% centrarchid. (http://www.ars.usda.gov/Research/docs.htm?docid=5521). This research indicates there are good opportunities to restore habitat in this region.

Specific Problems and Opportunities

Aquatic Habitat Problems

Cypress Creek contains poor quality aquatic habitat with little connectivity in the system. Pool-riffle complexes, riparian zones, and rooted aquatic vegetation have all been damaged or eliminated.

There are barriers to fish passage in the system. Erosion around culvert outlets and bridge protection have created barriers at many crossings. Sand deposits in some areas create stretches of stream with no surface flow.

Mussel habitat is degraded. Channel instability causes shifting sediments, aggradation and degradation, and large bank failures that smother mussels. Mussels depend on fish for part of their lifecycle, and cannot recolonize areas with limited fish passage.

Floodplain and Riparian Habitat Problems

There is no floodplain habitat remaining on Cypress Creek. The channels are deeply incised, the banks are steep and water cannot spread out on a floodplain.

There is very little riparian habitat. The banks are unstable and high water events often cause bank failures. The scoured banks are too steep for vegetation to reestablish.

Bottomland hardwood and wetland habitats are greatly diminished. Channel incision, bank instability and land use have combined to diminish bottomland hardwoods and wetlands.

Other Ancillary Problems

Bridge replacement is a common occurrence throughout the Loosahatchie watershed. Bridges are being replaced along Raleigh-Millington Road in Shelby County and U.S. Highway 70 in Fayette County. The bridge over the Loosahatchie River on Laconia Road (Fayette County) has recently been replaced after a prolonged closure. Emergency repairs are also frequent around road crossings. There was a catastrophic failure of a culvert on a tributary of Cypress Creek in 2011 and several other near failures. Repairs had to be done quickly to restore access to homes. Emergency repairs are expensive and often cause environmental problems. In 1989, a bridge over the Hatchie River (next major drainage north) collapsed due to scouring and eight people were killed.

Hard points that control stream grade and preserve stability are being lost. Free span bridges are replacing culverts and bridges with piers. The new bridges are often better for fish passage than the crossing they replace, but the hardpoints associated with culverts and piers are being lost.

There are no Best Management Practices (BMP) to guide land use and road design in the area. Development in the area is expected to increase and more habitat is likely to be lost without BMPs.

Collectively, the study area problems diminish biological diversity, water quality, environmental sustainability, and recreation values. A successful project on Cypress Creek could lead to other similar work to restore ecosystem structure and function throughout the Loosahatchie River watershed. The Mississippi River Commission's 200-Year Vision seeks to balance the nation's need for environmental sustainability with national economic priorities such as infrastructure, efficient transportation, flood risk management and clean water. There are opportunities in the Cypress Creek Watershed to advance these and other goals through watershed based ecosystem restoration and recreation planning.

Aquatic Habitat Opportunities

Restore aquatic habitat – pool-riffle complexes, meanders, and rooted aquatic plants.

Improve fish passage.

Stabilize substrate to restore mussel habitat.

Floodplain and Riparian Habitat Opportunities

Restore floodplain habitat and bottomland hardwoods.

Restore riparian habitat – stabilize banks to allow revegetation.

Other Ancillary Opportunities

Reduce the likelihood of emergency repairs at road crossings.

Work with Federal, state and local agencies to develop BMPs.

Enhance and extend the benefits of adjacent recreational facilities to the project area.

Planning Goal and Objectives

The goal of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded, more natural condition. Restored ecosystems should mimic, as closely as possible, conditions which would occur in the area in the absence of human changes to the landscape and hydrology. Indicators of success would include the presence of a large variety of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and the ability of the restored area to continue to function and produce the desired outputs with a minimum of continuing human intervention.

Objective: Increase the amount, quality, and sustainability of habitat in the ecosystem of Cypress Creek and its tributaries. The Slough Darter model and the Great Blue Heron model will measure success.

Planning Constraints

The benefits of local flood risk management features (storm sewers, etc.) cannot be reduced.

Existing Tennessee Valley Authority (TVA) power transmission line towers will be avoided.

Public Scoping

The Memphis District issued a Public Notice for the proposed Cypress Creek Ecosystem Restoration Project on October 24, 2014. The notice went to stakeholders and state and federal agencies and was posted to the Memphis District and City of Oakland websites. The District received six responses; four from members of the public and from two federal agencies. The public agreed that habitat loss and bank caving were significant concerns. US Fish and Wildlife Service (USFWS) noted that while no threatened or endangered species are known to inhabit the watershed, coordination would be required for any tree clearing activities as the project footprint likely includes potential habitat for the federally endangered Indiana bat and the northern long-eared bat. US Environmental Protection Agency (EPA) mentioned area experts in ecosystem restoration and noted a successful ecosystem restoration project in a similar watershed.

III. INVENTORY AND FORECAST CONDITIONS

Existing Conditions [Affected Environment]

Cypress Creek is tributary of the Loosahatchie River. It falls within the Mississippi Valley Loess Plains ecoregion. Streams in this region are typically low gradient and turbid with sand/silt bottoms and wide floodplains. The Loosahatchie River is a 64-mile long tributary of the Mississippi River and drains 470,000 acres mostly in Fayette, Shelby, and Tipton Counties (i.e. the Memphis metropolitan area). Cypress Creek is one of six sub-basins in the Loosahatchie watershed. Cypress Creek is approximately 13 miles long and drains 42,000 acres. At one time, the project area had oxbow lakes, extensive cypress-tupelo swamps, healthy riverfront forests, and seasonally flooded bottomland hardwoods.

Cypress Creek ranges in width from approximately 10 feet at the upper end of the project area to around 60 feet at the downstream end. Flow at the upper end is interrupted, but is perennial for most of the area. Substrate is predominately sand, silt, and fines. Soils are primarily of hydrologic group B or C in the USDA TR-55 classification system. Appendix C includes more detail about Hydraulics and Hydrology in Cypress Creek.

Direct channelization impacts are obvious in areas cleared for agricultural, residential, commercial, or industrial development. Channelization causes flashy flows, channel incision, bank sloughing, and bridge scour. Impacts are less obvious in uncleared forests. Although these areas remain forested, channelization dried the adjacent floodplain and wetlands. Non-native species, including privet and kudzu, are replacing seasonally flooded bottomland hardwoods and associated mid-story and understory species historically found in the area. The lowering of the Cypress Creek channel has prompted the headcutting of the tributaries, which have delivered excessive quantities of sediment to the Cypress Creek channel. The bridges at Highway 196, Mebane Road, and Highway 194 have been riprapped to provide stability (Figures 3 & 4).

Now, water velocity, depth, and substrate are uniform which is unsuitable for many forms of aquatic life. There is little to no riparian habitat to provide shade and nutrient input. Water depth is too shallow for many native species during the drier seasons. Excessive sedimentation and nutrients degrade water quality and cause further habitat losses.

Appendix B includes a detailed report of physical habitat and biotic communities in Cypress Creek.

Fish and Wildlife

West Tennessee provides habitat for a wide range of species. More than 100 species of fish, 35 mussels and 250 species of birds are known to occur in the region. The State of Tennessee lists 18 rare species that are known to occur in Fayette County including fish, mammals, reptiles, amphibians, birds, mollusks and plants. Fifteen of the 18 listed species are dependent on aquatic, wetland, floodplain and/or riparian habitat.

The riparian zone ranges from approximately 40 to 60 feet wide. Riparian vegetation along Cypress Creek includes birch, box elder, elm, sweet gum, sycamore, locust, pawpaw, tulip poplar, willow, river cane, wild grape, poison ivy, grasses, and invasive privet and kudzu. Animals known to use the area include coyote, deer, raccoon, beaver, great blue heron, swallows, Fowler's toads, bullfrogs, and

crayfish. Brook silverside, redhorse, green sunfish, bluegill, largemouth bass, blacktail shiner, bullhead minnow, Mississippi silvery minnow, redfin shiner, blackspotted topminnow, yellow bullhead, mosquitofish, and slough darter were found during sampling in 2014.

There are no federally listed species that are known to occur within the project area, but it is within the range of Indiana bat (*Myotis soldalis*) and northern long-eared bat (*Myotis septentrionalis*). The naked sand darter (*Ammocrypta beani),* a state-listed fish species, has been found in the Hatchie drainage to the north and the Wolf River drainage to the south and there is potential for it to occur in the Loosahatchie.

Slough darters were found in the project area in summer 2014. They range from Alabama to Texas, as far north as central Illinois and as far west as Kansas. They are typically found in pools and oxbows of lowland streams. They prefer warm, turbid waters with little or no flow and mud or silt substrates. This habitat would have been typical for Cypress Creek prior to channelization. Slough darters were chosen as a representative species to model existing habitat conditions in Cypress Creek and predict future conditions both with and without a project. There are approximately 90 acres of potentially suitable habitat for it. The slough darter habitat model analyzes habitat quality based on the water quality (dissolved oxygen turbidity, pH and temperature), substrate, slope, pools, and velocity. Cypress Creek scores well for most of these criteria. The upper areas of Cypress Creek have sections with interrupted flow which scores poorly on the velocity variable. The downstream portion of the study area does have better velocity scores. The existing habitat has an average Habitat Suitability Index (HSI) of approximately 0.11, or 9.45 average annual habitat units (AAHU). See Appendix A.

The great blue heron (GBH) is a large wading bird common throughout North America. It eats small fish, crayfish, aquatic insects, small mammals, amphibians, reptiles and small birds along streams, rivers, and wetlands. GBH breeds in colonies (called rookeries) in forested areas larger than 1 acre near water. The rookeries are located away from human disturbance. Great blue herons are good indicators of habitat for a wide variety of aquatic and riparian dependent species. GBH tracks are seen along Cypress Creek. The habitat suitability model for GBH was used to assess habitat quality in Cypress Creek. The model found that although there were 150 acres of potentially suitable habitat, the habitat suitability was 0. Human disturbance, lack of large trees, and poor quality fish habitat drove the model results.

Land Use and Infrastructure

Pasture and cropland cover more than half of the watershed, but approximately 30% is forested and 5-10% is residential and commercial. USDA has classified most of the area as prime farmland. Five bridges cross the main stem of Cypress Creek in the study area, and there are many culverts on tributaries. TVA transmission lines, local power lines and telephone lines also cross the creek. There is at least one pipeline under Cypress Creek.

Other Environmental Resources

Cypress Creek is on the state 303d list for impaired waters. It is listed for total phosphorus, *E. coli*, habitat alteration, and sedimentation. Water chemistry was measured in July and August 2014. Temperatures at the time ranged from 77°F to 86°F. Dissolved oxygen ranged from 5.9 to 10 ppm. The pH was between 7 and 8.28. Neither ammonia nor nitrites were detected.

Socio Economic Considerations

Fayette County has approximately 40,000 residents, and 7,500 of them live in Oakland, TN. Population in the area is rising slowly, and most of the population gain in the county is within the city of Oakland. The rural population in the county is declining. The home ownership rate in the county is over 80%, and is nearly 90% within the City of Oakland; the statewide average is less than 70%. Median home values in the county are slightly higher ($175,000) than in the city ($167,000), but both are higher than the statewide average ($144,000). The population in Oakland is younger than the county average. Most residents of the City and County travel more than 30 minutes to work, many of them into Memphis, TN.

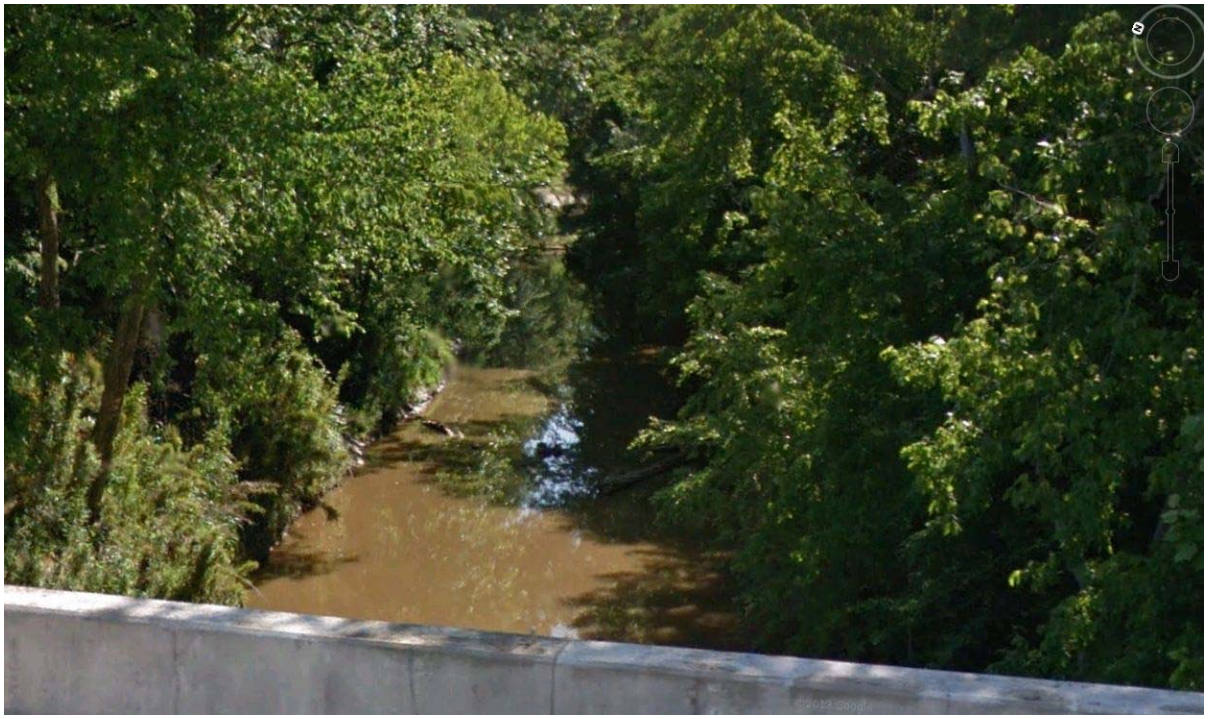

Figure 3. Cypress Creek upstream of HWY 196 Bridge. The bridge abutments have created a hardpoint and the habitat is in good condition in this reach

Figure 4. Cypress Creek downstream of Highway 196 bridge showing degraded aquatic habitat, eroding banks and loss of riparian habitat

Future Without Project Conditions

Cypress Creek (TN08010209003_0200) and its tributaries were channelized sometime in the 1920s or before. Historically, project area streams were slow moving, meandering channels with dynamic riffle/pool/run complexes, stable stream beds, and stable vegetated banks that provided fish and wildlife habitat. Development and population growth are anticipated in the already developed area, but development and population growth are not anticipated in the more rural areas.

The soils in the Cypress Creek watershed are highly erodible and it is unlikely the stream will reach a new equilibrium and stabilize without intervention. Bridge inspection surveys show a continuing pattern of scouring and bed degradation. Failures have occurred at road crossings and more road failures and utility disruptions are anticipated. Kudzu is present in the area and is spreading along riverbanks where caving has removed shade. Kudzu can kill or damage native trees and shrubs, increase erosion, and further degrade the habitat quality in the streams. These processes are expected to continue unchecked for the next 50 years.

The Nature Conservancy has submitted a proposal for a USDA Regional Conservation Partnership Program grant in the watershed. This project would establish BMPs to protect riparian buffers, guide the designs of culvert replacements, and assist farmers in installing drop pipes and other conservation measures. By itself, the RCPP would protect some watershed features, improve water quality and ecological integrity, and reduce some localized flooding issues. Major stream restoration is outside of the scope of RCPP. Cumulatively, the RCPP and this Cypress Creek restoration project would provide many benefits and ensure the long term sustainability of the watershed. The RCPP proposal relies, in part, on the progress of this ecosystem restoration project.

Fish and Wildlife

Unstable streambeds degrade habitat within the channel and on the adjacent floodplain. Colonization sites for aquatic macroinvertebrates (*e.g,* snails, freshwater mussels, aquatic insects) are either smothered in areas that aggrade or scoured in areas that degrade. Lack of channel complexity (*i.e.,* lack of deeper pools, shallow riffle areas, and undercut banks), loss of aquatic vegetation, reduced amounts of large woody debris and other structure, and poor water quality (*i.e.,* higher total suspended solids and water temperature, lower dissolved oxygen) all impact fish habitat.

It is likely that velocity in the downstream portion of the study area would decrease as it has in the upper reaches. Habitat for slough darter would degrade from 9.45 to 6.34 AAHUs. Habitat for great blue heron would remain unsuitable.

Land Use and Infrastructure

Small to medium-sized bridges in Tennessee were originally built with piers and abutments in the channel. These provide some incidental hardpoints and there is often good habitat remaining just upstream of the bridges. The State of Tennessee replaces small to medium-sized bridges with free span bridges where possible. The positive effect of the old style bridges is gradually being lost. The probability of bridge and culvert failures and resulting road closures will increase if nothing is done

to stabilize the system. These failures can cause traffic routing issues and can even cut off access to private homes. Instability will also threaten power lines, pipelines and other infrastructure.

Neither the City of Oakland nor Fayette County has a dedicated program to proactively address the stream stability and habitat loss. Over the last 20 to 30 years, most of the work in the watershed was done to address critical needs. The WTRBA has funding to address approximately one critical issue every three years in the watershed. Generally, the headcuts are allowed to progress through an area and the repairs are made behind them. There is no plan or program to address the headcuts and prevent them from continuing upstream. There is no indication that a more comprehensive program is likely without this project.

Fayette County and the City of Oakland are considering a new frontage road which would transect Cypress Creek and require at least one additional bridge. The frontage road would encourage development and further reduce floodplain and riparian habitat in the area near Oakland. Residential and commercial development is likely to continue in Oakland. Some agricultural, open and forested land in the area may be lost, but losses are not expected to be rapid. Larger farms may be divided into smaller lots and the numbers of roads, bridges and culverts on tributaries will increase. The population of Oakland will continue to increase, but the population in the rural area may continue to decline for a few years. The watershed of Cypress Creek upstream of Highway 64 has experienced development over the past 20 years. If development continues through the project life, then frequency flows and runoff volumes may be greater than at present.

Other Environmental Resources

Cypress Creek channel will continue to exhibit the flashiness of a channelized stream. The channel will continue to incise, sideslopes will collapse, and scouring around bridges will continue. Head cutting will be unchecked and excessive quantities of sediment will be delivered to the Cypress Creek main channel. All of this will cause further degradation to Cypress Creek which is already 303d listed for sedimentation and habitat alteration. Total phosphorus and *E. coli* concentrations would stay the same.

Socio Economic Considerations

Construction of homes will continue near Oakland. The population is likely to continue increasing in Oakland and declining in the rural areas.

IV. FORMULATE ALTERNATIVE PLANS

Management Measures

Measure 1. Grade Control

Stream instability is the underlying cause of many of the problems in Cypress Creek. Grade control weirs are the proven method to address stream instability. Their purpose is to control channel slope and elevation, and they are often used to raise the elevation of a channel that has incised. Weirs reduce stream slope and flow velocity and stabilize the banks and bed of the channel. They prevent and arrest head cut formation and channel bed erosion (Abt et al. 1992, Bormann & Julien 1991, Shields et al. 1998, Simon & Darby 2002). Appendix C includes typical plans for weirs.

Measure 2. Bench Cuts

Bench cuts are frequently used in incised streams to reestablish a more natural channel design and increase capacity of the channel. A bench cut is a new reach of floodplain excavated within the incised channel (Doll et al 2003, Rosgen 1997, Rosgen 1998). Bench cuts directly increase the amount of floodplain habitat in the watershed. These cuts would only be feasible in addition to grade control to address stability. Appendix C includes typical plans for bench cuts.

Measure 3. Meander restoration.

Meander restoration is often used to restore channelized streams. Meander restoration increases the length of rivers and adds aquatic habitat. This type of restoration requires a lot of land and is difficult in incised streams because the water surface elevation is far below the remnant meanders. Meander restoration in this area would only be possible in addition to grade stabilization.

Measure 4. Habitat Improvement Structures

Habitat structures can recreate habitat complexity that has been lost.

Measure 5. Convert access roads and staging areas to trails and trailheads post-construction.

Screening of Measures

Measures were screened based on: probability of providing benefits, technical implementability, contribution toward the objective, cost and land requirements, and avoidance of constraints.

Screening indicated measure 3 could contribute to the objective if feasible. Since most of the Cypress Creek watershed is deeply incised meander restoration would require a lot of land; costs would be high; technical issues would be likely; and TVA towers and other infrastructure (constraints) limit locations. Options for meander restoration were examined but the two alternatives that included it were dropped after further analysis found no area where meander restoration was likely feasible.

Screening indicated measure 4 was not likely to significantly contribute to achieving objectives. These types of structures are generally designed to benefit larger fish than what are likely to occur in

Cypress Creek. Fish habitat structures are appropriate to restore lost habitat in stable streams, but they are not appropriate in unstable systems with highly erodible soils.

Formulation Strategy

There were two formulation strategies identified for the project. The first was to only consider grade control weirs. This alternative would minimize real estate requirements and overall project footprint while delivering the most essential benefits. The river is stable with adequate habitat near US Highway 64. All alternatives will connect the restored habitat to the existing stable habitat.

The second strategy was to consider bench cuts associated with the weirs. This alternative would have a larger footprint and would require more real estate, but would add a second type of habitat restoration to the project. The channel is not stable enough to consider bench cuts without grade control.

Final Array of Alternative Plans

Alternative 1. No Action

USACE would not construct an ecosystem restoration project in the Cypress Creek watershed. Local entities would continue to make emergency repairs as needed. The WTRBA would implement proactive stabilization projects as budgets allow, approximately one every three years. The Nature Conservancy would continue to pursue an RCPP project with USDA.

Alternative 2. Grade Control Only

This alternative includes 12 grade control structures on the main stem of Cypress Creek and 8 structures on Cypress Creek tributaries (Figure 5). This alternative would restore instream habitat quality and allow for the stabilization of the bank and the return of native riparian vegetation.

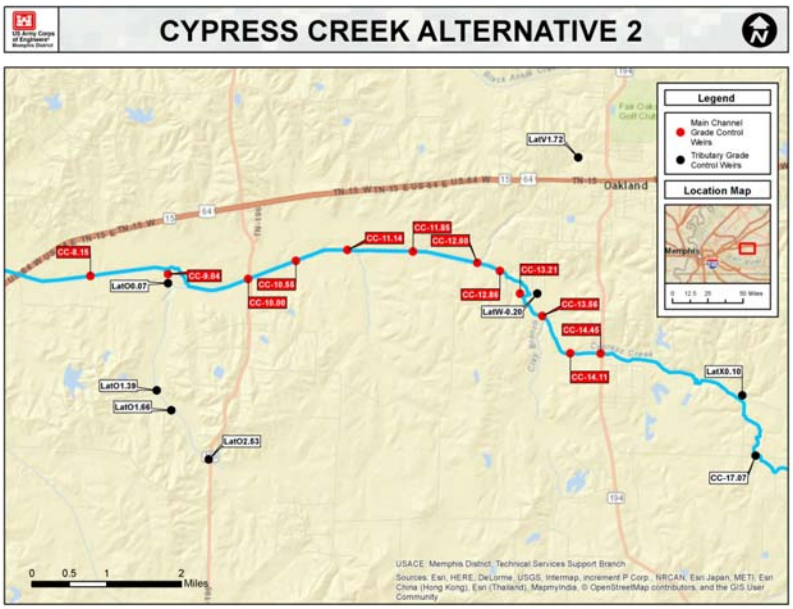

Figure 5. Alternative 2 Features

Hydraulic analysis showed that 12 structures on the main stem of Cypress Creek and 9 structures on tributaries would stabilize the entire system. One of these structures was found to provide no benefits and was dropped from consideration. Combinations of fewer weirs could provide benefits, however the ecosystem benefits of a smaller plan would not be sustainable because it would leave active headcuts and unstable channels above the restored reach and would eventually degrade the restored reach.

Alternative 3 Grade Control and Bench Cuts

This alternative includes 12 grade control structures on the main stem of Cypress Creek and 8 structures on Cypress Creek tributaries (the same proposed in Alternative 2) and 12 bench cuts totaling 19.7 acres. Each of the eleven bench cuts on the mainstem of Cypress Creek was estimated to be the same size (1.5 acres) and have the same cost and benefits. The bench cut on Oakland Branch was estimated to be more than twice as large as the rest (3.2 acres), twice the cost and more than twice the benefits. These combinations of bench cuts were compared using the Institute for Water Resources Cost Effectiveness Incremental Cost Analysis Model (CE/ICA). The analysis found three best buy plans – no action, Alternative 2 with no bench cuts, or Plan MM with all 12 bench cuts. Plan MM is Alternative 3.

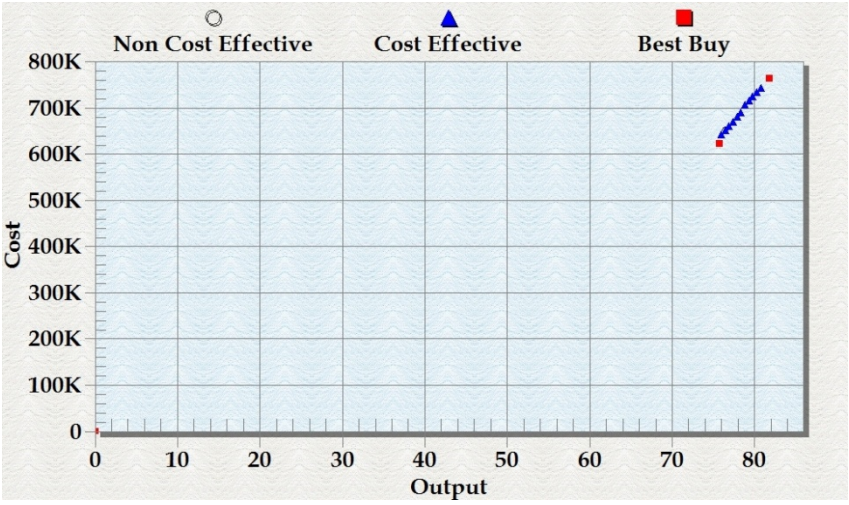

Figure 6. CE/ICA Results comparing average annual habitat units and average annual costs. (Average Annual costs were calculated based on a 3 year construction schedule and using the FY 2016 interest rate of 3.125%)

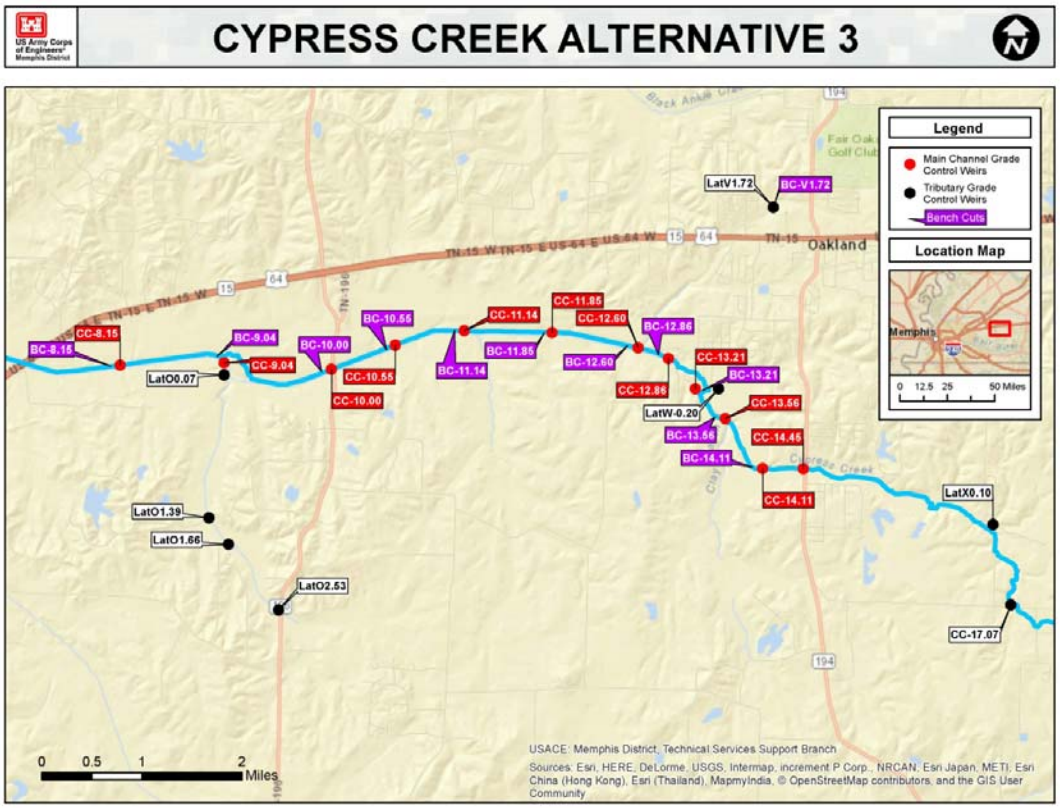

Figure 7 Map of weir and bench cut locations for Alternative 3

Alternatives Eliminated from Detailed Analysis

Alternative 4. Grade Control and Meander Restoration

This alternative would have considered adding meander restoration to grade control without bench cuts. Alternative 4 was dropped when initial analysis indicated meander restoration was not likely to be feasible.

Alternative 5. Grade Control, Bench Cuts and Meander Restoration

This alternative would have considered adding meander restoration to grade control and bench cuts. Alternative 5 was dropped when initial analysis indicated meander restoration was not likely to be feasible.

Alternative 6. Recreation Features Added to Another Alternative

This is not a standalone alternative. This alternative option would have considered adding a recreational trail to Alternative 2 or 3. The trail would only have been considered if the construction access necessary to implement the selected plan could be converted to a trail. Alternative 6 was dropped because the construction access for neither Alternative 2 nor Alternative 3 was conducive to trail conversion.

V. EVALUATE ALTERNATIVE PLANS

Alternative 1. The impacts of this alternative are described in the Future Without Project Conditions Section starting on page 15.

Alternative 2.

Fish and Wildlife

With this alternative, average stream velocity will improve as will the percentage of pools and stream slope. These factors will raise habitat suitability for the slough darter for a gain of 31.25 AAHUs. It would restore nearly 15 miles of stable stream bed and stream bank habitat and allow riparian vegetation to reestablish. The grade control weirs are designed to allow fish passage upstream.

Foraging habitat for great blue heron would improve, and the average habitat suitability would increase to 43.96 AAHUs.

This alternative would require clearing approximately 4 acres to allow construction access for each grade control structure, but the area would be replanted post-construction. Construction activities would also cause some temporary turbidity elevations, but turbidity would decrease to normal levels immediately upon completion. Haul routes for rock, equipment and other materials would be mostly on cleared land; but if clearing is necessary, all areas will be replanted. There are no known wetlands in the immediate construction area. If wetlands are found, they will be avoided.

Land Use and Infrastructure

Alternative 2 is not likely to change land use in the study area. Stabilizing Cypress Creek and its tributaries will benefit roads, bridges and utility lines in the area and decrease the risk of erosion induced failures. It will also reduce streambank failures and protect adjacent land.

Other Environmental Resources

Restoring pools and riffles, increasing stream velocity, and restoring the interrupted hydrologic system to a more perennial one will benefit water quality. It will address the issues driving the 303d listing for sedimentation and habitat alteration and may also help reduce *E. coli* and total phosphorus concentrations.

Socio Economic Considerations

Alternative 2 would have no effect on populations or demographics in the area. Noise would increase during construction, but only locally. The noise would be similar to that of ongoing home construction or road work and would have no adverse impact on residents.

Alternative 3. Grade Control and Bench Cuts

Fish and Wildlife

This alternative would produce the same benefits for slough darter described for Alternative 2.

The bench cuts would create 19.7 acres of bottomland hardwood habitat in the area and improve nesting habitat for great blue heron. It would add 6.31 heron AAHUs to those provided in Alternative 2, for a total of 50.27 AAHUs.

This alternative would require clearing approximately 4 acres to allow construction access for each grade control structure, but the area would be replanted post-construction. Each main stem bench cut would require clearing 3 acres to allow for construction access and the 1.5 acres for the bench cut. The bench cut on Oakland Branch is larger and would require clearing approximately 5 acres. The bench cuts would be replanted with bottomland hardwoods. Construction activities would also cause some temporary turbidity elevations, but turbidity would decrease to normal levels immediately upon completion. Haul routes for rock, equipment and other materials would be mostly on cleared land, but if clearing is necessary, all areas will be replanted. There are no known wetlands in the immediate construction area. If wetlands are found, they will be avoided.

Land Use and Infrastructure

Alternative 3 is not likely to change land use in the study area. Stabilizing Cypress Creek and its tributaries will benefit roads, bridges and utility lines in the area and decrease the risk of erosion induced failures. It will also reduce streambank failures and protect adjacent land.

Other Environmental Resources

Restoring pools and riffles, increasing stream velocity, and restoring the interrupted hydrologic system to a more perennial one will benefit water quality. It will address the issues driving the 303d listing for sedimentation and habitat alteration and may also help reduce *E. coli* and total phosphorus concentrations. Creation of 19.7 acres of floodplain habitat would also attenuate some of the phosphorus and *E.coli*.

Socio Economic Considerations

Alternative 3 would have no effect on populations or demographics in the area. Noise would increase during construction, but only locally. The noise would be similar to that of ongoing home construction or road work and would have no adverse impact on residents.

VII. COMPARE ALTERNATIVE PLANS

Several different sets of criteria were used to compare the alternative plans. The first presented here is from Engineer Regulation (ER) 1105-2-100 Appendix C on Ecosystem Restoration Significance. The second is from the 1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). The third is the output from the Institute of Water Resources Cost Effectiveness Incremental Cost Analysis Model (CE/ICA). Fourth is the system of accounts also from the P&G. The last table compares other pertinent information for the alternatives.

SIGNIFICANCE OF THE ALTERNATIVES – ER 1105-2-100

USACE Ecosystem Restoration policy acknowledges the challenge of dealing with non-monetized benefits and uses qualitative statements of significance to help decision-makers evaluate whether the value of the resources are worth the costs. "The significance of restoration outputs should be recognized in terms of institutional, public, and/or technical importance. This basically means that someone, some entity, some law/policy/regulation, or scientific evidence indicates that a particular resource is important."

Technical Importance

Ecosystem structures and functions in Cypress Creek and the entire surrounding region are severely degraded. Restoration of Cypress Creek would improve these functions locally and lead to more projects in the area to improve them regionally.

Scarcity: Bottomland hardwood habitat once covered as much as 24.7 million acres throughout the Mississippi Alluvial Valley. This area has experienced an 80% decline over the last 200 years with the most rapid changes occurring within the last 70 years. Channelization has played a major role in this degradation and the entire length of Cypress Creek and its tributaries have been channelized. Bottomland hardwoods provide habitat for amphibians, reptiles, mammals, and birds. Numerous scientific studies have documented population declines to all of these resources as a result of habitat loss (Benz and Collins, 1997). Figure 8 shows that this habitat has been lost in the Loosahatchie Watershed and is particularly critical in the Cypress Creek drainage. Alternative 1 would have no effect. Alternative 2 would stabilize the banks and protect existing riparian vegetation. In addition to the benefits Alternative 2 would provide, Alternative 3 would restore 19.7 acres of bottomland hardwoods.

Status and Trends: Aquatic habitat in Cypress Creek and the region will continue to degrade unless restoration projects are implemented. Channelized streams are shorter than meandering streams. The streams must constantly adjust to the valley slope. As the stream slope flattens, the channel deepens, the side slopes lose support and collapse. This will continue unless a nearly stable slope is attained or a more stable soil layer is exposed in the stream bed. Soils in the area are too erodible to allow streams to reestablish equilibrium and begin to recover on their own. Riparian vegetation cannot reestablish unless the stream bank reaches equilibrium. Alternative 1 would have no effect. Alternatives 2 and 3 would restore some of the hydrologic and geomorphic conditions in Cypress Creek and stabilize the banks.

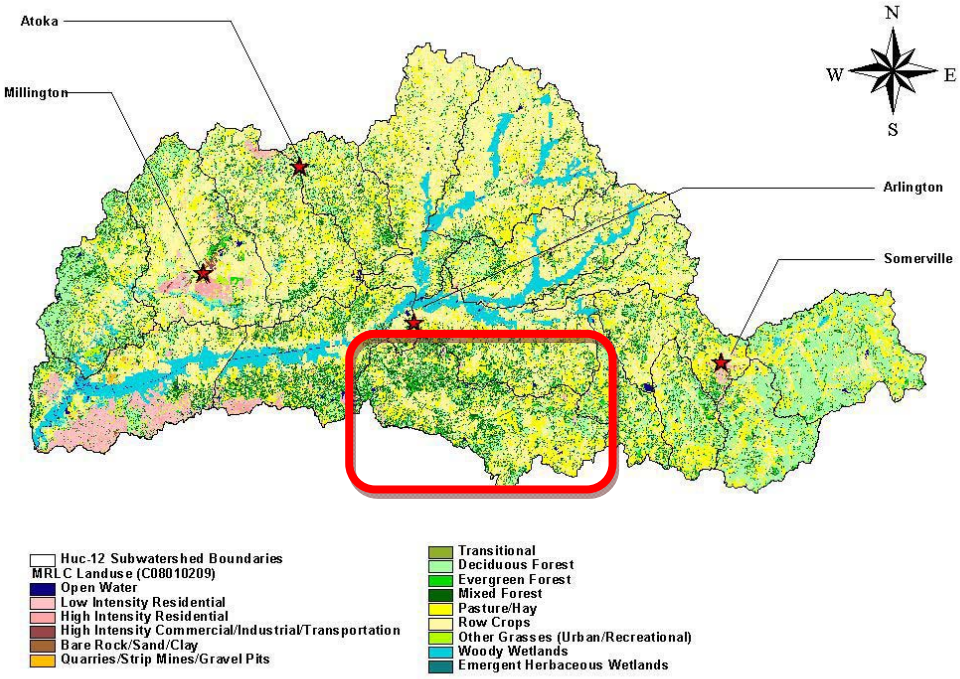

Figure 8. Map of land cover in the Loosahatchie Watershed.

Connectivity: The project has the potential to restore connectivity within Cypress Creek and its floodplain. Restoring connectivity would provide numerous ecological benefits and interactions between the creek and its floodplain. This restored connection would provide valuable habitat for fish, amphibians, reptiles, mammals, and birds. Likewise, establishment of riparian vegetation would provide a connection between isolated patches of forested areas that occur within the floodplain.

The Loosahatchie River flows downstream to Meeman-Shelby Forest State Park and Wildlife Management Area, a 13,467 acre park with a bottomland hardwood forest of large oak, cypress, and tupelo. Deer and turkey are abundant, and there are 200 species of birds known to use the area. An ecosystem restoration project on Cypress Creek would likely lead to other similar projects in the Loosahatchie River Watershed. Eventually these projects would recreate a larger functional ecosystem and reconnect downstream areas to the restored upstream reaches. Alternative 1 would have no effect. Alternative 2 would restore connected aquatic habitat, stabilize the banks and protect existing riparian vegetation. Alternative 3 would restore aquatic habitat, stabilize the banks, protect existing riparian vegetation, and restore 19.7 acres of bottomland hardwoods

Biodiversity: Aquatic habitats in western Tennessee provide for a wide range of species. More than 100 species of fish, 35 mussels and 250 species of birds are known to occur in the region. The State of Tennessee lists 18 rare species that are known to occur in Fayette County including fish, mammals, reptiles, amphibians, birds, mollusks and plants. Fifteen of the 18 listed species are dependent on aquatic, wetland, floodplain and/or riparian habitat.

There are no federally listed species that are known to occur within the project area, but there is potential for endangered Indiana bat (*Myotis soldalis*) and threatened northern long-eared bat (*Myotis*

septentrionalis). No direct impacts or benefits to any Federally listed species are anticipated, but restoration of riparian hardwoods could benefit bats in the long term. The naked sand darter (*Ammocrypta beani),* a state-listed fish species, occurs in the drainages north and south of the Loosahatchie, so there is potential for it in the Loosahatchie. Alternative 1 would have no effect. Alternative 2 would stabilize the banks and protect existing riparian vegetation. In addition to the benefits Alternative 2 would provide, Alternative 3 would restore 19.7 acres of bottomland hardwoods which could provide a greater long-term benefit for bats.

Institutional Importance

Restoration of Cypress Creek could further the goals set forth in several federal and state laws, and agency policies. Notable among these are:

Clean Water Act – Cypress Creek is listed on the 303d list of impaired waters for habitat alteration, sedimentation, total phosphorus and *E. coli*. Alternative 1 would have no effect. Alternative 2 would improve hydrologic and geomorphic conditions to address sedimentation and habitat alteration and may reduce total phosphorus and E. coli concentrations. Alternative 3 would address all of those factors and recreate some floodplain which would allow attenuation of phosphorous.

EO 11988 – Floodplain Management – This EO states: "Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." Alternatives 1 and 2 would provide no change in floodplains. Alternative 3 would recreate 19.7 acres of floodplain.

TN Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974 - It is the policy of this state to manage certain nongame wildlife to insure their perpetuation as members of ecosystems, for scientific purposes, and for human enjoyment. Species or subspecies of wildlife indigenous to this state which may be found to be endangered or threatened within the state should be accorded protection in order to maintain and, to the extent possible, enhance populations. Both Alternatives 2 and 3 would improve habitat for the naked sand darter.

Public Importance

The public in and around Cypress Creek recognize the importance of ecosystem restoration.

The NFS which is the State of TN, through the WTRBA, in cooperation with The Nature Conservancy, support the TSP; but both prefer Alternative 3 over Alternative 2

The USFWS led Partners in Flight Program identified bottomland hardwood forests throughout the southeast as a habitat of regional concern for breeding birds because this habitat is significantly reduced from historic levels and is highly fragmented. Alternative 2 would not improve conditions for breeding birds, but Alternative 3 would restore 19.7 acres of bottomland hardwood habitat.

The Southeast Aquatic Resources Partnership was established to protect, conserve, and restore aquatic resources (including habitats) throughout the Southeast, for the continuing benefit, use, and enjoyment of the American people. Both Alternatives 2 and 3 would improve habitat for aquatic resources.

Table 1. Comparison of Significance of Alternatives.

Significance Criteria	Alternative 1, No Action	Alternative 2	Alternative 3, MM
Technical			
Scarcity	**0**	**+**	**++**
Status and Trends	**0**	**+**	**+**
Connectivity	**0**	**++**	**++**
Biodiversity	**0**	**+**	**++**
Institutional			
Clean Water Act	**0**	**+**	**++**
EO 11988	**0**	**0**	**++**
TN Non Game	**0**	**++**	**++**
Public			
Agency support	**0**	**+**	**++**
Partners in Flight	**0**	**0**	**++**
SARP	**0**	**++**	**++**

0=no change
-= negative impact
+= generally positive impact
++= specifically positive impact

P & G CRITERIA

Table 2. Comparison of Alternatives using the P&G Criteria

	Alternative 1, No Action	Alternative 2	Alternative 3, MM
Completeness	This alternative provides no benefits.	This alternative is complete. All benefits can be achieved without further actions. The proposed RCPP would provide additional benefits that accumulate with the benefits of this alternative.	This alternative is complete. All benefits can be achieved without further actions. The proposed RCPP would provide additional benefits that accumulate with the benefits of this alternative.
Effectiveness	This alternative will not alleviate any problems or achieve any opportunities.	This alternative addresses some of the problems in the project area, e.g. aquatic habitat and connectivity, fish passage barriers and mussel habitat.	This alternative addresses problems in the project area, e.g. aquatic habitat and connectivity, fish passage barriers, mussel habitat, floodplain habitat, riparian habitat and bottomland hardwood habitat.
Efficiency	Although this alternative has no cost, habitat conditions will decline. It is not efficient.	This plan is the most efficient	This plan is efficient, but less efficient than Alternative 2.
Acceptability	There are no obstacles to implementing this plan, but it provides no solution to the identified problems.	This alternative is implementable and will address some of the identified problems.	This alternative is implementable and will provide more resolution of the identified problems.

CE/ICA RESULTS

The CE/ICA model compared results for Alternatives 2 and 3. Alternative 2 is more efficient and produces more habitat units per dollar than Alternative 3.

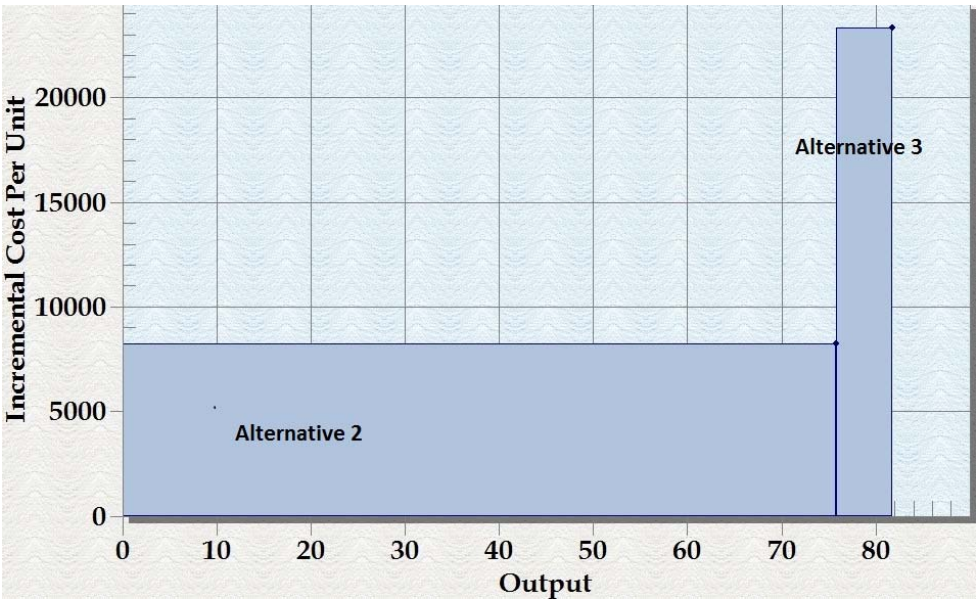

Figure 9. Comparison of alternatives using average annual cost and average annual habitat units.

Table 3. Comparison of Alternatives using CE/ICA

Alternative	First Cost	Annual Cost	AAHUs	Annual Cost per Habitat Unit	Cost Effective	Features*
U	14,224,620	593,086	75.78	7,826	Best Buy	Weirs Only
BB	14,432,904	611,317	75.95	8,049	Yes	Weirs + 1BC
CC	14,641,188	620,139	76.43	8,114	No	Weirs + 2BC
DD	14,849,472	628,962	76.91	8,178	Yes	Weirs + 3BC
EE	15,057,756	637,784	77.39	8,241	Yes	Weirs + 4BC
FF	15,266,040	646,606	77.87	8,304	Yes	Weirs + 5BC
GG	15,474,324	655,428	78.35	8,365	Yes	Weirs + 6BC
HH	15,682,608	671,165	78.83	8,514	Yes	Weirs + 7BC
II	15,890,892	680,079	79.31	8,575	Yes	Weirs + 8BC
JJ	16,099,176	688,993	79.79	8,635	Yes	Weirs + 9BC
KK	16,307,460	697,907	80.27	8,694	Yes	Weirs + 10BC
LL	16,515,744	706,821	80.75	8,753	Yes	Weirs + 11BC
MM	16,932,312	724,649	81.78	8,861	Best Buy	Weirs + 12BC*
NN	14,641,188	620,139	76.51	8,105	Yes	Weirs + 1BC*

*BC = Bench Cut; Alternatives MM and NN include the one larger Bench Cut on Oakland Branch, all other bench cuts are the same size and cost.

SYSTEM OF ACCOUNTS

The National Economic Development (NED) account displays changes in the economic value of national output of goods and services. The Environmental Quality (EQ) account displays nonmonetary effects on significant natural and cultural resources. The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity. The Other Social Effects (OSE) account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

Table 4. System of Accounts Comparison

Account	Alternative 1, No Action	Alternative 2	Alternative 3, MM
NED	Traffic disruptions from bridge and culvert failures would occur intermittently and would have some minor impacts on the local economy, but they are not forecastable. The most recent emergency repair was $75,000. Replacement costs range from $250,000 for box culverts to $1 million for bridges.	This alternative would provide some ancillary benefits for roads and infrastructure. These ancillary benefits would reduce traffic disruptions and may provide some minor economic benefit. There are 5 bridges and numerous culverts in the study area.	This alternative would provide some ancillary benefits for roads and infrastructure. These ancillary benefits would reduce traffic disruptions and may provide some minor economic benefit. There are 5 bridges and numerous culverts in the study area.
EQ	This alternative would not alleviate any problems or achieve any opportunities.	This alternative would restore 15 miles of aquatic habitat on Cypress Creek and benefit a variety of aquatic species.	This alternative would restore 15 miles of aquatic habitat and 19.7 acres of floodplain habitat and benefit a variety of aquatic species.
RED	No impact.	There would be some temporary RED benefits from the ($14 mil) construction activity. The rock (approx. $8 mil) for the structures will be sourced from Missouri or Alabama, but the wages, fuel purchases, equipment rental and other incidentals would likely be purchased locally.	There would be some temporary RED benefits from the ($17 mil) construction activity. The rock (approx. $8 mil) for the structures would be sourced from Missouri or Alabama; but the wages, fuel purchases, equipment rental and other incidentals would likely be purchased locally. This alternative is slightly larger, and most of the $3 mil difference would be expended locally.
OSE	There would be no improvement in the appearance of Cypress Creek. There would be no construction noise. There would be no disruption of community activities, travel or cohesion.	Some of the structures may be visible from roadways. The amount of raw eroding banks would be reduced. The health of the riparian zone would improve. Overall aesthetics would improve. There would be some construction noise, but it would be temporary and only during daylight hours. There would be no disruption of community activities, travel or cohesion.	Some of the structures may be visible from roadways. The amount of raw eroding banks would be reduced. The health of the riparian zone would improve. Overall aesthetics would improve. There would be some construction noise, but it would be temporary and only during daylight hours. There would be no disruption of community activities, travel or cohesion.

OTHER PLAN INFORMATION

Table 5. Other Plan Information Comparison

Account	Alternative 1, No Action	Alternative 2	Alternative 3, MM
First Cost of Construction*	0	$14,224,620	$16,932,313
Average Annual Cost**	0	$593,086	$724,649
Average Annual Habitat Units	0	75.48	81.78
Average Annual Cost per AAHU	NA	$7,826	$8,861
Acres of Habitat Improved	0	90	109.7
Cost per Acre	NA	$158,051	$154,351

*Costs are in 2016 dollars and do not include study costs.

**Average Annual costs were calculated based on a 3 year construction schedule and using the FY 2016 interest rate of 3.125%

VI. RECOMMENDED PLAN

Alternative 2 is a Best Buy and is the most efficient alternative. It is the National Ecosystem Restoration (NER) plan and the Tentatively Selected Plan (TSP).

The TSP includes 12 low drop grade control weirs on the main stem of Cypress Creek between U.S. Highway 64 and State Highway 194. The amount of drop through the structures ranges from 3.0 to 5.0 ft. The average spacing between the lower seven structures is 3,900 ft; while between the upper five structures it is 2,000 ft. Eight additional grade control weirs would be built on tributaries. The weirs would require 114,000 tons of riprap and bedding stone. The estimated cost of construction is $14.2 million. Appendix C includes drawings and details for the structures. Appendix D includes a detailed cost estimate.

National Significance of the Project

Restoration of Cypress Creek is part of a larger conceptual plan to restore habitat in several large tributaries of the Mississippi River. Channelization was a common practice throughout the Lower Mississippi River Valley; and only one Mississippi River tributary, the Hatchie River, was not channelized. Channelization has been identified as a leading cause of loss of biodiversity in aquatic systems. This project would improve the hydrologic function and geomorphic character of Cypress Creek and would likely contribute to preservation and restoration of biodiversity in the watershed. Bottomland hardwoods are a nationally significant habitat type, and over 80% of the historic bottomland hardwood forest has been lost in the Mississippi River Alluvial Valley. This project would stabilize the streambanks and protect the remaining bottomland hardwoods on Cypress Creek. It would also prevent further problems in the area, and protect remaining isolated wetlands in the upstream areas of the watershed. Cypress Creek does have elevated nutrient concentrations and the project would improve these conditions. Elevated nutrient levels in the Mississippi River watershed contribute to the hypoxic zone in the Gulf of Mexico.

Implementation Plan

Real Estate

Cypress Creek flows through residential, agricultural and wooded lands. The weirs will be constructed within the banks of the Creek. For purposes of this study, it is assumed that the waterbottoms are privately owned and that real estate interests will need to be acquired. Therefore, it is estimated that 20 landowners will be impacted by acquisition of real estate for the weirs. The fee excluding minerals estate will be acquired for the construction of the weirs. The plan at this time does not identify construction areas, disposal areas, staging areas or access over private lands, but does estimate the cost. These areas will be identified in the final feasibility report. The non-Federal Sponsor, the State of Tennessee West Tennessee River Basin Authority has responsibility to acquire all lands, easements and rights of ways necessary for the project. Appendix E contains a full description of real estate issues in the Real Estate Plan.

Weir Design

Weir designs are based on the Vicksburg District USACE Process for the Design of Low Drop Grade Control Structures (08816 MVK). Below are typical drawings for grade control weirs.

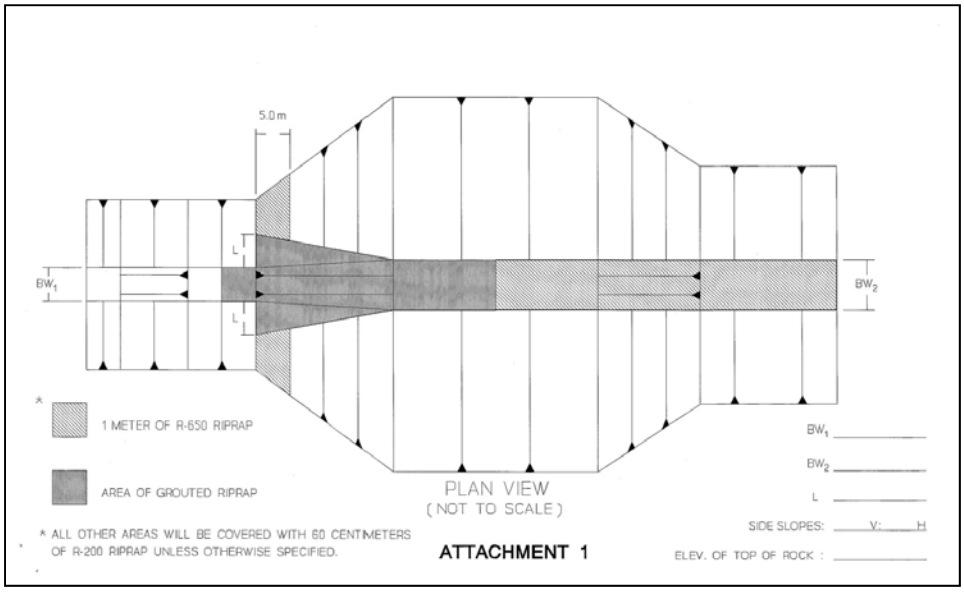

Figure 10. Typical Design of a Grade Control Weir (This typical is shown in metric units, however the actual designs will use English units per current guidance.)

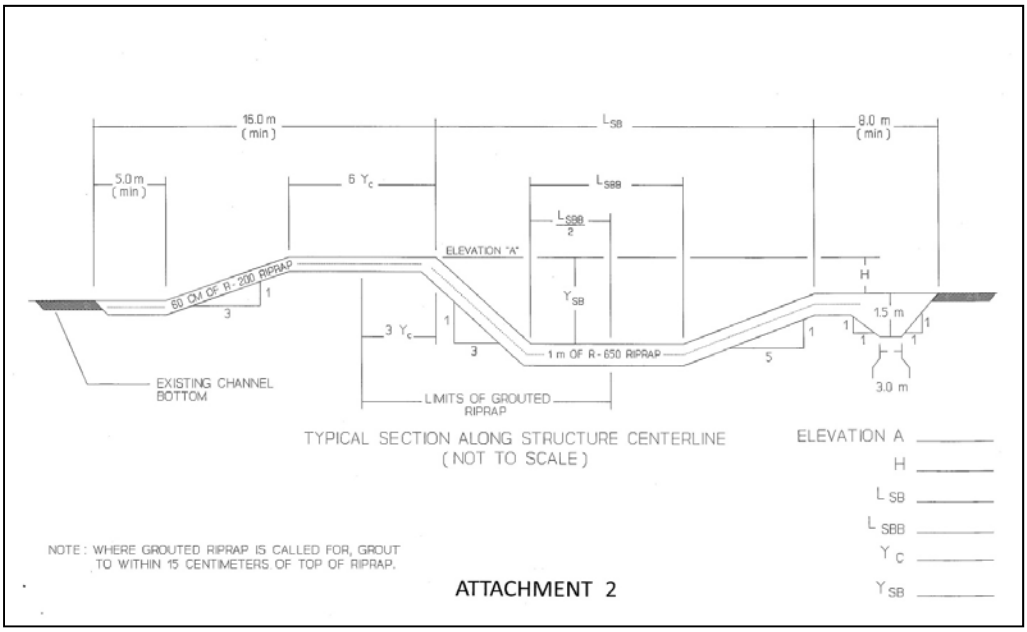

Figure 11. Typical Design of Grade Control Weir (This typical is shown in metric units; however the actual designs will use English units per current guidance.)

Construction Method

The weirs and bench cuts will be built using track hoes and draglines from the streambanks. Construction for the larger weirs will require access from both banks, but the smaller weirs and bench cuts can be constructed from one side. More detail regarding access and construction methods will be developed during the preparation of plans and specifications for the project.

Funding And Construction Schedule

A detailed funding and construction schedule cannot be developed until Congress provides construction authority and appropriations for the project. Below is a generic schedule which will be further refined after detailed plans and specifications are developed.

- Receive Congressional Authority and Appropriation
- Negotiate the Project Partnership Agreement – Duration 180 days
- Prepare for Surveying and initiate field work – Duration 45 days
- Develop Plans and Specs – Duration 180 days
- Perform Biddability/Constructability/Environmental Review (BCOE) – Duration 30 days
- Contracting Prepares for Advertisement – Duration 30 days
- Contract Advertised - Duration 30 days
- Process Award – Duration 15 days
- Preconstruction submittals – Duration 30 days
- Construction begins when conditions allow
- Construction will take two to three years depending on funding

Operations, Maintenance, Repair, Rehabilitation, And Replacement

The project has no operational features and is likely to require only minor maintenance for the first few years. As the weirs settle after construction, some rock might need to be replaced to maintain structure height.

Monitoring and Adaptive Management

The specific target of the project is:

> Re-establish a stable streambed, streambanks, and riparian vegetation along 15 miles of Cypress Creek and its tributaries.

The grade control weirs will be monitored to ensure they are stable. Trees will be planted around weirs. USACE and the Sponsor will monitor these plantings and ensure 80% survival.

Previous research on these types of structures has proven their effectiveness in improving biodiversity and ecological conditions. Biological monitoring for this project will confirm that this project has similar outcomes. An Index of Biotic Integrity (IBI), fish sampling, and vegetation inventories consistent with the inventories included in Appendix B will be done immediately post-construction and 2, 4 and 6 years after that. The results will be compared to pre-project inventories to assess the biological response to the project. Monitoring may be extended for 4 more years if the results are inconclusive or further action is necessary to achieve benefits. A more specific monitoring plan will be developed concurrent with the Operations and Maintenance Plan.

The TSP does not include any operational features, and there are no obvious adaptive management measures identified at this time. If monitoring shows the biological/ecological response is not what was anticipated, specific adaptive management may be identified at that time.

Cost-Sharing Requirements

The feasibility study is cost shared 50/50. Construction cost-sharing will be 65/35. In accordance with the terms of the PPA, the non-Federal sponsor must provide all lands, easements, rights-of-way, and dredged material disposal areas (LERRDs) required for the project. OMRR&R is a 100% non-Federal responsibility. See Table 6 below.

Table 6 Cost Apportionment For the TSP escalated to 2020 (estimated first year of construction)

Accounts	Description	Contingency	Total		
01 Real Estate	Lands and Damages	10%	$1,513,620		
06 Fish and Wildlife	Weirs	25%	$10,787,000		
30 PED	Feasibility Study		$450,000		
	E&D for Fish and Wildlife	25%	$1,618,000		
31 Construction Management		25%	$1,618,000		
Monitoring Costs			$15,000		
Total First Cost of Construction	Does not include study cost		**$15,551,620**		
Annual OMRR&R Cost	All non-federal		$2,000		
Total Cost-Shared Cost	Includes Study		$16,001,620		
Federal Share			$10,333,553		
Sponsor Share			$5,668,067		
			Federal Cost	**Non-Federal Cost**	**Total**
LEERDS				$1,513,620	
In kind Work	Study and Monitoring			$240,000	
Cash				$3,914,447	
Total			$10,333,533	$5,668.067	$16,001,620

Risk and Uncertainty

Risk and uncertainty for the project are both low. The techniques and measures proposed for Cypress Creek are standard practices that have been implemented throughout the region. If a structure fails some ecosystem benefits could be lost. Structures would not impact flood stages or durations. They will generally be located downstream of bridges so they will not impact bridges even if they fail.

Environmental Disclosures

Floodplain Management

Executive Order 11988, Floodplain Management (signed 24 May 1977), requires Federal agencies to recognize the significant values of floodplains and to consider the public benefits that would be realized from restoring and preserving floodplains. The Executive Order has an objective of the avoidance, to the extent possible, of long and short-term adverse impacts associated with the occupancy and modification of the base floodplain and the avoidance of direct and indirect support of development in the base floodplain wherever there is a practical alternative. Under this Order, the Corps of Engineers is required to provide leadership and take action to:

a. Avoid development in the base floodplain unless it is the only practical alternative;
b. Reduce the hazard and risk associated with floods;
c. Minimize the impact of floods on human safety, health, and welfare; and
d. Restore and preserve the natural and beneficial values of the base floodplain.

The TSP will not cause development in the floodplain or increase flood hazards or impacts.

Hazardous, Toxic, And Radioactive Waste (HTRW)

A record search has been conducted of the EPA's EnviroMapper Web Page (http://maps.epa.gov). The EPA search engine was checked for any superfund sites, toxic releases, or hazardous waste sites within the vicinity of the proposed project. Site inspection of the proposed project area was conducted in June 2015. The records search and site surveys did not identify the presence of any hazardous or suspected hazardous wastes in the project area. As a result of these assessments, it was concluded that the probability of encountering HTRW is low. If any HTRW is encountered during construction activities, the proper handling and disposal of these materials would be coordinated with the Tennessee Department of Environment and Conservation (TDEC).

Environmental Justice

According to 2014 U.S. Census Bureau estimates, 30% of the residents of Fayette County are minorities. The percentage of people living below the poverty level from 2009 to 2013 was 14%. The TSP would have no impact on minorities or low income communities.

State and Federal Holdings

There are no State or Federal holdings within the project area.

Wetlands

There are no wetlands within the project area, but upstream, isolated wetlands may benefit.

Endangered Species

The U.S. Fish and Wildlife Service has stated the area lies within the potential range for Indiana and northern long-eared bats. Surveys may be required prior to construction. USACE will continue to coordinate with USFWS to ensure the project does not impact listed bats. Long-term, the project will restore and protect bottomland hardwood habitat and may benefit bats.

Cultural Resources

Archaeological surveys on other projects in the watershed have found no significant sites. The construction sites would be surveyed for cultural resources prior to construction and any significant sites found will be avoided or mitigated. Coordination with the State Historic Preservation Officer is ongoing.

Prime & Unique Farmlands

Most of the project area is prime farmland. Project construction would cause some impacts to prime farmland, but stabilizing Cypress Creek would also prevent bank caving and loss of prime farmland. An NRCS rating will be completed after the detailed plans are completed.

Air Quality

Air quality in Fayette County is considered to be 'in attainment' by the TDEC Division of Air Pollution Control. With implementation of the proposed action, the project-related equipment would produce small amounts of engine exhaust during construction activities. The temporary, minor impacts to air quality would be localized to the project area and would not affect area residents. The project area would still be in attainment for all air quality standards. The project would not impact Tennessee's State Implementation Plan.

Water Quality

Cypress Creek is on the state 303(d) list for impaired waters. It is listed for total phosphorus, *E. coli*, habitat alteration, and sedimentation. This project would restore some habitat and reduce sedimentation which also contributes to elevated phosphorus. The project would have no direct effect on phosphorous or *E. coli*, but reestablishing more perennial flow to areas with interrupted flow may provide some benefits. A 404(b)1 evaluation is in Appendix F. The project would need an Aquatic Resources Alteration Permit from the TDEC prior to construction. The application for this project would be submitted after the feasibility level designs of the final selected alternative are complete.

Noise

Road and home construction in the area is common, so the temporary noise increase during project construction would not be unusual.

Mitigation

USACE policy in ER 1105-2-100 states, "Ecosystem restoration projects should be designed to avoid the need for fish and wildlife mitigation." This project was designed accordingly. The project would not impact wetlands. Some trees would be cleared for construction access, but these would be small isolated patches that currently have no habitat value and include invasive privet. All areas would be replanted with native bottomland hardwood species. No mitigation would be required.

Relationship of Plan to Environmental Laws and Regulations

The relationships of the recommended plan to the requirements of environmental laws, executive orders, and other policies are presented below:

Federal Policies and Acts	Compliance Status
Archeological Resources Protection Act of 1979	2
Bald Eagle Act	1
Clean Air Act Amendments of 1977	1
Clean Water Act of 1977, as amended	2
Endangered Species Act of 1973, as amended	2
Farmland Protection Policy Act of 1984	2
Fish and Wildlife Coordination Act of 1958	1
Flood Control Act of 1946, as amended	1
Food Security Act of 1985	1
National Environmental Policy Act of 1969	2
National Historic Preservation Act of 1966, as amended	2
River and Harbor and Flood Control Act of 1970	1
Water Resources Development Act of 1986	1
Water Resources Planning Act of 1965	1
Executive Orders	
Floodplain Management (E.O. 11988)	1
Protection, Enhancement of the Cultural Environment (E.O. 11593)	2
Protection of Wetlands (E.O. 11990)	1
Other Federal Policies	
Prime and Unique Farmlands	2
Water Resources Council, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies	1

1/ Full compliance with the policy and related regulations has been accomplished.
2/ Partial compliance with the policy and related regulations has been accomplished. Coordination is ongoing.

Coordination

U.S. Environmental Protection Agency	27 Oct 2014
U.S. Fish and Wildlife Service	4 Nov 2014
TN Wildlife Resources Agency	23 Oct 2014

Cumulative Effects

Channelization was common throughout the southeast and all of the tributary streams in the Loosahatchie drainage were altered. The Cypress Creek Ecosystem Restoration project proposes techniques that can be applied in other areas with only minor modification. The proposed project is likely to lead to other similar projects in the Loosahatchie and other adjacent drainages. The proposed RCPP project is also more likely to be implemented if the Cypress Creek Restoration Project is approved.

Instability in Cypress Creek has caused bank failures, bridge failures and culvert collapses. This project was not formulated to directly address these issues, but the project would benefit roads and other infrastructure and could lead to fewer emergency repairs.

Overall, this project combined with past projects and reasonably foreseeable future projects is likely to have positive impacts on environmental quality, connectivity, sustainability, and resilience. It would also have positive impacts on other aspects of the human environment.

Conclusion

This office has assessed the environmental impacts of the proposed action and has determined that the tentatively selected plan is expected to benefit aquatic species. It would have no significant negative impacts upon vegetation, fish, wildlife, cultural resources, or the human environment. Restoration of Cypress Creek would benefit the natural environment and would help protect infrastructure in the area.

Following public and technical review, more detailed construction plans will be developed and analyzed. All appropriate site specific surveys and coordination for water quality certification, cultural resources, HTRW, and federally listed species will be completed prior to construction.

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