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.

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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).

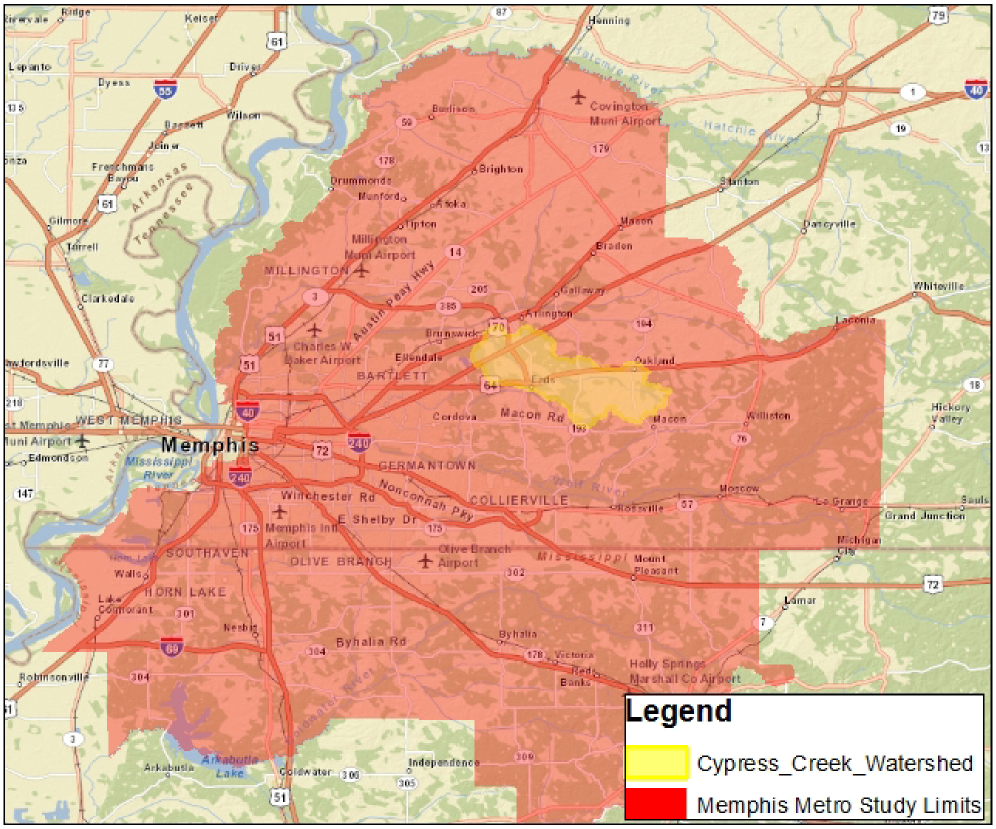

Figure 1. Vicinity Map, Cypress Creek, Tennessee

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.

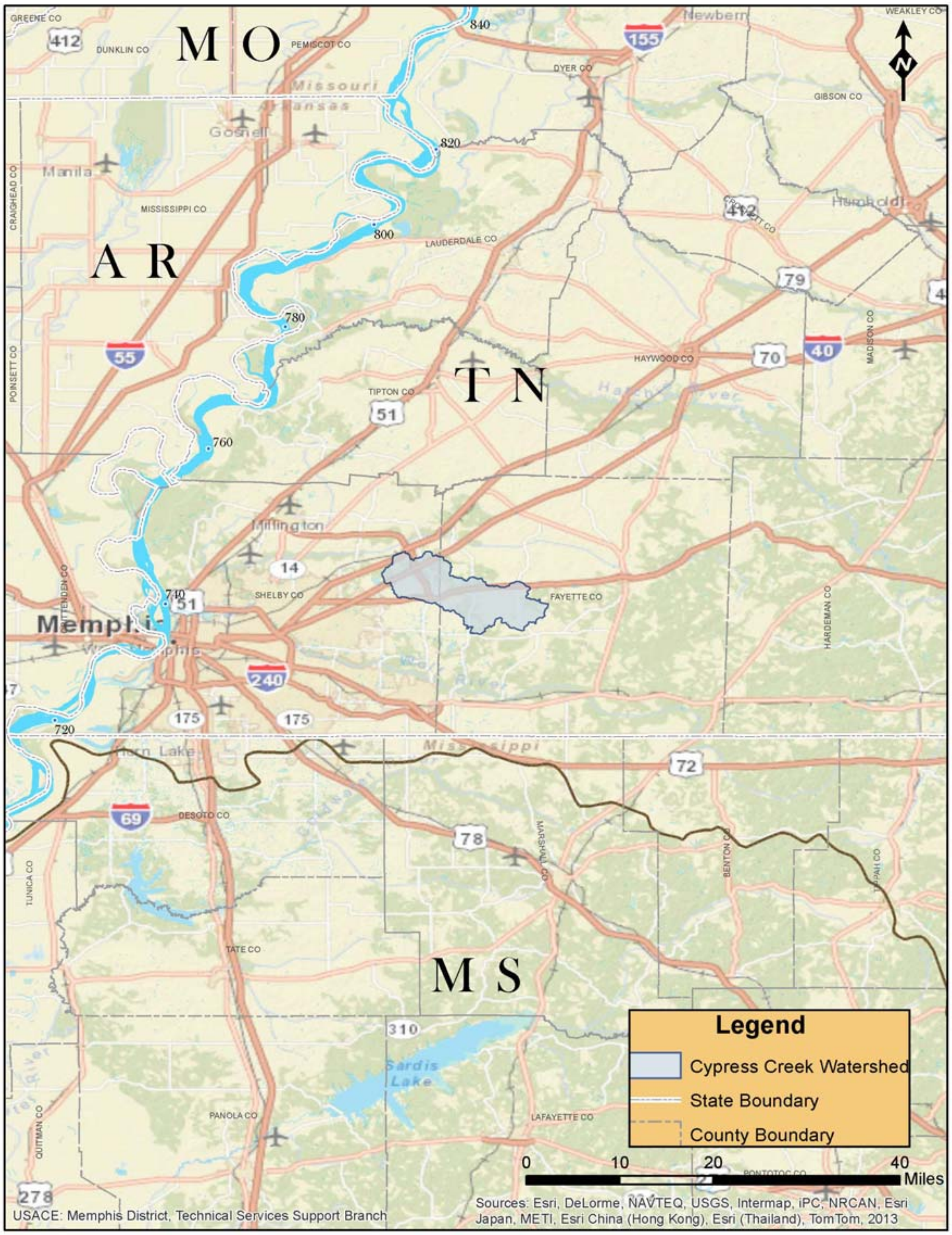

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Figure 2. Cypress Creek Watershed

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^{O}F to 86^{O}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.

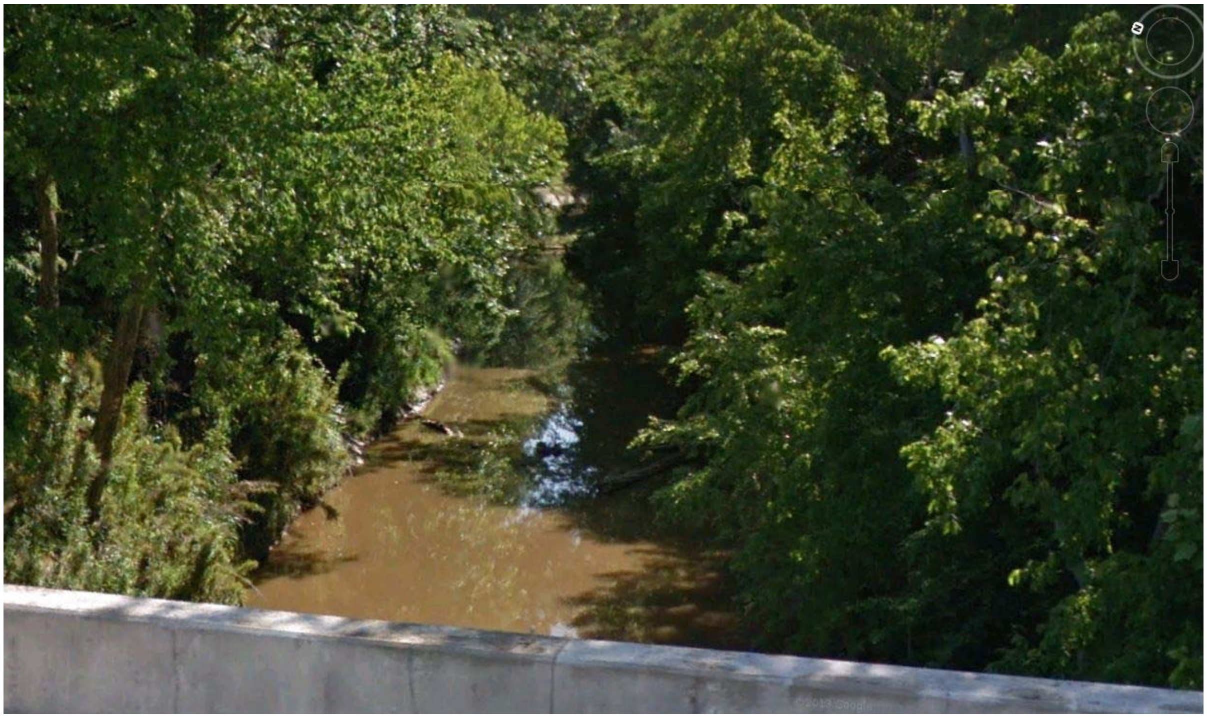

Figure 3. Cypress Creek upstream of HWY 196 Bridge. The bridge abutments have created a hardpoint and the habitat is in good condition in this reach

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.

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.

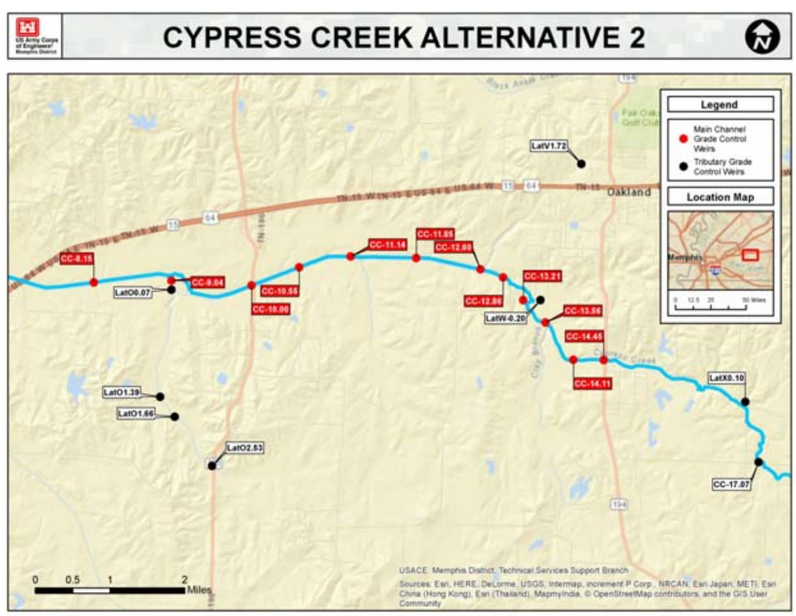

Figure 5. Alternative 2 Features

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.

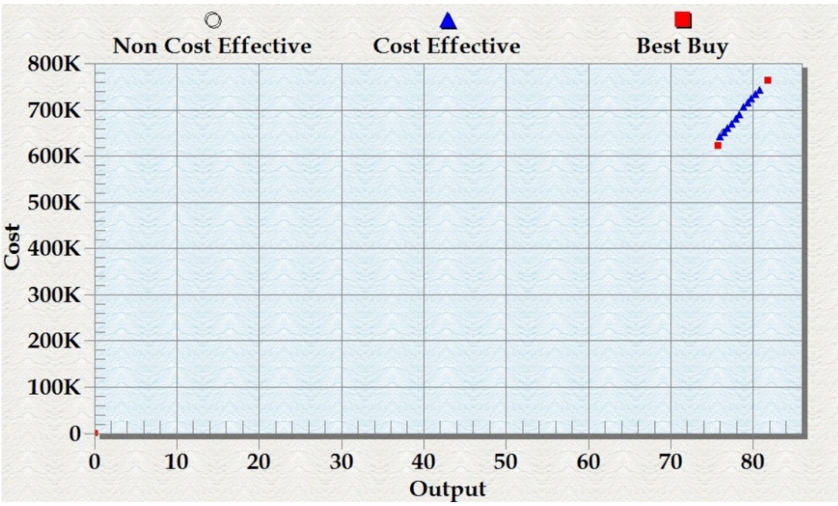

Figure 6. CE/ICA Results comparing average annual habitat units and average annual costs. (Average Annual costs were calculated based on a 3 year construction schedule and using the FY 2016 interest rate of 3.125%)

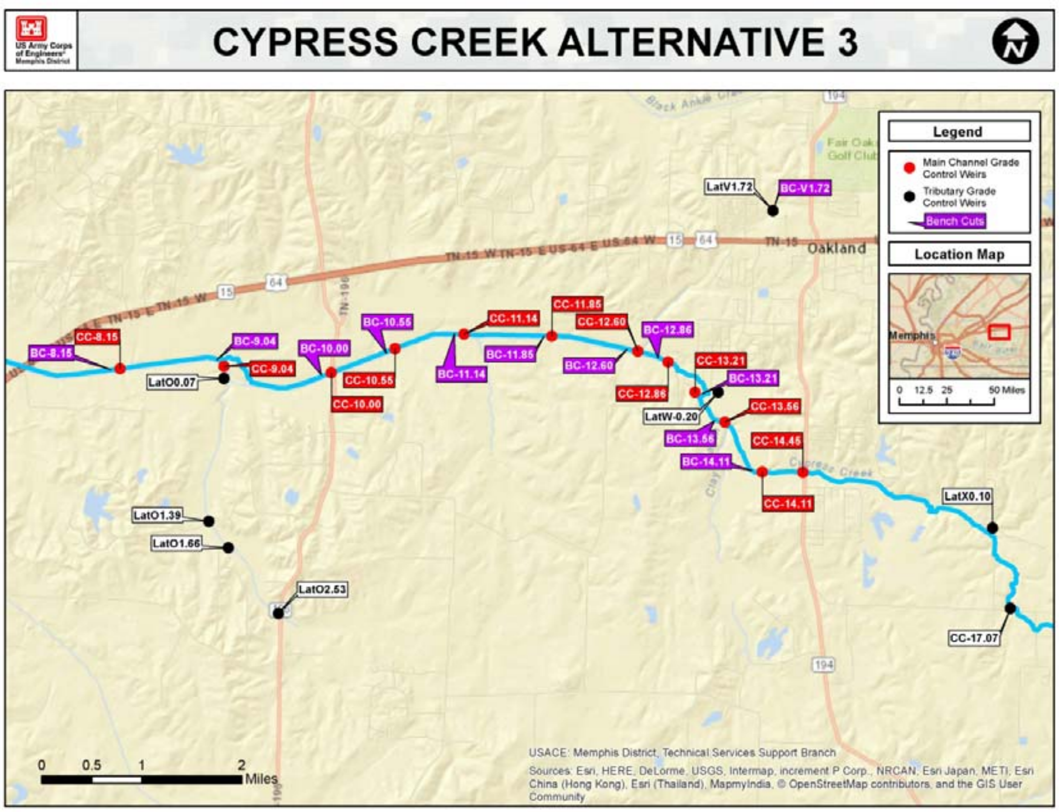

Figure 7 Map of weir and bench cut locations for Alternative 3

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.

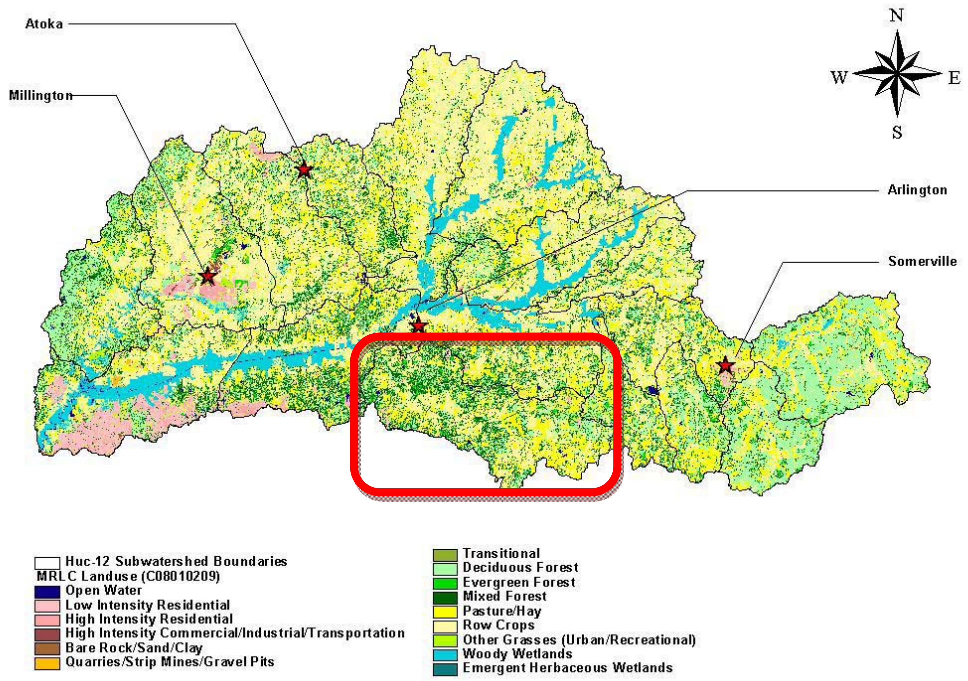

Figure 8. Map of land cover in the Loosahatchie Watershed.

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.

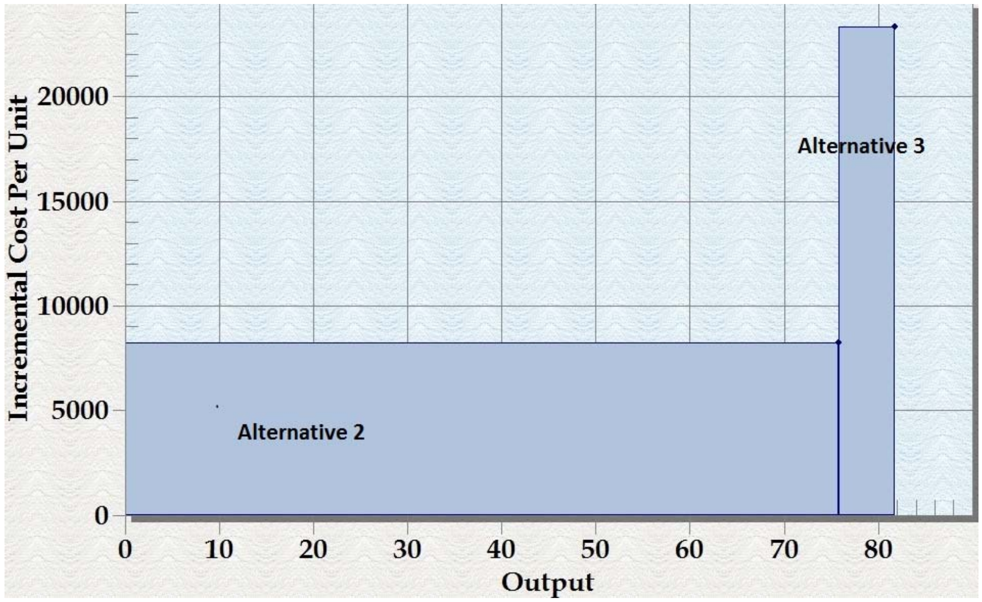

Figure 9. Comparison of alternatives using average annual cost and average annual habitat units.

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.

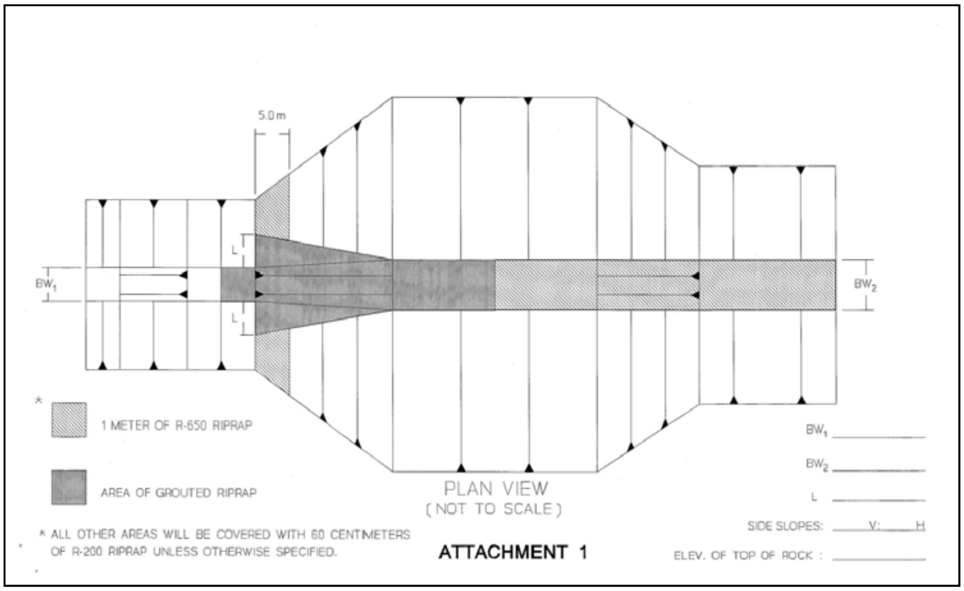

Figure 10. Typical Design of a Grade Control Weir (This typical is shown in metric units, however the actual designs will use English units per current guidance.)

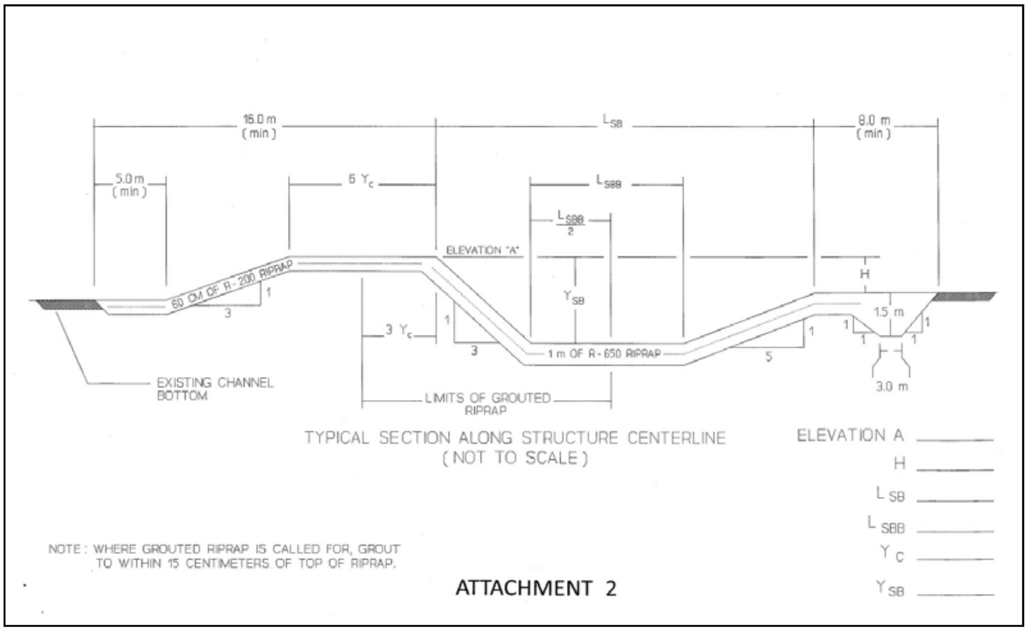

Figure 11. Typical Design of Grade Control Weir (This typical is shown in metric units; however the actual designs will use English units per current guidance.)

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	Contin gency	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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Appendix A

Results of Habitat Suitability Models

HEP Assumptions for Great Blue Heron (GBH)

GBH: The great blue heron is a large wading bird common throughout North America, and is often seen foraging for small fish and other aquatic organisms along streams, rivers, wetlands, and other aquatic sites. This species typically breeds in colonies (called rookeries) in forested areas larger than 0.4 hectares near water. The rookeries are often located in somewhat isolated areas as herons are sensitive to human disturbance. Proximity to food rich waters and areas that do not experience significant human disturbance are critical for the great blue heron. Because the restoration of this stream could improve GBH foraging habitat, this model was deemed appropriate for this study.

GBH variables and assumptions:

Variable 1 considers distance between potential foraging areas and rookery sites. All sites are currently within 1 kilometer of a potential rookery and will continue to be with the project. Therefore existing, future with project, and future without project condition for each site is valued as 1.

Variable 2 estimates the suitability of riverine habitat as foraging area. If potential foraging habitats usually have shallow, clear water with a firm substrate and a huntable population of small fish they are valued as a 1. If potential foraging habitats usually do not provide the desirable combination of conditions they are valued as a 0. As Cypress Creek and its tributaries do not currently usually provide the desirable combination of conditions they are valued as a 0 for Existing and Future without project. Future with project conditions are expected to provide regularly flowing shallow, clear water with a firm substrate and a huntable population of small fish; therefore, all sites are valued as a 1 (Table 1).

Variable 3 measures factors related to human disturbance and can be expressed by determining whether the potential foraging area is generally free from human disturbance during the 4 hours following sunrise or preceding sunset OR is generally ~100 m from human activities and habitation OR 50 m from roads with occasional slow moving traffic. If these conditions are met, the area is valued as a 1. If the above conditions are not usually met the area is valued as a 0. Although agriculture is the predominant land use adjacent to the proposed restoration reach, all sites sampled were valued as 1 except 14.45 due to the relatively low amount of human activity. Site 14.45 is within close proximity to a residential neighborhood increasing the likelihood of disturbance; therefore, V3 is scored as 0 for this site (Table 1).

Variable 4 defines a potential nest site as a grove of trees at least 0.4 hectares in area located over water or within 250 m of water. If the treeland habitat fulfills these conditions, the site is valued as a 1. If potential treeland habitats do not fulfill these conditions, the site is valued as a 0. Most sites sampled in the proposed restoration reach were within 250 meters of the stream and appear to provide suitable vegetative structure for nest sites. Therefore, those sites were valued as 1 for Existing, Future without Project and Future with Project conditions. Sites 10.0, 10.55, 14.11, and 14.45 do not currently fulfill these conditions; therefore, those sites were scored as 0 for Existing and Future without Project conditions. Future with Project conditions are expected to fulfill the conditions; therefore, those sites were valued as 1 (Table 1).

Variable 5 pertains to levels of human disturbance around potential nest sites. If the exclusion zone is usually free from human disturbance during the nesting season the site is valued as a 1. If the exclusion zone is usually not free from human disturbance during the nesting season the site is valued as a 0. All sites in the proposed restoration reach except Site 14.45 are usually free from human disturbance during the nesting season; therefore, were valued as a 1. Site 14.45 is within close proximity to a residential neighborhood increasing the likelihood of disturbance; therefore, V5 was valued as 0 for Existing, Future without Project and Future with Project conditions (Table 1).

Variable 6 considers proximity of a potential nest site to an occupied heron nest site. A grove of trees (>0.4 hectares) seems more likely to be used if it has close proximity to an active or existing heronry. For this variable, suitable treeland habitats were valued as 1 if they are within 1 kilometer of an established rookery. Suitable habitats more than 1 kilometer from an active have lower SI values with 0.1 being the lowest value at more than 20 kilometers from a known established rookery. It is stated in the model documentation that the rate of decrease in values associated with increasing distance were selected arbitrarily. No known established rookeries exist within 20 kilometers of the project area; therefore all Existing, Future with Project and Future with Project condition values were quantified as 0.1 (Table 1).

The reproductive index (RI) for GBH was also used to estimate for this project. Variables 1, 4, 5, and 6 were used (Table 2).

Table 1: Habitat Suitability Index for Great Blue Heron

Variables		**Existing**	**FWOP**	**FWP**
V1: Distance between foraging areas and potential heronries	Considers distance between foraging areas and heronry sites.	1	1	1
V2: Estimates the suitability of riverine habitat as foraging area	1: If potential foraging habitats usually have shallow, clear water with a firm substrate and a huntable population of small fish 0: If potential foraging habitats usually do not provide the desirable combination of conditions.	0	0	1
V3: The potential foraging area is genereally free from human disturbance during the 4 hours following sunrise or preceding sunset OR is generally ~100 m from human activities and habitation OR 50 m from roads with occasional slow moving traffic	1: If there is usually no human disturbance near the potential foraging zone during the 4 hours following sunrise or preceding sunset OR is generally ~100 m from human activities and habitation OR 50 m from roads with occasional slow moving traffic 0: If the above conditions are not usually met.	1	1	1
V4: Defines a potential nest site as a grove of trees at least 0.4 ha in area located over water or within 250 m of water.	1: If treeland habitats usually fulfill all of these conditions 0: If potential treeland habitats usually do not fulfill all of these conditions	1	1	1
V5: Pertains to levels of human disturbance around potential nest site	1: If the exclusion zone is usually free from human disturbance during the nesting season. 0: If the exclusion zone is usually not free from human disturbance during the nesting season	1	1	1
V6: Considers proximity of a potential nest site to an occupied heron nest site		0.1	0.1	0.1
Habitat Suitability Index		0	0	0.32

Table 2: Reproductive Index for Great Blue Heron

Variables		Existing	FWOP	FWP
V1: Distance between foraging areas and potential heronries	Considers distance between foraging areas and heronry sites.	1	1	1
V4: Defines a potential nest site as a grove of trees at least 0.4 ha in area located over water or within 250 m of water.	1: If treeland habitats usually fulfill all of these conditions 0: If potential treeland habitats usually do not fulfill all of these conditions	1	1	1
V5: Pertains to levels of human disturbance around potential nest site	1: If the exclusion zone is usually free from human disturbance during the nesting season. 0: If the exclusion zone is usually not free from human disturbance during the nesting season	1	1	1
V6: Considers proximity of a potential nest site to an occupied heron nest site		0.1	0.1	0.1
Reproductive Index		0	0	0.32

Table 3: Habitat Suitability Index for Slough Darter

Existing HSI score									
Reach	V1-DO	V2-% Pools	V3-Slope	V4-Substrate	V5-Temperature	V6-Turbidity	V7-Velocity	V8-pH	HSI
Reach 1 (HWY205	1	0.75	0.2	0.5	1	1	0.4	1	0.6
Reach 2 (HWY196)	1	0.6	0.1	0.5	0.92	1	0	1	0
Reach 3 (Mebane)	1	0.6	0.62	0.5	0.3	1	0	0.9	0
FWOP HSI score									
Reach	V1-DO	V2-% Pools	V3-Slope	V4-Substrate	V5-Temperature	V6-Turbidity	V7-Velocity	V8-pH	
Reach 1 (HWY205									0.4
Reach 2 (HWY196)									0
Reach 3 (Mebane)									0
FWP HSI score									
Reach	V1-DO	V2-% Pools	V3-Slope	V4-Substrate	V5-Temperature	V6-Turbidity	V7-Velocity	V8-pH	
Reach 1 (HWY205	1	0.95	0.2	0.5	1	1	0.95	1	0.73
Reach 2 (HWY196)	1	0.75	0.1	0.5	0.92	1	0.85	1	0.64
Reach 3 (Mebane)	1	0.75	0.62	0.5	0.3	1	0.92	0.9	0.72

HEP Results and Habitat Units

The habitat suitability index (HSI) was calculated for the length of the proposed project area resulting in an HSI of 0 for Existing and Future with Project conditions and an HSI of 0.32 for each site except 14.45 for Future with Project conditions, site 14.45 remained a 0. The variables reflecting change are Variables 2 and 4, which estimate the suitability of riverine habitat as foraging area and suitability of a grove of trees as suitable nesting habitat, respectively. Existing habitat is similar throughout the project area including the tributaries to Cypress Creek. The quality of the aquatic habitat would improve with perennial flow being restored to the stream as well as increased percentage of pools, more stable substrate, and increased habitat for small fish as required by the diet of the GBH. More suitable treeland habitat would also be available for potential nesting sites if bench cuts are included in the design of the project.

Habitat units were calculated for Existing conditions; expected Future without Project conditions (FWOP), and expected Future with Project (FWP) for GBH and slough darter using estimated acres to be restored on the main stem of Cypress Creek and its tributaries. Estimated acreage for GBH included riparian habitat adjacent to the stream totaling approximately 146 acres, estimated acreage for slough darter was in-channel only and totaled approximately 45.3 acres. Habitat units were calculated by multiplying the expected acreage of restoration by the HSI scores. Total habitat units for the GBH on the main stem of Cypress Creek and its tributaries are as follows: 0 HU Existing, 0 HU FWOP, and 46.72 HU FWP. The total HU gain over existing conditions for GBH is estimated at 46.72. Results are summarized in Table 4. For slough darter, total expected FWP conditions would provide 31.25 HU, 25.9 HU over FWOP conditions (Table 5).

Habitat units for restoration of habitat by including bench cuts in the project were calculated for the approximate amount of potential nesting habitat that would be stabilized by the action. Bench cuts on the main stem of Cypress Creek are expected to be approximately 500 feet long with riparian width of approximately 128 feet in area of approximately 1.5 acres. The bench cut proposed for Oakland branch is expected to be approximately 1,100 feet long with a similar riparian width resulting in approximately 3.2 acres of riparian area. Total acreage gained with benchcuts would total approximately 19.7 acres. The bench cuts are not designed to experience regular flow, but rather to provide stable riparian habitat; therefore, the reproductive life requisite index (RI) was determined for GBH in order to determine habitat units. Bench cuts in the main stem of Cypress Creek are expected to add approximately 6.3 HU over FWOP conditions to the project area (Table 6). Bench cuts are not expected to provide habitat units for slough dater.

Equations:

HSI for GBH: $(V1xV2xV3xV4xV5xV6)^{1/2}$

RI for GBH: $(V1xV4xV5xV6)^{1/2}$

Acreage of aquatic restoration with grade control: ((Length of stream to be restored (feet) x estimated width of stream (feet))/43,560).

Acreage of bench cuts (main stem): (Riparian area (128 feet) x Length of bench cut (500 feet))/43,560).

Acreage of bench cuts (Oakland Branch): (Riparian area (128 feet) x Length of bench cut (1,100 feet))/43,560).

Table 4. Habitat unit benefits for great blue heron due to grade control improvements based on estimated acreage and habitat suitability index.

Cypress Creek and Tributaries Restoration Feature	Acres of habitat restored	Existing Habitat Suitability Index	Future without Project Habitat Suitability Index	Future with Project Habitat Suitability Index	Existing Habitat Units	Future without Project Habitat Units	Future with Project Habitat Units
Weirs	146	0	0	0.32	0	0	46.72

Table 5. Habitat unit benefits for slough darter due to grade control improvements based on estimated acreage and habitat suitability index.

Cypress Creek and Tributaries Restoration Feature	Acres of habitat restored	Existing Habitat Suitability Index	Future without Project Habitat Suitability Index	Future with Project Habitat Suitability Index	Existing Habitat Units	Future without Project Habitat Units	Future with Project Habitat Units
Weirs-Reach 1	13.5	0.6	0.4	0.73	8.1	5.4	9.855
Weirs-Reach 2	18.8	0	0	0.64	0	0	12.032
Weirs-Reach 3	13	0	0	0.72	0	0	9.36
Total	45.3						31.25

Table 6. Habitat unit benefits for great blue heron due to benchcuts based on estimated acreage and habitat suitability index

Cypress Creek and Tributaries Restoration Feature	Acres of habitat restored	Existing Reproductive Index	Future without Project Reproductive Index	Future with Project Reproductive Index	Existing Habitat Units	Future without Project Habitat Units	Future with Project Habitat Units
Benchcuts	19.7	0	0	0.32	0	0	6.304

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Appendix B

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

FINAL REPORT

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

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Acknowledgements

We appreciate the field work, data entry and manipulation and dedication to the project of Austyn Harriman and Daniel Schenk. Their efforts will bear fruit in the form of oral presentations at the 2015 Annual Collegiate Meeting of the Tennessee Academy of Sciences and will be used for fulfillment of their Senior Research Projects at Christian Brothers University. We also thank Dr. James E. Moore (Christian Brothers University, Memphis, Tennessee) for his help with some of the field equipment and techniques and Dr. Jennifer L. Bouldin (Arkansas State University, Jonesboro, Arkansas) for lending her backpack shocker to the project. We thank William Simco for assistance with sample collection.

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Statement of Problem

The West Tennessee River Basin Authority (WTRBA) and U.S. Army Corps of Engineers – Memphis District recently released a public notice (U.S. Corps of Engineers 2014) for input into a study to determine the feasibility of construction improvements to stabilize the banks of Cypress Creek and to create better in-stream and stream-side habitat. The Public Notice, in part, follows.

> "**TITLE**: Cypress Creek, near Oakland, TN
>
> The West Tennessee River Basin Authority and the Memphis District of the U.S. Army Corps of Engineers are working together to address problems in the Cypress Creek watershed in Fayette County, TN. We are seeking public input to define the problems, identify concerns and develop solutions to address the needs of the watershed. Although water resource problems are common in the area, this study will focus on Cypress Creek watershed.
>
> **PURPOSE**: Cypress Creek and its tributaries have been channelized along with most streams and rivers in West Tennessee, causing significant changes in the ecosystem. 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. Channelization of natural waterways generally causes impacts such as increasing the stream gradient, erosion and bank instability along with lowering of the channel. All of these effects may cause significant changes to the ecology of the stream. Currently, Cypress Creek has long straight stretches of channel with heavy flows during precipitation, little or no surface flow in dry periods, and limited floodplain to mitigate flood events. Severe erosion is causing sloughing of stream banks, lowering of the creek bed, problems with culverts that pass under roads, and sand and sediment deposition. Floodplain and bottomland hardwood forest habitat, which are important for birds and mammals have also declined due to bank instability, erosion and bank sloughing. Wildlife habitat in Cypress Creek is poor and fish movement is limited. Collapsed road crossings have interrupted traffic flow in the area and required emergency repairs.
>
> **POSSIBLE SOLUTIONS**: Opportunities to stabilize the stream banks and restore habitat for a variety of species are being studied. No specific plans have been developed for addressing the problems in the Cypress Creek watershed; however, some practices have been used successfully in other area streams and are being investigated for application in the project area. Possible actions include construction of weirs to stabilize the streambed and banks, reestablishment of stream meanders, and restoration of bottomland hardwood forest. Weirs to stabilize the streambed and banks will likely be necessary regardless of other actions. Weirs are rock structures placed in the bottom of the stream channel to prevent the streambed from eroding. They usually rise about one third of the way up the bank. Bench cuts to stabilize some stream sections and increase floodplain habitat are also being investigated. The stream banks in some areas may be reshaped to stabilize them and improve habitat.
>
> **NEXT STEPS**: The US Army Corps of Engineers and the West Tennessee River Basin Authority will use the information gathered from the public, other state, local and federal agencies, field surveys, and published information to develop geographically specific alternatives, and evaluate them to determine which alternative will provide the best solution to the problems in Cypress Creek. The draft report will be made available to the public for review in 2015."

Scope of Work

This scope of work represents a field survey to provide information to help address current problems in Cypress Creek, Shelby and Fayette County, Tennessee, as indicated above. At the request of WTRBA, sampling and assessment of the fish and macroinvertebrate communities and a qualitative habitat assessment of Cypress Creek was performed by Christian Brothers University. Dr. Jeffrey Fore (West Tennessee Program Director, The Nature Conservancy) represented WTRBA and Ms. Lynda Miller represented Christian Brothers University. Below is a description of the scope of work for the assessment.

1. Conduct fish and macroinvertebrate community collections and conduct a qualitative physical habitat assessment of Cypress Creek Shelby and Fayette County, Tennessee.
    a. The three sample sites are located where Cypress Creek intersects
        i. Highway 205,
        ii. Highway 196, and
        iii. Mebane Road
    b. Sampling reaches will be defined as 20 times wetted channel width, but not longer than 200 meters.
    c. All collected data will be provided digitally in a spreadsheet to the West TN River Basin Authority.
2. A final report will be provided that describes the current environmental condition of Cypress Creek. The report should include the elements below.
    a. Measures of taxonomic richness and diversity for both faunal groups.
        i. Index of biotic integrity scores for macroinvertebrate samples.
        ii. Measures of fish community degradation (e.g., abundance of intolerant species or abundance of habitat generalists).
        iii. If data are available, a comparison to historical conditions of Cypress Creek.
    b. Characterization of current physical habitats, including discussion of habitat elements that are most likely degraded.
    c. Description of most likely causes for biological or physical habitat impairment. This section should inform conservation actions that may be undertaken in the future.

Setting

Climatological Regions

The two most fundamental traits that define our landscapes and waters are annual precipitation (the west-east divide) and temperature (the north-south divide): the continental United States is divided into three grand regions, Eastern Highlands, Plains and Lowlands, and West, based on these two climatic factors (National Rivers and Streams Assessment, NRSA; USEPA 2013). The Plains and Lowlands Climatic Region, of particular interest for this study, corresponds roughly with the drainage area of the Mississippi River and includes low gradient plains of the Atlantic and Gulf of Mexico coastal areas and the lowlands of the Mississippi delta (Figure 1a). West Tennessee lies within this region, where the climate is classified as humid subtropical and is characterized by hot humid summers and mild winters. The mean annual air temperature is 17 °C (62 °F). Hottest temperatures (≥ 33 °C or 92°F) occur July-August and coldest temperatures (≤ 3 °C or 37°F) in December-February. Precipitation averages approximately 1.4 m (53-54 in) per year. Late summer through early fall are the driest parts of the year and late winter through early spring are the wettest parts of the year. Flooding sometimes results from heavy and intense rainfall (Tennessee Climatological Service 2015).

Ecological Regions

The three climatic regions are divided into nine ecological regions (Figure 1b). Ecological regions are defined by physical features and conditions (geologic, physiographic, climatic, etc.) that are similar, so rivers and streams flowing within or through an ecoregion experience similar challenges and constraints. Understanding and interpreting the effects of these

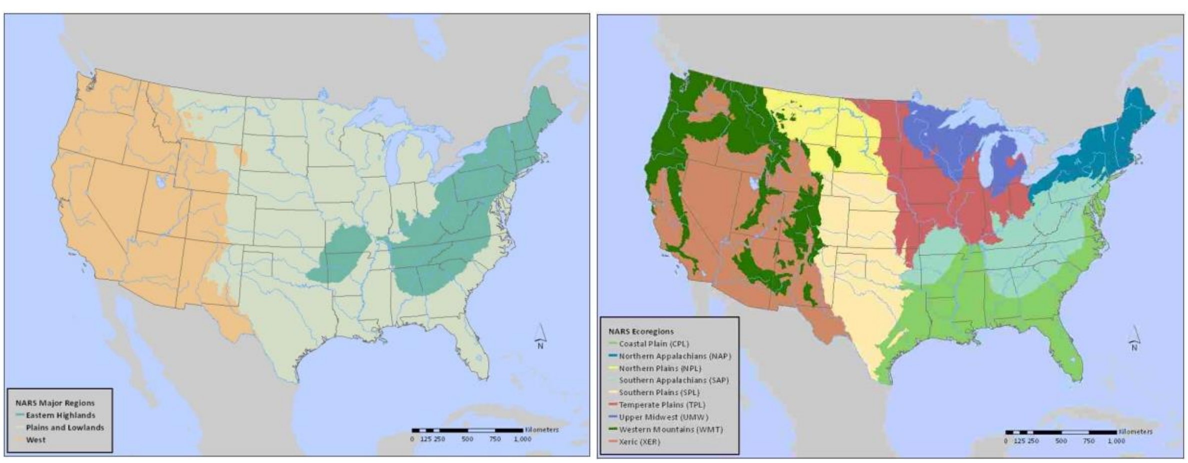


Figure 1. Map indicating the three major climatic regions (1a, left; west Tennessee is in the Plains and Lowlands Climatic Region shaded in light blue) and the nine major ecological regions (1b, right; west Tennessee is in the Gulf Coastal Plains Ecoregion shaded in light green) of the United States. Images are from National Rivers and Streams Assessment (USEPA 2013).

ecological systems on their rivers and streams, and on their responses to stressors, can lead to management practices that are applicable across the ecoregion (NRSA; USEPA 2013).

Among the nine ecological divisions in the United States, west Tennessee is in the Coastal Plains Ecoregion (Figure 1b) which covers the east coast from Florida to New Jersey, the Gulf Coast from Florida to eastern Texas, and lands along the Mississippi River to its confluence with the Ohio River. The Coastal Plains Ecoregion is characterized by rivers that typically meander across broad flat plains, can form complex wetlands, swamps and oxbow lakes, and have some of the highest species richness and diversity in the United States. Historically, this ecoregion had vast expanses of seasonally-flooded bottomland forests flanking their waterways, but intensive logging operations in the 19th and early 20th centuries have significantly reduced their acreage. Riparian forest buffers became severely restricted as conversion to agricultural lands proceeded and many waterways were altered by construction of impoundments, creation of diversion canals and channelization for irrigation and to control flooding.

Ecological Regions of West Tennessee

After further evaluation and refinement, the state of Tennessee was classified into eight distinct EPA Level III ecoregions and 25 EPA Level IV subregions (Griffith et al. 1997; Arnwine et al. 2000). The western one third of the state, one of the "Grand" divisions of the state, is dominated by the Southeastern Plains and Hills (subregion 65) to the east, and of particular interest for this study, the Mississippi Valley Loess Plains (subregion 74) to the west (Figure 2). The Mississippi Valley Loess Plains ecoregion covers almost 11% of the state of Tennessee (Arnwine et al. 2000) and stretches from the Ohio River in western Kentucky to Louisiana. It is a

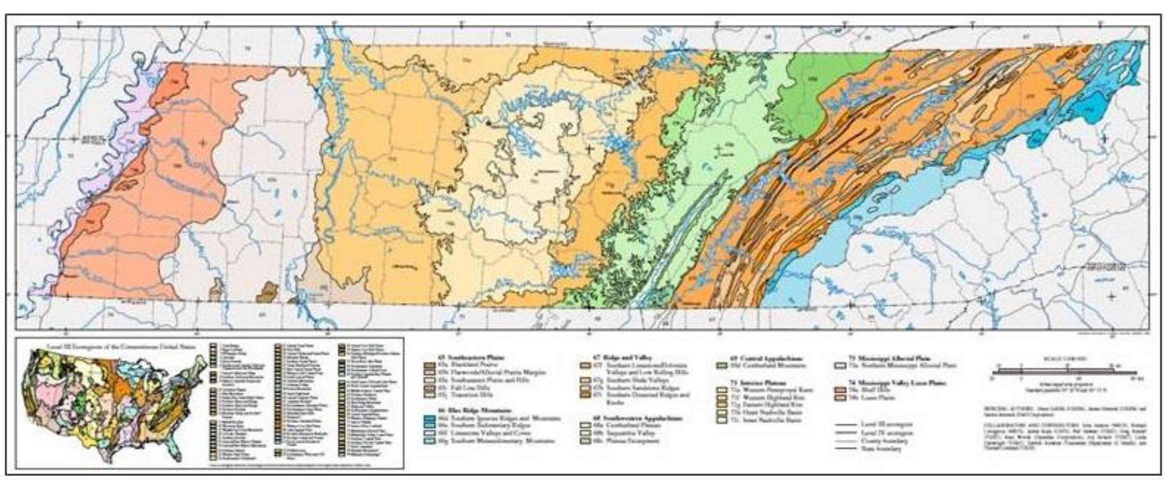


Figure 2. EPA Level III and Level IV Ecoregions of Tennessee. West Tennessee is dominated by two Level III subregions: the Mississippi Valley Loess Plains (subregion 74, salmon color) and the Southeastern Plains and Hills (subregion 65, light pink). Image from Griffith et al. 2012 (http://www.epa.gov/wed/pages/ecoregions/tn_eco.htm).

vast expanse of loess, silt, and sand, remnants of an ancient ocean that once occupied this part of the continent. The thick loess, a distinguishing feature of this ecoregion, is a powder-fine dust created by glacial scouring and is of relatively recent geologic origin (Figure 3a). Strong prevailing winds of the time drove loess accumulation onto the Mississippi River bluffs and eastward across the gently sloping, relatively flat terrain.

Loess soils are some of the most productive in the world, thus agriculture is the predominant land use in this region. Crops grown in west Tennessee include soybean, cotton, corn, milo and

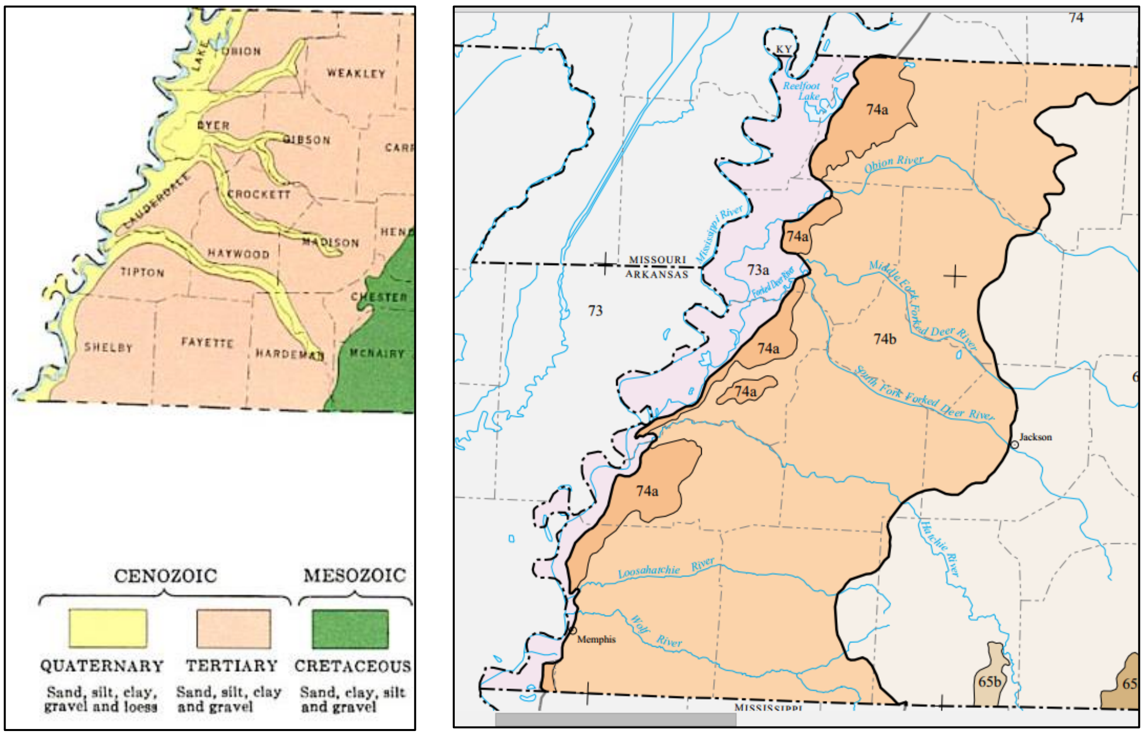


Figure 3. A general geologic map showing the relatively recent age of west Tennessee lands (3a, left) and a map showing ecoregion 74 in west Tennessee (3b, right). Ecoregion 74 is dominated by the Loess Plains subregion (74b shaded in salmon). Images from Tennessee Department of Environment and Conservation (TDEC/Geology/General Geologic Map http://www.tn.gov/environment/geology/geologic-map.shtml) and US Environmental Protection Agency (EPA Ecoregions of Tennessee http://www.epa.gov/wed/pages/ecoregions/tn_eco.htm).

sorghum, as well as some pastureland for cattle and poultry. Oak-hickory forest complexes are the natural vegetation type, but as mentioned earlier, most forested lands have been cleared for agriculture. Soil erosion has been a significant consequence of this land use conversion.

Rivers and streams in the Mississippi Valley Loess Plains ecoregion have wide floodplains, are low gradient (15-30 m or 50-100 ft local relief) and turbid, and have soft silt and sand bottoms (Griffith et al. 1997; Etnier and Starnes 1993). Notable river systems that cross this west Tennessee ecoregion are the Obion, Forked Deer, Hatchie, Loosahatchie, and Wolf (Figure 3b). The Obion, Forked Deer and Loosahatchie systems have been channelized essentially throughout their range and riparian vegetation removed to improve drainage of adjacent agricultural lands. The Hatchie River and much of the Wolf River have not been channelized, but many of their tributaries have been ditched and straightened. These practices have accelerated erosion, increased siltation of rivers and streams and had devastating effects on aquatic and riparian habitats (Etnier and Starnes 1993).

The Mississippi Valley Loess Plains ecoregion is further divided into the Bluff Hills ecoregion 74a), a disjunct and narrow band of deep loess (> 18 m or 60 ft) bordering the Mississippi River valley and the Loess Plains (ecoregion 74b), a wide swath of flat to rolling irregular plains with loess deposits up to 15 m (50 ft) deep (Figure 3b; Griffith et al. 1997). The Bluff Hills make up about 10% of the Mississippi Valley Loess ecoregion, while the Loess Plains comprise the majority ~90% (Arnwine et al. 2000). Elevations in the Loess Plains average about 150 m (500 ft) adjacent to the bluffs, decrease to 70-90 m (250-300 ft) in the center and increase to about 150 m again as the Loess Plains approach the Southeastern Plains and Hills subregion on its eastern flank. The Loess Plains cover most of ten west Tennessee counties: the southernmost counties of Shelby and Fayette are the location of the Cypress Creek study area.

The typical stream in low gradient loess areas has a characteristic U-shaped cross section with a flat bottom and high, unstable sides. Rivers and streams in this ecoregion are Rosgen-classified as F5 with the valley structure of type X, wide alluvial flats with very little relief. Wadeable and non-wadeable reference streams in the Loess Plains were found to have these characteristics (Arnwine et al. 2005).

The Loosahatchie River

The Loosahatchie River watershed traverses four EPA Level IV subregions in west Tennessee (Figure 3b, second river from bottom): its headwaters start in the Southeastern Plains and Hills (subregion 65e); nearly its entire length lies within the Loess Plains (subregion 74b); and it crosses briefly through the Bluff Hills (subregion 74a) and Northern Mississippi Alluvial Plain (subregion 73a) as it enters the Mississippi River (Tennessee Department of Environment and Conservation 2003). Anecdotally, “Hatchie” is a Native American word that means “river” and it is said that the Loosahatchie River was historically known for being a dark river flowing through a swamp. This reflects its slow, meandering ecological past, before deforestation.

The following is further characterization of the Loosahatchie River Watershed from the Tennessee Rivers Assessment Report (Tennessee Department of Environment and Conservation 2003). As part of the Mississippi River drainage, the Loosahatchie River is a 64-mile long waterway flowing in a gentle arc east to west in southwestern Tennessee (Figure 4a). Its 738 square mile watershed has the majority (98.6%) of its 1,443 stream miles located in Fayette, Shelby and Tipton counties, but very small portions also reach into Hardeman and Haywood

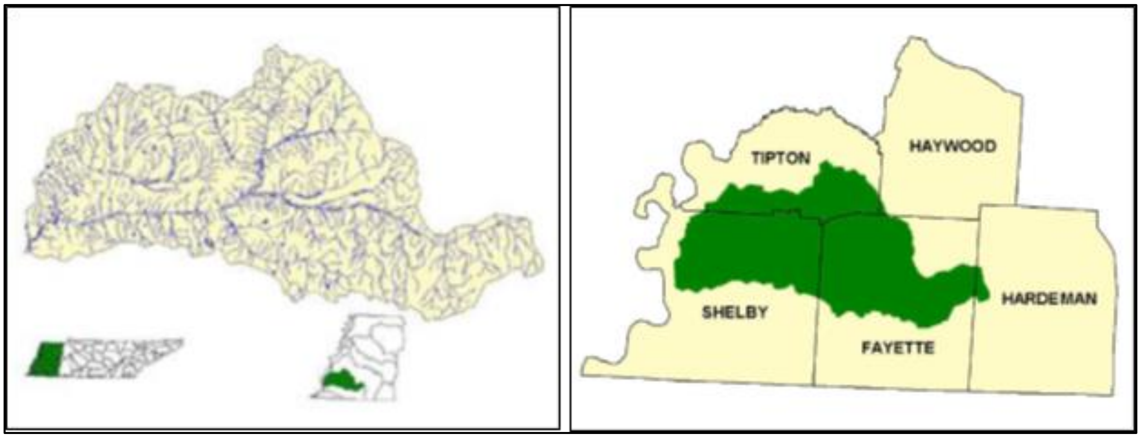


Figure 4. Relative location of the Loosahatchie River watershed (4a, left) in Tennessee and its location in portions of five counties in west Tennessee (4b, right). Images from Tennessee Department of Environment and Conservation.

counties (Figure 4b). Major roads crossing the Loosahatchie watershed are State Highway 51, State Highway 72, Interstate 40 and State Highway 64, west to east, respectively. The Loosahatchie watershed has 81 lakes and 53 dams with retaining structures at least 6 m (20 ft) high or holding back 37,000 m^4 (30 ac-ft) of water. At least 73 wetland sites have been inventoried, and the watershed has eleven animal (including one fish) and six plant species that are considered rare or endangered. The Loosahatchie River has been channelized along nearly its entire length except for short sections at its origin, mid-section and terminus. Along most of its length, its drainage basin has been highly reduced due to encroachment for agricultural production and urbanization. About 38% of its watershed remains forested or in wetlands, 57% is in pasture or cropland and 4.1% is in residential and commercial land use. However, this land use distribution was estimated from satellite images taken in the early 1990s, and may be very different now, as urbanization has progressed significantly in this part of west Tennessee.

Cypress Creek, Shelby and Fayette County, Tennessee

Six sub-watersheds contribute to the Loosahatchie River: one of those is the Cypress Creek watershed (Figure 5a). Cypress Creek is a 22 km (13.67 mi) east-to-west flowing stream with an approximate drainage area of 171 m^2 (66 mi^2 or about 42,000 acres) and 207 km (128.7 mi) of miscellaneous tributaries (U.S. Environmental Protection Agency 2010; U.S. Environmental Protection Agency and Tennessee Department of Environment and Conservation 2001). Its headwaters are in Fayette County, Tennessee near the City of Oakland and its watershed lies entirely within Fayette and Shelby Counties. Part of its western reach near the Shelby County / Fayette County border is known as the Cypress Creek Canal, and the westernmost 4.3 km (2.67 mi) portion, from the confluence with Hall Creek north of Interstate 40 to its terminus at the Loosahatchie River, is known as Clear Creek.

Three sites were chosen along Cypress Creek to conduct habitat and biotic measurements. Sites were selected based on accessibility to water; therefore, each site was located where a road with a bridge overpass intersected Cypress Creek. The easternmost site, Mebane Road, was near its headwaters, the middle site was where Cypress Creek intersected State Highway 196, and the downstream site was where Cypress Creek intersected State Highway 205, in the section known as Cypress Creek Canal (Figure 5b).

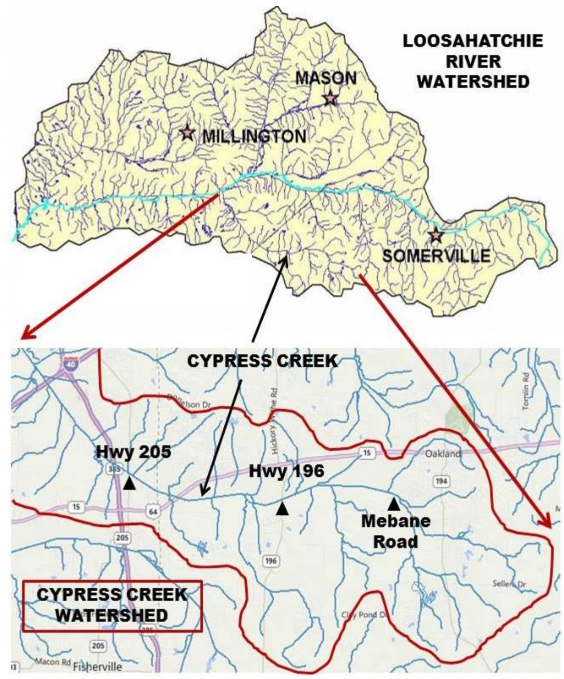


Figure 5. The Loosahatchie River watershed showing the Cypress Creek watershed as one of its components (5a, top inset). The bottom inset (5b) shows the location of the three sampling sites on Cypress Creek. Images from Tennessee Department of Environment and Conservation and Google Earth.

Field Sampling and Site Assessment

Field sampling and site assessment efforts followed those established in the Wadeable Streams Assessment (WSA) Field Operations Manual (U.S. Environmental Protection Agency 2004), although some deviations occurred (i.e., some samples and assessments were not done). WSA procedures were developed over a 10-year research period and are designed so that a small field crew can conduct rigorous sampling and assessment of wadeable streams (generally Strahler Stream Order 1 through 3) such as Cypress Creek.

The following briefly describes the intellectual merit of the WSA and its established protocols. The WSA keyed in on two principal types of indicators (condition indicators and stressor indicators) to determine ecological condition. Condition indicators are biotic or abiotic characteristics that can help estimate the condition of the ecological resource relative to some environmental value, such as biotic integrity, while stressor indicators are characteristics that are expected to change the condition of a resource if the intensity or magnitude changes. Water chemistry measurements then might be used to evaluate stressors such as acidification, nutrient enrichment, or various types of contaminants. Physical habitat measurements might be used to evaluate stressors such as stream channel alteration, bank modifications, housing or commercial development, or grazing and agricultural practices. Fish and macroinvertebrate assemblages might be used to reflect overall biotic integrity, as their composition responds differently to a wide array of stressors. They can also indicate temporal changes in habitat, as fish are mobile and can escape, but macroinvertebrates are modestly mobile or sessile and their assemblages can represent long-term stressors.

The WSA establishes a very methodical approach to sampling and assessment of water quality variables, physical habitat measurements and fish and benthic sampling. Figure 6 is a schematic itemizing the measurements taken at each sampling site to ensure a comprehensive and robust data set is available to analyze and interpret overall stream health and condition (U.S. Environmental Protection Agency 2013). Figure 7 shows the reach layout for physical habitat measurements and includes insets that show where in the stream certain characteristics are measured or collected.

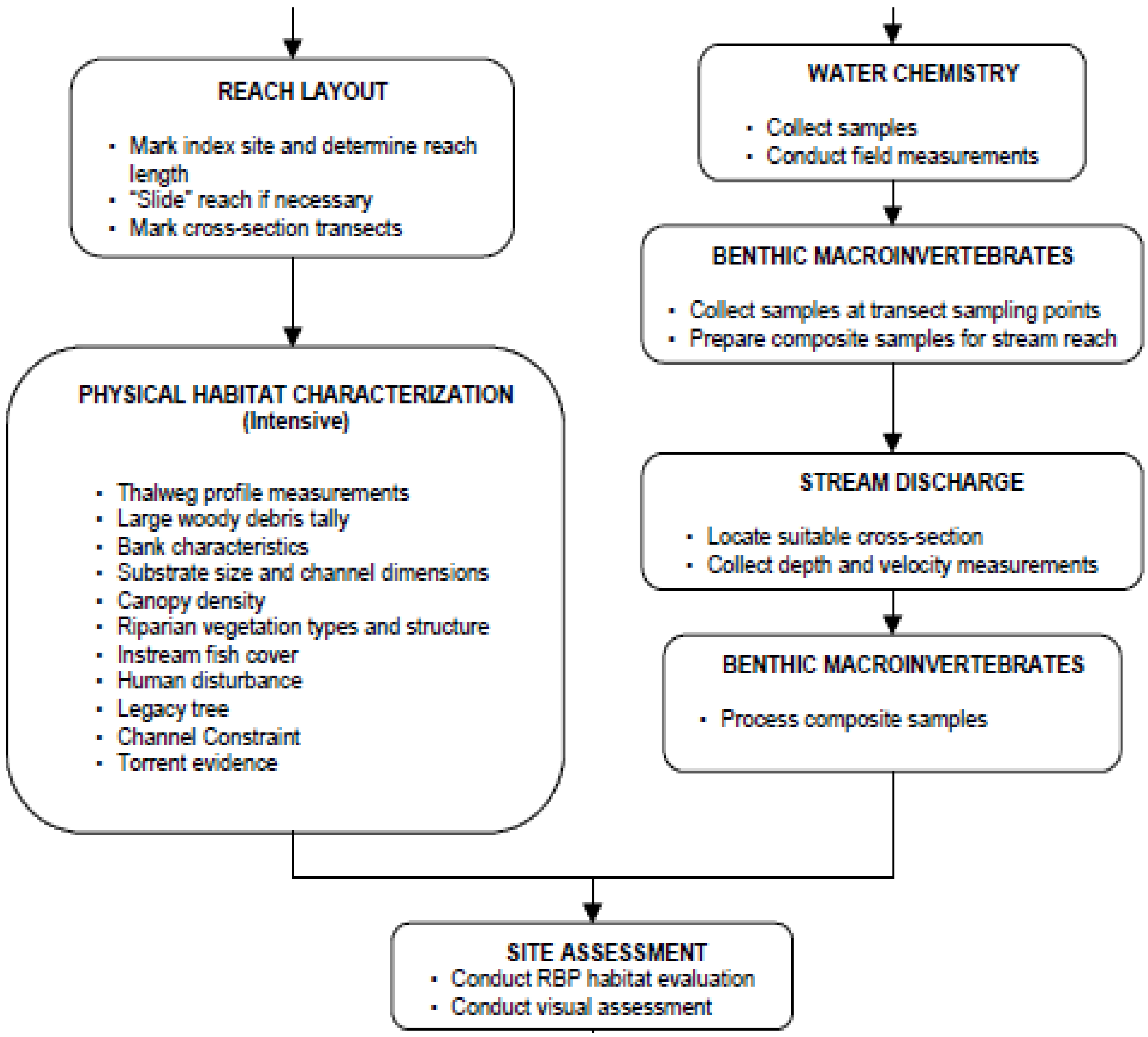


Figure 6. List of the measurements taken to conduct stream survey at three sites on Cypress Creek, Shelby and Fayette County, TN. Image from Wadeable Streams Assessment Field Operations Manual (U.S. Environmental Protection Agency 2004).

Sampling and assessment of the three Cypress Creek sites were completed during July 22-August 4, 2014. Sampling at a single site took 1-2 days to complete. The following is a brief description of the sequence of events that usually occurred upon arrival at each site.

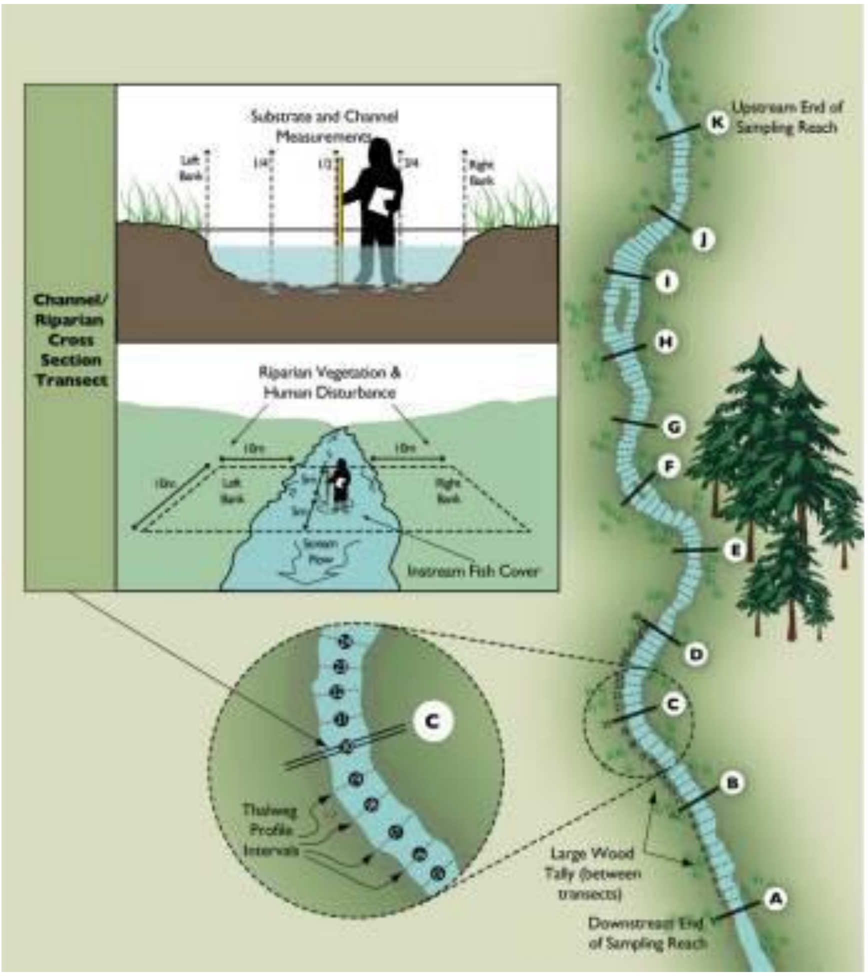


Figure 7. Cartoon drawing depicting the reach layout used for assessment of three sites on Cypress Creek, Shelby and Fayette County, TN. Image is from National Rivers and Streams Assessment 2008-2009 (U.S. Environmental Protection Agency (2013).

A water sample was obtained by one of the team members before anyone else entered the stream to ensure that it represented an undisturbed sample. Water chemistry was conducted onsite. Eleven transects were then established at equal distances (15 m) over a 150-m reach. Transects were marked by a lettered-stake with colored flagging on both sides of the stream. Latitude and longitude readings were taken with a hand-held GPS unit at each transect (Table 1). While transects were being established, one of the crew members drew a schematic of the reach that included representation of the established transects (Figure 8). Another crew member took photographs of each transect in each of the cardinal directions while standing mid-stream.

After transects were established, 2-3 crew members began the systematic collection of data related to habitat characterization, including thalweg profile determination, substrate cross-sectional information, fish cover identification, bank measurements, canopy cover measurements, and visual riparian estimates (these data were recorded on the Channel/Riparian Cross-Section Form and Thalweg Profile & Woody Debris Form; WSA, U.S.

Table 1. Latitude and longitude (degrees and decimal degrees) of transects established at three locations on Cypress Creek, Fayette and Shelby County, TN.

Site	**Mebane Road**															
	Left Bank (South)								Right Bank (North)							
	Latitude				Longitude				Latitude				Longitude			
Transect	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec
A	35	12	54.1	35.215028	89	35	14.5	-89.587361	35	12	53.9	35.214972	89	35	14.3	-89.587306
B	35	12	53.9	35.214972	89	35	14.0	-89.587222	35	12	54.0	35.215000	89	35	14.0	-89.587222
C	35	12	53.7	35.214917	89	35	13.4	-89.587056	35	12	54.0	35.215000	89	35	13.0	-89.586944
D	35	12	53.8	35.214944	89	35	12.8	-89.586889	35	12	53.7	35.214917	89	35	12.9	-89.586917
E	35	12	53.4	35.214833	89	35	11.9	-89.586639	35	12	53.5	35.214861	89	35	12.2	-89.586722
F	35	12	53.1	35.214750	89	35	11.6	-89.586556	35	12	53.2	35.214778	89	35	11.7	-89.586583
G	35	12	53.1	35.214750	89	35	11.0	-89.586389	35	12	52.9	35.214694	89	35	11.2	-89.586444
H	35	12	53.0	35.214722	89	35	10.2	-89.586167	35	12	52.9	35.214694	89	35	10.7	-89.586306
I	35	12	53.0	35.214722	89	35	9.9	-89.586083	35	12	52.9	35.214694	89	35	9.7	-89.586028
J	35	12	52.9	35.214694	89	35	9.3	-89.585917	35	12	52.9	35.214694	89	35	9.4	-89.585944
K	35	12	52.9	35.214694	89	35	8.6	-89.585722	35	12	52.9	35.214694	89	35	8.4	-89.585667
Site	**Hwy 196**															
	Left Bank (South)								Right Bank (North)							
	Latitude				Longitude				Latitude				Longitude			
Transect	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec
A	35	12	48.9	35.213583	89	35	6.3	-89.585083	35	12	48.5	35.213472	89	35	6.3	-89.585083
B	35	12	48.8	35.213556	89	35	5.7	-89.584917	35	12	48.5	35.213472	89	35	5.7	-89.584917
C	35	12	49.0	35.213611	89	35	5.1	-89.584750	35	12	49.4	35.213722	89	35	5.0	-89.584722
D	35	12	49.2	35.213667	89	35	4.6	-89.584611	35	12	49.0	35.213611	89	35	4.3	-89.584528
E	35	12	49.3	35.213694	89	35	4.2	-89.584500	35	12	49.1	35.213639	89	35	3.7	-89.584361
F	35	12	49.5	35.213750	89	35	3.8	-89.584389	35	12	49.2	35.213667	89	35	3.3	-89.584250
G	35	12	49.5	35.213750	89	35	3.1	-89.584194	35	12	49.3	35.213694	89	35	3.3	-89.584250
H	35	12	49.9	35.213861	89	35	2.2	-89.583944	35	12	49.6	35.213778	89	35	2.7	-89.584083
I	35	12	50.2	35.213944	89	35	1.8	-89.583833	35	12	50.1	35.213917	89	35	1.6	-89.583778
J	35	12	50.4	35.214000	89	35	1.5	-89.583750	35	12	50.1	35.213917	89	35	1.3	-89.583694
K	35	12	50.4	35.214000	89	35	0.9	-89.583583	35	12	50.3	35.213972	89	35	0.6	-89.583500

Table 1 (cont). Latitude and longitude (degrees and decimal degrees) of transects established at three locations on Cypress Creek, Fayette and Shelby County, TN.

Site	**Hwy 205**															
	Left Bank (South)								Right Bank (North)							
	Latitude				Longitude				Latitude				Longitude			
Transect	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec	deg	min	sec	dec
A	35	12	60.0	35.205417	89	35	19.5	-89.600000	35	12	59.9	35.205444	89	35	19.6	-89.599972
B	35	12	59.6	35.205278	89	35	19.0	-89.599889	35	12	59.3	35.205361	89	35	19.3	-89.599806
C	35	12	59.3	35.205250	89	35	18.9	-89.599806	35	12	58.9	35.205278	89	35	19.0	-89.599694
D	35	12	58.9	35.205167	89	35	18.6	-89.599694	35	12	58.4	35.205222	89	35	18.8	-89.599556
E	35	12	58.4	35.205083	89	35	18.3	-89.599556	35	12	57.8	35.205111	89	35	18.4	-89.599389
F	35	12	57.3	35.205028	89	35	18.1	-89.599250	35	12	57.2	35.205028	89	35	18.1	-89.599222
G	35	12	57.0	35.204944	89	35	17.8	-89.599167	35	12	56.7	35.204972	89	35	17.9	-89.599083
H	35	12	56.7	35.204833	89	35	17.4	-89.599083	35	12	56.2	35.204889	89	35	17.6	-89.598944
I	35	12	56.4	35.204806	89	35	17.3	-89.599000	35	12	55.6	35.204861	89	35	17.5	-89.598778
J	35	12	55.5	35.204694	89	35	16.9	-89.598750	35	12	55.1	35.204778	89	35	17.2	-89.598639
K	35	12	54.8	35.204639	89	35	16.7	-89.598556	35	12	54.6	35.204611	89	35	16.6	-89.598500

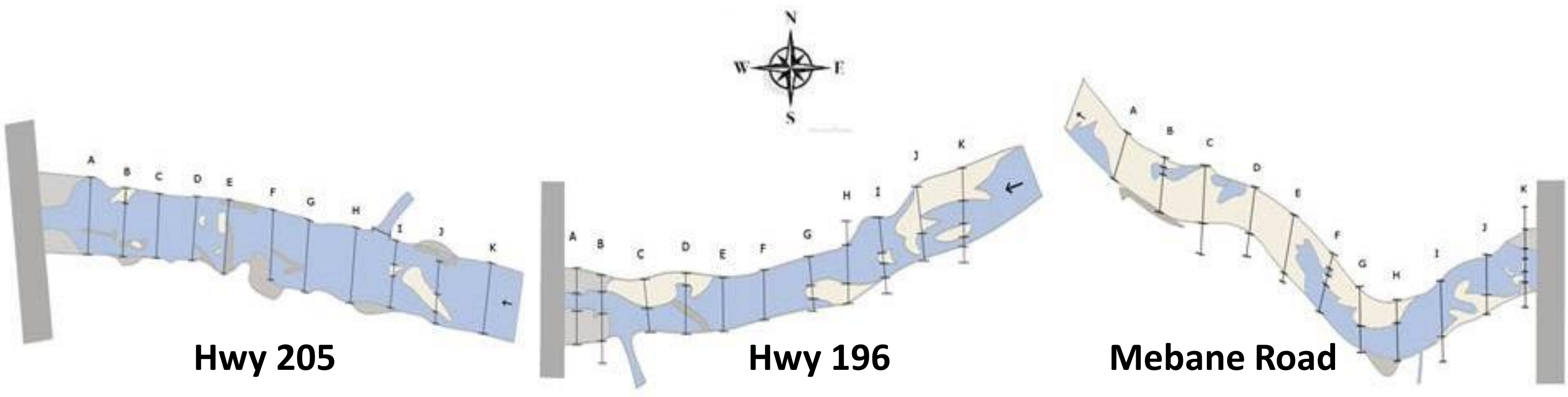


Figure 8. Schematic drawings showing transects established for three locations at Cypress Creek, Shelby and Fayette County, TN. Arrows indicate direction of water flow.

Environmental Protection Agency 2004). Two crew members sampled for macroinvertebrates. All crew members helped with collection of fish. The final steps at the site were collaborative completion of the Rapid Habitat Assessment Form for Glide/Pool Streams and the Stream Assessment Form (WSA, U.S. Environmental Protection Agency 2004). Elaboration of methods and rationale for these measurements is provided under separate headings in this report. All recorded data was compiled into an Excel spreadsheet (Microsoft Office 2010) that accompanies this report.

General Description of the Study Sites

Mebane Road was the easternmost reach of Cypress Creek, and nearest its headwaters. It was the narrowest site (average width = 7.0 m; range 3.0-10.1 m) and its streamside habitat was forested (abandoned field) on the north bank and row crops on the south bank with a relatively wide buffer zone. Residential housing was not present near the site. The Mebane Road section of Cypress Creek could be considered an “interrupted flow” stream because portions of it were completely dry at the time of sampling (Figure 8, right). However, evidence of a torrent event was present in the form of a large tree, trapped by its roots in the overhanging electrical wires across the stream at Transect K. The Mebane Road site had a deep bend that prevented visualization of the entire reach from one end to the other. A very small side stream (~1 m) joined this section of Cypress Creek from the southern bank between Transects H and I (Figure 8, right). Household materials (furniture, carpet, tires, etc.) had been dumped into the mid-portion of the site. Poison ivy *Toxicodendron radicans* was a dominant stream-side plant and the invasive kudzu *Pueraria lobata* and privet *Ligustrum sinense* occurred sporadically throughout the reach. Tree species along the banks included birch, box elder, elm, oaks, sweet gum, sycamore and willow. Animal tracks indicated

the presence of raccoon and heron, and Fowler's toads were observed on site. The site had very little noise pollution and the road was lightly traveled during the sampling period.

The **Hwy 196** site was slightly wider (average width = 9.4 m; range 2.7-13.0 m) than the Mebane Road site and streamside habit was forested (abandoned field) on the north bank and agricultural with a relatively narrow buffer zone on the south bank. Hwy 196 had water throughout its reach, but its flow was restricted to its deepest meanders when it was sampled. An approximately 3-m side stream joined this section of Cypress Creek from the southern bank between Transects B and C (Figure 8, center). A large sewer pipe drained the agricultural field south of this section of Cypress Creek about 50 m upstream of Transect K. Some interesting findings at the Hwy 196 site included presence of algae and crawfish chimneys. Swallow nests were built on the west side of the bridge overpass suggesting the presence of significant quantities of insects. Sunfish nests were excavated in the upstream section of the reach and small fish (most probably young-of-the-year) were using them as a possible refuge. Tracks suggested this site was visited or used by coyote, deer, raccoon, and heron, while bullfrogs were heard and juvenile toads were seen. The south bank of the site was dominated throughout by river cane *(Arundinaria gigantean);* some wild grapevine (possibly *Vitis riparia*, although not formally identified) was present; but kudzu and privet were not observed. Tree species were similar to those occupying the Mebane Road site. The Hwy 196 site was very noisy, even when well away from the bridge overpass, as residential

housing was under construction nearby and a constant parade of concrete trucks and construction-related vehicles were using the road during the sampling period.

The **Hwy 205** site represented the terminal portion of Cypress Creek, and occurred in a section of the stream that was actually referred to as a "canal". This reach was consistently the widest (average width = 16.4 m; range 15.2-17.7 m) and the straightest of the three sampled, with an unimpeded view of the entire reach. Streamside habitat was forested on the north bank and agricultural with a narrow buffer zone on the south bank. A transmission right-of-way intersected this section of Cypress Creek at Transect A on the north bank. Hwy 205 had water throughout its reach. An approximately 6-m side stream converged from the north between Transects H and I with this section of Cypress Creek (Figure 8, left). Animal tracks of coyote, deer, raccoon and heron were observed, as was evidence of beaver activity. Algae were present on and near the rip-rap at the downstream section of the site closest to the bridge overpass. Plants on the south bank included grasses and native cane, kudzu and privet. The north bank had much less kudzu and privet. Tree species were similar to those found at the other sites and also included locust, pawpaw and tulip poplar. This site was also very noisy because maintenance crews were resurfacing the road during the sampling period. The bridge overpass seemed to have a relatively steady stream of primarily passenger vehicle traffic.

Satellite images (Google Earth 2014) of the three Cypress Creek sample sites are shown in Figure 9 (upper panels). The lower panels of Figure 9 are taken mid-channel at Transect K, looking downstream.

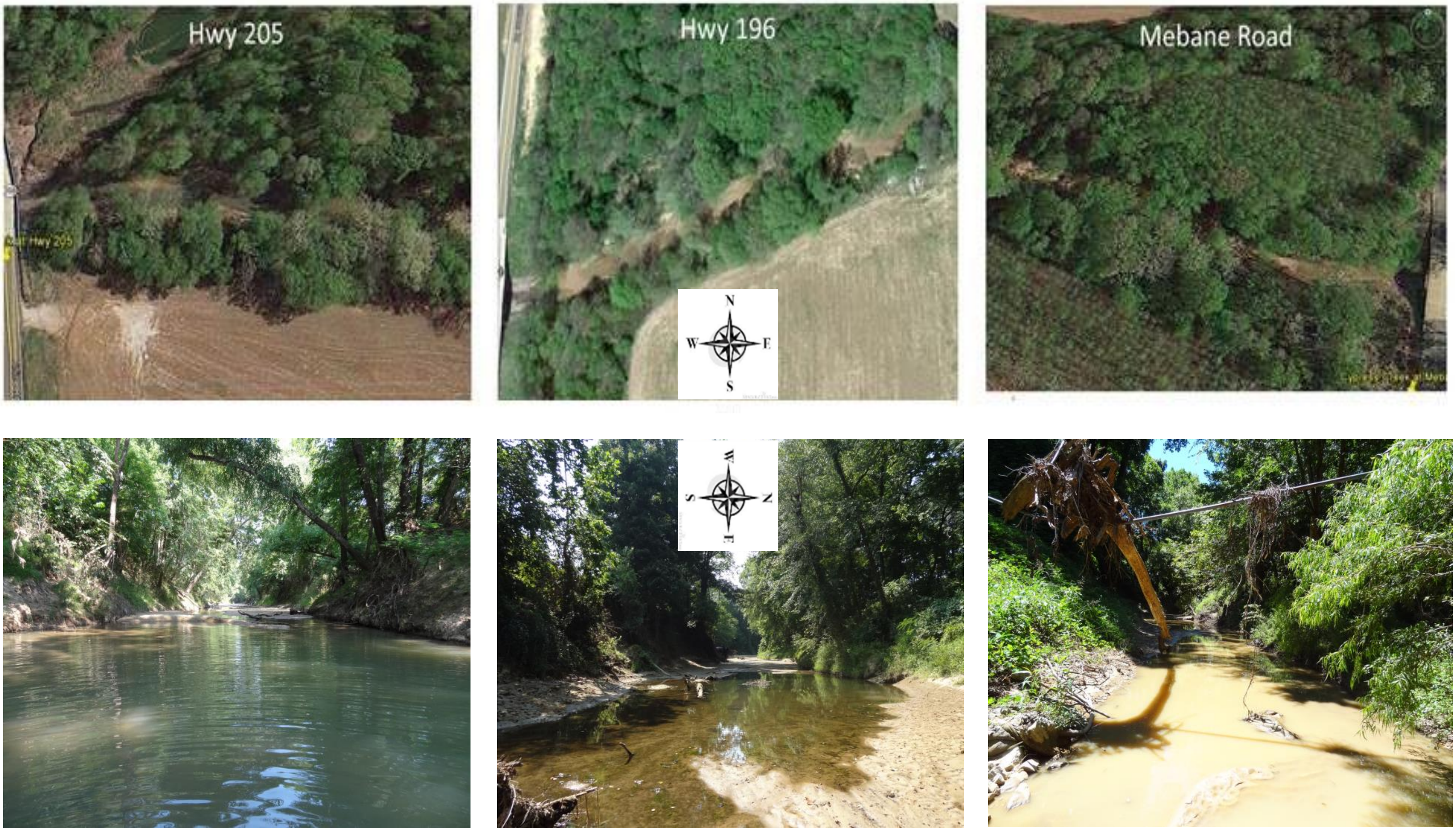


Figure 9. Google Earth images of the stream reach (upper panels) and photographs (lower panels) looking downstream from Transect K for three locations at Cypress Creek, Shelby and Fayette County, TN.

Physical Measurements

Thalweg Profile

Thalweg refers to the flow path of water in the deepest part of a stream. Determination of the thalweg might be informative relative to the geological features through which a stream flows, and when monitored over time, could be an indication of changes in stream flow related to stressors or riparian habitat improvements. The thalweg profile is described as a longitudinal survey of the depth of the stream (WSA; U.S. Environmental Protection Agency 2004). A thalweg profile was conducted at each of the three sampling sites. This was accomplished by identifying the deepest part of the stream beginning at Transect K. Distance was measured from the south bank to the deepest part of the water and depth and distance recorded. The crew advanced downstream at 1-m intervals and repeated the measurements until Transect A was reached and the longitudinal profile of the stream was completed.

Cartoon representations of the thalweg profiles are shown in Figure 10 (left panels): the black line is the thalweg. Also on the images are the wetted widths (the streambank-to-streambank distance that contains water, or would contain water under normal flow conditions). In these images, sandbars are also indicated. The thalweg depth is plotted in the right panels of Figure 10. These plots are useful for identifying locations of pools and their longitudinal distances downstream relative to the established transects. Temporal monitoring of these would also be a useful tool for assessing habitat changes and opportunities for habitat improvements.

Thalweg depth measurements for Mebane Road indicated the presence of two pools of at least 1-m depth in the upstream section of the reach. A trendline applied to the measurements indicated that the waters were deeper upstream and tended to get shallower at the downstream part of the reach. This reverse direction of the trendline for the Mebane Road site might be expected, given that its transects were established immediately downstream of a bridge overpass where rip-rap and other bank stabilization methods might have caused pools to develop. Thalweg depth measurements for Hwy 196 also indicated two pools of at least 1 m in depth, but the first was in the upper end of the reach and spanned the H-I transect and the other was in the downstream end of the reach and spanned two (the B-C and C-D) transects. The section of stream between the pools had a thalweg depth of ~0.5 m. The Hwy 196 trendline indicated that the thalweg got deeper as it proceeded downstream, which would be the expected response. The thalweg depth profile for Hwy 205 indicated an inconsistent depth along the reach and indefinite indication of specific pool features. Thus, the trendline for Hwy 205 was relatively flat. Trendlines for the three reaches, while not a statistical analysis, indicated that thalweg depth increased as Cypress Creek proceeded downstream.

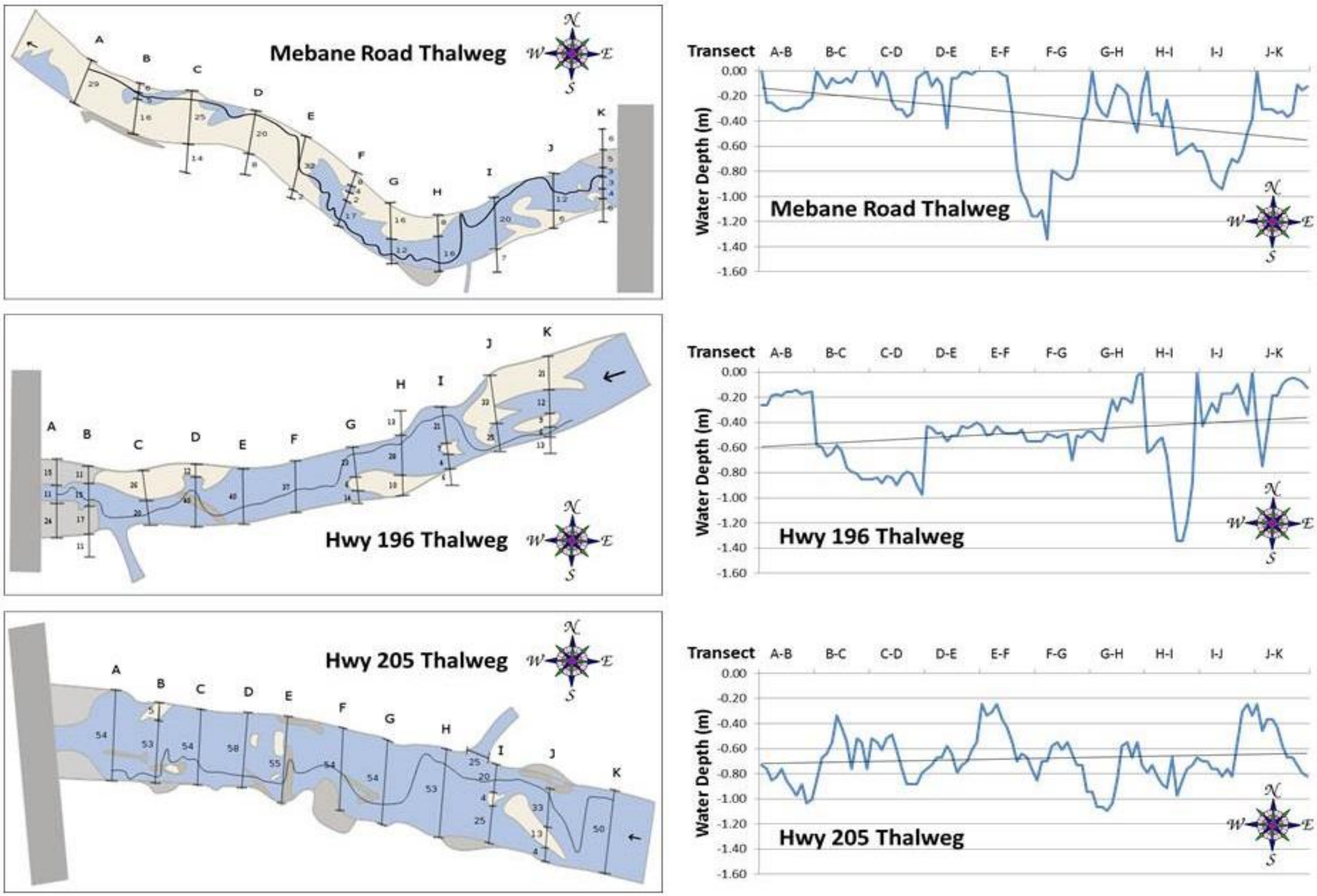


Figure 10. Thalweg (black line; left panels) and thalweg depth (m; right panels) for three locations at Cypress Creek, Shelby and Fayette County, Tennessee. A trendline is indicated in grey on the thalweg water depth.

Substrate Size Class

Substrate size class was identified at each of the 11 transects for the three Cypress Creek locations. Identifying the substrate composition of a stream helps explain the quantity and nature of habitats that might be available, especially for macroinvertebrates and some fish species. At each transect, measurements were taken at cross sections corresponding to left bank, left center, center, right center and right bank (or roughly 0, 25, 50, 75, and 100% of the width of the channel).

The overall predominant substrate size class was sand, representing the only type found at 50.3% of the possible 165 transect cross sections (Table 2). In fact, the smallest substrate types (silt and sand) were the predominant size classes for 83.6% of the stream bottom at all three reaches of Cypress Creek. Silt, sand and fine gravel were the only substrate size classes found at the Mebane Road and Hwy 205 sites, but slightly larger size classes (coarse gravel and cobble) were found in addition to silt and sand at the Hwy 196 site. Small boulder substrate found at the downstream transect of the Hwy 196 site was due to the presence of rip-rap as the reach approached the bridge overpass. Rip-rap was present at all three locations on Cypress Creek to stabilize the banks around bridge pilings, but also provided habitat that was not found elsewhere in the creek.

Table 2. Size class of substrate at transect cross-sections (left bank, left-center, center, right center and right bank) for three locations on Cypress Creek, Shelby and Fayette County, TN

	Mebane Road		Hwy 196		Hwy 205		Overall
Substrate	Transect Cross-Sections						
Size Class	(n)	%	(n)	(%)	(n)	(%)	(%)
FN	0	0.0	11	20.0	6	10.9	10.3
SA	14	25.5	35	63.6	34	61.8	50.3
FN/SA	24	43.6	1	1.8	13	23.6	23.0
GF	1	1.8	0	0.0	1	1.8	1.2
GF/SA	11	20.0	0	0.0	1	1.8	7.3
GC/SA	0	0.0	1	1.8	0	0.0	0.6
CB	0	0.0	2	3.6	0	0.0	1.2
CB/SB	0	0.0	5	9.1	0	0.0	3.0
Missing	5	9.1	0	0.0	0	0.0	3.0
Total (n)	55		55		55		165

FN = Silt / Clay / Muck (not gritty); SA = Sand (gritty; 0.06 to 2 mm); GF = Fine Gravel (2 to 16 mm);
GC = Coarse Gravel (16 to 64 mm); CB - Cobble (64 to 16 mm); SB = Small Boulder (250 to 1000 mm)
Missing = substrate at cross-section not recorded

Not surprisingly, the size classes of substrate that dominated the stream bed of Cypress Creek were silt, sand and fine gravel. This reflects the nature of the highly erodible loess soils of the Coastal Plains physiographic region of west Tennessee and results in relatively homogeneous streambeds. The finer-grained silt identified in the streambed was seemingly sand-based, rather than organic matter or clay, although at times the texture felt like a silt/clay mixture. Clay outcroppings were occasionally noted along exposed stream banks (Figure 11).

Figure 11. Exposed clay layer at Cypress Creek, Shelby and Fayette County, TN. Photo taken at Hwy 196 Transect D.

Bank Measurements

Further assessment of the habitat included measurements of the wetted width, the bar width, the bankfull width and the steepness of each bank. These measurements yield an indication of the stability of the bank and the degree of erosion of the stream material. The abundance and distribution of benthic macroinvertebrates can be determined by a suite of stream measurements, including those mentioned above.

Measurements were taken for each stream site at each of the 11 transects. To measure wetted width, two crew members stood across the stream and recorded the distance of the wetted width as measured with a forester's logging tape. If a sandbar was present across a transect, the crew would measure and record three distances: the distance from the south bank to the sandbar; the width of the sandbar; and the distance from the sandbar to the north bank. A telescoping surveyor's pole was used to measure the steepness of south and north banks at each transect. The base of the pole was placed at the maximum wetted width of the stream and its length was adjusted to give the best approximation of the bank steepness. An i-Phone with a compass function was laid along the length of the pole and the angle was recorded.

The wetted width averaged 7.0, 9.4 and 16.4 m for Mebane Road, Hwy 196, and Hwy 205, respectively (Table 3). Bankfull width similarly increased from upstream to downstream with 8.1, 13.4 and 17.2 m, respectively. The number of exposed sandbars was higher at the Mebane Road and Hwy 196 (n = 7 and n = 6, respectively) upstream reaches compared to just three sandbars for the Hwy 205 site. These results are primarily related to the amount of water that was present at each of the stream reaches, with the two upstream reaches having places where no water flowed, whereas the downstream Hwy 196 had water present in abundance throughout its reach. It was apparent that a least a few of the sandbars at the first two sites were caused by the accumulation of sediment around embedded snags, which of course would provide habitat for aquatic organisms when submerged for some time.

The average steepness of both stream banks appeared to increase as the stream reaches progressed downstream (Table 3). Bank angles in the Hwy 205 reach were at least one-third steeper than for the Mebane Road site. The north (right) banks had consistently, although perhaps not statistically, higher angles than the south (left) banks. Higher bank angles downstream may reflect the higher energy of water flow during flooding events that have eroded the susceptible soils as the stream has become wider and deeper downstream, a self-perpetuating effect of past channelization efforts.

Table 3. Summary of bank measurements for three locations at Cypress Creek, Shelby and Fayette County, TN.

	Mebane Road				
	Angle (Lft °)	Angle (Rgt °)	Wetted Width (m)	Bar Width (m)	Bankfull Width (m)
Low	27	20	3.0	1.2	6.7
High	75	80	10.1	12.2	10.7
Average	46	48	7.0	4.9	9.1
				n=7	
	Hwy 196				
	Angle (Lft °)	Angle (Rgt °)	Wetted Width (m)	Bar Width (m)	Bankfull Width (m)
Low	14	20	2.7	2.0	11.6
High	80	85	13.0	10.7	15.8
Average	50	58	9.4	5.6	13.4
				n=6	
	Hwy 205				
	Angle (Lft °)	Angle (Rgt °)	Wetted Width (m)	Bar Width (m)	Bankfull Width (m)
Low	30	58	15.2	1.2	15.2
High	80	85	17.7	4.0	18.3
Average	63	73	16.4	2.2	17.2
				n=3	

Canopy Closure

Measurements of the amount of vegetation over and along a stream help indicate conditions that reflect bank stability and the potential for organic input into the habitat. Overhead vegetation helps moderate stream temperatures and shading provides cover for cryptic species, while organic material becomes food for various organisms and provides structure for a more complex habitat. Mid-channel measurements may represent more stable and long-term vegetation occupants such as trees, while stream bank measurements may indicate more ephemeral or opportunistic vegetation. Observations are made at mid-channel and on stream banks to ensure that all vegetation inputs are measured, even when a stream may be wide enough that no canopy is present in the center of the stream.

Canopy closure (%) was estimated using a convex spherical densiometer (Model. A; Lemmon 1957). The densiometer was modified with a taped "V" (after Mulvey et al. 1992, OWEB 1999.) to restrict readings to only a portion of the mirrored surface. This is done to avoid the overlap in measurement of vegetation that occurs when multiple directions are measured while standing at the same point (i.e., stream center). Readings were taken at 0.3 m above the water surface and the densiometer was held level. One reading was taken facing the left bank, four readings were taken in the cardinal directions at channel center and one reading was taken facing the right bank at each of the transects, resulting in 66 observations per location. The four center readings were combined into one to give an average reading for mid-channel. Canopy closure can be expressed as an overall measure for left and right banks and channel center at each location or for the entire study area, as a single value for each location, or as a single value for the entire study area.

For the three locations at Cypress Creek, canopy closure estimates were 82.1, 77.6, and 79.0% for Mebane Road, Hwy 196 and Hwy 205, respectively (Table 4). For the entire study area, canopy closure for the left bank was 82.2%, for channel center was 65.9% and for the right bank 90.6%. Overall canopy closure for the entire study area was estimated at 79.5%. All of these

Table 4. Canopy closure (%) for the left bank, center channel and right bank at each transect for three locations at Cypress Creek, Shelby and Fayette County, TN.

	Canopy Closure (%)[1]								
	Mebane Road			Hwy 196			Hwy 205		
Transect	Left	Center[2]	Right	Left	Center[2]	Right	Left	Center[2]	Right
A	100.0	73.5	100.0	0.0	0.0	0.0	47.1	39.7	100.0
B	94.1	76.5	82.4	88.2	51.5	100.0	94.1	48.5	100.0
C	100.0	80.9	82.4	88.2	39.7	100.0	52.9	41.2	88.2
D	88.2	94.1	100.0	100.0	58.8	100.0	100.0	64.7	82.4
E	94.1	91.2	100.0	100.0	66.2	100.0	82.4	42.6	94.1
F	100.0	82.4	94.1	64.7	69.1	94.1	100.0	41.2	88.2
G	88.2	89.7	94.1	100.0	88.2	94.1	94.1	76.5	100.0
H	76.5	82.4	88.2	100.0	70.6	100.0	94.1	83.8	70.6
I	100.0	75.0	94.1	100.0	77.9	100.0	94.1	76.5	82.4
J	0.0	69.1	88.2	94.1	64.7	100.0	82.4	80.9	88.2
K	0.0	35.3	94.1	100.0	55.9	94.1	94.1	86.8	94.1
Transect[3]	76.5	77.3	92.5	85.0	58.4	89.3	85.0	62.0	89.8
Location[4]		82.1			77.6			79.0	
Direction[5]	82.2				65.9				90.6
Overall[6]					79.5				

[1]Estimated from convex spherical densiometer readings (Model A; Lemmon 1957; modified with taped "V")
[2]Represents the average of four densiometer readings taken in the cardinal directions at mid-channel
[3]Represents the average canopy closure at 11 transects
[4]Represents the overall average canopy closure for the location
[5]Represents the overal average canopy closure for left, center and right of stream
[6]Represents the overall canopy closure for the study area

overall measurements (except for channel center) were within ranges (70-100%) that indicate the canopy was completely closed.

Although canopy closure estimates for each of the reaches indicated that the canopy was essentially closed over the stream, very little organic matter (L. Miller, personal observation) was found during this study. This reflects the fact that Cypress Creek has been channelized, providing very little relief along its path. When flooding events happen, a relatively frequent

Table 5. Fish cover types and amount present (%) in the channel for three locations at Cypress Creek, Shelby and Fayette County, TN. Columns shaded in pink indicate absence of structure type or missing values (–) for that specific transect and rows shaded in grey indicate absence of that specific structure type throughout the reach.

	Mebane Road										
	Cover in Channel (%)										
Transect	A	B	C	D	E	F	G	H	I	J	K
Filamentous algae	0	0	0	0	0	0	0	0	–	0	0
Macrophytes	0	0	0	0	0	0	0	0	–	0	0
Woody Debris (>0.3 m)	0	0	0	0	0	0	0	0	–	<10	0
Brush/Woody Debris (<0.3 m)	0	0	0	0	<10	<10	0	0	–	<10	0
Live Trees or Roots	0	0	0	0	0	0	0	0	–	<10	0
Overhanging Vegetation (? 1 m)	0	0	0	0	0	0	0	0	–	<10	0
Undercut Banks	0	0	0	0	<10	<10	0	<10	–	0	0
Boulders	0	0	0	0	0	0	0	0	–	0	40-75
Artificial Structures	0	0	0	0	0	10-40	0	0	–	0	<10
	Hwy 196										
	Cover in Channel (%)										
Transect	A	B	C	D	E	F	G	H	I	J	K
Filamentous algae	10-40	10-40	0	0	<10	0	–	0	<10	<10	0
Macrophytes	0	0	0	0	0	0	–	0	0	0	0
Woody Debris (>0.3 m)	0	0	0	>75	10-40	0	–	0	0	0	<10
Brush/Woody Debris (<0.3 m)	0	<10	0	0	<10	0	–	0	0	0	<10
Live Trees or Roots	0	0	0	0	0	0	–	0	0	0	0
Overhanging Vegetation (? 1 m)	0	<10	0	0	0	0	–	0	0	0	0
Undercut Banks	0	0	<10	0	<10	0	–	0	0	0	40-75
Boulders	>75	10-40	0	0	0	0	–	0	0	0	0
Artificial Structures	0	0	0	0	0	0	–	0	0	0	0
	Hwy 205										
	Cover in Channel (%)										
Transect	A	B	C	D	E	F	G	H	I	J	K
Filamentous algae	<10	0	0	10-40	0	0	<10	<10	<10	<10	0
Macrophytes	0	0	0	0	0	0	0	0	0	0	0
Woody Debris (>0.3 m)	0	<10	<10	0	10-40	0	10-40	0	0	<10	0
Brush/Woody Debris (<0.3 m)	<10	0	0	0	0	<10	0	0	0	0	10-40
Live Trees or Roots	<10	0	0	<10	0	0	0	0	<10	<10	10-40
Overhanging Vegetation (? 1 m)	<10	0	0	<10	0	0	0	0	0	0	0
Undercut Banks	10-40	0	0	<10	>75	0	>75	10-40	10-40	0	10-40
Boulders	0	0	0	0	0	0	0	0	0	0	0
Artificial Structures	0	0	0	0	0	0	0	0	0	0	0

occurrence in the mid-South, and even in when rain falls in moderate amounts, the stream bottom is scoured of most debris, preventing accumulation of organic matter, and thus reducing this important nutrient input to the Cypress Creek ecosystem.

Cover Type in Channel

As the stream channel widened and deepened and water was more consistently present (that is, moving from the headwaters at Mebane Road to further downstream at Hwy 196 and Hwy 205), higher numbers and types of fish cover were present. Six of 11 transects for Mebane Road were completely devoid of cover types and three of 11 transects had no cover for Hwy 196 (Table 5). At the Hwy 205 site, the most downstream reach and the one with the most water, all 11 transects had some form of fish cover type in the channel.

The Mebane Road stretch of Cypress Creek had the lowest amount of cover available (11 of 99 possibilities or 12%) for fish habitat (Table 5). Fish cover availability was more apparent at the two downstream stretches (17 and 28 possibilities or 17 and 28%, respectively, for Hwy 196 and Hwy 205). Relatively few transects (6) were classified as having heavy (40-75%) or very heavy (>75%) fish cover habitat.

Filamentous algae was absent from Mebane Road, but 5 and 6 of the transects at Hwy 196 and Hwy 205, respectively, had at least sparse (<10) to moderate (10-40%) amounts. Macrophytes were completely absent from all three reaches. These two cover types are foundational imperatives for development of an ecologically diverse habitat and a biologically diverse fauna. Improvements made to increase the opportunity for balanced and beneficial algal and macrophyte colonization will improve Cypress Creek biodiversity.

Water Chemistry

Water chemistry was measured at each location one or more times during the study period (Table 6). Analyses were conducted using the following: Hach Test Kit (Model FF-1A), SPER Scientific pH Meter (Model 840087), and YSI Conductivity and Oxygen Meter (Model PRO 2030).

Water characteristics of this stream reflect those of the region; pH was neutral to slightly basic, alkalinity and hardness were above 40 mg/L of $CaCO_{3,}$ and dissolved oxygen was at concentrations typically above 7 mg/L; conditions that are adequate for the maintenance and growth of aquatic life. Nitrogen in the form of nitrite and ammonia were beneath detectable levels, reflecting the absence of non-point nitrogen contamination at this time from runoff from adjacent agricultural fields. Conductivity measurements were well within the range typical of streams supporting good mixed fisheries (150 and 500 µhos/cm.) Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates (Kemker 2014). Total dissolved solids in the stream are a consequence of

Table 6. Water chemistry analyzed at three sites on Cypress Creek, Shelby and Fayette County, TN.

Water Chemistry Variable	Mebane Road		Hwy 196		Hwy 205
Date	7/23/2014	8/4/2014	7/22/2014	8/4/2014	7/28/2014
Time of Day	11:20	15:30	14:30	10:15	10:45
Temperature (°C)	28	29.9	29	24.9	27
Dissolved Oxygen (mg/L)	6	8.5	10	5.9	7.5
Alkalinity (mg/L $CaCO_3$)	68.4	–	68.4	–	68.4
Hardness (mg/L CaCO3)	51.3	–	85.5	–	68.4
pH	7	8.28	7	7.3	7
Ammonia (mg/L)	–	0	0	0	0
Nitrite (mg/L)	–	0	–	–	0
Conductivity (uS/cm)	–	203.9	–	210.5	–
Total Dissolved Solids (mg/L)	–	121.1	–	123.3	–
Chloride (mg/L)	< 3		<3		< 3

the turbidity resulting from upstream erosion. Flow rates and the turbidity of the stream vary immensely related to rain events, with depths and turbidity increasing many-fold during periods of rain, returning to reduced turbidity and even intermittent flow between rain events.

The U.S. Environmental Protection Agency (2010) lists the water quality assessment status of waterbodies in the Unites States. According to their 2010 assessment of Cypress Creek and its downstream section Clear Creek, the overall status of both waterbodies was classified as "impaired." The status for two uses, fish and aquatic life and recreation, are both considered "impaired," while status for irrigation, livestock watering and wildlife are considered "good." Causes of impairment were listed as 1.) presence of the pathogen *Escherichia coli*, 2.) nutrient level of total phosphorous was high, 3.) the physical substrate and habitat had been altered and 4.) sedimentation, all posing threats or impediments to recreation and aquatic life. The sources of habitat alteration and sedimentation were related to channelization, and water quality issues were the result of livestock grazing and agricultural practices that produce run-off. These status classifications are reported unchanged for the year 2014 (Tennessee Department of Environment and Conservation 2014).

Fish

The number and type of fish assembled in a water body can be indicators of habitat suitability. An index of biotic integrity (IBI) is used to classify the number and types of fish into a single factor that reflects whether a particular habitat is conducive to producing a balanced and robust fish assemblage. Fish were collected at three locations on Cypress Creek in an effort to characterize the fish population and produce an IBI. Fish collection methods included seining and electroshocking using a backpack shocker. Seining was the sole method of collecting fish at the Mebane Road and Hwy 196 sites. Seining and electroshocking were used at the Hwy 205 site. Sections of the stream that had apparently suitable fish habitat were sampled more exhaustively to produce a more complete understanding of the fish assemblage. Fish were identified to species and released back into the water or taken back to the lab for identification.

Table 7. Fish (n) collected at three locations on Cypress Creek, Shelby and Fayette County, Tennessee. Simpson's Index of Diversity (a measure of evenness) is listed at the bottom for each site.

Family		Location			Total
Scientific Name	Common name	Mebane	Hwy 196	Hwy 205	(n)
Atherinopsidae					
Labidesthes sicculus	Brook silverside	–	–	2	2
Catostomidae					
Moxostoma sp.	Redhorse	–	1	–	1
Centrarchidae					
Lepomis cyanellus	Green sunfish	11	43	13	67
Lepomis macrochirus	Bluegill sunfish	12	4	53	69
Micropterus salmoides	Largemouth bass	13	10	6	29
Lepomis Juvenile	Sunfish juv. (unknown sp.)	66	2	–	68
Cyprinidae					
Cyprinella venusta	Blacktail shiner	–	1	15	16
Pimephales vigilax	Bullhead minnow	–	–	22	22
Hybognathus nuchalis	Mississippi silvery minnow	1	–	2	3
Lythrurus umbratilis	Redfin shiner	7	9	1	17
Fundulidae					
Fundulus olivaceus	Blackspotted topminnow	–	7	17	24
Ictaluridae					
Ameiurus natalis	Yellow bullhead	–	–	2	2
Percidae					
Etheostoma gracile	Slough darter	–	–	3	3
Poeciliidae					
Gambusia affinis	Mosquitofish	1	–	13	14
	Total (n)	111	77	149	337
	Simpson's Index (Evenness)	0.613	0.654	0.816	

Fish were present at all three locations on Cypress Creek. Eight families were represented among the 14 species identified (Table 7). Numbers of fish were greatest at the downstream Hwy 205 site (n=149), intermediate numbers were found at the upstream Mebane Road site (n=111) and the least number of fish (n=77) were collected at the mid-stream Hwy 196 site. Centrarchids (sunfishes and basses) and cyprinids (minnows) represented the majority of fish (69.1 and 17.2%, respectively) collected across all sites, but most of the cyprinids were found at the Hwy 205 location. Largemouth bass *Micropterus salmoides*, the top predator, were captured at all three sites, but they represented a relatively small percentage of the number of fish present (4, 13 and 11% for Hwy 205, Hwy 196 and Mebane Road, respectively; Table 7).

Simpson's Index of Diversity was calculated and presented for each site in Table 7. A value of "1" equals perfect evenness. The Mebane site and Hwy 196 site both had a value in the 0.6 range and the Hwy 205 site had a much higher value of 0.816. At each site, a single dominant fish was present in much higher numbers than the other species that were sampled. At the Hwy 205 site the dominant fish was green sunfish. The Hwy 196 site was dominated by bluegill. The Mebane Road site was dominated by juvenile sunfish. Other species that were recorded from these sites were in much lower abundance.

Four species were present at all three locations, five species were found at two locations, and five species were present at only one of the three locations (Figure 12). The Hwy 205 location represented the most diverse number of species collected (n=12; 85% of all species found were present here), while fish caught at Hwy 196 and Mebane Road sites represented eight and seven species (57 and 50%, respectively) for about half of the diversity of fish species collected. Bluegill *Lepomis macrochirus* were the most prevalent species of fish at Hwy 205 (36%), green sunfish *L. cyanellus* were the most prevalent species at Hwy 196 (56%) and unidentified juvenile sunfish were the most prevalent species at Mebane Road (59%).

Fish community assessment was accomplished by using an Index of Biotic Integrity (IBI) as established by Karr et al (1986). The IBI score over all three sites (46; Table 8) indicated that Cypress Creek is "moderately impaired", while the range of scores at each site (38-42) indicated the three locations were each "degraded". Of the 14 species of fish collected, 11 were insectivores, two were omnivores (Yellow bullhead *Ameiurus natalis* and Mississippi silvery minnow *Hybognathus nuchalis*) and one was a piscivore (Largemouth bass). The slough darter *Etheostoma gracile* was represented by only three individuals collected at the Hwy 205 site and suckers were represented by only one specimen (Redhorse *Moxistoma sp*.) at the Hwy 196 location. Large numbers of green sunfish were present at all three sites. The IBI varied little between the three sites that were sampled along Cypress Creek. All three values were low with the Hwy 196 and Mebane Road sites being categorized as "poor," while the Hwy 205 site was categorized as "fair". Care must be taken to minimize adverse effects from any mitigation that

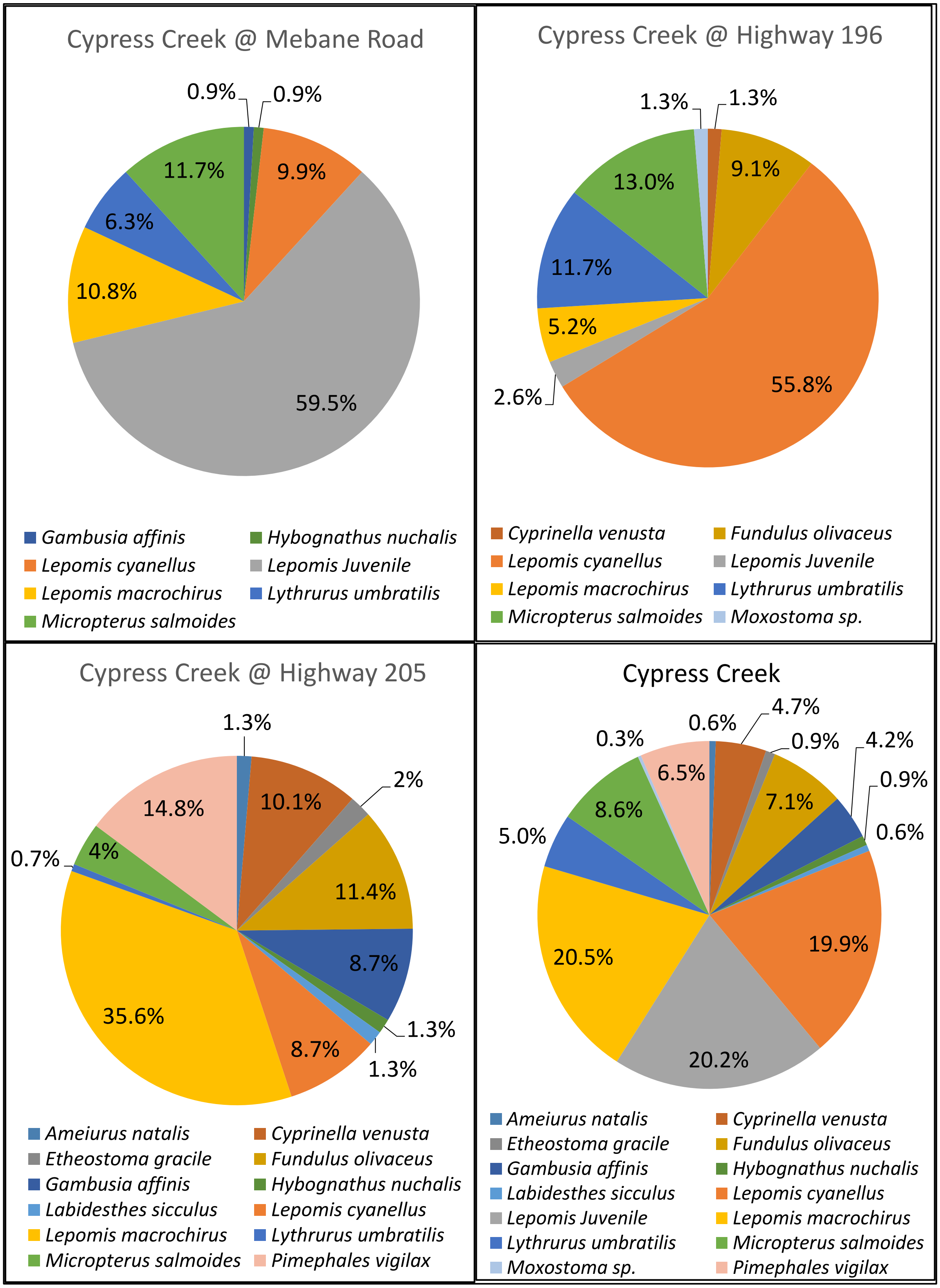


Figure 12. Fish diversity (%) at three locations on Cypress Creek, Shelby and Fayette County, TN.

would actually cause a decrease in the IBI, as in some reported cases, mitigation efforts actually caused a decrease in the IBI and never rebounded.

Table 8. Index of Biotic Integrity (IBI) for fish at three locations on Cypress Creek, Shelby and Fayette County, TN.

Metric		Location Score			
Number	Name	Mebane	Hwy 196	Hwy 205	Overall
Species Richness and Composition					
1	Total number of fish species	3	3	5	5
2	Number of darter species	1	1	3	3
3	Number of sunfish species	5	5	5	5
4	Number of sucker species	1	3	1	3
5	Number of intolerant species	1	1	3	3
6	% Green Sunfish	3	1	3	3
Trophic Composition					
7	% Omnivores	5	5	5	5
8	% Insectivorous Cyprinids	1	1	1	1
9	% Top carnivores	5	5	3	5
Fish Abundance and Condition					
10	Number of individuals	3	3	3	3
11	% Hybrids	5	5	5	5
12	% Diseased individuals	5	5	5	5
Fish IBI Score		38	38	42	46

Benthic Macroinvertebrates

Samples for benthic macroinvertebrates were collected at each transect, alternating from left bank to center stream to right bank as work progressed upstream. A 1-m^2 square area was sampled with D-frame nets. Macroinvertebrates were preserved in 70% ethanol and taken back to the science lab at Christian Brothers University for identification. Macroinvertebrates were keyed to the level of genus where possible, or otherwise, to the lowest identifiable taxonomic level.

The total number of organisms found was 1,015, representing twenty-five different taxa of macroinvertebrates across the three locations of Cypress Creek (Table 9). Abundance of organisms increased from the upstream Mebane Road site to the downstream Hwy 205 site. It is possible this difference is related to habitat differences, as water levels were much lower (more dry patches) at the Mebane Road site. Hwy 196 had the highest number of taxa (n=17), Mebane Road had an intermediate number of taxa (n=11) and the lowest number was found at Hwy 205 (n=10). Taxa evenness was greatest at Hwy 196 with a Simpson's Index of 0.697 and the Mebane Road site had the lowest evenness with a Simpson's Index of 0.388.

Table 9. Macroinvertebrates (n) collected at three locations on Cypress Creek, Shelby and Fayette County, TN. Simpson's Index of Diversity (a measure of evenness) is listed at the bottom for each site.

Organism	Location			Total
	Mebane	Hwy 196	Hwy 205	(n)
Chironomidae	99	182	335	616
Chironomidae #2	1	32	75	108
Chironomidae: Ablabesmyia	6	4	0	10
Baetidae: Centroptilum	0	15	43	58
Caenidae: Caenis	6	70	38	114
Ceratopogonidae: Bezzia	0	4	0	4
Chironomidae Pupae	2	11	24	37
Philopotamidae: Chimarra	0	1	0	1
Annelida: Oligochaeta	0	2	0	2
Unknown Caddisfly	0	1	0	1
Anopheles: Culicidae	0	7	0	7
Notonectidae: Notonecta	0	1	0	1
Bivalvia: Sphaeriidae	0	0	6	6
Naucoridae: Pelocoris	0	0	1	1
Unknown	3	0	0	3
Copepoda	1	0	0	1
Nepidae: Water Scorpion	1	2	1	4
Annelida: Hirudinea	0	1	0	1
Hydropsychidae: Cheumatopsyche	0	26	1	27
Hydropsychidae: Hydopsyche	0	3	0	3
Hydroptilidae: Agraylea	0	1	0	1
Chaoboridae:Chaoborus	0	0	1	1
Diptera: Dolicopodidae	2	0	0	2
Gastropoda: Hydrobiidae	5	0	0	5
Ceratopogonidae: Atrichopogon	1	0	0	1
Total (n)	127	363	525	1015
Simpson's Index	0.338	0.697	0.559	

Taxa richness was dominated by chironomids, a tolerant taxa, in all three reaches that were examined (Figure 14). On average, they account for >60% of the total abundance of organisms that were present. Habitat diversity and species richness are correlated (Hutchens et al. 2009), so it is not surprising that the species diversity is so low in Cypress Creek. The majority of the habitat is sand/silt substrate with very little structure available for macroinvertebrates to occupy. An abundance of fine sediment is common in streams such as Cypress Creek which

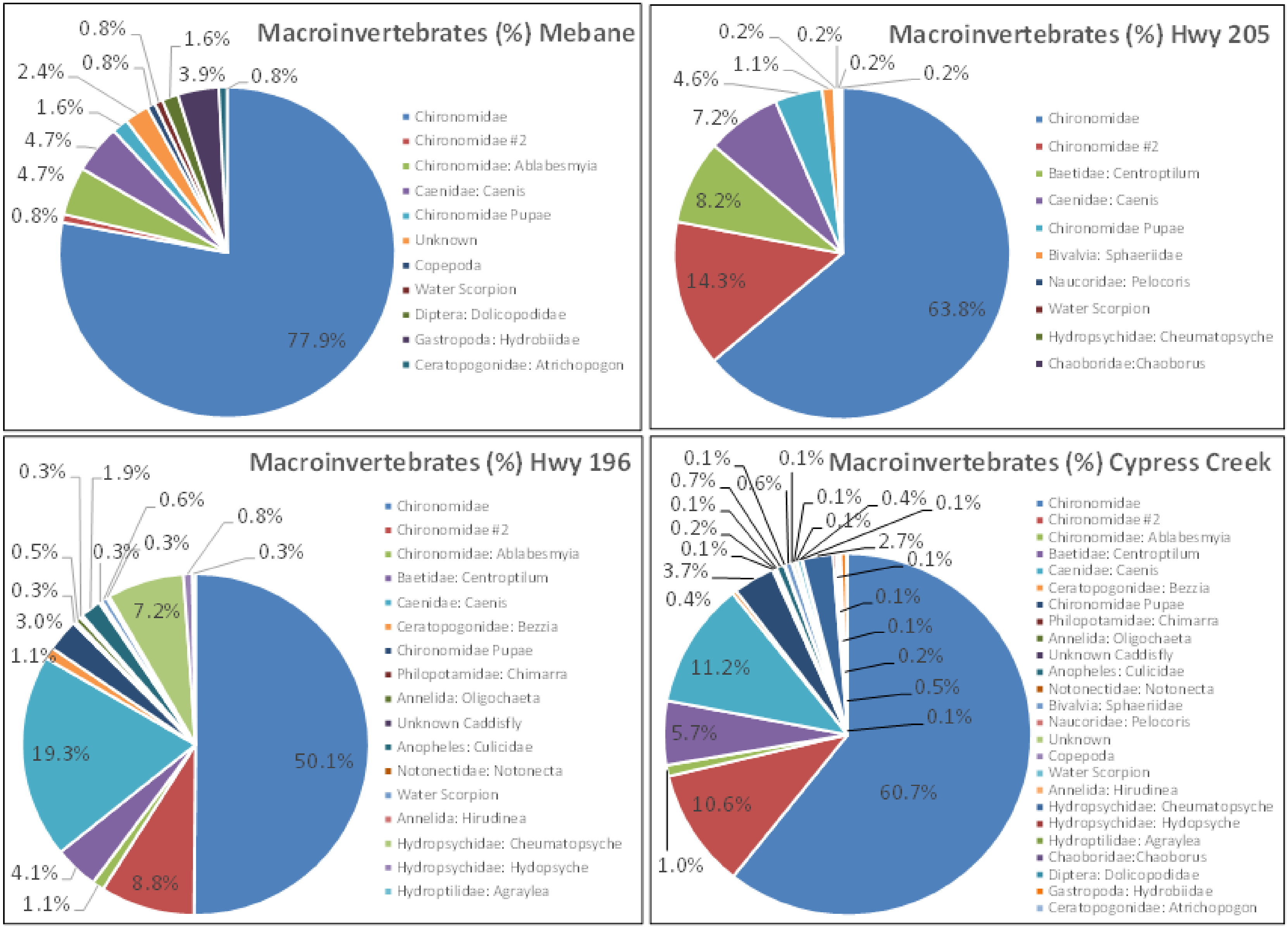


Figure 14. Macroinvertbrate diversity (%) at three locations on Cypress Creek, Shelby and Fayette County, TN.

have been channelized in the past (Landwehr and Rhoads, 2003). This results in an abundance of burrowing taxa such as the chironomids. Total abundance was dominated by collector/gatherers. This functional feeding group represented 93.5% of the individuals at Mebane Road and about 98% of the individuals at the Hwy 205 site. Collector/gathers represented about 88% of the individuals at the Hwy 196 site.

Table 10. Index of Biotic Integrity (IBI) for macroinvertebrates collected at three locations on Cypress Creek, Shelby and Fayette County, TN.

	Location Score			
Metric	Mebane	Hwy 196	Hwy 205	Overall
Taxa Richness and Composition				
Total Number of Taxa	1	3	1	3
Number of Ephemeroptera(mayfly) Taxa	1	1	1	1
Number of Plecoptera (stonefly) Taxa	1	1	1	1
Number of Trichoptera (caddisfly) Taxa	1	3	1	3
Number of long-lived taxa	1	1	1	1
Tolerance				
Number of Intolerant Taxa	1	1	1	1
Percent of Individuals in Tolerant Taxa	1	1	1	1
Feeding Ecology				
Percent of Predator Individuals	1	1	1	1
Number of Clinger Taxa	1	1	1	1
Population Attributes				
Percent Dominance (Top 3 Taxa)	1	1	1	1
Benthic IBI Score	10	14	10	14

A benthic index of biotic integrity (B-IBI) was used to assess macroinvertebrate assemblages. The metrics that were used followed the genus level B-IBI modified from Kerans and Karr (1994). The ten metrics used are shown in Table 10. Sensitive taxa (mayfly, caddisfly and stonefly; EPT taxa) were absent, in addition to a very low percentage of predator macroinvertebrates. Pollution tolerant taxa such as the chironomids are in greatest abundance. This indicates poor quality of water resource and/or habitat. All three reaches of Cypress had low B-IBI scores (range = 10-14) and the overall score of 14 (out of a possible 50) results in a classification of “critically impaired” for Cypress Creek.

Habitat Assessment

A visual-based habitat assessment of each stream reach was conducted to make a general visual assessment of the stream and adjacent area. This assessment recorded observations of catchment and stream characteristics that are useful for data validation, future data interpretation, ecological value assessment, development of associations and verification of

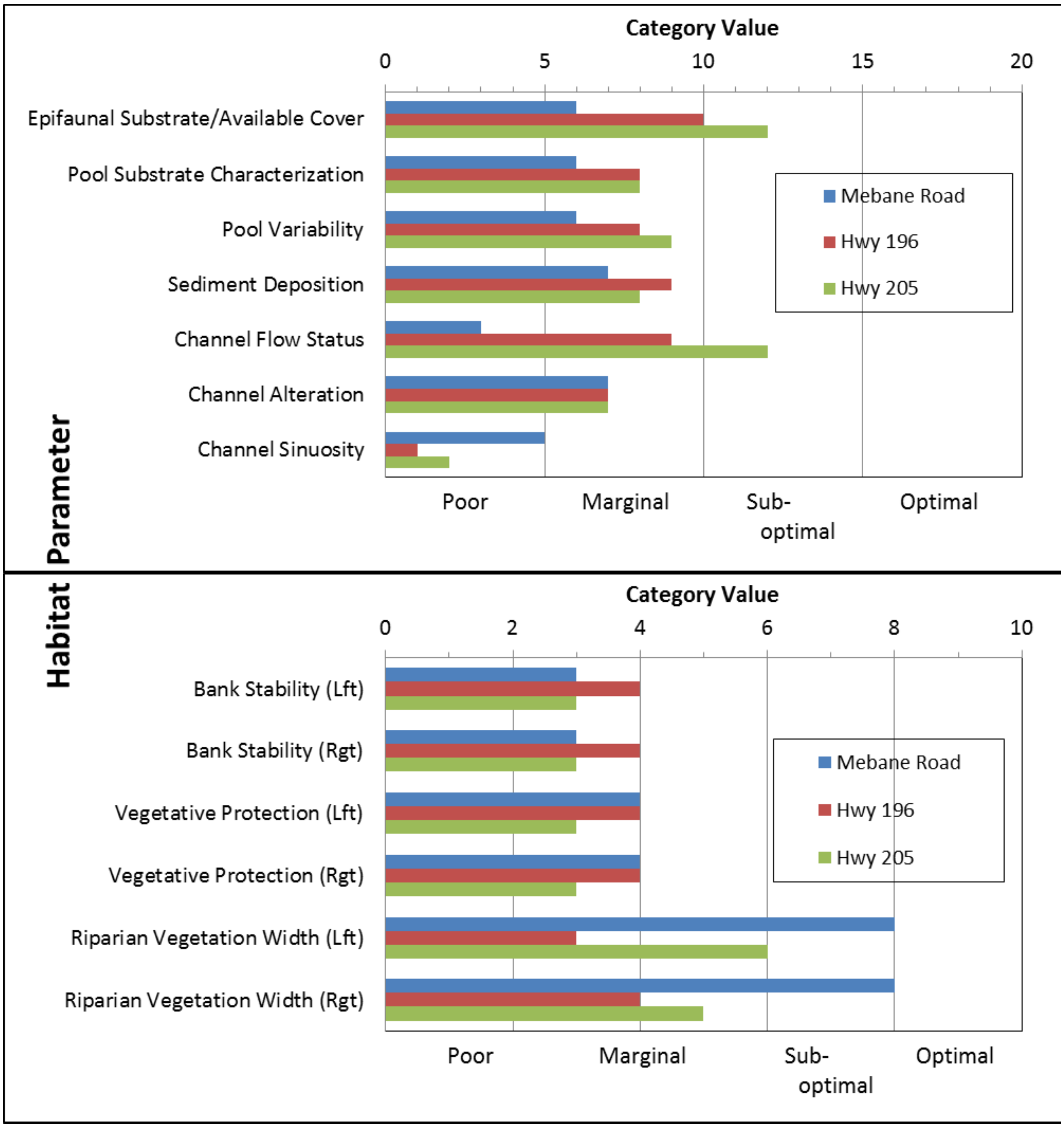


Figure 15. Habitat assessment for three locations on Cypress Creek, Shelby and Fayette County, TN.

stressor data (WAS Field Operations Manual). This assessment was designed for low-gradient streams characterized by glide/pool prevalent streams. These streambeds are dominated by finer substrates (fine gravel or smaller) with occasional areas of coarser sediments along the stream reach.

Habitat assessments were made for the three locations on Cypress Creek (Figure 15). Most variables were assessed as Marginal at each of the localities sampled. Conditions tended to be moderately better downstream during the interval sampled due to greater water depth and continuous flow rather than intermittent flows observed in the upstream sites during periods between significant rain events.

Epifaunal Substrate/Available Cover

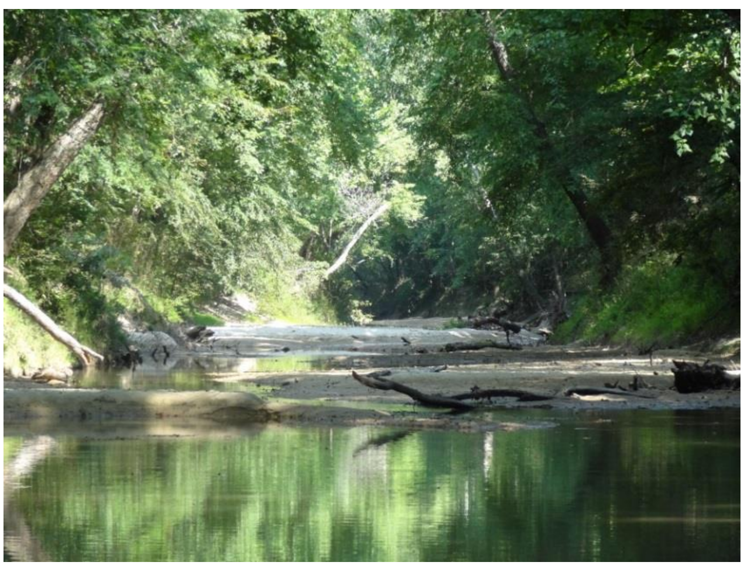
Epifaunal Substrate/Available Cover includes the relative quantity and variety of natural structures in the stream that affect habitat diversity to provide niches for refuge, feeding, and for reproduction of aquatic fauna. Although Cypress Creek offers relatively little habitat diversity in this channelized stream, the variable was considered to improve from “Marginal” to “Sub-optimal” along the length of the stream. The Mebane Road site was considered barely “Marginal” with the stream intermittent in flow and habitat availability less than desirable, and substrates were frequently disturbed or removed. Only 10-30% was considered a mix of stable habitat. Cypress Creek at Highway 196 was considered “Marginal” but somewhat more habitat was available due to continuous water flow, although the substrates were frequently disturbed. Cypress Creek at Highway 205 was considered “Sub-optimal”. Broader water reaches provided more adequate habitat for maintenance of populations than sites sampled upstream. Over 30% of the reach was considered a mixture of stable habitat. In this photo of the Hwy 196 site, the predominant aquatic habitat type is fallen logs. These would provide some habitat structure when submerged. They will cause sediment deposition, altering the water flow pattern and also the pool structure. However, the presence of such a large number of snags is troubling, because it indicates the instability of the stream banks and the long-term loss of natural vegetation as stream banks continue to erode.

Pool Substrate Characterization

Pool Substrate Characterization evaluates the type and condition of bottom substrates found in pools. Substrates with firm substrates and rooted aquatic plants support a wider variety of organisms than substrate dominated by mud, with the absence of plants. Streams with a uniform substrate support fewer types of aquatic organisms than when a variety of substrates are present. This variable was considered "Marginal" at all three sites. The Mebane Road site was considered less desirable than the two downstream sites. All sites had bottoms consisting of mud, clay or sand, with little or no root mat and little to no submerged vegetation. The lack of variability and stability of substrates limits the abundance and variety of aquatic organisms present.

Pool Variability

Pool Variability rates the overall mixture of pool types found in streams according to size and depth. The presence of a variety of pool types supports more diverse populations of aquatic species. Cypress Creek was considered "Marginal" at all three sites, but improved slightly along the length of the stream as water volume increased somewhat in the downstream reaches resulting in larger pool areas. Shallow pools were more prevalent than deep pools at all three sites. The relatively monotonous pool characteristics in Cypress Creek limit the quantity and types of habitat to support a diverse aquatic community. This photo of the Hwy 196 site shows the flatness of the streambed and the formation of wide (mostly shallow) isolated pools that form and can trap organisms during low or no water flow.



Sediment Deposition

Sediment Deposition is a measure of the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition. Cypress Creek was characterized as "Marginal" at all three sample sites as a result of large-scale movement of sediment, particularly during rain events. Islands formed as a result of deposition were more prevalent in upstream areas where stream flow decreased due to the meandering flow in low water areas. Sediment deposition contributes to an unstable and changing environment that becomes less suitable for many organisms.

Channel Flow Status

Channel Flow Status is an expression of the degree to which the channel is filled with water. This measure varied from "Poor" at the upstream Mebane Road site (as can be seen in the photo to the right, extensive portions of this reach were without water) to "Sub-optimal" at the most downstream site sampled. The amount of water in this stream is highly variable due to rain events, increasing many-fold following a rain to water volumes that may even result in the stream being intermittent in flow during dry intervals. At the time of sampling, very little water was present in the channel at the Mebane site and was mostly present as standing pools. Water filled 25-75% of the available channel with some riffle substrate exposed at the intermediate location and water filled over 75% of the available channel with less than 25% of the substrate exposed at the most downstream sampling site. During conditions of lowered water flow, few habitats are available, and conditions following strong rain events result in strong current flows with little protection for aquatic organisms. This high flow removes habitat structure such that over time little habitat diversity remains to support biological diversity.

Channel Alteration

Channel Alteration is a measure of large-scale changes in the shape of the stream channel. Cypress Creek is similar to many streams in urban and agricultural areas that have been straightened and deepened for flood control. Cypress Creek was characterized as "Marginal" due to the extensive channelization along its length. No concrete or rock revetments were being used to maintain the bank or the creek bed at any of the study sites, except around bridge pilings. Channelization reduces and alters diverse habitats available in naturally flowing streams.

Channel Sinuosity

Channel Sinuosity evaluates the meandering or sinuosity of the stream. Greater sinuosity provides for more diverse habitat and fauna, and the stream is better able to handle surges due to large rain events. This variable was characterized as "Poor" at all three sites sampled due to the straight channel resulting from channelization for a long distance. Following rain events, water moves as a plug flow, resulting in water flowing in a straight pattern contained by the steep banks on each shore. During dry periods, water levels are shallow enough that a meander flow develops in the bottom of the channel. This sinuosity is constrained within the tall banks of the stream. The frequent interruption of the "meander flow" due to rainfall events erases many of the flow patterns that have been established, and the bottoms of the stream are essentially scoured to obliterate these transient flow patterns.

Bank Stability

Bank Stability measures the susceptibility of the stream bank to erosion. Steep banks are considered to be unstable and are more likely to collapse than gently sloping banks. Unstable banks exhibit crumbling, un-vegetated banks with exposed tree roots and exposed soil. This variable was considered "Marginal" at best along both banks in the reaches of Cypress Creek that were sampled. Many of the large tree specimens had exposed root systems and will no doubt succumb to erosion pressure in the near future. Thirty to sixty per cent of the banks exhibited severe signs of erosion. The eroded banks present in Cypress Creed reflect sediment movement, and provide a scarcity of cover and organic input to the stream.

Bank Vegetative Protection

Bank Vegetative Protection measures the protection that plants afford to the stream bank and the near-stream portion of the riparian zone. The presence of root systems stabilizes stream banks, reducing the amount of soil lost to erosion. Vegetative banks provide habitat for fish and aquatic invertebrates. This variable was considered to be "Marginal" on both banks at all three sampling sites. The most downstream site, Highway 205, exhibited patches of bare soil with little vegetative covering. The absence of good vegetative covering on the banks reflects the scouring effects of high water flows and contributes to the erosion of soil into the stream. The lack of peripheral plant growth along the stream provides little habitat coverage for aquatic organisms where the potential for high biodiversity is not realized.

Riparian Vegetation Width

Riparian Vegetation Width measures the extent of natural vegetation from the edge of the stream bank through the riparian zone. This zone may modulate inputs from runoff, reduce erosion and provide habitat and nutrient input into the stream. This variable was similar on both banks for the regions sampled with the upper and lower reaches of the stream reflecting better conditions of classifications as “Sub-optimal” to “Marginal”. These sites had a riparian zone of 12-18 meters with minimal influence of human activity. The right bank (north) had no associated agriculture at the Mebane Road location. The left (south) bank contained kudzu growing in the riparian zone. Chinese privet and kudzu was common at the Highway 205 site. The Intermediate location, Highway 196, had a riparian zone of only 6-12 meters in width and row crops were closely associated with both banks. The left bank had strong stands of cane. The rural road crossing this site had lots of traffic. Some household dumping was present.

Summary of Findings

This report represents the findings of a summer 2014 field study that evaluated fish and macroinvertebrate community assemblages and habitat condition at three sites (Mebane Road, Hwy 196 and Hwy 205, east-to-west, respectively) on Cypress Creek, Shelby and Fayette County, Tennessee, a tributary of the Loosahatchie River. The Wadeable Streams Assessment protocols developed by EPA were used for the evaluation. Omitted from the assessment were measurements related to stream discharge and velocity due to inconsistent stream flow across the reaches. Attempts to sample in June 2014 were aborted due to frequent and relatively severe rainstorms that resulted in water levels that were too high to work safely. However, by the time sampling was conducted in late July, parts of all reaches were without water and it wasn't appropriate to conduct velocity and discharge measurements in remnant pools.

Cypress Creek could be classified as a third-order stream, but it is difficult to accurately judge due to the extensive ditching and channelization conducted in the past to drain land for agriculture. It fits the typical description for a low-gradient loess area F5 stream, as it has a U-shaped cross section with a flat bottom and high, unstable banks. However, as with stream order, ditching and channelization, and resulting hydrological modifications from storm events makes classification based on natural conditions somewhat unreliable.

Stream width varied from an average of ~7 m at the Mebane Road site to ~16 m at the downstream Hwy 205 site. About one-half of the Mebane Road site was complete dry but water covered almost the entire Hwy 205 site. All three sites had at least one lateral stream connection that increased in size from upstream to downstream. The narrower Mebane Road site had a sharp bend that prevented viewing of the entire reach, but the whole site was visible at Hwy 205 which was straight and twice as wide. Vegetation along the stream banks were highly sporadic (due to erosion) and included river cane and several invasive species (kudzu and privet, primarily). Tree species were similar among the sites with dominant species being oaks, sycamore, birch, box elder, and willow, among other riparian species. Tracks and other evidence showed that many non-aquatic organisms (e.g., beaver, coyote, deer, raccoon, heron, swallows, and a variety of amphibians and reptiles) were using or visiting Cypress Creek. Human occupation and visitation (in the form of household dumping and a temporary tent shelter under the Hwy 205 bridge) was also apparent.

Thalweg depth profiles indicated the presence of 1 or 2 ~1-m pools in each of these three stretches of Cypress Creek, but due to erratic water flow, the two upstream sites could not be relied upon for consistent and appropriate aquatic habitat. The dominant substrate size class was sand, and along with silt and fine gravel, comprised ~84% of the sampled stream bottom, reflecting the nature of the highly erodible loess soils of the west Tennessee Coastal Plains physiographic region. Steepness of the stream banks increased from upstream to downstream sites with the right bank usually being steeper than the left bank. Canopy closure was considered complete (>70%) at all three reaches of Cypress Creek, however, very little organic matter was found along the banks or in the channel, indicating that this vital nutrient input is swept away during heavy rain events. Vegetation cover was higher on the right bank compared with the left bank, suggesting an opportunity for restoration on the side of the stream most susceptible to heating from the afternoon sun. Fish cover types in the channel increased from the upstream Mebane Road to the downstream Hwy 205 site, but these still were not abundant or persistent enough to provide stable habitat for aquatic organisms. Water chemistry profiles were within expected ranges for west Tennessee streams, but Cypress Creek has been considered "impaired" for several years due to high phosphorous levels, sedimentation, habitat alteration and the presence of *E. coli*.

A surprisingly high number and diversity of fish species were found during the study (337 fish and 14 species), and evidence of spawning (sunfish beds) was even present – a testament to the resourcefulness and ability of organisms to exploit even marginal habitat when needed. Not surprisingly, the dominant species present, green sunfish, are one of the least desirable, and there was little evidence of a balanced fish population. Simpson's Index of Diversity (a measure of the evenness of species among sites) indicated that they were not even and each site was dominated by a single species of fish. The Index of Biotic Integrity also indicated that habitat was "degraded" to "moderately impaired" for suitable fish assemblages.

Benthic macroinvertebrates followed a similar trend, with over 1000 individuals representing 25 different taxa, and the abundance of organisms increasing from upstream to the downstream site, probably due to water level differences. Taxa richness was dominated by Chironomids, a tolerant taxa that can adapt to the stressful conditions that exist at Cypress Creek. Sensitive macroinvertebrate taxa were completely absent. The benthic Index of Biotic Integrity had an overall low score resulting in a classification of "critically impaired" for Cypress Creek.

Ten categories of overall habitat structure were visually assessed at each of the three study sites to help define stream characteristics, provide data validation and interpretation and for verification of quantitative data collected. Most of the variables classified out as "poor" or "marginal" for all three of the stream sites studied. As documented by data and photographs in this report, this is reflected in the streambed at all three Cypress Creek study sites being flat and rather monotonous, stream banks that were steep, poorly vegetated and susceptible to erosion, and the availability of little suitable habitat for aquatic organisms.

Recommendations

Because of the erodible nature of streams in these west Tennessee loess soils, the riparian enhancement opportunities are relatively limited. However, activities in specific areas of Cypress Creek, such as bank stabilization or habitat improvement may have some local success. Below are some possible strategies that might be considered.

Stream shade is one factor that both affects stream temperature and is also sensitive to management practices. Providing shade to a stream is one of the most important mechanisms that mitigate potential negative effects of land management. Any improvements that are undertaken at Cypress Creek should either increase shading (particularly on the south bank), or at the least, not alter the permanent stream-side vegetation that currently provides shade. While reduction or complete removal of invasive species is commonly and rightly recommended, at least one invasive plant species (kudzu) contributed somewhat to the ecological service of maintaining bank stability.

While difficult to implement and surely unpopular with land owners, the size of the riparian buffer should be increased, at least on the southern bank of the creek. Appropriate tree species could be planted to provide adequate canopy cover to the stream. This will help moderate summer temperatures, especially when water levels are low, and the shading will provide habitat for cryptic and transient species.

Meanders should be reestablished where possible, especially to have persistent water presence during low flow periods. For example, the section of Cypress Creek west of the confluence of Hall Creek is known as Clear Creek. This section has been channelized, but on Google Earth and other maps (Figure 16), adjacent meanders north and south of the channelized stream are still visible. The channelized portion of the stream could be engineered to divert water to the meanders under normal conditions, but water could overflow a dam during heavy rains to help manage stormwater excess.

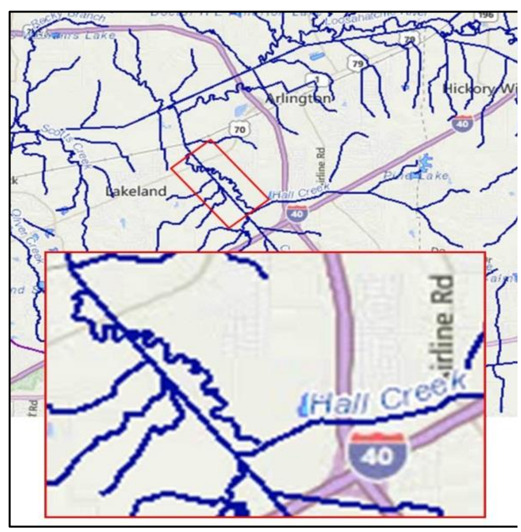


Figure 16. Section of Cypress Creek, Shelby and Fayette County, TN, west of the confluence with Hall Creek, where original meanders might be reestablished. Image from Google® Earth (2014).

Clean Water Act pollution control measures should be enforced to ensure that Cypress Creek is in compliance on a consistent basis for all of its assigned water use categories.

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Appendix C

Hydraulics & Hydrology

Appendix C. Hydraulics and Hydrology

C.1 Introduction

The section and bed slope of the Cypress Creek channel favor the installation of a series of Agricultural Research Service (ARS) low drop structures to obtain the desired project benefits. The ARS low drop structure is a weir and stilling basin made of riprap designed to drop flow a vertical distance less than the critical depth of the design flow through the trapezoidal weir notch. The Vicksburg District of the Corps of Engineers has considerable experience with ARS low drop structures installed in the Demonstration Erosion Control (DEC) Project of northern Mississippi. The Vicksburg District has produced a QMS document *Process for the Design of Low Drop Grade Control Structures*, September 22, 2011, and the structures proportioned for Cypress Creek are based on the guidance in that QMS document.

Twelve ARS low drop structures between Highway 64 and Highway 194 are proposed. The structures are indentified by the prefix CC and the river mile measured from the mouth of Cypress Creek. The line between Shelby and Fayette counties crosses Cypress Creek at mile 6.84. The amount of drop through the structures ranges from 3.0 to 5.0 feet. The average spacing between structures CC-8.15 through CC-12.60 is approximately 3900 feet. The average spacing between structures CC-12.60 through CC-14.47 is approximately 2000 feet. At locations where the channel is not deeply and narrowly incised, the outlet apron of the structures typically is set at the existing thalweg elevation and the crest of the structures is typically set 2 to 3 feet above the elevation at which the section has full bottom width. The straight line slope between the crest of a structure and the outlet apron of the next structure upstream is typically about 0.0005 ft/ft.

Nine additional riprap grade control structures are proposed on tributaries and the far upstream end of Cypress Creek. Channel benching was considered for short reaches of Cypress Creek and Oakland Branch.

The material in the hydraulics and hydrology appendix is presented under the headings of:

- existing conditions
- future-without-project conditions
- future-with-project conditions.

C.2 Existing Conditions

Existing conditions are discussed under the headings of:

- hydrology
- geomorphology
- Cypress Creek channel dimensions and roughness.

C.2.1 Hydrology

The watershed of Cypress Creek upstream of Highway 64 is a mixture of cropland, pasture, woods, residential, and commercial land uses. Soils are primarily of hydrologic group B or C in the USDA TR-55 classification system. Cypress Creek and its tributaries have been channelized, resulting in flashy flows. No hydrologic model such as HEC-HMS was developed for the Cypress Creek watershed. Hydrologic analysis was limited to the estimation of frequency flows based on regression equations for rural West Tennessee published in 2000 by USGS in WRIR 03-4176. The regression equations estimate frequency flow as a function of drainage area only. Subbasin drainage areas, frequency flows, and estimated equilibrium channel slopes are listed in Table C-1. Flows published in the FEMA flood insurance study for Fayette County, Tennessee are listed and agree closely with the USGS regression equation values. The right-most two columns in Table C-1 list channel slopes predicted by the Vicksburg District equilibrium slope equation for streams in the DEC project watersheds, provided in section 7.3 of *Process for the Design of Low Drop Grade Control Structures*.

Table C-1. Drainage Areas, Frequency Flows, and Equilibrium Slopes

Location	Sub Name	Sub Area acre	Cuml Sub Area acre	Cuml Sub Area sq mi	10-Yr FEMA cfs	100-Yr FEMA cfs	2-Yr USGS cfs	10-Yr USGS cfs	100-Yr USGS cfs	MVK Equilb Slope ft/ft	MVK Equilb Slope ft/mi
Cypr Ck @ Hwy 194	B6.1	4125	4125	6.45			1164	2064	3153	0.0021	11.0
Cypr Ck u/s confl w/Oakland Br	B6.2	3520	7645	11.95			1611	2904	4496	0.0017	8.8
Oakland Br @ Hwy 194	B1	405	405	0.63			343	570	830		
Oakland Br @ Hwy 64	B2	290	695	1.09			455	769	1132		
Oakland Br u/s abandoned RR	B3	135	830	1.30			500	849	1254		
Oakland Br d/s abandoned RR	B4	415	1245	1.95			619	1063	1583		
Oakland Br mouth	B5	155	1400	2.19			659	1134	1694		
Cypr Ck d/s confl w/ Oakland Br	Combo		9045	14.13			1761	3188	4952	0.0016	8.2
Cypr Ck d/s confl w/ unnamed trib sta 23200 ft	B7	3885	12930	20.20			2125	3886	6082	0.0014	7.2
Cypr Ck @ Hwy 196	B8	2670	15600	24.38	4140	6495	2346	4312	6775	0.0013	6.7
Cypr Ck @ abandoned RR	B9.1	4635	20235	31.62	4862	7675	2691	4980	7868	0.0012	6.1
Cypr Ck @ Hwy 64	B9.2	2950	23185	36.23	5209	8244	2891	5370	8509	0.0011	5.8
Cypr Ck @ co. line	B10	1150	24335	38.02	5419	8588	2966	5516	8749	0.0011	5.7

C.2.2 Geomorphology

The channelization of Cypress Creek and its tributaries has resulted in channel incision, bank sloughing, and bridge scour. 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, Melbane Road, and Highway 194 have been riprapped to resist continuing attack.

C.2.3 Cypress Creek Channel Dimensions and Roughness

In the Spring of 2015, 16 cross sections were obtained along the channel of Cypress Creek from the Shelby County line upstream to Highway 194. Plate C-1 is a location map of the sections. Plates C-2 through C-17 are plots of Sections 1-16, respectively. Sections 12-15 indicate active channel incision. Approximate 2015 channel dimensions are listed in Table C-2. No bridge survey data were collected.

Table C-2. 2015 Channel Sections

Location	Section Name	Station (Dist from Co. Line) ft	Top Bank Elev ft	Thalweg Elev ft	Depth ft	Top Width ft	Bottom Width ft
u/s county line	1	200	291	271	20	100	60
d/s Hwy 64	2	2400	291	271	20	100	60
u/s Hwy 64	3	3200	292	271	21	100	60
	4	7100	296	273	23	100	50
d/s abandoned RR	5	11400	302	278	24	100	50
u/s abandoned Rd	6	13200	303	281	22	110	40
d/s Hwy 196	7	16500	308	284	24	110	50
u/s Hwy 196	8	17200	308	287	21	100	40
	9	22400	317	295	22	100	40
	10	27500	324	300	24	100	40
d/s confl w/ Oakland Br	11	30200	329	305	24	110	30
d/s Mebane Rd	12	31500	331	307	24	110	30
u/s Mebane Rd	13	32500	332	308	24	90	30
	14	36500	343	317	26	100	10
d/s Hwy 194	15	39500	350	325	25	90	35
u/s Hwy 194	16	40200	353	338	15	70	30

No attempt was made to characterize the roughness of the channel by estimating Manning N-values. However, photographs provided by the surveyor should prove useful in estimating roughness during the feasibility phase of the project. The channel generally has a smooth sand bed. The sideslopes are composed of fine-grained cohesive soil and are steep, irregular, and vegetated with weeds and brush. Trees along top of bank shade the sideslopes. Trees that have fallen into the channel are obstacles to flow, roughen the bed, and cause bank erosion.

C.3 Future-without-Project Condition

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. No attempt has been made to estimate future-without-project and future-with-project hydrology. However, relative comparisons between future-without-project and future-with-project conditions should be similar using current or future hydrology.

The future-without-project condition will affect the hydrologic character and the geomorphic condition of the project area. Regarding hydrologic character, the channel between mile 8.15 and 14.47 on the Cypress Creek channel will continue to exhibit the flashiness of a channelized stream. Regarding geomorphic condition, the Cypress Creek channel between mile 10.00 and 14.47 will continue to incise, accompanied by sideslope collapse and bridge scour. Moreover, without the installation of the tributary structures, head cutting will continue unchecked and excessive quantities of sediment will be delivered to the Cypress Creek main channel.

C.4 Future-with-Project Conditions (Project Alternative)

Future-with-project conditions are discussed under the headings of:

- Cypress Creek ARS low drop structures
- tributary grade control structures
- benches.

Plates C-18 through C-23 are quad maps showing the locations of structures.

C.4.1 Cypress Creek ARS Low Drop Structures

No HEC-RAS model was developed for Cypress Creek and tributaries, but a model will be developed for the channel during the feasibility phase of the project. The tentative locations of twelve ARS low drop structures were determined by:

- selecting points along the thalweg where structures will be most effective
- selecting points immediately downstream of public road crossings to facilitate access and maintenance
- selecting points immediately downstream of large tributaries.

The reach from station 0 to 6900 feet includes the Highway 64 bridge and appears to have a stable bed. The most downstream structure, Structure CC-8.15, is located at station 6900 and depends on the stability of the channel bed at the Highway 64 bridge for its own stability. The stability of structures CC-9.04 through CC-14.47 depend on the stability of the structure immediately downstream. Plate C-24 is a profile of the 2015 survey of Cypress Creek and the locations of the 12 ARS low drop structures from CC-8.15 upstream to CC-14.47.

The proportions of the ARS low drop structures were estimated using the channel dimensions indicated by the 2015 survey and the approximate critical depth of the 100-year event. During the feasibility phase of the project, the HEC-RAS model will permit using additional design parameters for finalizing structure proportions, such as the bank-full discharge, the submergence flow, and the 2-year flow. Approximate structure vertical proportions are listed in Table C-3. Approximate structure horizontal proportions are listed in Table C-4. Structure hydraulic parameters are listed in Table C-5. Rough quantities are listed in Table C-6. Plates C-25 through C-28 show an example of the spreadsheet used to calculate proportions and quantities.

Table C-3. Vertical Structure Proportions

Location	Struct No.	Top Bank Elev ft	Crest Elev ft	Outlet Apron Elev ft	Drop H ft
	CC-8.15	295	276.5	271.5	5.0
d/s old RR	CC-9.04	301	283.5	278.5	5.0
d/s Hwy 196	CC-10.00	306	290.5	285.5	5.0
	CC-10.55	311	295.0	291.5	3.5
	CC-11.14	318	299.5	296.5	3.0
	CC-11.85	323	304.0	301.0	3.0
d/s confl w/ Oakland Br	CC-12.60	325	308.5	305.5	3.0
d/s Melbane Rd	CC-12.86	331	314.0	309.0	5.0
	CC-13.21	336	319.5	314.5	5.0
	CC-13.56	341	325.0	320.0	5.0
	CC-14.11	346	331.5	326.0	5.0
d/s Hwy 194	CC-14.47	351	336.5	331.5	5.0

Table C-4. Horizontal Structure Proportions

Location	Struct No.	Sta ft	Dist ft	Length ft	Max Width ft	Bottom Width B ft	Disturbed Area acre
	CC-8.15	6900	n/a	210	240	60	9
d/s old RR	CC-9.04	11600	4700	210	230	50	8
d/s Hwy 196	CC-10.00	16700	5100	210	210	50	8
	CC-10.55	19600	2900	200	200	40	7
	CC-11.14	22700	3100	190	210	40	7
	CC-11.85	26500	3800	180	210	40	7
d/s confl w/ Oakland Br	CC-12.60	30400	3900	190	190	30	6
d/s Melbane Rd	CC-12.86	31800	1400	210	200	30	6
	CC-13.21	33600	1800	210	200	30	6
	CC-13.56	35500	1900	210	200	30	6
	CC-14.11	38400	2900	190	180	30	6
d/s Hwy 194	CC-14.47	40300	1900	190	180	30	6

Table C-5. Structure Hydraulic Parameters

Location	Struct No.	Q100 cfs	Dc100 ft
	CC-8.15	7868	7.0
d/s old RR	CC-9.04	7868	7.5
d/s Hwy 196	CC-10.00	6775	7.0
	CC-10.55	6082	7.5
	CC-11.14	6082	7.5
	CC-11.85	4952	6.5
d/s confl w/ Oakland Br	CC-12.60	4952	7.5
d/s Melbane Rd	CC-12.86	4496	7.0
	CC-13.21	4496	7.0
	CC-13.56	4496	7.0
	CC-14.11	3153	6.0
d/s Hwy 194	CC-14.47	3153	6.0

Table C-6. Rough Quantities

Location	Struct No.	Excav. cu yd	Riprap R200 ton	Riprap R650 ton	Bedding Stone ton	Grout cu yd
	CC-8.15	7000	2100	7000	1200	400
d/s old RR	CC-9.04	7000	2000	6700	1100	400
d/s Hwy 196	CC-10.00	6000	1900	6100	1000	350
	CC-10.55	5000	1700	5400	900	300
	CC-11.14	5000	1700	5600	900	300
	CC-11.85	5000	1600	5200	900	300
d/s confl w/ Oakland Br	CC-12.60	5000	1400	5000	800	250
d/s Melbane Rd	CC-12.86	5000	1400	5600	900	300
	CC-13.21	5000	1400	5600	900	300
	CC-13.56	5000	1400	5500	900	300
	CC-14.11	5000	1300	4900	800	250
d/s Hwy 194	CC-14.47	5000	1300	4800	800	250
		65000	19200	67400	11100	3700

C.4.2 Tributary Grade Control Structures

Nine riprap grade control structures will be installed on tributaries to Cypress Creek and the upstream end of Cypress Creek to reduce the flashiness of flows, resist headcutting, afford protection to highway crossings, and reduce delivery of sediment to Cypress Creek. Upstream of the Shelby-Fayette County line, the larger tributaries of Cypress Creek include Laterals K-T and Clay Branch. Alternate names for Laterals O, U, and V are Bell Branch, Middle Branch, and Oakland Branch, respectively. The grade control structures are listed in Table C-7. Structures are identified by the name of the lateral and the river mile of the structure. Dimensions of a typical tributary structure are listed in Table C-8 and quantities for a typical tributary structure are listed in Table C-9.

Table C-7. Tributary Structures

Tributary	Struct I.D.
Lateral O (Bell Branch)	LatO-0.07
Lateral O (Bell Branch)	LatO-1.39
Lateral O (Bell Branch)	LatO-1.66
Lateral O (Bell Branch)	LatO-2.53
Lateral R	LatR-1.02
Lateral V	LatV-1.72
Lateral W	LatW-0.20
Lateral X	LatX-0.10
Cypress Creek	CC-17.07

Table C-8. Dimensions of a Typical Tributary Structure

Item	Value
crest width	20 ft
control section	40 ft
vertical drop	5 ft
total length	155 ft
sideslopes	3H:1V
riprap thickness	4 ft
topwidth	68 ft
seeding	2 ac

Table C-9. Quantities for a Typical Tributary Structure

Item	Quantities for 1 Typical Structure	Total Quantities (9 Structures)
geotextile	750 sy	6750 sy
riprap class B	1400 ton	12600 ton
riprap class A	600 ton	5400 ton
grout	300 cy	2700 cy
fill	1000 cy	9000 cy
excavation	1000 cy	9000 cy
gravel	200 ton	1800 ton
clearing	1 ac	9 ac
seeding	2 ac	18 ac

C.4.3 Benches

Benching short reaches of Cypress Creek and Oakland Branch was considered. Frequent flows in the channels would cause the benches to be submerged, changing the hydrologic character of the reaches and improving habitat. Benches would be installed on both sides of the channel and be symmetrical.

On Cypress Creek benches would be installed on the upstream side of the 12 ARS low drop structures. The benched reaches would be approximately 500 feet long.

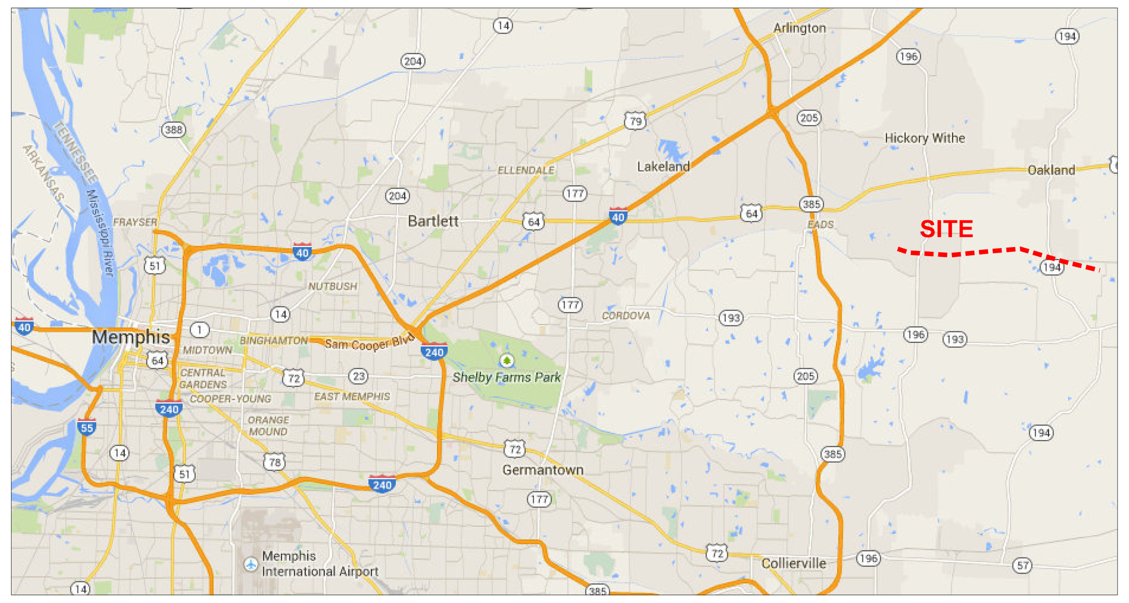
The outlet of Oakland Branch (Lateral V) is at river mile 12.62 on Cypress Creek. ARS low drop structure CC-12.60 will raise the base level of Oakland Branch approximately 5 feet. To improve the hydrologic character of Oakland Branch and increase habitat, both sides of the lateral would be benched from the outlet upstream to river mile 0.19 (1000 feet). Plate C-29 is a section view of typical benches considered for Oakland Branch. The existing channel is approximately 20 feet deep. The left and right benches would be symmetrical, be excavated approximately 8 feet deep below natural ground, and would have cut slopes of 3H:1V. The top width and bottom width of one bench would be 64 and 40 feet, respectively. The topwidth of the channel would be approximately 40 feet at bench elevation. The total topwidth of the channel and both benches would be approximately 168 feet, providing a riparian width of 128 feet.

Table C-10 lists channel benching for Oakland Branch, one typical Cypress Creek site, the total of the 12 Cypress Creek sites, and the total quantities for all the benching work.

Table C-10. Benching Quantities

Item	Oakland Branch	1 Typical Site Cypress Ck	Total of 12 Sites Cypress Ck	Total
clearing	4 ac	2 ac	24 ac	28 ac
excavation	34000 cy	15300 cy	183600 cy	217600 cy
seeding	8 ac	4 ac	48 ac	56 ac
erosion blanket	12000 sy	5500 sy	66000 sy	78000 sy
trees	1300 stems	600 stems	7200 stems	8500 stems
native grasses	2 ac	0.5 ac	6 ac	8 ac
silt fencing	6600 lf	3000 lf	36000 lf	42600 lf
riprap	400 ton	0 ton	0 ton	400 ton
easement	8 ac	2 ac	24 ac	32 ac

VICINITY MAP
not to scale



NOTES:

This Topographic Map was created using the Horizontal and vertical information derived From a field survey based upon random shots And cross-sections and complies with accuracy Required by Tennessee Land Surveyors Laws And Regulation, Effective Date 03-17-2011.

Topcon Hiper Ga L1/l2 with Nomad data-collector Was used collecting data for this site. A static Survey was Made April 23, 2015 and the data was Processed by "Opus" NGS.

Bearing Information

Bearing shown are Referenced to the Tennessee
UTM Zone 16
Datum: NAD 1983.
Vertical Datum: NAVD88

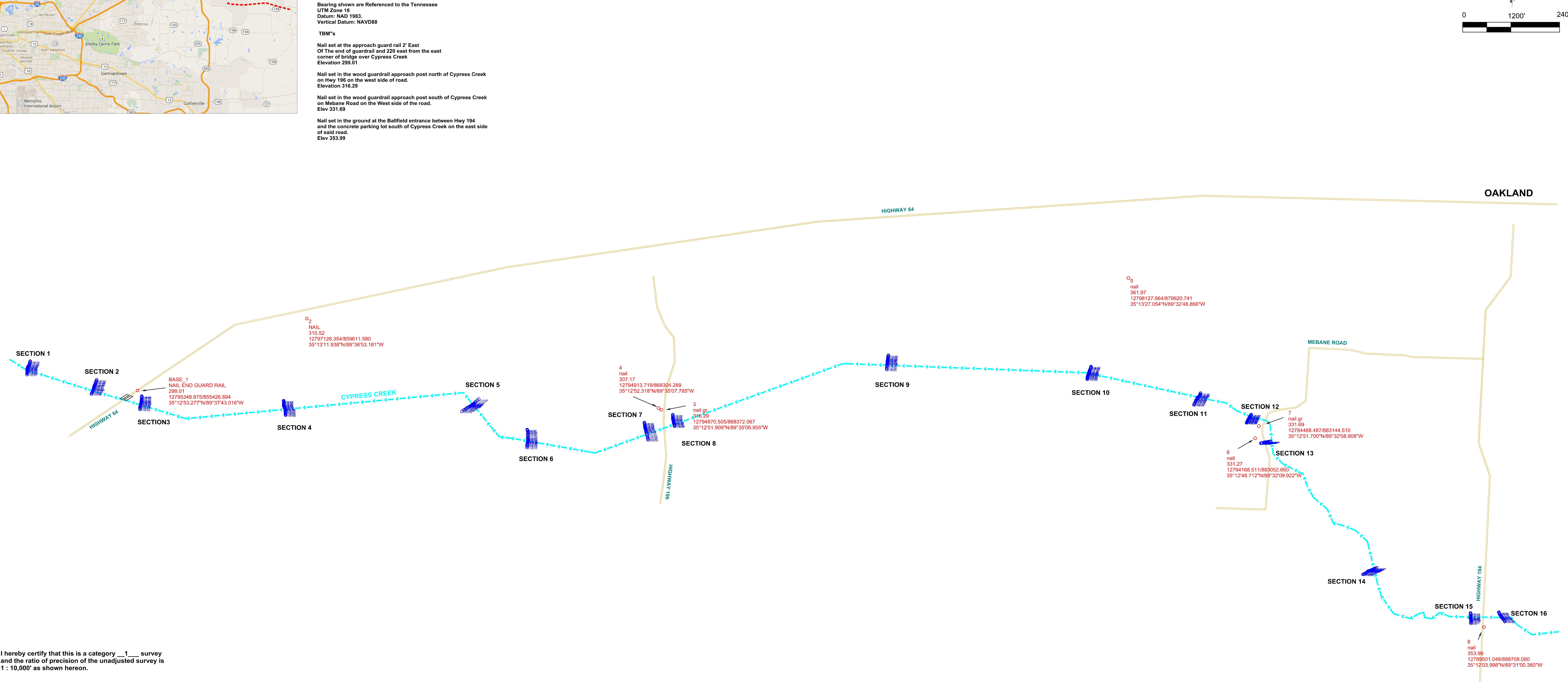
TBM"s

Nail set at the approach guard rail 2' East Of The end of guardrail and 220 east from the east corner of bridge over Cypress Creek
Elevation 299.01

Nail set in the wood guardrail approach post north of Cypress Creek on Hwy 196 on the west side of road.
Elevation 316.29

Nail set in the wood guardrail approach post south of Cypress Creek on Mebane Road on the West side of the road.
Elev 331.69

Nail set in the ground at the Ballfield entrance between Hwy 194 and the concrete parking lot south of Cypress Creek on the east side of said road.
Elev 353.99



I hereby certify that this is a category __1___ survey and the ratio of precision of the unadjusted survey is 1 : 10,000' as shown hereon.

Randall S. Carmack R.L.S. Tn. Reg. No. 1424
1295 Meeks Road Halls, Tennessee 38040
Tel. No (W)(731)836-9363 (C)(731)267-9701

RANDALL S. CARMACK
REGISTERED LAND SURVEYOR
AGRICULTURE COMMERCE
No. 1424
STATE OF TENNESSEE

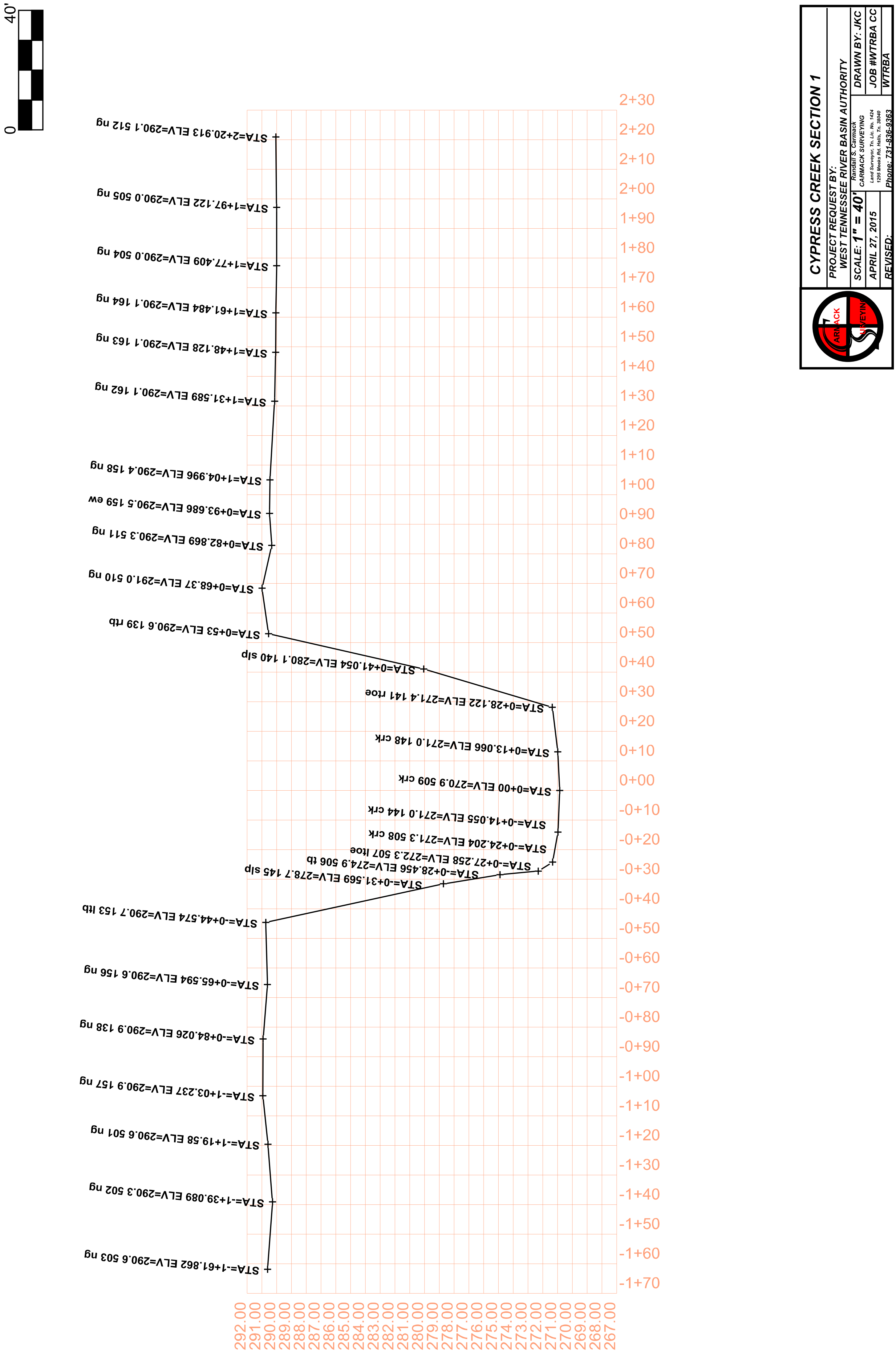
CYPRESS CREEK SECTIONS 1-16

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 1200'	Randall S. Carmack CARMACK SURVEYING Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040 Phone: 731-836-9363	DRAWN BY: JKC
MAY 5, 2015		JOB #WTRBA CC
REVISED:		WTRBA

CARMACK SURVEYING

Traverse PC


CYPRESS CREEK SECTION 1
PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY
SCALE: 1" = 40'
APRIL 27, 2015
REVISED:
Randall S. Carmack
CARMACK SURVEYING
Phone: 731-836-9363
DRAWN BY: JKC
JOB #WTRBA CC
WTRBA
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40'
STA=2+20.913 ELV=290.1 512 ng
STA=1+97.122 ELV=290.0 505 ng
STA=1+77.409 ELV=290.0 504 ng
STA=1+61.484 ELV=290.1 164 ng
STA=1+48.128 ELV=290.1 163 ng
STA=1+31.589 ELV=290.1 162 ng
STA=1+04.996 ELV=290.4 158 ng
STA=0+93.686 ELV=290.5 159 ew
STA=0+82.869 ELV=290.3 511 ng
STA=0+68.37 ELV=291.0 510 ng
STA=0+53 ELV=290.6 139 rtb
STA=0+41.054 ELV=280.1 140 slp
STA=0+28.122 ELV=271.4 141 rtoe
STA=0+13.066 ELV=271.0 148 crk
STA=0+00 ELV=270.9 509 crk
STA=-0+14.055 ELV=271.0 144 crk
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STA=-1+39.089 ELV=290.3 502 ng
STA=-1+61.862 ELV=290.6 503 ng
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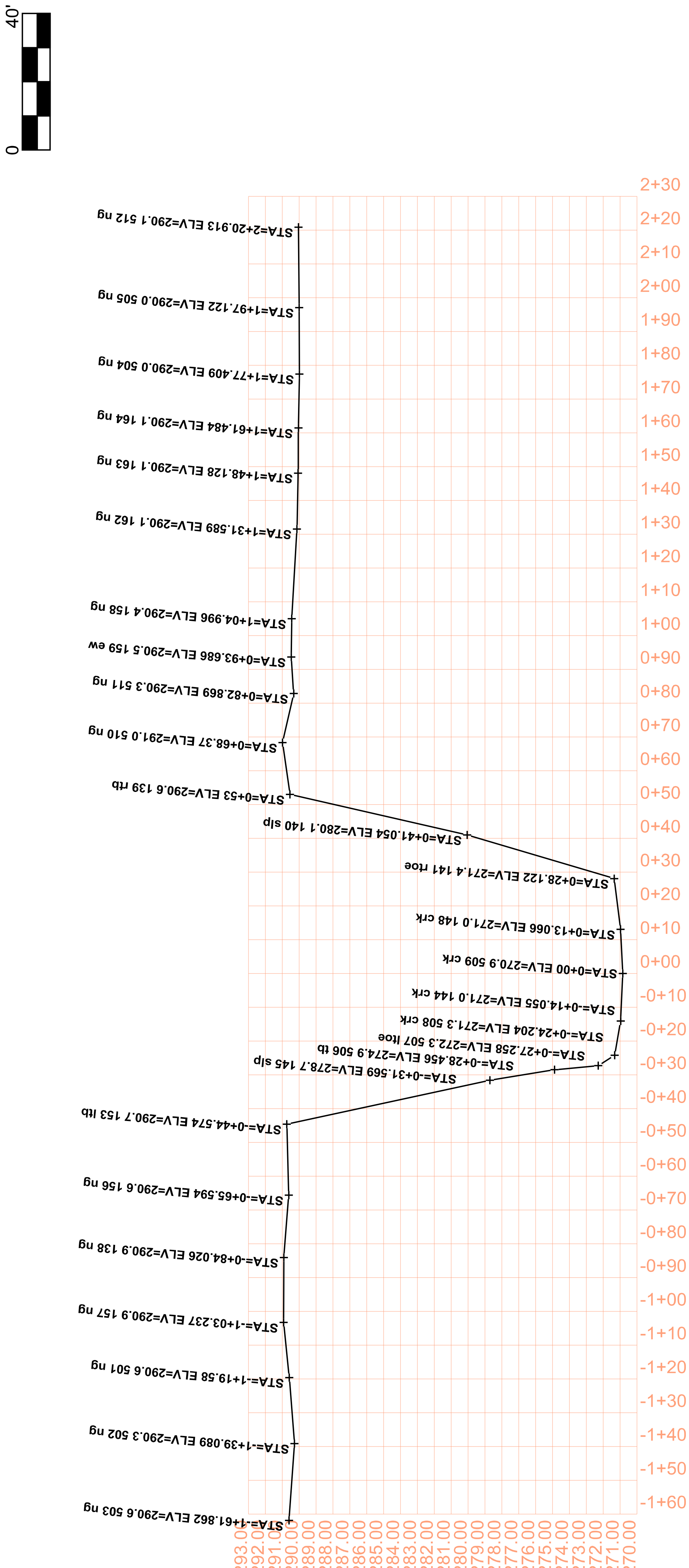
-0+70
-0+80
-0+90
-1+00
-1+10
-1+20
-1+30
-1+40
-1+50
-1+60
-1+70
292.00
291.00
290.00
289.00
288.00
287.00
286.00
285.00
284.00
283.00
282.00
281.00
280.00
279.00
278.00
277.00
276.00
275.00
274.00
273.00
272.00
271.00
270.00
269.00
268.00
267.00

Plate C-2



CYPRESS CREEK SECTION 2

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 40'

APRIL 27, 2015

REVISED:

Randall S. Carmack
CARMACK SURVEYING
Land Surveyor, Tn. Lic. No. 1424
1295 Meeks Rd. Halls, Tn. 38040
Phone: 731-836-9363

DRAWN BY: JKC

JOB #WTRBA CC

WTRBA

Plate C-3

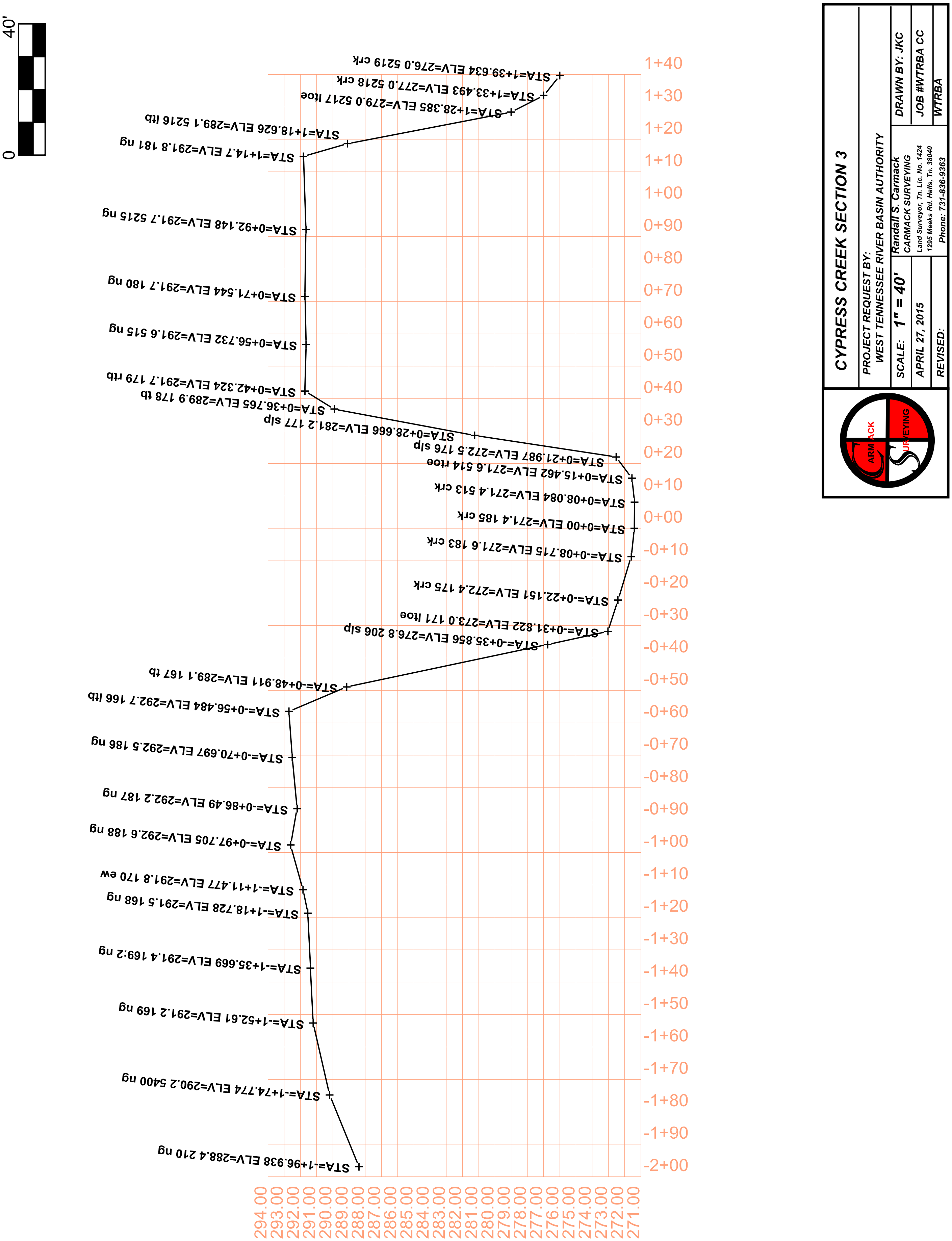
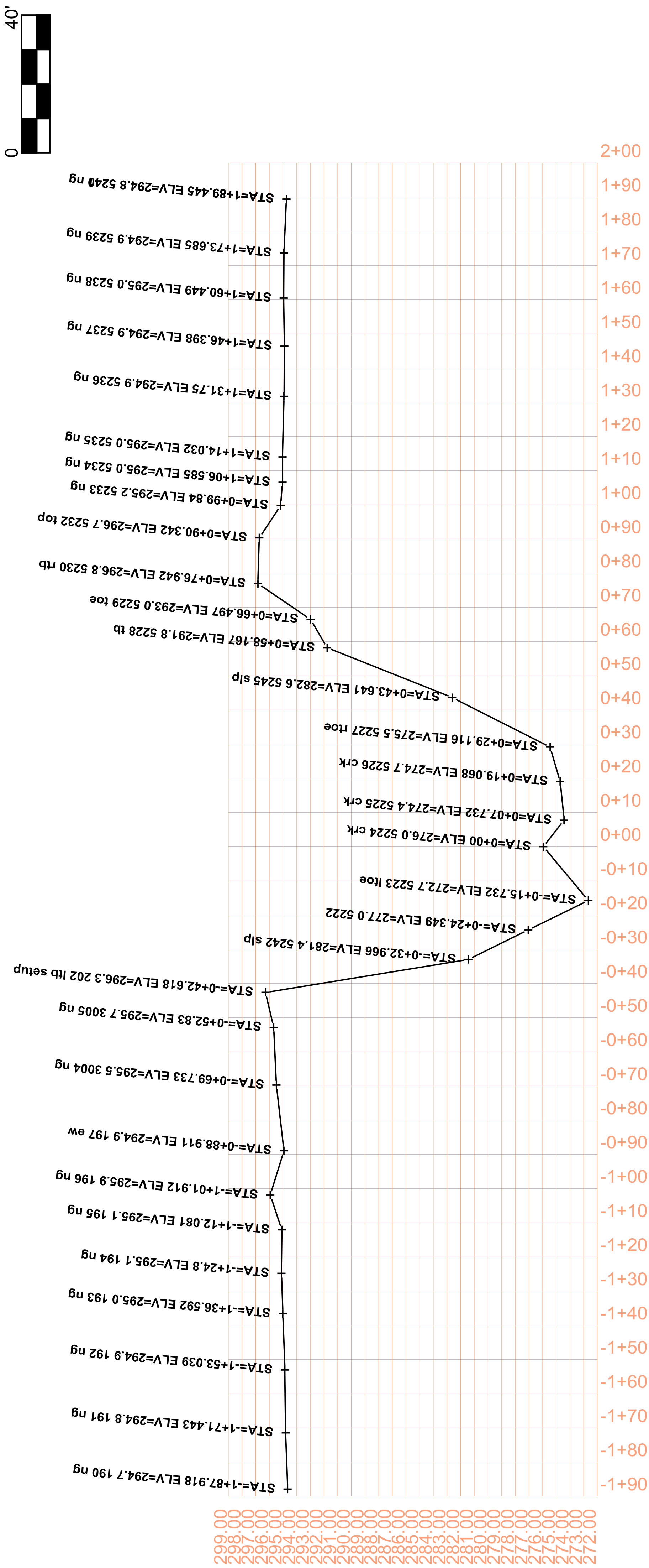


Plate C-4

Traverse PC



CYPRESS CREEK SECTION 4

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 40'
APRIL 27, 2015
REVISED:

Randall S. Carmack
CARMACK SURVEYING
Land Surveyor, Tn. Lic. No. 1424
1295 Meeks Rd. Halls, Tn. 38040
Phone: 731-836-9363

DRAWN BY: JKC
JOB #WTRBA CC
WTRBA

Plate C-5

Traverse PC

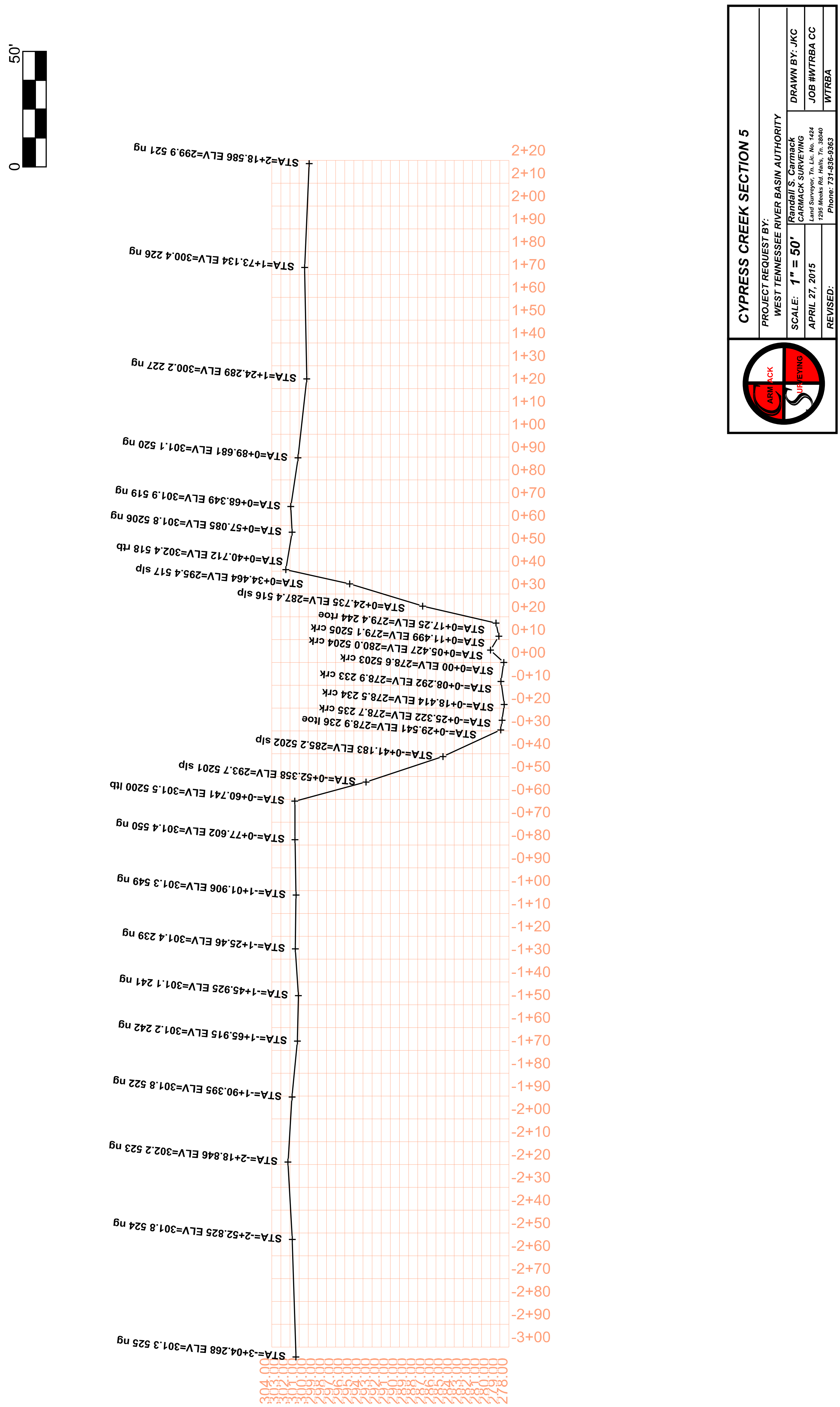
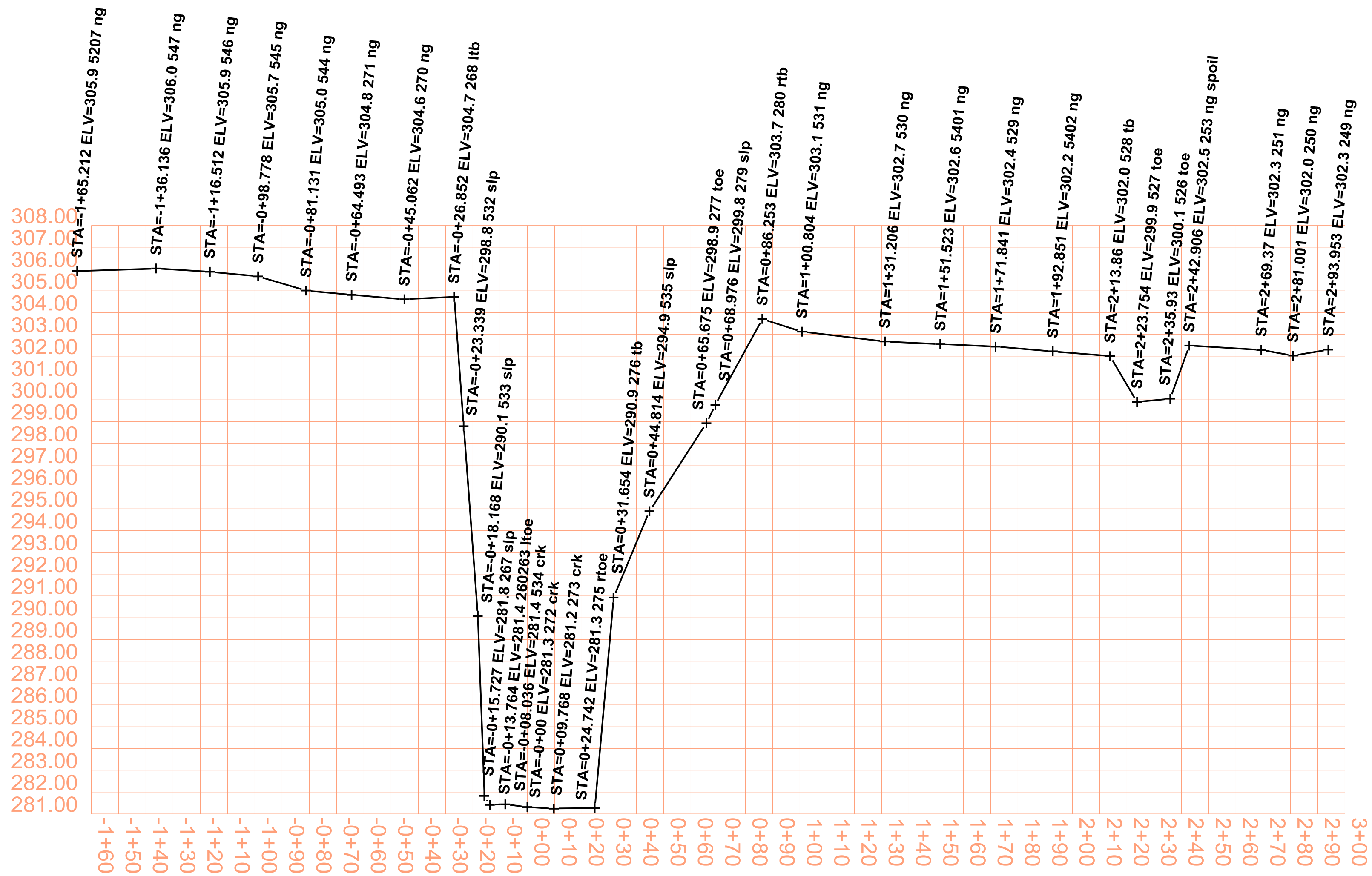


Plate C-6

Traverse PC



0 60'

CYPRESS CREEK SECTION 6

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 60'	Randall S. Carmack CARMACK SURVEYING Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040 Phone: 731-836-9363	DRAWN BY: JKC
APRIL 27, 2015		JOB #WTRBA CC
REVISED:		WTRBA

Plate C-7

Traverse PC

CYPRESS CREEK SECTION 7

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 40'

APRIL 27, 2015

REVISED:

Randall S. Carmack
CARMACK SURVEYING
Land Surveyor, Tn. Lic. No. 1424
1295 Meeks Rd. Halls, Tn. 38040
Phone: 731-836-9363

DRAWN BY: JKC

JOB #WTRBA CC

WTRBA

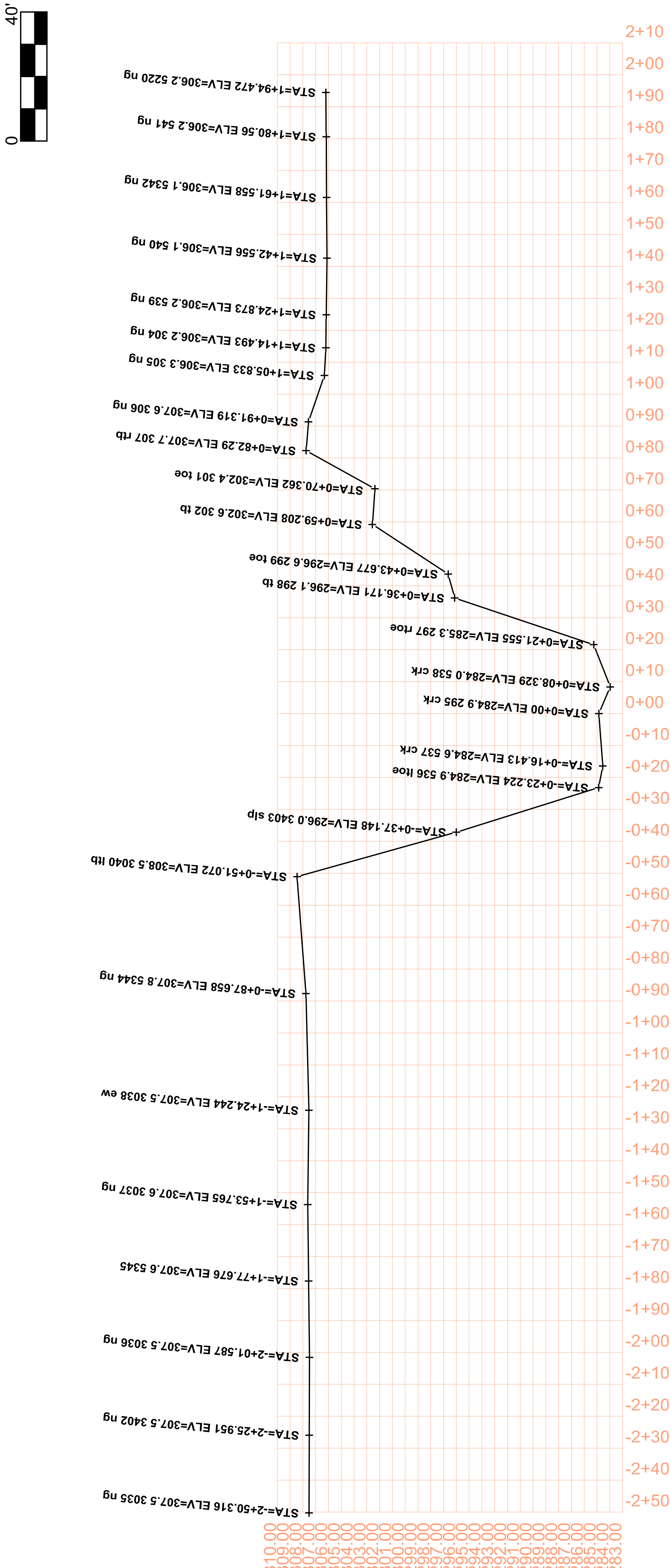


Plate C-8

Traverse PC

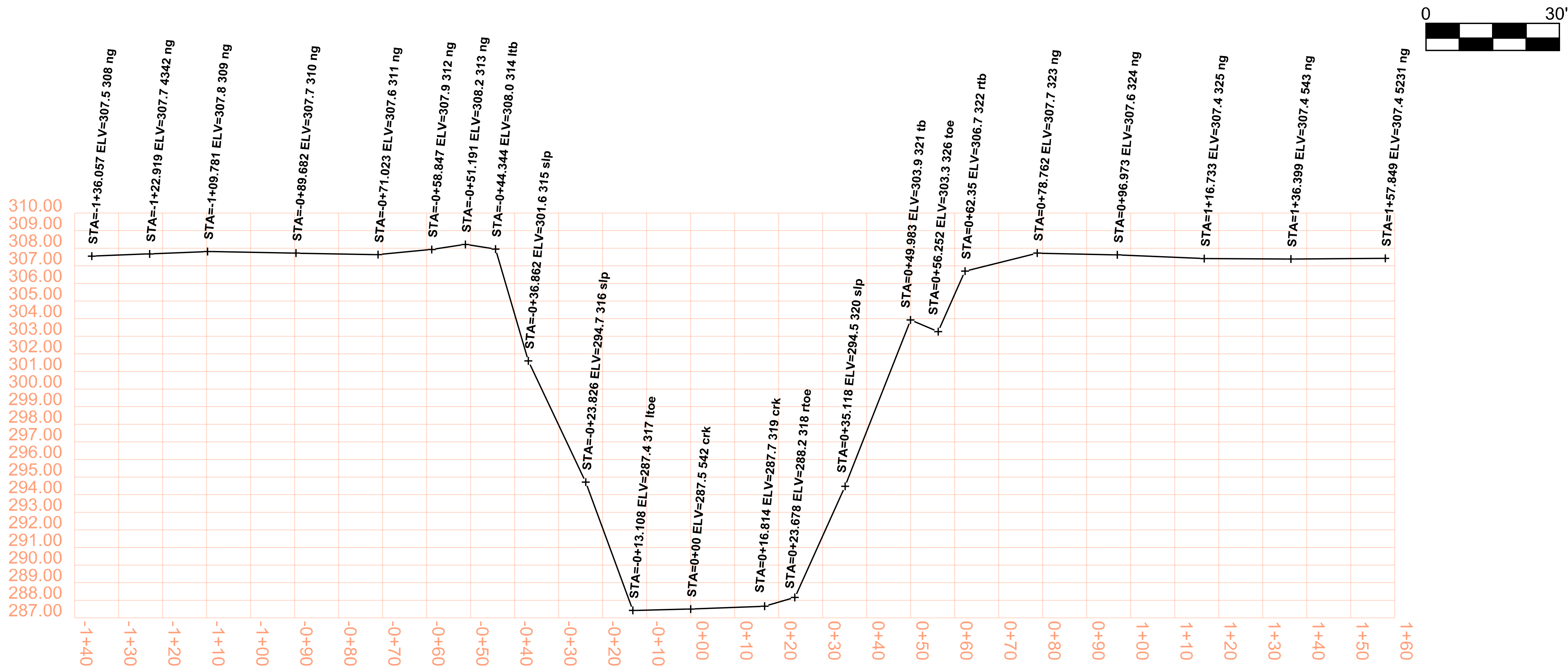


Plate C-9

CYPRESS CREEK SECTION 8

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 30'	Randall S. Carmack CARMACK SURVEYING	DRAWN BY: JKC
APRIL 27, 2015	Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040	JOB #WTRBA CC
REVISED:	Phone: 731-836-9363	WTRBA

Traverse PC

0 40'

CYPRESS CREEK SECTION 9

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 40'
APRIL 27, 2015
REVISED:

Randall S. Carmack
CARMACK SURVEYING
Land Surveyor, Tn. Lic. No. 1424
1295 Meeks Rd. Halls, Tn. 38040
Phone: 731-836-9363

DRAWN BY: JKC
JOB #WTRBA CC
WTRBA

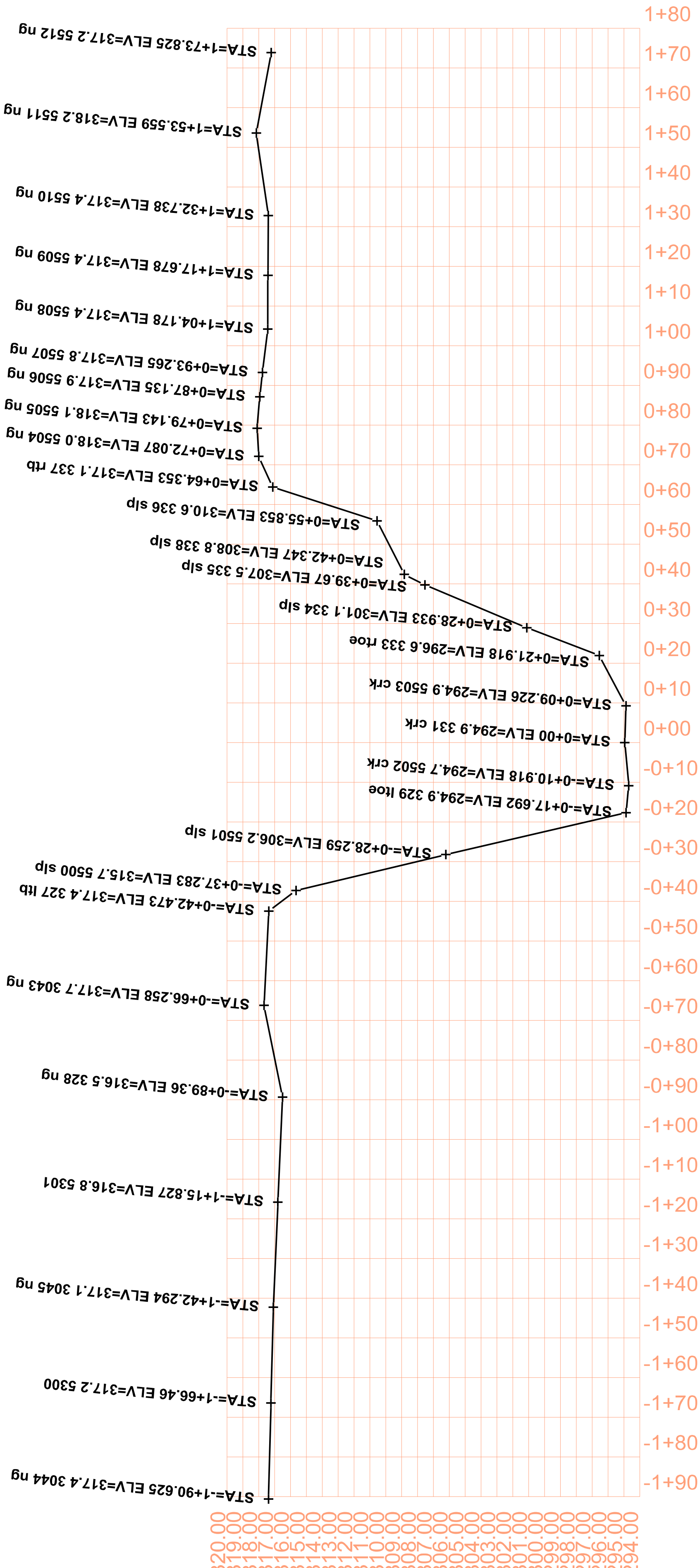
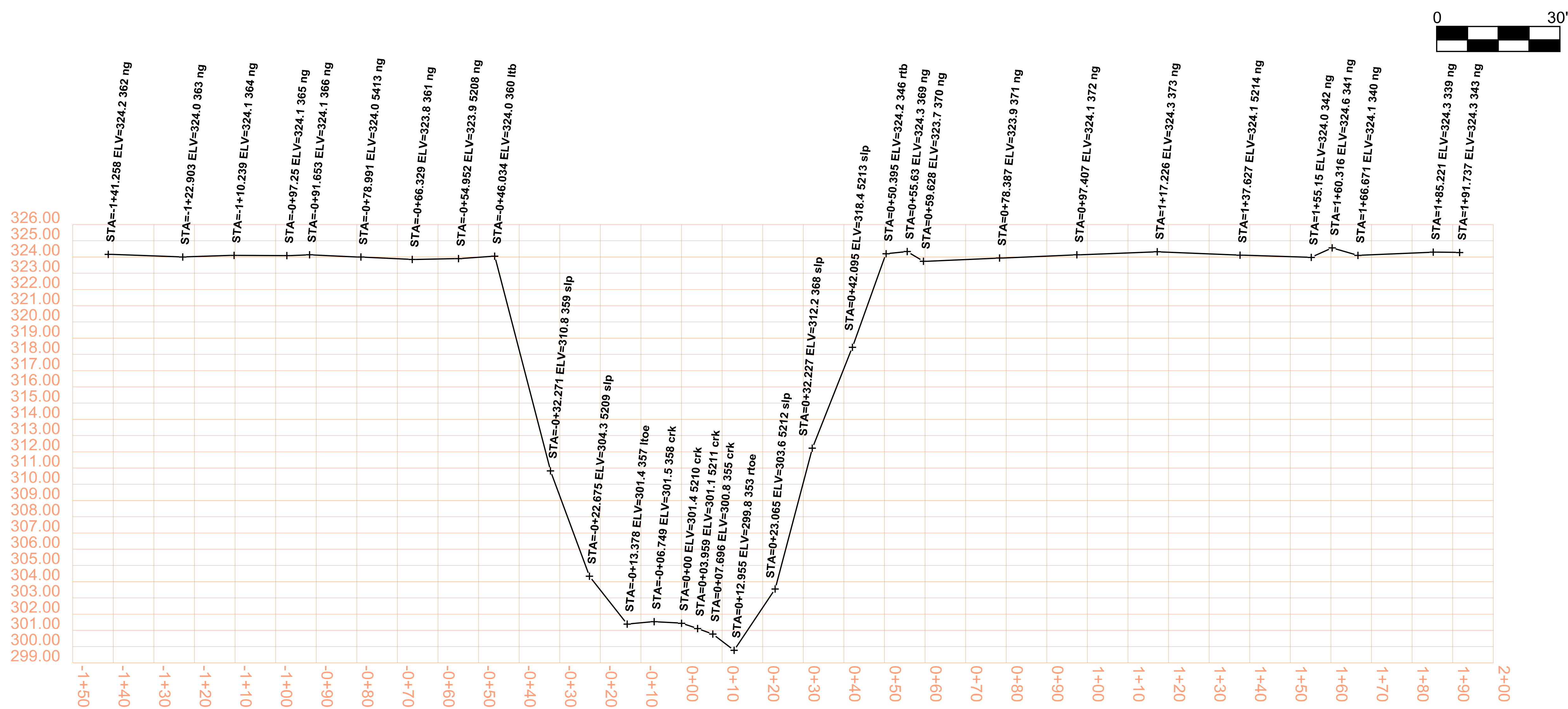


Plate C-10

Traverse PC

Plate C-11



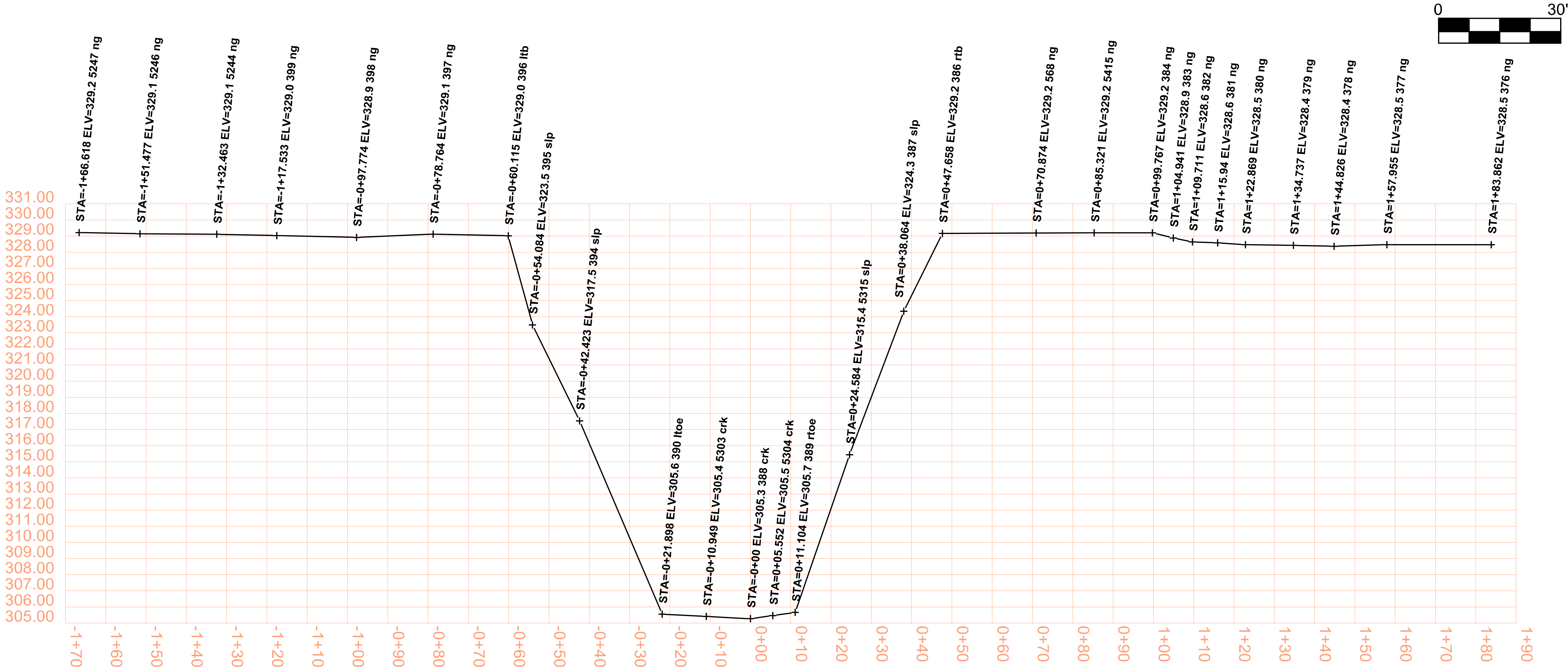
CYPRESS CREEK SECTION 10

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 30'	Randall S. Carmack CARMACK SURVEYING Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040 Phone: 731-836-9363	DRAWN BY: JKC
APRIL 27, 2015		JOB #WTRBA CC
REVISED:		WTRBA

Traverse PC

Plate C-12



CARMACK SURVEYING

CYPRESS CREEK SECTION 11

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 30'	Randall S. Carmack CARMACK SURVEYING Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040 Phone: 731-836-9363	DRAWN BY: JKC
APRIL 27, 2015		JOB #WTRBA CC WTRBA
REVISED:		

Traverse PC

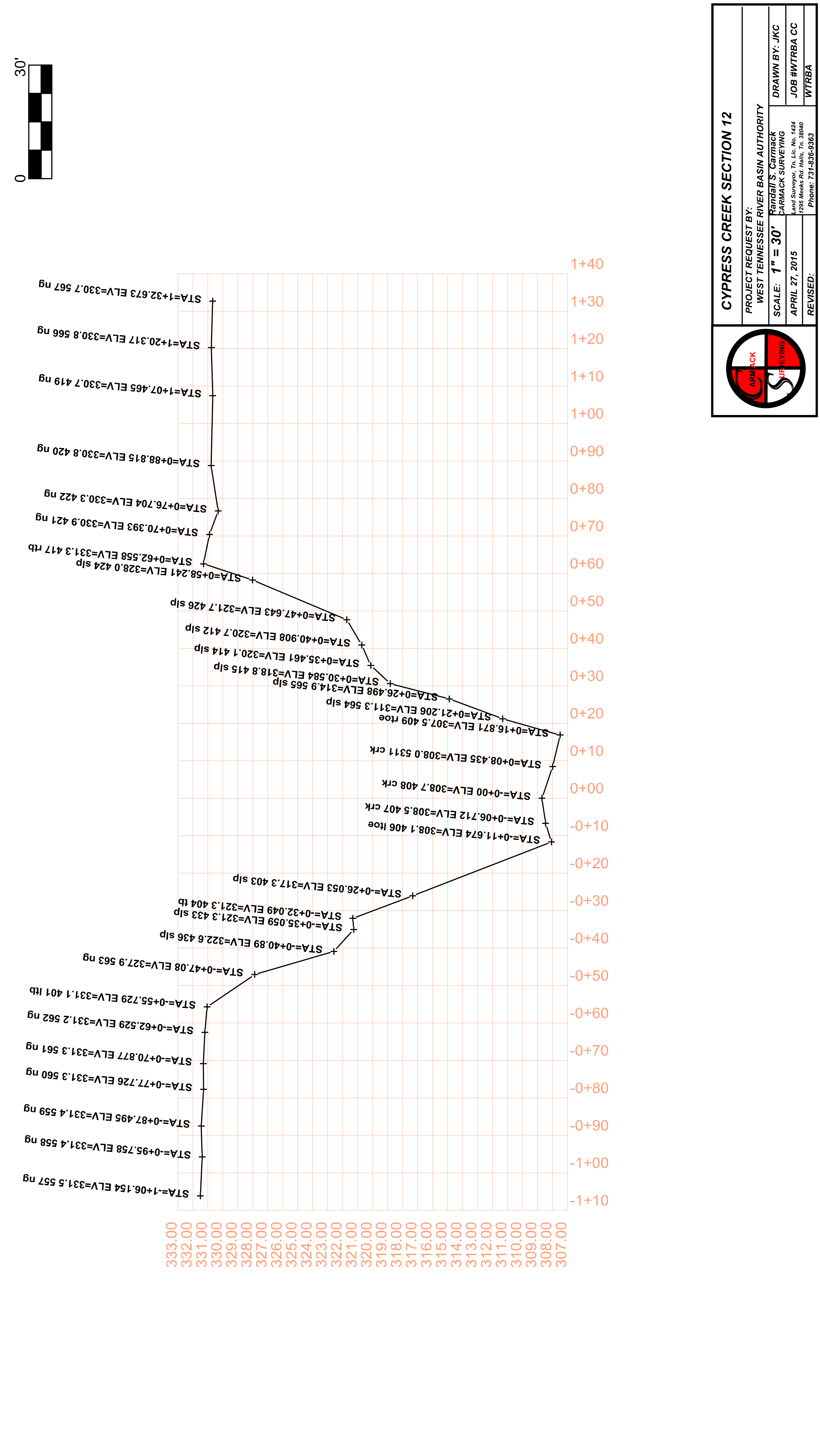
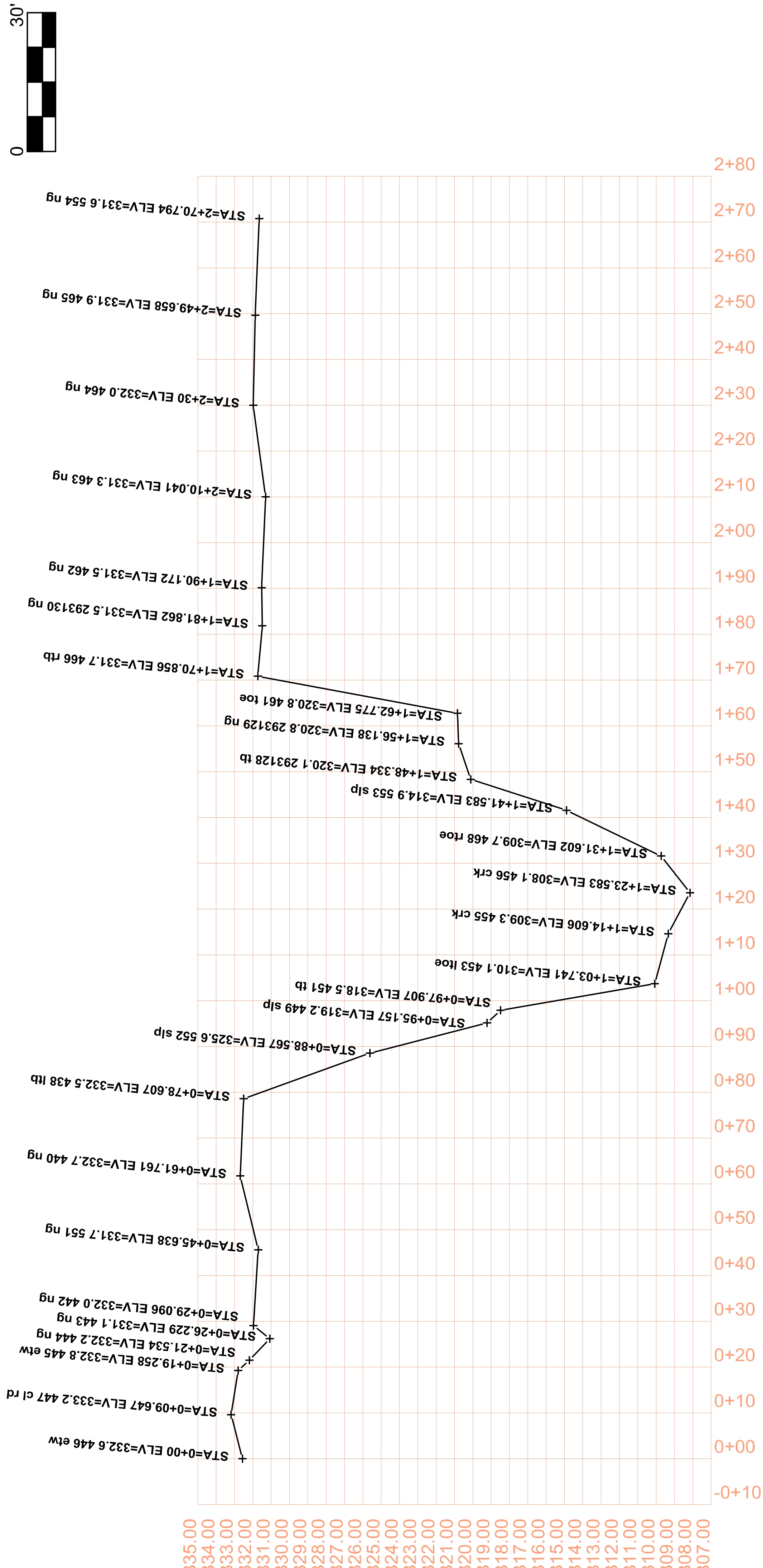


Plate C-13

Traverse PC



CYPRESS CREEK SECTION 13

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 30'

APRIL 27, 2015

REVISED:

Randall S. Carmack
CARMACK SURVEYING
Land Surveyor, Tn. Lic. No. 1424
1295 Meeks Rd. Halls, Tn. 38040
Phone: 731-836-9363

DRAWN BY: JKC
JOB #WTRBA CC
WTRBA

Plate C-14

Traverse PC

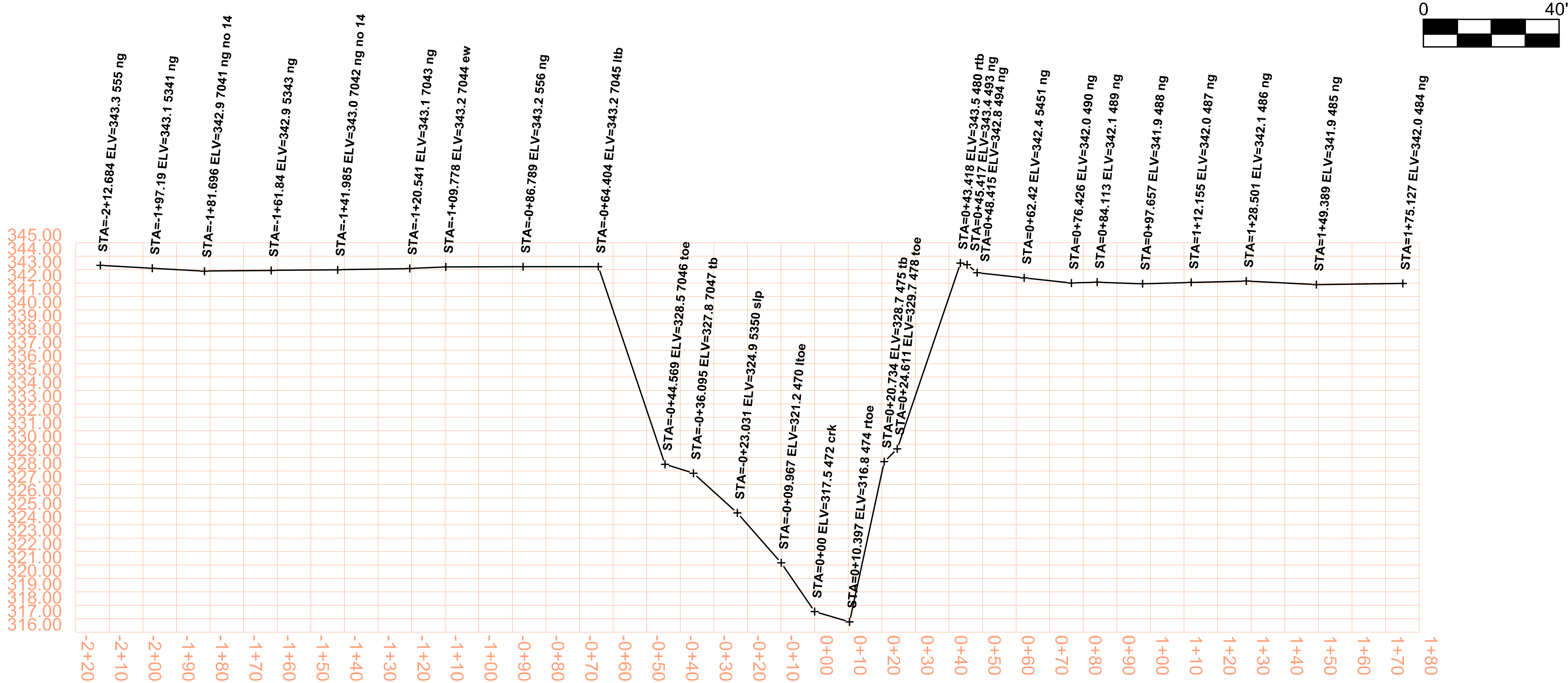


Plate C-15

CYPRESS CREEK SECTION 14

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 40'	Randall S. Carmack CARMACK SURVEYING	DRAWN BY: JKC
APRIL 27, 2015	Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040	JOB #WTRBA CC
REVISED:	Phone: 731-836-9363	WTRBA

Traverse PC

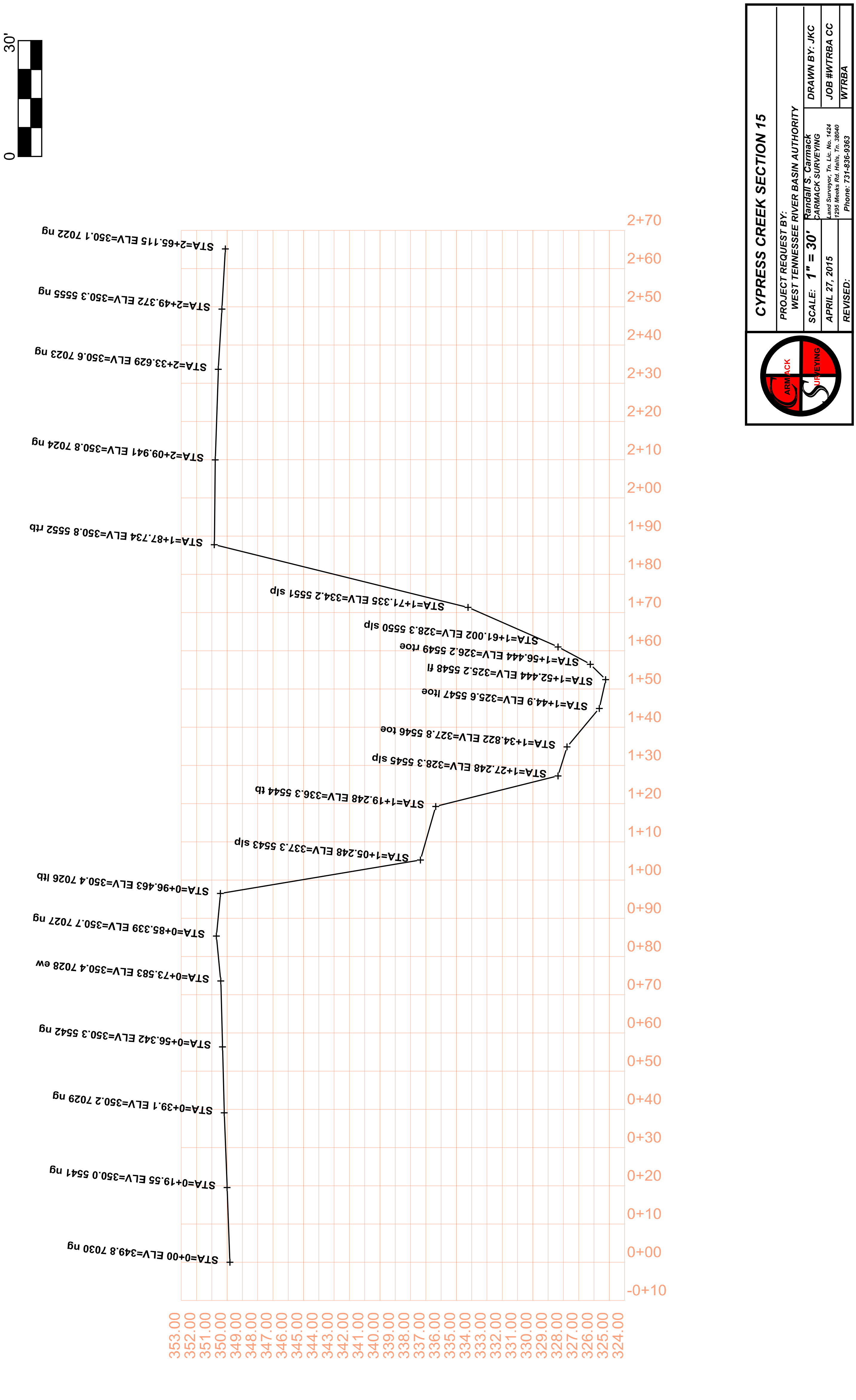


Plate C-16

Traverse PC

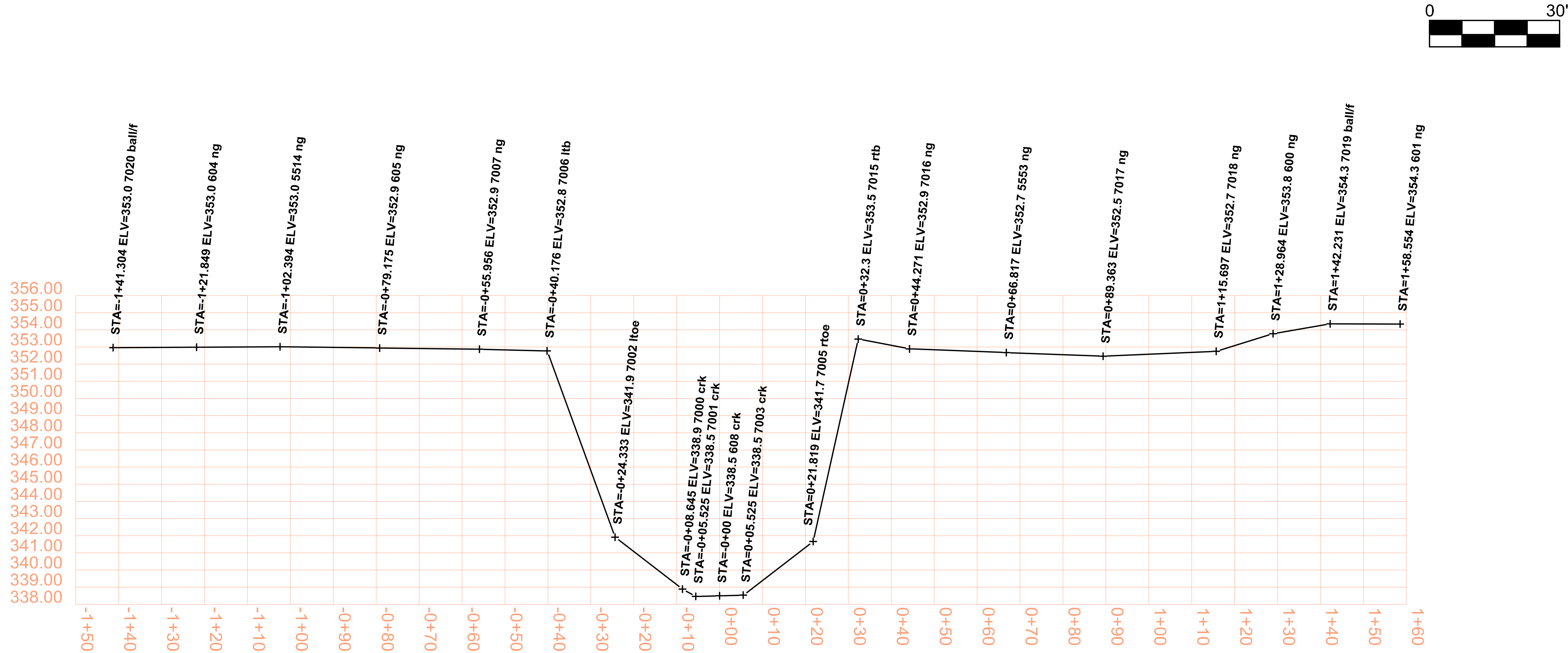


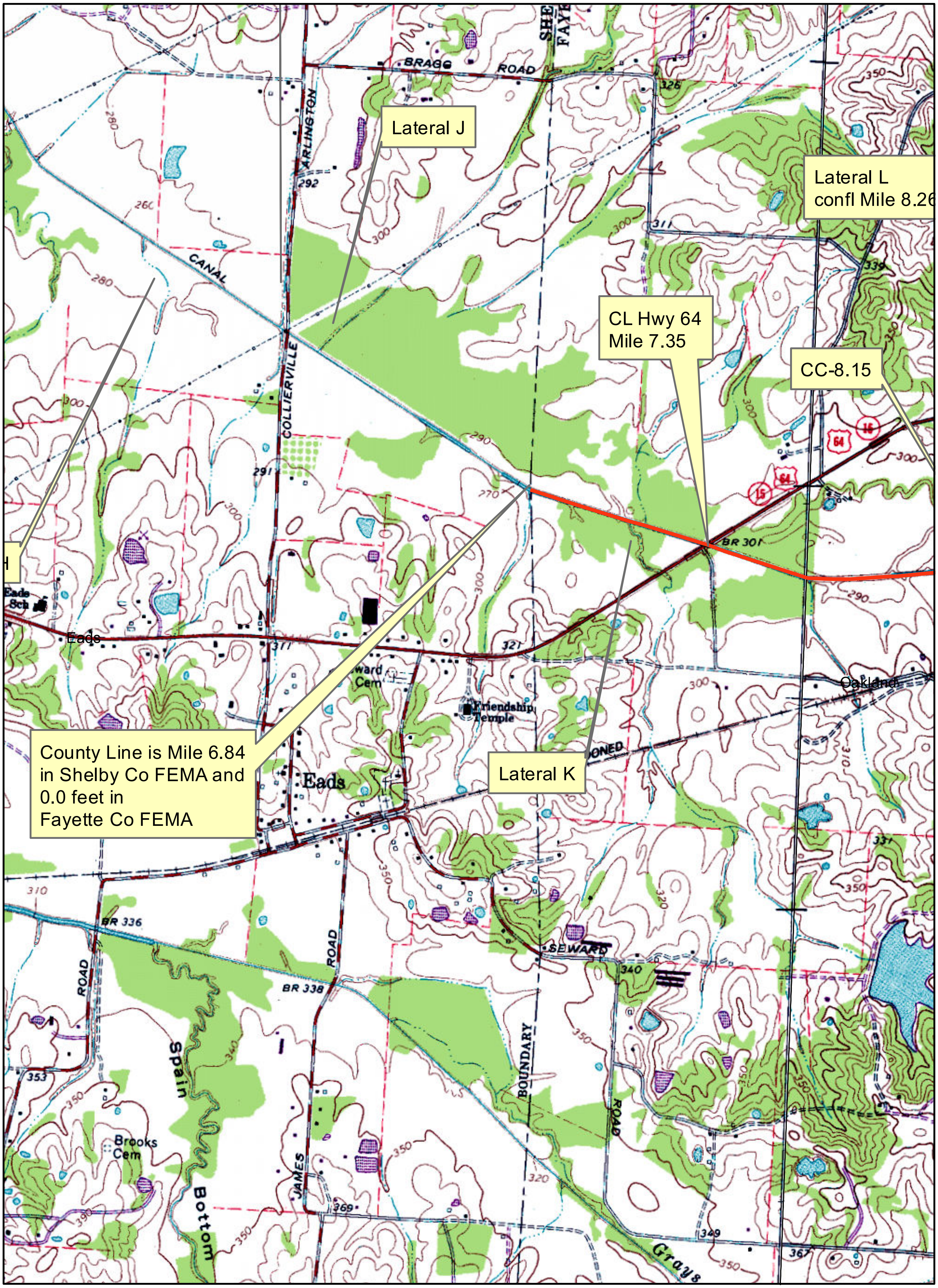
Plate C-17

CYPRESS CREEK SECTION 16

PROJECT REQUEST BY:
WEST TENNESSEE RIVER BASIN AUTHORITY

SCALE: 1" = 30'	Randall S. Carmack CARMACK SURVEYING	DRAWN BY: JKC
APRIL 27, 2015	Land Surveyor, Tn. Lic. No. 1424 1295 Meeks Rd. Halls, Tn. 38040	JOB #WTRBA CC
REVISED:	Phone: 731-836-9363	WTRBA

Traverse PC



Lateral J
Lateral L
confl Mile 8.26
CL Hwy 64
Mile 7.35
CC-8.15
County Line is Mile 6.84
in Shelby Co FEMA and
0.0 feet in
Fayette Co FEMA
Lateral K
Eads
Oakland
CANAL
COLLIERVILLE
ARLINGTON
BRAGG ROAD
BOUNDARY
Spain Bottom
Brooks Cem
Friendship Temple
SEWARD

Plate C-18


Lateral L
confl Mile 8.26
Lateral M
Lateral N
confl Mile 8.97
CC-9.04
CC-8.15
CL Hwy
Mile 10.
Eads
Oakland
ABANDONED
CYPRESS
CREEK
LatO0.07
CL old RR
Mile 9.06
CC-10.00
Lateral P
confl Mile 9.28
McCulley Cem
Lateral O
Bell Branch
Mile 9.10
Braswell
Cem
LatO1.39
LatO1.66
SEWARD

Plate C-19


CL old RR
Mile 9.06
LatO0.07
Lateral Q
confl Mile 10.0
CC-10.00
Lateral P
confl Mile 9.28
Lateral O
Bell Branch
Mile 9.10
LatO1.39
LatO1.66
Oakland
LatO2.53
ABANDONED
CYPRESS
CREEK
BR 307
BR 334
BM 331
McCulley Cem
Braswell Cem
Morning View Ch
SEWARD
ROAD
Bailey Cem
Dudney Cem
Grays
Creek

Plate C-20

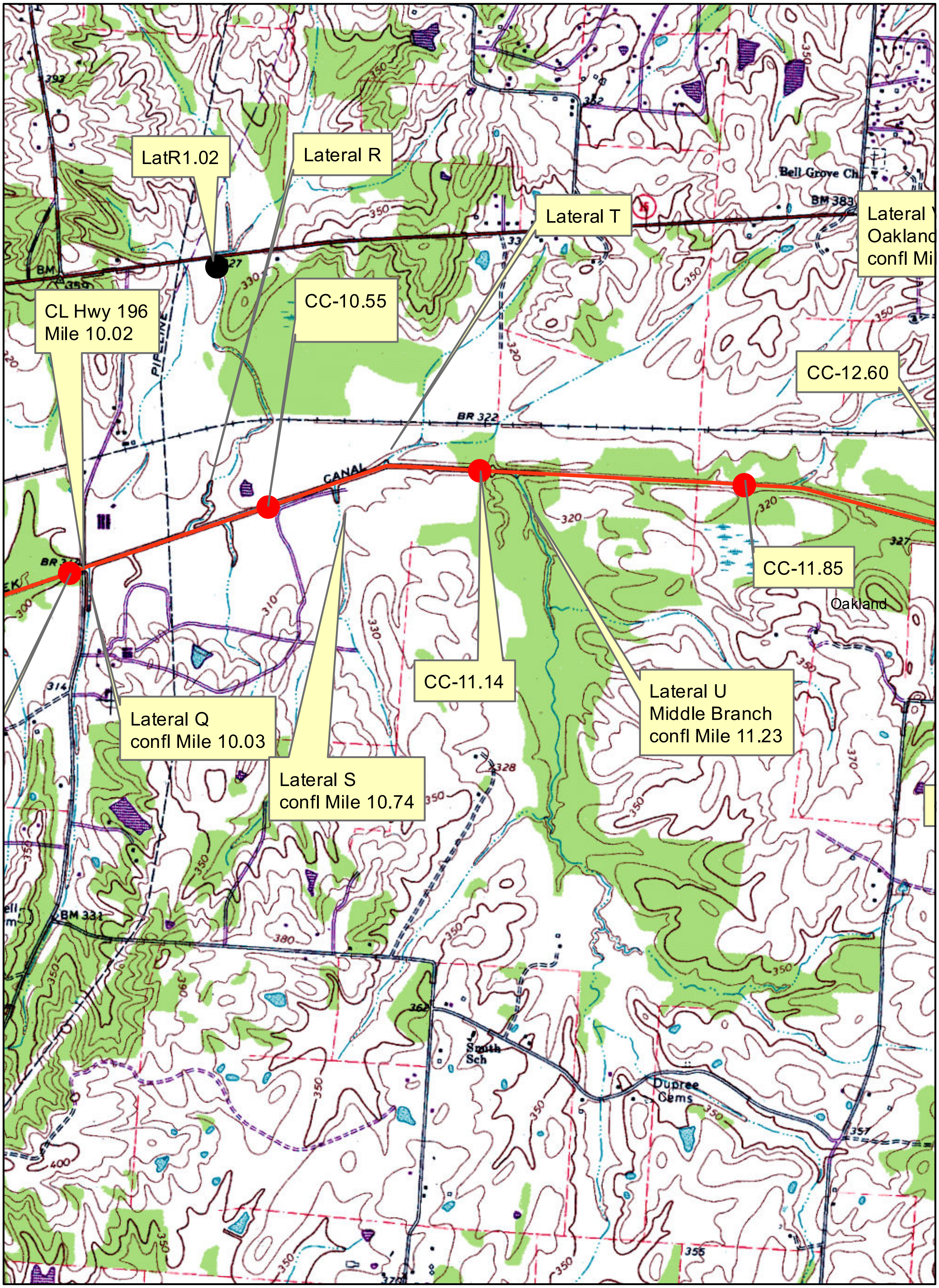

LatR1.02
Lateral R
Lateral T
CL Hwy 196
Mile 10.02
CC-10.55
CC-12.60
CC-11.85
CC-11.14
Lateral Q
confl Mile 10.03
Lateral S
confl Mile 10.74
Lateral U
Middle Branch
confl Mile 11.23
Bell Grove Ch
Oakland
PIPELINE
CANAL
BR 322
BM 383
BM 331
Smith Sch
Dupree Cems

Plate C-21

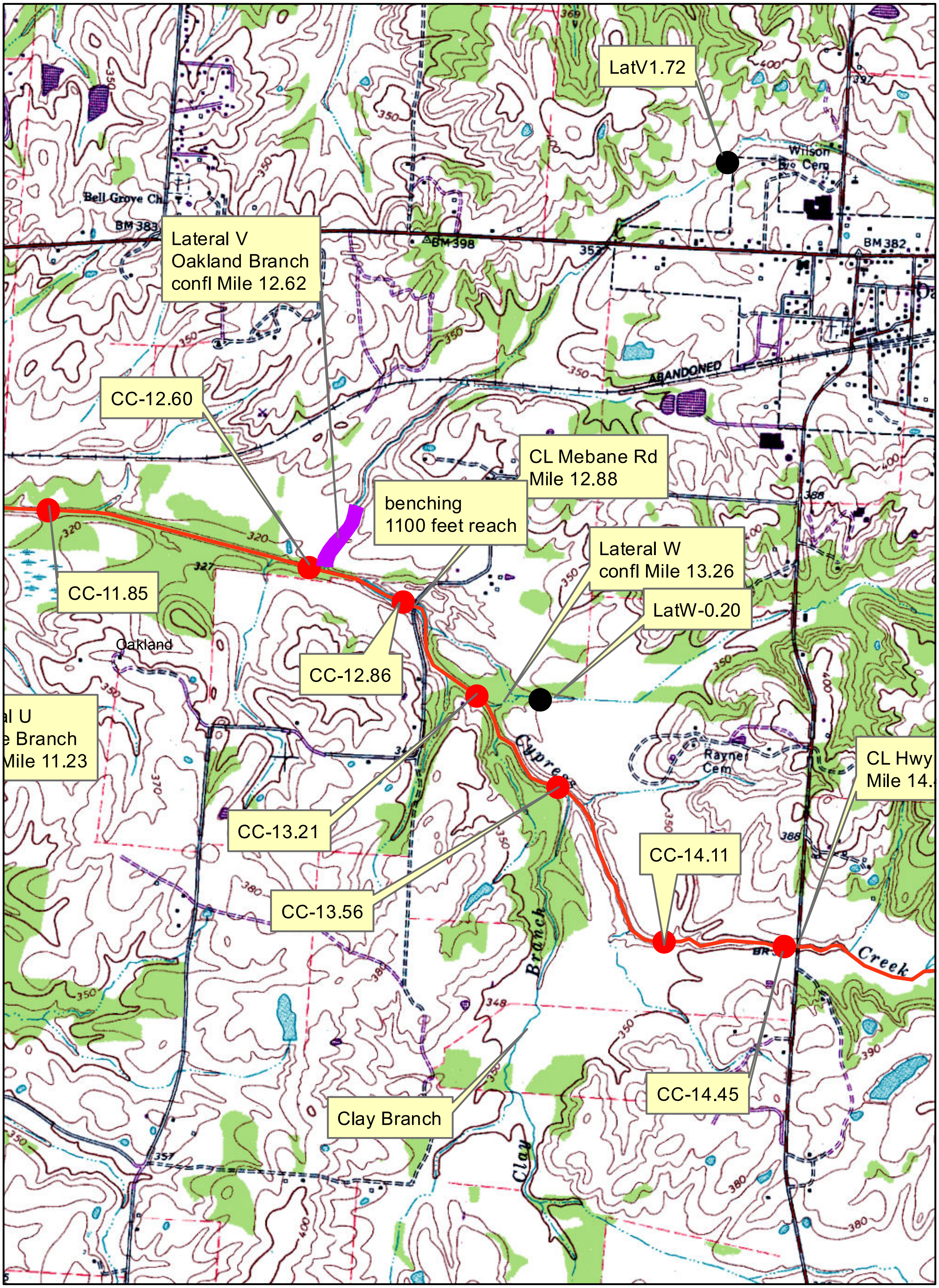
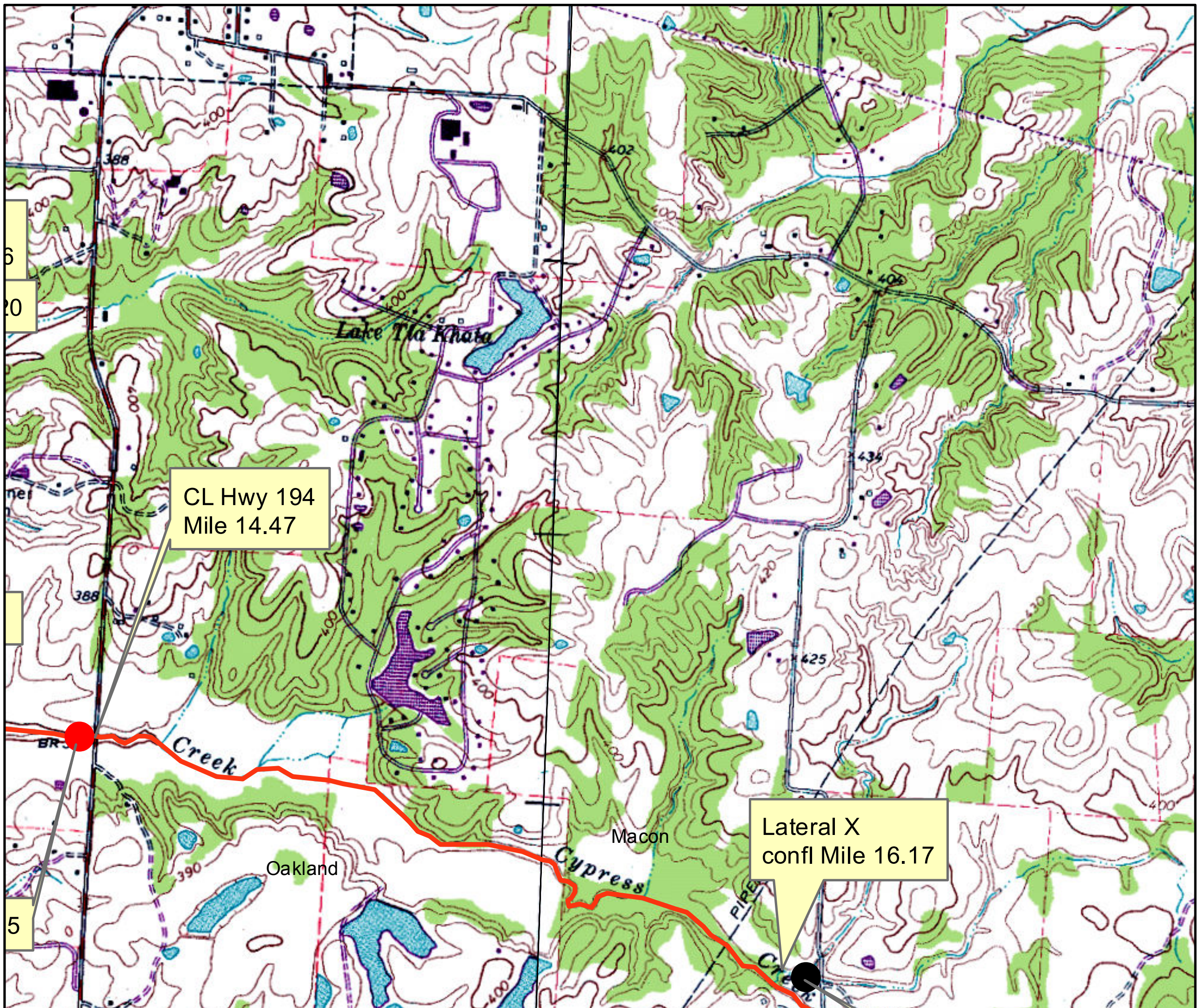
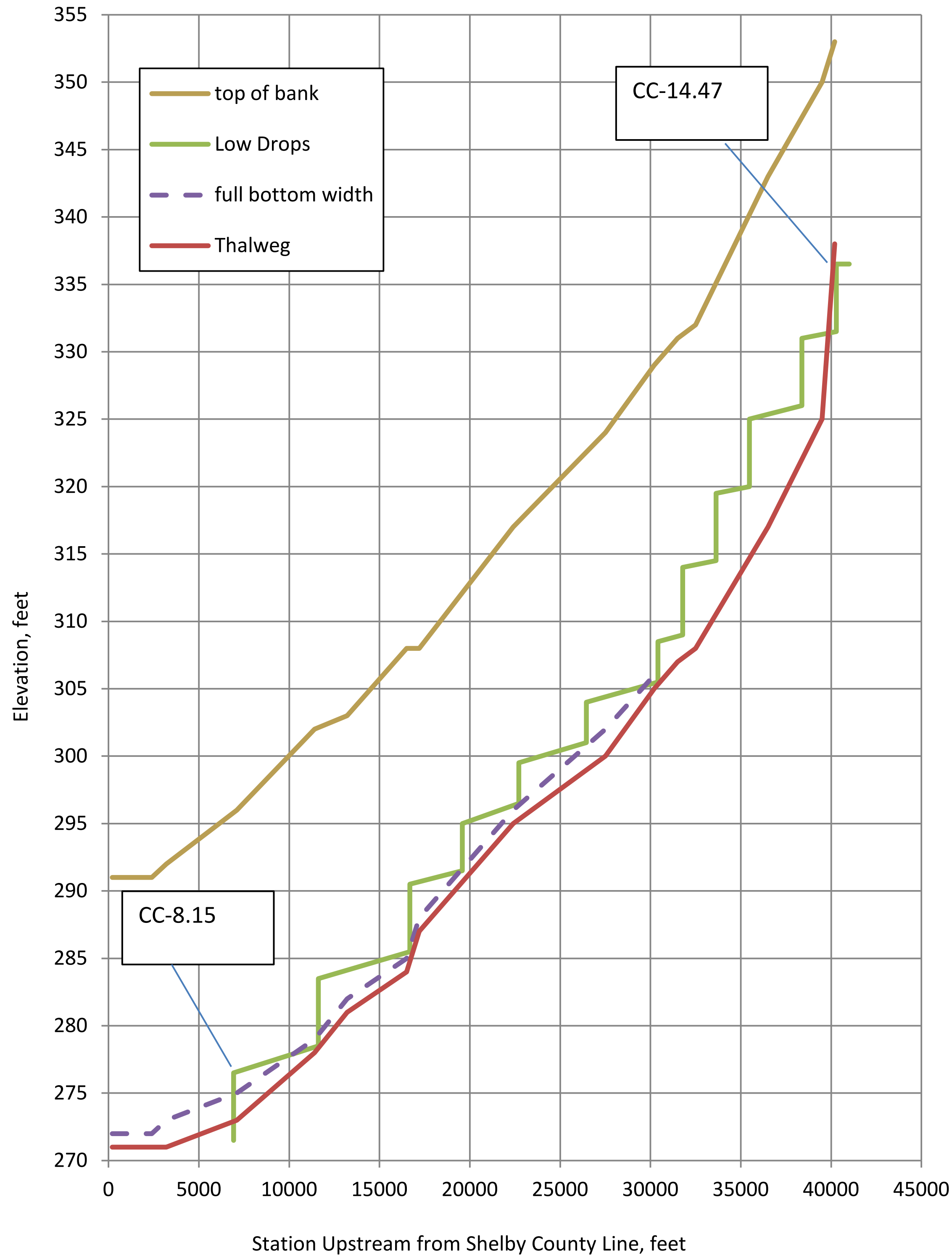

LatV1.72
Wilson Cem
Bell Grove Ch
BM 383
BM 398
BM 382
Lateral V
Oakland Branch
confl Mile 12.62
ABANDONED
CC-12.60
CL Mebane Rd
Mile 12.88
benching
1100 feet reach
Lateral W
confl Mile 13.26
LatW-0.20
CC-11.85
CC-12.86
Oakland
al U
e Branch
Mile 11.23
Cypress
Rayner
Cem
CL Hwy
Mile 14.
CC-13.21
CC-14.11
CC-13.56
Branch
Creek
CC-14.45
Clay Branch
Clay

Plate C-22



CL Hwy 194
Mile 14.47
Lake Tla Khata
Creek
Cypress
Macon
Oakland
Lateral X
confl Mile 16.17
LatX0.10
BR 376
CL Wilbourne Rd
Mile 16.44
Brooks Chapel
CC-17.07
BR 390
CL Sellers Drive
Mile 17.07

Plate C-23



top of bank
Low Drops
full bottom width
Thalweg
CC-14.47
CC-8.15
355
350
345
340
335
330
325
320
315
310
305
300
295
290
285
280
275
270
Elevation, feet
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Station Upstream from Shelby County Line, feet

ARS Low Drop	
Adapted from MVK Process Doc 08816	
Project: Cypress Ck, Memphis Metro	
Site: 8.15	
Variable	Value
INPUT	
Elevations	
Top of bank elev, ft	**295.00**
Weir crest elev, ft	276.50
U/S stream bed elev, ft	271.50
D/S stream bed elev, ft (future degraded)	271.50
Slopes	
All sideslopes, H:V	2.50
Inlet ramp slope, H:V	3.00
Chute slope, H:V	3.00
Basin ramp slope, H:V	5.00
Lengths	
Length inlet apron, ft	20.00
Length outlet apron, ft	15.00
Widths	
U/S stream bed width, ft	60.00
Weir crest width, ft	60.00
D/S stream bed width, ft	60.00
Riprap	
Layer thickness, R650, ft	3.00
Layer thickness, R200, ft	2.00
Bedding stone thickness, ft	0.50
Unit weight, tcy	1.50
Grout	
Grout void fraction	0.33
Hydraulics	
Critical depth @ design flow, Yc, ft	7.00

Messages
Ratio H/Yc
Ratio $B_{D/S}$ / BW_{sb}
Outlet Transition Flare

OUTPUT Dimensions	
Vertical	
Fall, H, Ft	**5.00**
Basin Depth, Ysb, ft	12.00
Basin Bottom Elev, ft	264.50
Depth of U/S Bed from Top of Bank, ft	**23.50**
Depth of Crest from Top of Bank, ft	18.50
Depth of Basin from Top of Bank, ft	30.50
Depth D/S Bed from Top of Bank, ft	23.50
Inlet ramp rise, ft	5.00
Basin ramp rise, ft	7.00
Hydraulics	
Submergence elev, ft (@Yc)	283.50
Submergence elev, ft (@0.75Yc)	281.75
Structure Width	
Width basin @ brink, 0.75 Yc, etc.	86.25
Topwidth inlet apron, ft	177.50
Topwidth weir crest, ft	152.50
Topwidth basin, ft	238.75
Topwidth outlet apron, ft	203.75
Topwidth of flow at design Yc, ft	95.00
Structure Length	
Half length, Xb, ft	45.75
Full length, Lsb, ft	91.50
Length inlet apron, ft (input)	20.00
Length inlet ramp, ft	15.00
Length weir crest, ft	42.00
Length chute, ft	36.00
Length basin floor, ft	20.50
Length basin ramp, ft	35.00
Length outlet apron, ft (input)	15.00
Length Type-E end protection, ft	22.50
Length Total	**206.00**

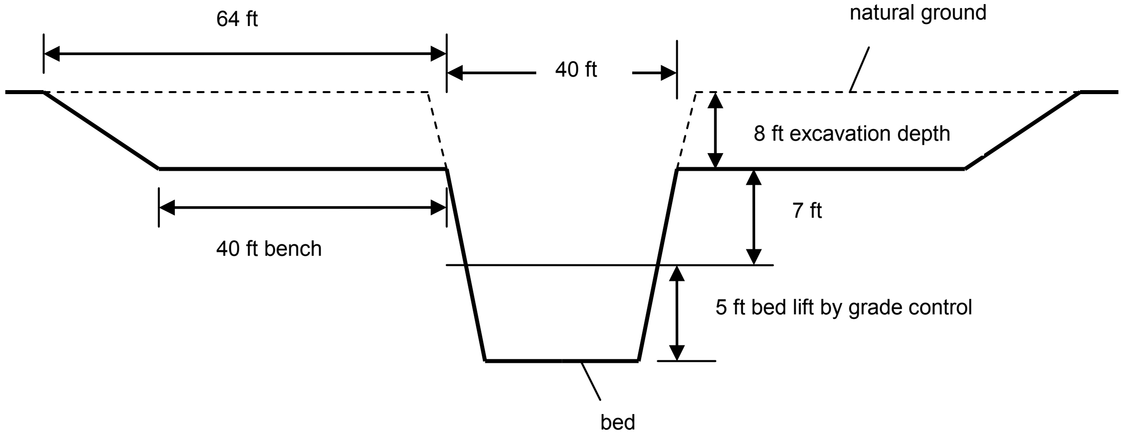
OUTPUT Riprap R600			Avg	
Location	XS Area	Segment	XS Area	Vol
	sq ft	ft	sq ft	cu ft
u/s end inlet apron	532.50	0	---	
d/s end inlet apron	532.50	20.00	532.50	10650.0
u/s end weir crest	457.50	15.00	495.00	7425.0
d/s end weir crest	457.50	42.00	457.50	19215.0
u/s end basin floor	716.25	36.00	586.88	21127.5
d/s end basin floor	716.25	20.50	716.25	14683.1
u/s end outlet apron	611.25	35.00	663.75	23231.3
d/s end outlet apron	611.25	15.00	611.25	9168.8
type-E end protection @ 11.25T^2 sq ft				20629.7
volume, cu ft				**126130.31**
volume, cu yd				4671.49
weight, ton				7007.24

OUTPUT Bedding Stone			
ratio	0.17	1168	ton

OUTPUT Grout			Grout		
	Grout		Avg		
Location	Width	Segment	Width	Area	
	ft	ft	sq ft	sq ft	
u/s edge of low grout (5ft gap)	95.00				
d/s edge of low grout (midpoint crest)	95.00	16.00	95.00	1520.00	
u/s edge of high grout(midpoint crest)	152.50	21.00			
d/s end weir crest	152.50	21.00	152.50	3202.50	
u/s end basin floor	95.00	36.00	123.75	4455.00	
d/s end basin floor	95.00	20.50	95.00	1947.50	
				11125.00	
vol grout				11013.75	cu ft
vol grout				407.92	cu yd

OUTPUT **Inlet & Outlet Channel Transition Riprap R-200 (no bedding stone)**		
Minimum Length U/S & D/S Transitions		
Absolute minimum, ft		75.00
Three basin floor widths, ft		258.75
Adopted min length, ft		258.75
Min D/S Length for Expand or Contract Flare		
Contract (+) and Expand (-)		
basin floor width		86.25
D/S bed width		60.00
D/S transition contracts (full)		26.25
D/S transition contracts (one-sided)		13.125
Min Length as 6L:1W one-sided		78.75
Adopted min length, D/S, ft		258.75
Lengths of R200 Protection		
Upstream left sideslope toe, ft		258.75
Upstream right sideslope toe, ft		258.75
Downstream left sideslope toe, ft		258.75
Downstream right sideslope toe, ft		258.75
	total	**1035.00**
Quantity U/S + D/S		
height, ft		5.00
width on stream bed, ft		6.00
area, sq ft		37.00
volume, cu ft		38295.00
volume, cu yd		1418.33
weight, ton		2127.50

OUTPUT **Disturbed Area**		
length upstream transition		258.75
length structure		206.00
length downstream transition		258.75
	total	**723.5**
width left fringe		150.0
width structure		238.8
width right fringe		150.0
	total	**538.8**
area, acre		8.95



Section View of Oakland Branch Benching

Appendix D

Cost Estimates

Alternative 2

Cost Year 2016

Corps of Engineers, Memphis District

Cypress Creek PAS, Oakland, Fayette County, TN

Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015

Alternative Review for 20 Low Drop Weir Structures

ALTERNATIVE II

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
01 Lands and Damages								
Lands and Damages	1	JOB	$1,376,200	$1,376,000	10%	$137,620	$1,513,620	$20,000 for USACE labor per aquisition and $10,000 per acre for easement acquisition costs (12 Acquisitions) in farm areas & 20,0000 per owner in residential type area (8 Acquistions) 81.62 acres on Main Channel Structures; & 16 acres on the Tributary Structures: Total Acreage 97.62 Total Acres; No Borrow Needed Land Acquisition $976,200 and $400,000 acquisition costs on 20 parcels
Mitigation Land	1	JOB		$0		$0	$0	No Mitigation Required
Total 01				$1,376,000		$137,620	**$1,513,620**	
02 RELOCATIONS								
Roads and Bridges	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any roads or bridges
Utilities	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any utility infrastructure
Total 02				$0		$0	**$0**	
16 Bank Stabilization								
Low Drop Weir Structures (Main Channel)								
Mob & Demob	1.00	JOB	$214,223	$214,000	25%	$54,000	$268,000	**Split into 3 mobilizations/demobilizations; 1 for structures 1,2,3,4, 1 for 5,6,7,8, and 1 for 9,10,11,12 Included a landscaping subcontractor as well as a prime contractor**
Access Road	1.00	JOB		$0	25%	$0	$0	All of the main Channel Structures are easily accessible by Farm Roads therefore no allowance was given to this item. However; I did allow for haul road/site access maintenance which is covered in the
Clearing and Grubbing	81.62	ACRES	$3,688	$301,000	25%	$75,000	$376,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
Divert Flow	1.00	JOB	$97,096.68	$97,000	25%	$24,000	$121,000	Cost to Dam up all 12 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	65,053.00	BCY	$2.05	$133,000	25%	$33,000	$166,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting
Riprap R600	67,293.00	TON	$54.36	$3,658,000	25%	$915,000	$4,573,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap R200	19,072.00	TON	50.08	$955,000	25%	$239,000	$1,194,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Bedding Stone	11,215.00	BCY	$41.68	$467,000	25%	$117,000	$584,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	3,656.00	CY	$200.75	$734,000	25%	$184,000	$918,000	All grout will be pumped by pump truck. production rate 10 cy/hr
Stormwater Pollution Prevention						$0		
Check Dams	36.00	EA	$1,267.27	$46,000	25%	$12,000	$58,000	Placed 3 check dams down stream of structures to catch any debris caused by construction, will be removed by the Bench Channel Contractor. Riprap Check Dams
Silt Fence	7,200.00	LF	$2.78	$20,000	25%	$5,000	$25,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF
Turfing	81.62	ACRES	$2,078.27	$170,000	25%	$43,000	$213,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1.00	JOB	$87,052.20	$87,000	25%	$22,000	$109,000	This will be for gas spill containment, Environmental Plan etc.
Field Road Restoration	14.36	ACRES	$376.15	$5,000	25%	$1,000	$6,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. These are mostly ag fields so tilling should suffice.

Corps of Engineers, Memphis District Cypress Creek PAS, Oakland, Fayette County, TN Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015 Alternative Review for 20 Low Drop Weir Structures ALTERNATIVE II								
ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
Low Drop Weir Structures (Main Channel)	**12.00**	**EA**	**$573,917**	**$6,887,000**	**25%**	**$1,722,000**	**$8,609,000**	**All Prices Escalated to July 2020 using 2.5% Esc per annum. (5 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Low Drop Weir Structures (Tributary Channel)								
Mob & Demob (8 Tributary Structures)	1	JOB	$121,208.57	$121,000	25%	$30,000	$151,000	Allows for one Mobilization and mob/demob between each structure (8 locations) as well as 1/2 final demobilization.
Access Road	1,400	TON	$35.90	$50,000	25%	$13,000	$63,000	Allows for 1400 Tons of Resurfacing to access the No. 2 Structure.
Clearing and Grubbing	8	ACRES	$3,698.52	$30,000	25%	$8,000	$38,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed
Divert Flow	1	JOB	$36,539.09	$37,000	25%	$9,000	$46,000	Cost to Dam up all 8 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	8,000	BCY	$2.05	$16,000	25%	$4,000	$20,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting
Riprap Class "A"	4,800	TON	$50.22	$241,000	25%	$60,000	$301,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap Class "B"	11,200	TON	$50.22	$562,000	25%	$141,000	$703,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	2,400	CY	$201.31	$483,000	25%	$121,000	$604,000	All grout will be pumped by pump truck. production rate 10 cy/hr Allowance of $100/cy for material
Stormwater Pollution Prevention				$0	25%	$0	$0	
Check Dams	24	EA	$1,270.81	$30,000	25%	$8,000	$38,000	Placed 3 check dams down stream of structures to catch any debris caused by construction. Includes Installation and Removal. Riprap Check Dams

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Silt Fence	4,800	LF	$2.65	$13,000	25%	$3,000	$16,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF per structure. Includes Installation and Removal.
Erosion Blanket	2,800	SY	$5.68	$16,000	25%	$4,000	$20,000	Placement of 300 SY per hour for 3 laborers and a flatbed truck
Turfing	16	ACRES	$2,084.06	$33,000	25%	$8,000	$41,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1	JOB	$58,196.54	$58,000	25%	$15,000	$73,000	This will be for gas spill containment, Environmental Plan etc.
Field Road Restoration	9.5	ACRES	$1,626	$15,000	25%	$4,000	$19,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. Most of these is over pasture and this allows for returfing.
Backfill	8,000.0	ECY	$1.63	$13,000	25%	$3,000	$16,000	Backfill will be a process of the excavation; However; since this was under the structure Compaction Equipment was included and this is what this is for.
Geotextile	6,000.0	SY	$3.96	$24,000	25%	$6,000	$30,000	For placement underneath the Riprap. 150 SY for 2 labors, 1 truck driver and a flatbed truck.
Low Drop Wier Structures (Tributary Channel)	**8.00**	**EA**	**$217,750**	**$1,742,000**	25%	**$436,000**	**$2,178,000**	**All Prices Escalated to July 2020 using 2.5% Esc per annum. (5 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Total 16				$8,629,000		$2,161,000	$10,790,000	
30 PLANNING, E&D								
E&D for Study Costs	1	LS	$ 450,000.00	$450,000	25%	$113,000	$563,000	This is the total provided by PM for the cost of the study. Includes sponsor work in kind estimates.
E&D fro Relocations	1	LS	$ -	$0	25%	$0	$0	There aren't any relocations, therefore there will be no study costs.

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
E&D for 16 Bank Stabilization	1	LS	$ 1,294,350.00	$1,294,000	25%	$324,000	$1,618,000	15% allowance for Engineering and Design. This was calculated on the total projected cost for construction of the bank stabilization measures.
Total 30				$1,744,000		$437,000	**$2,181,000**	20.21%
31 Supervision and Administration								
S&A for 16 Bank Stabilization	1	LS	$ 1,294,350.00	$1,294,000	25%	$324,000	$1,618,000	15% allowance for the supervision of the installation of bank stabilization measures.
Total 31				$1,294,000		$324,000	**$1,618,000**	15.00%
TOTAL PROJECT COSTS (June 2015)	1	LS		$13,043,000		$3,059,620	**$16,102,620**	There is a 25% contingency allowance on all construction items.
TOTAL PROJECT COSTS (June 2015)	1	LS	100.0%			23.5%	**$16,102,620**	

Alternative 3
Cost Year 2016

Corps of Engineers, Memphis District
Cypress Creek PAS, Oakland, Fayette County, TN
Prices Escalated to July 2016(Assummed Start of Construction Schedule); Preparation Date: 10/23/2015
Alternative Review for 20 Low Drop Weir Structures and 12 Benched Channel Eco System Restoration Measures
ALTERNATIVE III

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
01 Lands and Damages								
Lands and Damages	1	JOB	$1,856,200	$1,856,000	10%	$185,620	$2,041,620	$20,000 for USACE labor per aquisition and $10,000 per acre for easement acquisition costs (12 Acquisitions) in farm areas & 20,0000 per owner in residential type area (8 Acquistions) 81.62 acres on Main Channel Structures; & 16 acres on the Tributary Structures; 30 acres on Benched Channels: Total Acreage 127.62 Total Acres; No Borrow Needed Land Acquisition $1,436,200 and $420,000 acquisition costs on 21 (1 Extra at Oakland Branch) parcels
Mitigation Land	1	JOB		$0		$0	$0	No Mitigation Required
Total 01				$1,856,000		$185,620	**$2,041,620**	
02 RELOCATIONS								
Roads and Bridges	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any roads or bridges
Utilities	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any utility infrastructure
Total 02				$0		$0	**$0**	
06 Fish and Wildlife Facilities								
Benched Channels Eco System Restoration								
Mobilization/Demobilization	1.0	JOB	$ 157,890.52	$157,890.52	25%	$39,000	$196,891	Includes 3 mob/demobs as layed out in the Main Channel Structures
Clearing and Grubbing	26.0	ACRES	$ 3,351.91	$87,149.66	25%	$22,000	$109,150	Same as below.
Environmental Protection	1.0	JOB	$ 79,113.97	$79,113.97	25%	$20,000	$99,114	Same as below.
Stormwater Pollution Prevention						$0		
Check Dams	36.0	EA	$ 82.20	$2,959.20	25%	$1,000	$3,959	This includes removal of the check dams placed during the construction of the Main structures. I assumed they would come in after construction of the Main Channel Structures to prevent confusion at the site. Riprap Check Dams.
Silt Fence	39,600.0	LF	$ 2.40	$94,901.40	25%	$24,000	$118,901	Includes Installation and Removal and the production rate is 100 lf/hour
Erosion Blanket	72,500.0	SY	$ 5.15	$373,294.24	25%	$93,000	$466,294	Placement of 300 SY per hour for 3 laborers and a flatbed truck, Received quote from Lowes.
Excavation	202,300.0	BCY	$ 1.86	$376,644.57	25%	$94,000	$470,645	Long reach excavator, with a dozer assisting the spoil pile and compacting
Rirap (R600)	400.0	TON	$ 49.40	$19,760.21	25%	$5,000	$24,760	Placement of 90 tons per hour

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2016(Assummed Start of Construction Schedule); Preparation Date: 10/23/2015								
Alternative Review for 20 Low Drop Weir Structures and 12 Benched Channel Eco System Restoration Measures								
ALTERNATIVE III								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Turfing	59.5	ACRES	$ 1,940.75	$115,474.38	25%	$29,000	$144,474	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be 52 acres Bermuda type seeding. Replant 25% allowed. 7.5 acres Native Grasses
Access Road				$0.00	25%	$0	$0	All areas are readily accessible by field road and if done during the proper time of the season, the refurbshing should be enough.
Field Road Restoration	13.3	ACRES	$ 341.83	$4,529.20	25%	$1,000	$5,529	4 passess over the same area that was used in The Main Channel Construction to access the site. This land is mostly ag so tilling should suffice.
Trees	7,900.0	EA	$ 3.79	$29,975.40	25%	$7,000	$36,975	Received price quote from TN forestry for standard hardwoods. 2 men 50 trees per hour.
Benched Channels Eco System Restoration	**12.0**	**EA**	**$ 111,807.73**	**$1,341,693**	**25%**	**$335,000**	**$1,676,693**	**All Prices Escalated to July 2016 using 2.5% Esc per annum. (1 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Total 06				$1,341,693		$335,000	**$1,676,693**	
16 Bank Stabilization								
Low Drop Weir Structures (Main Channel)								
Mob & Demob	1.00	JOB	$194,077	$194,000	25%	$49,000	$243,000	Split into 3 mobilizations/demobilizations; 1 for structures 1,2,3,4, 1 for 5,6,7,8, and 1 for 9,10,11,12 Included a landscaping subcontractor as well as a prime contractor
Access Road	1.00	JOB		$0	25%	$0	$0	All of the main Channel Structures are easily accessible by Farm Roads therefore no allowance was given to this item. However; I did allow for haul road/site access maintenance which is covered in the
Clearing and Grubbing	81.62	ACRES	$3,341	$273,000	25%	$68,000	$341,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed

Corps of Engineers, Memphis District

Cypress Creek PAS, Oakland, Fayette County, TN

Prices Escalated to July 2016(Assummed Start of Construction Schedule); Preparation Date: 10/23/2015

Alternative Review for 20 Low Drop Weir Structures and 12 Benched Channel Eco System Restoration Measures

ALTERNATIVE III

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
Divert Flow	1.00	JOB	$87,965.52	$88,000	25%	$22,000	$110,000	Cost to Dam up all 12 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	65,053.00	BCY	$1.86	$121,000	25%	$30,000	$151,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting
Riprap R600	67,293.00	TON	$49.25	$3,314,000	25%	$829,000	$4,143,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap R200	19,072.00	TON	45.37	$865,000	25%	$216,000	$1,081,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Bedding Stone	11,215.00	BCY	$37.76	$423,000	25%	$106,000	$529,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	3,656.00	CY	$181.87	$665,000	25%	$166,000	$831,000	All grout will be pumped by pump truck. production rate 10 cy/hr
Stormwater Pollution Prevention						$0		
Check Dams	36.00	EA	$1,148.10	$41,000	25%	$10,000	$51,000	Placed 3 check dams down stream of structures to catch any debris caused by construction, will be removed by the Bench Channel Contractor. Riprap Check Dams
Silt Fence	7,200.00	LF	$2.52	$18,000	25%	$5,000	$23,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF
Turfing	81.62	ACRES	$1,882.83	$154,000	25%	$39,000	$193,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1.00	JOB	$78,865.56	$79,000	25%	$20,000	$99,000	This will be for gas spill containment, Environmental Plan etc.
Field Road Restoration	14.36	ACRES	$340.77	$5,000	25%	$1,000	$6,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. These are mostly ag fields so tilling should suffice.
Low Drop Weir Structures (Main Channel)	**12.00**	**EA**	**$520,000**	**$6,240,000**	**25%**	**$1,560,000**	**$7,800,000**	**All Prices Escalated to July 2016 using 2.5% Esc per annum. (1 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantities for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**

Corps of Engineers, Memphis District
Cypress Creek PAS, Oakland, Fayette County, TN
Prices Escalated to July 2016(Assummed Start of Construction Schedule); Preparation Date: 10/23/2015
Alternative Review for 20 Low Drop Weir Structures and 12 Benched Channel Eco System Restoration Measures
ALTERNATIVE III

ITEM DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	AMOUNT	Cont %	CONTING.	TOTAL	COMMENT
Low Drop Weir Structures (Tributary Channel)								
Mob & Demob (8 Tributary Structures)	1	JOB	$109,809.78	$110,000	25%	$28,000	$138,000	Allows for one Mobilization and mob/demob between each structure (8 locations) as well as 1/2 final demobilization.
Access Road	1,400	TON	$32.53	$46,000	25%	$12,000	$58,000	Allows for 1400 Tons of Resurfacing to access the No. 2 Structure.
Clearing and Grubbing	8	ACRES	$3,350.70	$27,000	25%	$7,000	$34,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed
Divert Flow	1	JOB	$33,102.85	$33,000	25%	$8,000	$41,000	Cost to Dam up all 8 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	8,000	BCY	$1.86	$15,000	25%	$4,000	$19,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting
Riprap Class "A"	4,800	TON	$45.49	$218,000	25%	$55,000	$273,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap Class "B"	11,200	TON	$45.49	$509,000	25%	$127,000	$636,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	2,400	CY	$182.38	$438,000	25%	$110,000	$548,000	All grout will be pumped by pump truck. production rate 10 cy/hr Allowance of $100/cy for material
Stormwater Pollution Prevention				$0	25%	$0	$0	
Check Dams	24	EA	$1,151.30	$28,000	25%	$7,000	$35,000	Placed 3 check dams down stream of structures to catch any debris caused by construction. Includes Installation and Removal. Riprap Check Dams
Silt Fence	4,800	LF	$2.40	$12,000	25%	$3,000	$15,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF per structure. Includes Installation and Removal.
Erosion Blanket	2,800	SY	$5.15	$14,000	25%	$4,000	$18,000	Placement of 300 SY per hour for 3 laborers and a flatbed truck
Turfing	16	ACRES	$1,888.07	$30,000	25%	$8,000	$38,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1	JOB	$52,723.58	$53,000	25%	$13,000	$66,000	This will be for gas spill containment, Environmental Plan etc.

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2016(Assummed Start of Construction Schedule); Preparation Date: 10/23/2015								
Alternative Review for 20 Low Drop Weir Structures and 12 Benched Channel Eco System Restoration Measures								
ALTERNATIVE III								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Field Road Restoration	9.5	ACRES	$1,473	$14,000	25%	$4,000	$18,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. Most of these is over pasture and this allows for returfing.
Backfill	8,000.0	ECY	$1.48	$12,000	25%	$3,000	$15,000	Backfill will be a process of the excavation; However; since this was under the structure Compaction Equipment was included and this is what this is for.
Geotextile	6,000.0	SY	$3.58	$21,000	25%	$5,000	$26,000	For Placement underneath the Riprap. 150 SY for 2 labors, 1 truck driver and a flatbed truck.
Low Drop Wier Structures (Tributary Channel)	**8.00**	**EA**	**$197,500**	**$1,580,000**	25%	**$395,000**	**$1,975,000**	**All Prices Escalated to July 2016 using 2.5% Esc per annum. (1 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Total 16				$7,820,000		$1,959,000	$9,779,000	
30 PLANNING, E&D								
E&D for Study Costs	1	LS	$ 450,000.00	$450,000	25%	$113,000	$563,000	This is the total provided by PM for the cost of the study. Includes sponsor work in kind estimates.
E&D fro Relocations	1	LS	$ -	$0	25%	$0	$0	There aren't any relocations, therefore there will be no study costs.
E&D for 06 Fish and Wildlife Facilities	1	LS	$ 201,253.91	$201,000	25%	$50,000	$251,000	15% allowance for Engineering and Design. This was calculated on the total projected cost for construction of Fish and Wildlife activities.
E&D for 16 Bank Stabilization	1	LS	$ 1,173,000.00	$1,173,000	25%	$293,000	$1,466,000	15% allowance for Engineering and Design. This was calculated on the total projected cost for construction of the bank stabilization measures.
Total 30				$1,824,000		$456,000	**$2,280,000**	19.91%
31 Supervision and Administration								
S&A for 16 Bank Stabilization & 06 Fish and Wildlife Meaures	1	LS	$ 1,374,253.91	$1,374,000	25%	$344,000	$1,718,000	15% allowance for the supervision of the installation of bank stabilization and fish and wildlife measures.
Total 31				$1,374,000		$344,000	**$1,718,000**	15.00%
TOTAL PROJECT COSTS	1	LS		$14,215,693		$3,279,620	**$17,495,313**	There is a 25% contingency allowance on all construction items.
TOTAL PROJECT COSTS	1	LS	100.0%			23.1%	**$17,495,313**	

Alternative 2

2020

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
01 Lands and Damages								
Lands and Damages	1	JOB	$1,376,200	$1,376,000	10%	$137,620	$1,513,620	$20,000 for USACE labor per aquisition and $10,000 per acre for easement acquisition costs (12 Acquisitions) in farm areas & 20,0000 per owner in residential type area (8 Acquistions) 81.62 acres on Main Channel Structures; & 16 acres on the Tributary Structures: Total Acreage 97.62 Total Acres; No Borrow Needed Land Acquisition $976,200 and $400,000 acquisition costs on 20 parcels
Mitigation Land	1	JOB		$0		$0	$0	No Mitigation Required
Total 01				$1,376,000		$137,620	**$1,513,620**	
02 RELOCATIONS								
Roads and Bridges	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any roads or bridges
Utilities	1	JOB		$0	25%	$0	$0	Low Drop Structures can be moved or positioned to miss any utility infrastructure
Total 02				$0		$0	**$0**	
16 Bank Stabilization								
Low Drop Weir Structures (Main Channel)								
Mob & Demob	1.00	JOB	$214,223	$214,000	25%	$54,000	$268,000	**Split into 3 mobilizations/demobilizations; 1 for structures 1,2,3,4, 1 for 5,6,7,8, and 1 for 9,10,11,12 Included a landscaping subcontractor as well as a prime contractor**
Access Road	1.00	JOB		$0	25%	$0	$0	All of the main Channel Structures are easily accessible by Farm Roads therefore no allowance was given to this item. However; I did allow for haul road/site access maintenance which is covered in the
Clearing and Grubbing	81.62	ACRES	$3,688	$301,000	25%	$75,000	$376,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed
Divert Flow	1.00	JOB	$97,096.68	$97,000	25%	$24,000	$121,000	Cost to Dam up all 12 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	65,053.00	BCY	$2.05	$133,000	25%	$33,000	$166,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Riprap R600	67,293.00	TON	$54.36	$3,658,000	25%	$915,000	$4,573,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap R200	19,072.00	TON	50.08	$955,000	25%	$239,000	$1,194,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Bedding Stone	11,215.00	BCY	$41.68	$467,000	25%	$117,000	$584,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	3,656.00	CY	$200.75	$734,000	25%	$184,000	$918,000	All grout will be pumped by pump truck. production rate 10 cy/hr
Stormwater Pollution Prevention						$0		
Check Dams	36.00	EA	$1,267.27	$46,000	25%	$12,000	$58,000	Placed 3 check dams down stream of structures to catch any debris caused by construction, will be removed by the Bench Channel Contractor. Riprap Check Dams
Silt Fence	7,200.00	LF	$2.78	$20,000	25%	$5,000	$25,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF
Turfing	81.62	ACRES	$2,078.27	$170,000	25%	$43,000	$213,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1.00	JOB	$87,052.20	$87,000	25%	$22,000	$109,000	This will be for gas spill containment, Environmental Plan etc.
Field Road Restoration	14.36	ACRES	$376.15	$5,000	25%	$1,000	$6,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. These are mostly ag fields so tilling should suffice.
Low Drop Weir Structures (Main Channel)	**12.00**	**EA**	**$573,917**	**$6,887,000**	**25%**	**$1,722,000**	**$8,609,000**	**All Prices Escalated to July 2020 using 2.5% Esc per annum. (5 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Low Drop Weir Structures (Tributary Channel)								
Mob & Demob (8 Tributary Structures)	1	JOB	$121,208.57	$121,000	25%	$30,000	$151,000	Allows for one Mobilization and mob/demob between each structure (8 locations) as well as 1/2 final demobilization.
Access Road	1,400	TON	$35.90	$50,000	25%	$13,000	$63,000	Allows for 1400 Tons of Resurfacing to access the No. 2 Structure.
Clearing and Grubbing	8	ACRES	$3,698.52	$30,000	25%	$8,000	$38,000	2 Oper, 3 labors, 1 dozer, 1 excavator, 3 chainsaws at 0.1 acres/hour heavy clearing assumed

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
Divert Flow	1	JOB	$36,539.09	$37,000	25%	$9,000	$46,000	Cost to Dam up all 8 locations on both ends with 150 LF of Pipe extending through to drain locations while the riprap is grouted.
Excavation	8,000	BCY	$2.05	$16,000	25%	$4,000	$20,000	2 long reach excavators; 1 working each bank, with a dozer assisting the spoil pile and compacting
Riprap Class "A"	4,800	TON	$50.22	$241,000	25%	$60,000	$301,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Riprap Class "B"	11,200	TON	$50.22	$562,000	25%	$141,000	$703,000	Received Quote from Fullen Dock for material, Used a dozer to work the pile as well as to assist in getting rock to the bottom of the channel. Used a 2.75 Cy Excavator to assist in spreading the material.
Grout	2,400	CY	$201.31	$483,000	25%	$121,000	$604,000	All grout will be pumped by pump truck. production rate 10 cy/hr Allowance of $100/cy for material
Stormwater Pollution Prevention				$0	25%	$0	$0	
Check Dams	24	EA	$1,270.81	$30,000	25%	$8,000	$38,000	Placed 3 check dams down stream of structures to catch any debris caused by construction. Includes Installation and Removal. Riprap Check Dams
Silt Fence	4,800	LF	$2.65	$13,000	25%	$3,000	$16,000	Approximately 300 LF of silt fence will be placed around each bank to stop any debris or runoff back into ag fields and into the channel. Total of 600 LF per structure. Includes Installation and Removal.
Erosion Blanket	2,800	SY	$5.68	$16,000	25%	$4,000	$20,000	Placement of 300 SY per hour for 3 laborers and a flatbed truck
Turfing	16	ACRES	$2,084.06	$33,000	25%	$8,000	$41,000	Allows for tilling, harrowing, watering, planting of seed. Subcontracted Item of Work and Seed will be Bermuda type seeding. Replant 25% allowed.
Environmental Protection	1	JOB	$58,196.54	$58,000	25%	$15,000	$73,000	This will be for gas spill containment, Environmental Plan etc.
Field Road Restoration	9.5	ACRES	$1,626	$15,000	25%	$4,000	$19,000	This item will allow the contractor to make at least 8 passes with a tiller/tractor over the access roads. This includes final cleanup. Most of these is over pasture and this allows for returfing.
Backfill	8,000.0	ECY	$1.63	$13,000	25%	$3,000	$16,000	Backfill will be a process of the excavation; However; since this was under the structure Compaction Equipment was included and this is what this is for.
Geotextile	6,000.0	SY	$3.96	$24,000	25%	$6,000	$30,000	For placement underneath the Riprap. 150 SY for 2 labors, 1 truck driver and a flatbed truck.
Low Drop Wier Structures (Tributary Channel)	**8.00**	**EA**	**$217,750**	**$1,742,000**	25%	**$436,000**	**$2,178,000**	**All Prices Escalated to July 2020 using 2.5% Esc per annum. (5 year), Bob Hunt of H&H provided quantities for the Main Channel Structures and the Sponsor provided quantites for the Tributary Channel Structures.This is just a roll up of the below costs to show a per structure cost.**
Total 16				$8,629,000		$2,161,000	$10,790,000	
30 PLANNING, E&D								

Corps of Engineers, Memphis District								
Cypress Creek PAS, Oakland, Fayette County, TN								
Prices Escalated to July 2020(Assummed Start of Construction Schedule); Preparation Date: 10/30/2015								
Alternative Review for 20 Low Drop Weir Structures								
ALTERNATIVE II								
ITEM DESCRIPTION	**QUANTITY**	**UNIT**	**UNIT PRICE**	**AMOUNT**	**Cont %**	**CONTING.**	**TOTAL**	**COMMENT**
E&D for Study Costs	1	LS	$ 450,000.00	$450,000	25%	$113,000	$563,000	This is the total provided by PM for the cost of the study. Includes sponsor work in kind estimates.
E&D fro Relocations	1	LS	$ -	$0	25%	$0	$0	There aren't any relocations, therefore there will be no study costs.
E&D for 16 Bank Stabilization	1	LS	$ 1,294,350.00	$1,294,000	25%	$324,000	$1,618,000	15% allowance for Engineering and Design. This was calculated on the total projected cost for construction of the bank stabilization measures.
Total 30				$1,744,000		$437,000	**$2,181,000**	20.21%
31 Supervision and Administration								
S&A for 16 Bank Stabilization	1	LS	$ 1,294,350.00	$1,294,000	25%	$324,000	$1,618,000	15% allowance for the supervision of the installation of bank stabilization measures.
Total 31				$1,294,000		$324,000	**$1,618,000**	15.00%
TOTAL PROJECT COSTS (June 2015)	1	LS		$13,043,000		$3,059,620	**$16,102,620**	There is a 25% contingency allowance on all construction items.
TOTAL PROJECT COSTS (June 2015)	1	LS	100.0%			23.5%	**$16,102,620**	

Appendix E

Real Estate

DRAFT REAL ESTATE PLAN

MEMPHIS METROPOLITAN AREA STORMWATER
CYPRESS CREEK
ECOSYSTEM RESORATION
FEASIBILITY STUDY
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

DRAFT REAL ESTATE PLAN

MEMPHIS METROPOLITAN AREA STORMWATER
CYPRESS CREEK
ECOSYSTEM RESORATION
FEASIBILITY STUDY
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

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DRAFT REAL ESTATE PLAN

MEMPHIS METROPOLITAN AREA STORMWATER
CYPRESS CREEK
ECOSYSTEM RESORATION
FEASIBILITY STUDY
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

DATE: NOVEMBER 24, 2015

1. PROJECT PURPOSE AND AUTHORIZATION

Cypress Creek is a tributary of the 64-mile long Loosahatchie River, a tributary of the Mississippi River, in the vicinity of Oakland, Tennessee in Fayette County, northeast of Memphis. The Creek is 13 miles long, one of six sub-basins in Loosahatchie Watershed lying within the Mississippi Valley Loess Plains Eco Region.

Cypress Creek was channelized in the 1920's. The habitat in Cypress Creek is degraded and continues to worsen. This project would place 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 hydraulic conditions and provide ancillary benefits to adjacent infrastructure.

This Real Estate Plan (REP) is submitted as a preliminary plan to outline real estate interest required for the access to and construction of the proposed Project. The information contained herein is tentative in nature for planning purposes only. At this time, the Project Delivery Team (PDT) reached the Tentatively Selected Plan (TSP) milestone and feasibility analysis is just beginning. The information contained in this REP is based on assumptions and does not yet conform to the requirements of Chapter 12 (ER 405-1-12). Once the feasibility analysis is complete, the REP will be revised to conform to Chapter 12 and will be an Appendix to the final Feasibility Report.

Project Authorization

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 purposed 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 Marshal 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.

2. LOCATION AND DESCRIPTION OF THE LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, AND DISPOSAL AREAS (LERRD'S) REQUIRED FOR THE PROJECT

This project has the potential to restore connectivity between Cypress 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. 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.

The Tentatively Selected Plan (Alternative Two) will restore instream habitat quality and allow for the stabilization of the bank and the return of native riparian vegetation. The TSP consists of the following features:

Grade Control Weirs – Will be used to correct stream instability, controlling the channel slope and elevation. Twelve (12) grade control structures will be located on the main stem of Cypress Creek and eight (8) structures located on the tributaries. The weirs will be constructed within the water bottoms and extend to the banks. This area will be acquired in fee estate and assumes that the water bottoms are privately-owned.

Construction of the weirs will require clearing approximately four acres of trees to allow construction access for each grade control structure. All trees will be replanted. The U.S. Army Corps of Engineers (USACE) and the Non-Federal Sponsor (NFS) will monitor plantings and ensure 80% survival. The riparian zone is 40' – 60' wide. A temporary work area easement will be acquired over areas needed for construction access.

Access sites and construction staging areas have not yet been identified, but will likely be from public roads or former railroad beds across private property. These routes will be needed for hauling rock, equipment and other materials. Disposal areas will be located on adjacent land, but the exact locations have not yet been identified. The access, construction staging and disposal areas will all be acquired through a Temporary Work Area Easement. These unknown locations will be addressed in the final feasibility study report. Construction will use track hoes and draglines from stream banks. Larger weir construction will require access from both banks while smaller weir construction requires access from just one side. Construction noise levels are equal to any typical construction site.

3. NON-FEDERAL SPONSOR-OWNED LERRD'S

The Non-Federal Sponsor on the Project is State of Tennessee West Tennessee River Basin Authority. At this time it is assumed that the Sponsor does not own any LERRDS within the Project.

4. STANDARD ESTATES

FEE EXCLUDING MINERALS (With Restriction on Use of the Surface) - Weirs

The fee simple title to the land, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the for the purpose of exploration, development, production and removal therefrom of said (coal) (oil and gas).

TEMPORARY WORK AREA EASEMENT – Access and Work Area
A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

TEMPORARY WORK AREA EASEMENT – Disposal Area
A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors including the right to deposit fill, spoil and waste material and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

5. EXISTING FEDERAL PROJECT(S) WITHIN THE PROJECT AREA
Oakland, TN Section 14 Project - Channelization of Cypress Creek caused headcutting up an unnamed tributary. 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.

6. FEDERALLY-OWNED LANDS WITHIN (LERRD'S FOR) THE PROJECT
There are no State or Federal holdings within the project. There are no known wetlands in the immediate construction area. If wetlands are found, they will be avoided.

7. NAVIGATIONAL SERVITUDE
The navigation servitude is the "dominant right of the government under the Commerce Clause of the U.S. Constitution to use, control and regulate the navigable waters of the United States and the submerged lands there under for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the mean high water mark. In non-tidal areas, the servitude extends to all lands within the bed and banks of a navigable stream that lie below the ordinary high water mark."

As of the writing of this REP, Office of Council had not provided its determination as to the navigability of Cypress Creek and whether the waterbottoms should be considered privately owned or owned by the State of Tennessee. For the purpose of this REP it is assumed that the navigation servitude will not be invoked. It is further assumed that the waterbottoms are privately owned.

8. PROJECT MAPS

Figure 1 below shows the Cypress Creek Watershed area (yellow) in the western part of Tennessee.

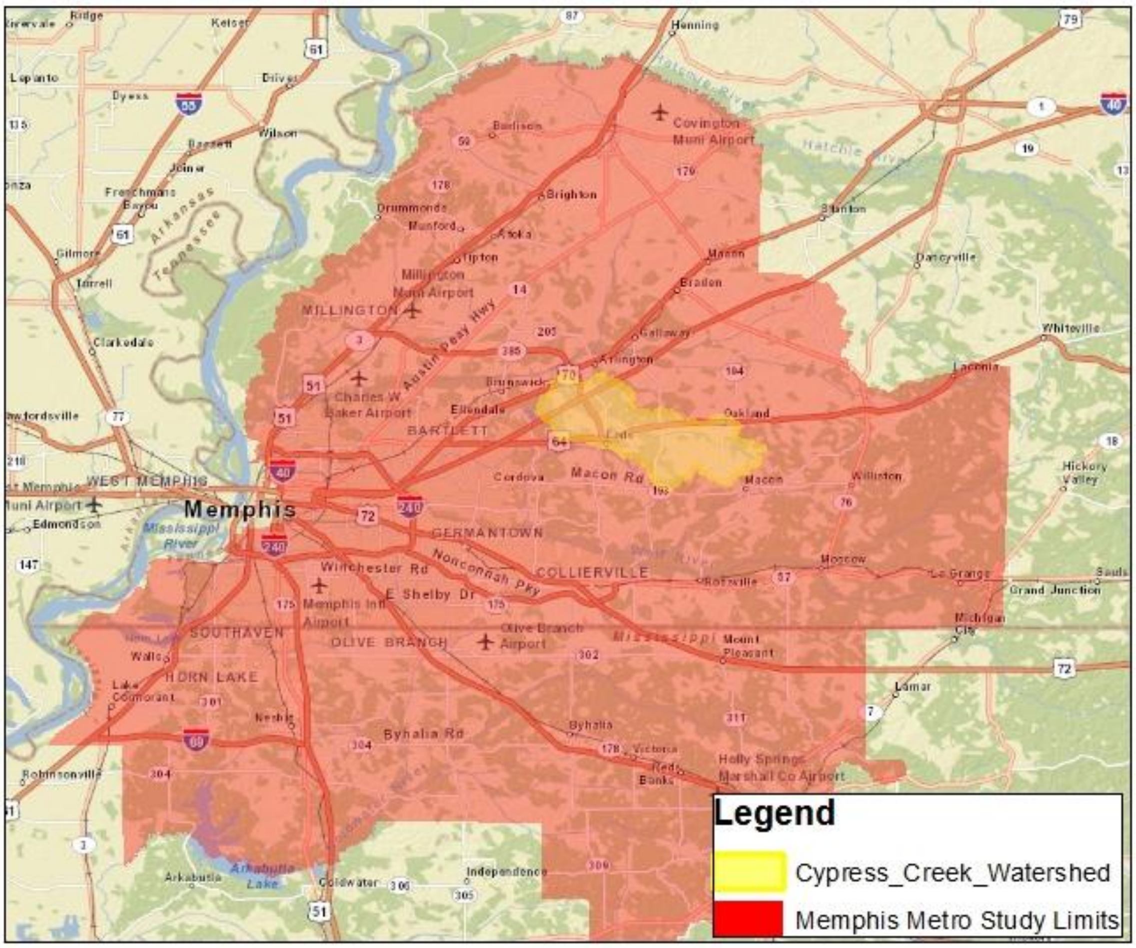


Figure 1

Figure 2 below shows areas of proposed weirs for Alternative 2 within the watershed along Cypress Creek.

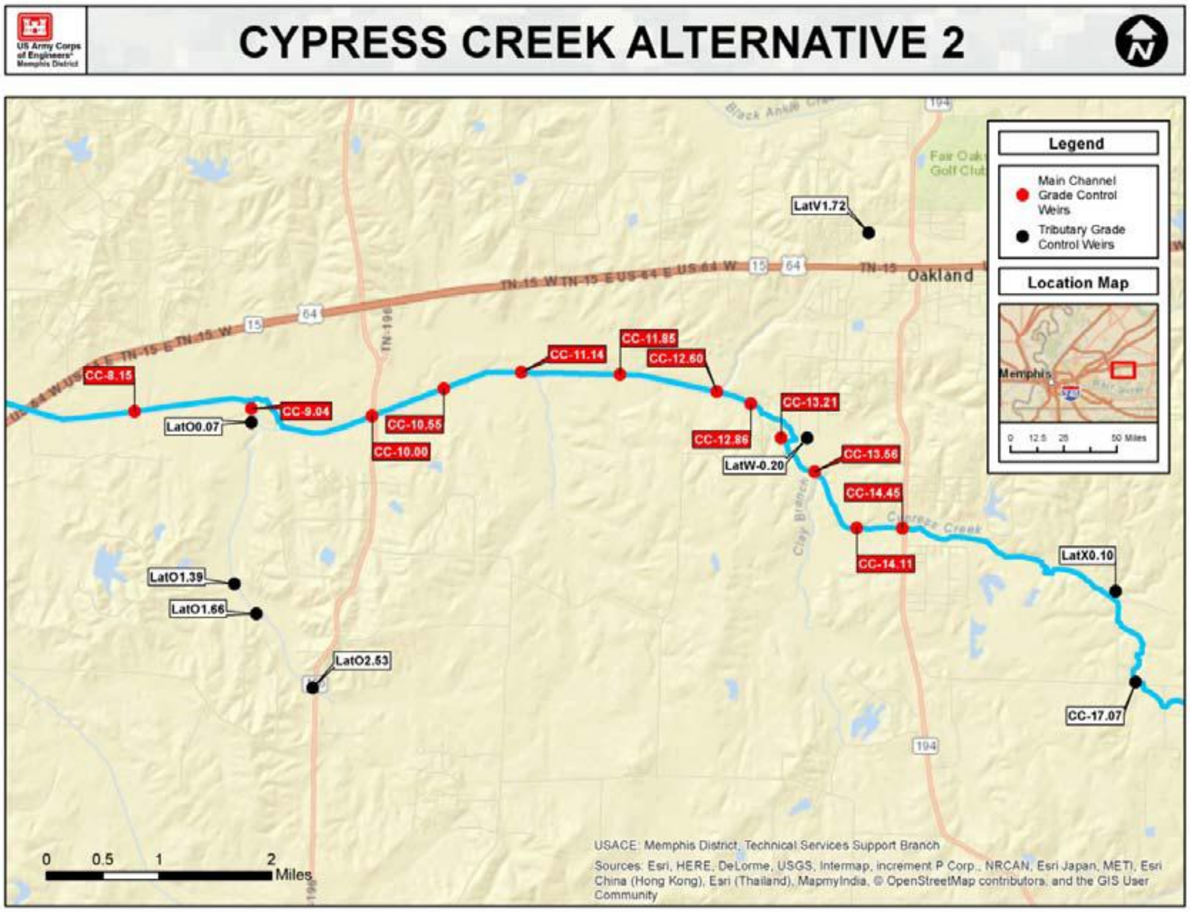


Figure 2

9. INDUCED FLOODING

Construction of this project will not induce flooding.

10. BASELINE COST ESTIMATES/CHART OF ACCOUNTS (COA'S)

The total estimated real estate costs for this Project are $1,513,820. Below is the synopsis of the real estate costs.

Land Payments		$976,200
PL 91-646 Assistance Payment		$0
Acquisition Costs		$400,000
Contingency		$137,620
	Total	$1,513,820

These costs are based on acquisition of fee title over 97.62 acres of privately owned channel bottoms, agricultural lands and residential lands to be acquired for construction of the weirs and access to the sites. Acquisition costs include the costs of negotiations, appraisal, mapping, title search, condemnation and processing the Non-Federal Sponsor's credit package. The real estate cost estimate includes a contingency. Estimated land payments are based on a cost estimate prepared by Memphis District staff appraiser. These costs are further broken down in the Chart of Accounts included in Exhibit A.

11. RELOCATION ASSISTANCE BENEFITS

This Project does not displace residential, commercial, industrial or habitable structures within the Project boundaries; therefore, the provisions under Title II of Public Law 91-646, as amended, are not applicable.

12. TIMBER/MINERAL/ROW CROP ACTIVITY

Access to the Project areas may require cutting of trees. It is the intent of the Project to replant any trees that are cut. The Government will not acquire mineral rights to the properties. Project impacts some agricultural lands, but it is assumed that the owner(s) will be allowed to harvest crops prior to project construction.

13. PROJECT SPONSOR/NFS CAPABILITY ASSESSMENT

The Non-Federal Sponsor (NFS) will acquire all LERRD's for this Project and will be advised of the Uniform Relocations Act requirements and Federal requirements for documenting expenses for credit. Prior to the final REP and final Feasibility Report, the NFS's capability assessment will be completed and added to this report as an Exhibit.

14. ZONING IN LIEU OF ACQUISITION

Zoning ordinances will not be enacted to facilitate the acquisition of real estate interests in connection with the Project.

15. ACQUISITION SCHEDULE

This schedule assumes that 20 landowners will be impacted. It is expected that additional owners will be impacted once construction, disposal and access areas are identified.

Non Federal Sponsor obtain mapping	1 month
Non Federal Sponsor obtain title information	3 months
Non Federal Sponsor obtain appraisals (concurrent w/title)	3 months
Non Federal Sponsor negotiate acquisition	6 months
Closing	2 months
Condemnation (if necessary)	1 year
Issuance of Right-of-Entry by NFS	1 month

16. FACILITY/UTILITY RELOCATIONS

No relocations are anticipated. At least one pipeline is located under Cypress Creek and there are TVA transmission lines, local power lines and telephone lines that cross the creek. These will not be affected by the Project. Existing Tennessee Valley Authority (TVA power) transmission line towers will be avoided. There are five bridges and numerous road culverts in the study area.

17. ENVIRONMENTAL CONSIDERATIONS

Cypress Creek is on the State 303d list for impaired waters. It is listed for total phosphorus, E. coli, habitat alteration and sedimentation. A record search was conducted of the EPA's EnviroMapper Web Page and a site inspection was conducted in June 2015. Neither the records search nor the inspection identified the presence of any hazardous or suspected hazardous waste in the project area. Probability of encountering Hazardous, Toxic and Radioactive Waste (HTRW) is low.

18. LANDOWNER CONCERNS

Over fifty percent (50%) of the land use in the watershed is pasture and cropland. Thirty percent (30%) is forested and the remaining five to ten percent (5 – 10 %) is residential and commercial. USDA classified most of the area as prime farmland. The project will cause some impacts to farmland, but the stabilizing of Cypress Creek will prevent bank caving and loss of prime farmland. It is assumed that landowners will be in favor of the project. However, landowner public meetings have not been conducted.

19. NON-FEDERAL SPONSOR NOTIFICATION OF RISKS

Prior to completion of the final REP and final Feasibility Report, the Non Federal Sponsor will be provided a letter outlining the risks of initiating acquisition activities prior to project authorization and design completion.

20. OTHER RELEVANT REAL ESTATE ISSUES

No federally listed species occur within the project area, but there is potential for the endangered bat. The Project Checklist is attached to the REP as Exhibit B.

PREPARED BY:

Pamela Fischer

____

Pamela M. Fischer
Realty Specialist

REVIEWED AND RECOMMENDED BY:

Judith Y. Gutierrez

____

Judith Y. Gutierrez
Chief, Planning and Appraisal

DATED: November 24, 2015

Exhibit A

Chart of Accounts

CEMVK-RE-E
REAL ESTATE DIVISION

MEMPHIS METROPOLITAN AREA STORMWATER
CYPRESS CREEK
ECOSYSTEM RESORTATION

NOVEMBER 24, 2015

					AMOUNT	CONTINGENCY ROUNDED	PROJECT COST
	TOTAL PROJECT COSTS				1,376,200	137,620	1,513,820
01	LANDS AND DAMAGES		CONTINGENCY	PROJECT COST	1,376,200	137,620	1,513,820
01B	ACQUISITIONS						
01B10	BY GOVERNMENT	0	0	0			
01B20	BY NON-FEDERAL SPONSOR (NFS)	170,000	17,000	187,000			
01B30	BY GOVERNMENT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0			
01B40	REVIEW OF NFS	90,000	9,000	99,000			
			0				
01C	CONDEMNATIONS		0				
01C10	BY GOVERNMENT	0	0	0			
01C20	BY NON-FEDERAL SPONSOR (NFS)	40,000	4,000	44,000			
01C30	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0			
01C40	REVIEW OF NFS	0	0	0			
			0				
01E	APPRAISAL		0				
01E10	BY GOVT (IN HOUSE)	0	0	0			
01E20	BY GOVT (CONTRACT)	0	0	0			
01E30	BY NON-FEDERAL SPONSOR (NFS)	40,000	4,000	44,000			
01E40	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0			
01E50	REVIEW OF NFS	20,000	2,000	22,000			
			0				
01F	PL 91-646 ASSISTANCE		0				
01F10	BY GOVERNMENT	0	0	0			
01F20	BY NON-FEDERAL SPONSOR (NFS)	0	0	0			
01F30	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0			
01F40	REVIEW OF NFS	0	0	0			
			0				
01G	TEMPORARY PERMITS/LICENSES/RIGHTS-OF-ENTRY		0				
01G10	BY GOVERNMENT	0	0	0			
01G20	BY NON-FEDERAL SPONSOR (NFS)	0	0	0			
01G30	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0			
01G40	REVIEW OF NFS	0	0	0			
01G50	OTHER	0	0	0			
01G60	DAMAGE CLAIMS	0	0	0			
			0				
01N00	FACILITY/UTILITY RELOCATIONS (Subordination Agreement)		0				
			0				

01R	**REAL ESTATE PAYMENTS**		0					
01R1	**LAND PAYMENTS**		0					
01R1A	BY GOVERNMENT	0	0	0				
01R1B	BY NON-FEDERAL SPONSOR (NFS)	976,200	97,620	1,073,820				
01R1C	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0				
01R1D	REVIEW OF NFS	0	0	0				
01R2	**PL 91-646 ASSISTANCE PAYMENTS**		0					
01R2A	BY GOVERNMENT	0	0	0				
01R2B	BY NON-FEDERAL SPONSOR (NFS)	0	0	0				
01R2C	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0				
01R2D	REVIEW OF NFS	0	0	0				
01R3	**DAMAGE PAYMENTS**		0					
01R3A	BY GOVERNMENT	0	0	0				
01R3B	BY NON-FEDERAL SPONSOR (NFS)	0	0	0				
01R3C	BY GOVT ON BEHALF OF NON-FEDERAL SPONSOR (NFS)	0	0	0				
01R3D	REVIEW OF NFS	0	0	0				
01R9	**OTHER**	0	0	0				
01T	**LERRD CREDITING**		0					
01T20	ADMINISTRATIVE COSTS (By Gov't and NFS)	40,000	4,000	44,000				

Exhibit B

DRAFT Quality Control Plan Checklist

Real Estate Plans

And other similar Feasibility-Level Real Estate Planning Documents

ER 405-1-12, Section 12-16, Real Estate Handbook, 1 May 1998

A Real Estate Plan (REP) is prepared in support of a decision document for full-Federal or cost shared specifically authorized or continuing authority projects. It identifies and describes lands, easements and rights-of-way (LER) required for the construction, operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of a proposed project including requirements for mitigation, relocations, borrow material, and dredged or excavated material disposal. It also identifies and describes facility/utility relocations, LER value, and the acquisition process. The REP does not just cover LER to be acquired by the non-Federal sponsor (NFS) or Government. The report covers all LER needed for the project, including LER already owned by the NFS, Federal Government, other public entities, or subject to the navigation servitude.

The REP must contain a detailed discussion of the following 20 topics, as set out in Section 12-16 of the ER, including sufficient description of the rationale supporting each conclusion presented. If a topic is not applicable to the project, this should be stated in the REP. The pages of a REP should be numbered.

PROJECT CYPRESS CREEK PROJECTTRIBUTARY OF THE LOOSAHATCHIE RIVER

____________ FAYETTE COUNTY, TENNESSEE __________________________.

REPORT TITLE _________PRELIMINARY REAL ESTATE PLAN - DRAFT________________

Date of Report November 12, 2015 **Date of REP** November 24, 2015

1. **Purpose of the REP**. __√___

a. Describe the purpose of the REP in relation to the project document that it supports.

b. Describe the project for the Real Estate reviewer.

c. Describe any previous REPs for the project.

2. **Describe LER**. _______

a. Account for all lands, easements, and rights-of-way underlying and required for the construction, OMRR&R of the project, including mitigation, relocations, borrow material and dredged or excavated material disposal, whether or not it will need to be acquired or will be credited to the NFS.

b. Provide description of total LER required for each project purpose and feature.

c. Include LER already owned by the Government, the NFS and within the navigation servitude.

d. Show acreage, estates, number of tracts and ownerships, and estimated value.

e. Break down total acreage into fee and the various types and durations of easements.

f. Break down acreage by Government, NFS, other public entity, and private ownership, and lands within the navigation servitude.

3. **NFS-Owned LER**._______

a. Describe NFS-owned acreage and interest and whether or not it is sufficient and available for project requirements.

b. Discuss any crediting issues and describe NFS views on such issues.

4. Include any proposed **Non-Standard Estates**. __√___

a. Use Standard Estates where possible.

b. Non-standard estates must be approved by HQ to assure they meet DOJ standards for use in condemnations.

c. Provide justification for use of the proposed non-standard estates.

d. Request approval of the non-standard estates as part of document approval.

e. If the document is to be approved at MSC level, the District must seek approval of the non-standard estate by separate request to HQ. This should be stated in the REP.

f. Exception to HQ approval is District Chiefs of RE approval of non-standard estate if it serves intended project purposed, substantially conforms with and does not materially deviate from the standard estates found in the RE Handbook, and does not increase cost or potential liability to the

Government. A copy of this approval should be included in the REP. (See Section 12-10c. of RE 405-1-12)

g. Although estates are discussed generally in topic 2, it is a good idea to also state in this section which standard estates are to be acquired and attach a copy as an appendix. The duration of any temporary estates should be stated.

5. **Existing Federal Projects**. _____

a. Discuss whether there is any existing Federal project that lies fully or partially within LER required for the project.

b. Describe the existing project, all previously-provided interests that are to be included in the current project, and identify the sponsor.

c. Interest in land provided as an item of local cooperation for a previous Federal project is not eligible for credit.

d. Additional interest in the same land is eligible for credit.

6. **Federally-Owned Lands** _____

a. Discuss whether there is any federally owned land included within the LER required for the project.

b. Describe the acreage and interest owned by the Government.

c. Provide description of the views of the local agency representatives toward use of the land for the project and issues raised by the requirement for this land.

7. **Navigation Servitude**. __√___

a. Identify LER required for the project that lies below the Ordinary High Water Mark, or Mean High Water Mark, as the case may be, of a navigable watercourse.

b. Discuss whether navigation servitude is available

c. Will it be exercised for project purposes? Discuss why or why not.

d. Lands over which the navigation servitude is exercised are not to be acquired nor eligible for credit for a Federal navigation or flood control project or other project to which a navigation nexus can be shown.

e. See paragraph 12-7 of ER 405-1-12.

8. **Map** _√____

a. An aid to understanding

b. Clearly depicting project area and tracts required, including existing LER, LER to be acquired, and lands within the navigation servitude.

c. Depicts significant utilities and facilities to be relocated, any known or potential HTRW lands.

9. **Induced Flooding** can create a requirement for real estate acquisition. ___√___

a. Discuss whether there will be flooding induced by the construction and OMRR&R of the project.

b. If reasonably anticipated, describe nature, extent and whether additional acquisition of LER must or should occur.

c. Physical Takings Analysis (separate from the REP) must be done if significant induced flooding anticipated considering depth, frequency, duration, and extent of induced flooding.

. d. Summarize findings of Takings Analysis in REP. Does it rise to the level of a taking for which just compensation is owed?

10. **Baseline Cost Estimate** as described in paragraph 12-18. _____

a. Provides information for the project cost estimates.

b. Gross Appraisal includes the fair market value of all lands required for project construction and OMRR&R.

c. PL 91-646 costs

d. Incidental acquisition costs

e. Incremental real estate costs discussed/supported.

f. Is Gross Appraisal current? Does Gross Appraisal need to be updated due to changes in project LER requirements or time since report was prepared?

11. **Relocation Assistance Benefits** Anticipated. __√___

a. Number of persons, farms, and businesses to be displaced and estimated cost of moving and reestablishment.

b. Availability of replacement housing for owners/tenants

c. Need for Last Resort Housing benefits

d. Real Estate closing costs

e. See current 49 CFR Part 24

12. **Mineral Activity**. __√___

a. Description of present or anticipated mineral activity in vicinity that may affect construction, OMRR&R of project.

b. Recommendation, including rationale, regarding acquisition of mineral rights or interest, including oil or gas.

c. Discuss other surface or subsurface interests/timber harvesting activity

d. Discuss effect of outstanding 3rd party mineral interests.

e. Does estate properly address mineral rights in relation to the project?

13**. NFS Assessment** _____

a. Assessment of legal and professional capability and experience to acquire and provide LER for construction, OMRR&R of the Project.

b. Condemnation authority

c. Quick-take capability

d. NFS advised of URA requirements

e. NFS advised of requirements for documenting expenses for credit.

f. If proposed that Government will acquire project LER on behalf of NFS, fully explain the reasons for the Government performing work.

g. A copy of the signed and dated Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability (Appendix 12-E) is attached to the REP.

14. **Zoning** in Lieu of Acquisition __√___

a. Discuss type and intended purpose

b. Determine whether the proposed zoning proposal would amount to a taking for which compensation will be due.

15. **Schedule** __√___

a. Reasonable and detailed Schedule of land acquisition milestones, including LER certification.

b. Dates mutually agreed upon by Real Estate, PM, and NFS. _____

16. **Facility or Utility Relocations** __√___

a. Describe the relocations, identity of owners, purpose of facilities/utilities, whether owners have compensable real property interest.

b. A synopsis of the findings of the Preliminary Attorney's Investigation and Report of Compensable Interest is included in the REP as well as statements required by Sections 12-17c.(5) and (6).

c. Erroneous determinations can affect the accuracy of the project cost estimate and can confuse Congressional authorization.

d. Eligibility for substitute facility

1. Project impact

2. Compensable interest

3. Public utility or facility

4. Duty to replace

5. Fair market value too difficult to determine or its application would result in an injustice to the landowner or the public.

e. See Sections 12-8, 12-17, and 12-22 of ER 405-1-12.

17. **HTRW** and Other Environmental Considerations __√____

a. Discussion the impacts on the Real Estate acquisition process and LER value estimate due to known or suspected presence of contaminants.

b. Status of District's investigation of contaminants.

c. Are contaminants regulated under CERCLA, other statues, or State law?

d. Is clean-up or other response required of non-CERCLA regulated material?

e. If cost share, who is responsible for performing and paying cost of work?

f. Status of NEPA and NHPA compliances

g. See ER 1165-2-132, Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects.

18. **Landowner Attitude**. __√____

a. Is there support, apathy, or opposition toward the project?

b. Discuss any landowner concerns on issues such as condemnation, willing seller provisions, estates, acreages, etc.?

19. A statement that the **NFS has been notified in writing about the risks of acquiring LER before the execution of the PPA**. If not applicable, so state. ____

20. **Other Relevant Real Estate Issues**. Anything material to the understanding of the RE aspects of the project. ___√____

A copy of the completed Checklist is attached to the REP. ____

(Draft REPs must contain a draft checklist and draft Technical Review Guide)

I have prepared and thoroughly reviewed the REP and all information, as required by Section 12-16 of ER 405-1-12, is contained in the Plan.

Pamela Fraile   November 24, 2015

_____________________________________   ___________________

Preparer   Date

A copy of the Real Estate Internal Technical Review Guide for Civil Works Decision

Documents is attached and signed by me as the Reviewer

11/24/15

______________________________________ _____________________

RE Internal Technical Reviewer Date

The REP has been signed and dated by the Preparer and the District Chief of Real Estate. ____√_______

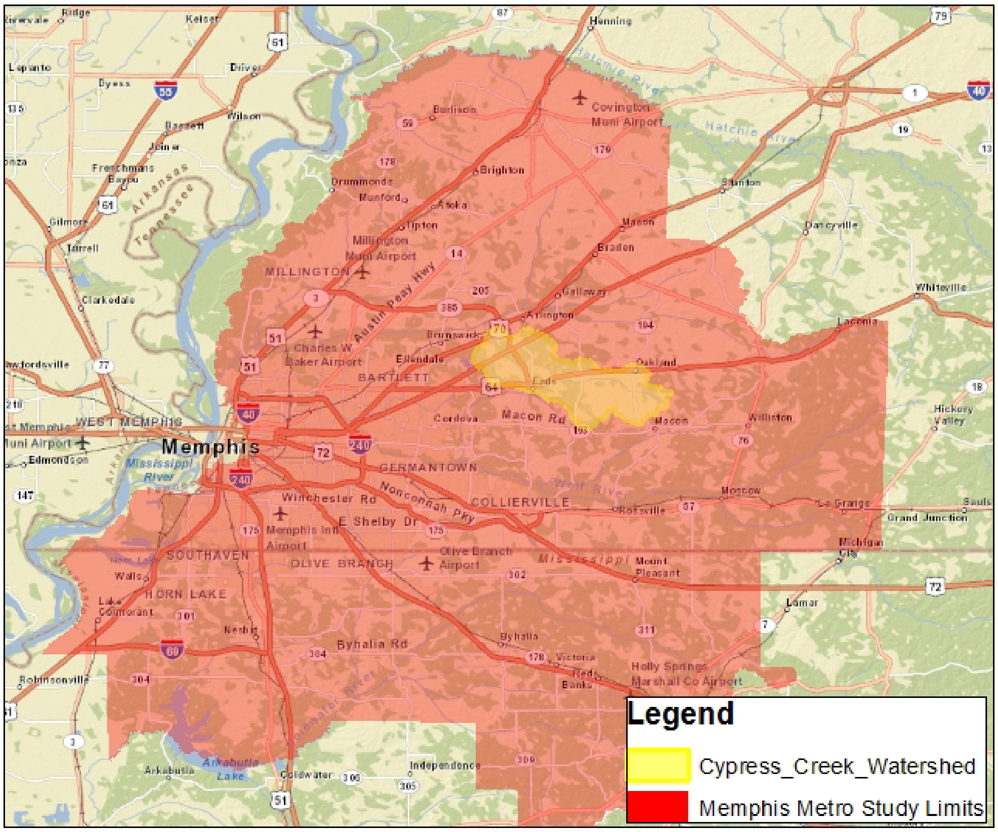
Appendix F

404 (b) 1 Evaluation

404(b)(1) Evaluation
Cypress Creek Ecosystem Restoration
Fayette County, Tennessee

I. Project Description

a. Location: Cypress Creek is a tributary of the Loosahatchie River located within the vicinity of Oakland, Fayette County, Tennessee (Figure 1). The project footprint would begin upstream of the Highway 64 bridge over Cypress Creek and proceed approximately 13 miles upstream.



b. General Description: The goal of this project is to increase the amount, quality, and sustainability of habitat in the ecosystem of Cypress Creek and its tributaries. 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.

Stream instability is the underlying cause of many of the problems in Cypress Creek which may be addressed with grade control weirs. Grade control weirs would begin with the downstream-most structures and proceeded upstream. The most downstream structure would connect the downstream habitat and the Loosahatchie River to the upstream areas.

c. Authority and Purpose: 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.

d. General Description of Dredged or Fill Material

1) General Characteristics of Excavated Material: Excavated materials would be composed mostly of highly erodible soils along the banks of Cypress Creek for placement of the grade control weirs.

2) Quantity of Material: Quantity of excavated material is not expected to exceed 65,053 cubic yards of material over the 13 miles of the proposed project. For the main stem Cypress Creek weirs, expected quantity of R600 riprap is approximately 75,293 tons, R200 is approximately 19,072 tons, and quantity of bedding stone is approximately 11,215 tons. For the tributary weirs, approximately 4,800 tons of Class A riprap would be used, and approximately 11,200 tons of Class B riprap with approximately 2,400 cubic yards of grout.

3) Source of Material: Excavated material would come from Cypress Creek banks and channel. Riprap would be sourced from approved contractor.

4) General Characteristics of Fill Material: Riprap and bedding stone would meet appropriate BMPs. R600 riprap would have a thickness of approximately feet and R200 would be approximately 2 feet thick.

e. Description of the Proposed Discharge Site(s)

1) Locations: The TSP includes 12 low drop grade control weirs between U.S. Highway 64 and State Highway 194. The amount of drop through the structures ranges from 3.0 to 5.0 feet and the average spacing between the lower seven structures is 3,900 feet (approximately 0.75 miles). The upper five structures would be spaced approximately 2,000 feet apart (approximately 0.40 miles). Nine additional grade control weirs would be built on tributaries. The exact locations of the sites have not been determined, but would be placed according to detailed hydrologic analysis prior to construction.

2) Size: Approximately 15 miles of Cypress Creek and tributaries would be restored. The final footprint of each weir would total approximately 1 acre.
3) Type of Site: Perennial Stream
4) Type(s) of Habitat: Degraded stream channel and banks as well as some moderate quality riparian forested habitat on the stream banks.
5) Timing and Duration of Discharge: Construction would be conducted in compliance with water quality certification, once it is obtained.

f. Description of Disposal Method: Low-drop weirs would be constructed using large equipment such as bulldozers and long-reach excavators. Best management practices would be followed per guidance from water quality certification. Application for water quality certification would be completed when construction plans are finalized.

II. Factual Determinations (Section 230.11)

a. Physical Substrate Determinations

1) Substrate Elevation and Slope: The intention of this action is to restore stable elevation and slope to the channel of Cypress Creek and tributaries. Due to channelization, the slope of the channel has been increasing over time, and incising has created steep banks which are subject to erosion and bank caving.

2) Sediment Type: The sediment in the Cypress Creek is characteristic of other streams in West Tennessee and is composed mostly of sand, silt, clay, and gravel.

3) Dredged/Fill Material Movement: Excavation materials and fill materials would be moved from the bank of the stream using land based equipment. Best management practices would be used to prevent or reduce the amount of sediment into the Cypress Creek.

4) Physical Effects on Benthos: No permanent effects to benthos are expected. Over time, conditions are expected to improve for benthos.

5) Actions Taken to Minimize Impacts (Subpart H): All construction activities would be performed in accordance with the conditions stated in the water quality certification and follow best management practices.

- The recommended plan is the least environmentally damaging plan that is economically feasible.
- Effective erosion control would be in place prior to construction and maintained throughout the construction period.
- Construction would take place as soon as possible, but every effort will be made to construct during periods of low water.
- Discharge material would be clean and free of pollutants, contaminants, toxic materials, hazardous substances, waste metal, construction debris and trash, and other wastes.
- Vegetation to be cleared would be the minimum necessary to allow for construction access.
- All disturbed areas would be seeded within 30 days after construction is completed.

- Heavy equipment shall be kept out of free flowing water.
- Construction debris would be kept from entering the ditch channel and shall be disposed of properly.
- Appropriate steps shall be taken to ensure that petroleum products or other chemical pollutants are prevented from entering the water.

b. Water Circulation, Fluctuation, and Salinity Determinations

1) Water. Effects on:

a) Salinity: N/A

b) Water Chemistry: No expected change

c) Clarity: Turbidity would increase during construction activities. Any increased sediment load would be local, temporary, and minor compared to the normal sediment load of the stream. No permanent change is expected.

d) Color: No expected change

e) Odor: No expected change

f) Taste: No expected change

g) Dissolved Gas Levels: No expected change

h) Nutrients: Restoration may enable the stream to breakdown nutrients more effectively preventing some of the problems associated with overgrowth of algae and low dissolved oxygen.

i) Eutrophication: No expected change

j) Others: No expected change

2) Current Patterns and Circulation

a) Current Patterns and Flow: Flow is expected to be restored to areas that have silted in over time, creating a more connected stream system.

b) Velocity: No expected change.

c) Stratification: No expected change.

d) Hydrologic Regime: No expected change.

3) Normal Water Level Fluctuations: The proposed action is expected to reduce some of the intense flashiness of Cypress Creek and its tributaries, and restore the creek to more natural fluctuations.

4) Salinity Gradients: N/A

5) Actions That Would Be Taken to Minimize Impacts: All construction would be performed in accordance with best management practices and any conditions stated in the water quality certification. Areas cleared for construction would be reseeded or replanted post construction. Construction would occur, where practicable, in areas that would not require tree clearing, and wetlands would be avoided.

c. Suspended Particulate/Turbidity Determinations

1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site: Turbidity would increase during construction activities. Any increased sediment load would be local and temporary.

2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column

a) Light Penetration: The proposed action would temporarily cause only an increase in turbidity. Light penetration is not expected to be affected.

b) Dissolved Oxygen: No expected change.

c) Toxic Metals and Organics: No expected change

d) Pathogens: N/A

e) Aesthetics: No expected change.

f) Others: None

3) Effects on Biota

a) Primary Production, Photosynthesis: Some improvement in primary production can be expected due to a more stable environment. Adverse effects on photosynthesis, if any, would be minor, local, and temporary.

b) Suspension/Filter Feeders: Overall the project would be expected to improve conditions for these species due to the improved stability of the stream.

c) Sight Feeders: The project would be expected to improve conditions for these species due to the improved stability of the stream. Many of these species may temporarily move up or downstream during times of increased turbidity due to construction.

d) Actions taken to Minimize Impacts (Subpart H): All construction would be performed in accordance with best management practices and the conditions stated in the water quality certification. Areas cleared for construction would be reseeded or planted with appropriate tree species post construction.

e) Contaminant Determinations: No contaminants are expected to be released during the construction of the proposed action.

d. Aquatic Ecosystem and Organism Determinations

1) Effects on Plankton: Overall the project would be expected to improve conditions for these species due to the improved stability of the stream. Adverse impacts, if any, are expected to be minor and temporary.

2) Effects on Benthos: During construction, benthic macroinvertebrates in the immediate proposed construction areas are likely to move up or downstream temporarily. Overall the project would be expected to improve conditions for these species due to the improved stability of the stream.

3) Effects on Nekton: Effects, if any, are expected to be minor and temporary.

4) Effects on Aquatic Food Web: Overall the aquatic food web is expected to improve with the project. Adverse impacts, if any, are expected to be local to construction areas and temporary.

5) Effects on Special Aquatic Sites

a) Sanctuaries and Refuges: N/A

b) Wetlands: No wetlands are expected to be impacted during the project construction.

c) Mud Flats: N/A

d) Vegetated Shallows: N/A

e) Coral Reefs: N/A

f) Riffle and Pool Complexes: Riffle and pool complexes are expected to increase with construction of the low-drop weirs creating habitat diversity and complexity.

6) Threatened and Endangered Species: The U.S. Fish and Wildlife Service (USFWS) commented on 4 November 2014 by e-mail that the USFWS database doesn't indicate any federally listed species in the Cypress Creek watershed. However, any proposed tree removal would need to be coordinated with USFWS as the project is within range of the Indiana and northern long-eared bat.

7) Other Wildlife: Effects, if any, are expected to be minor and temporary. The project would be expected to improve conditions for the state-listed naked sand darter and other fish species.

8) Actions Taken to Minimize Impacts (Subpart H): All construction would be performed in accordance with best management practices and conditions stated in the water quality certification. Areas cleared for construction would be reseeded or planted with appropriate tree species post construction.

e. Proposed Disposal Site Determinations

1) Mixing Zone Determinations

2) Determination of Compliance with Applicable Water Quality Standards: An Aquatic Resource Alteration Permit (401 Water Quality Certification) would be applied for when construction is expected to proceed. Presently, water quality certification has not been requested or obtained. Construction is not expected to occur in the immediate future, but would improve the conditions of the Cypress Creek system.

3) Potential Effects on Human Use Characteristic

a) Municipal and Private Water Supply: N/A

b) Recreational and Commercial Fisheries: N/A

c) Water Related Recreation: N/A

d) Aesthetics: N/A

e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves: N/A

f. Determination of Cumulative Effects on the Aquatic Ecosystem:
Channelization of most rivers and creeks in west Tennessee has led to the degradation of the Cypress Creek watershed in Fayette County, Tennessee. Cypress Creek is listed as 303(d) impaired for habitat alteration, sedimentation, and *E. coli.* Proceeding with the proposed project would result in a more stable channel system which would reduce the sedimentation and improve habitat stability for native wildlife. Negative impacts related to the proposed project that were evaluated during the preparation of this 404(b)(1) evaluation are minor in magnitude and duration. Cumulative effects of the project on the Cypress Creek watershed would be positive.

g. Determination of Secondary Effects on the Aquatic Ecosystem: N/A

III. Findings of Compliance or Non-Compliance With the Restriction on Discharge

a. Adaptation of the Section 404(b)(1) Guidelines to this Evaluation: No significant adaptation of the Section 404(b)(1) guidelines were made relative to this evaluation.

b. Evaluation of Availability of Practical Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem: The proposed Construction of low drop weirs would have a positive effect on the 303(d) listed Cypress Creek and tributaries by reducing sedimentation due to excessive erosion. An environmental assessment has been prepared to evaluate the potential adverse and beneficial environmental effects. Six alternatives were evaluated to address the habitat alteration, active erosion and sedimentation in Cypress Creek. The TSP was the most cost effective, and would address the outstanding issues within the creek.

c. Compliance with Applicable State Water Quality Standards: An Aquatic Resource Alteration Permit (401 Water Quality Certification), from the State of Tennessee, would be applied for when construction is expected to proceed. Presently, water quality certification has not been obtained, but all applicable permit conditions would be followed during construction.

d. Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 Of the Clean Air Act: Fayette County is in attainment for all air quality standards. Construction activities are not regulated, so no permitting is required. Fugitive dust will be minimized as well as use of best management practices to minimize air pollution.

e. Compliance with Endangered Species Act of 1973: USFWS has commented that the proposed project is within range of the federally listed endangered Indiana bat and the northern long-eared bat. Any proposed tree clearing associated with the project would be coordinated with USFWS prior to construction.

f. Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972: N/A

g. Evaluation of Extent of Degradation of the Waters of the United States

1) Significant Adverse Effects on Human Health and Welfare

a) Municipal and Private Water Supplies: N/A

b) Recreation and Commercial Fisheries: N/A

c) Plankton: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

d) Fish: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

e) Shellfish: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

f) Wildlife: No degradation of the Waters of the U.S. is expected. Restoration of the ecosystem and bank stabilization would be beneficial for these species.

g) Special Aquatic Sites: N/A

2) Significant Adverse Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems: None expected

3) Significant Adverse Effects on Aquatic Ecosystem Diversity, Productivity, and Stability: None expected

4) Significant Adverse Effects on Recreational, Aesthetic, and Economic Values: None expected

h. Appropriate and Practical Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem: All construction would be performed in accordance with best management practices and any conditions stated in the water quality certification. Areas cleared for construction would be reseeded or replanted post construction. Construction would occur, where practicable, in areas that would not require tree clearing, and wetlands would be avoided.

i. On the Basis of the Guidelines, the Proposed Disposal Site(s) for the Discharge of Dredged or Fill Material is:

1) __ Specified as complying with the requirements of these guidelines; or,

2) _X_ Specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem; or,

3) __ Specified as failing to comply with the requirements of these guidelines.

Date: 2 November 2015

Prepared by:
Andrea Carpenter
Fish and Wildlife Biologist
U.S. Army Corps of Engineers
167 North Main Street
Memphis, TN
(901)544-0817
Memphis District (MVM)

Appendix G

Draft FONSI

DRAFT
FINDING OF NO SIGNIFICANT IMPACT
Memphis Metropolitan Area Stormwater
Cypress Creek Ecosystem Restoration
Fayette County, Tennessee

The U.S. Army Corps of Engineers (USACE), Memphis District (MVM), is proposing an ecosystem restoration project on Cypress Creek in Fayette County in west Tennessee. An integrated feasibility study and environmental assessment have been drafted to explore increasing the amount, quality, and sustainability of habitat in the ecosystem of Cypress Creek and its tributaries.

Channelization in Cypress Creek, as with most streams in west Tennessee, has caused severe degradation of the ecosystem including flashy flows, stretches with no surface flow much of the time, a decrease in biodiversity, and changes in primary productivity and floral and faunal communities. 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. The banks of Cypress Creek are deeply incised, too steep for vegetation reestablishment, and bottomland hardwoods are diminished. There are opportunities to stabilize the stream and restore habitat for a variety of fish and wildlife species.

Management measures that could address the systemic aquatic degradation in the project area were identified in the feasibility study, and six alternatives were developed. The tentatively selected plan includes installing 12 grade control structures on the main stem of Cypress Creek and 8 structures on Cypress Creek tributaries. This alternative would restore instream habitat quality, stabilize the banks of Cypress Creek and its tributaries, and encourage the return of native riparian vegetation. Tree clearing will avoided when possible; however, areas where tree clearing is required for installations of grade control structures, haul routes for rock, equipment and other materials would be replanted immediately post-construction. There are no known wetlands known in the immediate construction area; however, if wetlands are identified they will be avoided.

No federally listed threatened or endangered species are known to occur in the area; however, the proposed project is within range of the Indiana bat (*Myotis sodalis*) and the northern long-eared bat (*Myotis septentrionalis*). Acoustic summer surveys would likely be required prior to tree clearing for project construction, along with coordination with the U.S. Fish and Wildlife Service. A 404(b)(1) evaluation has been completed; however, water quality certification would be coordinated with the Tennessee Department of Environment and Conservation (TDEC) prior to project construction. A records search of the U.S. Environmental Protection Agency's EnviroMapper website and several site visits revealed no HTRW sites within the project area; therefore, it was concluded that the probability of encountering hazardous, toxic, and radioactive waste (HTRW) is low. If any HTRW is encountered during construction activities, the proper handling and disposal of these materials would be coordinated with the TDEC.

The construction sites would be surveyed for cultural resources prior to construction, and any significant sites would be avoided or mitigated. Coordination with the State Historic Preservation Officer is ongoing. If any cultural resources are encountered during proposed construction activities, construction would stop and the Memphis District Archaeologist would be contacted immediately.

Based on a review of the analysis performed in the environmental assessment and supporting documentation, I have determined the proposed action is not a major Federal action significantly affecting the quality of the human environment. Therefore, I have determined that an environmental impact statement is not required.

DRAFT

____

Date

Jeffery A. Anderson
Colonel, Corps of Engineers
District Engineer