THREE FORKS of BEARGRASS CREEK
LOUISVILLE, KENTUCKY
ECOSYSTEM RESTORATION
FEASIBILITY STUDY

**Source: The Beargrass PDT during field work on the South Fork.*

US Army Corps of Engineers

April 2021

FINDING OF NO SIGNIFICANT IMPACT

THREE FORKS OF BEARGRASS CREEK
ECOSYSTEM RESTORATION FEASIBILITY STUDY

JEFFERSON COUNTY, KENTUCKY

The U.S. Army Corps of Engineers, Louisville District (Corps) has conducted an environmental analysis in accordance with the National Environmental Policy Act of 1969, as amended. The draft Integrated Feasibility Report (IFR) dated [*TBD*] for the Three Forks of Beargrass Creek Ecosystem Restoration Project addresses potential environmental impacts associated with the restoration of sections Beargrass Creek, its tributaries, and surrounding land in Jefferson County, Kentucky.

The Final IFR, incorporated herein by reference, evaluated action alternatives that would restore connectivity and function of riparian, wetland, and in-stream habitats in the Beargrass watershed. The recommended plan is the National Ecosystem Restoration (NER) Plan and includes restoration of 1,090 acres of riparian and wetland habitat and 46,007 linear feet of stream at 12 sites within the watershed. The plan also includes the removal of 19 connectivity barriers throughout the watershed. The overall benefits of the plan are an increase of 416 Average Annual Habitat Units and 416 Social Units.

In addition to a "no action" plan, 14 alternatives were evaluated in Section 5 of the IFR. Each alternative consisted of a combination of measures that could be implemented at 14 separate sites in the Beargrass Creek watershed.

For all alternatives, the potential effects were evaluated based on the proposed restoration measures. A summary assessment of the potential effects of the recommended plan are listed in Table 1:

Table 1: Summary of Potential Effects of the Recommended Plan

	Insignificant effects	Insignificant effects as a result of mitigation*	Resource unaffected by action
Aesthetics	☒	☐	☐
Air quality	☒	☐	☐
Aquatic resources/wetlands	☒	☐	☐
Invasive species	☒	☐	☐
Fish and wildlife habitat	☒	☐	☐
Threatened/Endangered species/critical habitat	☒	☐	☐
Historic properties	☒	☐	☐
Other cultural resources	☒	☐	☐

US Army Corps of Engineers

	Insignificant effects	Insignificant effects as a result of mitigation*	Resource unaffected by action
Floodplains	☒	☐	☐
Hazardous, toxic & radioactive waste	☐	☐	☒
Land use	☒	☐	☐
Navigation	☐	☐	☒
Noise levels	☒	☐	☐
Public infrastructure	☐	☐	☒
Socioeconomics	☐	☐	☒
Environmental justice	☐	☐	☒
Soils	☒	☐	☐
Tribal trust resources	☐	☐	☒
Water quality	☒	☐	☐
Climate change	☐	☐	☒
Wild and Scenic Rivers	☐	☐	☒
Transportation and traffic	☒	☐	☐

All practical means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices, as outlined in the IFR (e.g., use of silt fences, fiber rolls, etc.), would be implemented before, during, and after construction and would be expected to minimize the potential for deleterious effects to the environment by reducing storm water run-off, erosion, accidental spills of petroleum products, and other potentially harmful inputs.

No compensatory mitigation is required.

Public review of the IFR/EA was completed on [*TBD*]. All comments submitted during the public comment period were responded to in the Final IFR/EA. A 30-day state and agency review of the Report and EA was also completed on [*TBD*].

Pursuant to section 7 of the Endangered Species Act of 1973, as amended, the U.S. Army Corps of Engineers determined that the recommended plan would have no effect to the following listed species: least tern, clubshell, fanshell, Northern riffle shell, orangefoot pimpleback, pink mucket, rabbitsfoot, ring pink, rough pigtoe, sheepnose, and spectlecase. These species have not been observed in the Beargrass Creek watershed and would not be impacted by restoration activities.

The U.S. Army Corps of Engineers determined that the recommended plan may affect but is not likely to adversely affect the following species: gray bat, Indiana bat, Northern long-eared bat, and running buffalo clover. The U.S. Fish and Wildlife Service concurred with this determination on [*PENDING*].

Pursuant to section 106 of the National Historic Preservation Act of 1966, as amended, the U.S. Army Corps of Engineers (USACE) and the Kentucky Heritage Council (KHC) agreed that adherence to the terms and conditions of a Programmatic Agreement (PA) that has been executed between USACE and the KHC would resolve any adverse effect to historic properties from the recommended plan. *[PENDING]*

Pursuant to the Clean Water Act of 1972, as amended, the discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230). [*PENDING*].

A water quality certification pursuant to section 401 of the Clean Water Act has been obtained from the Kentucky Division of Water prior to construction. All conditions of the water quality certification will be implemented in order to minimize adverse impacts to water quality. *[PENDING]*

Technical, environmental, and economic criteria used in the formulation of alternative plans were those specified in the Water Resources Council's 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. All applicable laws, executive orders, regulations, and local government plans were considered in evaluation of alternatives. Based on this report, the reviews by other Federal, State and local agencies, Tribes, input of the public, and the review by my staff, it is my determination that the recommended plan would not significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

____
Date

____
Eric D. Crispino
Colonel, Corps of Engineers
District Commander

Executive Summary

The non-Federal sponsor (NFS), Louisville Metropolitan Sewer District requested that the Louisville District, United States Army Corps of Engineers (USACE) initiate a study to ascertain the feasibility of restoring instream, wetland, and riparian areas for the Beargrass Creek in Louisville, KY. This Integrated Feasibility Report (IFR) documents whether a project is warranted for Federal participation based on a feasibility level assessment of estimated costs, potential benefits, and possible environmental impacts of various alternatives, all of which follow the USACE planning and policy guidelines. The IFR contains an Environmental Assessment pursuant to 40 C.F.R. 1501.5. The purpose of the proposed project is ecological restoration that would provide habitat of the highest form and function for various fish and wildlife species. The need for the proposed project is due to past human induced disturbances within the watershed that have altered and/or modified natural biological processes and have reduced flora and fauna biodiversity. These induced disturbances include altered hydrology and hydraulics, increased colonization of invasive species, urbanization pressures, and fragmentation of the ecosystem.

Aquatic ecosystem restoration would re-establish and repair wetland, riparian, and in-stream habitat within the Beargrass Creek watershed, in-turn increasing localized plant and animal species richness and diversity. The 60 square mile study area is located in Louisville Metro, Jefferson County, KY and encompasses the entire Beargrass Creek watershed in northeast Louisville Metro. Study area parcels are numerous and owned by a variety of property owners, some including the NFS and Louisville Metro. Historically, the Three Forks of Beargrass Creek meandered through forested areas and wetlands but has been highly manipulated due to urbanization over the last 100 years. Currently, land use adjacent to the Three Forks includes single and multi-family residential, vacant, farmland, parks and open space, public and semi-private, commercial, and industrial uses.

Due to the size and complexity of the study area, the initial site selection began with over 200 locations throughout the watershed. Through site screening and iterative plan formulation, the final array of alternatives was comprised of 14 alternatives. These 14 alternatives generated approximately 16,000 combinations of plans in the Institute for Water Resources Planning Suite. The Project Delivery Team selected a cost-effective plan including 12 sites.

The total project cost is $ 157,413,000 (2022 price levels). The estimated Federal cost share of the project is approximately $ 102,318,450 and the non-Federal share is approximately $ 55,094,550. The USACE will complete the design and implementation phase, which includes additional design studies, development of plans and specifications, contracting for construction, overall supervision during construction, preparation of an operation and maintenance manual, and participation in a portion of the post construction monitoring.

US Army Corps
of Engineers

April 2021

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 Introduction

1.1 Study Authorization

Authority for Three Forks of Beargrass Creek, Kentucky – Ecosystem Restoration Feasibility Study is contained in a resolution adopted on May 5, 1987 by the Committee on Environment and Public Works of the United States Senate. This resolution reads as follows:

"RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 12, 1902, be, and is hereby requested to review the report of the Chief of Engineers of the comprehensive flood control plan for the Ohio and lower Mississippi Rivers, published as Flood Control Committee Document Numbered 1, 75th Congress, and other pertinent reports, with a view to determining the advisability of providing additional improvements for flood control and allied purposes in the Metropolitan region of Louisville, Kentucky, with particular reference to existing and potential flooding problems in the Pond Creek, Mill Creek, Beargrass Creek, and Floyds Fork drainage basins."

1.2 Purpose and Need

Wetland, riparian, and riverine ecosystems are threatened nationally due to human interference (Soule, 1986). These diverse areas provide habitat for a wide range of aquatic flora and fauna. Over the past century, land adjacent to streams and rivers in Louisville, Kentucky was converted from native wetland and bottomland hardwood forests to residential and industrial land uses. Through this process of development in and around Louisville, nearly all the wetland habitat along Beargrass Creek was drained and/or filled to facilitate new industrial, commercial, and residential areas. Channelization of the stream to increase conveyance of flood waters has reduced availability of riparian and in-stream habitat. These changes in land use have created an urbanized watershed with a severely altered hydrologic regime, degraded geomorphic form, and altered ecological structure. The compounded effects of these impairments justify the need for ecological improvement. In response, the purpose of this project is to address ecosystem scarcity and connectivity issues of the watershed. This, in turn, will have notable social impacts at the local and regional levels. Figure 1. illustrates an area of Cherokee Park on Middle Fork Beargrass Creek prior to the major development occurring in and around Louisville.

Aquatic ecosystem restoration would re-establish and repair wetland, riparian, and in-stream habitat within the Beargrass Creek watershed, in-turn increasing localized plant and animal species richness and diversity. This project has great potential to restore riparian corridors that provide habitat for three federally threatened and endangered species of bat: gray bat, Indiana bat, and northern long-eared bat. Restoration of habitat along Beargrass Creek near its confluence with the Ohio River could improve habitat suitability for ten different species of federally listed freshwater mussels. Each of these species relies on a host fish species to carry their microscopic larvae (glochidia) in the early stages of the mussel's life cycle. Restoration of in-stream channel features would improve aquatic habitat to support a diverse assemblage of host fishes for mussel species. Wetland and bottomland hardwood forest restoration would provide habitat for resident waterfowl and increase both quality and quantity of stop-over refugia for migratory birds utilizing the Mississippi Flyway.

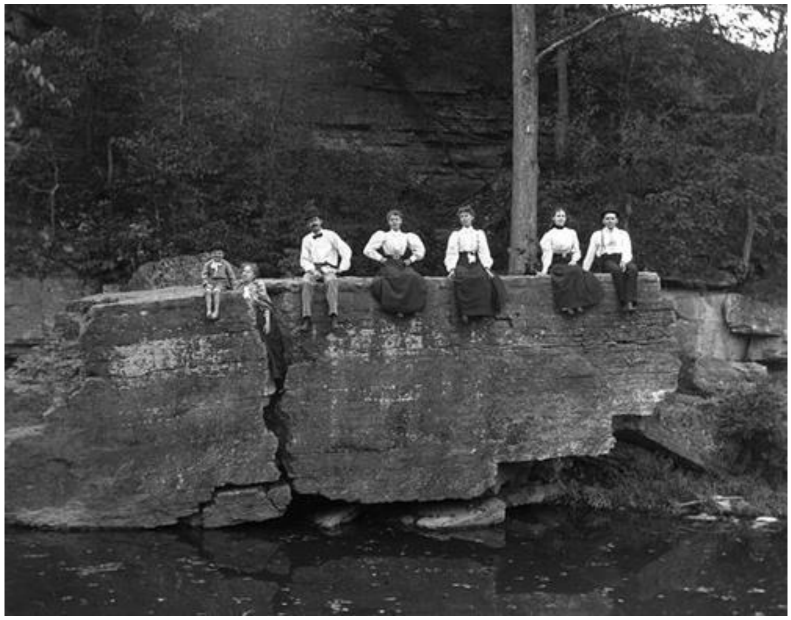

Figure 1. Big Rock at Cherokee Park in 1936. Photo credit - The Olmsted Conservancy

In addition to improving the ecological integrity of the watershed, recommendations from this study could improve the natural visual landscape of Cherokee Park and surrounding neighborhoods that are listed on the National Register of Historic Places (NRHP). This project provides an opportunity to reestablish the aesthetic qualities of Beargrass Creek through Cherokee Park, which was designed in 1891 by world renowned landscape architect, Frederick Law Olmsted. At that time, Olmsted had already designed Central Park in New York City, the U.S. Capitol Grounds and the Biltmore Estate Grounds. However, what is considered his greatest achievement was the concept of a system of parks connected by tree-lined parkways. The park system of Cherokee, Iroquois and Shawnee Park in Louisville is one of four park systems designed by Olmsted. It is the most fully realized and was the ultimate and last park system design of his career (Olmsted Parks Conservancy).

Beargrass Creek is the focal point of Cherokee Park and the surrounding neighborhoods were established to compliment the landscape and topography, which were shaped by the creek. Cherokee Park was designed as a pastoral setting to exemplify this region of Kentucky and was a response to rapid industrialization of the 19th century. Restoring the stream would reinstate the intrinsic value of this natural resource that inspired the original design plans of Fredrick Law Olmsted and preserve the historic significance of this region.

Beargrass Creek is well-acknowledged by the public as an ecological focal point and source of pride at national, state, and local levels. In 2019, the Congress of New Urbanism used the South Fork of Beargrass Creek as a case study for their 27th national conference on blending green space with innovative urban development. State recognition of the watershed is exemplified by the Beargrass Creek State Nature Preserve, Kentucky Waterways Alliance, and water quality reports by the Division of Water. Locally, the Louisville Metro Government consistently highlights the community and ecological value of the watershed directly through the Louisville Metropolitan Sewer District (MSD) Watershed Master Plan, but also indirectly through planning initiatives related to Cherokee Park, Tyler Park, Olmsted Parkways, Louisville Zoo, Waterfront Botanical Gardens, and Metro Park's Naturalization Master Plan. Non-profit entities such as the Beargrass Creek Alliance, Beargrass Creek Watershed Council and Salt River Watershed Watch compose a substantial force of volunteers dedicated to improving the ecological health of the watershed.

This project also has potential to improve access to green space for low-income and minority populations. While numerous studies cite the positive physical and mental health impacts of living near and having access to green space (Reid et al, 2017 and Triguero-Mas, 2015), there are many communities in the watershed where green space is sparse. In particular, work on the concrete channel and in the headwaters of the South Fork will positively impact underserved populations in Louisville.

Together with various master plans, public parks, nature preserves, and local watershed alliances, the Beargrass Creek watershed provides an environmental science and ecosystem restoration case study that strengthens educational opportunities for academic institutions and universities. Bellarmine University, University of Louisville, and Louisville Male High School use the watershed as an outdoor classroom to educate students on the impacts of urbanization on ecological balance. An aquatic ecosystem restoration project of this magnitude and significance would allow for students to monitor biological responses to restoration measures and add hands-on learning experiences to public and private school curricula.

1.3 Watershed Location and Location of Study Area

1.3.1 Watershed Description and Location

The Beargrass Creek system contains three major sub-watersheds: the South Fork (27 square miles), the Middle Fork (25 square miles), and the Muddy Fork (7 square miles). The Three Forks converge just east of downtown Louisville before discharging into the Ohio River (Figure 2).

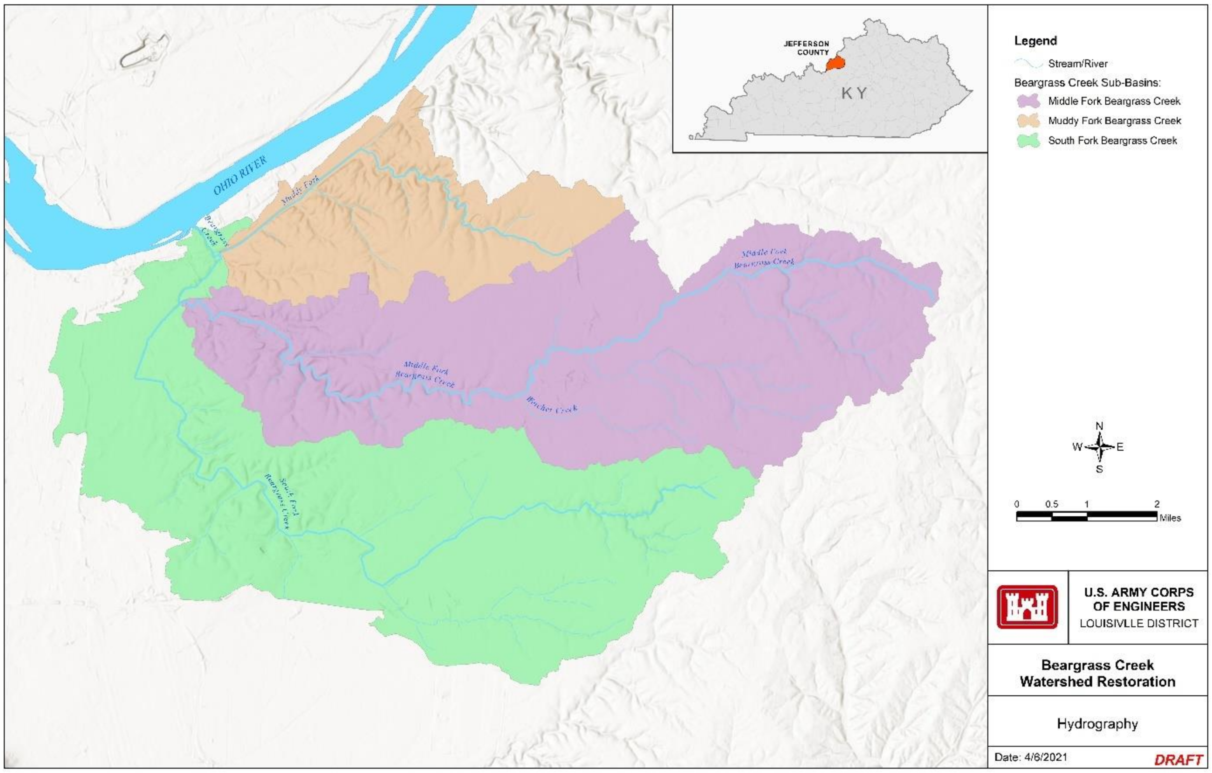

Figure 2: Beargrass Creek watershed boundaries

The South Fork has its headwaters above Bardstown Road and the Buechel area. It runs generally north through the Audubon Park and Germantown neighborhoods to its convergence with the Middle Fork near the Butchertown and Irish Hill neighborhoods. The Middle Fork begins in the Middletown area. It runs through St. Matthews and Seneca and Cherokee Parks to its convergence with the South Fork. The combined South and Middle Forks flow northward from this convergence through the Butchertown neighborhood. The Muddy Fork begins near Windy Hills in eastern Louisville. It flows along I-71 to where it converges with the combined South and Middle Forks just before discharging into the Ohio River (Figure 3).

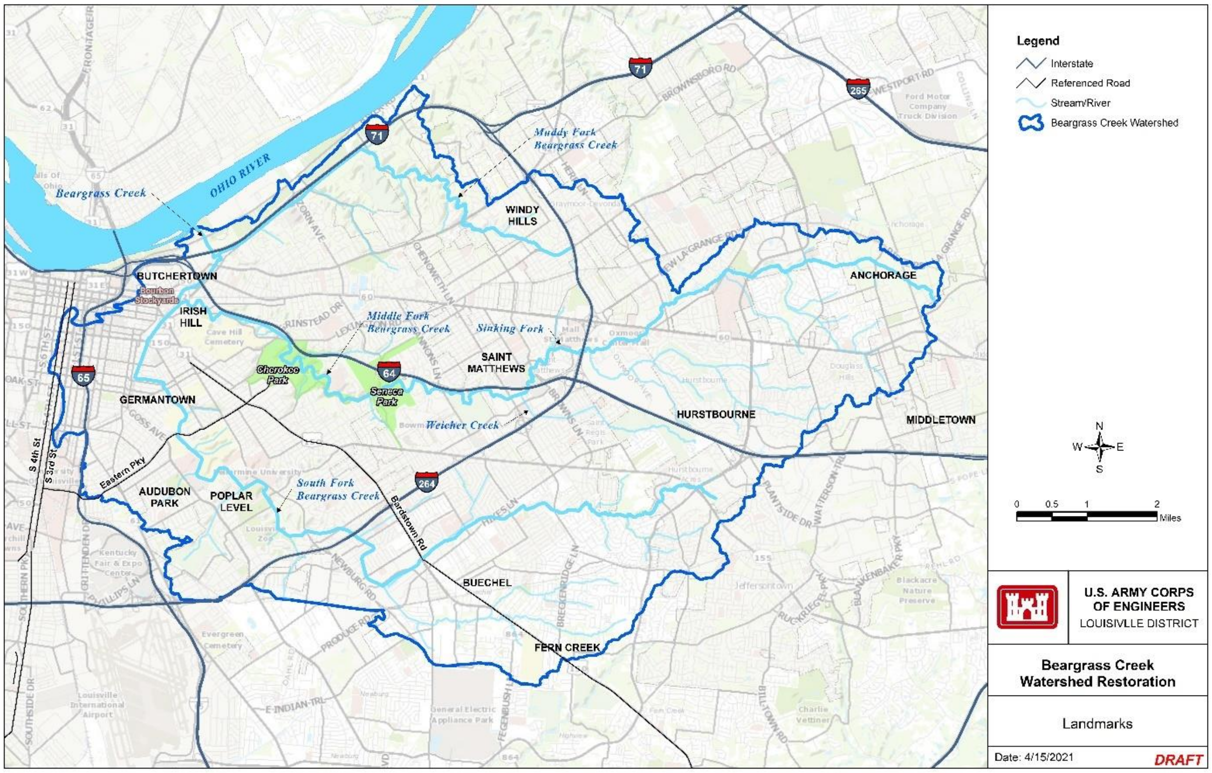

Figure 3: Neighborhoods and landmarks within the Beargrass Creek watershed

1.3.2 Location of Study Area

The study area is within the Louisville Metropolitan area which encompasses all of Jefferson County, Kentucky. It is the most populous county in the commonwealth with 617,790 residents in Louisville Metro (U.S. Census, 2019). The Beargrass Creek watershed takes up a 60 square mile area of Jefferson County just east of downtown and includes the South, Middle and Muddy Forks (Figure 3**Error! Reference source not found.**).

1.3.3 Historic Conditions

The Three Forks of Beargrass Creek once meandered broadly across their floodplains before reaching their confluence with the Ohio River between 3rd and 4th streets in downtown Louisville (Figure 3). Beargrass Creek influenced early settlement patterns of Louisville by allowing easy access to shallow, clean water for daily routines. As development progressed and trade in the region grew, the streams became an obstacle and likely a health issue. In the 1850s, the stream was re-routed to today's channelized alignment. The confluence was originally located farther west near the downtown area but was re-routed two miles east near Towhead Island due to heavy pollution causing unpleasant sights and smells.

Many portions of the stream channel have been modified over the last century and a half in order to accommodate development and to move storm water out of urban areas more quickly as populations grew and impervious area around the stream increased. Many areas in the most urbanized parts of the watershed were converted into concrete channels by the city, most notably the 2.5 mile section of the South Fork that runs from the Butchertown neighborhood all the way to Eastern Parkway (Figure 3).

1.4 Study/Project Participants and Coordination

The non-federal sponsor (NFS) is the Louisville and Jefferson County MSD. The primary stakeholders include, but are not limited to, Louisville Metro Government, the Kentucky Waterways Alliance, the Louisville Nature Center and University of Louisville. The U.S. Army Corps of Engineers (USACE) is the lead federal agency under the National Environmental Policy Act (NEPA). This report serves as an integrated Environmental Assessment pursuant to 40 C.F.R. 1501.5. The USACE worked closely with the NFS, the U.S. Fish & Wildlife Service (USFWS), the Commonwealth of Kentucky Department of Natural Resources (KNDR), various county and municipal agencies, and local ecosystem restoration support groups to develop the most environmentally beneficial and most cost-effective project that achieves the study goals and objectives.

1.5 Related Studies and Reports

1.5.1 U.S. Army Corps of Engineers

- 1997. USACE. Metropolitan Region of Louisville, Kentucky Study, Interim Reconnaissance Report-Beargrass Creek Basin. This document reports the results of a reconnaissance level investigation of water resource problems in the Beargrass Creek Basin in Jefferson County, Kentucky in order to determine whether there is a potential Federal interest in providing improvements to the watershed that would alleviate flooding and other water resource problems.
- 2002. USACE. Beargrass Creek Wetland Restoration Area, Preliminary Restoration Plan; May 2002. Prepared in partnership with Louisville Metro Government. This is an approved Preliminary Restoration Plan that proposed restoration of the aquatic ecosystem along a stretch of Beargrass Creek from the MSD pump station to the creek's confluence with the Ohio River, approximately 3,000 linear feet. This project proposed the creation of a wetland area at Eva Bandman Park, containing 11 acres of riparian forest and 2 acres of aquatic area with a viewing platform.
- 2017. USACE. Beargrass Creek Trail Conceptual Shared Use Path and Ecological Restoration Report; Feb. 2017. Prepared in partnership with Louisville Metro Parks and Recreation. This report proposes improvements to the existing shared use path along the downstream reach of the Middle Fork of Beargrass Creek, as well as improvement and preservation of creek buffer zones, wetlands and urban tree canopy.
- 2019. USACE. Buechel Branch Watershed Hydrologic and Hydraulic Model Development; March 2019. Prepared in partnership with Louisville and Jefferson County Metropolitan Sewer District. This study performed a review of existing models and flood plain mapping and utilized current hydraulic modeling to access existing and fully developed conditions of Buechel Branch, a tributary in the South Fork of Beargrass Creek watershed. The report also developed modified conditions and performed a floodway analysis for floodway development and mapping.

1.5.2 Individual, Local, and Agency Reports

- 2011. Commonwealth of Kentucky. Total Maximum Daily Load for Fecal Coliform Six Stream Segments within the Beargrass Creek Watershed. Dec. 2011. Prepared by Commonwealth of Kentucky Energy and Environment Cabinet, Division of Water. This plan identified potential load and wasteload reductions that could be potentially used to satisfy the water quality standards for Beargrass Creek.
- 2016. MSD. State of the Streams: 2016 Water Quality Synthesis Report. Prepared by Louisville and Jefferson County Metropolitan Sewer District. This report reflects monitoring data at 27 Long Term Monitoring sites on Beargrass Creek, maintained by MSD and is focused on the conditions of fish, aquatic insects, algae, stream habitat, bacteria, nutrients, total suspended solids, trace metals, stream flow, dissolved oxygen, stream flow, dissolved oxygen, and water temperature of the streams in the Louisville community.
- 2017. Fish Assessment Report. MSD. Prepared by Redwing Biological Services, Inc. This report displays the results of fish monitoring at 27 Long Term Monitoring sites in and around Jefferson County during the sampling period of October 2017.
- 2017. MSD. Macroinvertebrate Community Assessment Report. Prepared by Redwing Biological Services, Inc. This report displays the results of macroinvertebrate sampling at 27 Long Term Monitoring sites in and around Jefferson County during the period of May and June 2017.
- 2018. Redwing Biological Services, Inc. Beargrass Creek Water Quality Assessment. Focus Area Habitat Maps. The report is a series of maps showing natural woodland, maintained park space, and wildlife activity at focus areas along Beargrass Creek in order to identify priority monitoring sites.
- 2019. MSD. Connecting Beargrass Creek: South Fork. May 2019. Prepared by The Congress for the New Urbanism in partnership with Louisville MSD and Kentucky Waterways Alliance. This plan proposes ecosystem and recreation improvements to areas along the South Fork of Beargrass Creek.
- 2019. MSD. Long-Term Monitoring Network- Algae Component, Algae Results for the 2013, 2015, and 2017 Sampling Events. Prepared by Stantec. This report summarizes algae monitoring methods and data collected in 2013, 2015, and 2017.

1.5.3 Concurrent Project and Studies

- MSD Middle Fork Water Quality Project 319 Grant: This project is funded by the Environmental Protection Agency (EPA) focused on water quality improvements and not specifically ecosystem and habitat restoration. While the projects that would come from this grant will not be focused on or have a direct impact on ecosystem restoration, some projects may have secondary effects that would improve the ecosystem health due to the connection between ecosystem health and water quality. As for assumptions related to future improvements to ecosystem restoration sites, no projects were identified that have potential impacts from the 319 grant at this time.
- MSD Water Quality Project at Grinstead Drive: This project is focused on water quality improvement through removal of invasive species, native species planting, and restoration of the stream corridor at a tributary of the Middle Fork. MSD worked with

the Louisville Jefferson County Environmental Trust to restore an area held in conservation easement that will help support native plant and animal species through water quality improvement.

- Butchertown/Nulu/Phoenix Hill Neighborhood Plan: This plan is in draft form and is expected to be finalized in early 2021. The plan aims to outline the priorities, strengths, and goals of the Butchertown, Nulu, and Phoenix Hill neighborhoods, where a portion of the South Fork is located. The plan emphasizes the importance of the creek historically and to surrounding neighborhoods. The plan includes connections to the creek, as well as educational opportunities and a recreational component in a greenway along the creek.

1.5.4 Existing Water Resource Projects

- Ohio River Navigation Project – Beargrass Creek is a tributary to the Ohio River, which is operated for navigation purposes by USACE. McAlpine Locks & Dam is located on the Ohio River approximately 2 miles downstream of the confluence of Beargrass Creek. McAlpine Locks & Dam is used to hold a normal pool on the Ohio River between elevations of 419.7 and 420.5 feet NGVD29, which extends backwater up Beargrass Creek about 1.25 miles.
- Louisville Metro Flood Protection System - During flood events on the Ohio River, Beargrass Creek and its main tributaries are protected from backwater flooding by a levee with gated structure and pump station, which was implemented by USACE in the 1950's. The Muddy Fork is not protected from Ohio River flood events and experiences backwater flooding annually. Historically, USACE recognizes the impact of flooding on Beargrass Creek and importance of maintaining navigation on the Ohio River as is borne out through the substantial investments made by the federal government into these two systems. The streams connectivity with the Ohio River provides a unique opportunity to provide improvements to the ecosystem in the lower portions of the watershed when considering the highly regulated nature of the Ohio River. The Louisville Metro Flood Protection System consists of a levee and floodwall system and numerous pump stations and that protect Louisville Metro from Ohio River floodwaters. The system is operated and maintained by Louisville MSD. USACE and MSD are currently working together on a feasibility study to repair and replace portions of the project that are aging and in need of updates. The South Fork of Beargrass Creek passes under the Beargrass Creek Pump Station.
- MSD currently has two ongoing basin projects and one tunnel project within the Beargrass Creek watershed. The Clifton Heights and Logan/Breckinridge Street storage basins both store storm and sewer water and protect Beargrass Creek from combined sewer overflows. The Waterway Protection Tunnel extension runs from Grinstead Drive at Interstate 64 and travels north west to meet the existing tunnel at Story Ave. When the tunnel is complete, the above ground site will serve as a trailhead for the existing Beargrass Creek Trail (Figure 3).

1.6 Report Organization

This document has been divided into 10 primary chapters, each dealing with a specific subject area relating to the project components, alternatives, and planning process. Chapters noted below by an asterisk (*) are compliant with and required by the Council on Environmental Quality's Regulations for Implementing the National Environmental Policy Act (NEPA).

- Chapter 1*, Introduction: provides background information concerning the purpose of and need for the study, authorization, study status, and the scope of the study. This chapter also notes relevance and integration of other related studies and reports.
- Chapter 2*, Affected Environment: provides a detailed presentation of the existing environmental conditions within the study area. This chapter also includes a complete discussion of environmental resources that would be affected by implementation of project alternatives.
- Chapter 3*, Project Background: describes the resource significance of the project.
- Chapter 4*, Plan Formulation: public involvement, problems and opportunities, plan formulation overview, description of measures and measure development, development of alternatives.
- Chapter 5*, Alternatives Evaluation, explains habitat evaluation, Cost Effectiveness and Incremental Cost Analysis, final array of alternatives and selection of NER plan
- Chapter 6*, Environmental Impacts, action vs no action evaluation of final array of alternatives.
- Chapter 7, Tentatively Selected Plan (TSP), summarizes the environmental, economic, and social benefits and costs of plan.
- Chapter 8, Remaining Reviews, Approvals, Implementation, and Schedule, identifies the estimated project timeline for future actions, defines commitments and responsibilities, and verifies the fulfillment of procedural notice and review requirements.
- Chapter 9, Recommendation, letter of support from Commander
- Chapter 10, References, lists references including studies, reports, analyses, and other reference materials used in the preparation of this report.

2.0 Affected Environment

The following sections describe the existing conditions within the study area for a suite of environmental resources. This provides a baseline to compare the potential impacts that may result from implementation of the proposed alternatives. General descriptions are provided first, followed by descriptions of each fork, when applicable. Some resources cannot be described by reach, such as air quality. Chapter 5 describes alternative impacts on the environment.

2.1 Geology Seismology, Soils and Minerals

2.1.1 Topography, Geology, and Soils

The study area is located in the Outer Bluegrass Region, which is generally characterized by underlying fossiliferous limestone, dolomite, and shale of the Ordovician geological age. The study area lies within the Ohio River Alluvium physiographic region of Kentucky. Deposits in the county include limestone, shale, dolomite, lacustrine, and alluvial deposits. The Ohio River Alluvium is primarily made up of Pleistocene glacial outwash material and unconsolidated alluvium, which consists of sand, gravel, clay, and silt. Regionally, the lithology is comprised of a 5 to 45-feet thick layer of clay, silt, and fine sand that overlays sand and gravel containing discontinuous lenses of clay. Beneath the aquifer are relatively tight shale and limestone bedrock.

The topography of the study area can be obscured by the extensive urban and suburban development, appearing flat. However, it is essentially a gently southwestward sloping surface from a high of 751 feet on the east to around 404 feet near the Ohio River. The highest point in the Beargrass Creek watershed is in the upper reaches of the Middle Fork. Figure 4. shows the terrain and elevation of the watershed. Sinkholes make up the majority of karst features within the watershed, with the most occurring within the Muddy Fork watershed. A map generated by the Kentucky Groundwater Data Repository of known sinkholes in the Beargrass Creek watershed is located in Appendix F.

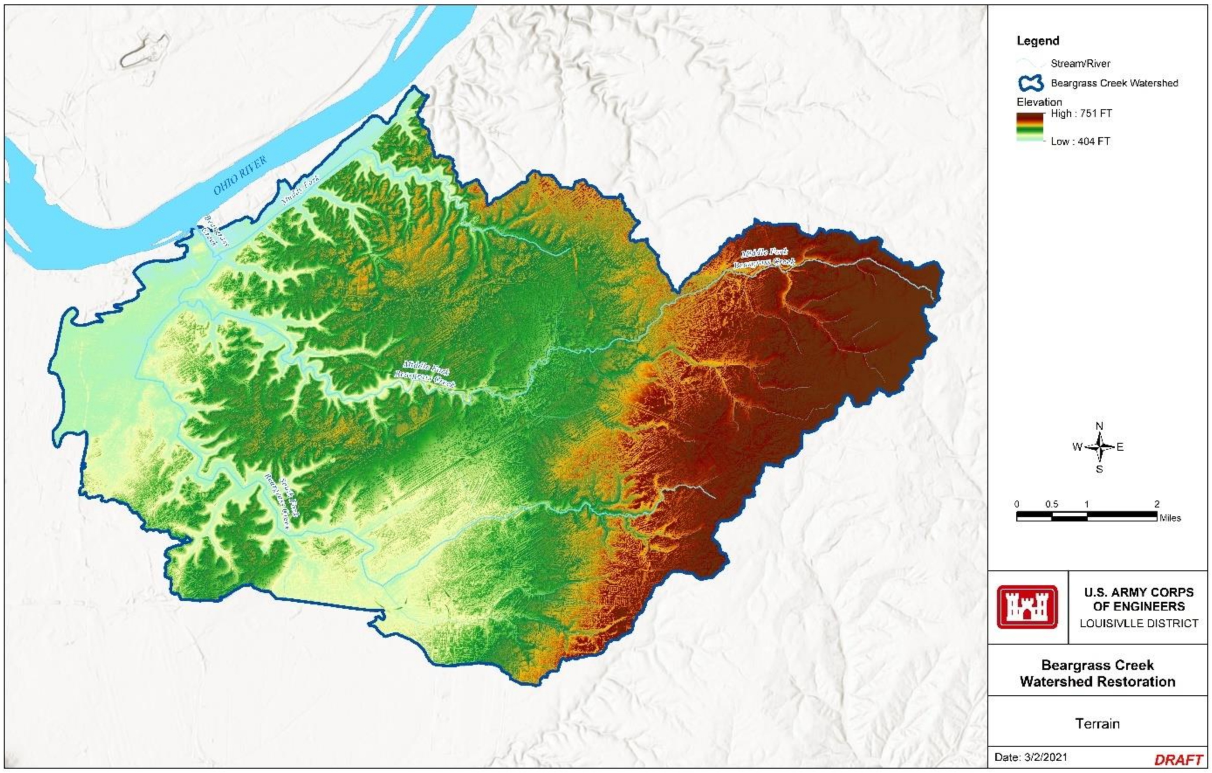

Figure 4. Terrain map of the Beargrass Creek Watershed

The Ohio River flood plain is relatively narrow near the mouth of Beargrass Creek but widens substantially to the south and southwest. Floodplains of the Three Forks of Beargrass Creek are shown in Figure 5.

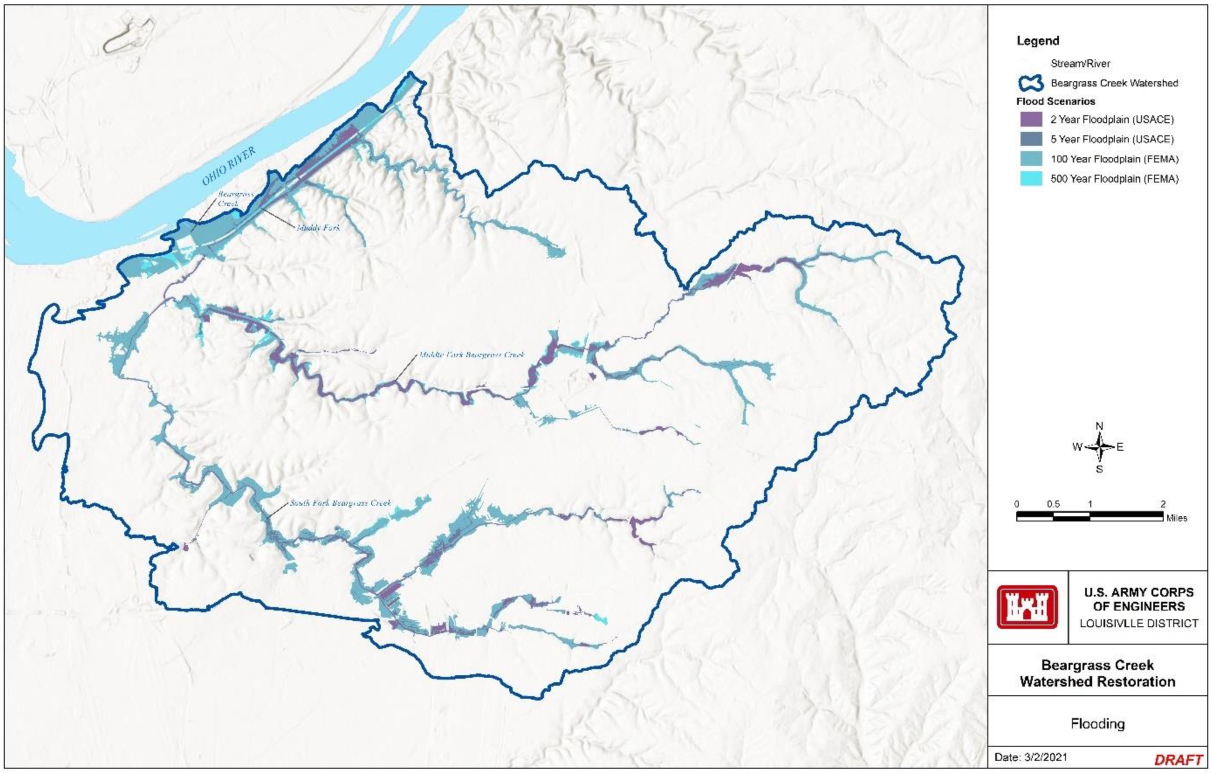

Figure 5. Floodplains of the Three Forks of Beargrass Creek

As the study area is mostly developed land, most soils in the study area are classified as urban land, with varying amounts of Udorthents and Udarents soil complexes with between 0 - 12% slope according to the Natural Resources Conservation Service (NRCS) Web Soil Survey, which provides soil data and information produced by the National Cooperative Soil Survey. Soil maps produced from the same data source are located in Appendix F.

2.1.2 Seismicity and Faults

Louisville sits between two fault zones. The New Madrid Seismic Zone—located to the west of the study area in western Kentucky—is the most active fault in the central and eastern United States. This zone is a source of continuing small and moderate earthquakes, and it poses a significant risk for a major earthquake. To the east is the Lexington Fault Zone, which is related to the origin of the stresses that upbowed the Cincinnati Arch, deep beneath the surface of Kentucky. According to the Kentucky Geological Survey (2019a), Louisville is not located in an active seismic zone, but has experienced three earthquakes with magnitudes greater than 3.0 since records have been kept.

2.2 Air Quality

2.2.1 Environmental Setting

The U.S. Environmental Protection Agency (USEPA) Office of Air Quality Planning and Standards has set National Ambient Air Quality Standards (NAAQS) for six principal pollutants, called "criteria" pollutants. They are carbon monoxide, nitrogen dioxide, ozone, lead, particulates of 10 microns or less in size (PM-10 and PM-2.5), and sulfur dioxide. Ozone is the only parameter not directly emitted into the air but forms in the atmosphere when three atoms of oxygen (O^3) are combined by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC, also known as ozone precursors. Strong sunlight and hot weather can cause ground-level ozone to form in harmful concentrations in the air.

As of March 3, 2021, Jefferson County in Kentucky had nonattainment status for sulfur dioxide and 8-hour ozone. The county was in attainment for all other criteria pollutants (USEPA, 2020). The Louisville Metro's 8-hour ozone (2015 standard) classification was "marginal—"—the least severe classification.

2.3 Land Use

2.3.1 Land Management and Administrative Agencies and Organizations

The largest land manager in the study area is Louisville Metro. As of 2020, the Metro Parks system had 120 parks covering more than 13,000 acres, and the nation's largest municipal urban forest in Jefferson Memorial Forest. The MSD owns and maintains many smaller parcels for sewer infrastructure within the watershed.

2.3.2 Applicable General Plans

Louisville Metro's comprehensive plan, called Plan 2040, went into effect On January 1, 2019. Plan 2040 was developed to guide Louisville Metro's growth and development over the next 20 years. The plan updates and builds upon its predecessor, Cornerstone 2020, while recognizing changing conditions and shifting community priorities.

Within the Community Form Plan element of Louisville Metro's comprehensive plan, there are five overarching goals, which are supported by a series of objectives and action-oriented policies to help frame the community's vision for land use and development. One goal of the existing plan that is directly applicable to the current study is to enhance neighborhoods by protecting and integrating open space, watersheds and other natural resources. The stated objectives of this goal are:

a. Environmental impacts of development are diminished.
b. Environmentally sensitive areas are preserved and/or enhanced.
c. Open spaces are integrated into development, where appropriate.

d. The built environment provides connections to parks, recreation and natural resources.

2.3.3 Land Use in the Study Area

Greater than 60 percent of the Louisville Metro area has been developed to some extent, which has greatly modified the existing natural resources within the city. Land use adjacent to the Three Forks includes single- and multi-family residential, vacant, farmland, parks and open space, public and semi-private lands, and commercial and industrial land types (Figure 6.). Land use adjacent to the upstream reach of the Middle Fork includes high-usage park and single-family residential areas. Land use adjacent to the downstream part of the Middle Fork study reach includes limited-use park, recreational, and commercial areas. A biking and walking path on Middle Fork Beargrass Creek, beginning just upstream from its confluence with South Fork Beargrass Creek, extends over a mile. Land use adjacent to the upstream reach of the South Fork includes moderate-use park and recreational areas, open areas, and limited residential and commercial areas. Land use adjacent to the downstream reach of the South Fork includes the highest concentration of commercial and industrial usage.

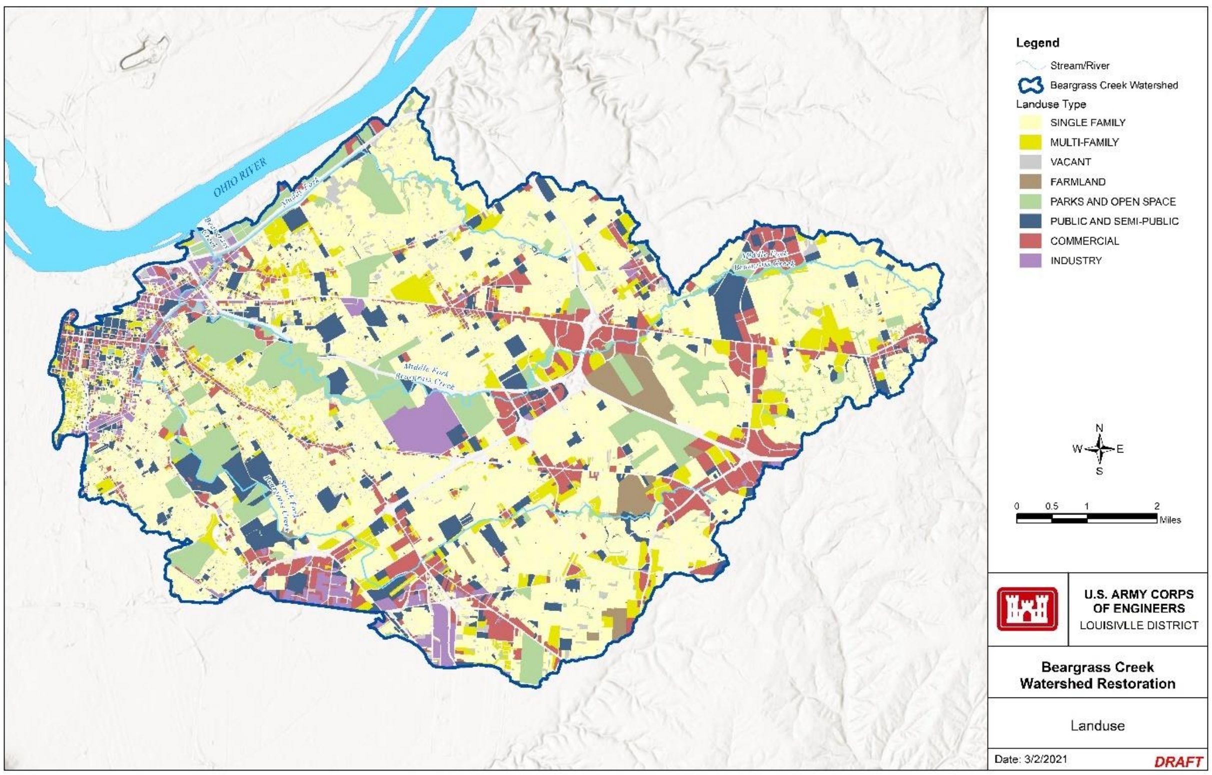

Figure 6. Land uses within the Beargrass Creek Watershed

According the Kentucky State Data Center, the population of Louisville is projected to increase by over 10% by 2040 (Ruther, 2016). While much of the study area is built out, continued increase in population may result in further build out and recycling of land which could result in further detrimental impacts to aquatic and riparian ecosystems from pressures such as habitat fragmentation and increased runoff from impermeable surfaces.

2.4 Water Resources

2.4.1 Beargrass Creek

The study area consists of the Three Forks of Beargrass Creek—the Middle, South, and Muddy forks—in northcentral Jefferson County, Kentucky. The Beargrass Creek watershed (**Error! Reference source not found.**) is the largest in the county, with a drainage area of approximately 60 square miles. From 2010-2019, average discharge of the stream at River Road in Louisville (just upstream of the confluence with the Ohio River) was 103.5 cubic feet per second (US Geological Survey, 2020).

The three forks of the Beargrass Creek separate east of the downtown Louisville area, near the intersection of Interstates 71 and 64. The South Fork watershed covers 26.7 square-miles. This fork runs through Butchertown and Germantown, through the Poplar Level area, and eventually the Fern Creek neighborhood. The South Fork originally ran through downtown Louisville but was rerouted in the 1850s due to the city's growing population and infrastructure needs. The original route was converted into a sewer. In the 1920s, the stretch near Germantown was placed into a concrete channel in an attempt to alleviate sewer issues (Figure 3).

The Middle Fork has two branches—Weicher Creek and the Sinking Fork. Weicher Creek flows from the Hurstbourne Area, and the Sinking Fork has its headwaters near Anchorage, Kentucky. Weicher Creek and Sinking Fork merge in St. Matthews to form the Middle Fork, which flows through Cherokee Park until its confluence with the South Fork near the Bourbon Stockyards (Figure 3). There are just over 25 square miles of land in the Middle Fork watershed, and impervious surfaces such as roads, rooftops and driveways cover about 23 percent of this watershed. The lower portion of this fork has been heavily altered by the construction of the I-64 roadway.

The Muddy Fork rises at a stone springhouse in Windy Hills and runs parallel to the Ohio River. This fork is the smallest subwatershed, covering about nine square miles, and was rerouted during the construction of Interstate 71. Impervious surfaces cover about nine percent of this watershed (Louisville Metropolitan Sewer District, 2016).

2.4.2 Surface Water Quality

The current manipulated state of the watershed and Louisville's issues with combined sewer overflows (CSO's) often leads to poor water quality. Urbanization and increased impervious surfaces in a watershed speeds stormwater tainted with oil, chemicals and other potential contaminates into the stream, often with little or no vegetative buffer to filter it (Waite et al. 2008). Figure 7 shows impervious surface area in the Beargrass Creek watershed. Data from Louisville Metro/Jefferson County Information Consortium (LOJIC) system indicates that approximately 60 percent of the South Fork watershed is covered by impervious surfaces, compared to 23 percent of the Middle Fork, and nine percent of the Muddy Fork (LOJIC, 2021). According to LOJIC's land classification dataset, impervious surface covers approximately 13,333 acres of the total Beargrass Creek watershed, which is 39,056 acres (34.1 percent impervious area).

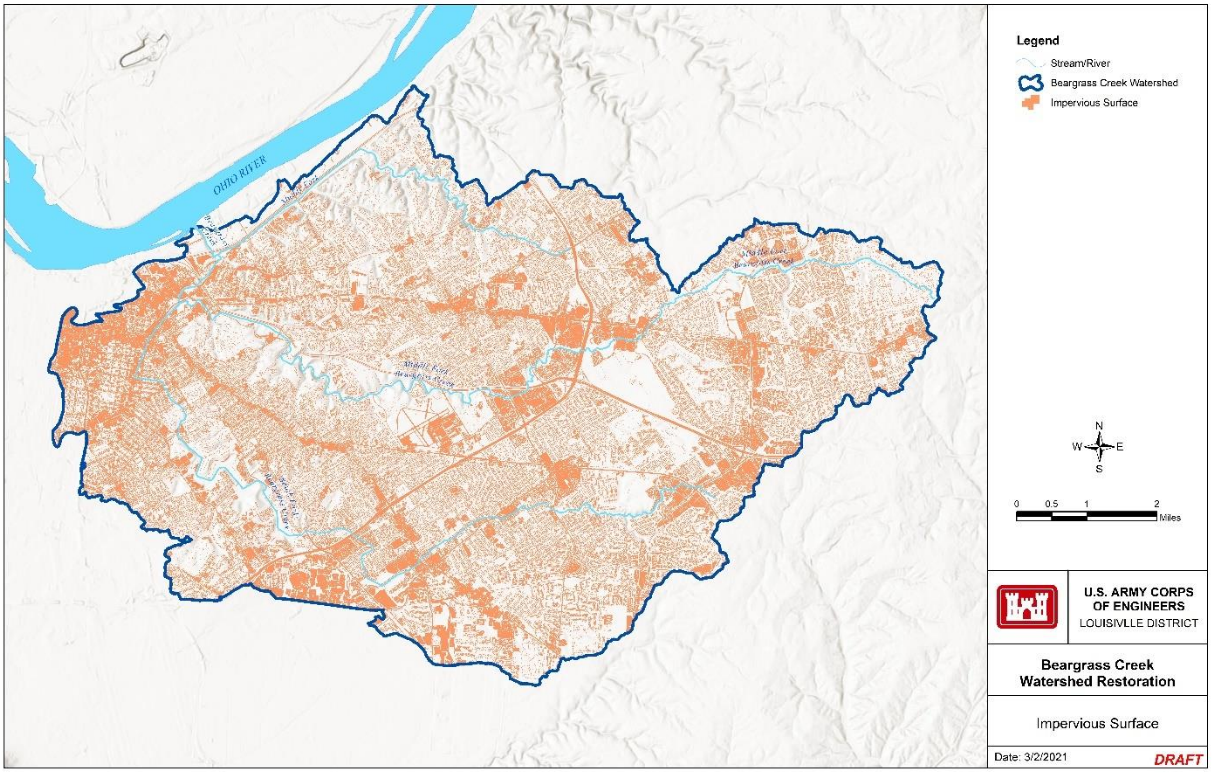

Figure 7. Impervious Surface Area in the Beargrass Creek Watershed

Additionally, combined sewer overflows (CSOs) release untreated sewage into the Three Forks of Beargrass Creek during heavy rain events causing decreased water quality. CSOs contain untreated or partially treated human and industrial waste, toxic materials, and debris as well as stormwater. CSOs are outlets that dump excess water from the sewers into streams and rivers, keeping the sewers from backing up into homes, business and streets when it rains.

There are more than 50 CSOs along the South and Middle Forks of Beargrass Creek. In places where there were severe drainage problems and no nearby creeks, large underground relief drains were constructed by the city to take water from CSOs directly to Beargrass Creek or the Ohio River. The Sneads Branch relief drain serves an area along Shelby Street from near Eastern Parkway to Kentucky Street, and flows directly into the South Fork of Beargrass Creek.

MSD's Integrated Overflow Abatement Plan (IOAP) addresses both Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) that discharge to Beargrass Creek and the Ohio River during wet weather events, with the vast majority of the overflow volume coming from the CSOs. The Long-Term Control Plan (LTCP) portion of the IOAP addresses CSOs, and the Sanitary Sewer Discharge Plan (SSDP) addresses SSOs. To date, MSD has completed 24 of the 25 LTCP projects, and 47 of the 63 SSDP projects. Only some of these projects impact Beargrass Creek. Table 1 below summarizes the pre-IOAP, current conditions, and post-IOAP conditions along the three forks of Beargrass Creek during a Typical Year related to CSOs.

Table 1. Beargrass Creek Combined Sewer Overflow Summary.

Scenario	# of Active CSOs	Typical Year Overflow Volume (MG)	Typical Year Range of Ind. CSO Occurrence	Typical Year Approximate Min. Rainfall Depth for CSO Occurrence
Pre-IOAP	43	1140	0-72	0.1”
Current	40	412	0-71	0.1”
Post IOAP	38	71	0-7	1.0”

SSO volumes, modeling, and mitigation are based on discrete, three-hour cloudburst events rather than the typical year. While SSOs can impact water quality, they have a negligible impact on stream volumes and flow rates. SSO values for SSOs along the three Forks of Beargrass Creek are provided in Table 2.

Table 2. Beargrass Creek Sanitary Sewer Overflows Summary

Scenario	# of Active SSOs (2-year)	2-Year (1.8”, 3hr) App. Overflow Volume (MG)	10-Year (2.6”, 3-hr Rain App. Overflow Volume (MG)
Pre-IOAP	99	21	75
Current	43	4	36
Post IOAP	0	0	20

The Kentucky 2010 303(d) Report identified 35.8 miles of stream segments in the Beargrass Creek watershed as not supporting the designated use of primary contact recreation (swimming) due to fecal coliform impairment (Kentucky Division of Water, 2010). These included 13.6-, 15.3- and 6.9-mile segments of the South Fork, Middle Fork and Muddy Fork of Beargrass Creek, respectively. Although the main stem of Beargrass Creek (i.e. the 1.8 mile segment downstream of the confluence with Muddy Fork) was not listed for fecal coliforms in the 2010 303(d) report, compliance of this segment with the associated water quality standards was verified as part of the overall total maximum daily load (TMDL) analysis. According to the report, sources of the fecal coliform impairment in the watershed included municipal point sources, urban runoff/storm sewers, land disposal, combined sewer and sanitary sewer overflows.

The MSD, in cooperation with the United States Geological Survey (USGS), operates a Long-Term Monitoring Network (LTMN) to collect physical, chemical and biological data about streams in the Louisville Metro area. In 2016, MSD released the State of the Streams Report, which focused on the conditions of fish, aquatic insects, algae, stream habitat, bacteria, nutrients (nitrogen and phosphorus), total suspended solids (sediment in water), trace metals, stream flow, dissolved oxygen, and water temperature of the streams in our community, and whether or not these were improving. MSD has been collecting data at 27 LTMN sites since 1999. Seven of the sites are located within the Beargrass Creek watershed (Figure 8).

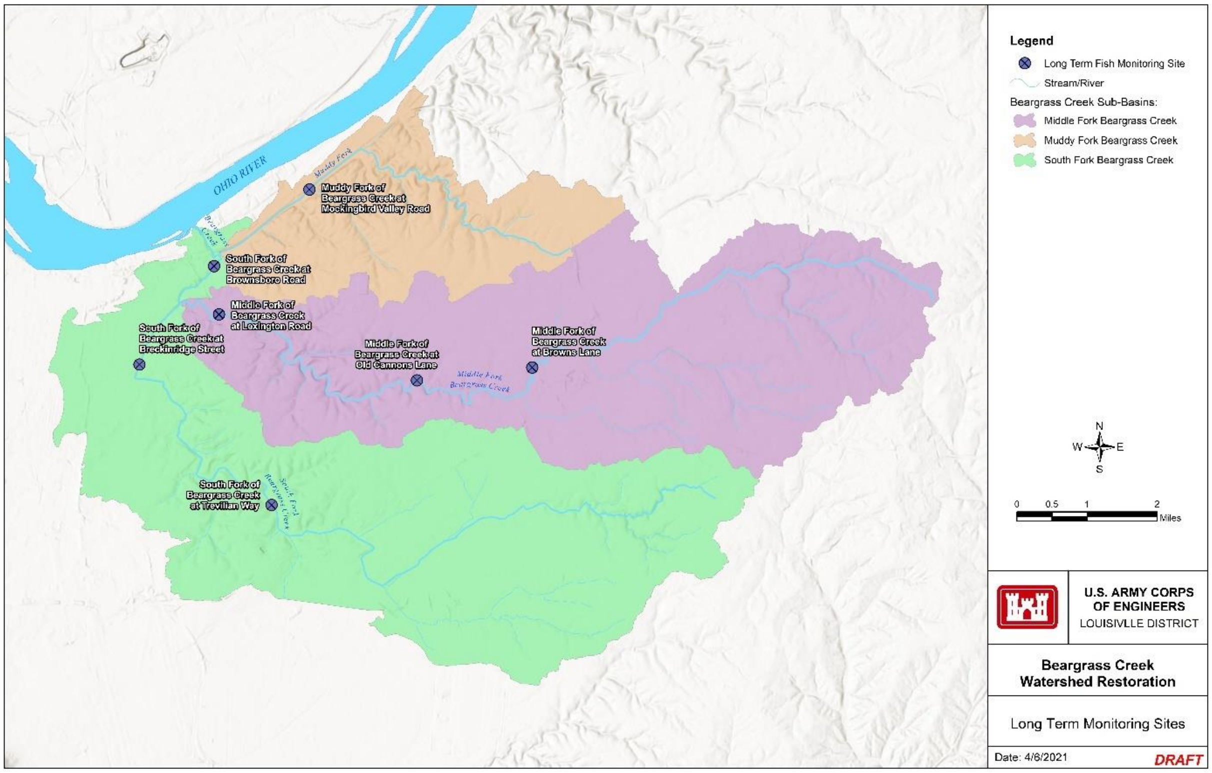

Figure 8. MSD Long-term Monitoring Network sites in the Beargrass Creek watershed.

Muddy Fork

Kentucky, like many other states, does not have numeric criteria for nutrients or suspended solids. For MSD's 2016 report, 2006 to 2015 data for each site were compared to the range of concentrations from all sites, and used the following thresholds:

- Total Nitrogen: 0.9 milligrams per liter
- Nitrate: 1.32 milligrams per liter (parts per million)
- Phosphorus: 1.35 milligrams per liter
- Suspended Solids: 12 milligrams per liter

Sites were classified as good, fair, or poor for nutrients and suspended solids based on the percent of samples above the thresholds:

- Good: Less than 29% above the threshold
- Fair: Between 29% and 48% above the threshold
- Poor: More than 48% of samples above the threshold

According to MSD water quality sampling in 2015 (most current sampling data) at the Mockingbird Valley Road sampling station on the Muddy Fork (Figure 8), nitrogen, phosphorus, ammonia, suspended solids and trace metal concentrations were low. Dissolved oxygen was good [100 percent of days above five parts per million (ppm)] and showed an improving trend over time, and temperature was good (100 percent of days below 31.7°C).

The Kentucky Division of Water (DOW) has established water quality criteria for fecal coliform bacteria to reduce the risk of infection for people using the water. The criteria require collection of at least five stream samples each month during the May 1 through October 31 recreation season. The criteria require the geometric mean of five bacteria samples for each month to be less than 200 bacteria colonies for swimming and less than 1,000 bacteria colonies for wading, boating or fishing. The 2015 sampling indicated fecal coliform concentrations were elevated (geometric mean above 1,000 colonies) but stable (MSD, 2016), and exceeded The DOW water quality criteria.

Middle Fork

The MSD utilizes three sampling locations on the Middle Fork—Browns Lane (Figure 8) , which drains 15.2 square miles, Old Cannons Lane, which drains 18.9 square miles, and at Lexington Road, which drains 24.8 square miles. Sampling in 2015 at Browns Lane indicated Total nitrogen, phosphorus, ammonia, suspended solids and trace metal concentrations were low, however nitrate concentrations were elevated. Kentucky does not have numeric criteria for nutrients or suspended solids. Fecal coliform bacteria concentrations were in exceedance of DOW water quality criteria and were some of the highest in Louisville Metro, and were getting worse.

At Old Cannons Lane (Figure 8), total nitrogen, ammonia, phosphorus and suspended solids concentrations were low, however nitrate concentrations were elevated. Trace metal concentrations (cadmium, copper, lead and zinc) exceeded aquatic life criteria more often than most other monitoring sites. Dissolved oxygen was good and improving; water temperature was good. Fecal coliform bacteria concentrations were consistently elevated.

At Lexington Road (Figure 8) , Nitrate, ammonia, and total nitrogen concentrations were low, however phosphorus and suspended solids concentrations were elevated. Metals concentrations exceeded aquatic life criteria more often than other monitoring sites. Dissolved oxygen was fair (90 percent of days above five PPM) and improving; water temperature was good. Fecal coliform bacteria concentrations were elevated but improving.

South Fork

MSD monitors water quality and flow at three sites in the South Fork watershed—Trevilian Way (Figure 8), which drains 17.2 square miles, Schiller Avenue, which drains 22.8 square miles, and Brownsboro Road, which drains 51.5 square miles including the Middle Fork. MSD moved the Schiller Avenue site downstream to Breckinridge Street in 2015 because the Schiller Avenue site was not accessible during construction of a nearby wet weather basin. Data from the two sites was integrated for this assessment.

At the Trevilian Way site in 2015, data collected by MSD indicated nitrate, ammonia, phosphorus, and trace metal concentrations were low, however total nitrogen and suspended solids were moderate. Dissolved oxygen was fair and stable; water temperature was good. Fecal coliform bacteria concentrations were some of the highest in Louisville Metro, and were getting worse.

At Schiller Avenue (Figure 8), Nitrogen, ammonia, and phosphorus concentrations were low, however suspended solids were moderate. Cadmium and lead exceeded aquatic life criteria more often than other sites. Dissolved oxygen was poor (Less than 90 percent of days above five PPM) and declining (the percent of days that dissolved oxygen was above five PPM decreased by ten percent or more); water temperature was good. Fecal coliform bacteria concentrations were some of the highest in Louisville Metro, and were getting worse. Since temperature readings were good at his site, we can infer that organic pollution, like fecal coliform, likely plays a significant role in reducing dissolved oxygen levels. Kentucky's water quality criteria for dissolved oxygen specify no readings less than four PPM, and the 24-hour average reading must be above five PPM.

At Brownsboro Road (Figure 8), Total nitrogen, ammonia, phosphorus and suspended solids were low, however nitrate concentrations were moderate. Cadmium and lead exceeded aquatic life criteria more often than other sites. Fecal coliform bacteria concentrations were some of the highest in Louisville Metro, but were improving.

2.4.3 Groundwater

The vast extent of impervious surfaces in the city like roads, parking lots, and rooftops prevent rain and snowmelt from infiltrating into the ground. Most of the rainfall and snowmelt remains above the surface, where it runs off rapidly in unnaturally large amounts.

Storm sewer systems concentrate runoff into smooth, straight conduits, which increases velocity and erosional power of the water as it travels underground. When this runoff leaves the storm drains and empties into a stream, its increased volume and power can quickly erode streambanks, damaging streamside vegetation and degrading aquatic and riparian habitats. These increased storm flows carry sediment loads from construction sites and other denuded surfaces and eroded streambanks. They often carry higher water temperatures from streets, roof tops, and parking lots, which are harmful to the health and reproduction of aquatic life. The loss of infiltration from urbanization may also cause profound groundwater changes such as reduced water tables and slower recharge rates. Although urbanization leads to increases in flooding during and immediately after wet weather, in many instances it results in lower stream flows during dry weather.

The Ohio River alluvium aquifer is the most dependable source of groundwater in Louisville. Domestic wells drilled in the alluvium are generally drilled to a depth of 100 feet below ground surface and can produce approximately 1,000 gallons of water per minute. In the upland areas of the rest of Jefferson County, 30 percent of the county, most drilled wells will not produce enough water for a dependable domestic supply, unless they are drilled along drainage lines, in which case they may produce enough water except during dry weather (Kentucky Geological Survey, 2019b) . Some natural springs occur within the watershed, as well as karst features like sinkholes. Maps of sinkholes and springs in the Beargrass Creek watershed generated by the Kentucky Groundwater Data Repository is located in Appendix F.

2.5 Biological Resources

Biological resources within the proposed study footprint have been impacted due to channelization and intense development within the watershed. According to the LOJIC (2021) land classification dataset, approximately 90 percent of the Beargrass Creek watershed, has been developed to some extent, which has greatly modified the existing natural resources and available habitat within the area.

2.5.1 Vegetation

Before development of the study area, a diversity of habitats including floodplain and upland forest, Bluegrass savannah, canebrakes, and wetlands would have likely comprised much of the watershed. The vegetative landscape has since been fragmented for agricultural uses and urban development. Only slim corridors of floodplain forest still exit in the Beargrass Creek watershed and consist on common bottomland tree species such as box elder (*Acer negundo*), silver maple (*Acer saccharinum*), sugar maple (*Acer saccharum*), hickories (*Carya* spp.), ash (*Fraxinus* spp.), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*). Figure 9 shows tree canopy density within the watershed. Areas with the best quality canopy tend to be in the park areas such as Cherokee, Seneca Park on the lower Middle Fork, Joe Creason Park on the lower South Fork, and the Indian Hills neighborhood around the middle reaches of the Muddy Fork. The South Fork and the Middle Fork upstream of Seneca Park exhibit are generally lacking significant canopy density.

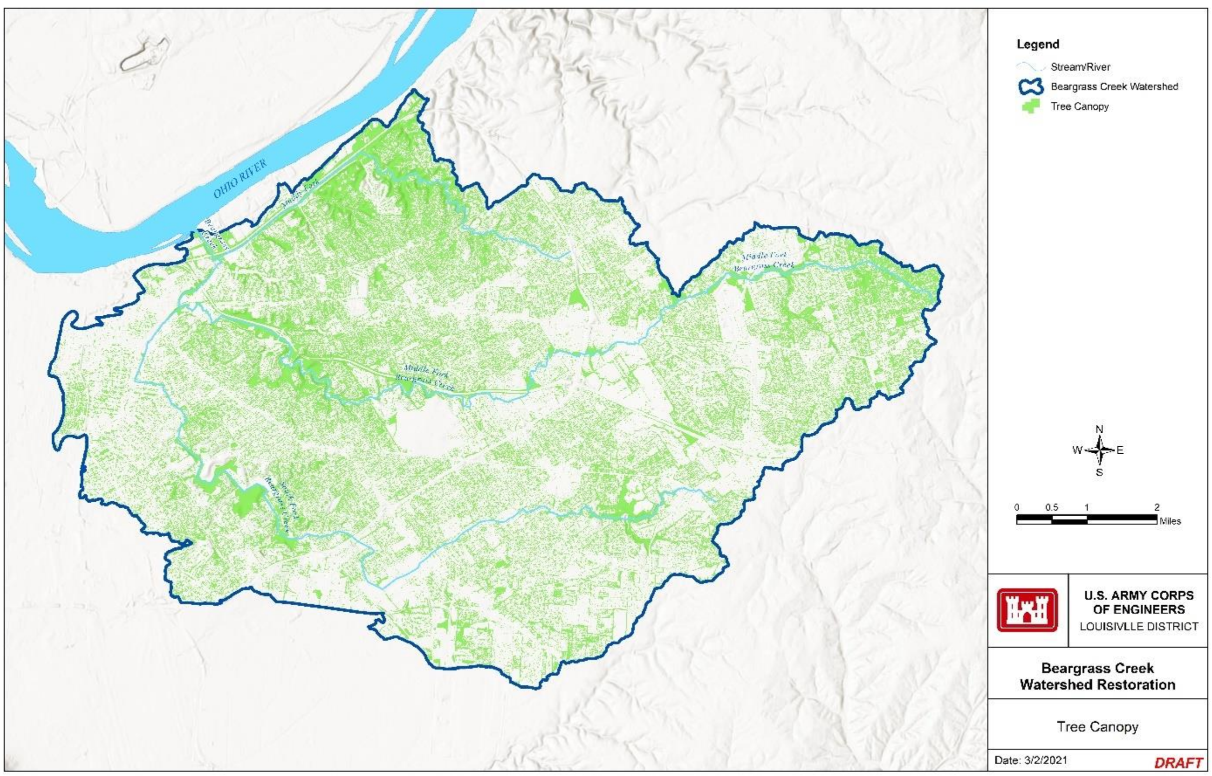

Figure 9. Tree Canopy in the Beargrass Creek Watershed

The disturbance of habitats within the watershed has also facilitated the introduction and spread of invasive plant species. Some of the most abundant invasive species include Japanese honeysuckle, porcelain berry, English ivy, winter creeper, oriental bittersweet, bush honeysuckle, privet, multiflora rose, tree of heaven, ground ivy, chickweed, and Japanese stilt grass.

Muddy Fork

Vegetation in the Muddy Fork watershed is comprised of sporadic forest with an abundance of invasive species typical of disturbed and developed landscapes. Field assessments of the riparian vegetation at potential restoration sites indicated that the suburban development has impaired vegetation along the stream's riparian corridor. Portions of the Muddy Fork watershed contain good quality forest canopy, however; the understory and herbaceous ground layers have been adversely impacted from development and invasive species infiltration. A qualitative assessment of the riparian condition was conducted at six sites on the Muddy Fork and resulted in an average score of 7.5 out of a possible 20 (see Appendix B for complete data sets). This score indicated the riparian zones are of marginal quality and exhibited significant loss of some ecological functions. While this was the lowest score among the Three Forks, the Muddy Fork contained the fewest sample sites and its average was largely influenced by poor scores near highly developed areas. The assessment included aspects important to riparian form and function including buffer development, canopy structure, and invasive vegetation dominance. See Figure 47 in Section 5.7.3 of this report for an example of the form used in these assessments.

Middle Fork

The Middle Fork contains pockets of healthy forest and riparian zones, especially in Cherokee and Seneca parks. However, impacts from urban development and invasive species have degraded much of the watershed. A qualitative assessment of the riparian condition was conducted at 23 sites on the Middle Fork and resulted in an average score of 9.04 (scoring sheets in Appendix B). While this was the highest score among the Three Forks, the score still indicated marginal quality of the riparian zones.

South Fork

The South Fork is the most negatively impacted of the Three Forks due to intense residential and commercial urbanization. The best quality vegetation exists near the Beargrass Creek State Nature Preserve. A qualitative assessment of the riparian condition was conducted at 24 sites on the South Fork and resulted in an average score of 8.1, indicating marginal health of the riparian zones.

2.5.2 Wildlife

Wildlife in the Beargrass Creek watershed is typical of urban environments, although small isolated pockets of natural habitat and the proximity of the city to natural areas does provide occurrences of wildlife not typically associated with urban areas. Numerous small and large mammals utilize the riparian corridors and green spaces within the watershed. These included species such as whitetail deer, cottontail rabbit, raccoon, opossum, striped skunk, woodchuck, muskrat, gray squirrel, and fox squirrel. Somewhat more secretive and less noticeable are the grey fox, red fox, coyote, and numerous species of mice, moles, shrews and bats.

Amphibians and reptiles can also be found within or adjacent to the study area. Salamander species include slimy and long tail salamanders, red-spotted newt and mudpuppy. Frogs and toads in this area include bullfrog, leopard frog, green frog, pickerel fog, spring peeper, gray tree frog, American toad, fowler's toad, and eastern narrow mouth toad. Several species of snakes and turtles also commonly utilize the area. These include common snapping turtle, red-eared slider, common box turtle, eastern spiny softshell, rough green snake, black rat snake, and northern water snake.

Because of its proximity to the Ohio River and position in Mississippi Flyway, the Beargrass Creek watershed plays host to numerous bird species. The species that utilize habitats within the study area change throughout the year as birds use the area to rest while on their migration routes. Neotropical migrants can be plentiful in the late spring and summer including warblers, vireos, grosbeaks, and sparrows. Woodpeckers, ducks, and hawks are more abundant in the fall and winter. Restoration of floodplain forests is a priority in this region because they are utilized as staging areas for migratory waterfowl and serve as breeding grounds for species like the wood duck.

2.5.3 Fish

Fish communities within the Three Forks of Beargrass Creek have been greatly impacted from the adverse effects to the stream from surrounding development and urbanization. Poor water quality and decreased habitat quantity and quality have contributed to the decline in health of the stream's fish communities. Species that currently inhabit the streams are those that are relatively hardy generalists and can persist in less than ideal conditions. A fish community assessment of seven sites within the Three Forks completed in 2017 by Redwing Ecological Services, Inc. for MSD described fish communities as "fair" at three sites, "poor" at two sites, and "very poor" at one site.

Connectivity is defined as the degree to which habitats allow animal movement and other natural processes. The connectivity of a stream upstream and downstream (longitudinal connectivity) influences the movement of sediment, nutrients, carbon and aquatic organisms through a river system. The connectivity of a stream is an important indicator of its health. Highly fragmented stream systems generally have less biodiversity and abundance of native fish species than free flowing systems.

Artificial barriers that have the potential to prevent movement of fish include dams, weirs, bridges, and culverts. The extent to which a structure forms a barrier to fish passage depends on several factors including the structure's size, the flow regime of the waterway, the fish species present, their movement patterns and the location of the structures in relation to those patterns. The presence of potential barriers to connectivity in the Beargrass Creek watershed is shown in Figure 10.

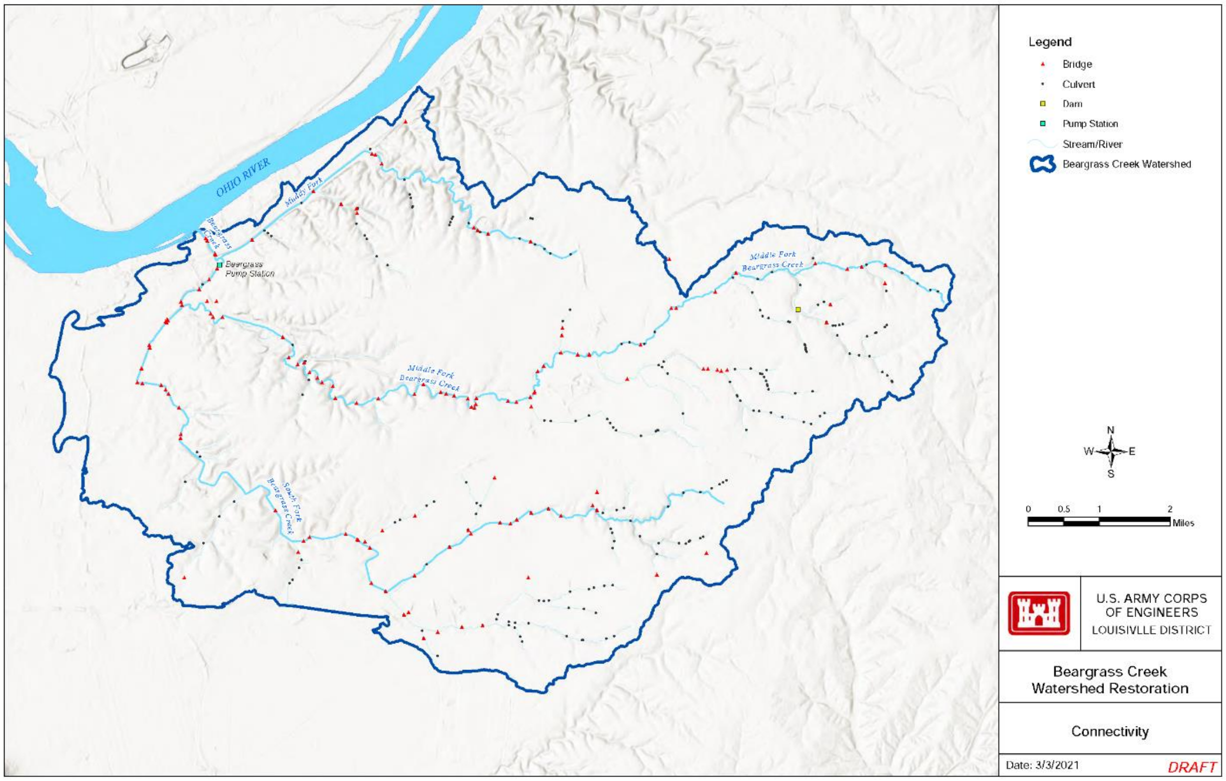

Figure 10. Potential Barriers to Aquatic Connectivity in the Beargrass Creek Watershed

Muddy Fork

According to MSD (2016) the health of the fish communities was fair in 2015, highly variable from year to year, with a declining trend. Poor aquatic macroinvertebrate and algal communities are factors affecting fish in the Muddy Fork. An analysis of the long-term sampling data from seven sampling events between 2002 and 2017 suggested the Muddy Fork generally has the best fish community among the three forks.

Middle Fork

The health of fish communities was fair and improving in 2015 at the Browns Lane sampling site. At Old Cannons Lane, the health of fish communities was fair and declining, and at Lexington Road, community health was poor, but the data still indicated a positive trend in health. Despite healthy algal communities at each site, aquatic insect communities, which are an important food source for fish, were graded as fair. In the Middle Fork, long-term sampling data suggests the upstream sites had the best community, with decreasing community conditions downstream.

South Fork

In 2015, at the Trevilian Way sampling location, the health of fish communities was graded as fair and improving. At Schiller Avenue, the health of fish communities was not assessed in 2015 due to construction but has been declining according to past data collection. At Brownsboro Road, the health of fish communities was poor and improving. Despite fair to excellent algal communities, aquatic insect communities were graded as poor at all sites and declining at Brownsboro and Schiller Avenue sites. Long-term sampling data suggests the South Fork generally has the poorest fish community among the Three Forks, and like the Middle Fork, fish community health decreased while going downstream. The Brownsboro Rd sampling station on the South Fork had the poorest fish community of all the Beargrass Creek sites.

Table 3 lists species observed (*n*=41) in a 2017 fish survey for MSD's long-term monitoring sites on the Muddy Fork (one sample site), Middle Fork (three sample sites), and South Fork (three sample sites). All species encountered are considered to be native to the watershed.

Table 3. Observed fish species in a 2017 survey (Redwing, 2017).

Species	Common Name	Species	Common Name
Atheriniformes		**Ictaluridae**	
Atherinidae		*Ameiurus natalis*	Yellow Bullhead Catfish
Labidesthes sicculus	Brook Silverside	*Noturus flavus*	Stonecat
Cypriniformes		**Scorpaeniformes**	
Cyprinidae		**Cottidae**	
Campostoma anomalum	Stoneroller	*Cottus carolinae*	Banded Sculpin
Carassius auratus	Goldfish	**Perciformes**	
Cyprinella spiloptera	Spotfin Shiner	**Centrachidae**	
Hybopsis amblops	Bigeye Chub	*Ambloplites rupestris*	Rock Bass
Luxilus chrysocephalus	Striped Shiner	*Lepomis gulosus*	Warmouth
Lythrurus umbratilis	Redfin Shiner	*Lepomis cyanellus*	Green Sunfish
Notropis atherinoides	Emerald Shiner	*Lepomis macrochirus*	Bluegill
Notropis boops	Bigeye Shiner	*Lepomis megalotis*	Longear Sunfish
Notropis photogenis	Silver Shiner	*Lepomis microlophus*	Redear Sunfish
Notropis stramineus	Sand Shiner	*Micropterus dolomieu*	Smallmouth Bass
Ericymba buccata	Silverjaw Minnow	*Micropterus punctulatus*	Spotted Bass
Pimephales notatus	Bluntnose Minnow	*Micropterus salmoides*	Largemouth Bass
Semotilus atromaculatus	Creek Chub	*Pomoxis annularis*	White Crappie
Catostomidae		**Percidae**	
Catostomus commersoni	White Sucker	*Etheostoma blennioides*	Greenside Darter
Hypentelium nigricans	Hog Sucker	*Etheostoma caeruleum*	Rainbow Darter
Minytrema melanops	Spotted Sucker	*Etheostoma flabellare*	Fantail Darter
Moxosotoma duquesnei	Black Redhorse	*Etheostoma nigrum*	Johnny Darter
Moxosotoma erythrurum	Golden Redhorse	*Etheostoma spectabile*	Orangethroat Darter
Cypriniodontiformes		*Etheostoma zonale*	Banded Darter
Fundulidae		**Sciaenidae**	
Fundulus notatus	Blackstripe Topminnow	*Aplodinotus grunniens*	Freshwater Drum
Poeciliidae			
Gambusia affinis	Mosquitofish		

2.5.4 Special Status Species

Lists of threatened, endangered and species of special concern are maintained by the USFWS. Under the Endangered Species Act (ESA) of 1973 (16 U.S.C. §§ 1531-1544), endangered species are defined as any species in danger of extinction throughout all or portions of its range. A threatened species is any species likely to become endangered in the foreseeable future. The ESA defines critical habitat of the above species as a geographic area that contains the physical or biological features that are essential to the conservation of a particular species and that may need special management or protection.

An official list of federally protected species was generated using the USFWS IPaC (Information for Planning and Consultation) website. The list from the Kentucky Ecological Field Office is included in Appendix F. The list (Table 4) included 15 species that could potentially be affected by activities near the study area. The presence of a species on the list does not indicate presence within the study area.

Table 4. Federally listed species that could potentially be affected by activities near the study area, according to the U.S. Fish and Wildlife Services

Group	Common Name	Scientific Name	Status
Mammals	gray bat	*Myotis grisescens*	Endangered
	Indiana bat	*Myotis sodalis*	Endangered
	northern long-eared bat	*Myotis septentrionalis*	Threatened
Birds	least tern	*Sterna antillarum*	Endangered
Mussels	clubshell	*Pleurobema clava*	Endangered
	fanshell	*Cyprogenia stegaria*	Endangered
	Northern riffleshell	*Epioblasma torulosa rangiana*	Endangered
	orangefoot pimpleback	*Plethobasus cooperianus*	Endangered
	pink mucket	*Lampsilis abrupta*	Endangered
	rabbitsfoot	*Quadrula cylindrica cylindrica*	Threatened
	ring pink	*Obovaria retusa*	Endangered
	rough pigtoe	*Pleurobema plenum*	Endangered
	sheepnose mussel	*Plethobasus cyphyus*	Endangered
	spectaclecase	*Cumberlandia monodonta*	Endangered
Plants	running buffalo clover	*Trifolium stoloniferum*	Endangered

The mussels on this listed were included because the Beargrass Creek's proximity to the Ohio River. There are no recent or historical records of the 10 mussel species in Beargrass Creek. The least tern is also not known to occur in the watershed but does use sand and gravel bars in open areas and along large rivers like the Ohio River for nesting.

The Beargrass Creek watershed lies within the range of three federally listed bat species. The USFWS classifies a portion of the Muddy Fork watershed as "known summer 1 habitat" for Indiana bats and northern long-eared bats, which means Indiana bat maternity habitat and/or northern long-eared bat summer habitat occurs in the area (USFWS 2015). These bats have the potential to utilize dead, dying, or damaged trees along the stream corridors for roosting in the summer months.

The Office of Kentucky Nature Preserves maintains list of stated listed species by county in which they occur. The list species of conservation concern that have historical records in Jefferson County is presented in Table 5.

Table 5. State listed species that could potentially be affected by activities near the study area, according to the Kentucky Office of Nature Preserves (2021)

Group	Scientific Name	Common Name	State Status*
Fishes	*Alosa alabamae*	Alabama Shad	S1
Reptiles	*Clonophis kirtlandii*	Kirtland's Snake	S2
Crayfishes	*Faxonius jeffersoni*	Louisville Crayfish	S1
Plants	*Leavenworthia exigua*	Tennessee Gladecress	SNR
	Leavenworthia exigua var. laciniata	Kentucky Gladecress	S1S2
	Trifolium stoloniferum	Running Buffalo Clover	S2S3
Mammals	*Myotis grisescens*	Gray Myotis	S2
	Myotis sodalis	Indiana Myotis	S1S2
Mussels	*Plethobasus cyphyus*	Sheepnose	S1
	Pleurobema clava	Clubshell	S1
	Potamilus capax	Fat Pocketbook	S1
Insects	*Pseudanophthalmus troglodytes*	Louisville Cave Beetle	S1

* S1 = Critically imperiled, S2 = Imperiled, S3 = Vulnerable, SNR = Unranked. A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species.

2.5.5 Waters of the United States

The study area encompasses waters of the United States as defined under the Clean Water Act. These jurisdictional areas also include wetlands and other special aquatic sites. The Three Forks of Beargrass Creek are considered waters of the United States. The discharge of dredged or fill materials into waters of the United States is regulated pursuant to Section 404 of the Clean Water Act. Preliminary findings of compliance with Section 404 has been documented in the draft Section 404(b)(1) analysis included in Appendix F of this IFR.

All sizable wetland complexes that once existed in the study area have been drained and/or filled during the urban development. Some small, isolated wetlands do exist within Beargrass Creek watershed, but most are of moderate quality at best. No wetland delineation has been completed to date to identify jurisdictional wetlands. For planning purposes, the USFWS National Wetland Inventory (NWI) was consulted. According to the NWI, there are three different types of wetlands present within the study area. Ponds and riverine habitat comprise essentially all wetlands present. There are a few small, isolated forested/shrub wetlands scattered around the watershed. One emergent wetland was identified by the NWI but it has since been converted to soccer fields.

Although NWI maps are not definitive regarding the presence or absence of wetlands, they are useful as an initial planning tool. Figure 11. shows wetlands within the watershed, according to the NWI.

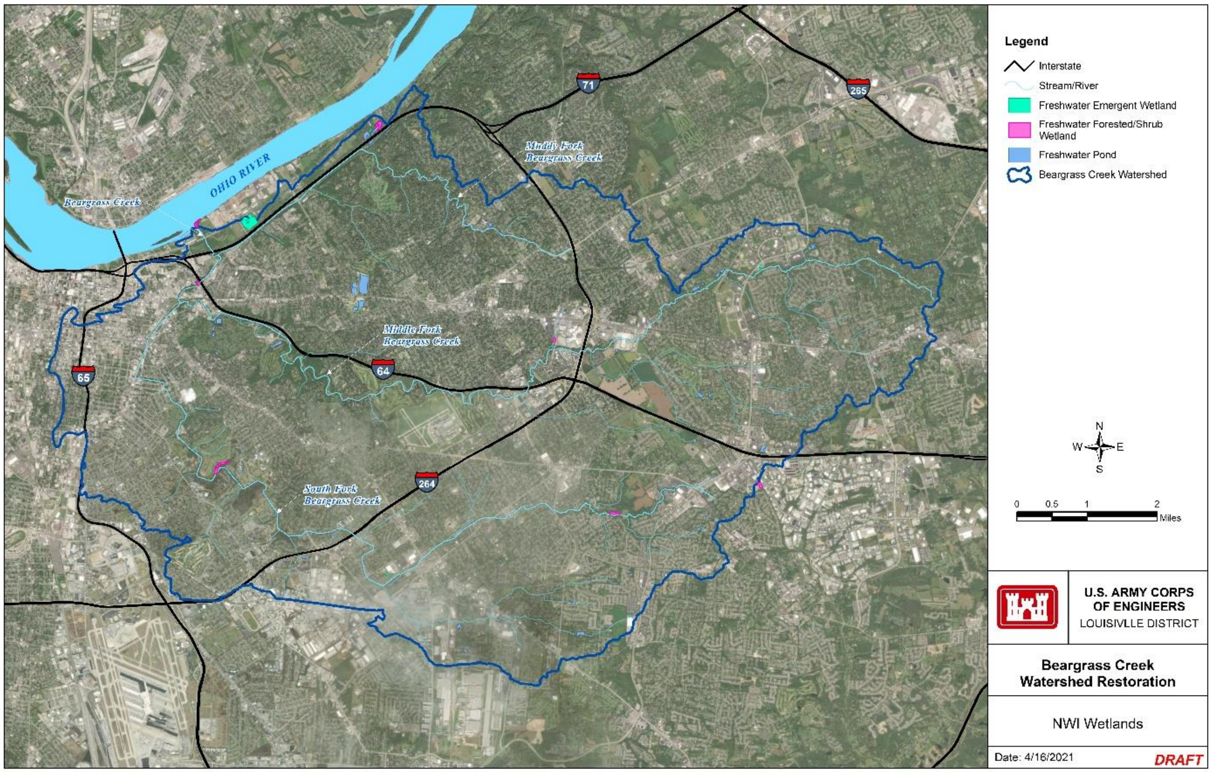

Figure 11. National Wetlands Inventory Mapped Wetlands

2.5.6 Significant Ecological Areas and Wildlife Corridors

Preserved areas of habitat in the watershed like Cherokee Park on the lower Middle Fork and the Beargrass State Nature Preserve on the South Fork act as islands of biodiversity in the metropolitan area. Due to their size, these areas provide wildlife refuge from anthropogenic disturbances and are critical to maintain life history requirements of native species. While highly fragmented, the Three Forks of Beargrass Creek are likely play a critical role as corridors for movement of both terrestrial and aquatic species in an otherwise urban landscape (Beier and Noss, 1998). These wildlife corridors allow plant and animal species to move between the larger islands of habitat. This ability for species to migrate regionally makes the entire ecosystem more resilient to natural disasters, climate change, disease, and other issues that might affect native species in the area. Additionally, the study area is located directly adjacent to the Ohio River, which acts as a larger wildlife corridor for migratory and resident wildlife.

2.6 Cultural Resources

A number of steps were taken in an effort to identify cultural resources within the Study Areas. USACE searched the online database of the NRHP maintained by the National Park Service, the Kentucky Office of State Archaeology (OSA), and USACE GIS files to identify any previously recorded archaeological sites and above ground structures located within any of the Study Areas. Review of the online database maintained by the National Park Service identified 20 NRHP listed historic properties and eight historic districts within a 0.5-mile radius of the Study Areas. NRHP properties along the South Fork include: Eclipse Woolen Mill, Hadley Mary Alicia House, Hope Worsted Mills, Howard Getty's House, Klotz Confectionary Company, Leslie Abbott House, L&N Steam Locomotive No.152 Nelson Distillery Warehouse, Paget House and Heigold House Facade, Schneikert Valentine House, St. Francis of Rome School, St. Therese Roman Catholic Church, School, and Rectory, Steam Engine Company No.4 and No. 10, Wirth, and Lang and Company - The Louisville Leather Company Tanner Building. Historic District along the South Fork are the Phoenix Hill Historic District and portions of the Highland Historic District. NRHP Properties along the Middle Fork include: Brown Theodore House, Cave Hill Cemetery, Cave Hill National Cemetery, Commodore Apartment Building, Olmsted Park System of Louisville, Peterson-Dumesnil House. Historic districts along the Middle Fork include: Crescent Hill Historic District, Clifton Historic District, Oxmoor Historic District, Cherokee Triangle Area Residential District, Gardencourt Historic District, and Highlands Historic Districts. Historic Districts along the Muddy Fork is the Mockingbird Valley Historic District.

A search of the OSA database identified ten previously recorded archaeological sites either located within or adjacent to the Study Areas. These sites are listed in Table 6.

Table 6. Previously recorded archaeological sites located within or adjacent to the Study Areas. Data taken from Kentucky Office of State Archaeology [database accessed December 10, 2020]

Site Number	Cultural Affiliation/ Site Type	NRHP Status
15Jf22	Open Habitation without Mounds	Not Assessed
15Jf27	Late Archaic Indeterminate Open habitation without Mounds	Not Assessed
15Jf28	Indeterminate Prehistoric Open habitation without Mounds	Not Assessed
15Jf30	Middle Archaic/Early-Middle Woodland/Late Prehistoric Open Habitation without Mounds (Cemetery)	Not Assessed
15Jf553	Historic Euro-American 1851-1900	Not Assessed
15Jf592	Historic Euro-American 1801-1950 Open habitation without Mounds	Inventory site (does not meet NR criteria)
15Jf645	Late Prehistoric Indeterminate/ Historic Euro-American 1801-1950 Open habitation without Mounds	Not Assessed
15Jf668	Late Woodland/Late Prehistoric Indeterminate/ Historic Euro-American 1801-1950 Open habitation without Mounds	Considered Eligible but not nominated by SHPO
15Jf734	Early Archaic Indeterminate/Indeterminate Prehistoric/ Historic Euro-American 1801-1950	Not Assessed
15Jf820	Indeterminate Prehistoric/ Historic Euro-American 1801-1950	Not Assessed

Portions of the Study Area have previously been surveyed. There have been 20 different archaeological investigation within the Beargrass Creek Watershed listed in Table 7.

Table 7. Previous Archaeological Investigations that occurred within the Study areas of the Three Forks of the Beargrass Creek Feasibility Study

Author	Date	Title
Ball	1998	*A Phase I Cultural Resources Reconnaissance of the Proposed Beargrass Creek Local Flood Protection Project, Jefferson County, Kentucky*
Esarey	1992	*Phase I Cultural Resources Survey of 12 City Blocks in the 50-acre Municipal Harbor/Thurston Park Section of the Proposed Waterfront Redevelopment Project, Louisville, Jefferson County, Kentucky*
Glover & Clover	1977a	*An Archaeological Survey of the Proposed New Sewer Pumping Station in Louisville (Northern Jefferson County), Kentucky (056-013)*
Granger & Smith	2006	*An Archaeological Subsurface Reconnaissance at the Proposed Location of the WFIA-AM Radio Tower at 900 River Road (Louisville Metro), Jefferson County, Kentucky.*
Herndon & Faberson	2007	*Archaeological Monitoring of Geotechnical Borings for the Proposed Kennedy Bridge Interchange Area of the Ohio River Bridges Project in Jefferson County, Kentucky: Phase 1 through 5.*
Thomas & Bybee	2015	*An Archaeological Survey of the Proposed Clifton Heights Combined Sewer Overflow Storage Basin and Associated Infrastructure, Jefferson County, Kentucky.*
Pool	2019	*Cultural Historic Determination of Eligibility Survey for the Louisville Reach and Louisville Gas and Electric Building in Jefferson County, Kentucky.*
Evans	1998	*Phase I Archaeological Reconnaissance of the Whipps Mill Road Flood Control Facility, Jefferson County, Kentucky*
Wetzel & Bader	2009	*Phase I Archaeological Survey for the Proposed Whipps Mill Bike and Pedestrian Improvements at A.B. Sawyer Park Jefferson County, Kentucky*
DelCastello	2006	*An Archaeological Survey of the Proposed Construction of the Center for Preventative Medicine, University of Louisville, Jefferson County, Kentucky.*
Russell et al.	2011	*An Archaeological Survey for the Proposed Construction of the Jeffersontown Force Main, Pump Station, and Upper Billtown Interceptor in Jefferson County, Kentucky.*
Stottman &Schlarb	2008	*An Archaeological Survey of a Trail at Joe Creason Park (15Jf734) Jefferson County, Kentucky.*
Bader & Hardesty	1991	*A Phase I Archaeological Reconnaissance of Three Segments of the North County Sewer System in Jefferson County, Kentucky.*
Prybylski	2007	*A Phase I Archaeological Survey for the Proposed Crossings at Irish Hill Development, Louisville, Jefferson County, Kentucky.*
Curran	2011	*A Cultural Resources Survey of the Proposed I-64/Grinstead Drive Combined Sewer Overflow Storage Basin Development in Jefferson County, Kentucky.*
Bybee	2016	*An Archeological Survey of the Proposed CSO 125 Strom Water Separation Project, Jefferson County, Kentucky.*

Author	Date	Title
Wilson & Bybee	2016	*An Archaeological Survey of Additional Areas for the Proposed I-64/ Grinstead Drive Combined Sewer Overflow Basin Project in Jefferson County, Kentucky.*
Stephenson	2008	*A Phase I Cultural Resources Survey for the Proposed Expansion of the Calvary Cemetery in Jefferson County, Kentucky*
Curran	2013	*An Archaeological Survey of the Proposed Nightingale Road Pump Station and Storage Basin Development in Jefferson County, Kentucky.*
Henderson	1988	*Archaeological Assessment of the Beargrass Creek State Nature Preserve.*
Janzen & Hedgepeth	1988	*A Cultural Resources Assessment of the Corps of Engineers Permit Area for the Willow Lake Commercial Development, Jefferson County, Kentucky*
Bader & Hardesty	1991	*A Phase I Archaeological Reconnaissance of Three Segments of the North County Sewer System in Jefferson County, Kentucky.*
McKelway	1995	*Historic and Prehistoric Archaeology at Falls Harbor, Jefferson County, Kentucky.*

Given that some of the project area has not been previously surveyed for cultural resources, it is unclear if the project will adversely affect historic properties that are either listed or eligible for listing to the NRHP. Due to time constraints, it was not possible to complete the identification of historic properties for the Tentatively Selected Plan (TSP). The Corps, the Kentucky State Historic Preservation Office (KY-SHPO), and Tribal Nations have agreed to develop and execute a Programmatic Agreement (PA) outlining the delayed identification of historic properties for the project. The PA also outlines mitigation measures to address potential effects on historic properties by the Project. The PA would be executed prior to the signed EA and FONSI for the project. A draft copy of the PA and copies of all agency and Tribal communications can be found in Appendix G.

2.7 Noise

Changes in noise are typically measured and reported in units of A-weighted decibels (dBA), a weighted measure of sound level. Noise ranging from about 10 dBA for the rustling of leaves to as much as 115 dBA (the upper limit for unprotected hearing exposure established by the Occupational Safety and Health Administration) is common in areas where there are sources of recreational activities, construction activities, and vehicular traffic. Primary sources of noise at the study area include traffic on nearby streets and highways (typically between 50 and 60 dBA at 100 feet), residential and commercial maintenance equipment such as mowers, railways, and air traffic. Noise monitoring was not conducted as a part of this study. Existing noise levels vary greatly within the watershed and at the proposed restoration sites depending upon the adjacent land uses. Levels are generally lower along stretches of the stream that are that farther away from highways and urban development.

2.8 Recreational, Scenic, and Aesthetic Resources

Muddy Fork

Approximately 2.5 miles of the Muddy Fork was straightened and channelized during the construction of Interstate 71. This greatly reduced the aesthetic nature of the lower half of the stream. However, the upper half of the Muddy Fork still maintains some scenic appeal with its high sinuosity, occasional riffles, and relatively healthy forest canopy. The lower reach of the Muddy Fork can be used for kayaking or canoeing, although access is limited.

Middle Fork

Of the Three Forks, the Middle Fork provides the most outdoor recreational opportunities in large part to Seneca and Cherokee parks (Figure 12), both of which are very popular Olmsted parks. The parks are 531.5 acres 389.1 acres, respectively, and both parks offer numerous features including golf courses, baseball fields, basketball courts, biking, cross country trails, field hockey, soccer fields, volleyball, horseback riding trails, picnic tables, playgrounds, and walking paths.

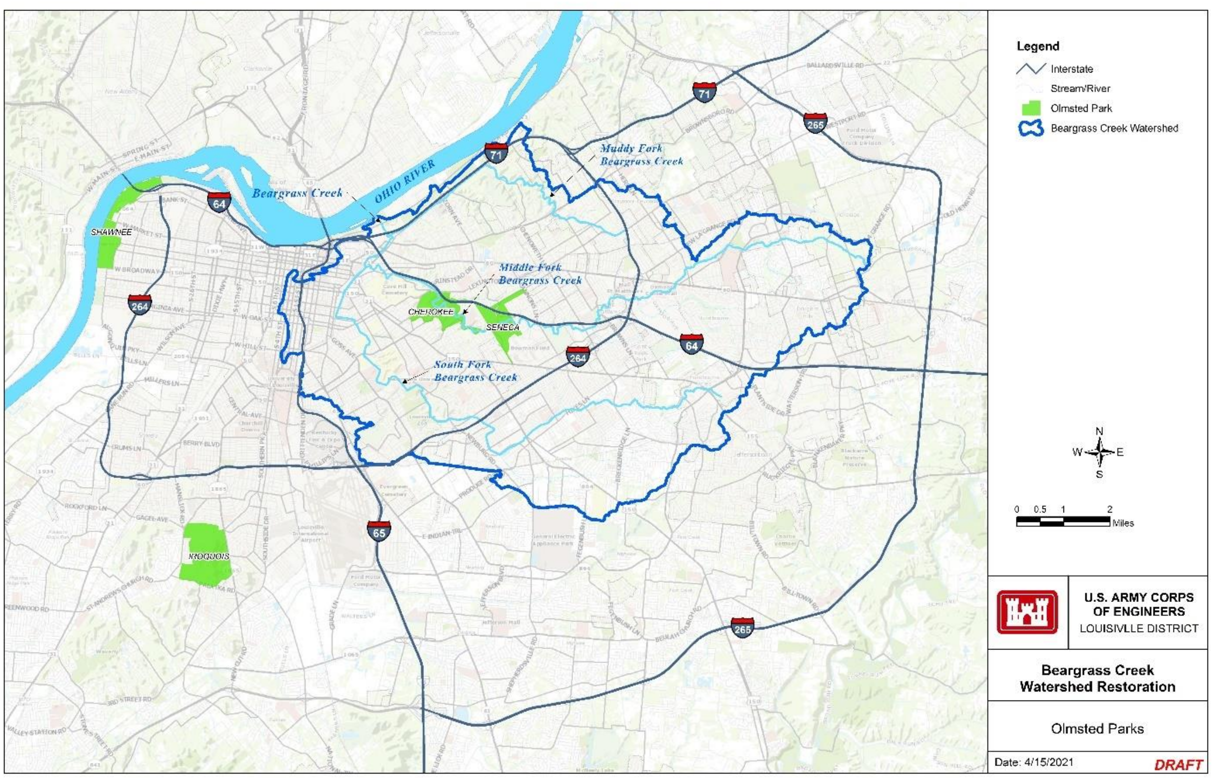

Figure 12: Olmsted Parks in Louisville, KY

The main attraction of Cherokee Park is a 2.3-mile scenic loop, with separate lanes for vehicle traffic and recreational users. The park was designed by Frederick Law Olmsted, and provides a pastoral setting amid rolling hills, open meadows and woodlands of the Beargrass Creek valley. The hills and mature forest along the Middle Fork in Cherokee Park offer some of the most scenic views in the city.

Seneca Park, which boasts a more formal design than Cherokee, has an 18-hole golf course and has 500,000 visitors annually, according to The Trust for Public Land, placing it in the top 100 municipal parks in the United States.

Farther upstream on the Middle Fork, the City of St. Matthews owns and maintains two smaller parks that offer outdoor recreation opportunities for the public. Brown Park (28 acres in size) is located just a few blocks away from Arthur K. Draut Park (24.4 acres), which allows visitors to walk between each, utilizing the public sidewalk system.

Brown Park contains asphalt walking trails that meander through wooded areas along the Middle Fork and offers educational opportunities such as interpretive, multi-layered stone columns that represent geological periods of limestone formation in region. The park also includes a pavilion with picnic tables, play area, and open green spaces.

Arthur K. Draut Park was developed to be utilized for water retention after heavy rain events, but also offers outdoor recreational opportunities during dry periods. When dry, the park is available for walking, jogging or relaxing in the green space.

South Fork

The South Fork has experienced more degradation from urbanization that the other forks. Because of this, it has lost much of its scenic and aesthetic qualities. Isolated sections that have maintained moderately healthy riparian zones do offer some aesthetic appeal against the backdrop of the residential and commercial development. The Louisville Nature Center manages the Beargrass Creek State Nature Preserve and offers outdoor recreational and educational opportunities including gardens, nature paly areas, and a bird blind for bird viewing. The Preserve consists of 41 acres of urban forest with 3.1 miles of public trails.

Louisville Metro’s 62-acre Joe Creason Park is located adjacent to the Nature Center. The park is a popular spot for bird watchers and joggers and has nine tennis courts. The park is adjacent to the Louisville Zoo, which exhibits more than 1,100 animals on 130 acres, provides an excellent opportunity for conservation education.

2.9 Hazardous, Toxic and Radioactive Waste

The terms “hazardous materials” refers to any item or agent (biological, chemical, radiological or physical) which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. Issues associated with hazardous materials typically center around waste streams, underground storage tanks (USTs), above ground storage tanks (ASTs), and the storage, transport, use, and disposal of pesticides, fuels, lubricants, hazardous toxic and radioactive waste (HTRW) and other industrial substances. When such materials are improperly used, they can threaten the health and well-being of wildlife species, habitats, soil and water systems, and humans.

USACE policy prohibits the use of Civil Works funds to respond to concerns associated with HTRW and requires appropriate investigation to identify potential HTRW concerns early in planning and development of a civil works project. Several actions were conducted to address the existence of, or potential for, potential HTRW contamination on lands in and adjacent to the proposed project site, including structures and submerged lands, which could impact, or be impacted by project implementation.

Multiple environmental databases and related records were searched and reviewed for information regarding current and former land use indicating storage, disposal or use of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulated substances, toxic chemical releases, water discharge permit compliance, hazardous waste handling processes, and Superfund status. Sanborn Fire Insurance Maps were accessed to identify the historic uses of the sites nearer to downtown Louisville. The assessment did not indicate significant concerns from potentially HTRW contamination at any of the proposed restoration sites. Reports for each site are located in Appendix F.

2.10 Socioeconomics and Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Executive Order, 1994), directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. When conducting NEPA evaluations, the Corps of Engineers incorporates Environmental Justice (EJ) considerations into both the technical analyses and the public involvement in accordance with the U.S. Environmental Protection Agency (USEPA) and the Council on Environmental Quality guidance (CEQ, 1997).

The CEQ guidance defines “minority” as individual(s) who are members of the following population groups: American Indian or Alaskan native, Asian or Pacific Islander, Black, not of Hispanic origin, and Hispanic. The Council defines these groups as minority populations when either the minority population of the affected area exceeds 50-percent of the total population, or the percentage of minority population in the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographical analysis.

The USEPA online EJ Screen environmental justice mapping tool was used to assess the environmental and demographic indicators within the Beargrass Creek watershed. The full EJ Screen Report is located in the Appendix F. Figure 13 compares environmental and demographic indicators of the study area with the other block groups within the state, EPA region, rest of the U.S.

The screening indicated the watershed ranked higher than 82 percent of block groups in the U.S. for exposure to wastewater discharge. All other EJ indexes were below the 50 percentiles when compared to the rest of the U.S.

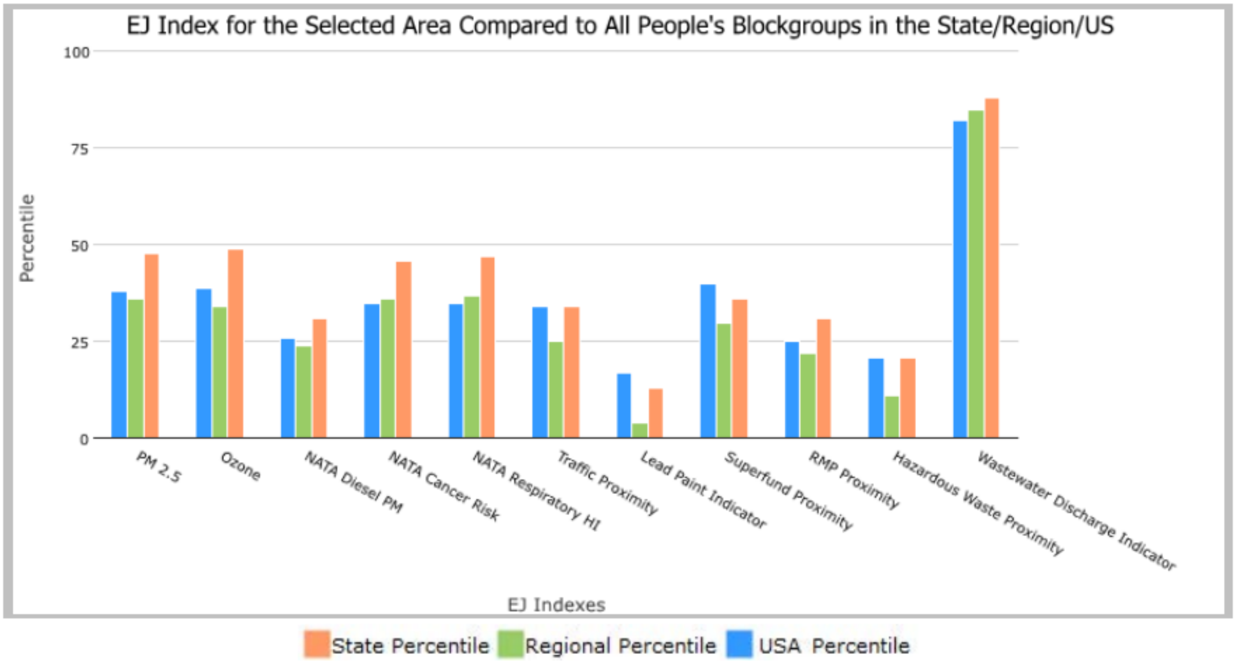

Figure 13 Values for Environmental and Demographic Indicators and EJSCREEN Indexes for the Beargrass Creek Watershed

According to the 2014-2018 American Community Survey (ACS) estimates, the approximate population within the Beargrass Creek watershed is 219,000, with 22% of the total population being comprised of the previously defined minority groups. Per capita income of that same area was $39,258 per year. Figure 14 shows median household income data in Jefferson County, Kentucky. Approximately 31% of the population in the watershed is under the age of 18 years old. Appendix F contains the EJ Screen ACS summary report generated for the watershed.

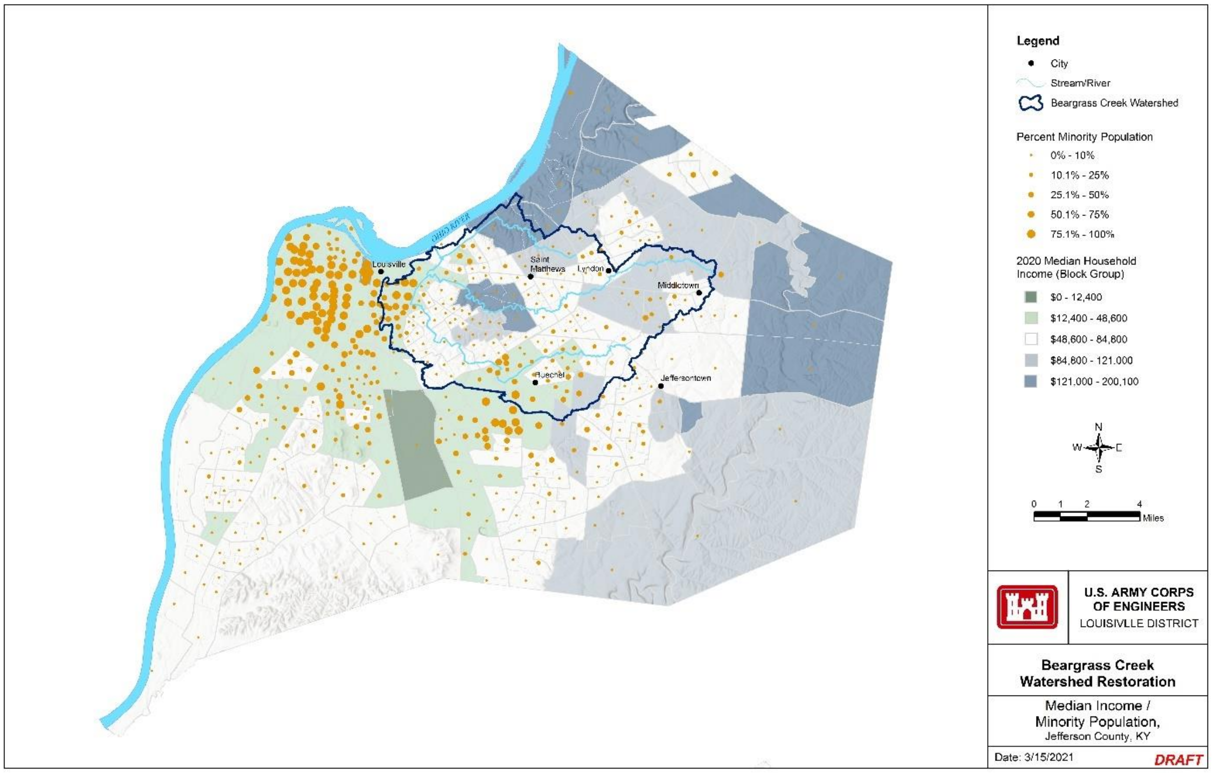

Figure 14 Percent Minority Population and Median Household Income for Jefferson County, Kentucky

3.0 Study Background

3.1 Resource Significance Overview

3.1.1 Technical Recognition

Nationally, there is a scarcity of healthy urban watersheds. Scarcity is a measure of a resource's relative abundance within a specified geographic range. Generally, scientists consider a habitat or ecosystem to be rare if it occupies a narrow geographic range or occurs in small groupings. Unique resources, which are unlike any others found within a specified range, may also be considered significant, as are resources that are threatened by interference from both human and natural causes (Soule, 1986).

Beargrass Creek represents both a scarce habitat and a habitat threatened by human development. It is difficult to find a reach of the stream that has been unaffected by the historical and current development patterns in Louisville. The stream that once meandered through a landscape scattered with wetlands is now channelized and manipulated to provide suitable land to build subdivisions and to provide for a fast exodus of floodwaters. In a 1953 Courier-Journal article (Figure 15) titled "Improved Beargrass Creek Drainage Gives Land a Boost", the plans to deepen and channelize the stream to decrease flooding along the South Fork are explained. In the article, the authors talk about the once marshy lands along the stream and how the plans include the removal of giant sycamores from the riparian zone.

yet, the project looks promising to such landowners as Dr. and Mrs. Armand E. Cohen, whose four-acre wooded lot on Newburg Road is bisected by the new channel.

"The old creek flooded every time there was a good rain, all the way from Bernheim's Lake to my own pond, and on down the valley," said Dr. Cohen. He once kept a pony and mule in the woodlot, but gave them up for a tractor after rescuing both animals from breast-deep floodwaters.

Marshy and Swampy

"All of this country through here was marshy and swampy back in George Rogers Clark's day, I've heard some of the old men of the neighborhood say," he noted. "We've even heard there used to be beavers and all sorts of game through here."

One result already apparent to Mrs. Charles C. Krebs, whose home is next door to the Cohens', is that "You can see all across the valley now."

This visible result—opening up of the valley visually—has been a mixed blessing. Some of the landowners hate to see the giant sycamores being chopped and bulldozed out of the old creek bed. But most of them interviewed confess they'll prefer the new ditch to the old creek—providing it lives up to its advance billing as a flood-control measure.

Farther upstream, part of "Haylands Farm," the 70-acre property of contractor Gil Whittenberg, has benefited somewhat—but not from the widening. Whittenberg has hauled hundreds of loads of dirt and rubble from a downtown building project to raise the level of his bottomland level with Gardiner Lane. Later, the widening should provide more dirt for even more filling.

May Hurt Parkway

However, the whole project may end up by either forestalling or increasing the cost of a long-dreamed-of Beargrass Parkway up this valley.

Various city plans have proposed a handsome, wide parkway up this valley from Eastern Parkway to Bardstown Road or farther. The current improvements will certainly make the land more expensive, if such a parkway is ever built.

When the present job is finished—which should be by December 31—the Metropolitan Sewer District will have converted the South Fork from a meandering, partly ditched and sometimes overgrown creekbed into a giant flume. This project starts at a point about 1,000 feet north of Trevilian Way (opposite Bellarmine College); and runs south to the city boundary near Gardiner Lane.

If you drive out you can see the size of the job. The creek now is 26 feet wide at the bottom, nine to 12 feet deep, sides sloping at a ratio of 1½ to 1, and a 100-foot right-of-way (which also includes the recently installed 42-inch sanitary sewer from Appliance Park into the city's sewers.)

This part of the job cost $104,000. (A 1951 estimate by Soil

Figure 15 1953 Courier-Journal Article Excerpt

This article is just one example of the past management of the stream and surrounding land. With restoration such as planting of native plants, reestablishment of natural meanders and the reestablishment of floodwater access to the floodplain, the habitat that once existed can be returned to some of its former function. A restored Beargrass Creek will be an example of a healthy balance between human development in an urban watershed and nature at its highest form and function.

3.1.2 Institutional Recognition

There are several Acts and Executive Orders that support habitat restoration in Beargrass Creek such as:

- Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)

- Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)
- Invasive Species (E.O. 13112)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)
- National Invasive Species Act of 1996 (Public Law 104 – 332)
- Protection of Wetlands (E.O. 11990)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Preparing the United States for the Impacts of Climate Change (E.O. 13653)

There are also other partnerships and organizations that are supported by the efforts of this study. The Ohio River Basin Fish Habitat Partnership was formed to protect, restore, and enhance priority habitat for fish and mussels in the watersheds of the Ohio River Basin. This partnership includes a multitude of state and federal agencies, including the USACE.

The Ohio River Basin Alliance (ORBA) advocates for the ecological health and economic well-being in the Ohio River Basin. ORBA includes representatives from over 80 member organizations, including local, state and federal agencies, as well as industry, academia, and not-for-profit organizations. A recent Planning Assistance to States study with Ohio River Valley Water Sanitation Commission (ORSANCO) and ORBA looked for goals and strategies to improve the ecology of the entire Ohio River Basin. Improvements to Beargrass Creek are an excellent way to meet some of these goals and leverage federal funds.

3.1.3 Public Recognition

The Beargrass Creek watershed is in an urban environment and therefore touches many communities, giving it high visibility and recognition by the residents of Louisville. Historically, the Beargrass Creek spurred development because of the need for clean water for Louisville's growing industrial businesses. That development led to a dense urban environment around much of the watershed.

As discussed in Chapter 1, the Middle Fork flows through Cherokee Park, one of three parks designed by Frederick Law Olmsted in Louisville in 1891, which consisted of Cherokee, Iroquois, and Shawnee Parks (Figure 12), all of which are connected with scenic tree lined parkways. The location and design of these parks were chosen because they exemplified three distinguishing landscapes found in Louisville. Cherokee Park was designed to represent the landscape surrounding Beargrass Creek.

Additionally, there are several Master Plans and Projects that include or focus on Beargrass Creek, including:

- Louisville Metro Comprehensive Plan
- Louisville MSD 2017 Watershed Master Plan
- The Master Plan for Louisville's Olmsted Parks and Parkways
- The Congress for the New Urbanism's South Fork Legacy Project 2019
- Louisville Zoo Master Plan
- Metro Parks Naturalization Plan
- Butchertown, Phoenix Hill, and Nulu Neighborhood Plan
- The Waterfront Botanical Gardens Mast Plan

There are multiple local environmental groups working for a cleaner, more sustainable watershed. These include the Beargrass Creek Alliance and the Kentucky Waterways Alliance.

3.2 Southeastern Riparian Ecosystem Significance

3.2.1 Scarce/Rare Southeastern Riparian Ecosystems

Scarce resources in the historic and/or current area of the Beargrass Creek include Karstic Caves and Springs, Canebrakes and bedrock streams confluent to the Ohio River. Canebrakes, for example, have been reduced to less than two percent of their former area and are considered a critically endangered ecosystem in the Southeastern US (Pratt and Brantley, 1997). This native plant was likely once prominent in this region, especially along big river floodplains like the Ohio River, as well as in the floodplains of tributaries, like the Beargrass Creek.

Representation is a measure of a resource's ability to exemplify the natural habitat or ecosystems within a specified range. The presence of a large number and percentage of native species, along with the absence of exotic species, is an example of representation as does the presence of undisturbed habitat. Examples of representation within the Beargrass Creek watershed include Cherokee Park and the Oxmoor Farm wetland on the Middle Fork. These are representative of the once abundant wetland habitats in Kentucky. Beargrass Creek Nature Preserves is another example of a representative of a high-quality habitat within the study area and is located next to Joe Creason Park on the South Fork.

There are several habitat examples in the study area that would support significant species if restored. Karstic caves and springs, canebrake, wetlands, bedrock streams and riparian woodland are all examples of habitat that once existed within the Beargrass Creek watershed.

3.2.2 Biological Diversity

There are several state or federally listed threatened and endangered species recorded in Jefferson County (though not all in the study area) that would typically utilize riparian or stream habitats, including the least tern, Louisville crayfish, and Kirtland's snake (Tables 4 and 5, Section 2.5.4). The federally-listed Indiana, gray, and Northern long-eared bats also occur in the region and may rely on habitat provided by Beargrass Creek for foraging of insects and roosting.

3.2.3 Status and Trends

Status and Trend measures the relationship between previous, current and future conditions. The current condition of Beargrass Creek as compared to historical conditions is highly degraded due to years of development and alteration of the stream. The future without project conditions would remain relatively the same as current conditions because the stream corridor is confined and most areas within the watershed are already developed. Therefore, we can assume invasive species will continue to spread and fortify their presence without any maintenance or removal.

Implementation of a federal ecosystem restoration project (i.e., future with project condition) would not fully restore the stream to its historical conditions due to the constraints of the urban environment. However, targeted restoration could substantially improve currently degraded habitats and provide benefits through connectivity of existing and restored habitat. Targeted habitat restoration could also improve downstream habitat (e.g., reduced sediment loading) and water quality. These actions, while not fully restoring the stream to its historical conditions, will improve the current conditions and exemplify the restoration that is possible within an urban watershed.

3.2.4 Habitat Connectivity

Connectivity is the measure of a resource's connection to other significant natural habitats. There are 10 species of threatened and endangered mussels in the Ohio River region where Beargrass discharges to the Ohio. The Ohio River and Beargrass Creek are strongly connected with an interchange of species between these two aquatic environments. An example of this interchange and dependency is with glochidia, the larval form of fresh mussels. These larvae attach to gills and rely on fish to travel to small streams for spawning and habitat. This allows the mussels to broaden their range and makes it easier for populations to rebound. Migratory birds also need connected habitats. Black Crowned Night Herons as well as the Sand Hill Crane are good examples found in the southeastern US.

3.2.5 Importance of Restoring a More Natural Hydrologic Regime and Geographic Character

Urban development and the subsequent channelization of the stream has had major hydrologic impacts as the city has become more urbanized. Restoring the historic character and the more natural hydrologic regime of the Three Forks goes hand in hand with restoring habitat. A natural hydrologic regime provides more stable flows and less variation between base flows and storm flows. In the hydrologic regime's current state, storm flows are more frequent and extreme, making habitat unstable and less likely to support diverse species. Restoration of these natural flows would make the stream more suitable for aquatic life, improve long-term habitat stability, and improve water quality.

4.0 Plan Formulation

Plan formulation is an iterative process resulting in the development, evaluation, and comparison of alternative plans to address identified study problems by achieving the outlined objectives. The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (1983) established four accounts to facilitate the evaluation and display of the effects of alternative plans. These accounts are: national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). These four accounts encompass all significant effects of a plan on the human environment as required by NEPA (42 U.S.C. 4321 et seq.). As required by Section 122 of the Flood Control Act of 1970 (Pub. L. 91-611, 84 Stat. 1823), all four accounts were considered in the selection of the Tentatively Selected Plan (TSP).

Plan formulation for ecosystem restoration (ER) presents a challenge because alternatives have non-monetary benefits. To facilitate the plan formulation process, the methodology outlined in the Corps' Engineering Circular 1105-2-404, "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003 was used. The steps in the methodology are summarized below:

1. Identify a primary project purpose. For this portion of the study, ecosystem restoration (ER) is identified as the primary purpose. Alleviating local drainage or water quality issues are not purposes of this project.
2. Formulate management measures to achieve planning objectives and avoid planning constraints, where measures are the building blocks of alternative plans.
3. Formulate, evaluate, and compare an array of alternatives to achieve the primary purpose (ER) and identify cost effective plans.
4. Perform an incremental cost assessment on the cost-effective plans to support selection of the NER plan.

4.1 Public Involvement

The development of the proposed restoration study has resulted from a systematic process of evaluating the stream's existing conditions and any associated problems and opportunities, then identifying objectives to help solve the problems and measures for realizing those opportunities. Due to the visibility of the stream and its value as a community asset, public, agency and stakeholder input was very important during the scoping phase of the study as is shown in Figure 16 from a public meeting in November 2019.

The public comment period for this draft report is also an important opportunity to receive feedback from community stakeholders and the public on the draft Integrated Feasibility Report, as well as tribal groups that have cultural resources in the area. The public comment period is scheduled for April/May of 2021.

Figure 16 Photos from the public meeting held on 14 November 2019

4.1.1 Beargrass Creek Ecosystem Restoration Feasibility Study Workshops

A total of three workshops were held during the scoping phase of the feasibility study. The first took place on October 10, 2019 for community stakeholders that included groups such as Louisville MSD, Kentucky Waterways Alliance, Beargrass Creek Alliance, Louisville Metro Government, University of Louisville, River City Paddle Sports, Kentucky Division of Water, and Natural Resources Conservation Service. These groups were chosen for their intimate knowledge and previous and on-going work within the watershed. The intent of this meeting was to identify gaps in the evaluation of the problems and opportunities in the watershed, brainstorm initial management measures, and draw from local knowledge and expertise. The group was subdivided into three focus groups for each sub watershed in Beargrass Creek. Maps were provided that facilitated the collection of input from stakeholders on site specific restoration opportunities and local expertise in the watershed.

The second and third workshop meetings were targeted to agencies and the public, both held on November 14, 2019. The goals of the public meeting were to provide a venue for the public to supply input into the planning process, draw from local knowledge and expertise and provide constructive feedback on the problems, opportunities, objectives, and constraints that had been scoped to that point.

The public was shown examples of past USACE ecosystem projects and possible management measures, given a history of Beargrass Creek and asked to participate in a map exercise to find gaps in the existing problems and opportunities. Figure 17 illustrates some of the feedback received from the public participants. The focus of this exercise was to relate these ideas to locations within the watershed that would assist the team with site selection. This workshop was attended by over 50 members of the public.

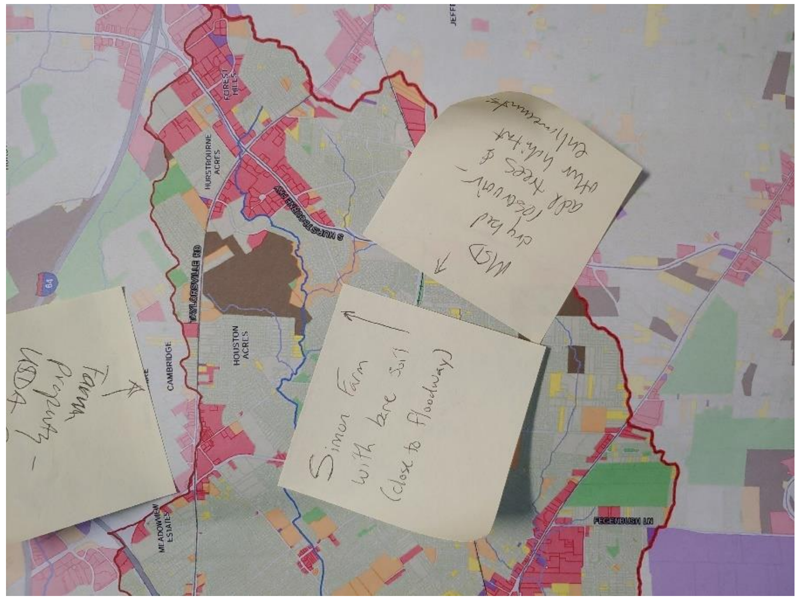

Figure 17 Public Comments on a Beargrass Map at the Public Meeting

The agency workshop was held the same day and was geared toward local, state and federal agencies with interest in ecosystem restoration. Agency components such as USFWS, Kentucky Department Fish and Wildlife Resources, the Great Lakes and Ohio River Division (LRD), National Ecosystem Planning Center of Expertise (ECO-PCX), Louisville MSD(Sponsor) and Louisville District (LRL) Project Delivery Team (PDT) were all in attendence. During this meeting, the team went through a series of preliminary sites to elucidate discussion on site selection evaluation and criteria, management measure evaluation and criteria, and key risks and uncertainties. Figure 18 below shows all entities that participated in the scoping phase of the study.

The specific issues and opportunities discussed at the public meeting included the following:

- Opportunities at Confluence for recreation and restoration
- Public education opportunities
- Excessive bank erosion
- Lack of riparian zone along steep reaches
- C-Cell tower leg in Muddy Fork causing erosion
- LGE bank stabilization
- Big parcel of land on River Road recently donated to Collegiate
- Restore outfall streams that draw to Muddy Fork
- Abundance of honeysuckle at a portion of Muddy Fork close to I-71
- Connect golf course to maintain park area
- Remove cement blocks from Belvedere and repurpose

- Improve straightened channel to more natural state
- Reconnections to flood plain where possible
- Native tree canopy wherever possible
- Reintroduce beavers where appropriate
- Safe spaces to access the water- stream walk, paint/photography, education

Figure 18 Entities that Participated in the Scoping Process

4.2 Summary of Problems and Opportunities

Problem and opportunity statements were framed in terms of the Federal objective and the specific study planning objectives. Problems and opportunities were defined in a manner that does not preclude the consideration of all potential alternatives and does not include discussion of potential solutions. The problem and opportunity statements provided below were evaluated and modified at multiple times during plan formulation, therefore accounting for the dynamics of the iterative planning process.

4.2.1 Problems

Currently, the Three Forks of Beargrass Creek are completely contained within urbanized Jefferson County. Significant portions of the creeks have been channelized to obtain faster flow and increased capacity during floods. Loss of riparian zones and associated wetlands have resulted in in-stream habitat degradation, loss in resiliency and morphology of natural banks, reduced natural organic inputs (woody debris/leaves/insects), and poor water quality. Concrete channels further eliminate in-stream habitat in affected areas, result in elevated water temperatures that exceed thermal limits for most aquatic life and reduce connectivity between upstream and downstream reaches. Accordingly, riparian, wetland

and stream ecosystems have been severely impacted with reduced abundance, diversity, and health of aquatic and riparian organisms. Figure 19 illustrates some of the current issues observed within Beargrass Creek watershed.

Specific preliminary problems are summarized below:

1. Loss of Fluvial-geomorphic Processes (Riverine Habitat): The degradation of the physical shapes of waterways, their water and sediment transport processes, and the landforms they create.
   a. Loss of cut & fill alluviation (actively meandering and migrating)
   b. Abnormal sediment inputs, transport and substrate sorting
   c. Instability of banks, streambank armoring and lack of native vegetation
   d. Loss of habitat features (e.g. riffles, pools)
   e. Flow velocities homogenized (hydraulics)
   f. Presence of foreign debris and loss of natural organic debris (e.g., large wood)

2. Degradation of Hydrologic Regime: Negative variations in the state and characteristics of the stream such as the quantity and dynamics of waterflow or connection to groundwater bodies.
   a. 9 to 60% impervious surface across watershed
   b. Natural hydrologic inputs altered
   c. Flashy urban hydrography with extremely high flood flows
   d. Loss of hydrologic periods
   e. Fragmentation of channel by culverts, abutments and channelization

3. Loss of Riparian Zone: A decrease in the size and quality of the plant habitats along the banks of the stream.
   a. Reduced extent of riparian buffers
   b. Habitat fragmentation
   c. Loss of riparian inputs (large woody debris, leaf litter, insects/other food)

4. Loss of Species Richness (riverine and riparian native species): A decrease in the number of species within the region.
   a. Extirpation through physical removal; development/agriculture
   b. Loss in remnant areas via invasive species and other degradation
   c. Fragmentation of stream channels and riparian zones

Figure 19 Example of common problems seen in Beargrass Creek. Top left- concrete channel on the South Fork, Bottom left- Channel incision on the Middle Fork, and Right- Channelization and loss of riparian zone on the Muddy Fork

4.2.2 Opportunities

Opportunities are benefits, or positive aspects, for the community or environment that can be achieved in addition to the study objectives. Opportunities may not necessarily be related to the study objectives, but they may be achieved in the process of meeting the objectives. Below are major opportunities for the Beargrass Creek study:

1. Increase native species richness/abundance of riverine, wetland and riparian communities
2. Increase aquatic habitats appropriate to unique local conditions
    a. Ephemeral and perennial streams
    b. Ohio River floodplain
    c. Sloped wetlands and springs
    d. Riverine and palustrine
    e. Karstic and calcareous formations
3. Increase amount of viable and connected stream habitats
4. Increase extent of riparian habitats
    a. Abandoned and/or flooded lands
    b. Detention/retention basins
    c. Parks and agricultural lands
    d. MSD / Metro lands, easements, & right of ways
    e. Natural areas & preserves
5. Realign / move aging MSD infrastructure to support habitat restoration
6. Foster a clean, safe place to play and live
    a. Improved recreation and community engagement with watershed
    b. Education areas that provide nature and information
    c. Provide public access to streams and other wetlands

d. Site stewardship programs
7. Improve water quality

4.3 Plan Formulation

4.3.1 Federal Objective

The Federal objective of water and related land resources planning is to contribute to the restoration, conservation and management of environmental resources in accordance with numerous national environmental statutes, applicable executive orders, and other Federal planning requirements and policies. The use of the term “Federal objective” should be distinguished from planning/study objectives, which are more specific in terms of expected or desired outputs, whereas the Federal objective is considered more of a national goal. Water and related land resources project plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study objectives and to the Federal objective. Contributions to national improvements are increases in the net value of the national output of goods, services, and ecosystem integrity as well as ecosystem services that are or are not marketable.

Protection of the Nation’s environment is achieved when damage to the environment is eliminated or avoided and important cultural and natural aspects of our nation’s heritage are preserved. Various environmental statutes and executive orders assist in ensuring that water resource planning is consistent with protection. The objectives and requirements of applicable laws and executive orders are considered throughout the planning process in order to meet the Federal objective. The following laws and executive orders that specifically provided guidance for this study are not limited to, but include:

- Safeguarding the Nation from the Impacts of Invasive Species (E.O. 13751)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)
- National Invasive Species Act of 1996 (Public Law 104 – 332)
- Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)
- Fish and Wildlife Coordination Act, as amended (16 USC 661)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)
- Clean Air Act of 1970, as amended (42 USC 7401)
- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Resource Conservation and Recovery Act of 1976, as amended (42 USC 6901, et seq.)
- Protection and Restoration of the Great Lakes (E.O. 13340)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Protection of Wetlands (E.O. 11990)
- Wild and Scenic Rivers Act of 1968 (16 USC 1271-1287 Public Law 90-542 82 Stat. 906)

4.3.2 Specific Planning Objectives

Planning objectives are statements that describe the desired result(s) of the planning process by refining the problems identified into achievable actions. Objectives must be clearly defined and flexible (non-prescriptive). They should be supported by: information on the effect desired (quantified and/or qualified), the subject of the objective (what will be changed), the location where the expected result will occur, the timing of the effect, and the duration of the effect. The planning objectives presented below are directly related to the problems identified in the previous sections.

1. Reestablish quality and connectivity of riverine habitats
All three forks of Beargrass Creek have experienced channel realignment, bank erosion, loss of alluvial processes, homogenized flow velocities, etc. The South Fork in particular has been dramatically modified with nearly 3 miles of concrete channel designed to increase conveyance of floodwaters. These impairments are specific to impeding riverine hydraulics, sediment transport and substrate sorting, which results in a loss of structural habitat heterogeneity (e.g. homogenized geomorphology). The effects desired by meeting this objective are to provide riverine functions and/or structure to restore, connect and sustain habitats. The targeted location of these effects would be within stream channel. These effects would be sustained over the life of the project and optimistically in perpetuity. This objective seeks to reestablish natural fluvial-geomorphic parameters (hydraulics/substrates) and structure (morphology/habitat) to support riverine and riparian habitats within the study area. Improvement is measured via the predicted increase in quality of riverine habitat as evaluated by the Qualitative Habitat Evaluation Index for Louisville Streams (QHEILS).

2. Reestablish quality and connectivity of riparian and wetland habitats
Beargrass Creek watershed is a highly urbanized system. Impervious surfaces, land use change, habitat fragmentation, the disruption of ecological inputs, etc. have all contributed to degraded riparian zones. Existing riparian buffer zones are impaired in terms of width, connectivity and/or species composition. The effect desired by meeting this objective is to return tracts of healthy native riparian vegetation with increased species richness of insect, amphibian, reptile, bird and mammal species. The targeted location of these effects would be within the riparian zone and supporting communities. These effects would be sustained over the life of the project and optimistically in perpetuity. This objective seeks to reestablish native riparian plant community species richness and structure for resident and transient riparian animal species. Improvement is measured via the Simple Model for Urban Riparian Function (SMURF) habitat restoration planning model developed by the USACE Engineer Research and Development Center (ERDC) using parameters from various accepted models from state and federal agencies.

4.3.3 Planning Constraints

Planning constraints represent restrictions that limit the extent of the planning process. The planning constraints considered to this point in the study are as follows:

- Avoid areas of potential contamination and potentially contaminated sediments
- Avoid inducing local flooding
- Avoid impacting railroad and transportation infrastructure

The cause of these constraints is almost entirely due to the alterations made to the watershed since the settling of the surrounding area and subsequent development of homes, businesses and supporting infrastructure. Urbanization has channelized much the system to make way for development that now physically constrains the streams riparian zone. Since the stream has also been altered to move stormwater out of the city as quickly as possible, any changes to the system such as restoration of natural substrate, for example, must be cautious of inducing flooding. With the growth of the city occurring since the late 1800's, there are also many areas with known and potential contamination from unregulated development. All these constraints have been recognized and considered throughout plan formulation in order to decrease risk and costs and avoid impacting vital infrastructure.

4.4 Conceptual Ecosystem Model

USACE typically follows a conceptual ecosystem/habitat model (Figure 20) that breaks down components into functions of hazard(s), performance, and consequences. These three (3) concepts are utilized to illustrate mechanisms of change, which focus the effectiveness of potential ecosystem alternatives under consideration for federal investment.

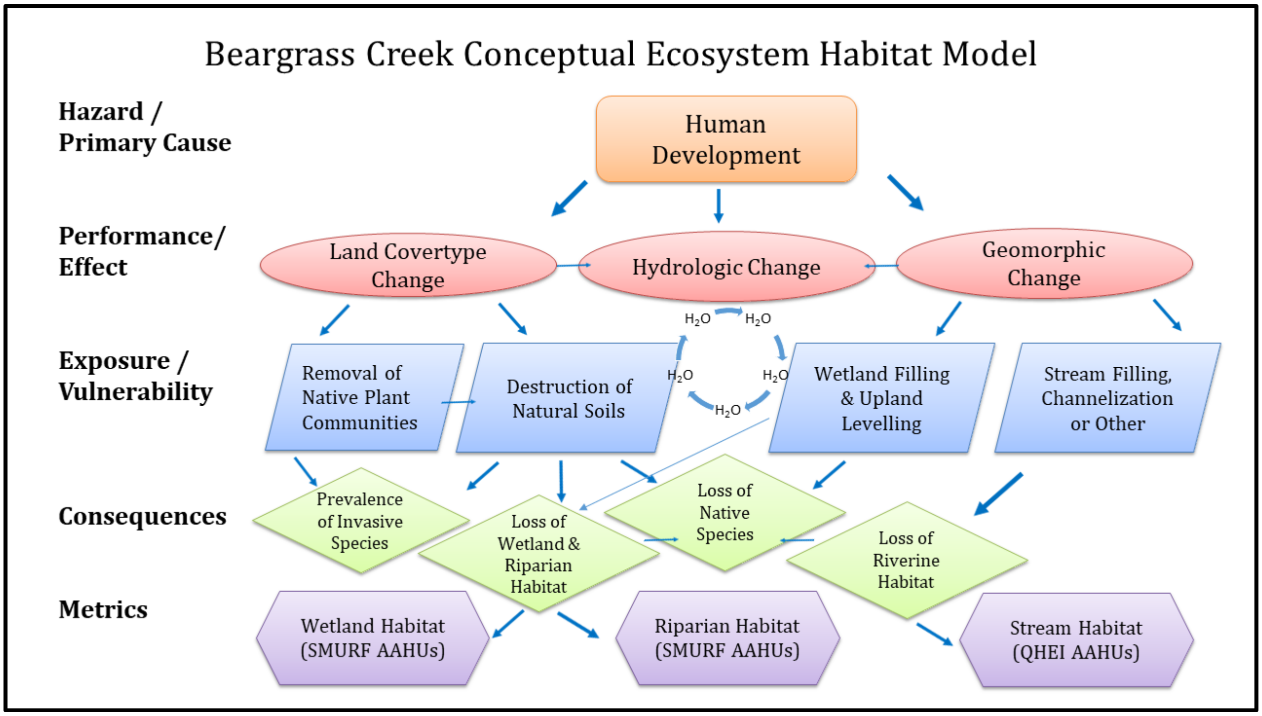

Figure 20 Conceptual Ecosystem Habitat Model showing process for Average Annual Habitat Units (AAHUs)

Hazard

The hazard, or potential cause for harm, refers to the major land use changes caused by development, which is described in Section 4.2.

Performance
Performance refers to the system's reaction to the hazard, or how the Beargrass Creek ecosystem changed, or is anticipated to change based on major land use, hydrologic and geomorphic changes. Performance in this study is primarily tied to land use change and channelization of the river. A description of the existing system's performance in terms of ecological function is presented in Chapter 2 Affected Environment.

Consequence
Consequences are measured in terms of metrics such as economic damage, acreage of habitat lost, value of crops damaged, etc. This study specifically looks at the consequences of lost native species and replacement by non-native species due to losses in native stream, riparian and supporting wetland habitat. These consequences would specifically be measured QHEILS for the stream zone and the SMURF for riparian and wetland zones.

4.5 Site Identification and Selection

The goal of this analysis was to acquire an initial array of locations that would be best suited for aquatic ecosystem restoration (AER) utilizing USACE expertise within policy limitations. An aerial based Geographic Information Systems (GIS) analysis of the Beargrass Creek watershed was completed to identify all potential restoration spaces within the watershed. Additional sites were identified during the meetings referenced above. Criteria presented in Table 8 specifically looked for traits that would make a site more viable for habitat restoration. Available national, county, and municipal geospatial data was utilized to fulfill the criteria needs. Most boundaries for sites were based on existing county data features such as land use, roads, important property lines, watershed boundaries, stakeholder ownership, land designations, etc. Smaller sites that were touching each other or closely separated by features that do not significantly fragment the sites from each other were grouped to generate a larger site. Ultimately, 266 open space parcels were generated.

Table 8. Site screening criteria and scoring

#	Screening Criteria	Score	Description
A	Potential restoration acrerage (based on site polygon size)	6	greater than 25 acres
		4	between 10 & 25 acres
		2	between 3 & 9 acres
		0	less than 3 acres
B	Proximity to existing stream or wetland (based on USGS streams coverage)	6	stream or wetland within site
		4	directly riparian to water touching
		2	between 51 & 100 feet
		0	over 100 feet
C	% of site that is hydric soil or fluvequents (based on NRCS soil mapping)	6	75 - 100%
		4	50 - 74%
		2	25 - 54%
		0	0 - 24%
D	Number of potential cover types & edaphic conditions (based on NRCS soil mapping)	6	5 or more
		4	3 - 4
		2	1 - 2
		0	0
E	Available Impervious Surface Conversion	6	75 - 100%
		4	50 - 74%
		2	25 - 54%
		0	0 - 24%
F	Connectivity (addressing site issues would restore connectivity)	6	within ¼ mile buffer
		4	between ¼ & ½ mile buffer
		3	between ½ & 1 mile buffer
		0	over 1 mile buffer
G	Proximity to an existing natural area (based on state nature preserves data)	6	within ¼ mile buffer
		4	between ¼ & ½ mile buffer
		2	between ½ & 1 mile buffer
		0	over 1 mile buffer
	Maximum Points	42	
	Minimum Points	0	

Since it is not practical to restore every open space parcel within the watershed, a set of criteria was developed by the PDT and NFS that was aimed to identify those sites with most potential for AER in an unbiased fashion.

An ArcGIS spatial analysis was conducted to apply specific criteria and associated scores to each site. An initial iteration was performed to ensure criteria and results had reliability. As shown in Table 8, each criteria was given a score range of 0-6 which was intended to measure the opportunity for restoration, with 0 being none and 6 being optimal. This criterion allowed a path forward and enabled utilization of a quantitative geospatial tool to find the best opportunities from the original 266 sites that were identified from the meetings and land use evaluation (Figure 21 and Figure 22). The scoring threshold for screening was decided by looking at a natural breakpoint in frequencies. This screening took place in two iterations.

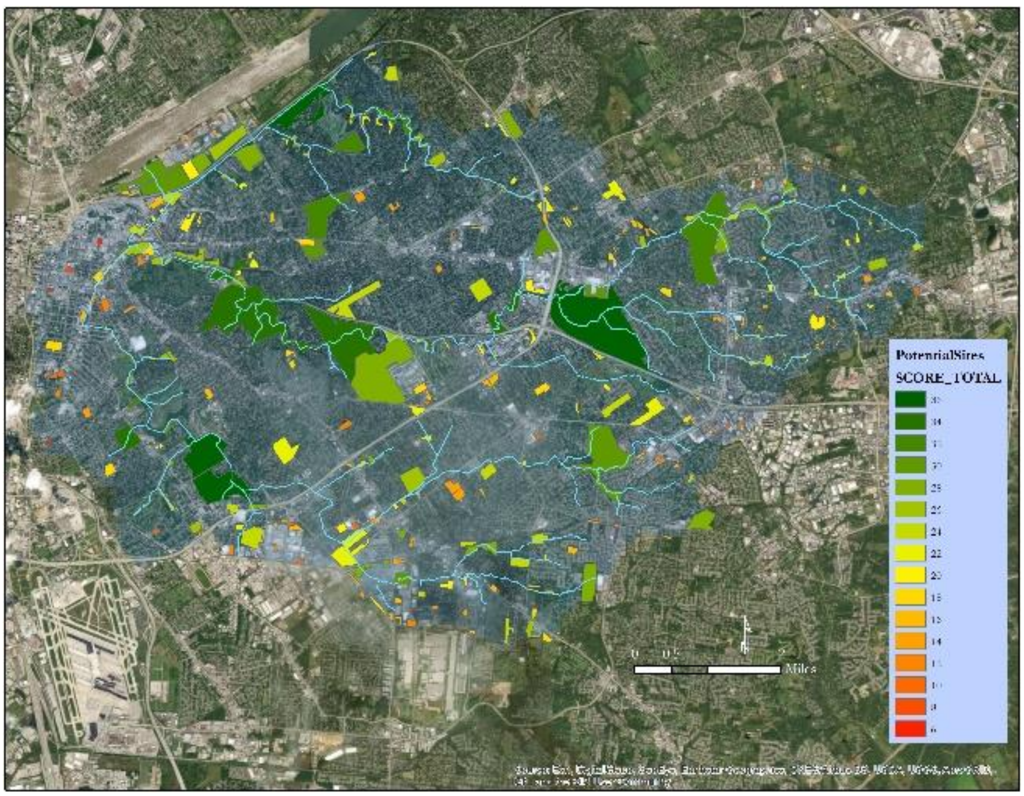

Figure 21. Full array of sites

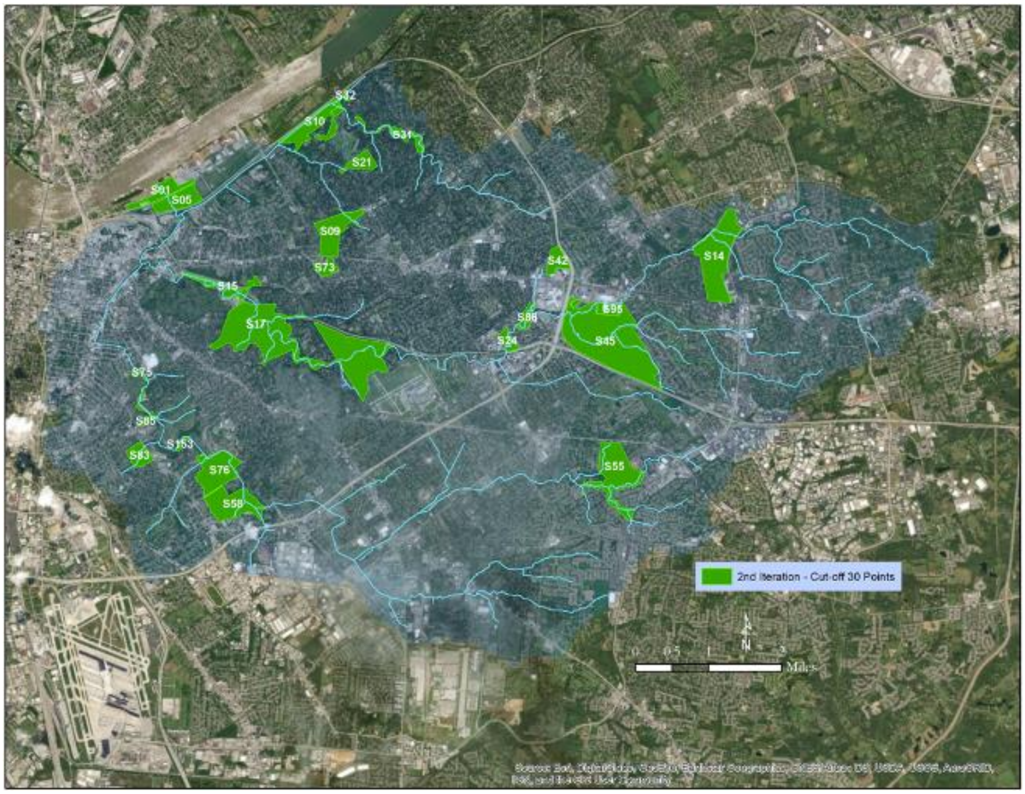

Figure 22. Remaining Sites after Geospatial Analysis

The next iteration of this GIS screening took place after the PDT performed field work and had a knowledge of the sites from an "on the ground" perspective. This allowed some additions of sites that the team felt would offer good opportunities for habitat lift that had not been captured previously. The team also performed adjustments to site boundaries based on technical expertise and feasibility of work. This second iteration screened an additional seven sites.

The last site screening was based on logistical factors such as potential for habitat lift and real estate risk. Each site received a score for each based on the list below:

- PDT Opinion- Based on previous PDT discussions and potential for habitat lift
    - 1-Low potential
    - 2-Med potential
    - 3-High potential
- Real Estate
    - 1-Privately owned and low potential for partnership/acquisition
    - 2-Privately owned and good potential for partnership/acquisition
    - 3-Public/Partner owned

This iteration screened out an additional four sites, leaving the focused array of sites that was utilized for alternative application Figure 23.

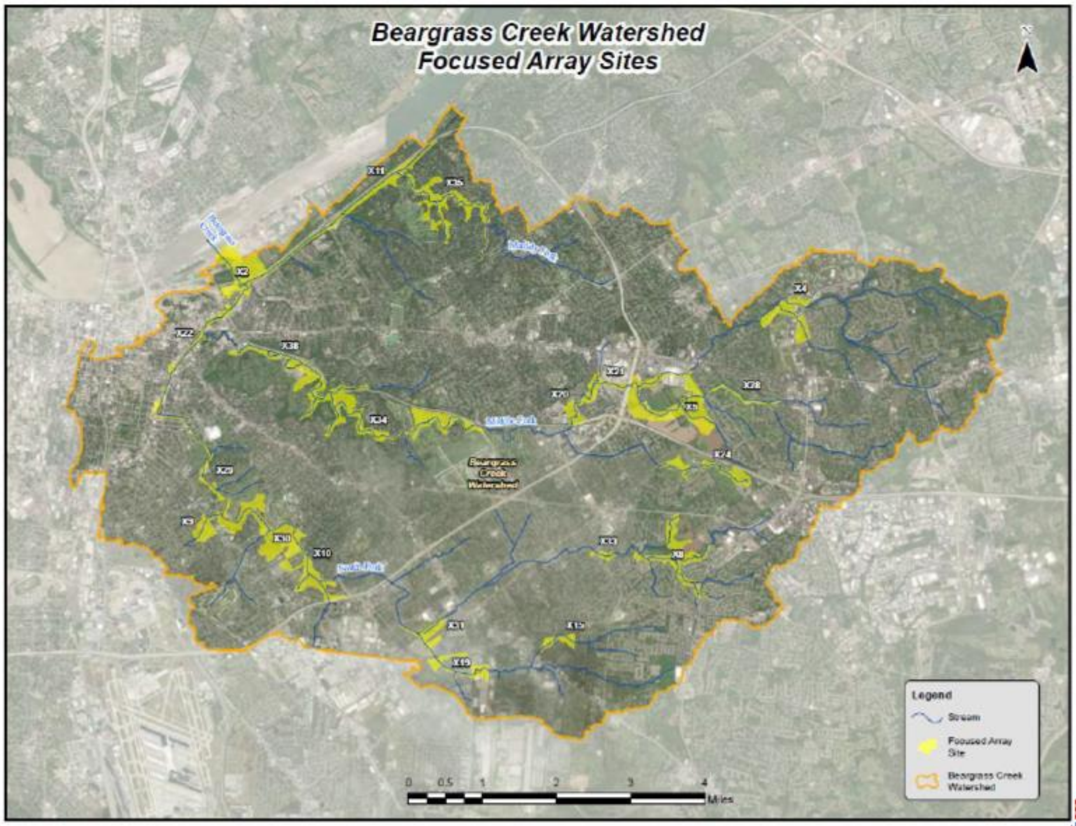

Figure 23. Twenty-one Focused Array Sites used for Alternative Formulation

4.6 Plan Formulation Overview

The complex nature of this study with multiple sites that would eventually be combined to generate the TSP created a challenge for this study as far as plan formulation and terminology. Below is a series of figures that lay out the plan formulation steps, as well as the terminology used for the actions at each stage.

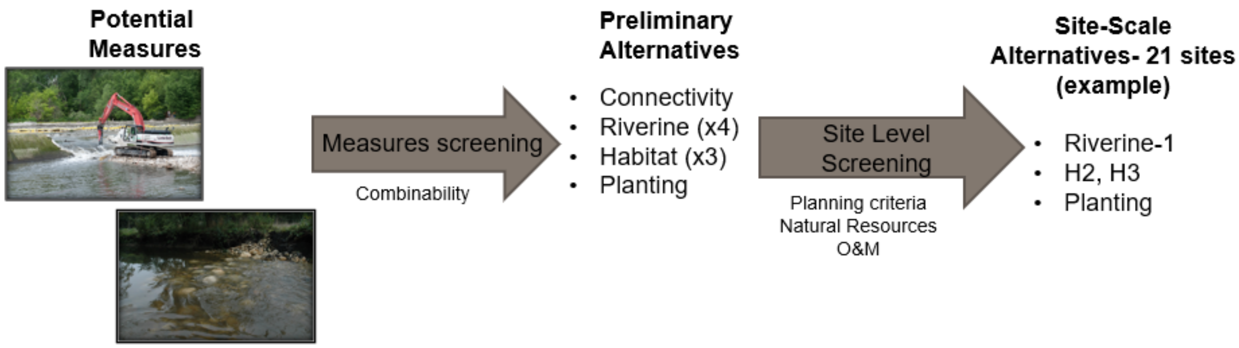

Figure 24, all of the potential measures such as demolition, grading, placement of native rock structures, etc. were screened for combinability to create the preliminary alternatives. These preliminary alternatives are generalized descriptions of various desired ecological improvements the measures could yield. These were then applied at each of the 21 sites based on the site level technical feasibility. Next, these preliminary alternatives were screened at each site with Planning and Guidance (P & G) criteria, Operations and Maintenance (O&M) requirements, and natural resources (potential for habitat lift). This resulted in the site-scale alternatives array.

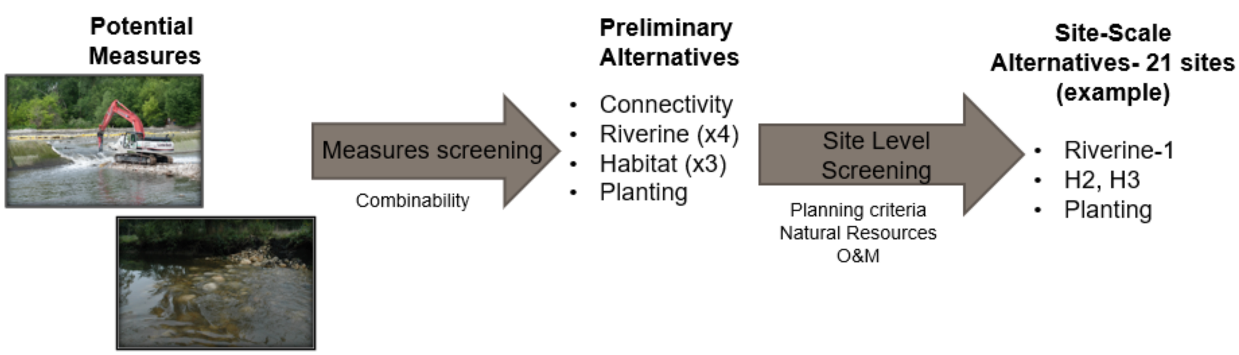

Figure 24. Plan formulation from measures or "building blocks" to the site-scale alternatives creation

The site scale alternatives array consisted of 21 sites and their remaining preliminary alternatives. As shown in Figure 25, the site scale Cost Effectiveness and Incremental Cost Analysis (CEICA) was a comparison of the habitat outputs and associated costs of the alternatives at each site. The site scale recommendations resulted in a remaining 14 plans that would be carried forward to the watershed scale CEICA.

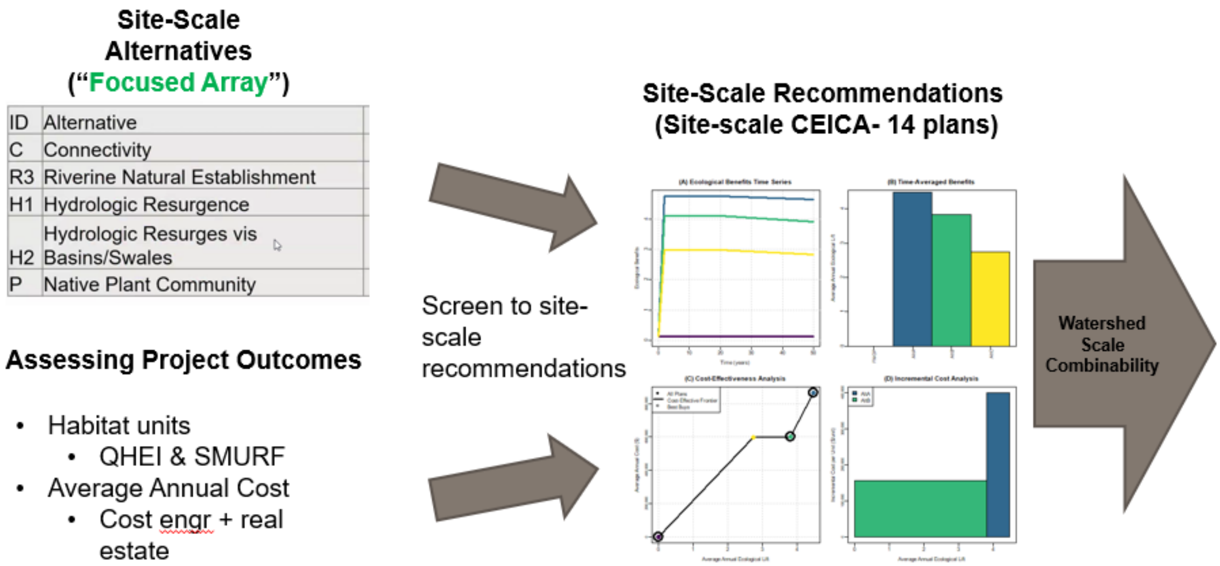

Figure 25. Plan form from focused array to watershed scale comparison

As shown in Figure 26, the last step in the plan formulation process was a watershed scale comparison of all possible combinations of the remaining 14 site-scale alternatives. This resulted in 16,000 possible plans. The team screened to the Tentatively Selected Plan (TSP) utilizing decision criteria based on the four accounts (discussed later in Chapter 5).

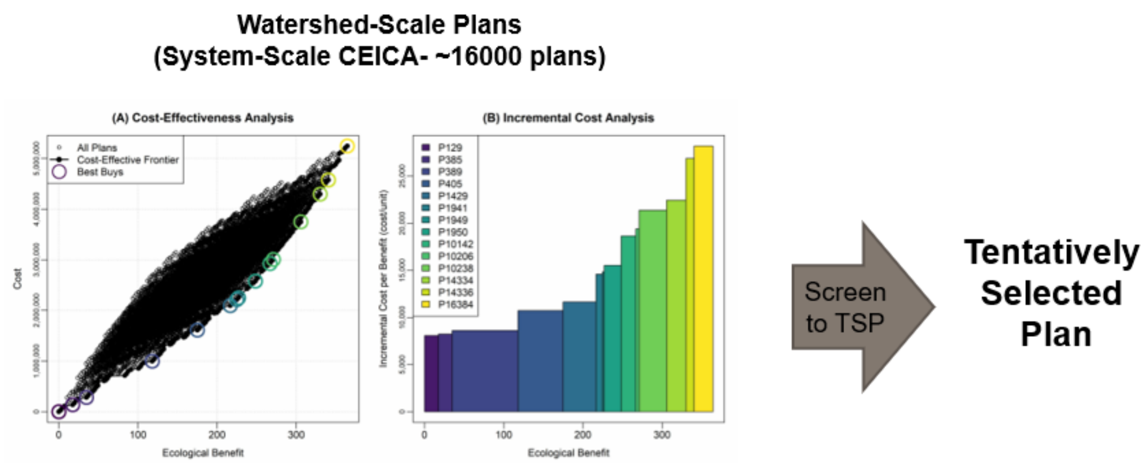

Figure 26. Plan formulation from watershed-scale comparison to Tentatively Selected Plan

4.7 Management Measures as Building Blocks

Management measures are features or activities that can be implemented at a specific geographic location to address all or a portion of the identified study problems. Measures can directly address the hazards, the way the hazards behave (performance), or indirectly address them through eliminating or reducing the consequences. Measures considered for this study are categorized as hydrogeomorphic, native plant community, and adaptive management.

The following measures have been frequently used in past restoration projects within the USACE Lakes and Rivers Division (LRD) area. These measures were developed in a fashion so that parametric costs could be applied for plan formulation purposes. The measures as building blocks would then have additive costs as they are mixed and matched to build the alternatives. Most measures do not inherently have significant benefits associated with them individually, so must be combined with other measures to achieve habitat outputs; therefore, measures were not screened, but developed to be technically effective and parametrically flexible. These are “rubber meets the road” measures which would ultimately comprise the set of plans and specifications for implementation of any engineering regulations (ER). The following provides the potential breadth of specific measures that can be combined, or in some instances stand alone to solve problems and achieve the planning objectives. All measures developed for this study are considered either natural or nature-based features except for water control structures, which are structural measures per Section 1184 WRDA 2016.

4.7.1 Hydrogeomorphic Measures

The following is a list of potential measures that were considered for repairing and creating the hydrogeomorphic setting(s) for native communities.

4.7.1.1 Demolition – This measure entails those activities associated with the removal of structures within the channel, bank and floodplain zones. An example of a past demolition measure implementation is provided in Figure 27. Specific structures that could be removed include but are not limited to dams, weirs, bridge abutments, retaining walls, improved channels, pipes, outfalls, and other defunct infrastructure. Specific materials to be removed under this measure include but are not limited to large foreign debris, concrete, asphalt, metal, angular riprap, gabion baskets and geotextile fabrics. All materials removed would be appropriately reused, recycled, or disposed of.

Figure 27. Demolition of a Low Head Dam

4.7.1.2 Excavation – this measure includes the removal of earthen materials to achieve required geomorphologic and hydrologic conditions for native communities. Large to small earth moving machines would be utilized to excavate earthen materials to specific elevations as required by the targeted native community. An example of a past excavation measure implementation is provided in Figure 28. All materials would be reused on site to create diverse geomorphologies; stockpiled for reuses by others; and/or disposed of appropriately. This measure is typically coupled with grading.

Figure 28. Excavation of Lagoon

4.7.1.3 Grading – this measure includes the movement of earthen materials to achieve required geomorphologic and hydrologic conditions for native communities. Large to small earth moving machines would be utilized to spread, smooth and undulate surface soils to specific elevation as required by the targeted native plant community. An example of a past grading measure implementation is provided in Figure 29.. This measure would typically be combined with excavation to provide final elevation, and/or soil amendments to ensure proper incorporation into surficial soils.

Figure 29. Grading Riverbank to Mimic Natural Shapes and Morphology

4.7.1.4 Native Rock Structures – this measure includes the placement of rock/stone into the stream channel to provide required geomorphologies and substrates for native stream community. This measure would be more applicable to those channel reaches that exhibit higher stream velocities. Large to small construction machinery would place rock slabs, boulders and/or cobbles that are of the same make up and general shapes as natural reaches with similar gradient. An example of a past native rock structure measure implementation is provided in Figure 30. Rock/stone materials would take on various configurations as necessitated by the particular stream parameters present at the restoration site. Different configurations of rock structures would include but not be limited to slab-rock, riffle, boulder cluster, j-hook, cross-vein and cobble bar. All stone structure materials would be appropriately sized based on in-channel parameters. All materials would be sourced for local permitted sources to ensure clean and inert materials. This measure is combinable with a variety of measures as it can add critical habitat and stability components.

Figure 30. Boulder and Cobble Riffle Placement

4.7.1.5 Large Woody Debris Structures – this measure includes the placement of large woody debris (LWD) into the stream channel or into wetlands for habitat and stability components. An example of a past large woody debris structure measure implementation is provided in Figure 31. This measure would be more applicable to those channel reaches that exhibit lower stream velocities and wetlands. Large woody debris consists of trees, their major branches, their rootwad and combinations of such. Typically, larger trees (20+ diameter at breast height) removed for excavation, grading or native plant community restoration are retained and utilized. These structures may consist of one to many trees placed into the stream channel and bank zones in various configurations to provide habitat and temporary stability. Depending on the forces exhibited in the area targeted, LWD may or may not need to be keyed into and/or tethered to the stream floor or earthen bank.

Figure 31. Large Woody Debris Structure and Soil Terracing and Diagram Inset

4.7.1.6 Water Control Structures – this measure includes modification to or creation of water control structures to stabilize hydroperiodicity of palustrine wetlands (Figure 32.). This measure would help to support native plant communities and wildlife habitat. Structures would promote wildlife passage and would not create hydrological surface disconnection. This measure is combinable with a variety of measures and can help to provide critical hydrology for native plant communities.

Figure 32. Water Control Structure to Stabilize Hydroperiod at Indian Ridge Marsh, AER

4.7.2 Native Plant Community Measures

Figure 33. Removal of Cottonwoods and Ash from Globally Imperiled Ridge and Swale

4.7.2.1 Invasive Species Removal – this measure includes the complete removal of non-native weeds and the selective removal of native weeds in areas that are not treated with other measures that would also provide clearing, such as excavation, grading and some demolition activities. An example of a past native plant community measure implementation is provided in Figure 33. Methods for removing invasive plant species include but are not limited to clearing and grubbing, mowing, burning, flooding, broad-cast herbicide application, spot-treatment herbicide application, etc. This measure is a one-time initial application or an initial series of applications to provide conditions for native plantings; this measure is not the same as those small spot treatment applications under the Native Plant Establishment measure.

4.7.2.2 Soil Amendments – this measure includes the addition of inorganic and/or organic materials to site soils to provide the required conditions for native plant communities. Inorganic materials would primarily include sand or small gravel and potentially other components such as crushed mussel shells or limestone fines (lime). An example of a past soil amendment measure implementation is provided in Figure 34. Organic materials would primarily include leaf litter compost, leaf litter, wood chips, saw dust, etc. These materials would be spread over the top of the site as the final elevation grade or incorporated into the specified depths of soil by disking or during implementation of grading measures.

Figure 34. Spreading Organic Compost

4.7.2.3 Native Plantings – this measure includes the procurement and planting of native plant species. Native planting lists would be specifically developed per plant community type specifying the rates of native seed, live root stock, live plugs and live tree/shrub containers. An example of a past native plantings measure implementation is provided in Figure 35. Current potential for plant community general types include aquatic bed, swamp, meadow, woodland and forest.

4.7.2.4 Native Plant Establishment – this measure includes those elements required to establish and maintain newly created or restored plant communities. Specific elements include but are not limited to invasive species management, depredation control, protective fencing, limited short-term watering, general plant survival, growth and coverage, etc.

Figure 35. Planting Native Wetland Plugs

4.7.3 Adaptive Management Measures

Figure 36. Common Carp and Canada Geese Protection for Newly Planted Wetlands Plugs

A 5-year contract would be utilized to ensure recruitment and establishment of native communities (abiotic and biotic) is successful. All hydrogeomorphic work would be accomplished within the first several months of the contract to allow establishment and monitoring time. Options would be placed in the contract for future adaptive management measures that could be exercised at any point of the contract duration, but most frequently in years 3, 4 and 5. These may include but are not limited to changing or adjusting features to achieve the required hydrology, hydraulics and/or geomorphology; additional native plant treatments; or other improvements. All adaptive management decisions and exercising of contract options would be driven by monitoring. Figure 36 provides an example of an adaptive management measure. To be conservative, three adaptive management options would be included under this measure for high, medium and low adaptive adjustment needs. These would be Option A – for more intensive adjustments of geomorphology or hydrology costing approximately $75,000; Option B – for more moderate adjustments of habitat and/or additional plantings costing approximately $25,000; Option C – for minor habitat adjustments or additional plantings costing approximately $10,000.

4.8 Measure screening

Measures were screened based on the completeness and technical feasibility to obtain the desired outcome of each of the preliminary alternatives. While no measures were eliminated, some were screened under each of the given alternatives if they were unnecessary to achieve that alternative. The resulting table (Table 9) was the total suite of alternatives and comprising building block measures.

The screening of measures was an iterative process that was site dependent, due to the complexity and size of the watershed. Utilizing the total suite of measures, each of the possible alternatives was evaluated at each site. The measures that applied to that alternative at that specific site were compiled to create that site-specific alternative. These alternatives are described in more detail in Section 4.10.1.

Table 9. Total suite of measures and preliminary alternatives

	Alternative								
Measure	**C**	**R1**	**R2**	**R3**	**R4**	**H1**	**H2**	**H3**	**P**
Demolition	X	X	X	X	X		X		
Excavation	X				X	X	X	X	
Grading	X		X	X	X	X	X	X	
Water Control Structures								X	
Native Rock Structures	X	X	X	X	X				
Large Woody Debris		X	X	X	X				
Invasive Species Removal									X
Soil Amendments									X
Native Plantings									X
Native Community Establishment									X
Adaptive Management	X	X	X	X	X	X	X	X	X
BMPs	X	X	X	X	X	X	X	X	

4.9 Recreation Management Measures

Recreation features were discussed throughout plan formulation and were chosen based on location and surrounding land use, public input, and technical feasibility. Some possible features discussed are listed below, although specific features were discussed on a site by site basis.

1. Trails, 3' Wood Chip Mulch
2. Trails, Asphalt, 8' wide - 6" stone base, 2" binder course, 1" topping
3. Boat Launch Ramp, 150 SF
4. Picnic tables
5. Pavilion
6. Interpretive Signage
7. Outdoor classroom
8. Fishing access
9. Birding Platform- for larger wetlands or meadows

4.10 Development of Alternatives

4.10.1 Preliminary Array of Alternatives

As stated in Section 4.6, the preliminary alternatives were formed by combining applicable measures to reach each of the desired "actions" as defined below.

The Connectivity alternative is combinable with any of the other alternatives, and the Riverine alternatives are dependent on this alternative, if necessary. Dependency is based on the logic that if aquatic organisms cannot gain access to a restored habitat, then the plan is incomplete and inefficient.

4.10.2.1 *C – Connectivity of Riverine Habitats* – This alternative would entail eliminating fragmentation points within the river channel of all Three Forks of the Beargrass Creek system, including those specific to connection with the Ohio River. All fragmentation points and types were identified by GIS analysis and by field assessments during the summer 2020 field season by PDT members (Figure 37). Measures included in this alternative would address structures or features that fragment habitat and impeded dispersal of aquatic species. These fragmenting structures or features generally include perched culverts, bridge abutments, structure footings, weirs, cross channel pipes, foreign debris jams, online detention basins, piped reaches, chronically dry reaches of stream, other. Specific measures considered include removal of structures/features (demolition) or bypassing structure/feature (i.e. geomorphic/grading).

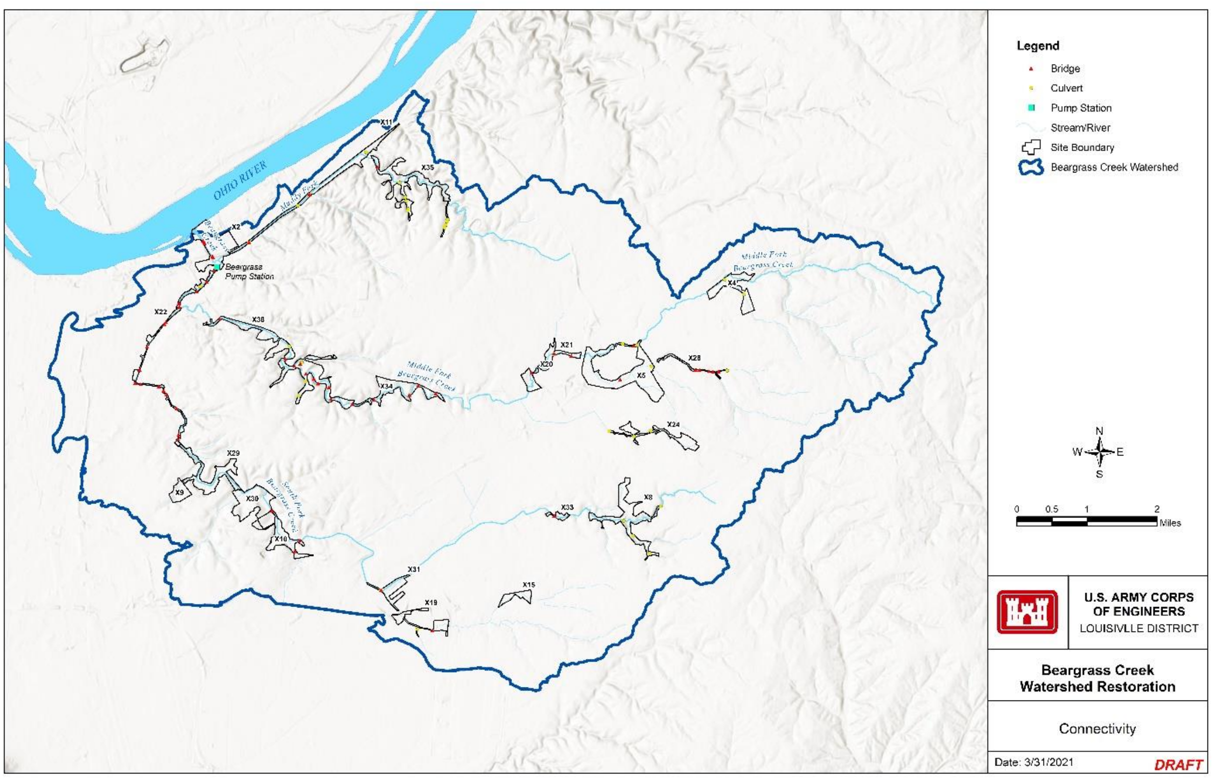

Figure 37. Connectivity Barriers in the Beargrass Creek Watershed

4.10.2.2 R- Riverine Habitat Restoration Alternatives

These alternatives are applied to select reaches of stream channel throughout the entire watershed, including those riparian sites identified for alternative analyses. Figure 38 illustrates an example on the Middle Fork Beargrass Creek near Mall St. Mathews where a connectivity issue exists. Figure 39. shows the riverine reaches identified during the 2020 summer sampling season that would be assessed for restoration treatments. These points were utilized because they are existing MSD access sites. While not all of these points were located within the prioritized sites, these assessments allowed the team to get an overall characterization of the stream throughout the watershed. The field assessments of some of these points outside of prioritized sites resulted in the addition of sites that were overlooked in the scoping phase.

Figure 38. Connectivity Barrier under Mall St. Matthews on the Middle Fork

Riverine alternatives (R1 – R4) are not combinable with each other for the same reach, can be combinable with different reaches within the same site, and are combinable with Connectivity and Riparian alternatives. This alternative is dependent on the Connectivity alternative, if necessary. Some alternative components may require dependency on native plants (P) for proper function, such as under R4 (see below for details).

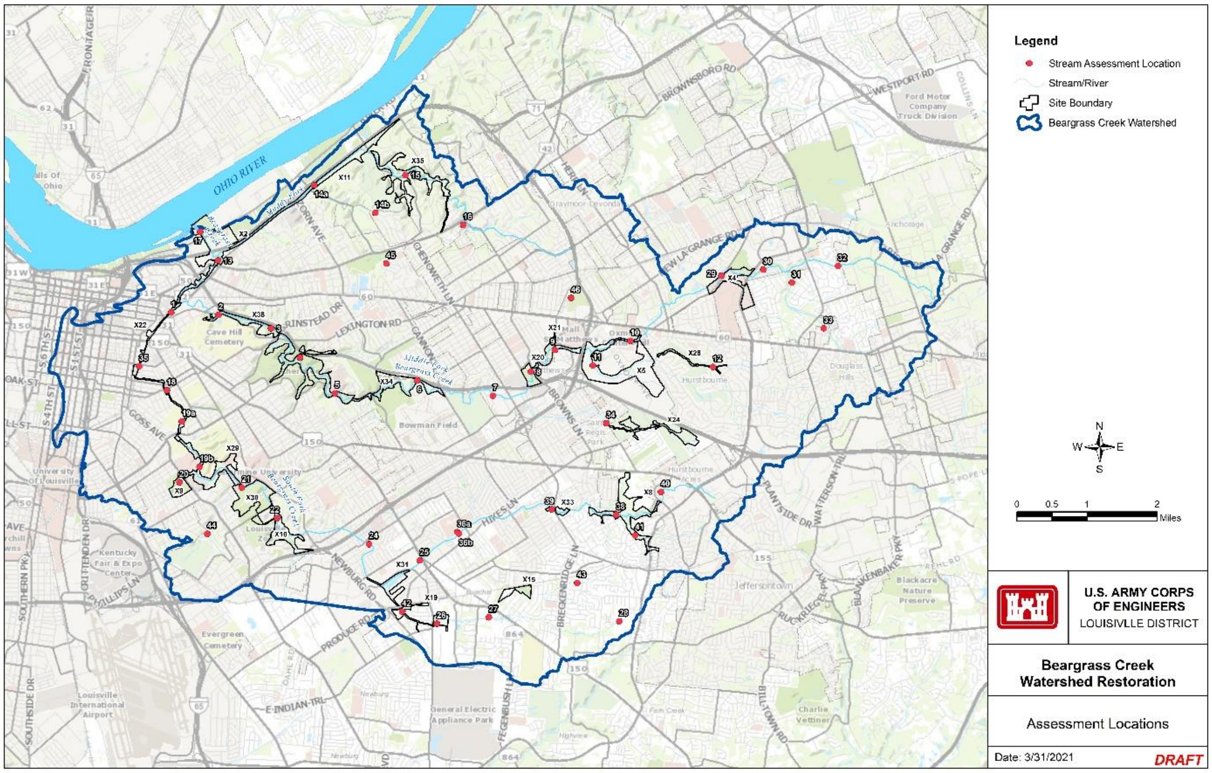

Figure 39. Locations where the Project Delivery Team took Field Assessments in the Summer of 2020

<u>R1 In Stream Habitat Only</u> – This alternative would maintain the current channel alignment and hydraulic and geomorphic conditions while placing low-profile riffle, slab rock, boulder, cobble and large woody debris structural habitats. These would be placed directly on the stream/ditch bed and banks with different configurations for areas of aggradation (i.e. sediment accumulation) and erosion; ensuring there is no induced movement to the stream channel alignment.

<u>R2 In Stream Habitat & Floodplain Connectivity</u> – This alternative would maintain the current channel alignment while grading banks to reconnect the river to the floodplain and installing medium-profile riffle, boulder, cobble and large woody debris structural habitat on bed and on bank. The furthest extent of the floodplain grading would be the location for the excess material's beneficial reuse. This includes creating micro-drainage divides and gaps for surface water connectivity, rerouting and natural drainage patterns. It is not practical or necessary to fund extensive erosion control blankets for this activity in large areas; spot treatments of coir logs and fabric would be utilized in target zones on the new banks until native cover crop or plant community vegetation establishes.

<u>R3 Natural Riverine Establishment</u> – This alternative would entail inducing certain stream reaches to erode their own banks to jump start meandering and migration or allow the stream to continue as it is already recovering. The stream's alignment would initially be the same as the existing alignment but would be subject to natural channel migration over longer periods of time. For more active interventions, this process would specifically be induced by placing sacrificial large woody debris and/or rock structures in the stream channel; the structures would eventually become bank or stream habitat.

These structures would intentionally direct flow into the bank to cause a moderate to high rate of erosion and deposition. This natural process is termed cut and fill alluviation. This process naturally creates and sustains riverine habitats including but not limited to oxbows, backwaters, islands, riffles, pools, undercut banks, substrates, sandy point bars and large woody debris inputs. This alternative also considers the use of rock structures to ensure the stream safely enters and exits from the reach/site. To make this alternative more feasible from an acceptability aspect, elements of floodplain grading are included to greatly reduce the amount of material eroded and moved within the wetted stream channel.

Figure 40. Setback Levees to allow Restoration via Natural Processes

R4 Sculpted Riverine Establishment – This alternative would entail returning riverine habitat structure without natural processes by sculpting the landscape. The stream's alignment would be changed to mimic that of a meandering channel. This would be accomplished via excavation, grading, placing native rock structures and large woody debris. Stream channel and banks would be sculpted to mimic a natural geomorphology, where channel development - glide, riffle, run and pool - features would be strategically placed and graded to maintain the new stream form (Figure 40). Bank ratios of a typically healthy stream would be used where achievable: outside bend (20:1); inside bend (5:1); straight run (10:1). Low flow channels would be made more sinuous. Stream dynamic equilibrium would be controlled with large woody debris, rock structures and native plant communities. This alternative also includes the use of rock structures to ensure the stream safely enters and exits from the site. Figure 41. illustrates an example of the implementation of an R4 Sculpted Riverine Establishment alternative.

Figure 41. Example of Stream Sculpting on Little Calumet River at Red Mill Pond AER

Figure 42. Example of Excavation for Hydrologic Resurgence

4.10.2.3 H- Riparian Hydrology Alternatives

These alternatives are applied to the riparian zone sites selected for alternative analyses. Figure 23 in section 4.5 above shows the selected sites that have moved forward to the alternatives screening phase. These sites also represent the selected stream reaches chosen for alternative development. Riparian hydrology alternatives H1, H2 and H3 are combinable with each other, and can be combined with Connectivity, Riverine or Native Plant Community alternatives. Figure 42 provides an example of a riparian hydrology alternative implementation of a basin/swale structure.

<u>H1 Hydrologic Resurgence</u> – This alternative would resurge natural surface and subsurface hydrology and hydroperiodicity via strategically installing backwater valves, removing drain tiles and/or filling and plugging of unnatural ditches. This would permanently disable the existing drain tile system. Backwater

valves may be necessary to avoid potential off-site flooding effects; and have benefits to assist in plant community distributions, planting schemes, and drainage pattern development. Drain tiles would be permanently disabled at some point during the 5-year construction period by grouting the valves shut or being completely removed. This alternative also includes the filling or plugging of minor internal ditches.

H2 Hydrologic Resurgence Via Basins/Swales – This alternative would resurge natural surface and subsurface hydrology and hydroperiodicity by excavating and/or grading swaths of landscape down to the normal water table, primarily to alleviate past filling impacts. This alternative also includes a low amount of flexible acres for low-intensity grading to adjust topography to further refine hydrologic expression once other alternatives or components are implemented.

H3 Hydrologic Resurgence via Water Control Structure – This alternative would both induce surface hydrology and stabilize or moderate extreme hydrologic fluctuations. A stop log style water control structure would be utilized for off-stream channel and palustrine wetlands. Control structures for in-line stream channel placement would consist of a fixed elevation riffle, or a fixed elevation hybrid riffle with embedded stop-log structure to allow both fish passage and the ability to draw down wetlands for hydroperiod support. This measure would maintain more consistent water levels and promote different marsh or swamp types and other fringing wetland types (e.g. sedge meadow, wet prairie). Water levels could also be raised or lowered for vegetation management purposed including drawdowns to allow for easier access or flooding for control of unwanted invasive and opportunistic plant species.

Considerations: The use of control structures can be successful if properly maintained and operated for the project life cycle (period of analysis). Operations and Maintenance (O&M) tasks to ensure the structures are operating to maximize wetland hydrology would include inspection after every flood event, monthly routine inspections during the growing season, and an operation plan that is adhered to. Therefore, future risk of failure, and operations and maintenance costs would be higher for this alternative. The moment the control structure no longer functions as the hydrologic life support, or is removed, the plant community will change.

4.10.2.4 P – Native Plant Community Restoration – This alternative includes invasive species elimination, planting of native plant materials and associated establishment activities required to restore a healthy native plant community. All invasive and opportunistic plant species would be initially removed with any combination of clearing, grubbing, herbicide application, flooding, mowing and or prescribed burning. Targeted species for removal include, but are not limited to Japanese honeysuckle, porcelain berry, English ivy, winter creeper, oriental bittersweet, bush honeysuckle, privet, multiflora rose, tree of heaven, ground ivy, chickweed, and Japanese stilt grass. This alternative would also seed and plant native species of local genotype. Feasibility level planting lists per community type were developed for cost purposes and would be refined during the design phase. Warranties and substitutions for plant materials and survival would be included. Establishment activities would include spot herbicide treatments, mowing, prescribed burns, herbivory control and temporary watering for some plug, tree and shrub species.

Table 10 below is a reference for alternative abbreviations used throughout the study.

Table 10. Alternative abbreviation key

Abbreviation	Alternative
C	Connectivity
R1	In Stream Habitat Only
R2	In Stream Habitat & Floodplain Connectivity-
R3	Natural Riverine Establishment
R4	Sculpted Riverine Establishment
H1	Hydrologic Resurgence
H2	Hydrologic Resurgence Via Basins/Swales
H3	Hydrologic Resurgence via Water Control Structures
P	Native Plat Community Restoration

4.10.3 Site Level Alternative Formation and Screening

Action alternatives were screened utilizing relevant USACE planning guidance and compared against the No Action alternative. Screening criteria utilized were Completeness (C), Effectiveness (E), Efficiency (EFF), Acceptability (A) (the four criteria established in the P&G (1986)), Natural Resources Effects (NR), and Sustainability O&M requirements (O&M). Descriptions of the P &G criteria are listed in section 5.8.5.

Each screening criterion was assigned a qualitative score from 0–4 to differentiate between alternative plans, with a higher score being more favorable. Overall scores for each alternative were compared and cutoffs for screening were determined by natural breaks in scoring frequencies. This screening analysis was used to guide decisions on which of the developed alternatives would be retained for further detailed cost effective analyses. The detailed screening matrix that provides both rational and screening scores is presented in Appendix H.

4.11 Designs

Once the alternatives per site were screened, the remaining alternatives were conceptually applied to each site utilizing firsthand knowledge, topography, land use, existing conditions, and historical plant communities. Figure 43 shows the conceptual alternative map for site X2. Team members developed a conceptual map for all 21 sites (Appendix H).

Design assumptions were made to develop a conceptual design based on the proposed measures shown on the conceptual alternative maps for each site. The conceptual designs were developed to estimate quantities. Detailed design analyses, such as geotechnical and scour investigations were not performed. These detailed engineering designs, as well as additional modeling, data collection and analysis will be completed after the feasibility study. The quantities and associated costs represent a baseline that will be refined in future phases. Additional design information and drawings can be found in the appendices. The project delivery team made assumptions to develop the conceptual design and quantities, including:

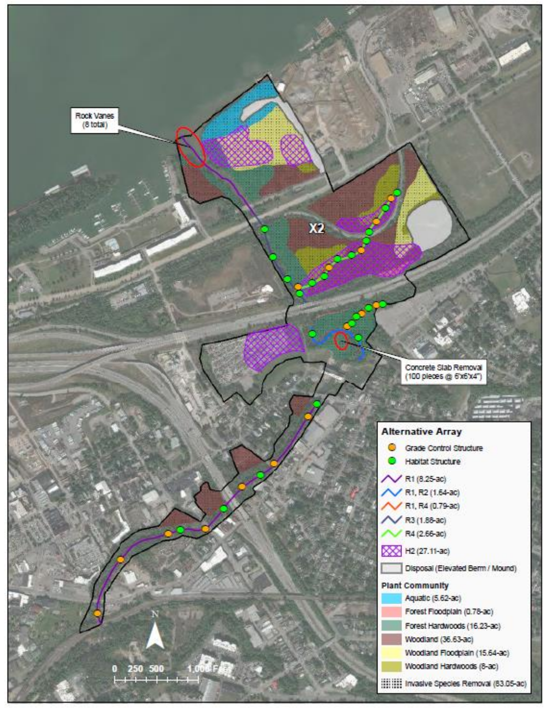

Figure 43. Example of Conceptual Alternatives Array at Site X2, the Confluence

- Cross sections for the proposed R work units were developed based on existing available digital elevation model information.
- R work unit cross sections were connected to form a proposed surface to develop earthwork quantities.
- H2 work units would have a net balance of earthwork. The H2 areas would be graded to better detain water.
- Existing vegetation in H2 and R work units would be cleared and grubbed to allow for grading operations.
- H2 work units will receive plantings after grading work is complete.
- Proposed H2 work units at existing MSD basins would not reduce available storage capacity. Existing MSD basins were designed for flood control, which will not be changed.
- Erosion control would be included throughout the project.
- Invasive species removal and would be included in conjunction with proposed planting work units.
- Impacts to existing levees would be avoided.
- New access roads and construction laydown areas will have gravel surfacing where heavy truck haul traffic is expected.

4.12 Costs

Cost estimates were developed based on the conceptual designs developed for the measures, as described previously. Appendix C describes the assumptions, unit costs, and price levels developed for the measures and alternatives.

Project first cost currently represents a rough-order-of-magnitude estimate inclusive of real estate, restoration actions, pre-construction engineering and design, construction management, monitoring, and adaptive management. Monitoring and adaptive management are currently assumed to comprise 5% of total project first cost and spread over a ten-year window. Interest during construction was computed based on project first costs minus the 5% for monitoring and adaptive management with an assumed construction duration of 12-months for all actions. The FY21 Federal discount rate (2.50%) was used to annualize project first cost (presented in FY22 price levels), interest during construction, and monitoring and adaptive management expenses over a 50-year planning horizon (base year 2025). Table 11 provides an example of cost estimates for Site-X10.

Table 11: Example cost summary for the Alpaca Farm / Zoo site (X10).

Site	Alternative	Project First Cost ($)	Average Annual Cost ($)
X10	FWOP	0	**0**
X10	C	1,022,000	**36,000**
X10	R1	291,000	**10,000**
X10	R2	3,472,000	**123,000**
X10	R4	7,470,000	**265,000**
X10	H2	768,000	**27,000**
X10	H3	688,000	**24,000**
X10	**P**	**9,187,000**	**325,000**

Utility relocations were estimated with assistance from the Hydrology and Hydraulics (H&H) PDT member by performing a visual survey to determine the likelihood and impact of utilities being encountered, ranking them as low, medium, or high. A percentage was then determined, based on the overall construction cost (including contingency), level of identified risk through the visual survey, and what information was known about the utilities (pipe size, depth, etc.). These costs will be better refined as the possible alternatives and sites are further screened.

The other cost to be included were Planning, Engineering, & Design and Construction Management. These costs were applied as percentages based upon past/similar projects and are 18% and 8% respectively.

5.0 Alternatives Evaluation and Comparison

5.1 Ecological Benefits

Ecological services are the "socially valued aspects or outputs of ecosystems that depend on self-regulating or managed ecosystem structures and processes" (Institute for Water Resources, 2013). For ecosystem restoration studies, these outputs must be clearly defined and quantified in order to evaluate them in a cost-benefit analysis. The ecological benefits or outputs in this study were measured in habitat units (HUs). The following sections outline the justification and process for calculating these habitat units.

5.1.1 Ecological Models

The riverine and riparian study objectives are assessed separately using two different ecological models, the Qualitative Habitat Evaluation Index for Louisville Streams (QHEILS, pronounced "quails", McKay et al. 2021a) and the Simple Model for Urban Riparian Function (SMURF, McKay et al. 2021b). These models are applied to separate study areas (i.e., nonoverlapping channel and riparian polygons), and thus are treated separately throughout the analysis. This section briefly describes each tool to provide readers with context on how ecological benefits are assessed. Further details can be found in the model documentation referenced.

QHEILS is simple tool for assessing stream outcomes relative to macrohabitat, geomorphology, and longitudinal connectivity. The macrohabitat module is adopted from the Qualitative Habitat Evaluation Index (QHEI), which is a rapid stream assessment protocol originally developed for applications in Ohio (Rankin 2006). The model has been approved for use on multiple USACE ecosystem restoration studies, and evaluates stream ecosystem integrity relative to six primary dimensions: substrate (20 points), instream cover (20 points), channel morphology (20 points), bank erosion and riparian zone (10 points), relative distribution of habitat types (20 points), and channel gradient (10 points). Each factor is assessed independently through a series of field observations, visual assessments, desktop analyses, and scoring procedures. The second module of QHEILS assesses geomorphic condition of urban streams relative to channel incision and the degree of floodplain connectivity. The third module of QHEILS quantifies connectivity of the system relative to aquatic organism passage (20 points) and material transport (20 points). Overall ecosystem quality is assessed as the average of the 0 to 1 indices derived from each module. This habitat quality metric is combined with an assessment of channel area (in acres) to compute "habitat units."

Instream assessments such as QHEILS and QHEI often include riparian variables (such as the riparian zone metric above); however, these assessments are inherently focused on in-channel processes and outcomes. As such, we apply a separate rapid assessment technique to assess the integrity of riparian ecosystems. The SMURF (McKay et al. 2021) was designed for application in the Beargrass Creek study (USACE model certified March 2021).2021 The SMURF addresses three major categories of outputs: (1) indirect effects of riparian zones on instream processes, (2) riparian areas as important providers of native faunal habitat, and (3) riparian zones as ecological corridors and sources of resilience in highly disturbed areas. The model uses data collected through a combination of rapid field assessment protocols and desktop geospatial assessments, which are applied independently to left and right bank riparian zones. Similarly, to the QHEILS, the SMURF outputs are calculated by normalizing the assessment score for both left and right banks and multiplied by the bank polygon to find the habitat units. To get total habitat units for each site, the left and right bank habitat units were combined.

5.1.2 Existing Condition

QHEILS and SMURF were applied to each restoration site to assess the existing conditions at that location. A large-scale field campaign was executed in summer 2020 to assess locations in the Beargrass Creek watershed. Some of these assessment points were screened out of additional analyses, and some assessment points were combined into larger areas based on logical mobilization actions for restoration. When multiple sites were combined, the inputs to the QHEILS and SMURF were averaged across the number of locations. Table 12 summarizes the existing conditions associated with each restoration site in terms of "habitat units" for the channel, left bank riparian zone, and right bank riparian zone.

Table 12: Habitat units associated with the existing condition at each restoration site.

Site Number	QHEILS Channel (HU)	SMURF Left Bank (HU)	SMURF Right Bank (HU)	Total (HU)
X2	9.1	6.8	18.4	**34.4**
X4	0.9	10.2	17.5	**28.7**
X5	3.9	20.4	8.4	**32.7**
X8	2.6	30.5	33.0	**66.1**
X9	0.2	5.5	1.5	**7.1**
X10	1.2	1.7	8.7	**11.6**
X11	1.5	17.5	16.6	**35.6**
X15	0.6	0.6	0.5	**1.7**
X19	0.9	3.8	1.2	**5.9**
X20	0.8	1.7	0.7	**3.3**
X21	2.9	2.3	5.8	**11.0**
X22	1.6	1.5	1.0	**4.2**
X24	2.5	0.8	7.1	**10.4**
X28	1.2	0.7	0.1	**2.0**
X29	4.3	23.3	16.3	**43.9**
X30	1.4	35.3	1.0	**37.8**
X31	1.8	0.9	0.4	**3.1**
X33	0.4	2.6	0.5	**3.5**
X34	5.0	25.6	32.4	**62.9**
X35	1.9	17.6	23.1	**42.6**
X38	**2.2**	**1.1**	**4.1**	**7.4**

5.1.3 Alternative Forecasting

Restoration alternatives typically have differential effects on ecosystems through time. For instance, an alternative installing rock features within a stream may begin providing benefits relatively quickly compared to riparian forest restoration. For Beargrass Creek, five assessment points through time were deemed appropriate for adequately capturing the trajectories of these systems in response to restoration.

- Year-0: Captures that state of the ecosystem prior to any action. Assumed to be equivalent to the existing condition assessment.
- Year-2: Addresses the initial response of the stream following construction and the initial accrual of benefits. Only the QHEILS is assessed at this time period, given longer time scales for riparian response.
- Year-10: Assumes the initial riparian canopy response has occurred with growth to the mid-story size. This time period also corresponds with the end of the USACE adaptive management horizon.
- Year-20: Captures the growth of the riparian zone to a young forest with maturing of forest structure and arrival of overstory. Only the SMURF is applied at this time period, given the assumed consistency in performance of in-channel features from years 10-50.
- Year-50: Assesses the state of the system at the end of the design life. This time period assumes riparian forests have matured with fully functioning dynamics (e.g., gap processes are included).

The future without project condition (FWOP) is a dynamic state, particularly in a world of rapid change associated with land use, invasive species, climate, and other factors. MSD's Stormwater Quality Management Plan (SWQMP) lays out stormwater management activities to comply with the Stormwater Quality Program permit and is designed to improve stormwater quality through eight programs areas including public education, monitoring and discharge detection and elimination. While this program could potentially have a positive impact on water quality in the FWOP condition, it was decided by MSD and USACE that these impacts alone would not directly impact ecosystem habitat quality.
Three main factors were considered in forecasting how the FWOP could deviate from the existing condition. Notably, all three factors have considerable uncertainty, and rather than introducing additional uncertainty, the FWOP mirrored the existing condition, unless there were compelling reasons to deviate.

Land use change: Urban systems often undergo rapid land use development. This factor includes site-specific changes based on known development plans (e.g., Oxmoor Farms) and mirrors assumptions made by the engineering teams regarding long-term developmental trajectories in the basin.

Project completion: A variety of actors are currently undertaking water management actions that could influence restoration sites. However, projects are at varying stages of planning and significant uncertainty exists in implementation. Ongoing projects from the cost-share sponsor (MSD) were included, but none of these actions include proposed restoration sites.
Climate change: Over the life of the project, temperature in the region is expected to increase, and precipitation is anticipated to increase in the winter/spring and decrease in the summer/fall. These changes were used to adjust variables in the riparian assessment based on a few qualitative factors.

Detrital processes were assumed to accelerate under increased temperature. Organic matter retention, embeddedness, and bank erosion are all anticipated to be negatively impacted by increasingly flashy stream hydrology as a result of precipitation changes. Effects of climate on all other variables were deemed too uncertain to justify altered forecasts.

Existing condition values served as the basis for all assessments of temporal trajectories and alternatives. The existing condition was modified through a set of agreed upon guidelines to be applied uniformly across sites (Appendix B, Tables B6 & B7). The scoring "rubric" differed for each model input (e.g., deadfall vs. buffer flowpaths), each type of action (e.g., R1 vs. P), and each point in time (e.g., Year-10 vs. Year-50). For each action, both riparian and riverine variables may be altered, but no variables are altered by both actions to avoid "double counting" of benefits.

The rubric specifies a percent improvement in the remaining ecological degradation at a site. The metric value for a given alternative and time is then computed based on the following equation and examples. Table 13 shows the overall effects of this forecasting rubric on riverine and riparian outputs for proposed restoration actions at Site-X10.

$$X_{alt} = X_{existing} + \Delta_{rubric}(X_{max} - X_{existing})$$

Where X_{alt} is the value of metric X for a given alternative and time, $X_{existing}$ is the existing condition value for the metric X, Δ_{rubric} is the percent improvement in the remaining ecological condition at a site, and X_{max} is the maximum value for the metric X.

Example 1: $X_{existing} = 13$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$
$X_{alt} = 13 + 0.5(20 - 13) = 16.5$
Example 2: $X_{existing} = 2$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$
$X_{alt} = 2 + 0.5(20 - 2) = 11$
Example 3: $X_{existing} = 18$, $\Delta_{rubric} = 0.5$, and $X_{max} = 20$
$X_{alt} = 18 + 0.5(20 - 18) = 19$
Example 4: $X_{existing} = 13$, $\Delta_{rubric} = 0.8$, and $X_{max} = 20$
$X_{alt} = 13 + 0.8(20 - 13) = 18.6$

Table 13: Example of habitat units for the Alpaca Farm / Zoo site (X10).

Site	Alternative	Year	QHEILS	SMURF Left	SMURF Right
X10	FWOP	0	1.2	1.7	**8.7**
X10	FWOP	2	1.2	NA	**NA**
X10	FWOP	10	1.2	1.7	**8.7**
X10	FWOP	20	NA	1.7	**8.6**
X10	FWOP	50	1.2	1.7	**8.5**
X10	C	0	1.2	1.7	**8.7**
X10	C	2	1.6	NA	**NA**
X10	C	10	1.6	1.7	**8.7**
X10	C	20	NA	1.7	**8.6**
X10	C	50	1.6	1.7	**8.5**
X10	R1	0	1.2	1.7	**8.7**
X10	R1	2	1.2	NA	**NA**
X10	R1	10	1.2	1.7	**8.9**
X10	R1	20	NA	1.8	**9.1**
X10	R1	50	1.2	1.8	**9.2**
X10	R2	0	1.2	1.7	**8.7**
X10	R2	2	2.2	NA	**NA**
X10	R2	10	2.3	2.0	**9.9**
Site	Alternative	Year	QHEILS	SMURF Left	**SMURF Right**

Site	Alternative	Year	QHEILS	SMURF Left	SMURF Right
X10	R2	20	NA	2.0	**10.0**
X10	R2	50	2.3	2.0	**10.0**
X10	R4	0	1.2	1.7	**8.7**
X10	R4	2	2.5	NA	**NA**
X10	R4	10	2.5	2.1	**10.2**
X10	R4	20	NA	2.1	**10.2**
X10	R4	50	2.5	2.0	**10.1**
X10	H2	0	1.2	1.8	**8.7**
X10	H2	2	1.2	NA	**NA**
X10	H2	10	1.2	2.4	**9.6**
X10	H2	20	NA	2.5	**9.7**
X10	H2	50	1.2	2.6	**10.0**
X10	H3	0	1.2	1.7	**8.7**
X10	H3	2	1.2	NA	**NA**
X10	H3	10	1.2	1.7	**9.6**
X10	H3	20	NA	1.8	**9.7**
X10	H3	50	1.2	1.8	**10.0**
X10	P	0	1.2	2.4	**9.3**
X10	P	2	1.2	NA	**NA**
X10	P	10	1.2	30.0	**21.6**
X10	P	20	NA	30.7	**22.0**
X10	**P**	**50**	**1.2**	**31.8**	**22.7**

5.1.4 Benefit Annualization

Restoration benefits and costs are often distributed across the planning horizon. For instance, the ecological benefits of a riparian planting scheme may not be realized until the trees reach a certain size or height threshold. Annualization provides a mechanism for consistent comparison of benefits and costs. Ecological outputs are assessed at multiple time periods as described above, and benefits are computed as the time-averaged quantity over the planning horizon. Benefits are annualized by computing the area under the benefits curve and dividing by the duration of the planning horizon. A linear trajectory is assumed between all time periods.

Benefits are annualized separately for the channel (QHEILS), left riparian zone (SMURF), and right riparian zone (SMURF). For this study the total habitat at a site is computed as the sum of these three habitat outputs, which used non-overlapping assessment areas. For each alternative, net benefits were computed over the future without project (FWOP) condition to reflect the change in ecological condition associated with the restoration expenditure. This “lift” in benefits provides a consistent baseline for comparison. Table 14 provides an example of annualized benefits associated with Site-X10, which is derived from the temporally distributed data in Table 13 above.

Table 14: Example of average annual habitat units for the Alpaca Farm / Zoo site (X10).

Site	Action	QHEILS Channel	SMURF Left Bank	SMURF Right Bank	Total Benefits	Ecological Lift
X10	FWOP	1.2	1.7	8.6	11.5	**0.0**
X10	C	1.5	1.7	8.6	11.8	**0.3**
X10	R1	1.2	1.8	9.0	12.1	**0.5**
X10	R2	2.3	2.0	9.9	14.1	**2.6**
X10	R4	2.5	2.0	10.0	14.5	**3.0**
X10	H2	1.2	2.4	9.7	13.3	**1.8**
X10	H3	1.2	1.8	9.7	12.7	**1.1**
X10	**P**	**1.2**	**28.1**	**20.9**	**50.2**	**38.7**

5.2 Cost Effectiveness/Incremental Cost Analysis

Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the most return-on-investment (i.e., the most environmental benefits for a given level of cost or the least cost for a given level of environmental benefit). An "efficiency frontier" identifies all plans that efficiently provide benefits on a per cost basis.

Overall, restoration recommendations were made to "reasonably maximize environmental benefits" (USACE 2000). In general, CEICA was interpreted through five guiding questions to identify a recommended alternative:

- Does this alternative/plan meet the planning objectives? Specifically, actions would ideally incorporate both riverine and riparian benefits.
- Which alternative/plan provides a "good" investment relative to increasing incremental unit cost? Specifically, increases in marginal cost could encourage (or discourage) a recommendation.
- Which alternative/plan has the lowest overall unit cost (i.e., $/Average Annual Functional Capacity Unit (AAFCU) or $/AAHU)? Overall unit cost is an important metric for agencywide budgeting decisions and "roll-up" of restoration outcomes. This metric also strongly drives watershed scale site prioritization, so effort was made to avoid site-scale recommendations with high overall unit cost.
- Which alternative/plan is cost affordable relative to other sites and overall project limitations?
- What other qualitative decision factors are important? The Planning Guidance Notebook (USACE 2000) suggests that recommendations be made in light of non-linearities in the cost-benefit data, incremental cost associated with additional investment, and qualitative benefits not captured by ecological models. Additionally, alternatives (or sites) may provide disproportionate benefits relative to economic outcomes, other social effects, or other USACE or MSD mission areas.

Cost and ecological benefits provide the primary inputs to CEICA. A summary of all inputs for the site level CEICA can be found in Appendix B.

Throughout this section, project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%.

5.2.1 Cost Effectiveness Analysis

CEICA can be applied multiple ways when examining a multi-site restoration study such as Beargrass Creek. First, recommendations can be made at the site-scale (e.g., Alt-A at Site-1). Second, site-scale recommendation can be combined logically with other recommended actions to develop different "portfolios" of projects (e.g., Alt-A at Site-1 and Alt-C at Site-2). Third, all permutations of sites and alternative can be assessed to develop project portfolios. Here, we applied CEICA using all three approaches with the logic that greater confidence may be placed in a recommendation arrived at through competing methods.

Figure 44. is an example cost-effectiveness graph showing cost vs benefits for site X34, Cherokee Park. All possible site level combinations were analyzed and are listed in Table 15 below with habitat units, average annual costs, unit costs and project first costs. These costs represent rough order of magnitude calculated at the time of the CEICA. The columns on the far right indicate if the plan is cost effective or a best buy.

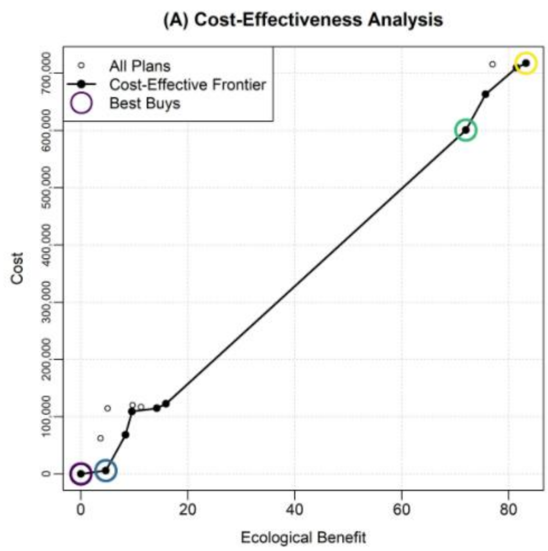

Figure 44. Cost Effective Analysis for X34, Cherokee Park, Showing All Cost-Effective Plans on the Line with Best Buy Plans Circled

Table 15. Cost Effective Plans for X34

Alt	Lift (AAHU)	Avg Ann Cost ($)	Unit Cost ($/AAHU)	Project First Cost ($)	CE?	BB?
X34.1.	0	0	NaN	0	1	1
X34.2.P	72	600,800	8,300	16,961,000	1	1
X34.3.H2	4.7	5,800	1,200	163,000	1	1
X34.4.CR4	9.5	109,200	11,500	3,084,000	1	0
X34.5.CR4P	81.5	710,000	8,700	20,045,000	1	0
X34.6.CR4H2	14.2	115,000	8,100	3,247,000	1	0
X34.7.CR3	3.7	62,500	16,900	1,764,000	0	0
X34.8.CR3P	75.7	663,200	8,800	18,724,000	1	0
X34.9.CR3H2	8.3	68,200	8,200	1,927,000	1	0
X34.10.CR2	11.2	116,900	10,400	3,301,000	0	0
X34.11.CR2P	83.2	717,700	8,600	20,262,000	1	1
X34.12.CR2H2	15.9	122,700	7,700	3,464,000	1	0
X34.13.CR1	5	114,600	23,000	3,236,000	0	0
X34.14.CR1P	77	715,400	9,300	20,197,000	0	0
X34.15.CR1H2	9.6	120,400	12,500	3,399,000	0	0

5.2.2 Incremental Cost Analysis

Incremental cost analysis is conducted on the set of cost-effective plans. This technique sequentially compares each plan to all higher cost plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide benefits on an incremental unit cost basis. Specifically, this analysis examines the slope of the cost-effectiveness frontier to isolate how the unit cost ($/unit) increases as the magnitude of environmental benefit increases. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish the objective relative to unit costs and are typically referred to as “best buys.” Importantly, all “best buys” are cost-effective, but not all cost-effective plans are best buys. Figure 45. and Table 16 illustrate examples of the results from the incremental cost analysis.

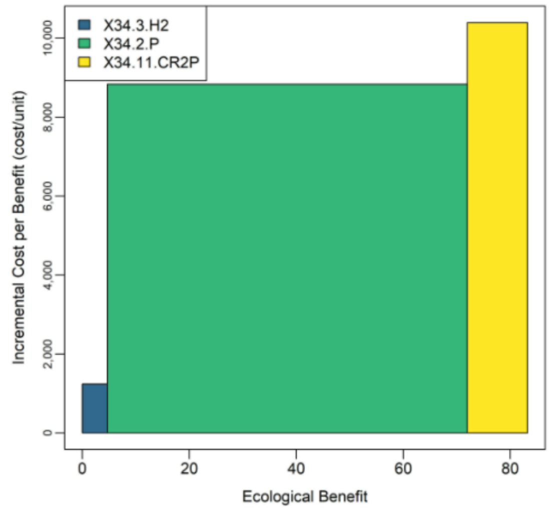

Figure 45. Incremental Cost Analysis for Site X34

Table 16. Incremental cost summary table for site X34

Alt	Lift (AAHU)	Avg Ann Cost ($)	Overall Unit Cost ($/AAHU)	Inc Unit Cost ($/AAHU)	Project First Cost ($)
X34.1.	0	0	NaN	0	0
X34.3.H2	4.7	5,800	1,200	1,200	163,000
X34.2.P	72	600,800	8,300	8,800	16,961,000
X34.11.CR2P	83.2	717,700	8,600	10,400	20,262,000

5.2.3 Identification of Final Array

At each site, multiple alternatives were developed varying in their conceptual basis, costs, and benefits. The cost-effectiveness and incremental cost analysis were applied to compare alternatives at each site to identify both cost-effective (CE) and best buy (BB) alternatives. These data were synthesized with other decision criteria (described in Section 5.7.2) to arrive at a preliminary recommended action.

5.2.4 Selection of the Final Array

The prior analyses describe the logic of decision-making relative to 21 potential restoration sites. The “no action” alternative is recommended at 7 of these sites. Table 17 in section 5.5 below summarizes the 21 sites with recommended restoration actions including those with “no action”. Table 18 in section 5.5.2 below summarizes the costs and benefits of the 14 recommended sites. The recommended actions vary widely in costs ($1.0M-$20.3M project first) and benefits (2.4-83.2 AAHUs). This range of outcomes provides an opportunity to examine effective combinations of actions at the watershed-scale.

5.3 Objectives Performance

Objective 1: Reestablish quality and connectivity of riverine habitats
During the focused array analysis, both quality and connectivity of riverine habitats was met by all alternatives chosen for the final array, with varying degrees of performance. Those that were not able to meet an acceptable level of performance were screened out. The X9- Clark Park, X15- Buechel Park, X24-

Oxmoor Country Club, and X28- Hurstbourne Country Club sites were all screened at this stage due in part to their size and disconnection with other sites in the watershed. All of these sites were relatively small and located on tributaries in the headwaters of the system. The application of the connectivity or in stream alternatives would not have a significant impact on downstream sites within the watershed.

The X5- Oxmoor Farms, X11- Collegiate and X31- Champions Trace all would have had significant impacts to instream connectivity and quality. However, these sites were screened for different reasons. Oxmoor Farms was primarily screened due to real estate and cost issues. Collegiate and Champions Trace both screened because they are both very constrained sites where work would have been difficult and costly due to infrastructure impacts.

All other chosen alternatives met instream connectivity and quality objective. Most met these through applying either the Connectivity or Riverine alternatives that directly improve instream conditions. The X8, Houston Acres site did not apply any direct instream alternatives because existing instream conditions were good. The P alternative was chosen to clear invasive species and plant natives that would have secondary benefits on instream conditions. The X22- Concrete Channel site also did not include instream improvements due to very high real estate and construction costs. Instead, it was decided that the creation of natural swales at select locations along the stream would allow areas of refuge and have some secondary instream benefits. The X33, MSD basin site also only applied H2. While this could have some secondary instream impacts, this was chosen partly because the site is very small and instream conditions are fair. Therefore, instream improvements would have minimal impact on the system as a whole. The retrofitting of this existing basin was also a priority for MSD.

<u>Objective 2: Reestablish quality and connectivity of riparian and wetland habitats</u>
All selected focused array alternatives contained improvements to the riparian quality and connectivity using the Planting alternative or the Hydrologic Resurgence via Basins or Swales. Two sites, X22- Concrete Channel and X2- Confluence will be removing impervious surface to create wetland areas which has significant system impacts on hydrologic function and increased habitat area. Eight of the chosen alterative includes invasive removal and planting of native species that will improve large areas of forested habitat within the watershed and connect existing habitats. Seven alternatives include the H2 alternative that will create wetland habitat where it does not currently exist.

Similar to the first objective, the sites that were not retained were either screened due to their size and location within the system or the existing constraints such as infrastructure. X5, Oxmoor Farms was primarily screened to due cost and real estate constraints.

5.4 Comparisons

For these comparisons, the PDT held multi- day team workshops where we discussed the CEICA results site by site. We discussed the tradeoffs of cost vs benefit as well as other qualitative issues that were not captured through that analysis. All decision logic was recorded, and meetings were attended by members of the PDT that represented different disciplines and allowed us to compare the sites through multiple perspectives.

To analyze the CEICA results we looked at thresholds of incremental cost and overall cost, compared to magnitude of benefits. The team also considered the two planning objectives as well. The qualitative issues discussed were issues such as recreation potential, neighborhood, or local political interest, known real estate acquisition issues, local economic impact, etc. Below (Table 17) is a summary of justification for screening or retaining each alternative. The decision logic is described in detail for each site in Appendix B.

5.5 Final Array of Alternatives

At each site, multiple combinations of alternatives were developed varying in their conceptual basis, costs, and benefits. Each site had varying numbers of Best Buy (BB) plans and Cost Effective (CE) plans. The team prioritized best buy plans but, in some cases, chose a cost-effective alternative that was justified by qualitative criteria.

Table 17. Focused array site screening summary with red text indicating screened sites

Site	Recommend Alt	Justification Highlights for Recommendation
X2- Confluence	R2H2	Cost effective, Meets both objectives, Avoids real estate issues, Recreation potential
X4- AB Sawyer	CR4P	Best buy, Meets both objectives, Alleviates connectivity issue central to site
X5- Oxmoor Farms	No action	Affordability concerns, Real estate costs greater than 25% of project first cost
X8-HoustonAcres	P	Lowest overall unit cost of all best buys, Good existing instream quality justifies P only
X9- Clark Park	No action	Small site, Small investment better suited to localized partnership
X10- AlpacaFarm	CR2P	Best buy, low overall cost unit, large footprint, potential for partnership
X11- Collegiate	No action	Constrained site, concerns over efficacy of planting actions along freeway,
X15- Buechel Park	No action	Benefits deemed too small for warrant USACE action, isolated site
X19- NewburgRd	R1H2	Low overall cost unit and affordable, MSD owned, Actions align with MSD management strategy
X20- BrownPark	R2P	Prior restoration work requires repair, potential network to other X21 site
X21- DrautPark	R2P	Lowest cost best buy that meets both objectives, potential network to X20
X22- ConcreteChannel	H2	Very high social benefits, potential intersection with other current studies
X24- Oxmoor Country Club	No action	Disconnected site, real estate issues
X28- Hurstbourne Country Club	No action	Disconnected site, real estate issues
X29- EasternCreasonConnector	CR4P	Best buy, meets planning objectives, strong stakeholder interest, recreation potential
X30- NaturePreserve	CR4P	Lowest cost best buy alternative that meets the planning objectives, Good connectivity to other major sites
X31- Champions Trace	No action	Technical challenges, constrained site, potential conflicting project footprints
X33- MSD Basin	H2	Potential synergy with ongoing MSD activities at site
X34- CherokeePark	CR2P	Lowest cost best buy that meets both objectives, Very large site, big ecological and social impact
X35- MuddyForkTrbs	CR2H2	Lowest cost best buy that meets both objectives, potential for hydrologic actions to provide offsite benefits
X38- CaveHill	R2H2	Lowest cost best buy that meets both objectives, important site connectivity

5.5.1 No Action Alternative

Section 2.0, Affected Environment, discusses an inventory of historic and existing conditions and a forecast of future without-project conditions. Without-project condition describes the study area's future if there is no federal action taken to address the problem at hand and are synonymous with the No Action Alternative. Every alternative plan that is formulated is compared to the same future without-project condition. Future without-project conditions are based on forecasting and are considered the most likely future conditions.

5.5.2 Action Alternatives

Table 18 below lists the final array of alternatives that resulted from the site level CEICA screening. This table lists the remaining 14 sites with their recommended alternative and a summary of their cost and benefits. This list includes the confluence site, one site on the Muddy Fork, seven on the South Fork and five on the Middle Fork. A full list of choice justifications can be found in Appendix B and conceptual maps can be found in Appendix H.

Table 18. Final array summary table

Site	Recommend Alternative	Ecological Lift (AAHU)	Average Annual Cost ($)	Project First Cost ($)
X2 – Confluence	R2H2	18.5	344,800	9,733,000
X4 – Shelby Campus/AB Sawyer	CR4P	24.5	548,800	15,493,000
X8 – Houston Acres	P	23.8	670,200	18,920,000
X10 – Alpaca Farm	CR2P	41.6	484,600	13,682,000
X19 – Newburg Rd	R1H2	7.9	115,700	3,266,000
X20 – Brown Park	R2P	17.3	142,500	4,024,000
X21 – Draut Park	R2P	17.4	140,800	3,974,000
X22 – Concrete Channel	H2	4.3	83,600	2,361,000
X29 – Eastern Creason Connector	CR4P	34.7	741,300	20,927,000
X30 – Nature Preserve	CR4P	57.1	613,200	17,312,000
X33 – MSD Basin	XH2	2.4	35,700	1,009,000
X34 – Cherokee and Seneca Park	CR2P	83.2	717,700	20,262,000
X35 – Muddy Fork Tribs	CR2H2	10.4	279,300	7,885,000
X38 – Cave Hill	R2H2	21.3	331,700	9,364,000

NOTE Project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%. These are the costs calculated at the time of the CEICA.

5.5.2.1 Alternative 1 (X2 Confluence- R2H2)

This site is located where the stream meets the Ohio River. The site contains a public park, the MSD pump station, a portion of the Beargrass Creek greenway and is located adjacent to the Waterfront

Botanical Gardens. Due to is location and features, this site has high visibility and recreation potential. The recommendation includes the Riverine 2 alternative that would add in native rock structures and woody debris, as well as grade banks to allow access to the floodplain along approximately 1500 linear feet of stream near the pump station, as well as two areas of H2 and some native plantings. Weirs will be constructed at the mouth of the stream to control sediment and erosion and concrete slabs near the pump station that were dumped will be removed. This alternative was chosen because it was cost effective at the site scale, meets both objectives and would provide social benefits due to its location.

5.5.2.2 Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)

This site is located in the headwaters of the Middle Fork and contains property owned by the university of Louisville as well as a portion of a Metro Park. This alternative proposes to realign the stream throughout the site to a natural meander, as well as two locations of barrier removal for fish passage. It also includes planting and invasive removal along the stream channel on site. This plan meets both objectives, is a best buy at the site scale and alleviates connectivity issues central to the site.

5.5.2.3 Alternative 3 (X8 - Houston Acres- P)

This site is a large wooded site in the headwaters of the South Fork. It is surrounded by medium density single family homes and agriculture. This site contains a large earthen dam structure that is owned by MSD for flood control purposes. This site had good instream conditions and many wild animals were observed here during field work. The Planting alternative was the lowest overall unit cost of the best buy plans and was chosen due to cost issues with the other alternative choices. Additionally, with the good existing condition of the stream, native plantings and invasive removal would be an affordable option that would have secondary benefits for instream functions.

5.5.2.4 Alternative 4 (X10 - Alpaca Farm- CR2P)

This site is located on the South Fork adjacent to the zoo and just upstream of the Joe Creason site. It consists of some property owned by the Louisville Metro, as well as private property. The chosen plan consists of the addition of riffles to overcome culverts that pose as barriers to fish and other aquatic organisms. Instream work will include native rock structure and woody debris placement and bank grading to open the stream up to the floodplain. The alternative also includes invasive removal and native plantings throughout the site. This plan was chosen because it is a best buy with low overall unit cost that provides both instream and riparian benefits and offers opportunity for intangible benefits associated with its location next to the Louisville Zoo.

5.5.2.5 Alternative 5 (X19 - Newburg Rd- R1H2)

This site is comprised to two MSD owned basins located upstream on the South Fork, as well as a portion of stream that connects them. The proposal includes retrofitting the existing basins to plant native wetlands plants to create a more natural wetland area and instream improvements to improve the connection between the basins. This is a cost-effective plan at an intermediate cost level and provides both in stream and riparian benefits.

5.5.2.6 Alternative 6 (X20/X21 – Brown and Draut Park- R2P)

These two parks are located on the Middle Fork and are owned by the City of St. Matthews. Both sites have historic restoration work that is proposed to be updated as well as native planting and invasive removal throughout. This was a non-cost-effective plan that was recommended because of technical issues seen at the site and the benefits of connecting the two sites to one another. These sites were evaluated separately at the site level but were viewed as one site for the watershed analysis.

5.5.2.7 Alternative 7 (X22 – Concrete Channel- H2)

This site is the 2.5-mile concrete stretch of the South Fork that has been historically channelized. The H2 alternative was chosen for this site due to the comparatively high incremental and overall costs of other plans for this site and due to the benefits of habitat islands created by areas of H2 along the channel. This plan also offers large social benefits since the site is located in a dense urban neighborhood with high visibility and proximity to downtown.

5.5.2.8 Alternative 8 (X29 - Eastern Creason Connector- CR4P)

This site is located between sites X22 and X30 on the South Fork. Three riffles will be added to eliminate connectivity issues along this reach and a portion of the stream will be resculpted utilizing the R4 alternative. This site will also have work done to plant native species and remove invasives. The alternative was a best buy and meets both planning objectives. This site also has strong stakeholder interest and opportunity for recreation and educational aspects due to the proximity of schools, churches and other community center establishments.

5.5.2.9 Alternative 9 (X30 - Nature Preserve- CR4P)

This site is located just upstream of site X29 and proposed the same alternative that would improve connectivity between the sites. Plantings and invasive removal throughout with one large barrier removal, as well as channel resculpting is proposed here. Being an active city park and a nature preserve, this site has high visibility and opportunity to enhance the recreation and educational features. This alternative was a lowest cost best buy and meets both planning objectives.

5.5.2.10 Alternative 10 (X33 – MSD Basin- H2)

This site is comprised of one MSD owned basin located upstream on the South Fork. The proposal includes retrofitting the existing basin to plant native wetlands plants to create a more natural wetland area. This is a cost-effective plan at an intermediate cost level.

5.5.2.11 Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)

This is the largest site and contains two active parks, both of which are considered historic. The alternative includes the addition of riffles to eliminate instream barriers at five points along the stream reach, native plantings on about 5 acres, invasive removal on over 200 acres and instream improvements with floodplain access impacting over 8 acres. This plan was the lowest cost best buy and meets both objectives and the plan offers opportunities to enhance recreational aspects of this highly visible city park.

5.5.2.12 Alternative 12 (X35 – Muddy Fork Tribs- CR2H2)

This location is the only site selected on the Muddy Fork; however, it is the second largest site overall. The recommendation is to add riffles to eliminate barriers at seven locations along the stream with R2 instream work and floodplain connectivity impacting about 2 acres. H2, wetland creation is also proposed on about 16 acres that will have positive impacts on the Muddy Fork downstream of the site. This plan was the lowest cost, cost effective plan and met both objectives.

5.5.2.13 Alternative 13 (X38 – Cave Hill- R2H2)

This site is located just downstream of the X34 site on the Middle Fork. This site is highly channelized and located along a major expressway. The chosen plan was the lowest cost best buy and meets both objectives, providing instream R2 work that aligns with the creation of 15 acres of wetland creation. This site provides important connectivity to upstream Middle Fork sites and actions would be complementary to other community management actions.

5.6 Recreation Plan

While recreation is ancillary to ecosystem restoration, recreation can be included in an ecosystem restoration plan as long as it remains under 10% of the total project cost. USACE and the NFS recognize the value and importance of recreation to the local and regional community of Louisville. Recreation features that would complement and enhance the ecosystem improvements were discussed and considered throughout the process, but the recreation plan was not formally created until after the selection of the TSP.

The conceptual recreation features were chosen based on existing recreation features or plans and opportunities to connect to or further improve those features. Additionally, some features were chosen to fill a need where the availability of such a feature may not be readily available. Public input from the community also played a part in the selection of features.

5.6.1 Proposed Recreation Features

Potential recreation features are listed by site below in Table 19. The proposal only contains recreational features at 11 of the selected plan sites. Site X35, Muddy Fork and tributaries was not included in the recreation plan because the ownership status is not conducive to public access.

Table 19. Proposed recreation features

Location	Potential Recreation Features
X2- Confluence	• Boat Access Ramp near mouth of stream • Pedestrian Bridge and trail enhancements connecting Beargrass Greenway trail and park • Observation mound at Champions Park
X10- Zoo/Alpaca	• Trail improvements/Overlooks- connection with existing recreation features • Outdoor Classroom
X20 & X21- Arthur and Draut Parks	• Connection to St Matthews Mall from existing recreation features
X19 & 33- MSD Basins	• Birding Platforms
X22- Concrete Channel	• Overlook at Logan Street
X29- Eastern Creason Connector	• Soft surface trail along length of stream, crossing stream at pedestrian bridge planned by the city for 2022 (not part of this project), benches • Connections to surrounding amenities with signage
X30- Joe Creason/Nature Preserve	• Outdoor classroom • Enhanced trail connections between TNC and Joe Creason and Bellarmine/neighborhoods • Interpretative signage in Joe Creason park
X34- Cherokee Seneca Park	• Update soft surface trails • Enhance Willow pond observation platform
X38- Cave Hill	• Realign and enhance existing trail • Expand Cave Hill arboretum

5.6.2 Benefits of the Recreation Plan

With the Beargrass Creek watershed's location in a dense urban area, the social and economic benefits to the local and regional community are numerous. There are direct and indirect benefits to the communities where the recreation features are proposed. The direct benefits would include:

- Improved access to the stream for surrounding communities
- Enhanced quality and quantity of trails for multiple users
- Improved viewsheds of the stream
- Improved public health benefits related to access to green space
- Opportunity for recreation related/adjacent business and eco-tourism
- Opportunity for education about the stream's history

The communities surrounding Beargrass Creek have investment in the health of the stream and access from neighborhoods for recreational and educational purposes. The direct benefits to these communities would enhance access to green space, viewsheds, and boost recreation related business and tourism.

Beyond the adjacent communities, the restoration and additional recreation features would also have an impact on the larger population of Louisville. For instance, the trail enhancements and connections at the Confluence site that connect to the Cave Hill site would be adding to the Louisville Loop trail system, a 200-mile multi-use trail that loops the metro area. This trail is still under construction, however, the portion that follows the waterfront is complete and stretches over 20 miles from southwest Jefferson County to east of downtown.

Other recreational features will be addressing underserved areas such as the MSD basin sites that are in lower income areas that are in need of better access to greenspace. Additionally, the Eastern Creason Connector trail will be connecting several neighborhoods that currently do not have safe pedestrian access between them due to the arterial roads that dissect this part of the city.

5.6.3 Benefit Cost Analysis

There is currently no quantitative evaluation for recreation benefits. The PDT will further refine qualitative benefits as the recreation plan is designed for the final report.

5.7 Comparison of Alternative Plans

The comparison of plans in the final array of alternatives is used to assist in the identification of the National Ecosystem Restoration (NER) Plan and the TSP.

As part of the planning process, the USACE identifies the NER Plan. As described in USACE planning guidance, the NER Plan is the alternative and scale of implementation having the maximum monetary and non-monetary beneficial effects over monetary and nonmonetary costs. This plan occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated, where the extra environmental value is just worth the extra costs. The guidance also notes that in all but the most unusual cases, the NER Plan should be derived from the final set of “Best Buy” solutions. To put it simply, the USACE and MSD must answer the question about whether the plan’s benefits are worth the costs, but this is a difficult process because monetary calculations do not capture all ecosystem benefits. Environmental benefits analysis is still developing as an area of study. Therefore, other comparisons between ecosystem benefits are provided within this chapter as well.

This section provides a comparison of the final array of alternatives that were described in Section 4. The final array of alternatives consisted of 14 sites in the watershed, each with a selected alternative. The TSP would consist of a combination of these sites that would represent a holistic watershed recommendation.

5.7.1 Final Array Comparison by Project Objective

The planning objectives for this study, described in detail in Section 4, are summarized below.

- Objective 1: Reestablish quality and connectivity of riverine habitats.
- Objective 2: Reestablish quality and connectivity of riparian habitats.

The objective analysis for the final array was conducted qualitatively through discussion of the best buy and cost-efficient plans. Location and size within the watershed were important factors as the team considered the possible combinations of sites and the overall impact of upstream sites on downstream sites regarding connectivity of both riverine and riparian habitats.

5.7.2 Use of decision criteria to Assess Alternatives by Restoration Objective

The team used four main decision criteria to make a final alternative selection (Figure 46.) to recommend. The habitat units or benefits were calculated using the two ecological models (QHEILS and SMURF) for assessment of existing conditions as well as forecasting future with and without project conditions.

The Cost Effective and Incremental Cost Analysis (CEICA) allowed an analysis of costs vs benefits. In accordance with policy ER 1105-2-100, Page E-163, the CEICA was meant to compare all possible combinations of alternatives at each site to choose the alternative that, first, met our planning objectives and, second, maximized environmental benefits while remaining cost effective and able to meet other planning criteria. This also ensured that our TSP met the Principals and Guidelines (P&G) screening criteria for cost efficiency.

The planning objectives guided decisions as well, not only for the final selection, but throughout the planning process. The team ensured that the final plan recommendation met both planning objectives which additionally meets the P&G screening criteria for completeness.

Other Social Effects were included in our decision criteria semi-quantitatively with a scoring table that was organized by metrics for logistical, economic, social and technical issues. Logistical metrics included site construction access and real estate issues. This would also meet P&G criteria for completeness and acceptability. Economic effects included existing businesses and potential for local economic growth as well as flooding impacts. Social effects included site visibility, recreation potential and environmental justice. Technical effects were habitat scarcity and connectivity.

Figure 46. Decision Criteria for Selection of the Tentatively Selected Plan

5.7.3 Comparison of Restoration of Natural Hydrological Function and Habitat Connectivity

The two ecological models utilized for existing conditions and forecasting of FWP and FWOP scores ultimately determined the Average Annual Habitat Units (AAHUs). As discussed in Section 5.1, the

QHEILS assessment included two specific parameters for connectivity. Each alternative for the watershed analysis was given a score of 0-20 for connectivity as it relates to both organic material transport and aquatic organism transport through the site.

All barriers including bridge crossings and culverts were mapped (Figure 37., Section 4.8.2) and considered when scoring each site. Scoring was based on the number and severity of the barriers and fragmentation points such as dams or major elevation changes within the stream channel were considered more detrimental than barriers such as culverts that would inhibit movement only during low flow.

The SMURF assessment included metrics for hydrologic benefits onsite. One metric included in the riparian valuation was buffer development. This metric scored the left and right banks of the given reach on the quality of the riparian zone as it relates to disturbances such as roadways, mowed lawns or structures. The assessment also scored buffer flowpaths by looking at the amount and severity of runoff flows. Other metrics included in the SMURF that assessed hydrologic quality included canopy structure and herbaceous ground cover (Figure 47.).

Parameter	**Optimal** 20 19 18 17 16	**Suboptimal** 15 14 13 12 11	**Marginal** 10 9 8 7 6	**Poor** 5 4 3 2 1 0	**Left**	**Right**
Buffer properties						
Buffer Development	Very minor evidence of human disturbance and no impact to corridor function.	Notable impacts within footprint (e.g., paths, lawns) but minor effect on animal movement.	Large scale impacts to buffer reducing migratory corridor function.	Significant major impacts inhibiting corridor functions.	12	15
Buffer Flowpaths	Runoff flows through buffer evenly, in natural channels, or through wetlands.	Minor rills / channels are visible but mostly used during large events.	Major rills, flow paths, and channels used during small events.	Obvious short-circuiting of buffer by pipes and drainage at most events.	10	10
Riparian habitat properties						
Multi-story Canopy Structure	Check all that are present and associated habitat quality in the LEFT riparian zone: Quality: High / Medium / Low Canopy / Overstory: Medium ✓ Midstory: Low ✓ Woody Shrubs: Low ✓		Check all that are present and associated habitat quality in the RIGHT riparian zone: Quality: High / Medium / Low Canopy / Overstory: Medium ✓ Midstory: Low ✓ Woody Shrubs: Low ✓			
Snag Density	Greater than 3 pieces of large, *standing* deadwood (4+in diameter, 36+in length) in 25'x100' area.	1-3 pieces of large, *standing* deadwood (4+in diameter, 36+in length) in 25'x100' area.	No large, *standing* deadwood, but large live trees for future snags.	No large, *standing* deadwood or large *live* trees.	8	13
Deadfall Density	Greater than 10 pieces of large, down woody stems (4+in diameter, 36+in length) in 25'x100' area.	5-10 pieces of large, down woody stems (4+in diameter, 36+in length) in 25'x100' area.	0-5 pieces of large, down woody stems (4+in diameter, 36+in length) in 25'x100' area.	No large, down woody stems (4+in diameter, 36+in length).	3	6
Detrital Ground Cover	Organic ground cover >70%. Mostly covered by thick detritus / woody debris layer.	Organic ground cover (detritus/woody debris) is 40-70%.	Organic ground cover (detritus/woody debris) is 20-40%.	Organic ground cover is <20%. Ground is mostly bare, lawn, or impervious.	5	8
Herbaceous Vegetation Cover	Extensive and layered throughout reach.	Extensive, but lacks complexity and layering/	Patchy and lacks complexity or layers.	Minimal or absent throughout reach.	11	12
Invasive Vegetation Dominance	Primarily native taxa. Little, if any, ecological effect of invasives.	Invasives notably present, but playing a minor ecological role.	Invasive species are dominant, but natives remain.	Invasive dominance in both composition and function.	11	11

Figure 47. Example Simple Model for Urban Riparian Function Datasheet

5.7.4 Comparison by Objectives Conclusion

The objectives analysis of the final alternative array brought a focus on larger and better-connected sites within the watershed. The X4- Shelby Campus and X8- Houston Acres sites were screened out partly due to their location in the headwaters of the Middle and South Forks. The downstream benefits to connectivity would be partly lost due to the sites being disconnected from other remaining sites.

5.7.5 Flood Risk Management Conclusion

As evident from the results of the H&H analysis, not only do the proposed alternatives not represent a significant flood risk, they will most likely result in reduced flood risk. These flood risk management benefits are discussed more completely in Appendix B and show that the proposed plan will provide both environmental and flood risk management benefits along with regional economic development and other social benefits.

5.8 Comparison by National Objectives and the Four Accounts

In the 1970 Flood Control Act, Congress identified four equal national accounts for use in water resources development planning. They are national economic development (NED); regional economic development (RED); environmental quality (EQ); and social well-being (OSE, other social effects). Policy in the 1970s regarded making contributions to only two of these, NED and EQ, as national objectives. Now, as stated in the Memorandum dated 3 April 2020, entitled Comprehensive Documentation of Benefits in Feasibility Studies, all four accounts must be equally considered in plan formulation.

The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.
The four categories, known as the System of Accounts as suggested by the U.S. Water Resources Council, address long-term impacts and are defined in such a manner that each proposed plan can be easily compared to the No Action plan and other alternatives. Collectively, the four accounts are required to include all significant effects of a plan on the human environment.

5.8.1 National Economic Development

The TSP is justified by the National Economic Development (NED) account as quantified by the CEICA results in both the site scale screening, as well as the final watershed scale screening to reach the TSP. The CEICA results allowed the team to choose the plan that maximizes habitat lift, as well as cost-efficiency.

5.8.2 Environmental Quality

The Planning Manual describes environmental quality as "favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources." Adverse effects within these categories can also be included in this assessment. Resource and use types that were assessed in this document (Chapter 5) include the following:

- Geology, Soils, Seismic Hazards, or Mineral Resources
- Air Quality
- Land Use
- Water Resources
- Biological Resources
- Cultural Resources
- Traffic and Circulation
- Noise
- Recreation and Public Access
- Aesthetics
- Public Health and Safety, including HTRW
- Utilities and Public Services
- Socioeconomics and Environmental Justice

Appendix F contains the comparison of environmental quality between No Action and the final array of alternatives.

5.8.3 Regional Economic Development

RED impacts include, principally, changes in income and employment. There may be some overlap with the other accounts. Section 7.4 discusses the Regional Economic Development and Economic Impacts Summary (RECONS) in more detail. Indirect and induced impacts are the focus of the RED account, and differences between it and NED are considered transfers from the rest of the nation. The study area for RED is the Louisville metropolitan area, which is home to 615,924 people. Louisville is the largest city in the state of Kentucky and is the 29th largest city in the US.

Local and regional economic impacts were considered qualitatively during the watershed screening analysis. A more detailed analysis will be performed prior to the final report. Regional economic impacts assessed are listed in the OSE screening table (Appendix H). Alternatives were scored based on their location in the watershed as it relates to existing and potential business and job production. Predicted impacts to flooding was also scored from flood inundation modeling. Section 5.7.5 also summarizes the benefits to flood risk management from the selected plan while Appendix D gives detail on the flood inundation modeling.

5.8.4 Other Social Effects Assessment

A secondary screening table matrix was created that scored each site/alternative based on logistical factors such as construction accessibility and real estate, social impact such as recreational value, economic impacts (potential for bringing in business) and technical value (scarcity) (Appendix H). This matrix covered screening criteria within all four accounts as well as the Other Social Effects assessment. Figure 48. summarizes the assessment inputs. Each site was given a score for each subcategory on a scale of 1-20, these scores were normalized and multiplied by the site acreage to give a social unit score on the same scale as habitat units.

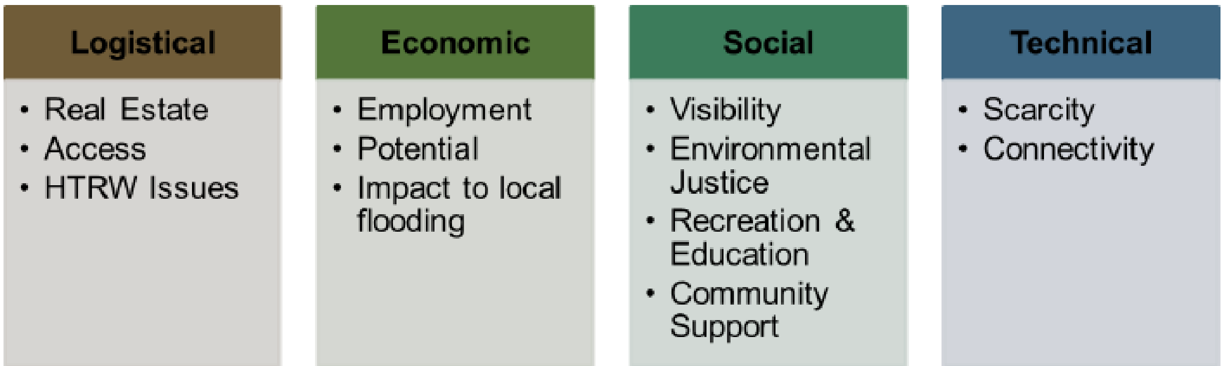

Figure 48. Secondary screening criteria

5.8.5 Principles and Guidelines

Principals and Guidelines criteria were utilized early in the screening process to perform the first round of alternative screening at the site level. Plan formulation tables were created for the initial array of 21 sites. Each alternative was given a score of 0-4 for completeness, effectiveness, efficiency, and acceptability. O&M and natural resources (potential for habitat lift) were also scored with this screening exercise. Decision logic was recorded for every score and cutoffs for screening were decided by finding the natural break point in frequencies.

Additionally, these criteria were covered in other steps of screening later in the process. The two rounds of CEICAs, ensured the cost efficiency of the Tentatively Selected Plan, as well as the effectiveness since benefits would be maximized. The OSE analysis also covered completeness and acceptability when weighing logistical issues such as access or technical issues such as connectivity of habitat.

5.9 Final Array Cost Estimates in Draft IFR

From the results of the site level CEICA 14 site scale alternatives were selected to move on to the watershed scale CEICA. These results can be seen in Table 20. It is of note, that at the time of this evaluation, Recreational Features had not been included.

From the (14) original plans, (2) of the sites (X4 and X8) were further screened and the resulting list of plans was developed, seen in Table 21. Costs for the TSP are presented later in the report and were refined based upon more detailed design and cost estimates.

Table 20. Cost summary of 14 final array alternatives

SITE	ALT	01 LANDS & DAMAGE	02 RELOCATION	06 FISH & WILDLIFE	18 CULTURAL	30 PLANNING, ENG, & DESIGN	31 CONST. MNGT	TOTAL PROJECT FIRST COST
X2 – CONFLUENCE	C, R2, H2	$550,000	$118,000	$7,184,000	$0	$1,305,000	$576,000	$9,734,000
X4 – SHELBY CAMPUS	C, R4, P	$4,454,000	$322,000	$8,505,000	$0	$1,531,000	$680,000	$15,493,000
X8 – HOUSTON ACRE'S FARM	P	$4,556,000	$230,000	$11,400,000	$0	$2,052,000	$535,000	$18,773,000
X10 – ALPACA FARMS	C, R2, P	$1,047,000	$127,000	$9,827,000	$0	$1,887,000	$794,000	$13,682,000
X19 – NEWBURG RD	C, R1, H2	$720,000	$0	$1,986,000	$0	$399,000	$162,000	$3,267,000
X20 – BROWN PARK	C, R2, P	$312,000	$83,000	$2,845,000	$0	$553,000	$230,000	$4,023,000
X21 – ARTHUR DRAUGHT	C, R2, P	$308,000	$44,000	$2,840,000	$0	$552,000	$230,000	$3,973,000
X22 – CONCRETE CHANNEL	H2	$309,000	$151,000	$1,499,000	$0	$282,000	$121,000	$2,361,000
X29 – EASTERN/CREASO	C, R4, P	$5,236,000	$925,000	$11,693,000	$0	$2,134,000	$937,000	$20,926,000
X30 – JOE CREASON PARK	C, R4, P	$1,622,000	$571,000	$11,914,000	$0	$2,245,000	$960,000	$17,312,000
X33 – MSD BASIN	H2	$687,000	$0	$245,000	$0	$56,000	$20,000	$1,009,000
X34 – CHEROKEE PARK	C, R2, P	$6,492,000	$183,000	$10,740,000	$0	$1,975,000	$862,000	$20,252,000
X35 – MUDDY FORK &	C, R2, H2	$564,000	$283,000	$5,541,000	$0	$1,050,000	$447,000	$7,884,000
X38 – CAVE HILL CORRIDOR	R2, H2	$124,000	$230,000	$6,665,000	$0	$1,223,000	$535,000	$8,777,000
		$26,980,000	$3,266,000	$92,886,000	$600,000	$17,244,000	$7,089,000	$148,065,000

NOTE Costs are presented in FY22 price levels. Costs represent calculations made at the time of the CEICA

Table 21. Cost summary of the 12 alternatives included in the Tentatively Selected Plan

SITE	ALT	01 LANDS & DAMAGE	02 RELOCATIONS	06 FISH & WILDLIFE	18 CULTURA	30 PLANNING,	31 CONST. MNGT	TOTAL PROJECT FIRST COST
X2 – CONFLUENCE	C, R2, H2	$550,000	$118,000	$7,184,000	$0	$1,305,000	$576,000	$9,734,000
X10 – ALPACA FARMS	C, R2, P	$1,047,000	$127,000	$9,827,000	$0	$1,887,000	$794,000	$13,682,000
X19 – NEWBURG RD	C, R1, H2	$720,000	-	$1,986,000	$0	$399,000	$162,000	$3,267,000
X20 – BROWN PARK	C, R2, P	$312,000	$83,000	$2,845,000	$0	$553,000	$230,000	$4,023,000
X21 – ARTHUR DRAUGHT	C, R2, P	$308,000	$44,000	$2,840,000	$0	$552,000	$230,000	$3,973,000
X22 – CONCRETE CHANNEL	H2	$309,000	$151,000	$1,499,000	$0	$282,000	$121,000	$2,361,000
X29 – EASTERN/CREASON CONNECTOR	C, R4, P	$5,236,000	$925,000	$11,693,000	$0	$2,134,000	$937,000	$20,926,000
X30 – JOE CREASON PARK	C, R4, P	$1,622,000	$571,000	$11,914,000	$0	$2,245,000	$960,000	$17,312,000
X33 – MSD BASIN	H2	$687,000	-	$245,000	$0	$56,000	$20,000	$1,009,000
X34 – CHEROKEE PARK	C, R2, P	$6,492,000	$183,000	$10,740,000	$0	$1,975,000	$862,000	$20,252,000
X35 – MUDDY FORK & TRIBUTARIES	C, R2, H2	$564,000	$283,000	$5,541,000	$0	$1,050,000	$447,000	$7,884,000
X38 – CAVE HILL CORRIDOR	R2, H2	$124,000	$230,000	$6,665,000	$0	$1,223,000	$535,000	$8,777,000
		$17,970,000	$2,714,000	$72,980,000	$600,000	$13,661,000	$5,874,000	$113,799,000

NOTE Costs are presented in FY22 price levels. Costs represent calculations made at the time of the CEICA.

5.10 Comparison of Alternatives to Support TSP Selection and Designation of NER for Draft IFR

The overarching purpose of the USACE ecosystem restoration mission is "…to restore significant structure, function and dynamic processes that have been degraded" (ER 1165-2-501). This goal statement emphasizes that restoration plan formulation, evaluation, and selection should emphasize environmental outcomes. The Planning Guidance Notebook reinforces this issue by stating that plans should be selected to "reasonably maximize environmental benefits" (USACE 2000).

However, water resources projects often influence outcomes beyond their intended purpose. The 1983 Principles and Guidelines outlines four "accounts" related to National Economic Development, Regional Economic Development, Environmental Quality, and Other Social Effects (WRC 1983). USACE projects have often focused narrowly on one of these accounts as dictated by the Congressionally authorized purposes (e.g., a narrow focus on economic development for flood risk management or a narrow focus on environmental quality for restoration, James 2020). Recent USACE policies have directed teams "to ensure the USACE decision framework considers, in a comprehensive manner, the total benefits of project alternatives, including equal consideration of economic, environmental and social categories" (James 2021).

Sections 1-3 of this report have emphasized the Congressionally authorized purposes of the Beargrass Creek ecosystem restoration feasibility study. Proposed restoration actions have been justified through the lens of ecological benefits and costs. This chapter explores alternative approaches to decision-making that place greater emphasis on social outcomes and qualitative factors. Specifically, two methods are applied. First, a decision analysis is presented based on conducting CEICA relative to social factors alone. Second, a qualitative decision method is presented that compares sites to each other based on professional opinion (i.e., pairwise comparison). For both analyses, only the 14 restoration sites with proposed actions are included (Table 18 in section 5.5.2) with the assumption that the sites must first meet ecological objectives before addressing secondary outcomes.

5.11 Cost Effectiveness and Incremental Cost Analysis

The Beargrass Creek feasibility study ultimately recommends a suite of restoration actions at the watershed scale to address both riverine and riparian ecological degradation. Portfolio planning presents a technical challenge to restoration teams faced with examining thousands, millions, or billions of potential combinations of actions. For instance, all combinations of restoration actions at the 14 remaining sites produces 2.9510^ {15} combinations of actions. Even a reduced analysis examining only best buy actions produces 89,579,520 combinations. These logistical and computational realities often lead to simplifying assumptions associated with portfolio analysis at a watershed-scale.

For this study, a "winners compete" approach to CEICA was used, which examines all combinations of site-scale recommendations. The benefit of this method is that it preserves the nuanced thinking about alternatives at the site-scale, which may be obscured at the watershed-scale. This technique also provides a numerically feasible set of plans. The drawback of this approach is that is does not comprehensively search the full range of possible plans. However, the qualitative factors involved in site-scale decision making were deemed more important than searching a larger number of watershed plans.

The recommendations at the 14 remaining sites were combined into 16,384 watershed plans. Ecological outcomes and monetary costs were computed for each plan as the sum of site-scale benefits. Plans range widely in investment cost and ecological benefit (i.e., $0-147.6M and 0-352 AAHUs). These plans were subjected to CEICA to identify efficient and effective portfolios of actions (Figure 49). This analysis identified 133 cost-effective plans and 15 best buy plans at the watershed-scale. Incremental unit cost increases from $0-34,300 / AAHU with increasing investment (

Table 22).

Project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%.

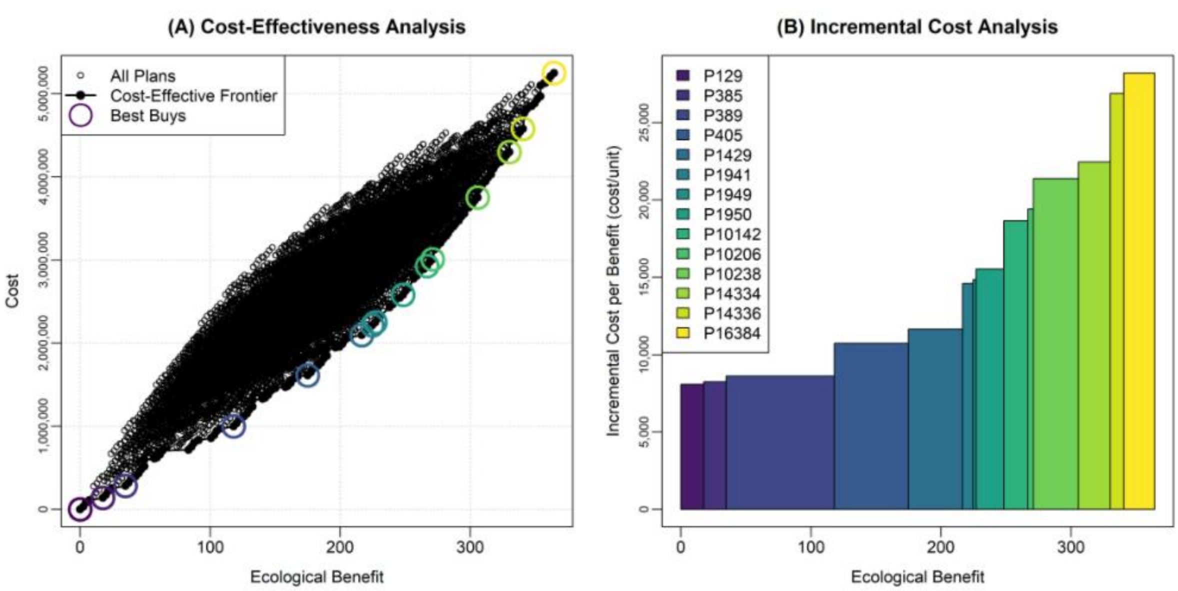

Figure 49. Cost Effectiveness and Incremental Cost Analysis results for the watershed analysis

USACE policy specifies that restoration plan selection should seek to “reasonably maximize environmental benefits” (USACE 2000). As described in Section 5.14, CEICA results were interpreted through five main lenses: the degree to which a plan has met planning objectives, increasing marginal cost, overall unit cost, affordability, and qualitative decision factors not captured in cost and benefit estimates. For Beargrass Creek, six “best buy” watershed-scale plans were identified as an initial decision array (See Appendix B for data).

- *Plan 10142 (X2 + X10 + X19 + X20 + X21 + X30 + X33 + X34 + X38)*: This plan includes actions at nine restoration sites in the Middle and South Fork. The plan has low overall unit cost ($11,000/AAHU). This plan incorporates actions at X2 at the confluence of the three forks, which is an extremely high visibility location with important ecologically connectivity to South, Middle, and Muddy Fork. This plan is the smallest plan that is ecologically and socially acceptable.
- *Plan 10206 (X2 + X10 + X19 + X20 + X21 + X22 + X30 + X33 + X34 + X38)*: This plan incorporates small-scale actions along X22, which is a centrally located concrete channel near downtown Louisville. Ecological models are likely to be undervaluing the benefit of restoration actions in this extremely degraded system. The overall unit cost remains very low ($11,100/AAHU), and the incremental unit cost is very similar to the prior plan ($19,400/AAHU). This plan provides 74% of the potential ecological benefits in the watershed at 57% of the investment cost, indicating an efficient investment. The site is of high social importance, and the site has been a focal point for river revitalization plans associated with the Congress on New Urbanism.
- *Plan 10238 (X2 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X38)*: This plan adds X29 to the recommendation. Ecological benefits increase significantly from this action (34 AAHUs). The increase in overall and incremental unit cost is deemed “worth the investment” at this location, particularly considering significant ecological benefits. X29 is near X30, so the inclusion of this site is likely to have synergistic ecological effects not accounted for in analyses. This site also has known stakeholder interest, willing landowners, and the potential for complementary actions by other entities. The plan also crosses thresholds in ecological benefits and project first cost (i.e., it is less the first plan greater than 300 AAHUs and $100M).
- *Plan 14334 (X2 + X4 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X38)*: This plan adds restoration actions at site X4, which increases the total ecological benefit above 300 AAHUs. This site is at an educational institution and likely provides opportunities relative to education and site maintenance. The site occurs in a portion of the watershed not reached by other sites, and thus, this site reaches a different segment of the community.
- *Plan 14336 (X2 + X4 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X35 + X38)*: This plan incorporates actions at X35, which represents the only site on the Muddy Fork. This plan occurs at a threshold in incremental unit cost (i.e., Plan 14334 was $22,400/AAHU). This plan is the largest plan that is worth the investment cost.
- *Plan 16384 (X2 + X4 + X8 + X10 + X19 + X20 + X21 + X22 + X29 + X30 + X33 + X34 + X35 + X38)*: This plan includes all sites with recommended actions by incorporating X8. Only minor riverine actions were considered at this site because of the quality of existing instream conditions and the constraint of an onsite dam. This action is not deemed “worth the investment” considering these constraints relative to increased incremental unit cost.

Table 22. Costs and habitat units for the watershed scale alternatives

Plan Name	Plan Description	Average Annual Cost ($000)	Output (Average Annual Habitat Units)
P1	Default No Action Plan	0	0
P129	X21	140.75	17.414
P385	X20, X21	283.28	34.702
P389	X20, X21, X34	1000.95	117.93
P405	X20, X21, X30, X34	1614.14	175.027
P1429	X10, X20, X21, X30, X34	2098.75	216.586
P1941	X10, X19, X20, X21, X30, X34	2214.43	224.512
P1949	X10, X19, X20, X21, X30, X33, X34	2250.17	226.917
P1950	X2, X10, X19, X20, X21, X30, X33, X34	2594.92	245.392
P10142	X2, X10, X19, X20, X21, X22, X30, X33, X34	2678.54	249.698
P10206	X2, X10, X19, X20, X21, X22, X29, X30, X33, X34	3419.79	284.355
P10238	X2, X4, X10, X19, X20, X21, X22, X29, X30, X33, X34,	3968.54	308.807
P14334	X2, X4, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35	4247.82	319.196
P14336	X2, X4, X8, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35	4917.98	342.959
P16384	X2, X4, X8, X10, X19, X20, X21, X22, X29, X30, X33, X34, X35, X38	5228.86	352.028

This initial decision array was narrowed to a range of watershed plans bracketed by Plan 10142 and Plan 14336. Figure 50. below shows a summary of best buy plans. A full list of cost-effective plans analyzed can be found in Appendix B.

The addition of X22 (Plan 10206) was identified as an important USACE-MSD contribution to a high visibility restoration priority for the region. Adding X29 (Plan 10238) provides significant ecological benefits both in quantitative and qualitative terms via 34 AAHUs and connectivity to Site-X30, respectively. This set of 11 sites represent a large amount of ecological lift (305 AAHUs) that are incrementally justified, but these sites do not include actions on all three branches of Beargrass Creek (i.e., Muddy Fork is absent). X4 is somewhat distantly located on the Middle Fork and does not represent a known priority for local partners. X35 incorporates actions on the Muddy Fork and provides hydrologic benefits anticipated to benefit other sections of the stream.

Given this context, a cost-effective plan was identified that includes all actions in Plan 10238 along with site-X35. Plan 10240 addresses major sources of ecological degradation throughout the watershed and efficiently obtains ecological benefits at a low unit cost ($12,800/AAHU). The incremental unit cost from P10238 to P14334 (the next best buy) would have been $22,400, and the incremental unit cost from P10238 to P10240 (the TSP) is $26,900. The added value of incorporating all Three Forks of Beargrass Creek is deemed worth this increase incremental unit cost.

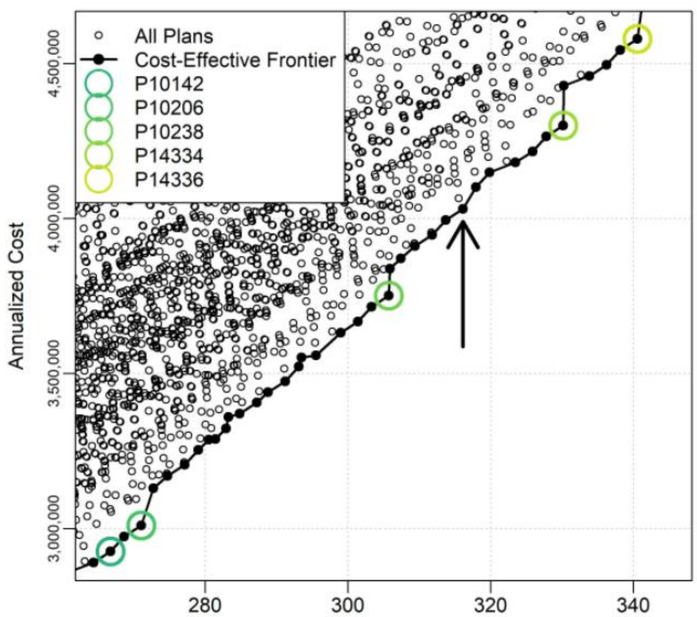

Figure 50. Cost Effective Tentatively Selected Plan

5.12 Other Decision Criteria Analysis

Water resource management inherently affects a variety of economic, environmental, and social factors. Social outcomes are often particularly important in urban environments with higher population density. Regardless of location, OSEs are playing an increasingly prominent role in USACE decisions nationwide with diverse examples such as ecosystem restoration in the Hudson-Raritan Estuary, New York / New Jersey, flood risk management in Princeville, North Carolina, and coastal erosion in Barrow, Alaska. This analysis explores decision-making in Beargrass Creek assuming that social factors are the primary decision criteria. This extreme approach gives primacy to social factors over environmental outcomes and ignores the USACE restoration mission goals, but it also provides an avenue for examining the reliability of decisions. For instance, are the same sites recommended based on both environmental and social outcomes? Are some sites “worth the investment” socially but not environmentally or vice versa?

Social concepts and processes can be examined through a wide variety of indicators (Dunning and Durden 2007, Durden and Wegner-Johnson 2013, Hicks et al. 2016). In this study, OSEs were assessed using semi-quantitative metrics relative to four categories of outcomes related to logistics, economics, social factors, and technical issues used in agency budgeting. The logic of each factor is described below in more detail. Each category was assessed using a consistent constructed scale of 0 to 20, where 0 is undesirable and 20 is desirable. While a more empirical approach would be preferred (e.g., a stakeholder survey indicating community support), these simple scoring metrics have been used effectively to distinguish outcomes in other USACE projects (McKay et al. *in review*). Each metric was scored for the recommended alternative at the 14 remaining sites (data in Appendix B). The raw data were summed for each category and normalized from 0 to 1 for consistent comparison across categories (Table 23).

- *Logistics*: Social factors often inhibit the execution of restoration projects. This category addresses logistical factors that can slow down (or eliminate) restoration plans at a given location such as real estate constraints, construction access, and Hazardous, Toxic and Radioactive Waste (HTRW) issues. While not strictly social “benefits”, the absence of these social factors is crucial to restoration success.
- *Economic Effects*: This category addresses potential economic benefits associated with restoration such as a site’s proximity to economic development corridors and employment opportunities. The effect of actions on flood levels were also incorporated into this category due to the potential for floods to inhibit economic development.
- *Social Outcomes*: This category assessed benefits of sites relative to community-oriented outcomes like visibility, equity, recreation and education, and stakeholder support.
- *Technical Significance for Budgeting*: USACE defines the significance of an ecosystem relative to institutional, public, and technical dimensions. Technical significance is also a crucial factor in determining the competitiveness of a USACE project in the budgeting process. Two criteria for budget prioritization were adapted as a qualitative metric of site significance (EC-11-2-206, USACE 2014).

Table 23: Other Social Effects scoring for the final array of alternatives

		OSE Criteria					
		Logistical	Economic	Social	Technical	Total	Normalized
Site	**Recommend Alt**	Real Estate, HTRW, Access	Employment/ Employment Potential, Flood impact	Recreation, Education, Environmental Justice, Visibility, Community	Connectivity, Scarcity		
X2-Confluence	R2H2	35	40	62	34	171	0.71
X4- AB Sawyer	CR4P	50	30	37	30	147	0.61
X8-HoustonAcres	P	40	19	42	13	114	0.46
X10-AlpacaFarm	CR2P	43	42	53	30	168	0.7
X19-NewburgRd	R1H2	41	33	48	19	141	0.59
X20-BrownPark	R2P	39	32	49	24	144	0.6
X21-DrautPark	R2P	33	42	45	24	144	0.6
X22-ConcreteChannel	H2	37	54	76	21	188	0.78
X29-EasternCreasonConnector	CR4P	31	40	59	31	161	0.67
X30-NaturePreserve	CR4P	54	44	57	31	186	0.78
X33- MSD Basin	H2	56	25	39	22	142	0.60
X34-CherokeePark	CR2P	46	50	53	30	179	0.74
X35-MuddyForkTrbs	CR2H2	33	23	43	23	122	0.51
X38- CaveHill	R2H2	37	34	57	25	153	0.64

5.13 Pairwise Comparison

Intangible benefits and costs are well-acknowledged challenges in decision-making (Saaty 2008), and recent USACE guidance explicitly acknowledges the potential importance of qualitative factors in agency choices (James 2020, James 2021). A spectrum of decision-making methods exists for comparing, combining, and synthesizing diverse information (Linkov et al. 2009), but USACE decisions tend to emphasize quantitative criteria and qualitative methods are infrequently applied. This section presents a qualitative decision-making technique, pairwise comparison, as a means to verifying and supporting more rigorous quantitative approaches shown earlier in this chapter.

At the simplest level, pairwise comparison is a dichotomous choice. Would you rather sit or stand? Is coffee or tea better? A sophisticated suite of methods exist for using pairwise choice to develop weights for multiple criteria (Saaty 2008). However, for this application, we use the simplest notion of directly comparing alternative restoration sites. Four project team members were presented with a pairwise choice experiment for each of the 14 sites with recommended action (Table 24). Team members represented different organization perspectives (e.g., project management, planning, and engineering) and different disciplinary backgrounds (biology, landscape architecture, engineering, economics). For each combination of sites, an analyst had to choose their preferred action considering assessed ecological benefits and costs as well as qualitative factors such as watershed position, known stakeholders support, and professional judgments of the efficacy of restoration actions. The number of pairwise "wins" provides a simple metric of the relative importance of a site. For instance, a site with 13 "wins" would indicate that the site is consistently preferred over all other sites. The average number of pairwise "wins" across the four team members was computed for each site.

Table 24. Example of the pairwise comparison process

Site	Name	Fork	X2	X4	X8	X10	X19	X20	X21	X22	X29	X30	X33	X34	X35	X38
X2	Confluence	South														
X4	Shelby Campus	Middle	X2													
X8	Houston Acre's Farm	South	X2	X8												
X10	Alpaca Farm / Zoo	South	X10	X10	X10											
X19	South Fork / Newburg Rd	South	X2	X19	X8	X10										
X20	Brown Park	Middle	X2	X20	X8	X10	X19									
X21	Arthur Draut Park	Middle	X2	X21	X8	X10	X21	X21								
X22	Concrete Channel	South	X22	X22	X22	X22	X22	X22	X22							
X29	Eastern / Creason Connector	South	X2	X29	X29	X29	X29	X29	X29	X22						
X30	Joe Creason Park	South	X30	X30	X30	X30	X30	X30	X30	X30	X30					
X33	MSD Basin	South	X2	X33	X33	X10	X19	X33	X33	X22	X29	X30				
X34	Cherokee / Seneca Parks	Middle	X34	X34	X34	X34	X34	X34	X34	X34	X34	X34	X34			
X35	Muddy Fork and Tribs	Muddy	X2	X35	X35	X10	X35	X35	X35	X22	X29	X30	X35	X34		
X38	Cave Hill Corridor	Middle	X2	X38	X38	X10	X38	X38	X38	X22	X38	X30	X38	X34	X38	
Number of Pairwise "Wins"			9	0	4	9	3	1	3	11	8	12	4	13	6	8

The results of the pairwise comparisons clearly distinguish between sites (Table 24). Five sites were consistently preferred (X2, X22, X29, X30, and X34). Conversely, four sites were consistently not represented in preferences (X4, X8, X20, and X33).

These results largely confirm prior analyses from CEICA with ecological and social inputs. The rank order of sites from the three methods were used as a consistent scale for comparing these analyses. Some sites effectively meet ecological objectives but underperform in social and intangible factors (e.g., X20). Whereas other sites may not provide ecological benefits as efficiently, but they are enormously important socially (e.g., X2). The average rank across these three diverse assessments provides a simple assessment of the general level of expected outcomes. For instance, X34 is a large-scale restoration project in the high-profile location of Cherokee and Seneca Parks, and this site is identified by all three analyses as crucial. Conversely, sites X4 and X8 are ranked low in all three analyses.

5.14 National Ecosystem Restoration (NER) Plan

After completion of all analysis and screening and application of decision criteria, the PDT selected Plan 10240. This watershed-scale plan includes 12 restoration sites at the confluence of the Three Forks (x2), Alpaca Farm and Louisville Zoo (X10), Newburg Road (X19), Brown Park (X20), Arthur Draut Park (X21), a concrete channel near downtown Louisville (X22), the Eastern-Creason Connector (X29), Joe Creason Park (X30), a small MSD Basin (X33), Cherokee and Seneca Parks (X34), a neighborhood along the Muddy Fork (X35), and the Cave Hill Corridor (X38).

6.0 Evaluation of Alternative Plans and Environmental Consequences

A consequence, or effect (the terms “effects” and “impacts” may be used synonymously (40 C.F.R. § 1508.8)), is defined as a modification to the human or natural environment from the proposed action or alternatives that is reasonably foreseeable and has a reasonably close causal relationship to the proposed action or alternatives. Effects include those that occur at the same time and place as the proposed action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives

Effects may be temporary (short-term), long lasting (long-term), or permanent. Temporary effects are defined as those that would occur during construction of one of the alternatives. Long-term effects are defined as those that would extend from the end of the construction period through some point within the project life cycle. Permanent effects are assumed to be present throughout the period of analysis.

This section evaluates the environmental effects of the no action alternative and the action alternatives. The environmental conditions for each resource are compared with future conditions for each alternative plan. Both beneficial and adverse effects are considered, including direct effects during construction and operation and indirect effects of restoration under each of the proposed alternatives along with related actions.

For this NEPA analysis, the 14 site-specific options were grouped according to the ecological issue they were designed to address. The four groups are as follows:

- Connectivity of Riverine Habitats
- Riverine Habitat Restoration
- Riparian Hydrology Restoration
- Native Plant Community Restoration

See Section 4.5.3 of this report for details of what measure each of these restoration efforts entails.

The following alternatives include features to restore riverine connectivity:

- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)
- Alternative 12 (X35 – Muddy Fork Tribs- CR2H2)

The following alternatives include features to restore riverine habitat:

- Alternative 1 (X2 Confluence- R2H2)
- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 5 (X19 - Newburg Rd- R1H2)
- Alternative 6 (X20/X21 – Brown and Draut Park- R2P)

- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)
- Alternative 12 (X35 – Muddy Fork Tribs- CR2H2)
- Alternative 13 (X38 – Cave Hill- R2H2)

The following alternatives include features to restore riparian hydrology:

- Alternative 1 (X2 Confluence- R2H2)
- Alternative 5 (X19 - Newburg Rd- R1H2)
- Alternative 12 (X35 – Muddy Fork Tribs- CR2H2)
- Alternative 13 (X38 – Cave Hill- R2H2)

The following alternatives include features to restore native plant communities:

- Alternative 2 (X4 – Shelby Campus/AB Sawyer- CR4P)
- Alternative 4 (X10 - Alpaca Farm- CR2P)
- Alternative 6 (X20/X21 – Brown and Draut Park- R2P)
- Alternative 8 (X29 - Eastern Creason Connector- CR4P)
- Alternative 9 (X30 - Nature Preserve- CR4P)
- Alternative 11 (X34 – Cherokee and Seneca Park- CR2P)

6.1 Geology, Seismology, and Soils

6.1.1 Connectivity of Riverine Habitats (C)

Implementation of alternatives intended to address longitudinal connectivity of streams would have no significant or long-term impact on the geology, seismology, or soils within the study area. Construction activities associated with implementing the Action Alternatives would be expected to have minor and insignificant effects to soils in the immediate site areas. The current channel alignment, hydraulic, and geomorphic conditions would be maintained by reestablishing connectivity, and no significant long-term impacts to soils would be expected. Construction best management practices (BMPs) would be implemented to minimize soil loss from erosion induced by construction activities. These would include silt fences, coir logs, grass mats, and construction mats and work pads if necessary.

6.1.2 Riverine Habitat Restoration (R1, R2, R4)

Implementation of alternatives intended to restore instream riverine habitat only (R1) would have no impact on the geology or seismology within the study area. These alternatives would be expected to have temporary, minor, and insignificant effects to soils in the immediate site area, as the alternative design would maintain the current channel alignment, hydraulic and geomorphic conditions. Alternatives that include more intensive restoration measures, such as bank grading and channel realignment (R2 and R4) would not have a significant impact on study area topography or underlying geology. Restoration measures under these alternatives do not propose to alter or modify distinct topographic or geologic landforms in the study area. Regrading of channel banks would result in slight changes in topography, but these changes are within the already modified topography of the stream channel.

Ground-disturbing activities during construction could result in soil erosion, or loss of topsoil in areas both within the channel itself and on upland areas above the channel. Under these, ground-disturbing activities that may occur include:

- Demolition and excavation of concrete and earthen material for the construction of side channels,
- Demolition of channel walls and excavation of overbank areas at storm drain outlets for daylighting and wetland habitat creation,
- Widening of channel bed and top of banks via excavation and grading of earthen material,
- Use of heavy equipment for hauling away of concrete debris and excavated material, and
- Excavation for topsoil fill and vegetation establishment on side slopes of maintenance roads and channel.

Disturbances to soil in all areas would be controlled through a suite of erosion control measures designed for construction activities. The extent of ground disturbance would be minimized prior to construction by identifying the minimum required area for staging and access routes. Staging areas and access routes would consider existing conditions and would be located where soils are not already exposed or where disturbance has already occurred. Industrial districts, parking lots, and undeveloped ruderal areas would provide the best locations. Some lands intended for ecosystem restoration may also be used for staging areas prior to construction of features on those sites. Areas that have aesthetic, recreational, open space or habitat value would be avoided to the extent possible.

During construction, areas that would be disturbed within the study footprint, at staging locations, and along hauling routes would be evaluated to determine where erosion control measures would be necessary. These controls would include BMPs such as (1) the placement of straw bales or other filters that prevent soils from moving off-site during precipitation events, (2) placement of mulch or chemical stabilizers, and/or use of watering trucks where dry conditions could result in creation of fugitive dust, (3) identification of suitable locations for deposit of excavation spoils, and (4) minimization of number of truck trips or hauling distances, among others. Following construction efforts, disturbed ground would be restored with native plantings to stabilize exposed areas and return the site to aesthetically suitable conditions.

Because of these BMPs, implementation of these alternatives would result in long-term positive impacts to soils within the study area. Through the reestablishing natural flow regimes and the natural process of cut and fill alluviation, down cutting and excessive scour of streambanks would be eliminated and would lessen the erosion of soils.

6.1.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives intended to restore riparian hydrology of streams would not have a significant impact on study area topography or underlying geology. Restoration measures under these alternatives do not propose to alter or modify distinct topographic or geologic landforms in the study area. Excavation for creation of swales and regrading activities would result in slight changes in topography, but these changes are within the already modified topography of the stream channel. Implementation of these alternatives would result in long-term positive impacts to soils within the study area. Restoration of the natural hydrology with the riparian zones of these stream reaches would act to restore soils by reestablishing natural nutrient and water cycles, and further diversification of native plant assemblages. These alternatives would facilitate the return of natural soil structure and health. All appropriate construction BMPs would be implemented to minimize disturbances to soils from construction activities.

6.1.4 Native Plant Community Restoration (P)

Implementation of alternatives intended to restore the native riparian plant communities would have no impact on the geology or seismology within the study area. Implementation of these alternatives would have long-term beneficial effects to soils within the study areas. Reestablishment of healthy native plant communities act to reduce erosion of soils and cultivate a healthy microbiome within the soils that better facilitate native plant growth. Any soil disturbance caused during implementation would be minimized be use of erosion control BMPs mentioned above.

6.1.5 No Action Alternative

Under the No Action Alternative, topography and geology, soils, and seismic hazards would not be affected by construction activities since no construction would occur under this alternative. Topographic and geologic features, such as basin sediment in-fill and subsequent aggradation would persist indefinitely, subject to weathering and possibly by other effects.

Soils would continue to be eroded and deposited from fluvial processes. Soil erosion in the headwaters of the watershed would continue to result in the transport and deposition of sediment along the soft bed channel sections of the study area.

6.2 Air Quality

6.2.1 Connectivity of Riverine Habitats (C)

Machinery and equipment employed for the construction of these alternatives would release emissions, including greenhouse gases. Equipment such as dump trucks and front-end loaders would have mufflers and exhaust systems in accordance with state and federal standards. The potential impacts on air quality from construction activities would be from particular matter (PM) (fugitive dust) and emissions from vehicle exhaust generated from earth-moving operations during construction. Overall, adverse impacts from construction would be localized, minor, and temporary. If dust generated at the work sites is deemed to be a potential problem, water will be used for dust control from earthwork activities.

Emissions from the proposed construction activity would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. Though Jefferson County did not meet air quality standards for sulfur dioxide and 8-hour ozone, the proposed work is not expected to affect air quality compliance. For these reasons, implementation of alternatives intended to address longitudinal connectivity of streams would have no significant or long-term impact to air quality.

The following is a list of recommendations to attenuate air quality impacts. The recommendations, modified as appropriate, would be implemented for construction activities.

Mobile Emission Attenuating Measures:

- Provide temporary traffic controls such as a flag person, during all phases of construction to maintain smooth traffic flow.
- Provide dedicated turn lanes for movement of construction trucks and equipment on- and off-site.
- Reroute construction trucks away from congested streets or sensitive receptor areas.
- Utilize electricity from power poles rather than temporary diesel or gasoline power generators to the extent practicable.

Fugitive Dust Attenuating Measures:

- Suspend all excavating and grading operations when wind speeds (as instantaneous gusts) 22 exceed 25 miles per hour.
- Require frequent street sweeping surrounding the study site to minimize fugitive dust emissions from track-out.
- Install wheel washers where vehicles enter and exit the construction site onto paved roads or wash off trucks and any equipment leaving the site each trip.
- Apply water three times daily, or non-toxic soil stabilizers according to manufacturer's specifications, to all unpaved parking or staging areas or unpaved road surfaces.
- Replace ground cover in disturbed areas as quickly as possible.
- Apply non-toxic soil stabilizers according to manufacturers' specifications to all inactive construction areas (previously graded areas inactive for ten days or more).

6.2.2 Riverine Habitat Restoration (R1, R2, R4)

Implementation of alternatives intended to restore instream riverine habitat would result in similar impacts as those of the connectivity alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives intended to restore riparian hydrology would result in similar impacts as those of the connectivity and riverine habitat alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.4 Native Plant Community Restoration (P)

Implementation of alternatives intended to restore native plant communities would result in similar impacts as those of the connectivity and riverine habitat alternatives. Emissions from the proposed construction would be exempted as *de minimis*, and therefore would meet the General Conformity Criteria pursuant to Section 107 of the Clean Air Act, as amended. The proposed work is not expected to affect air quality compliance and would have no significant or long-term impact to air quality.

6.2.5 No Action Alternative

There would be no construction related or operational air emissions under the No Action Alternative since no construction would occur.

6.3 Land Use

6.3.1 Connectivity of Riverine Habitats (C)

Alternatives implemented to address connectivity of riverine habitat would not result in changes to future land use, as work would be contained within the stream. Alternatives that include restoring connectivity would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. All sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives implemented to restore riverine habitat would not result in changes to future land use, as work would be contained within the stream or in the immediate riparian zone, adjacent to the stream. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. All sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.3 Riparian Hydrology Restoration (H2)

Implementing alternatives focused on restoring riparian hydrology would not result in changes to future land use, as work would occur in undeveloped stream floodplains. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. All sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.4 Native Plant Community Restoration (P)

Implementing alternatives focused on restoring plant communities would not result in changes to future land use, as work would occur in undeveloped stream floodplains. These alternatives would not encumber services or opportunities, and there would likely be no change in the land use of adjacent properties. All sites selected for restoration would have to remain as such in perpetuity, so restoring the sites would also protect them from any future development efforts.

6.3.5 No Action Alternative

Under the No Action Alternative, no construction efforts would be undertaken and no significant impacts to land use would be expected. Future land use would continue to be regulated and guided via Federal, state, regional, and local guidance, general plans, master planning, ordinances, and land use zoning plans. Land use zoning is expected to remain the same without implementation of restoration. Industrial, commercial, and residential areas would continue to occupy their current extent, or changes in zoning would be controlled via jurisdictional guidance. Continued deterioration of land use conditions could occur if parcels not utilized for restoration, such as privately owned lots or undeveloped parcels are not rehabilitated or restored independently.

Open space, parks, and recreation would continue to be limited in the study area. Non-Federal actions to introduce parks or conduct small scale restoration would incrementally increase recreational land use value to the area, but would occur slowly, incurring only minimal benefits to land use.

6.4 Water Resources

6.4.1 Connectivity of Riverine Habitats (C)

The purpose of these alternatives is to eliminate fragmentation points within the stream channels to improve the dispersal ability of aquatic species. Structures or features generally causing this fragmentation can include perched culverts, bridge abutments, structure footings, weirs, cross channel pipes, foreign debris jams, online detention basins, or piped reaches. While removal or modification of these structures would act to restore habitat and animal movement, it would not result in significant impacts to surface or groundwater resources. The installation of riffle features in place of an existing structure could act to oxygenate the water and improve dissolved oxygen concentration, which is critical for aquatic organisms.

Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 5.1.2.

During construction, hydrologic features would not be adversely affected. It is assumed that instream construction and modification of the study reaches would be conducted primarily in dry weather months (April 15 – October 31) to avoid wet weather storm flows, or that work areas would be adequately protected and not affect flood conveyance. In areas where instream construction would occur, diversions would be implemented to bypass dry weather flows downstream. Some areas may require dewatering during construction. Base flows supportive of beneficial uses, which protect aquatic life and human uses, may be temporarily affected in the immediate construction zone, but would not be affected upstream or downstream of the study area.

Under these alternatives, modifications to the channel will not increase the maximum water surface elevation. Under these alternatives, modifications to the channel are not expected to result in substantial changes to water velocity and circulation. During the next detailed design phase, restoration measures will be further designed to not impair flood risk management functions in any portion of the study area or areas downstream. Additional hydraulic analysis will be conducted, and design modifications will be implemented during the design phase to provide more detail on the channel hydraulics with the TSP in place. Under all the alternatives and with implementation of such design refinements, there will be no increase in flood damages through the study area as compared to existing conditions. Impacts would be less than significant.

Implementation of these alternatives would not be expected to significantly impact groundwater resources.

Implementation of BMPs would be guided through permitting, certification, and plan development. The proposed erosion control measures, would include, but are not be limited to, the following:

- Limiting most in-channel construction to the low-flow period between April 15 and October 31 to minimize soil erosion.

- Require the construction contractor to prepare a storm water pollution prevention plan (SWPPP) consistent with the USEPA's 2017 NPDES Construction General Permit. At a minimum, the SWPPP would include the following elements:

    - Work areas, staging areas, or stockpile areas that could be subject to erosion during storm events would be stabilized with erosion control measures as appropriate. These measures could typically include silt fencing, straw bales, sandbags, filter fabric, coir rolls or wattles.
    - Erosion control methods used to prevent siltation would be monitored weekly and maintained as needed.
    - Stabilize and reseed disturbed upland areas with native grasses, shrubs, and trees upon completion of construction.
    - Stationary equipment such as motors, pumps, generators and welders located within or adjacent to the channel or basin will be positioned over drip pans.
    - Any equipment or vehicles driven and/or operated within or adjacent to the channel or basin should be checked and maintained daily, to prevent leaks. All maintenance will occur in a designated offsite area. The designated area will include a drain pan or drop cloth and absorbent material to clean up spills.
    - Fueling and equipment maintenance will be done in a designated area removed from the area of the channel or basin such that no petroleum products or other pollutants from the equipment may enter these areas via rainfall or runoff. The designated area will include a drain pan or drop cloth and absorbent materials to clean up spills.
    - Materials for the containment of spills (i.e., absorbent materials, silt fencing, filter fabric, coir rolls) will be identified and be available onsite prior to commencement of construction or maintenance activities.
    - Any accidental spill of hydrocarbons or coolant that may occur within the work area will be cleaned immediately. Absorbent materials will be maintained within the work area for this purpose.
    - No wet concrete product will come into contact with any flowing or standing water at any time. Areas where raw cement or grout are applied or where concrete curing or finishing operations are conducted will be separated from any ponded or diverted water

flows by a cofferdam or silt-free, exclusionary fencing. All equipment involved with the concrete or grouting operations will be located within a contained area while using any slurry or concrete product. A protective berm or other structure will be in place prior to maintenance and/or repair activities.

- Any spill of the grout, concrete, concrete curing or wash water adjacent to or within 45 feet of the work area will be removed immediately.

6.4.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives that include restoration of instream habitat only (R1) would maintain the current channel alignment, hydraulic and geomorphic conditions while placing low-profile riffle, slab rock, boulder, cobble and large woody debris structural habitats. Like the connectivity alternatives, this would improve habitat, but would not be expected to result in any long-term significant impacts to surface or groundwater quality.

Alternatives that include more intensive riverine habitat restoration techniques (R2 and R4) would be expected to have greater impacts from construction activities through increases in turbidity and suspended solids due the amount in required earthwork. However, these adverse impacts would be minimized by implementing BMPs designed to address soil erosion and protect water quality as detailed in Section 6.1.2 to ensure they are temporary and insignificant.

None of the alternatives that include restoration of instream habitat would increase the maximum water surface elevation and would not increase flood damages in the study area as compared to existing conditions. As with all alternatives, these restoration measures will be further designed to not impair flood risk management functions in any portion of the study area or areas downstream during the next detailed design phase.

Implementation of these alternatives would not be expected to significantly impact groundwater resources.

6.4.3 Riparian Hydrology Restoration (H2)

Implementation of alternatives to restore riparian hydrology would result in new acres of riparian and wetland habitat within the watershed and would provide additional filtration of stormwater entering the system. The restored habitat would be expected provide benefits by helping to provide biological and chemical removal of constituents that contribute to the stream’s impairment, including nitrate, ammonia, phosphorus, suspended solids, bacteria, fecal coliform, and nutrients. Improved riparian and wetland vegetation would combine to increase shading of the river, which may reduce microclimate temperatures, which in turn would allow for increased dissolved oxygen levels.

Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 6.1.2.

Groundwater benefits from these alternatives would include increased groundwater infiltration and recharge for future water uses, though these benefits would likely not be significant.

6.4.4 Native Plant Community Restoration (P)

Healthy riparian plant communities play an important role in protecting streams from nonpoint source pollutants and in improving the quality of degraded stream water. Riparian vegetation influences stream water chemistry through diverse processes including direct chemical uptake and indirect influences such as by supply of organic matter to soils and channels, modification of water movement, and stabilization of soil (Dosskey et al. 2010). Removal of invasive plant species and restoration of native vegetation along the Three Forks of Beargrass Creek would result in a long-term beneficial impact to surface water resources. Groundwater benefits from these alternatives would include increased groundwater infiltration and recharge for future water uses, though these benefits would likely not be significant.

Construction activities required to implement these alternatives could result in short-term, insignificant adverse impacts to surface water quality through increases in turbidity and suspended solids from soil disturbance. These impacts would be minimized by implementing BMPs designed to address soil loss as detailed in Section 6.1.2.

6.4.5 No Action Alternative

Hydrologic, water quality, and groundwater conditions within the study area will continue changing based on population pressures, new and continuing regulations, and future climate conditions. The hydrologic regime in the study area will continue to be characteristic of urban environments with high peak flows and short durations, with resultant peaks in pollutants that quickly dissipate to normal levels. Although increased population density and impervious areas within the watershed, upstream of and on tributaries within the study area, could potentially increase these conditions, measures within the local, state, and federal permits are designed to curtail this potential. However, Beargrass Creek is an urbanized and degraded system, and due to pollution impacts from the urban and industrial land use activities located in the watershed, water quality problems will likely persist at measurable levels. Current climate change studies have indicated a likely increase in the frequency of extreme weather conditions in the future. These extreme weather events could compound and increase watershed peak flows.

6.5 Biological Resources

Impacts to biological resources would result from temporary construction efforts and construction of new habitat features. Impacts may include those to vegetation or wildlife resulting from site preparation, grading, bank lowering, channel widening, removal of concrete, excavation of swales, riverside plantings, removal or alteration of existing structures, and construction of new connections to water sources. The magnitude of the disturbance would determine the significance of the impact to biological resources. However, most of the effects from the construction of the restoration measures proposed under the action alternatives would be highly beneficial to biological resources over the long term.

In this section, beneficial impacts are qualitatively described for the alternatives, while also providing the quantitative measure of restoration benefits in terms of Habitat Units (HUs). Additional details regarding the calculation of HUs are provided in Section 5.1.

6.5.1 Vegetation

6.5.1.1 Connectivity of Riverine Habitats (C)

Under these alternatives, added or modified features would be contained within the stream channel. Some existing vegetation may be disturbed during construction of features by creating access for machinery; however, native plants and especially mature native trees would be avoided to the extent practicable. Therefore, impacts to vegetation would be insignificant.

6.5.1.2 Riverine Habitat Restoration (R1, R2, R4)

During construction of alternatives to restore riverine habitat, existing native vegetation within the river channel and along the stream banks would be left in place to the extent practicable, with removal of invasive species throughout the project footprint. Some existing vegetation may be disturbed during construction of features adjacent to the stream channel, such as grading the streambanks.
Some portions of the study area have an abundance of non-native invasive vegetation. These invasive species may spread further where construction efforts disturb soils. Increased presence of invasive weed species reduces ecological diversity and minimizes habitat value. However, restoration designs specifically call for revegetation of disturbed areas with native plant species, including those areas disturbed during the construction period. Non-native infestations would be treated either mechanically or chemically after construction is complete. Construction of the restoration features and invasive species control would remove weedy and ornamental vegetation and replace it with native riparian and wetland habitat, which would be a benefit to the river ecosystem.

With the implementation of restoration measures, installation of native habitat, and control of invasive species, construction of these alternatives would not cause significant adverse impacts to vegetation. Any impacts would be minimal, localized, and short term, and would ultimately be beneficial after native habitats are restored.

6.5.1.3 Riparian Hydrology Restoration (H2)

Under these alternatives, some existing vegetation may be disturbed during construction of features, such as excavation of swales and contouring of the floodplain. Healthy native plant communities and mature trees would be avoided to the extent practicable. Native seed mixes suitable for wetlands and frequently flooded areas would be used to revegetate the study areas, resulting in a long-term beneficial impact to vegetation.

With the implementation of restoration measures, installation of native habitat, and control of invasive species, construction of these alternatives would not cause significant adverse impacts to vegetation. Any impacts would be minimal, localized, and short term, and would ultimately be beneficial after native habitats are restored.

6.5.1.4 Native Plant Community Restoration (P)

Alternatives that include restoration of healthy native plant communities (Alternatives 2, 3, 4, 6, 8, 9, and 11) would have direct and immediate positive, long-term impacts to the vegetative communities within the study sites. Restoration activities would entail removing invasive species, planting of native tree, shrub, and herbaceous species of local genotype at the study sites. Invasive plant species would be initially removed with any combination of clearing, grubbing, herbicide application, flooding, mowing and or prescribed burning. These Action Alternatives would provide a total of 299.6 average annual HUs.

6.5.1.5 No Action Alternative

While limited habitat exists within the study area, supporting some native plants and wildlife, under the No Action Alternative it is anticipated that non-native species will continue to invade, and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing habitat and ecological functions are extremely degraded. These degraded conditions would persist with implementation of the No Action Alternative.

Without consistent maintenance, native plant and wildlife diversity would continue to decline while existing habitats would be increasingly infested by non-native species. Non-native species do not provide adequate habitat to support a diverse population of fish and wildlife. Mechanical or chemical treatment would continue to be necessary as a means of maintaining native vegetation.

6.5.2 Wildlife

6.5.2.1 Connectivity of Riverine Habitats (C)

Construction activities under these alternatives may temporarily disturb wildlife within the study areas by removing vegetation, increasing noise levels, and increasing vibration levels. Wildlife is expected to vacate the study areas and find alternate habitat nearby during construction. Construction would take place in phases, and only be performed in limited portions of the study area at any given time. Much of the wildlife inhabiting the study area are urban adapted species that are acclimated to human presence, generally higher noise levels, and some level of disturbance. These species may adapt more readily to the type of disruptions that occur during construction. Wildlife is expected to re-colonize the construction areas after construction is complete. No significant adverse effects are expected to impact these commonly occurring wildlife species as a result of construction activities included in this alternative.

Wildlife movement within the study area may be disrupted during construction activities due to disturbance of vegetation, increased noise levels, and increased vibrations. Disturbance would be temporary and movement opportunities would be restored after and possibly improved by these alternatives once construction is complete.

6.5.2.2 Riverine Habitat Restoration (R1, R2, R4)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to commonly occurring wildlife species as a result of construction activities included in this alternative. Impacts to wildlife movement would be temporary and not significant, and overall, the project would be beneficial for wildlife species in the study area by restoring and expanding native habitat.

6.5.2.3 Riparian Hydrology Restoration (H2)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to impact commonly occurring wildlife species as a result of construction activities included in this alternative. However, restoration and expansion of native vegetation by the project would provide additional and improved wildlife habitat and result in a long-term beneficial impact to wildlife.

Opportunities for wildlife movement would be marginally improved in this alternative. These alternatives include restoration of historic riparian habitat adjacent to the stream corridors. The restored habitat will connect to other habitats currently existing within the riparian zone in several areas. By reestablishing natural riparian hydrology, key ecological processes may be restored such as a more natural disturbance regime, scour and deposition of sediment and vegetation, nutrient cycling, biotic interactions, and colonization of new habitat areas (Opperman et al. 2007), as well as improved wildlife movement between the river and floodplain.

6.5.2.4 Native Plant Community Restoration (P)

Impacts from construction of these alternatives to wildlife would be similar to those expected from the rest of the alternatives. No significant adverse effects are expected to impact these commonly occurring wildlife species as a result of construction activities included in this alternative. However, restoration and expansion of native vegetation by the project would provide additional and improved wildlife habitat and result in a long-term beneficial impact to wildlife.

6.5.2.5 No Action Alternative

Under the No Action Alternative, it is anticipated that non-native species will continue to invade, and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing degraded habitat and ecological functions would persist with implementation of the No Action Alternative.

6.5.3 Fish

6.5.3.1 Connectivity of Riverine Habitats (C)

Under these alternatives, construction activities in the river channel may result in disturbance to native fish through disturbance of habitat and invertebrate prey items, as well as through increased turbidity with potential sediment runoff into the river. Construction equipment working near the river has the potential to introduce sediment or pollutants into the water, although BMPs will be implemented to minimize this potential.

Fish may be exposed to suspended sediment concentrations during construction, which may cause clogging of the gills of fish in the immediate vicinity. It is expected that most fish would avoid the immediate construction area due to increased noise levels, turbidity, and oxygen depletion resulting from increased sediment load in the river. The proposed project will implement water quality BMPs during construction (BMPs are outlined 6.4.1) and will operate under applicable Federal and state permits, which would protect water quality and minimize impacts to fish. Any construction-related impacts to fish would be temporary and less than significant.

Barriers such as dams, perched culverts, cross channel pipes, etc. interrupt longitudinal connectivity and promote species isolation, thus affecting fish movements for reproduction, feeding and habitat colonization purposes, with potential genetic impoverishment and loss of population fractions, while possibly promoting the spread of invasive species (Falke and Gido, 2006). Improving the longitudinal connectivity of stream system should in turn reduce these pressures on native fish populations and result in long-term benefits to fishes by allowing upstream and downstream fish migration cycles to occur.

6.5.3.2 Riverine Habitat Restoration (R1, R2, R4)

Under these alternatives, construction activities would result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable Federal and state permits.

Restoration of riverine habitat would result in direct beneficial impacts to fish by providing refugia from high water velocities, increasing interstitial spaces for prey species, and providing ambush points for predatory fish. These alternatives would likely result in a local increase in species richness and abundance of native fish species through improved riverine hydraulics, reconnection of the river to the floodplain, and reestablishment of proper channel development, which is necessary for riverine species.

6.5.3.3 Riparian Hydrology Restoration (H2)

Under these alternatives, construction activities adjacent to the stream may result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable Federal and state permits.

The restored habitat would be expected to provide benefits to fish by facilitating biological and chemical removal of constituents that contribute to the stream’s impairment. These alternatives would result in long-term beneficial Impacts to fish.

6.5.3.4 Native Plant Community Restoration (P)

Under these alternatives, construction activities adjacent to the stream, such as clearing and grubbing may result in temporary and minor impacts to fish, similar to those of the connectivity alternatives. Impacts would also be minimized by utilizing the same BMPs and operating under applicable Federal and state permits.

A restored riparian plant community can protect streams from nonpoint source pollutants and improve the quality of degraded stream water. Removal of invasive plant species and restoration of native vegetation along the Three Forks of Beargrass Creek would result in a long-term beneficial impact to fish through improved water quality. Improved riparian vegetation would also increase shading of the river, which may reduce microclimate temperatures, allow for increased dissolved oxygen levels, and therefore, become more inhabitable by native fish species.

6.5.3.5 No Action Alternative

Fish communities within the Three Forks of Beargrass Creek have been greatly impacted from the adverse effects to the stream from surrounding urbanization. Poor water quality and decreased habitat quantity and quality have contributed to the decline in health of the stream's fish communities. Under the No Action Alternative, the continued degradation of water quality and habitat would be expected to persist into the foreseeable future.

6.5.4 Special Status Species

6.5.4.1 Connectivity of Riverine Habitats (C)

The only listed species that may potentially occur within the study site are the gray bat, Indiana bat, northern long-eared bat, and running buffalo clover. No roosting locations for the bats are known within the watershed, but Indiana bats and northern long-eared bats may utilize riparian trees along the stream for roosting in the summer months.

The removal of trees greater than three inches diameter at breast height (DBH) would be avoided during construction activities to eliminate the potential for disturbing roosting habitat. Implementation of alternatives that restore the connectivity of riverine habitat would have no effect on the gray bat, Indiana bat, or northern long-eared bat.

Running buffalo clover grows in partially shaded woodlands along streams. Although this species is not currently known to occur at any of the study sites, there is a possibility it exists. Once areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted from construction activities. For this reason, implementation of alternatives to restore the connectivity of riverine habitat would have no effect on running buffalo clover.

There would be no effect to designated critical habitats as there are none in any of the study areas.

6.5.4.2 Riverine Habitat Restoration (R1, R2, R4)

Alternatives implemented to restore riverine habitat would benefit endangered and threatened species if they were to colonize the study site. Restoration features would directly increase the quality of the habitat present within the Beargrass Creek watershed, which could potentially encourage colonization of the area by special status species such as the Indiana bat, northern long-eared bat, and gray bat.

Given the highly mobile nature of these bat species, a restriction on tree removal between April 1 through October 31 would be imposed to reduce any potential for harm to maternal roosts. While direct impacts to these species would be limited by these tree clearing restrictions, the loss of potential habitat from project construction could affect bat species. For this reason, the USACE has concluded that alternatives to restore riverine habitat may affect, but are not likely to adversely affect the Indiana bat, northern long-eared bat, and gray bat. Once implemented, alternatives to restore riverine habitat would be expected to result in long-term benefits to these species by improving the drinking water sources and the increasing the abundance of aquatic emergent insects as a source of food.

Once areas of disturbance are identified in the design phase of this project, surveys will be completed to ensure running buffalo clover is not impacted from construction activities. For this reason, implementation of alternatives to restore riverine habitat would have no effect on running buffalo clover.

6.5.4.3 Riparian Hydrology Restoration (H2)

Construction activities associated with implementation of alternatives to restore riparian hydrology would have similar impacts to listed species as those alternatives to restore riverine habitat. The same tree removal restrictions would also be implemented for protection of maternal roosts, but an initial loss of habitat may occur during construction from tree removal. Long-term effects to the species are expected to be positive due to an increase in the quality and quantity of riparian habitat and the potential increase in emergent aquatic insects from the creation of wetlands. For these reasons, the USACE has determined that alternatives to restore riparian hydrology may affect, but are not likely to adversely affect the Indiana bat, northern long-eared bat, and gray bat.

Pre-construction surveys for the presence of running buffalo clover would be performed to ensure any no impacts to this species. Additionally, native herbaceous seed mixes that include running buffalo clover would be used for the restoration of disturb areas outside of wetlands. For these reasons, the USACE has determined that alternatives to restore riparian hydrology may affect, but are not likely to adversely affect running buffalo clover.

6.5.4.4 Native Plant Community Restoration (P)

Construction activities associated with implementation of alternatives to restore native plant communities would have similar impacts to listed species as those alternatives to restore riverine habitat. The same tree removal restrictions would also be implemented for protection of maternal roosts, and any potential roost trees would be left undisturbed. These alternatives would be expected to result in an increase in the quality and quantity of riparian habitat, which would result in long-term beneficial effects to listed species. For these reasons, the USACE has determined that alternatives to restore native plant communities may affect, but are not likely to adversely affect the Indiana bat, northern long-eared bat, and gray bat.

Surveys for running buffalo clover would be performed before construction to ensure any no impacts to existing populations are avoided. Additionally, native herbaceous seed mixes that include running buffalo clover would be used for the restoration of disturb areas outside of wetlands. For these reasons, the USACE has determined that alternatives to restore riparian hydrology may affect, but are not likely to adversely affect running buffalo clover.

6.5.4.4 No Action Alternative

Under the no action alternative is anticipated that non-native species will continue to invade, and that native habitat and wildlife diversity will decline. Due to the urbanization in the study area, the existing degraded habitat and ecological functions would persist with implementation of the No Action Alternative. Because none are known to occur in the study area, the No Action Alternative would have no effect to listed species.

6.6 Impacts to Waters of the United States from the Action Alternatives

The Recommended Plan consists of all four types of action alternatives in some measure. A preliminary evaluation of compliance of the Recommend Plan with the Section 404(b)(1) Guidelines, as required for compliance with Section 404 of the Clean Water Act, has been prepared (Appendix F).

6.6.1 Connectivity of Riverine Habitats (C)

No wetland delineation has been completed to date to identify jurisdictional wetlands. For planning purposes, National Wetland Inventory information was consulted. Riverine wetlands are the only wetland type of Waters of the United States (WOTUS) found in the study areas.

Construction activities for alternatives intended to address connectivity of riverine habitat would occur in the streams. Water quality BMPs will be implemented during construction (BMPs are outlined 5.4.1) and all applicable Federal and state permits will be obtained prior to construction, which would minimize adverse impacts to WOTUS. Any construction-related impacts to WOTUS would be temporary and less than significant.

Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS.

6.6.2 Riverine Habitat Restoration (R1, R2, R4)

Construction activities for alternatives intended to improve riverine habitat quality would occur in the streams. Water quality BMPs will be implemented during construction (BMPs are outlined 5.4.1) and all applicable Federal and state permits will be obtained prior to construction, which would minimize adverse impacts to WOTUS. Any construction-related impacts to WOTUS would be temporary and less than significant.

Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS.

6.6.3 Riparian Hydrology Restoration (H2)

Any construction-related impacts from alternatives implemented to restore riparian hydrology would be temporary and insignificant. Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS and would likely result in the creation of new wetland within the riparian zones of each fork of Beargrass Creek.

6.6.4 Native Plant Community Restoration (P)

Any construction-related impacts from alternatives implemented to restore native plant communities would be temporary and insignificant. Restoration activities implemented under this alternative would provide long-term beneficial impacts to WOTUS.

6.6.5 No Action Alternative

Under the No Action Alternative, implementation of restoration features would not occur, so no impact to WOTUS would occur.

6.7 Cultural Resources

The TSP may have an effect on twenty-one NRHP listed historic properties and eight historic districts within a half mile of the project areas. The 21 NRHP listed historic properties include the Eclipse Woolen Mill, Hadley Mary Alicia House, Hope Worsted Mills, Howard Getty's House, Klotz Confectionary Company, Leslie Abbott House, L&N Steam Locomotive No.152, Nelson Distillery Warehouse, Paget House and Heigold House Facade, Schneikert Valentine House, St. Francis of Rome School, St. Therese Roman Catholic Church, School, and Rectory, Steam Engine Company No.4 and No. 10, Wirth, Lang and Company - The Louisville Leather Company Tanner Building, Brown Theodore House, Cave Hill Cemetery, Cave Hill National Cemetery, Commodore Apartment Building, Olmsted Park System of Louisville, and Peterson-Dumesnil House. The eight historic districts include the Crescent Hill Historic District, Clifton Historic District, Oxmoor Historic District, Mockingbird Valley Historic District, Cherokee Triangle Area Residential District, Gardencourt Historic District Olmsted Park System of Louisville, and Highlands Historic Districts. In addition to the previously recorded historic properties and historic districts, ten previously recorded archaeological sites [15JF22, 15JF27, 15JF28, 15JF30, 15JF553, 15JF592, 15JF645, 15JF668, 15JF734, 15JF820] that have not been evaluated for listing to the NRHP are located within the TSP. The Corps will continue to complete identification and evaluation efforts for any other currently unidentified historic properties and cultural resources within the TSP under the terms of the PA (see Appendix G for a copy of the PA). The USACE and the Kentucky State Historic Preservation Office (SHPO) have agreed to develop and execute a PA outlining the delayed identification of historic properties for the project. The PA also outlines any mitigation measures for historic properties that may be affected by the project. The PA would be executed prior to the signed EA and FONSI for the project. A copy of the draft PA and copies of all agency and Tribal communications can be found in Appendix G.

6.7.1 Action Alternatives

Construction activities for any of the action alternatives considered will have an effect on historic properties including any NRHP listed historic property and any unevaluated archaeological sites.

6.7.2 No Action Alternative

Under the No Action Alternative, there would be no effect on cultural resources or historic properties.

6.8 Noise

6.8.1 Action Alternatives

Construction activities for any of the Action Alternatives would cause a minor and temporary increase in local noise levels during the day beyond the current conditions. The minor noise effects would stem from machinery utilized for grading banks, placing cobble riffles, and removal of vegetation. Long term, significant effects in terms of noise are not expected.

6.8.2 No Action Alternative

Under the No Action Alternative, implementation of restoration features would not occur, so there would be no impact to noise levels.

6.9 Recreational, Scenic, and Aesthetic Resources

6.9.1 Connectivity of Riverine Habitats (C)

Construction activities for alternatives to restore connectivity of riverine habitat would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of stream reaches as man-made hard structures and replaced or modified by adding more natural elevation transitions such as riffles. No effect to recreational resources is anticipated.

6.9.2 Riverine Habitat Restoration (R1, R2, R4)

Temporary impacts to scenic and aesthetic condition would occur during the construction phase of these alternatives. The proposed restoration measures under this alternative require large equipment to be present, extensive earthwork be done in some cases (R4), and mechanical removal of vegetation for bank grading. These alternatives would result in long-term beneficial impacts to scenic and aesthetic qualities of the stream reaches as they are modified to a more natural state with resultant meanders and improved channel development (formation of pools, riffles, and runs).

In areas regularly utilized for recreation, such as in the parks, where aesthetic appeal is particularly desirable, construction efforts would be streamlined to occur quickly, to avoid interfering with recreational opportunities, and to affect as small an area as possible in order to minimize impacts. Staging areas would be located away from recreation sites as much as possible. Overall, due to the temporary nature of the impacts to visual resources, and the objective of creating dramatically improved visual conditions as a result of restoration, the adverse impacts are less than significant.

6.9.3 Riparian Hydrology Restoration (H2)

Construction activities for alternatives to restore riparian hydrology would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of study areas habitat is restored. No effect to recreational resources is anticipated.

6.9.4 Native Plant Community Restoration (P)

Construction activities for alternatives to restore native plant communities would cause temporary adverse impacts to recreational, scenic, and aesthetic resources of the study sites, as restoration measures are implemented. These alternatives could result in long-term beneficial impacts to scenic and aesthetic qualities of study areas habitat is restored. No effect to recreational resources is anticipated.

6.9.5 No Action Alternative

No impacts to recreational, scenic, and aesthetic resources would occur from construction under this alternative because construction would not occur. The study sites suffer from extensive invasive plant species and degraded aquatic and terrestrial habitats. Without restoration efforts, these trends are expected to continue.

6.10 Hazardous, Toxic and Radioactive Waste

6.10.1 Action Alternatives

Project implementation is not expected to result in a release of HTRW. The risk of encountering HTRW in the study area has been reduced with the completion of a HTRW Phase I Environmental Site Assessment (Appendix F). The study area does not contain any Recognized Environmental Condition (REC) within its boundaries. Because the NER Plan would manage all excavated material on-site to the maximum extent possible, no releases of soil are anticipated. Low (*de minimis*) concentrations of anthropogenic constituents in soils are not expected to impact the project. Erosion and sediment controls will be maintained during construction to reduce movement of soil from the site by storm water runoff or vehicular traffic.

If suspected HTRW is encountered prior to construction, a thorough investigation would be conducted. If a site is found to contain HTRW, remediation of the sites would be conducted before construction activities are undertaken. The sponsor would be responsible at 100 percent non-project cost for addressing treatment and disposal of potentially contaminated soils and therefore there would be no resulting significant hazard to the public or the environment from ground disturbing activities on those sites.

6.10.2 No Action Alternative

No impacts to public health and safety from release of HTRW would occur from construction under this alternative because construction would not occur.

6.11 Socioeconomics and Environmental Justice

6.11.1 Action Alternatives

None of the Action Alternatives are expected to significantly affect environmental justice populations (minority and/or low income populations) during construction. The alternatives may result in other minor and temporary adverse effects, such as increased noise or dust around the construction areas, which may affect adjacent populations. However, these effects would be managed by implementing BMPs and staying within noise limits and construction periods specified in city and county plans. All populations adjacent to the construction area would be affected equally, rather than environmental justice populations being disproportionately affected. It is likely that all communities adjacent to the river would experience similar levels of temporary adverse effects mentioned above. However, the nature of this restoration study is such that study location is entirely driven by the location of the streams and cannot be located elsewhere. Moreover, adverse effects are temporary in nature.

Furthermore, the Action Alternatives may result in beneficial impacts to socioeconomic conditions in the study area. Improved aesthetic quality of the streams, improved habitat value, improved quality and quantity of recreation resources along the streams, and improved accessibility would be the catalyst for these beneficial effects such as improvements in environmental quality (such as water quality) in the region as a result of a cleaner, active riverine system would benefit all populations in the study area.

6.11.2 No Action Alternative

Due to the existing level of development, it is unlikely that changes in the local or regional economy will result in drastic changes in land use, population, or demographics in the study area. Other factors such as gentrification, poverty rates, and local businesses can affect the local economy and land uses, but no clear trends have emerged at the time of this assessment. Any changes that do occur in the period of analysis would likely be coincident with larger regional trends and would not materially alter the conditions in which an ecosystem restoration study would be constructed.

Under the No Action Alternative, environmental justice considerations would not likely be altered substantially. Income and poverty in the assessment area appear to reflect national and regional trends of slow but increasing recovery from the recent recession. Unemployment in the assessment area is below that of the City or the County. The demographics of the assessment area may shift slowly in proportion to larger regional trends, but there is no indication for large shifts in demographics over the period of analysis.

6.12 Environmental Compliance

The proposed alternative plans presented are in compliance with appropriate statutes and executive orders including the Endangered Species Act of 1973 as amended, 33 U.S.C. §§ 1251-1388; the Fish and Wildlife Coordination Act of 1934 as amended, 16 U.S.C. §§ 661-667g-2; Executive Order 12898 (Environmental Justice); Executive Order 11990 (Protection of Wetlands); Executive Order 11988 (Floodplain Management); and the Rivers and Harbors Act of 1899 as amended, 33 U.S.C. § 403; the Clean Air Act, as amended, 42 U.S.C. §§ 4701-7671q, and NEPA.

6.12.1 Endangered Species Act

The Louisville District has determined implementation of the recommended plan will have no effect to the following listed species: least tern, clubshell, fanshell, Northern riffle shell, orangefoot pimpleback, pink mucket, rabbitsfoot, ring pink, rough pigtoe, sheepnose, and spectlecase. These species have not been observed in the Beargrass Creek watershed and would not be impacted by restoration activities.

The Louisville District as determined implementation of the recommended plan may affect but is not likely to adversely affect the following species: gray bat, Indiana bat, Northern long-eared bat, and running buffalo clover. Direct adverse impacts to roosting bats will be avoided by restricting tree removal to the period between October 1 and March 31, when roosting bats would not be present.

Implementation of the recommended plan would result in long-term benefits to bat populations by restoring wetlands and bottomland hardwood forest along stream corridors, thus creating more foraging opportunities, improving travel corridors, and providing roosting habitat. There would be no caves disturbed during the construction of the TSP, which are critical gray bat habitat year-round. As such, there would be no negative effects expected for this species. Native planting efforts of the recommended plan would include seeding of Running Buffalo clover. This would allow the species to reestablish in areas throughout the watershed.

This IFR and integrated EA will serve as a biological assessment for the recommended plan and will be provided to the USFWS for comment and/or concurrence with the Corps' effects determinations above, pursuant to Section 7 of the Endangered Species Act.

6.12.2 Fish and Wildlife Coordination Act

The purposes of the FWCA include recognizing the contribution of wildlife resources to the nation, acknowledging the increasing public interest and awareness of wildlife resources and ensuring that wildlife conservation receives due consideration in water resources development programs (16 USC 661). Under the FWCA, the FWS provides its recommendations to the Corps to consider.
The District has provided details of the recommended plan to the USFWS for comment and will provide this report for coordination during the 30-day agency and public review. The Corps will continue to work with USFWS as well as other resource agencies and wildlife experts during PED to refine project designs and incorporate the specificity needed to achieve restoration goals and including connectivity in the context of the project's constraints.

6.12.3 Environmental Justice EO 12898

The proposed alternatives would not cause adverse human health effects or adverse environmental effects on minority populations or low-income populations. Executive Order 12898 (environmental justice) requires that, to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

The proposed alternatives are not expected to significantly affect environmental justice populations during construction. The alternatives may result in other minor and temporary adverse effects that would be managed by implementing BMPs. No populations adjacent to the construction area would be disproportionately affected. The alternatives may result in beneficial impacts to socioeconomic conditions in the study area.

6.12.4 Clean Air Act

The temporary source emissions from this project, for any alternative, are *de minimis* in terms of the NAAQSs and the State Implementation Plan. Construction emissions will not cause or contribute to any new violation of NAAQS, increase the frequency of an existing violation, or delay the attainment of standard, interim emission reduction, or other milestone. Due to the small scale and short duration of this study, a General Conformity Analysis was not completed. All construction vehicles will comply with federal vehicle emission standards. USACE and its contractors comply with all Federal vehicle emissions requirements. USACE follows EM 385-1-1 for worker health and safety and requires all construction activities to be completed in compliance with Federal health and safety requirements. The project is not expected to be a significant source of greenhouse gas emissions.

6.12.5 Section 404 & 401 of the Clean Water Act

Section 401 requires compliance with water quality standards. The Corps will apply to the Kentucky Division of Water (DOW) for Section 401 certification, pursuant to 33 CFR 336.1(a)(1). The Corps will continue to coordinate with the DOW throughout the remaining study, design and construction phases of this project.

Section 404 addresses discharges of dredged or fill material to waters of the United States. The Corps does not issue itself permits for Corps Civil Works projects but must comply with the 404(b)(1) guidelines. A Section 404(b)(1) evaluation based on based on currently anticipated activities under the recommended plan has been prepared and is found in Appendix F. With implementation of the avoidance and minimization measures listed therein, the proposed discharges of fill will be in compliance with Section 404 of the Clean Water Act.

6.12.6 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966, as amended, requires federal agencies to take into account the effects of their undertakings on historic properties and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such undertakings. The procedures in 36 CFR Part 800 define how federal agencies meet these statutory responsibilities. The Section 106 process seeks to accommodate historic preservation concerns with the needs of federal undertakings through consultation among the agency official and other parties with an interest in the effects of the undertaking on historic properties, including the SHPO or Tribal Historic Preservation Officer (THPO) and any Tribe that attaches religious or cultural significance to historic properties that may be affected by an undertaking. The goal of consultation is to identify historic properties potentially affected by the

undertaking, assess its effects and seek ways to avoid, minimize or mitigate any adverse effects on historic properties.
The USACE and SHPO will sign a Programmatic Agreement (PA) for the Project that delays the identification of historic properties prior to the signing of the FONSI and IFR. The identification of historic properties will be conducted during design of the Project. A copy of the draft PA can be found in Appendix G. The PA will outline the process to identify historic properties within the TSP and the mitigation of any effects to identified historic properties. Both tasks will occur prior to construction of the Project.

6.12.7 Public Interest

This draft Feasibility Report with Integrated EA is being sent to Federal, State and local agencies along with the general public for a 30-day period of review.

6.13 Conclusion

In accordance with the National Environmental Policy Act of 1969, 42 U.S.C. § 4321-4347, as amended, the U.S. Army Corps of Engineers has assessed the environmental impacts associated with this project. The purpose of this EA is to evaluate the impacts that would be associated with the restoration of aquatic habitat within the Three Forks of Beargrass Creek.

The assessment process indicates that the final array of alternatives would not cause significant adverse impacts on the environment. These alternatives would be expected to have long-term beneficial impacts upon the ecological, biological, social, or physical resources of this area, and would provide environmental benefits to the Louisville Region.

7.0 Tentatively Selected Plan

7.1 Ecosystem Restoration Features of the NER

As described in the previous section, plan 10240 was identified as the NER plan based on CEICA of ecological outputs at the site- and system-scales. This recommendation was also supported through assessment of social outputs and qualitative factors not captured in purely ecological approaches. The NER plan is a cost-effective alternative from an ecological perspective, but it is not a best buy. The choice to recommend a cost-effective plan was bolstered by the OSE and pairwise analysis, which identified a larger suite of benefits associated with site X35 over sites X4 and X8. The cost-effective recommendation also allowed restoration actions to be executed in all Three Forks of the Beargrass Creek watershed.

The plan utilizes a wide range of ecological measures to improve riverine and riparian function and connectivity. A full list of sites and associated alternatives is listed in Table 25 below.

Table 25. Summary of Tentatively Selected Plan

Site	Site Name	Fork	Recommended Alternative	Lift	Average Annual Cost ($)	Unit Cost ($/AAHU)	Project First Cost ($)	Site Area (ac)	Restored Channel (ft)	Social Units
X2	Confluence	South	CR2H2	18	345,000	18,700	9,733,000	171	1,068	123
X10	Alpaca Farm / Zoo	South	CR2P	42	485,000	11,700	13,682,000	79	4,913	56
X19	South Fork / Newburg Rd	South	CR1H2	8	116,000	14,600	3,266,000	44	4,489	26
X20	Brown Park	Middle	CR2P	17	143,000	8,200	4,024,000	30	628	18
X21	Arthur Draut Park	Middle	CR2P	17	141,000	8,100	3,974,000	40	1,527	24
X22	Concrete Channel	South	H2	4	84,000	19,400	2,361,000	47	0	35
X29	Eastern / Creason Connector	South	CR4P	35	741,000	21,400	20,927,000	98	4,549	66
X30	Joe Creason Park	South	CR4P	57	613,000	10,700	17,312,000	121	3,830	95
X33	MSD Basin	South	H2	2	36,000	14,900	1,009,000	12	0	7
X34	Cherokee / Seneca Parks	Middle	CR2P	83	718,000	8,600	20,262,000	267	12,951	201
X35	Muddy Fork and Tribs	Muddy	CR2H2	10	279,000	26,900	7,885,000	128	8,717	66
X38	Cave Hill Corridor	Middle	R2H2	21	332,000	15,500	9,364,000	52	3,335	35
All Sites				316	4,031,000	12,800	113,799,000	1,090	46,007	751

NOTE Project first costs are presented in FY22 levels and were annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%.

7.1.1 Tentatively Selected Plan

The TSP consists of 12 sites – six on the South Fork, four on the Middle Fork, one on the Muddy Fork and the Confluence site. The plan is a total of 1,090 acres and will restore 46,007 linear feet of stream. The plan also includes the removal of 19 connectivity barriers throughout the watershed. The overall benefits come to 416 Average Annual Habitat Units and 416 Social Units. Average annual cost is $6,114,000 with a project first cost of $157,413,000. Project first cost is presented in FY22 levels and was annualized over a 50-year period of analysis (base year 2025) using the FY21 federal discount rate of 2.5%. Figure 51. shows the locations of all sites composing the Tentatively Selected Plan.

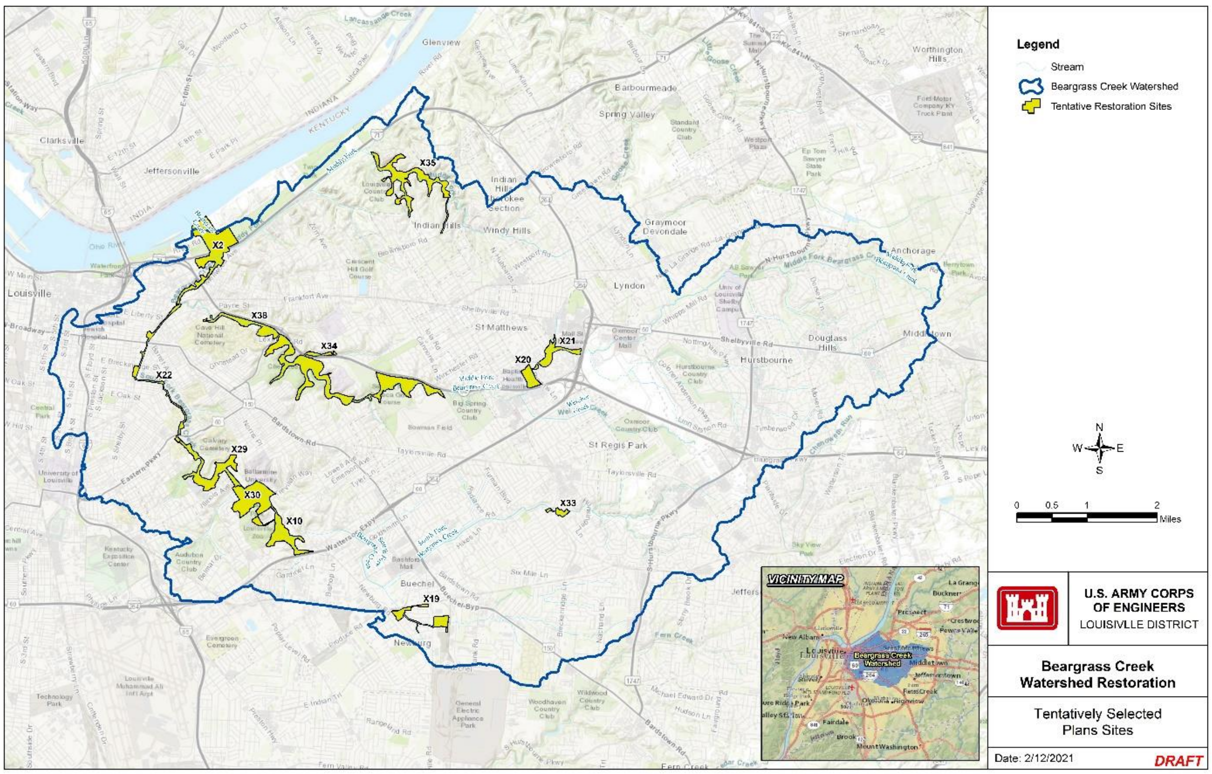

Figure 51. Mapping of All Sites included in the Tentatively Selected Plan

The TSP supports other watershed purposes outside of ecosystem restoration. Certain measures for habitat restoration such as the creation of wetlands, stream bank improvements and native plantings can have flood risk reduction benefits by adding floodwater storage and high-water access to floodplains. Water quality can be improved through removal of impervious surfaces and addition of planting that can increase filtration of water before it enters the system. Recreation opportunities are another benefit, especially considering that the project location is in an urban area within proximity to schools, trails and parks.

Each site and recommended alternative included in the TSP is described below. The order of sites presented begins with the most upstream of each fork and works its way downstream to represent the downstream benefits of the restoration work in the upper reaches of each fork.

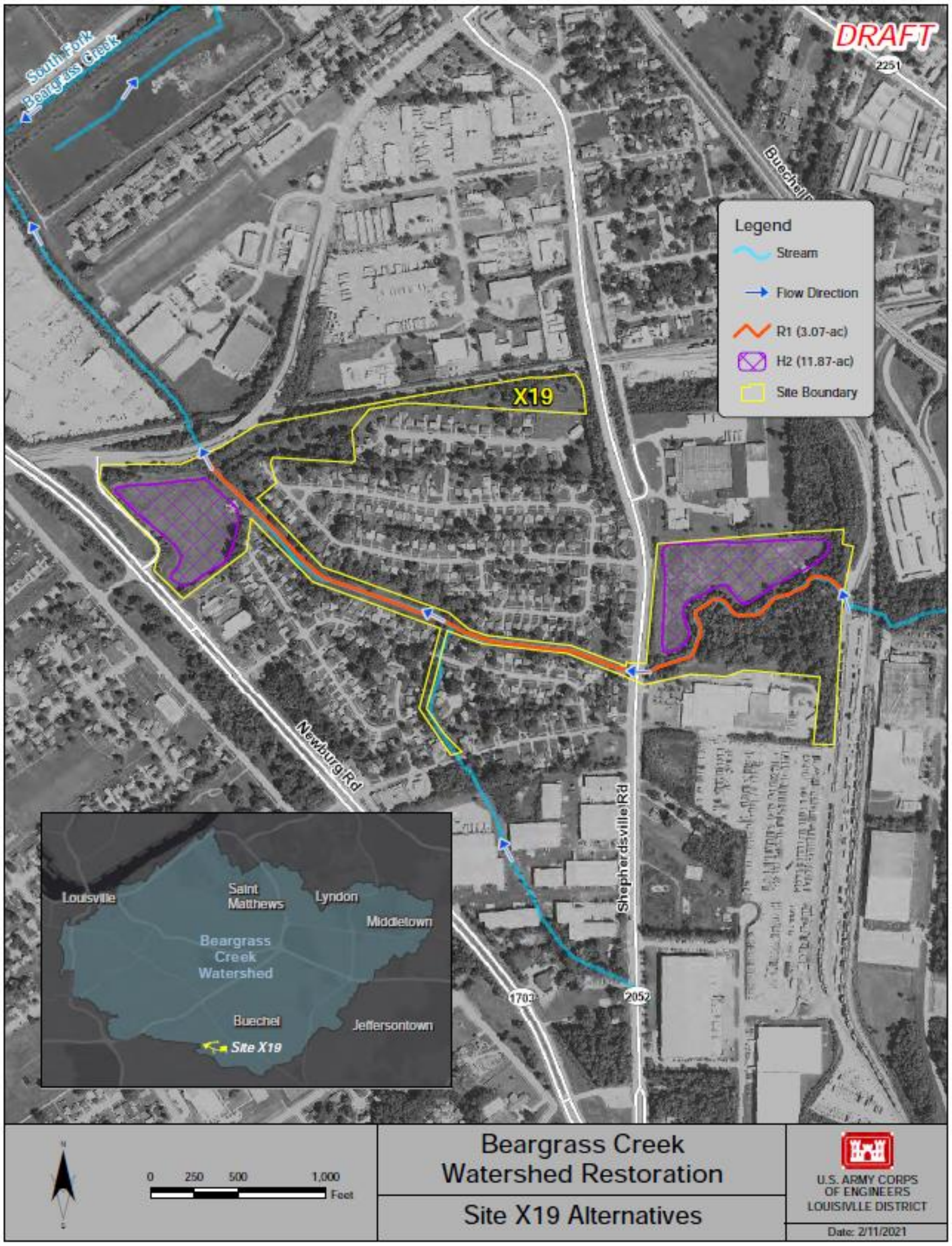

Figure 52. Conceptual Alternative Mapping for Site X19

Site X19 (Figure 52.), Newburg Rd, is in the upstream area of South Fork. This alternative includes retrofitting existing MSD basins through minor excavation to lower the water table and planting native wetland species within the area of hydrologic resurgence. This alternative also includes placement of native rock structures and woody debris in-stream only between the basins to improve connectivity between the two restored basins.

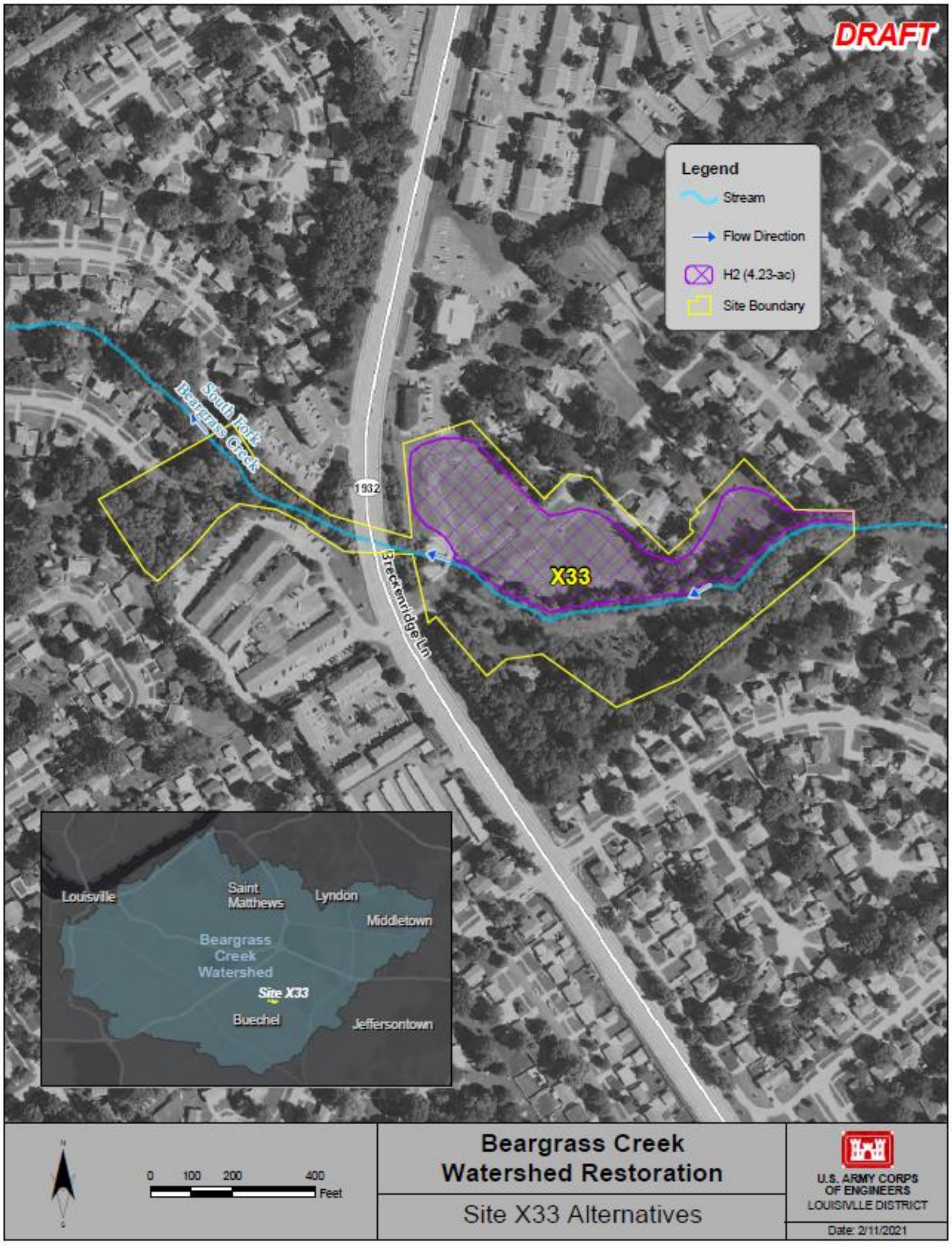

Figure 53. Conceptual Alternative Mapping for Site X33

Site X33 (Figure 53.), MSD Basin, is located on a tributary in the upstream area of the South Fork and includes retrofitting an existing basin. Similar to site X19, only minor excavation to lower the water table would be required since it is an existing basin. Appropriate native plant species would be seeded within in the basin area to create a more natural wetland area.

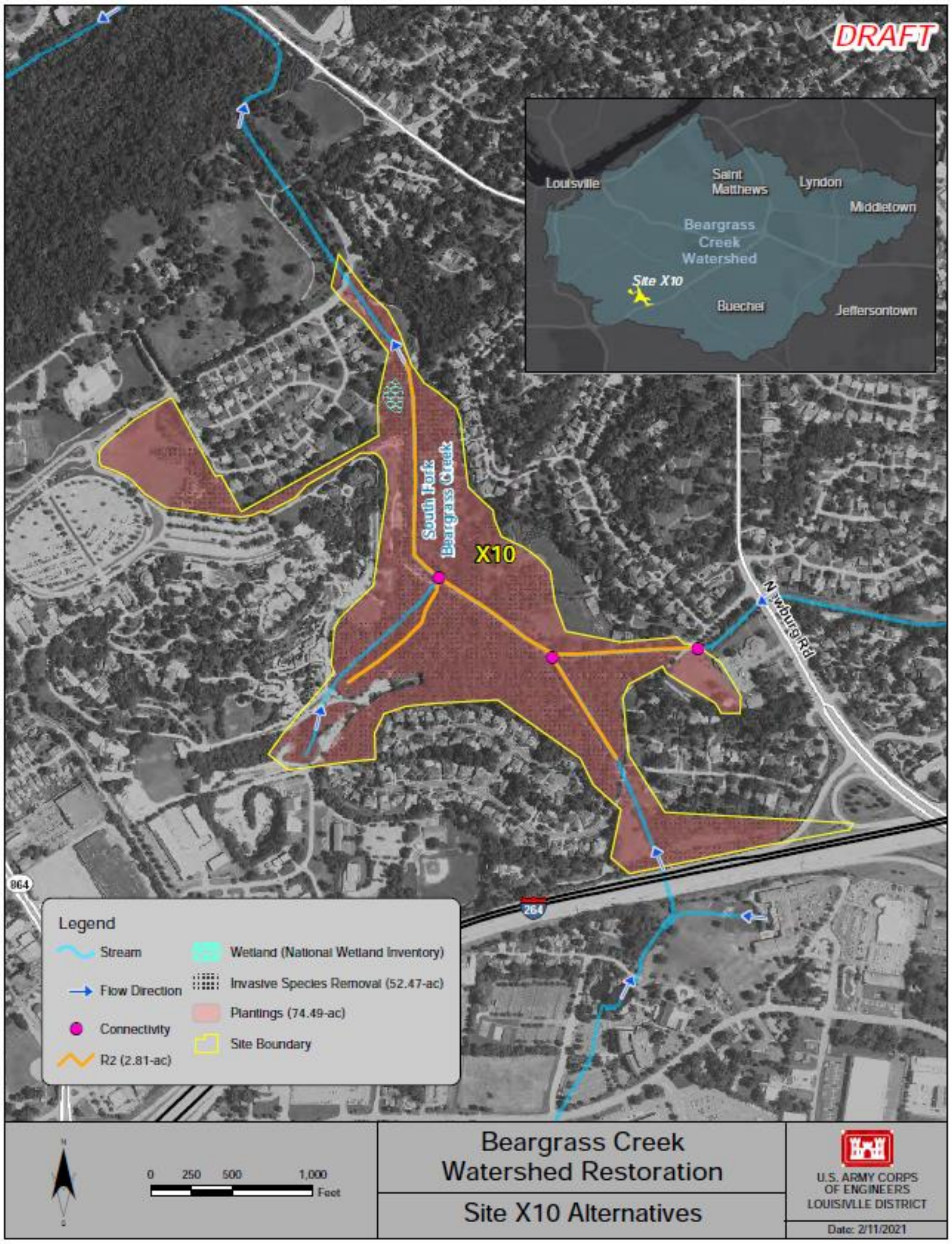

Figure 54. Conceptual Alternative Mapping for Site X10

Site X10 (Figure 54.), the Alpaca/Zoo site is located just upstream of the Watterson Expressway on the South Fork. Restoration work includes riffles to overcome barriers with the native rock structures and woody debris to improve instream conditions as well as grading of banks to improve floodplain connectivity. Work would also include native plantings and invasive removal. This site has good recreation and education potential, as it is adjacent to the Louisville Zoo.

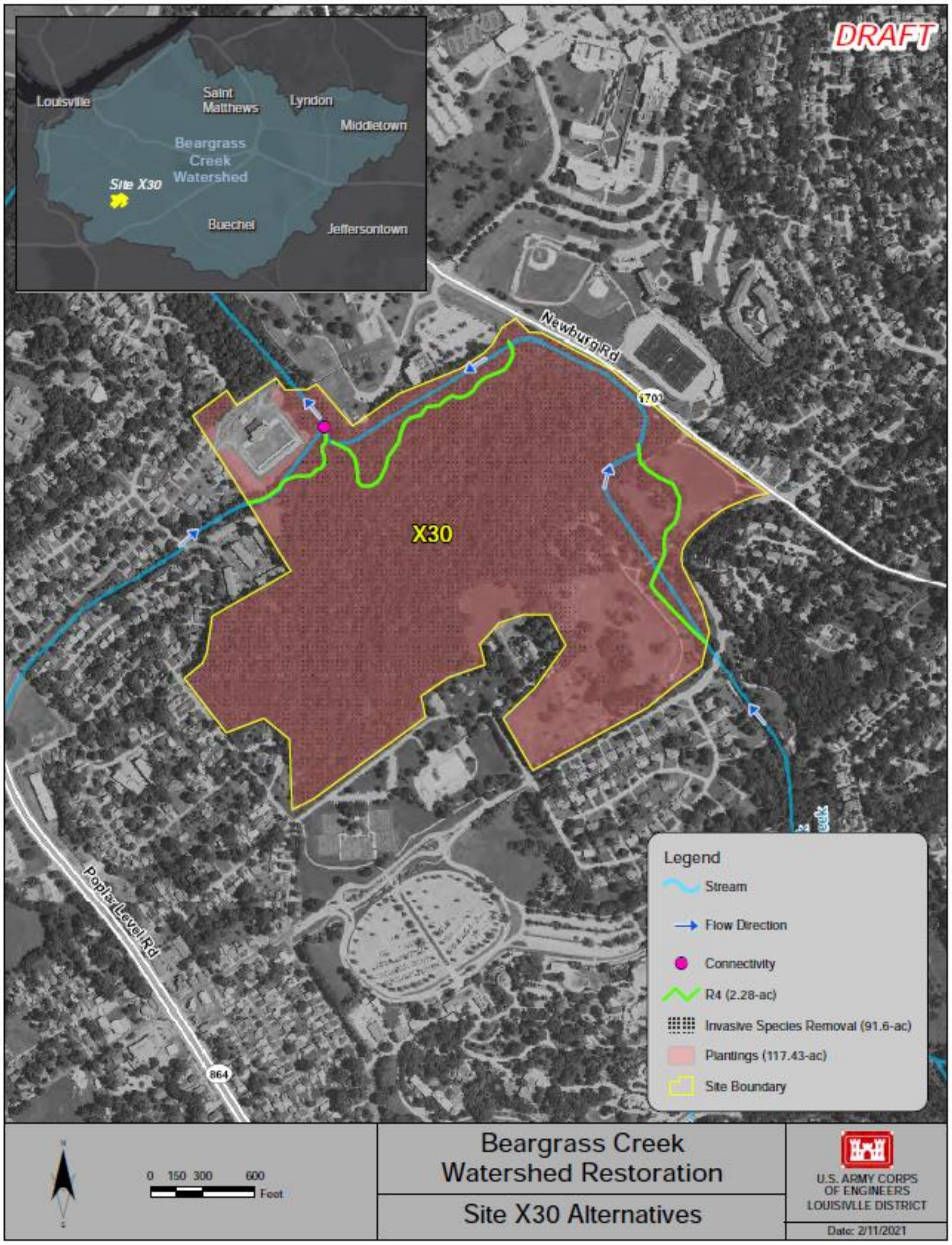

Figure 55. Conceptual Alternative Mapping for Site X30

Site X30 (Figure 55.), Joe Creason, is located between sites X10 and X29 and includes riffles to overcome barriers. This work would include resculpting of the stream with placement of native rock structures and woody debris as well as plantings and invasive removal. This site also provides an excellent opportunity for recreation and education, as the Beargrass Creek Nature Preserve is part of the site.

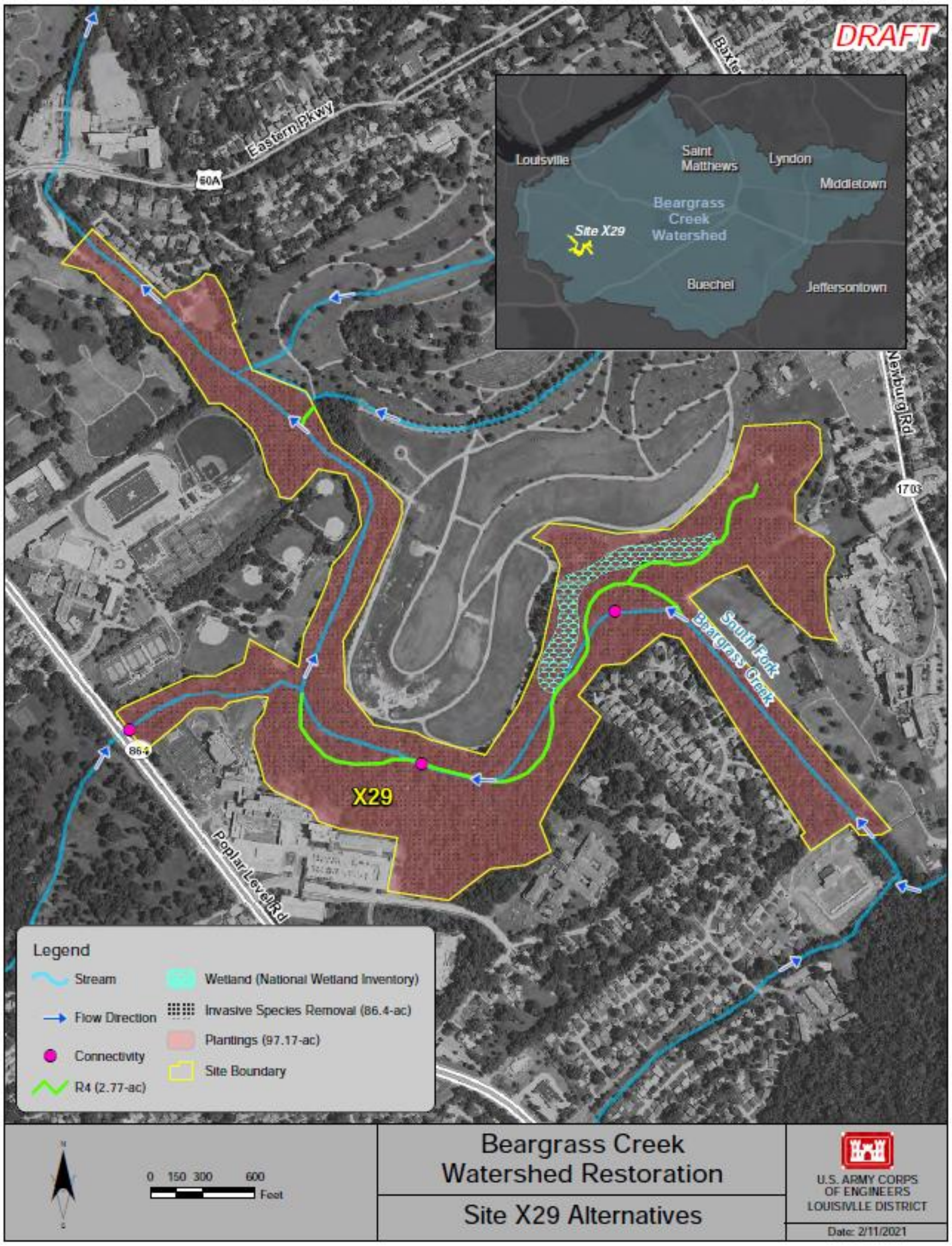

Figure 56. Conceptual Alternative Mapping for Site X29

Site X29 (Figure 56.), Eastern Creason Connector, is located between X30 and X22 and includes riffles to overcome barriers at three points. Portions of the stream would be realigned with native rocks and woody debris placement, as well as plantings and invasive removal throughout the site. This site has local interest in a recreational trail.

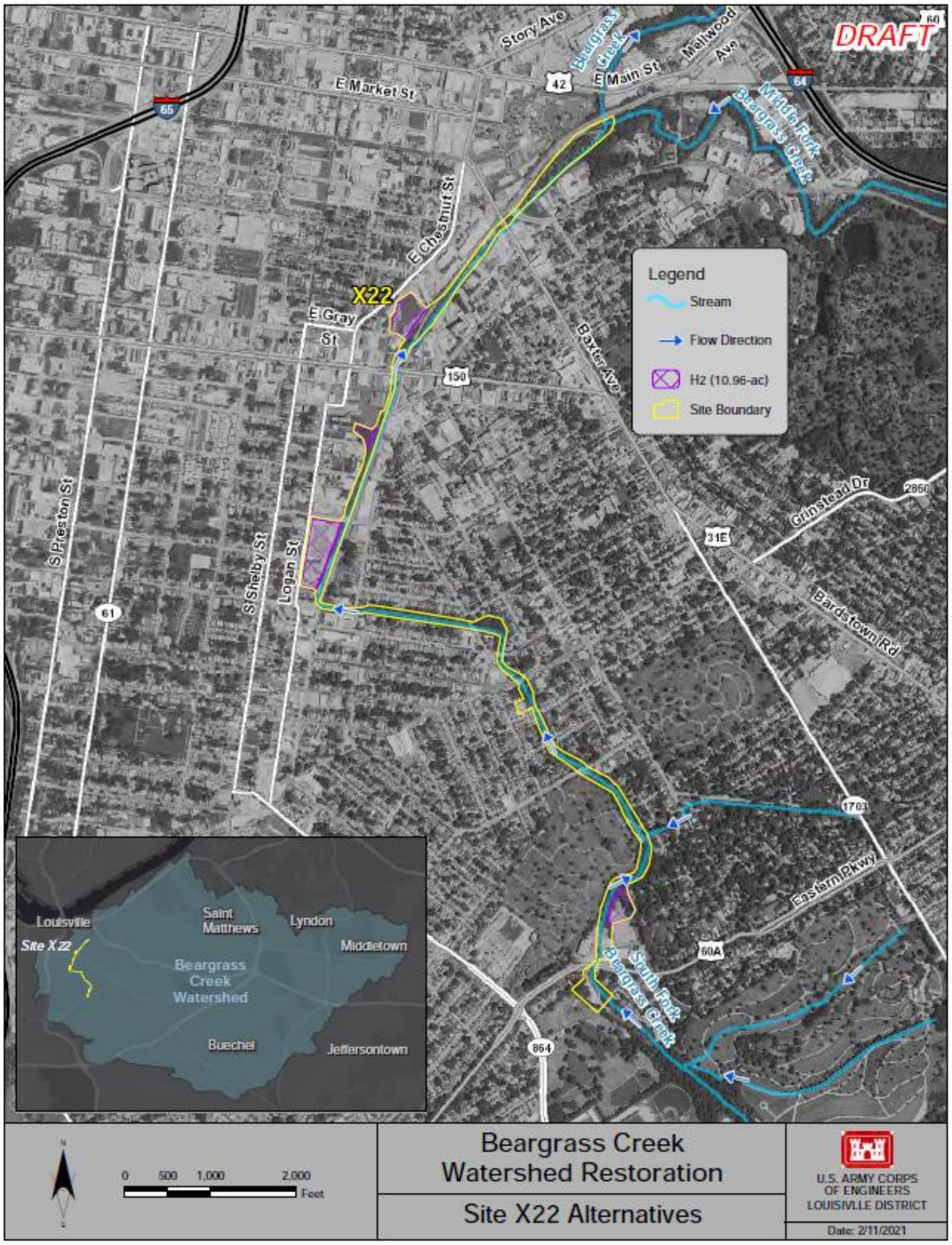

Figure 57. Conceptual Alternative Mapping for Site X22

Site X22 (Figure 57.), the Concrete Channel, touches many neighborhoods and runs through the most densely populated area of all the reaches. This site includes hydrologic resurgence via basins at 4 sites along the channel. One site would include removal of a parking lot. All basins would include wetland plantings.

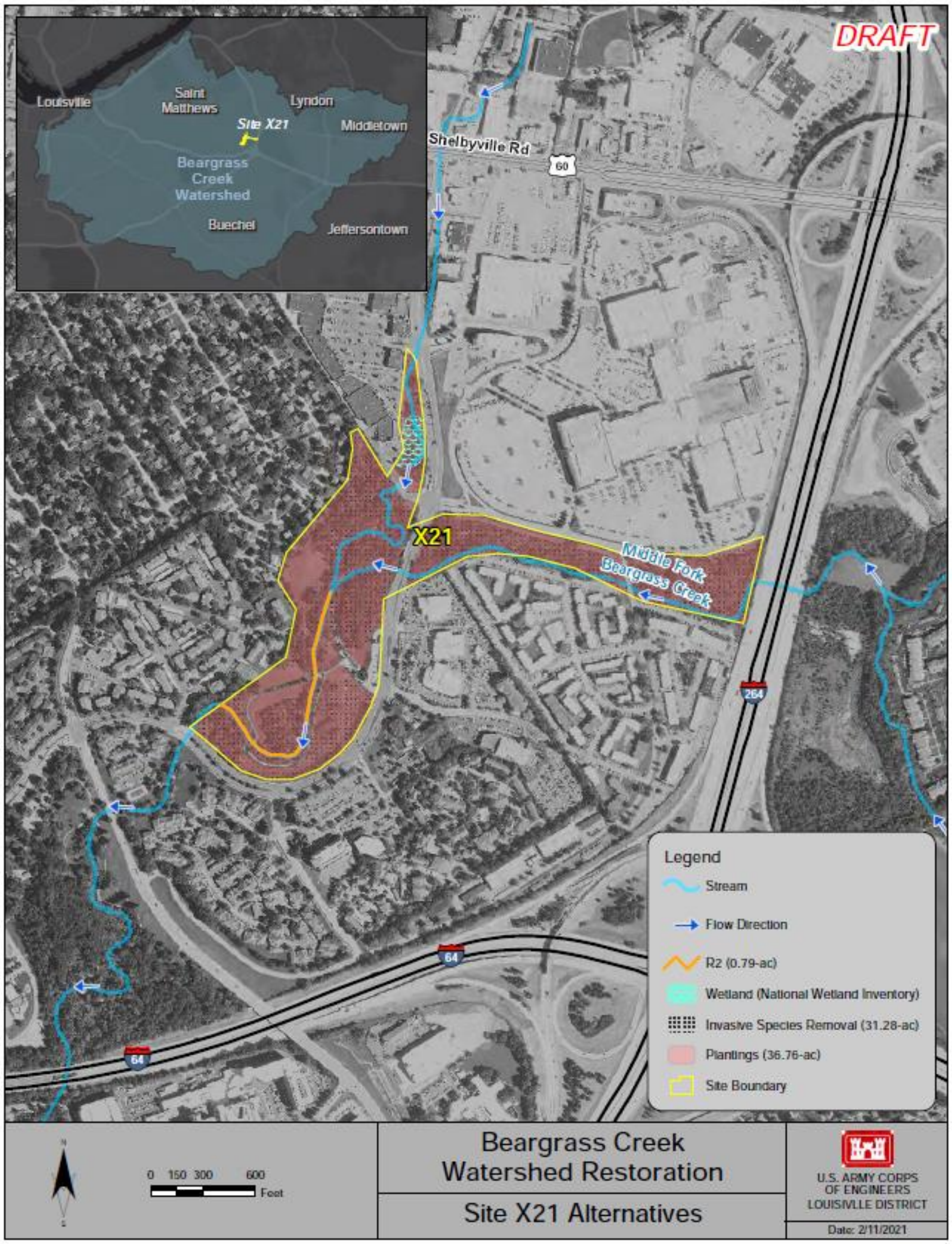

Figure 58. Conceptual Alternative Mapping for Site X21

Site 21 (Figure 58.), Arthur Draut Park, is the most upstream site on the Middle Fork and proposes in stream work with floodplain connectivity. This will entail some improvements to previous restoration work that has taken place such as bank stabilization. This alternative will also include some invasive removal and native plantings throughout the riparian zone.

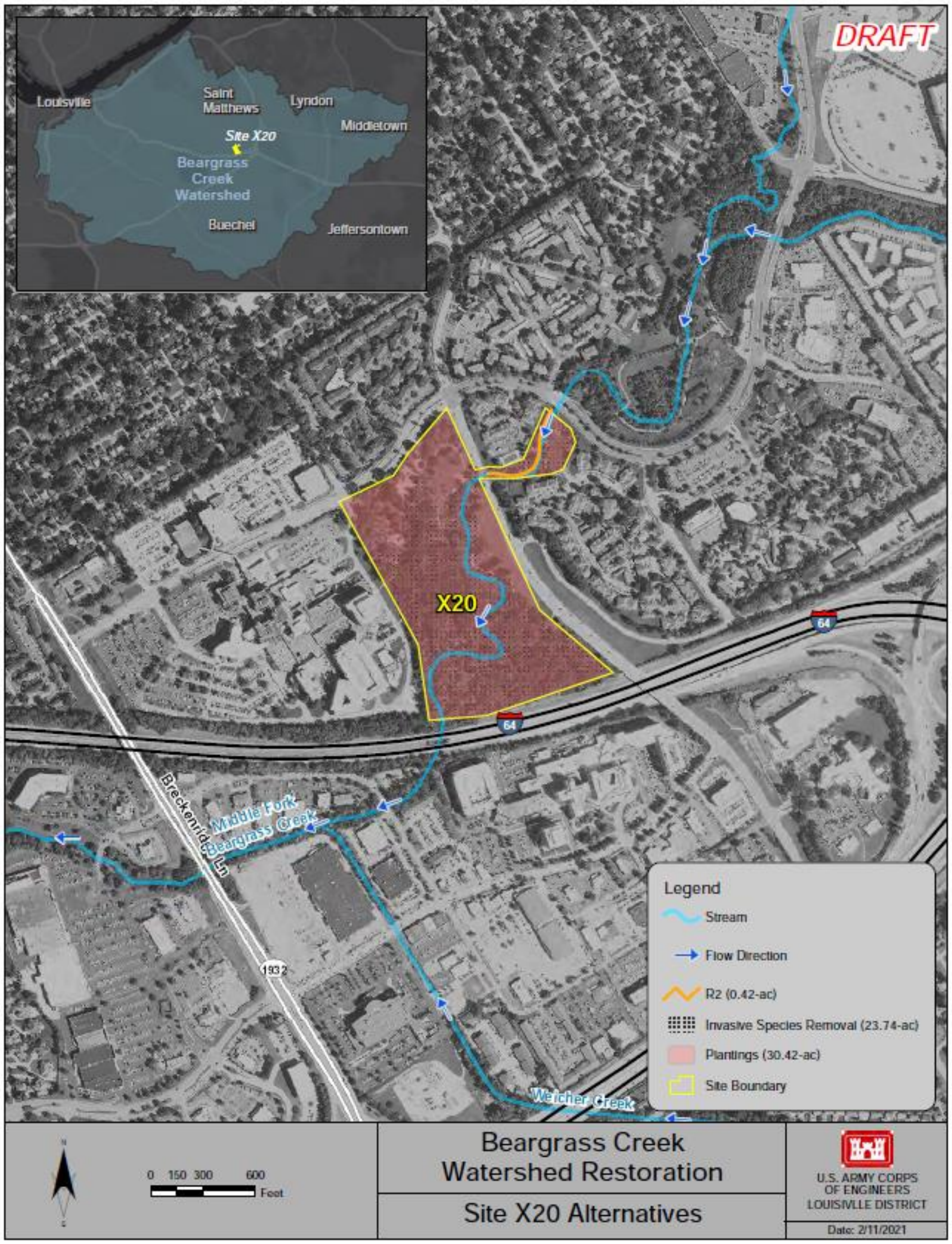

Figure 59. Conceptual Alternative Mapping for Site X20

Site 20 (Figure 59.), Brown Park, is just downstream of site X21 and proposes instream work with floodplain connectivity to increase the quality of the connection between the two parks and to restore existing historic stream work. It also includes plantings and invasive removal.

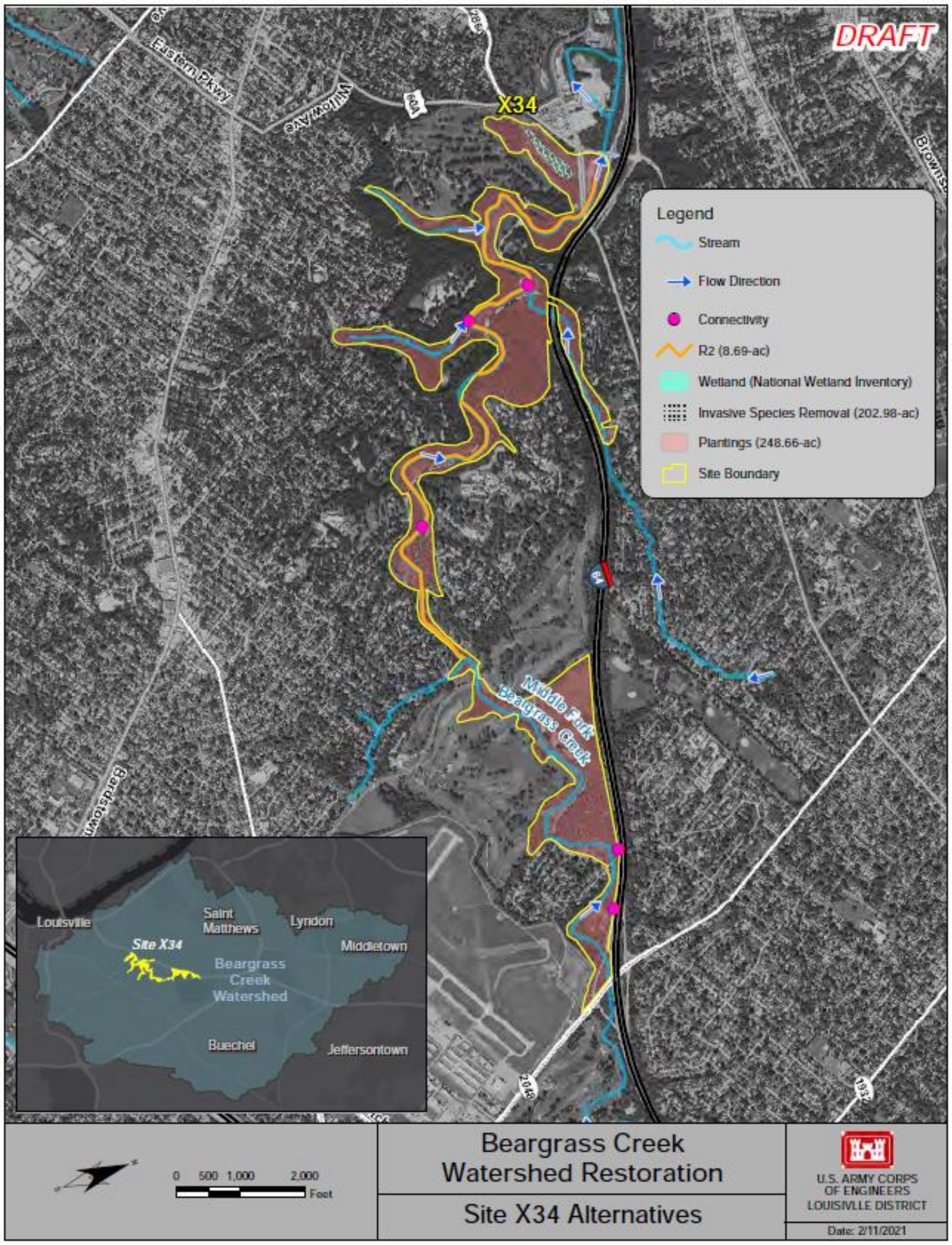

Figure 60. Conceptual Alternative Mapping for Site X34

Site 34 (Figure 60.), Cherokee Park, is the largest site in the TSP and includes riffles to overcome connectivity issues in five locations, instream work and floodplain access on about half of the stream reach within the park and native plantings and invasive removal throughout. This park is one of the most popular parks in Louisville and is one of three in the city that are part of the Olmsted design. This work would likely also include replacing and enhancing trails that are impacted by the restoration work.

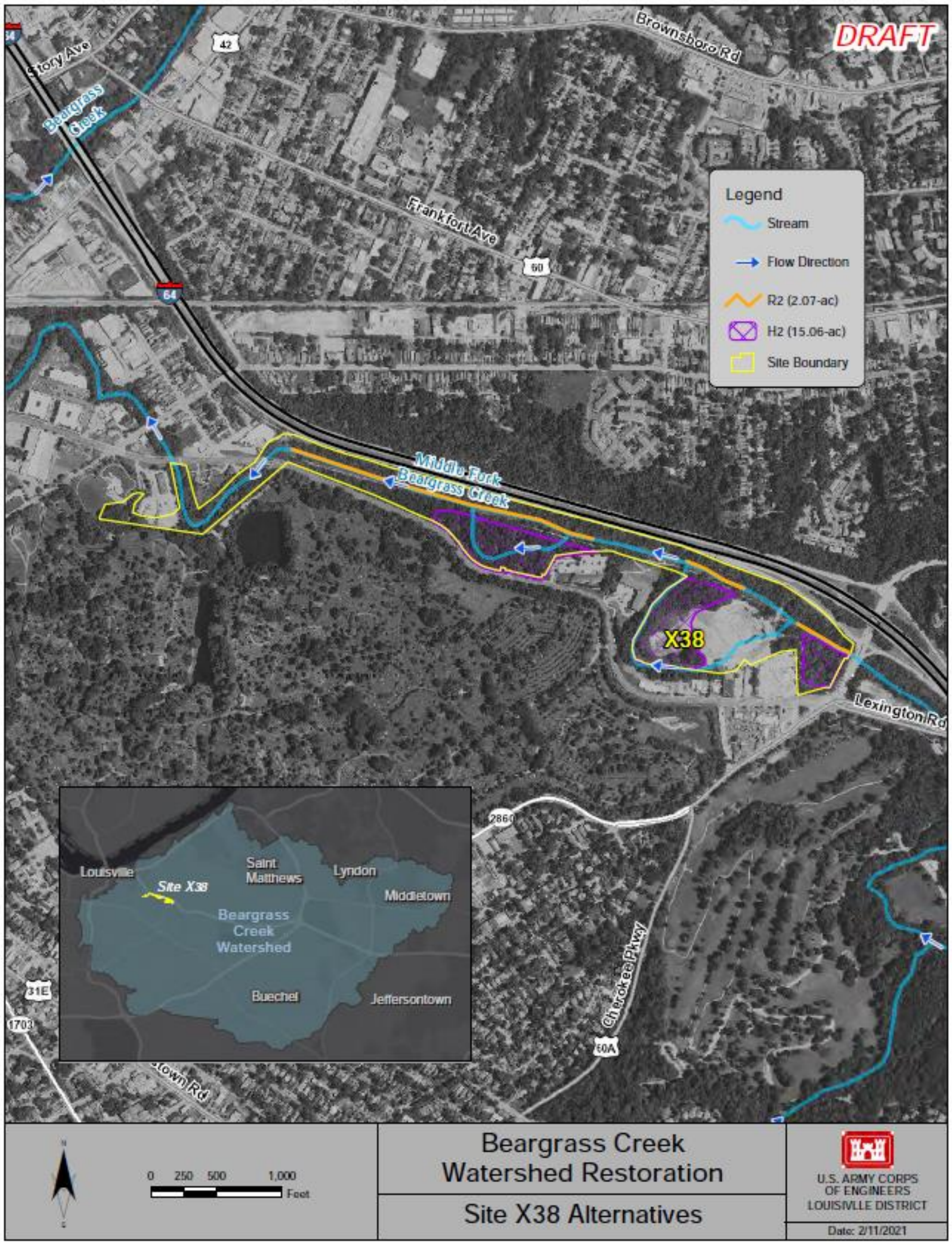

Figure 61. Conceptual Alternative Mapping for Site X38

Site 38 (Figure 61.), Cave Hill, is located just downstream of Cherokee Park and includes hydrologic resurgence via basins/swales with connectivity to the stream through bank grading and in stream improvements. The basins would be excavated and planted with native wetland plants. The existing trail would have to realigned around the basins which would enhance the trail experience.

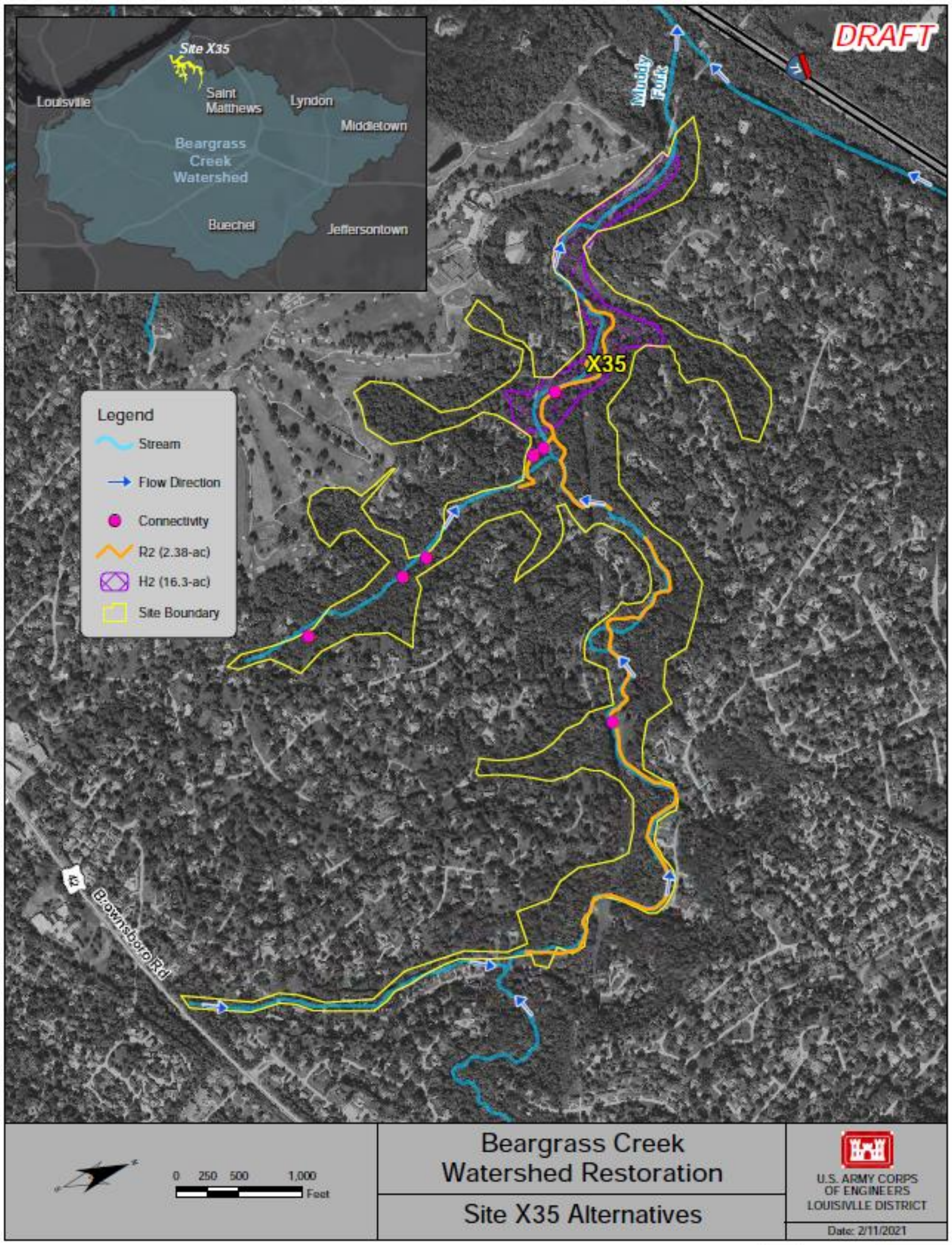

Figure 62. Conceptual Alternative Mapping for Site X35

Site 35 (Figure 62.), Muddy Fork and Tributaries, is the only site on the Muddy Fork although it is the second largest. It includes riffles to overcome six barriers, instream work and floodplain connectivity and a large area of hydrologic resurgence that will have major positive downstream impacts.

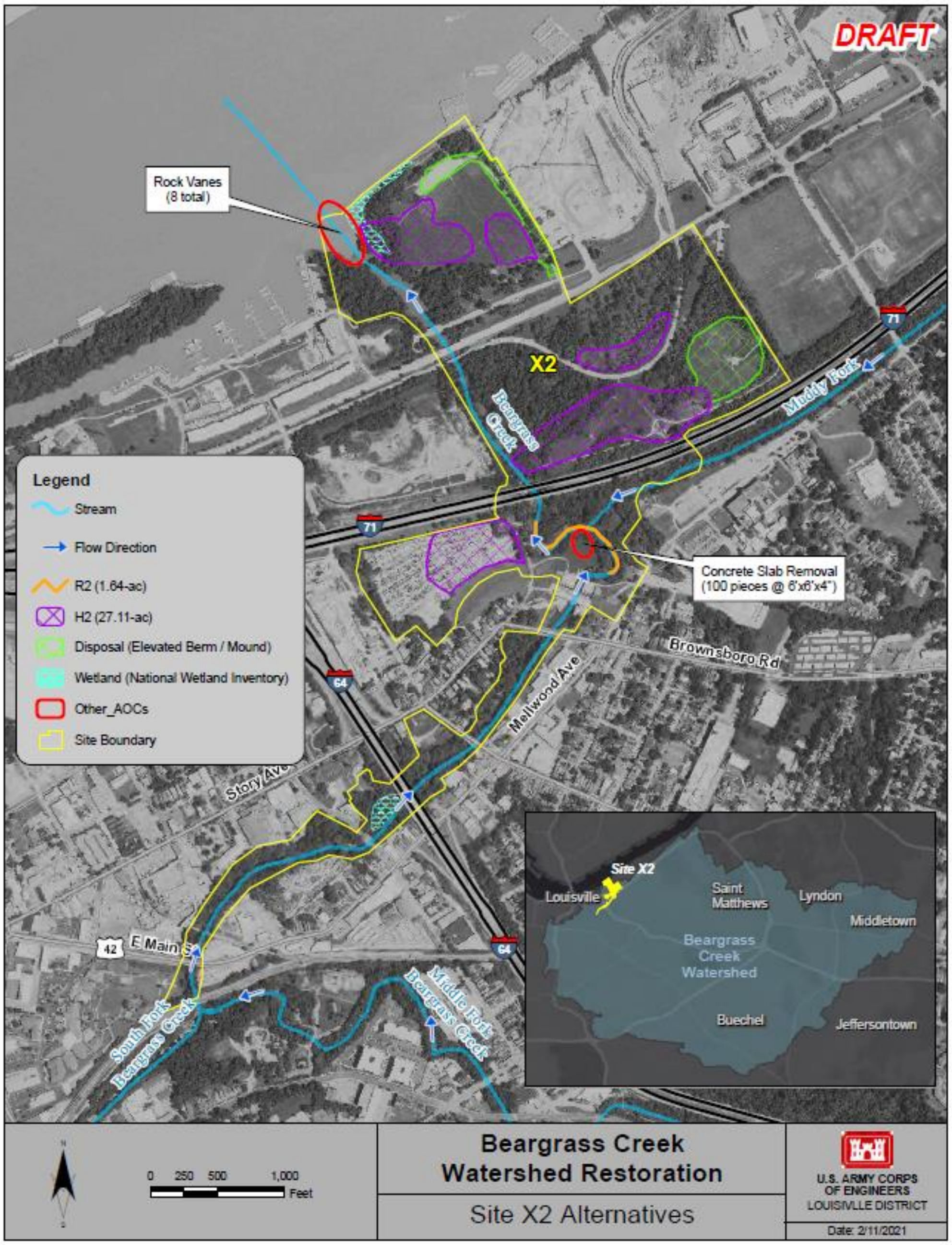

Figure 63. Conceptual Alternative Mapping for Site X2

Site X2 (Figure 63.), the Confluence, is located at the mouth of the stream with the Ohio River and includes a small amount of instream work near the MSD pump station and three areas of hydrologic resurgence including removal of a portion of asphalt at the Louisville Metro Impound Lot. This site also includes removal of concrete slabs that were dumped in the riparian zone near the pump station as well as rock vanes at the mouth of the stream to control erosion.

7.2 Real Estate Considerations

These 21 sites are made up of 784 separate land parcels totaling nearly 1,800 acres. The sites are located throughout the eastern half of Jefferson County. Some sites are located entirely, or almost entirely, on publicly owned lands, such as local parks or NFS owned infrastructure. Other sites are entirely privately owned and would require extensive acquisitions. A rough order of magnitude real estate screening and analysis of the 21 sites was conducted. Preliminary cost estimates were determined based on assessed land values. The screening level analysis also provided additional context for each site by breaking down how much of each site was already owned by the NFS or another public entity, and how many acquisitions would be required at each site. Additional site-specific special circumstances were highlighted in the analysis as well, such as exceptionally costly acquisitions and relocations or potentially uncooperative private property owners. A Cost Effectiveness and Incremental Cost Analysis (CEICA) was conducted on the remaining 21 sites, which narrowed the selection down to 14 prospective sites. A further watershed-level CEICA eliminated another 2 sites, leaving the final TSP with 12 project sites.

The 12 sites chosen for the TSP are located throughout the eastern half of Jefferson County. Seven sites are located on the South Fork, four on the Middle Fork, and one the Muddy Fork of Beargrass Creek. While the design process will likely reduce the footprint of many project sites to some degree, the sites as currently envisioned encompass approximately 850 total acres. Of those, the NFS owns roughly 43 acres. The NFS will need to acquire significant interest in approximately 300 parcels of land totaling roughly just over 800 acres. If total real estate costs of the TSP exceed 25% of total project costs, additional refinements may occur to real estate elements in the Recommended Plan.

7.3 Recreation Plan

The objective of the recreation plan is to maintain and improve the quality and quantity of recreation amenities that complement the ecosystem restoration, especially in regard to promoting access and connectivity between both banks of the stream and throughout the length of the reach. The recreation plan was developed through coordination with the NFS to take advantage of existing recreation facilities, as well as proposed ecosystem restoration improvements, while complying with USACE policies and regulations pertinent to recreation improvements at ecosystem restoration projects. The recreation features will be designed and managed to avoid any negative impacts to the restoration areas. The recreation plans formulated to be consistent and compatible with the NER plan includes the modification, upgrade, or creation of multi-use trails and related basic amenities.

7.3.1 Recreation Plan Formulated

The recreation plan formulated for the NER includes the following features listed in Table 26.

Table 26. Recreation plan description

Location	Details about location	Proposed New Feature
X2	Waterfront park (most visited park in city). New waterfront botanical building just upstream of park. Path along waterfront connects to Louisville Loop, proposed 200-mile multi-use path that spans the entire city. Beargrass Creek Greenway connects to Louisville Loop at this site.	Boat Access Ramp at Eva Brandman - 150SF: would provide a water access point for small vessels.
		Pedestrian Bridge - connecting botanical gardens and greenway to east side of stream and park area
X38	Beargrass Stream Greenway runs along length of stream here, connects several neighborhoods, Girl Scout building, realignment goes with Beargrass Creek Alliance trail plans	Realign existing trail around new wetland areas. Boardwalk to smaller wetland area on eastern side of site.
X29	Local, political interest in trail in this location for several years. Trail would connect several neighborhoods that currently are separated by major roads and cemeteries. Would also provide potential access for St. X, medical center, Earth and Spirit Center	Soft surface trail along length of stream, crossing stream at pedestrian bridge planned for 2022, benches (5)
X30	The Nature Center and Beargrass Creek Nature Preserve is located within this site. Congress for the New Urbanism 2019 South Fork Legacy Plan proposes "integration with Nature Preserve" from park, USACE plan would work to connect these enhancements with nature preserve trails.	Enhanced trail connections between TNC and Joe Creason Park
X10	The Louisville Zoo is directly adjacent to the stream with trail access- an outdoor classroom could be used for zoo programs to educate children about the importance of the stream. Programs could work with public and private schools.	Outdoor Classroom
X19/33	These sites on the South Fork are located in an area with limited access to green space. Birding platforms that utilize existing MSD access would offer residents easy access to wetland viewshed.	Birding Platforms (3)

The conceptual recreation plan includes four high priority sites and three low priority sites for recreation. The X2 Confluence site is seen as a high priority due to its location and existing features. The

Louisville Loop, the 200-mile multi use path that will eventually circle the Louisville Metro, is connected to this site, which lies just east of the Louisville Waterfront Park and the Big Four Pedestrian Bridge which connects Louisville to Jeffersonville, Indiana. A small vessel boat ramp is proposed near the mouth of the stream at an already public park. Additionally, a pedestrian bridge to connect not only an existing stream side trail but also the Waterfront Botanical Gardens to the east side of the stream is proposed. This will connect these amenities with the park.

The second-high priority site is the X38, Cave Hill site which also has an existing trail. The plan would realign approximately 2000 feet of this trail and add birding platforms at the proposed wetland areas. These plans align with the Beargrass Creek Alliance Planning Assistance to States study that proposed trail improvements and connections in this area. The third high priority site is the X29, Eastern Creason Connector. This stretch of stream joins Joe Creason Park and the Beargrass Creek Nature Center to several neighborhoods. The plan would add a soft surface trail along this reach with connections to key community features and adjoining neighborhoods. Small additions such as benches along the way will enhance the trail experience and offer opportunities for birders.

The Joe Creason/Beargrass Nature Preserve site (X30) is an existing park and natural area with trails that connect the park to The Nature Center, an educational center that hosts nature programming for children. In alignment with The Congress for the New Urbanism's 2019 South Fork Legacy Plan, the proposal would enhance these connections and provide a more accessible and engaging trail experience that would link the community to the preserve more effectively.

The low priority recreation sites are the MSD Basins on the South Fork (X19/X33) and the X10 Zoo/Alpaca Farm site. For the MSD basins, the plan proposes to add birding platforms at all three basins and utilize the MSD access points. For the Zoo site, the addition of an outdoor classroom near the existing zoo trail would offer opportunities for education about stream health and importance and ecosystem services, for example. Figure 64. shows the recreation plan locations.

While other sites may have opportunity for recreation, many already have existing recreational plans that our plan will support.

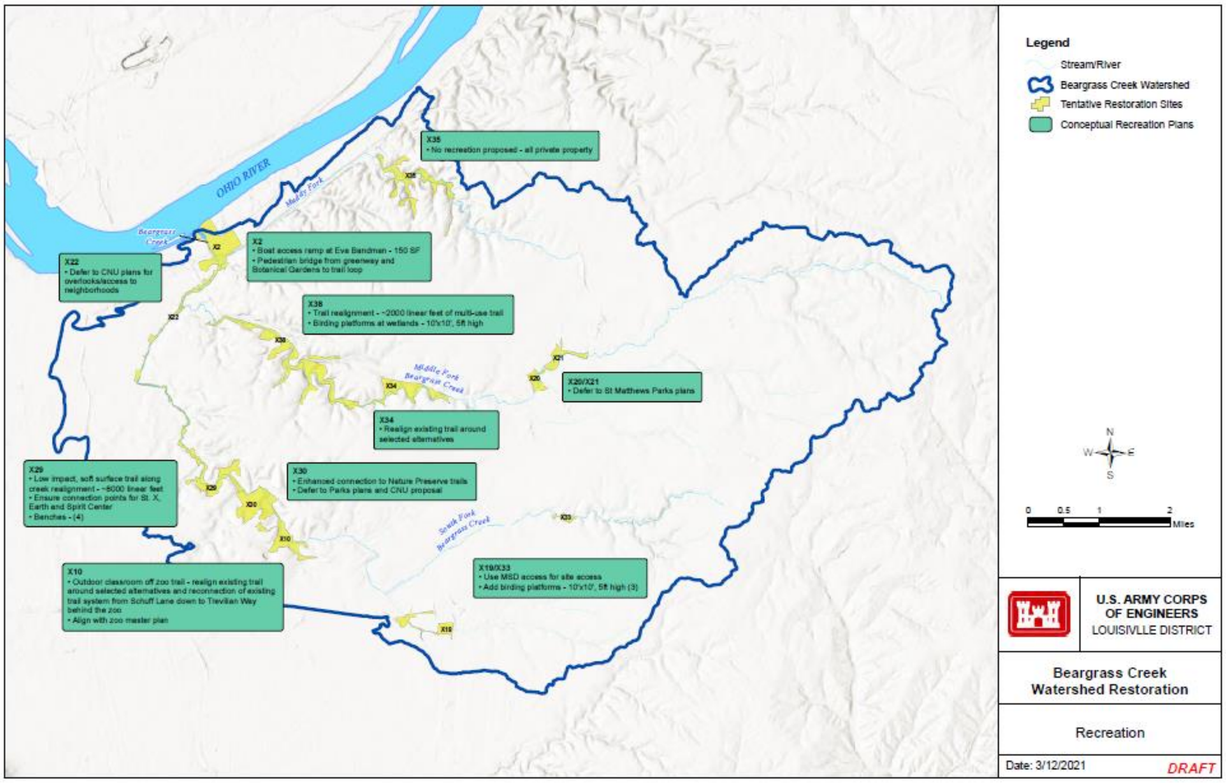

Figure 64. Recreation plan locations

7.4 Regional Economic Development and Economic Impacts Summary Comparison

The Principles and Guidelines (1983) established the RED account to register changes in the distribution of regional economic activity that would result from each alternative plan. In addition to the benefits accounted for within the National Economic Development (NED) account, the implementation of the TSP would result in local economic activity which is accounted for within the RED account.

The USACE Regional Economic System (RECONS) is a regional economic impact modeling tool that was developed to provide accurate and defendable estimates of regional economic impacts associated with USACE spending. It is the only USACE certified Regional Economic Development model for agency wide use. RECONS incorporates impact area data, as well as multipliers, direct ratios (jobs to sales, income to sales, etc.), and geographic capture rates to estimate jobs, labor income, and other critical impacts to the local, county, and state economy. Table 27 provides an overview of the impact areas utilized for the RED analysis, which was completed for the Three Forks of Beargrass Creek Ecosystem Restoration Study. Construction expenditures were analyzed in RECONS using the Construction Activities for Ecosystem and Habitat Restoration or Improvements (construction contracts) activity in the Environment business line. All costs are presented in FY22 price levels.

Table 27. Regional Economic Development and Economic Impacts Summary impact area

Economic Impact Areas	
Local Impact Area	Clark (IN), Floyd (IN), Harrison (IN), Scott (IN), Washington (IN), Bullitt (KY), Henry (KY), Jefferson (KY), Oldham (KY), Shelby (KY), Spencer (KY), Trimble (KY)
State Impact Area	Kentucky, Indiana

The project is expected to result in approximately $102,082,000 in construction expenditures across the region. These expenditures are expected to occur between 2025 and 2031. Of this total expenditure, $91,481,280 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The expenditures are expected to support approximately 1,710 full-time equivalent jobs and $193,766,000 in economic output in the local impact area.

More broadly, these expenditures are expected to support approximately 2,360 full-time equivalent jobs and $325,810,000 in economic output in the nation.

The share of economic impacts for each year over the construction period are directly proportional to project expenditures incurred each year. Therefore, if 20% of the construction expenditures occur in year 2025, those expenditures would be expected to support approximately 340 jobs and approximately $38,753,000 in local value added within the local impact area in that year.
Table 28 outlines the impacts at the local, state, and national level.

Table 28. Economic impacts summary

Region	Local Capture	Output	Jobs	Labor Income	Value Added
Local					
Direct Impact		$91,481,000	1,140	$70,830,000	$48,037,200
Secondary Impact		$102,284,000	560	$34,373,000	$56,032,000
Total Impact	$91,481,000	$193,766,000	1,710	$105,203,000	$104,069,000
State					
Direct Impact		$94,878,000	1,210	$77,009,000	$51,539,000
Secondary Impact		$110,894,000	600	$36,073,000	$59,664,000
Total Impact	$94,878,000	$205,772,000	1,810	$113,083,000	$111,204,000
US					
Direct Impact		$102,031,000	1,370	$86,703,000	$59,542,000
Secondary Impact		$223,778,000	980	$69,483,000	$120,523,000
Total Impact	$102,031,000	$325,810,000	2,360	$156,185,000	$180,065,000

Streamlined RECONS Definitions:

- Output: Economic output or total industry output is the value of production by industry for a given time period. It is also known as gross revenues or sales.
- Labor Income: Labor income represents all forms of employment earnings.

- Jobs (Employment): The work in which one is engaged; an occupation by which a person earns income. Employment includes both part-time and full-time jobs. All jobs are presented in full- time equivalence (FTE).
- Value Added: These are payments made by industry to workers, which also include interest, profits, and indirect business taxes. Value-added is an estimate of the gross regional or state product.

7.5 National Economic Development Impacts

The National Economic Development (NED) account includes information such as changes in the economic value of the national output of goods and services. It is expected that the project will result in NED benefits from recreation value added as well as the reduction of flood risk to structures in the watershed.

Recreation
Recreation features will be quantified in the final report.

Flood Risk Management
Without a detailed flood risk analysis, a quantitative value cannot be appropriately estimated for flood damages prevented by the TSP. However, to establish that the plan can reasonably be expected to contribute to a reduction in flood damages in the watershed, a geospatial analysis was performed to obtain a count of the structures that would be inundated across a range of flood frequency events without project and with the TSP. Inundation boundaries were provided by USACE Hydraulics and Hydrology engineers and compared against the National Structure Inventory 2.0. The inventory was checked against aerial imagery to correct for incorrectly placed structures along the Three Forks of the stream. Results are shown in Table 29.

Table 29. Count of flooded structures with and without project

Flood event	Structures Inundated	
	Without Project	With Project
2-year	26	26
5-year	71	66
10-year	157	148
20-year	300	289
50-year	638	605
100-year	1,222	1,174
200-year	1,676	1,616
500-year	2,226	2,182

7.6 Cost Summary

Table 30 summarizes the Project First Cost of the TSP. Project First Cost are escalated to the Fiscal Year (FY) 2022 price level. Data for this estimate is provided in Appendix C, the Cost Appendix. These costs were developed using the MACASES version MII software. A Total Project Cost Summary was put together and upon completion of a detailed Cost and Schedule Risk Analysis (CSRA) refined contingency cost will be incorporated. Until then, these costs estimates are considered Class 4 cost estimates per ER 1105-2-1302.

Table 30. Project First Cost Summary Table for the Tentatively Selected Plan (FY22)

Beargrass Creek Ecosystem Restoration (Price Level October 2021)	
Lands & Damages	$ 40,487,000
Relocations	$ 21,900,000
Fish & Wildlife Facilities	$ 71,931,000
Adaptive Management & Monitoring	$ 1,923,000
Recreation Facilities	$ 585,000
Cultural Resource Preservation	$ 778,000
Planning, Engineering, & Design (PED)	$ 13,460,000
Construction Management (S&A)	$ 6,730,000
Total Project First Cost	**$ 157,413,000**
Average Annual Cost	**$ 6,114,000**

7.7 Plan Implementation

7.7.1 Recommended Plan

The Real Estate Plan (REP) presents the real estate requirements for the Three Forks of Beargrass Creek Ecosystem Restoration Project in accordance with ER 405-1-12. It is tentative in nature and preliminary for planning purposes only. The plan includes estimated land values and costs associated with the acquisition of lands, easements, and rights-of-way. It also identifies any facility/utility relocations necessary to implement the project. Anticipated requirements for lands, easements, rights-of-way, relocations and disposal areas (LERRD) are based on information furnished by the project development team. Real estate estimates utilized in the planning phase were rough order of magnitude and calculated by looking at comparable parcels near the site. A real estate appraisal is under way and costs will be refined as the recommended plan is optimized.

A 5-year contract with options (options would not be fulfilled if success criteria is not met before the 5th year) would be utilized to ensure successful recruitment and establishment of native communities (abiotic and biotic). All hydrogeomorphic work would be accomplished within the first several months of the contract to allow establishment and monitoring time. Options would be placed in the contract for future adaptive management measures that could be exercised at any point of the contract duration, but most frequently in years 3, 4 and 5. These may include but are not limited to changing or adjusting features to achieve the required hydrology, hydraulics and/or geomorphology; additional native plant treatments; or other improvements. All adaptive management decisions and exercising of contract options would be driven by monitoring. Monitoring and adaptive management details will be laid out in the PPA signed with the sponsor. At this time, it is anticipated that MSD will be the sole sponsor for design and construction.

7.7.2 Operation and Maintenance Considerations

Once construction activities are completed, functional portions of the project will be turned over to the NFS. Operation, maintenance, repair, replacement, and rehabilitation activities (OMRRR) would occur after the project is constructed toto keep project features functioning as designed. Activities would be similar among the alternatives and vary in scale consistent with each alternative. This will include annual inspections and maintenance, periodic repair and/or replacement of project features, management of invasives throughout the constructed restoration features and channel bottom areas within the restoration footprint, and provision of irrigation to constructed features such as wetlands during drought. MSD will also be responsible for public education and organizing stewardship for restored habitats

Costs are based on a percentage of the initial construction cost of items anticipated to require maintenance over the life of the project, as well as estimates for inspection and maintenance and invasives management and are listed in Appendix C- Cost. A detailed OMRRR Plan will be developed during implementation. The estimate annual costs for O&M is $132,417 per year.

7.7.3 Detailed Design

Detailed design for the project will occur in the Preconstruction Engineering and Design (PED) phase. PED will include all technical engineering disciplines and will be completed in accordance with all required regulations and criteria. This report and appendices discuss design assumptions made during the feasibility phase and design elements that will be refined or determined during the PED phase.

Future design elements and investigations include the following:

- Hydrologic and hydraulic analysis including flood risk, two-dimensional modeling, verification of existing bridge impacts on design, wetlands, and groundwater.
- Refinement of the proposed planting work units including existing stand composition, clearing and grubbing requirements, proposed species mix, and planting density.
- Sour, erosion, and sediment transport analysis and plans.
- Geotechnical investigations including soil analysis for slope stability, infiltration, channel protection if needed, and erosion control products.
- Grading design for proposed H and R work units, and grading design for access roads where needed.
- Coordination with NFS on utility relocations and how they affect the design.
- Cultural resource investigations will be performed, and avoidance or impact minimization will be incorporated into the design.

Detailed design drawings of all project work units including plans, profiles, and cross sections will be developed in PED.

7.7.4 Monitoring and Adaptive Management

Section 2039 of WRDA 2007, 33 U.S.C. § 2330a, directs the Secretary to ensure that when conducting a feasibility study for a project (or a component of a project) for ecosystem restoration that the recommended project can include a plan for monitoring the success of the ecosystem restoration for a period of up to ten years from completion of construction of an ecosystem restoration project. This monitoring shall be cost-shared.

A five-year monitoring plan will be implemented for this project (Appendix I). The USACE, Louisville District would conduct monitoring in conjunction with the NFS to determine the success of the project. Baseline data for current conditions at Beargrass Creek are detailed in this report. The monitoring plan will identify:

- A systematic approach for identifying potential Project success criteria in areas of habitat restoration;
- The process for future decision-making related to management activities in the Study area;
- Criteria, triggers, and implementation of remedial actions to meet success criteria;
- Establish the framework for effective monitoring, assessment of monitoring data, and decision making for implementation of adaptive management activities in the study area;
- Provide the process for identifying adaptive management actions in the study area; and
- Establish decision criteria for vegetation and wildlife evaluation and modification of adaptive management activities.

7.7.5 Construction Phasing

During feasibility phase and upon selection of the recommended plan, the USACE and sponsor discussed the possibility of phasing construction due to the size and complexity of the project. As the feasibility study progresses to completion, details of implementation and construction phasing will be refined, and a construction plan will be created.

7.7.6 Environmental Operating Principles

The Tentatively Selected Plan supports USACE operating procedures by:

- Fostering sustainability as a way of life throughout the organization.
- Proactively consider environmental consequences of all Corps activities and act accordingly.
- Creating mutually supporting economic and environmentally sustainable solutions.
- Continuing to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.
- Considering the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

- Leveraging scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.
- Employing an open, transparent process that respects views of individuals and groups interested in Corps activities.

7.7.7 Division of Plan Responsibilities

MSD has tentatively agreed to serve as the local cost-sharing sponsor for Three Forks of Beargrass Creek Ecosystem Restoration project. The cost-sharing requirements and provisions will be formalized with the signing of the Project Partnership Agreement (PPA) between the local sponsor and USACE prior to initiation of contract award activities. In this agreement, the local sponsor will agree to cost sharing requirements. Based on the cost sharing requirements, the total project cost (FY22 price levels) and pertinent cost-sharing information for the restoration project are summarized in Table 30 above.

Federal - The estimated Federal cost share for implementation of the project is about $ 102,318,450. The USACE would accomplish the plans and specifications phase, which includes additional design studies and plans and specifications, contract for construction, overall supervision during construction, prepare an operation and maintenance manual, and participate in a portion of the post construction monitoring.

Non-Federal Responsibilities - Prior to initiation of the design phase, the Federal Government and the NFSs will execute a PPA. The Lands, Easements, Right of way, Relocations and Disposals (LERRDs) and OMRR&R of the project will be the responsibility of the NFSs for the proposed project. The estimated non-Federal cost share for implementation of the project is about $ 55,094,550 and will be covered by LERRDs credit and a cash contribution. The NFSs shall, prior to implementation, agree to perform the following items of local cooperation:

1. Provide 35 percent of the separable project costs allocated to environmental restoration as further specified below:
    a) The Non-Federal Sponsor shall pay 5 percent of construction costs.
    b) the Non-Federal Sponsor shall provide the real property interests, placement area improvements, and relocations required for construction, operation, and maintenance of the Project.
    c) In providing in-kind contributions, if any, the Non-Federal Sponsor shall obtain all applicable licenses and permits necessary for such work.
    d) After determining the amount to meet the 5 percent required by paragraph B.1., above, for the then-current fiscal year and after considering the estimated amount of credit that will be afforded to the Non-Federal Sponsor.
    e) No later than August 1st prior to each subsequent fiscal year, the Government shall provide the Non-Federal Sponsor with a written estimate of the full amount of funds required from the Non-Federal Sponsor during that fiscal year to meet its cost share. Contribute all project costs in excess of the USACE implementation guidance limitation of $10,000,000
2. To the extent practicable and in accordance with Federal law, regulations, and policies, the Government shall afford the Non-Federal Sponsor the opportunity to review and comment on solicitations for contracts, including relevant plans and specifications, prior to the Government's

issuance of such solicitations; proposed contract modifications, including change orders; and contract claims prior to resolution thereof.

3. The Government, as it determines necessary, shall undertake actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties as those properties are defined in the National Historic Preservation Act (NHPA) of 1966, as amended.
4. When the District Commander determines that construction of the Project, or a functional portion thereof, is complete, within 30 calendar days of such determination, the District Commander shall so notify the Non-Federal Sponsor in writing and the Non-Federal Sponsor, at no cost to the Government, shall operate, maintain, repair, rehabilitate, and replace the Project, or such functional portion thereof.
   a) The Non-Federal Sponsor shall conduct its operation, maintenance, repair, rehabilitation, and replacement responsibilities in a manner compatible with the authorized purpose of the Project and in accordance with applicable Federal laws and specific directions prescribed by the Government in the OMRR&R Manual.
   b) The Government may enter, at reasonable times and in a reasonable manner, upon real property interests that the Non-Federal Sponsor now or hereafter owns or controls to inspect the Project, and, if necessary, to undertake any work necessary to the functioning of the Project for its authorized purpose.
5. The Non-Federal Sponsor shall not use Federal Program funds to meet any of its obligations under this Agreement unless the Federal agency providing the funds verifies in writing that the funds are authorized to be used for the Project.
6. In addition to the ongoing, regular discussions of the parties in the delivery of the Project, the Government and the Non-Federal Sponsor may establish a Project Coordination Team to discuss significant issues or actions.
7. Notwithstanding any other provision of this Agreement, the Non-Federal Sponsor shall be responsible for all costs in excess of the Federal Participation Limit.
8. The Non-Federal Sponsor may request in writing that the Government perform betterments on behalf of the Non-Federal Sponsor.

7.7.8 Non-Federal Sponsor's Financial Capability

Design and implementation phases would be cost-shared, with the NFS to provide a minimum of 35% of the total being a Rough Order of Magnitude (ROM) cost of $ 157,413,000 (FY22 dollars). The estimated non-Federal share is approximately $ 55,094,550. Additionally, the NFS must provide all LERRDs. The sponsor may receive credit toward this cost-share for work-in-kind and LERRDs. Table 30 above shows the implementation costs.
The cost-sharing requirements and provisions will be formalized with the signing of the PPA between the NFS and USACE prior to initiation of contract award activities. In this agreement, the local sponsor will agree to cost sharing requirements.

7.8 Public Review Comments

This draft report will be circulated for a 30-day public review concurrently with Agency Technical Review and the Legal and Policy Compliance Review. All public and agency comments will be compiled and recorded adequately.

7.9 Validation Process for the NER Plan and Identification of Refined NER

Following the public review period for the Draft IFR, the USACE will performed further analysis to include a more detailed cost analysis, real estate cost updates, and further modifications of contingencies based upon a cost and schedule risk analysis.

8.0 Remaining Reviews, Approvals, Implementation, and Schedule

Section 8.2 below describes the remaining reviews and approvals required for this report. The following major milestones are currently scheduled.

Agency Decision Milestone	15 SEP 2021
District Engineer's Transmittal of Final Report Package	04 FEB 2022
Division Engineer's Transmittal of Final Report Package	15 JUN 2022
Chief of Engineer's Report Signed	05 AUG 2022

8.1 Project Partnership Agreement

Prior to advertisement for the construction contract, a PPA will be required to be signed by and between the Federal Government and the non-Federal sponsor, requiring formal assurances of local cooperation from the NFS. This agreement will be prepared and negotiated prior to the PED (Plans and Specifications) Phase.

8.2 Approval and Implementation

The study approval process will follow the steps found in PB 2018-01(S). These steps are listed below with additional general tasks for implementation:

a. The Integrated Feasibility Report, NEPA document, and appendices, along with the proposed report of the Chief of Engineers, will be circulated to state and Federal agencies and the public as directed by HQUSACE for the 30-Day State, Agency, and public review. The Agency Technical review and policy compliance review will be conducted concurrently during this 30 day period.

b. Chief of Engineers' Approval – the Chief of Engineers will sign the report signifying approval of the project recommendation and will submit the Chief of Engineers' Report, the IFR, and the unsigned FONSI to the ASA(CW).

c. ASA(CW) Approval – HQ USACE team will finalize the Chiefs Report for the Chiefs signature and the FONSI for signature by the ASA(CW). The ASA(CW) will review the documents to determine the level of Administration support for the Chief of Engineers' recommendation. The ASA(CW) will formally submit the report to the Office of Management and Budget (OMB). OMB will review the recommendation to determine its relationship to the program of the President. OMB may clear the release of the Chief of Engineers' report to Congress.

d. The Recommended Plan requires congressional authorization for project construction.

e. Funds could be provided, when appropriated in the budget, for preconstruction, engineering and design (PED), upon the Division Commander's endorsement of the District Engineer's report and submittal to HQUSACE announcing the completion of the final report and pending project authorization for construction.

f. Surveys, model studies, and detailed engineering and design for PED studies will be accomplished first, and then plans and specifications will be completed, upon receipt of funds.

g. Construction would be performed with Federal and non-Federal funds in accordance with the PPA.

9.0 Recommendation

I have considered all significant aspects of the problems and opportunities as they relate to the project resource problems of the Three Forks of Beargrass Creek watershed. Those aspects include environmental, social, and economic effects, as well as engineering feasibility.

I recommend Alternative Plan 10240, the NER/TSP, which consists of 1,090 acres and will restore 46,007 linear feet of stream. The plan also includes the removal of 19 connectivity barriers throughout the watershed. The overall benefits come to 416 Average Annual Habitat Units and 416 Social Units. Average annual cost is $6,114,000 with a project first cost of $157,413,000. All costs associated with the restoration of Three Forks of Beargrass Creek ecosystem have been considered.

In accordance with the National Environmental Policy Act of 1969, 42 U.S.C. § 4321-4347, as amended, the U.S. Army Corps of Engineers has assessed the environmental impacts associated with this plan, and the findings indicate that the proposed action is not a major Federal action significantly affecting the quality of the human environment.

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

The Non-Federal Sponsor understands its responsibilities as discussed in Section 7.6.8 above and has indicated its willingness to execute a PPA with the Federal Government for implementation of the recommended plan. I recommend approval of the recommended plan as presented in this report, with such modifications thereof as in the discretion of the Commander, HQUSACE, may be advisable.

Eric D. Crispino, P.E., PMP
Colonel, U.S. Army Corps of Engineers
Commander, Louisville District

10.0 References

American Association of State Highway and Transportation Officials. 2008. The Environmental 6 Stewardship Practices in Construction and Maintenance Compendium. Prepared under the 7 National Cooperative Highway Research Program as an effort of the AASHTO Standing 8 Committee on Environment, with input from the Highway Subcommittees on Construction and 9 Maintenance. Accessed September 2012 at http://environment.transportation.org.

Beier, P. and Noss, R.F. 1998. Do Habitat Corridors Provide Connectivity?. Conservation Biology, 12: 1241-1252.

Institute for Water Resources. Sept 2013. Using information on ecosystem goods and services in Corps planning: An examination of authorities, policies, guidance and practices.

James R.D. 2020. Comprehensive Documentation of Benefits in Feasibility Studies. Department of Army, Office of the Assistant Secretary, Civil Works, Washington, D.C.

James R.D. 2021. Policy Directive: Comprehensive Documentation of Benefits in Decision Document. Department of Army, Office of the Assistant Secretary, Civil Works, Washington, D.C.

Kentucky Division of Water, 2010, 303(d) List of Waters for Kentucky, Department for Environmental Protection, Kentucky Natural Resources and Environmental Protection Cabinet.

Kentucky Geological Survey. 2019a. Why Earthquake Research Matters. https://www.uky.edu/KGS/earthquake/earthquake_matters.php. Accessed 17 Dec 2020.
Louisville Metropolitan Sewer District. 2016. State of The Streams 2016 Water Quality Synthesis Report

Kentucky Geological Survey. 2019b. Ground-Water Resources in Kentucky. Accessed 07 Apr 2021. http://www.uky.edu/KGS/water/library/webintro.htm.

Linkov, I., Loney, D., Cormier, S., Satterstrom, F.K. and Bridges, T., 2009. Weight-of-evidence evaluation in environmental assessment: review of qualitative and quantitative approaches. Science of the Total Environment, 407(19), pp.5199-5205.

Louisville Metro/Jefferson County Information Consortium (LOJIC). 2021. Louisville Open GeoSpatial Data from LOJIC (Louisville and Jefferson County, KY Information Consortium). https://data.lojic.org. accessed 02 APR 2021.

MSD. 2016. State of the Streams Report.

McKay, S.K, Moulder, N., Russell, D., Mattingly, S., and Mattingly, L. 2021. Decision Models to Inform Urban Watershed Restoration in Beargrass Creek. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

McKay S.K., Pruitt B.A., Harberg M., Covich A.P., Kenney M.A., and Fischenich J.C. 2010. Metric development and application for environmental benefits analysis. ERDC TN-EMRRP-EBA-04. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

McKay S.K., Linkov I., Fischenich J.C., Miller S.J., and Valverde L.J. 2012a. Ecosystem restoration objectives and metrics. ERDC TN-EMRRP-EBA-16. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

McKay S.K., Wilson C.R., and Piatkowski D. 2012b. Currituck Sound estuary restoration: A case study in objective setting. ERDC TN-EMRRP-EBA-17. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

National Park Service. 1994. Report to Congress, Report on effects of aircraft overflights on the National Park System.

Office of Kentucky Nature Preserves. 2021. https://www.natureserve.org/conservation-tools/listed-and-imperiled-species-county-and-watershed/county-map. Accessed 07 APR 2021.

Olmsted Parks Conservancy. Website found at https://www.olmstedparks.org/about/frederick-law-olmsted/

Opperman, J.J, R. Luster, B.A. McKenney, M. Roberts, A. Wrona Meadows. 2010. Ecologically Functional Floodplains: Connectivity, Flow Regime, and Scale. Journal of the American Water Resources Association. Vol. 46: Issue 2. pp. 211-226.

Platt, S.G. and Brantley, C.G. 1997. Canebrakes: An Ecological and Historical Perspective. South Appalachian Botanical Society. https://www.jstor.org/stable/4034098.

Redwing Ecological Services, Inc. 2017 Fish Community Assessment Report. MSD Long Term Monitoring Network. Jefferson County, Kentucky. Redwing Project 12-104-02.

Reid, C.E. et al. 2017. Is all urban green space the same? A comparison of the health benefits of trees and grass in New Your City. International Journal of Environmental Research and Public Health.

Ruther, M., et al. 2016. Projections of Population and Households: State of Kentucky, Kentucky Counties, and Area Development Districts, 2015-2040, Vintage 2016. Kentucky State Data Center.

Soule M.E. 1986. Conservation Biology: The Science of Scarcity and Diversity.

Triguero-Mas, M. et al. 2015. Natural outdoor environments and mental and physical health: Relationships and mechanisms. Environment International. Volume 77.

U.S. Army Corps of Engineers (USACE). 2000. Planning Guidance Notebook. ER-1105-2-100. Washington, DC.

U.S. Army Corps of Engineers (USACE). 2011. Assuring quality of planning models. EC-1105-2-412. Washington, DC.

U.S. Army Corps of Engineers (USACE). 2014. Appendix C: Environment. EC-11-2-206. Headquarters, USACE, Washington, D.C.

U.S. Army Corps of Engineers (USACE). 2018. Anacostia Watershed Restoration, Prince George's County, Maryland: Ecosystem restoration feasibility study and integrated environmental assessment. Baltimore, Maryland.https://www.nab.usace.army.mil/Portals/63/docs/Environmental/Anacostia/AWR_PG_Main_Report_FINAL_Dec2018.pdf.

U.S. Environmental Protection Agency. 2020. Current Nonattainment Counties for All Criteria Pollutants. http://www3.epa.gov/airquality/greenbook/ancl.html. 31 July 201p. Accessed 17 Dec 2020.

U.S. Fish and Wildlife Service. 2015. Conservation Strategy for Forest-Dwelling Bats in the Commonwealth of Kentucky. U.S. Fish and Wildlife Service, Kentucky Field Office. April 2015

U.S. Geological Survey. 2020. USGS Surface-Water Annual Statistics for Kentucky. https://waterdata.usgs.gov/ky/nwis/annual/?referred_module=sw&site_no=03293510&por_03293510_58866=2459234,00060,58866,2008,2020&year_type=W&format=html_table&date_format=YYYY-MM DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed 17 Dec 2020.

Waite IR, Sobieszczyk S, Carpenter KD, Arnsberg AJ, Johnson HM, Hughes CA, Sarantou MJ, Rinella FA. 2008. Effects of urbanization on stream ecosystems in the Willamette River basin and surrounding area, Oregon and Washington: US Geological Survey Scientific Investigations Report 2006-5101-D, 62.

Water Resources Council (WRC). 1983. Economic and Environmental Principles and Guidelines for Water and Land Resources Implementation Studies, March 10, 1983.

Wolch, Jr, Byrne, J, & Newell, JP. 2014. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Lanscape and Urban Planning, 125. https://escholarship.org/content/qt8pf8s47q/qt8pf8s47q.pdf