Draft Integrated Feasibility Report and Environmental Assessment

Kentucky River, Beattyville, Kentucky Flood Risk Management Feasibility Study



Beattyville, Kentucky during the March 2021 flood event

August 2024

US Army Corps of Engineers®
Louisville District

FINDING OF NO SIGNIFICANT IMPACT

Kentucky River, Beattyville Kentucky, Flood Risk Management Feasibility Study

The U.S. Army Corps of Engineers, Louisville District (USACE) has conducted an Environmental Assessment (EA) in accordance with the National Environmental Policy Act of 1969, as amended, for the Kentucky River, Beattyville, Kentucky, Flood Risk Management Investigation Feasibility Study, which addresses potential means of flood risk reduction within Beattyville, Kentucky.

The Draft EA, incorporated herein by reference, evaluated various alternatives that would provide flood risk reduction to the community of Beattyville, Kentucky. The Recommended Plan is Alternative 5C, which consists of nonstructural measures for essential community assets and historical structures, a flood warning and emergency evacuation plan (FWEEP), restoration of the acquired floodplain land via native plantings, and the construction of a new recreational trail. Nonstructural measures include the following:

- Acquisition of property for removal from the floodplain
- Dry floodproofing of structures
- Wet floodproofing of structures
- Raising structures in place
- FWEEP

In addition to Alternative 1, a “no action alternative,” twelve action alternatives were evaluated. Alternatives 2A, 2B, 2C, and 2D each consisted of flood wall alignments with nonstructural components outside of the floodwalls combined with a FWEEP, with each alternative being designed for different flood stages including 672.2, 669.2, 666.5, and 663.0 respectively. Alternatives 3A, 3B, 3C, and 3D consisted of only nonstructural measures combined with a FWEEP, with each alternative being designed for different flood stages including 672.2, 669.2, 666.5, and 663.0 respectively. Alternative 4 consisted of only implementing a FWEEP. Alternatives 5A, 5B, and 5C included a FWEEP with incremental nonstructural measures added. Alternative 5A was a FWEEP with floodplain acquisitions. Alternative 5B was a FWEEP with floodplain acquisitions and floodproofing for essential community assets and services. Alternative 5C was a FWEEP with floodplain acquisitions, floodproofing of essential community assets and services, and floodproofing of historical structures. Comparison of alternatives and selection of the Recommended Plan are addressed in Section 5.1 and 5.2.

For all alternatives, the potential effects were evaluated, as appropriate. A summary assessment of the potential effects of the Recommended Plan are listed in Table i. For the complete evaluation see Section 4 of the appended report.

Table i. Summary of Potential Effects of the Recommended Plan

	Insignificant effects	Insignificant effects due to mitigation	No effects	Positive Effects
Climate Resiliency	☐	☐	☐	☒
Climate Change (Greenhouse Gas Emissions)	☒	☐	☐	☐
Soils and Geology	☒	☐	☐	☐
Prime and Unique Farmland	☐	☐	☒	☐
Surface Waters	☐	☐	☐	☒
Groundwater	☐	☐	☒	☐
Floodplains	☐	☐	☐	☒
Wetlands	☐	☐	☒	☐
Terrestrial Habitats and Fauna	☐	☐	☐	☒
Aquatic Habitats and Fauna	☐	☐	☐	☒
Federally Listed Species	☐	☐	☐	☒
State Listed Species	☐	☐	☐	☒
Designated Critical Habitat	☐	☐	☐	☒
Recreational, Scenic, and Aesthetic Resources	☐	☐	☐	☒
Historic Properties	☐	☐	☐	☒
Tribal Resources	☒	☐	☐	☐
Other Cultural Resources	☐	☐	☒	☐
Air quality	☒	☐	☐	☐
Invasive species	☐	☐	☐	☒
Noise levels	☒	☐	☐	☐
Transportation and traffic	☒	☐	☐	☐
Hazardous, toxic & radioactive waste	☒	☐	☐	☐
Socioeconomics	☐	☐	☒	☐
Environmental justice	☐	☐	☒	☐

All practical and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the Recommended Plan. Best management practices (BMPs) as detailed in the Draft EA will be implemented, if appropriate, to minimize impacts. BMPs include, but are not limited to, a stormwater pollution prevention plan (SWPPP).

No compensatory mitigation is required as part of the Recommended Plan.

Public review of the draft EA and Finding of No Significant Impact (FONSI) was completed on [PENDING] All comments submitted during the public review period were responded to in the Final EA and FONSI, and any necessary changes were incorporated.

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, USACE determined that the Recommended Plan may affect but is not likely to adversely affect the following federally listed species or their designated critical habitat: fanshell, snuffbox, longsolid, round hickorynut, clubshell, rabbitsfoot, and salamander mussel. The U.S. Fish and Wildlife Service concurred with USACE's determinations [PENDING].

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, USACE determined that the Recommended Plan would have no effect on the following federally listed species or their designated critical habitat: Virginia big eared bat, grey bat, northern long-eared bat, Indiana bat, and monarch butterfly.

Pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended, the USACE determined that historic properties would not be adversely affected by the recommended plan. The Kentucky State Historic Preservation Officer concurred with the determination on [PENDING].

All applicable environmental laws have been considered and coordination with appropriate agencies and officials has been completed [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 cause significant adverse effects on the quality of the human environment; therefore, preparation of an Environmental Impact Statement is not required.

Date

[redacted]
Colonel, U.S. Army
District Commander

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1 INTRODUCTION

1.1 INTRODUCTION

This General Investigation feasibility study researched potential flood risk management measures and methods, evaluated these measures, and generated alternatives that sought to meet the objectives of the study. The goal was to provide a recommendation for an optimal solution to reduce flood damages from the Kentucky River and increase resiliency within the community of Beattyville, Kentucky, over the 50-year period of analysis. Potential recommendations consisted of structural measures including, but not limited to, impoundments, floodwalls, levees, pumping stations, and diversions as well as a wide array of nonstructural measures, including but not limited to, floodproofing, acquisitions, elevating in place, and flood warning and emergency evacuation planning.

The study focused on Beattyville, Kentucky, near the confluence of the North and South forks of the Kentucky River. Beattyville is the county seat of Lee County, Kentucky.

1.2 USACE PLANNING PROCESS

The U.S. Army Corps of Engineers (USACE) planning process, which was used in this study, follows the six-step process defined in the USACE Principles, Requirements, and Guidelines (PR&G). This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six-step process is used for all planning studies conducted by USACE. The six steps are:

Step 1 - Identifying Problems and Opportunities

Step 2 - Inventorying and Forecasting Conditions

Step 3 - Formulating Alternative Plans

Step 4 - Evaluating Alternative Plans

Step 5 - Comparing Alternative Plans

Step 6 - Selecting Recommended Plan

USACE decision-making is generally based on the accomplishment and documentation of all these steps. It is important to stress the iterative nature of this process. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. The six steps, though presented and discussed in a sequential manner for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete, and acceptable plans.

In addition, this feasibility study includes an integrated Environmental Assessment (EA), in accordance with the National Environmental Policy Act (NEPA). Fundamental to the USACE planning process is the identification of the Problems, Opportunities, Objectives and Constraints (POOCs). These elements of the study have been developed by the Project Delivery Team (PDT) through the initial scoping effort in coordination with local stakeholders during the kickoff charette.

1.3 STUDY AUTHORITY

Authority for the Kentucky River, Beattyville, Kentucky General Investigation Feasibility Study is as follows:

> *Section 6 of the Flood Control Act of 1939, PL 76-396 authorizes the Secretary of the Army to perform examinations and studies for flood control on the Kentucky River and its Tributaries, Kentucky, and the Consolidated Appropriations Act of 2022 (PL 117-103), Division D, Title 1, through an explanatory statement authorized funds for a flood control study at Beattyville Kentucky.*
>
> *Section 105(a) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2215(a), specifies the cost-sharing requirements*

1.4 STUDY AREA (PLANNING AREA)

1.4.1 Study Area

The study area encompasses Beattyville in Lee County, Kentucky (Figure 1). The main stem of the Kentucky River is formed in Beattyville by the confluence of the North and South forks. From Beattyville, the Kentucky River flows 250 miles to the northwest to join the Ohio River in Carrollton, Kentucky. The North Fork Kentucky River headwaters are located in Letcher County. From there, the river flows 168 miles northwest through the communities of Whitesburg, Hazard, and Jackson before reaching Beattyville, where it joins with the South Fork. The Carr Fork, a tributary of the North Fork, is impounded to form Carr Creek Lake, a USACE reservoir. About five miles upstream of Beattyville, the Middle Fork Kentucky River enters the North Fork. The Middle Fork is about 105 miles long and rises in the Appalachian Mountains in southernmost Leslie County. In Buckhorn, the Middle Fork is impounded to form USACE's Buckhorn Lake reservoir. The South Fork Kentucky River is approximately 45 miles long and is formed in Clay County. The South Fork flows generally north in a meandering course before joining the North Fork in Beattyville. Nearby locks within the watershed were utilized for the purpose of modeling specific measures and for evaluating effects on floodwater elevations.

The non-Federal sponsor (NFS) for this effort is Lee County, Kentucky. The Federal Cost Share Agreement (FCSA) was developed and executed by USACE Louisville District on January 3, 2023. Lee County is located in Kentucky's 5th Congressional District. The Congressional Representative is Hal Rogers.

1.4.2 Project Area

The project area is the city limits of Beattyville. The portion of the community most affected by flood damages is the downtown area of Beattyville (Figure 2).

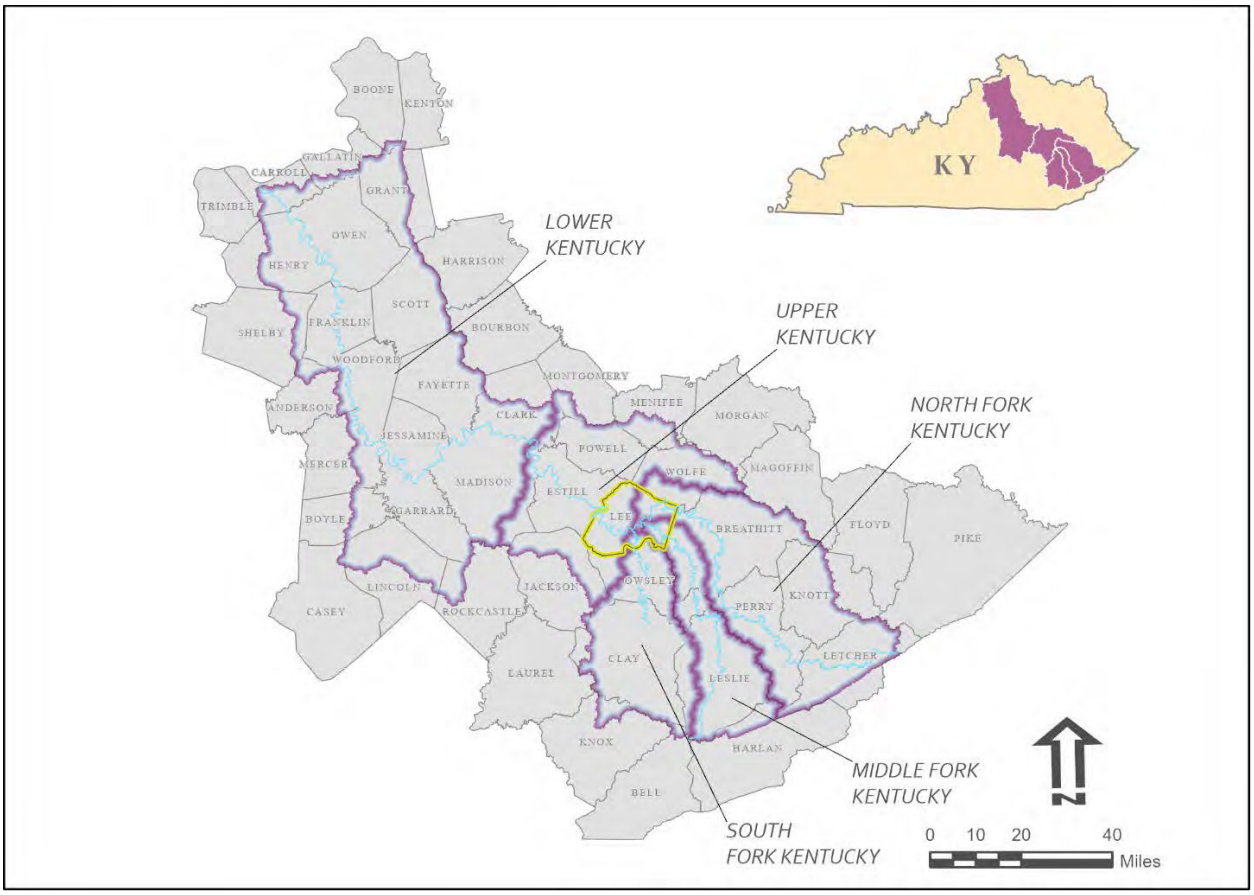


Figure 1. General location map showing the greater Kentucky River watershed and Lee County, Kentucky

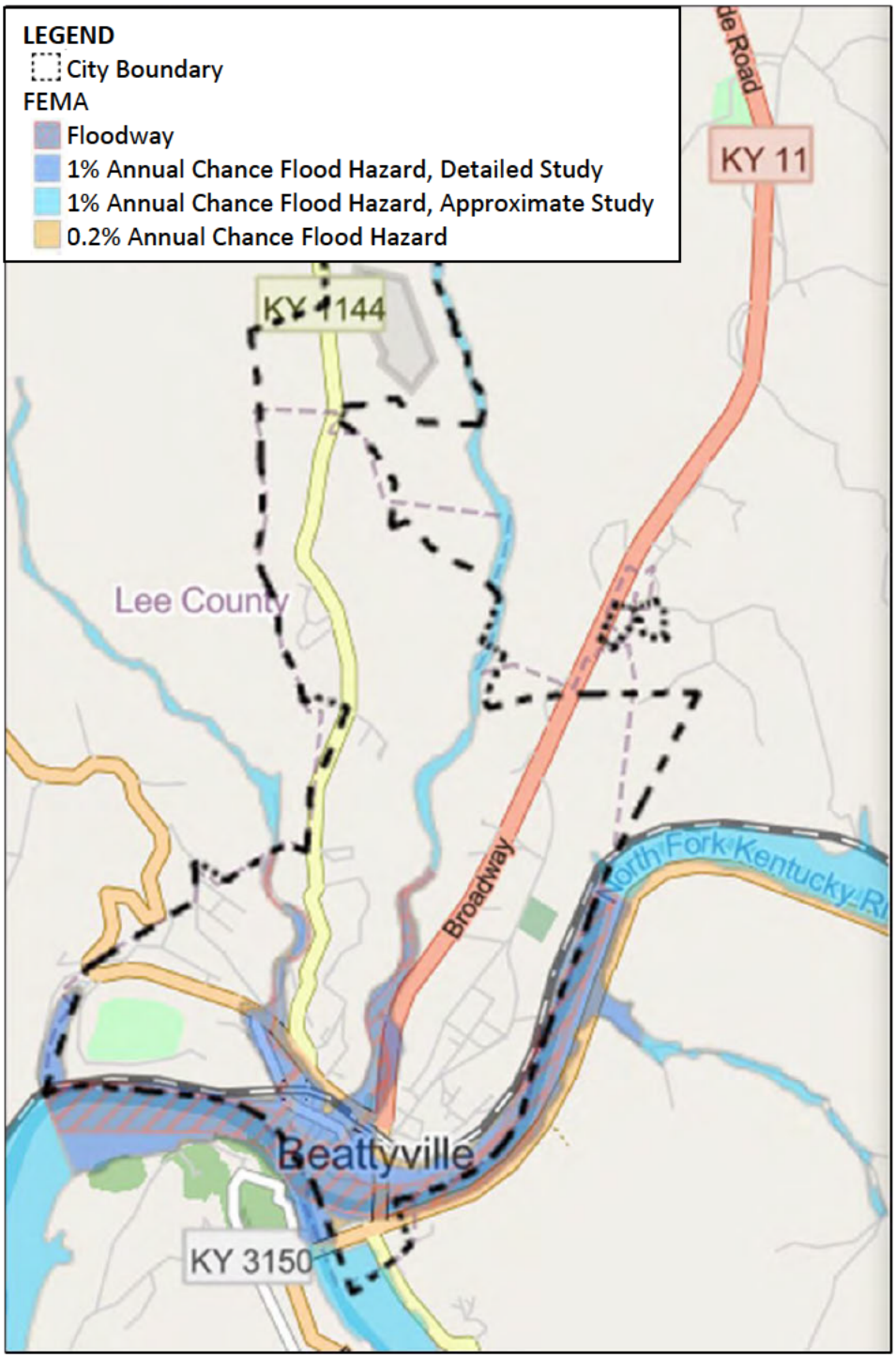


Figure 2. Flood Zones within the project area.

1.5 Background and History

In March of 2021, the City of Beattyville (Beattyville) suffered a severe flood event, estimated to have been a 50-year or 2% annual exceedance probability (AEP) event, which crested at

approximately 666.5 feet (ft) North American Vertical Datum of 1988 (NAVD88), and impacted significant portions of the downtown area. On April 23, 2021, a Presidential Major Disaster Declaration (4595-DR-KY) was declared for nine Kentucky counties, including Lee County. This declaration opened the Federal Emergency Management Agency's (FEMA) Individual Assistance (IA) and Public Assistance (PA) programs.

Due to the development pattern of Beattyville and its proximity to the Kentucky River, most of the businesses are in a high-risk flood area and some are located in the floodway. The recurrent flooding threatens life, causes loss of access to parts of downtown, and has lasting adverse economic impacts for this already disadvantaged area. Additionally, frequent flooding creates a negative impact on the community structure and its identity, damages essential structures and infrastructure, and serves as a repetitive hazard to recreational facilities, activities, and tourism. Specific to the March 2021 event, although there were no fatalities, most if not all businesses in downtown Beattyville suffered water damage and were closed for some time after the event (WYKT, 2021). The flooding threat to human life, property damage, and economic loss for government, local businesses, and residents is substantial.

1.6 PURPOSE AND NEED

The compounded effects of Beattyville's location near the convergence of three forks of the Kentucky River (the North, Middle, and South forks) and the increased frequency and intensity of precipitation predicted for the area support the need for a flood risk management investigation in Beattyville. In response, the purpose of this feasibility study is to evaluate flooding concerns in the area and identify potential alternatives that yield a positive impact on flood risk management and, ultimately, a tentatively selected plan.

1.7 PROBLEMS AND OPPORTUNITIES

A two-day planning charette was held in Beattyville April 18-19, 2023 (see Section 7.2 for additional information). During the charette, the PDT, local sponsor, vertical team, and various stakeholders and agencies identified the main problems.

Problem Statement

Beattyville, Kentucky, is at risk of repeated flooding, resulting in economic decline, social hardship to an already underserved and disadvantaged community, and potential life safety risk.

Problem Narrative

Beattyville is located at the confluence of the North and South forks of the Kentucky River, just downstream of the confluence with the Middle Fork of the Kentucky River. Due to its complicated hydrology at the confluence of multiple forks, Beattyville is at risk of flooding and has experienced numerous major floods in the past century, as well as frequent nuisance flooding throughout the floodplain. The flooding results in damages to structures and the contents therein, many of which are entirely within the floodway. In addition, there is currently a lack of comprehensive, effective floodplain management. Inadequate data, warning systems, and emergency response plans adversely impact the community. Repeated flood events contribute to decreased economic activity in this already underserved community.

Opportunities

Successful completion of this study and identification of a federally justified project have the potential to enable USACE to realize the following identified opportunities (i.e., chance to create a future condition that is desirable through project implementation):

- Reduce flood risk and cost of flood insurance with respect to the National Flood Insurance Program (NFIP), improve flood insurance mapping (FIM), and the potential for FEMA certification and reducing costly nuisance flooding along the Kentucky River shoreline.
- Improve flood response through better flood forecasting infrastructure and risk communication and through increased resilient Floodplain Management, local zoning and building regulations, and land use and development.
- Increase economic vitality and activity in Beattyville through improved recreational and ecological tourism opportunities along the shoreline and in-stream, which will also promote placemaking and brand identity.

1.8 OBJECTIVES AND CONSTRAINTS

Discussions during the planning charette resulted in the development of the following objectives and identification of the following constraints associated with the project.

1.8.1 Planning Objectives

1. Life Safety - Over the 50-year period of analysis, reduce risks to life and community safety associated with riverine flooding from the Kentucky River, Silver Creek and Crystal Creek in Beattyville.
    - Fortunately, there was no loss of life during the March 2021 event. However, the flood occurred at night when few people were present in downtown Beattyville, an area composed primarily of commercial structures. If a similar flood occurred in Beattyville during the day, life safety risk would increase. Improvement to life safety risk could be measured by life loss modeling, reduction of flood depths on roadways and in structures, emergency response and warning times, and maintenance of critical routes.
    - Updated flood maps would help guide future emergency management efforts, evacuation routes, and land use and building code regulations. Improvement could be measured by the development of more accurate and current flood mapping.
    - Flood risk preparedness could be improved by more accurate gage and flood level data, which could strengthen emergency action plans and provide better warning systems for citizens. Improvement could be measured by more accurate flood data and updates to emergency action plans.
2. Flood Risk Management - Over the 50-year period of analysis, reduce flood damages associated with riverine flooding from the Kentucky River, Silver Creek, and Crystal Creek to commercial, residential, and public properties, as well as public infrastructure in Beattyville.
    - The flood event of March 2021 is estimated to have been in the range of the 50-year (2% Annual Exceedance Probability [AEP]) event and resulted in approximately $149K spent on cleanup efforts (including payroll). Several

commercial structures and public buildings (for instance the Lee County Courthouse and the Lee County Health Center) experienced damages from flooding. After the March 2021 flood, seven of 51 businesses left Main Street: four moved permanently and three relocated. Don Begley Auto Sales, located in downtown Beattyville, lost 120 cars. As of the planning charette in April 2023, there were 11 empty structures on Main Street. Four mobile homes did not return to the mobile home park on River Drive. The local IGA (grocery store) was flooded. Combined with the cost of damages resulting from the flood, economic recovery has been difficult. Improvement could be measured by reduction in flood damages expressed through improved national economic development (NED) and regional economic development (RED) benefits.

- Beattyville does not have zoning or land use regulations to guide the city's development, so many structures are built in flood prone areas with no structural measures to resist potential flooding. Additionally, Silver Creek and Crystal Creek lack a cohesive management strategy for debris clearing and culvert maintenance, resulting in the buildup of debris and sediment. This objective seeks to provide planning and land use guidance to the NFS. Improvement could be measured by updated floodplain management plans and resiliency measures for existing structures.

3. Community Cohesion - Over the 50-year period of analysis, enhance community connections (physical and cultural) to the Kentucky River, Silver Creek, and Crystal Creek to promote health, access, and community identification (place-making).
    - The March 2021 flood event and the threat of recurrence, along with the frequent nuisance flooding along the Kentucky River shoreline has negatively impacted development in Beattyville that would otherwise provide connections between the river and the city. A public park near the river experiences yearly flood events that requires sediment removal, which has become such a financial burden that Beattyville is planning to relocate the park. A recreational vehicle campground developed on the shoreline was flooded, leaving only a few camping spaces; reestablishment of the lost spaces does not seem likely. The old police station, located in the floodway, was damaged during the March 2021 event and is in such a state of disrepair that the building has been abandoned, and the police station relocated to a building on Main Street.
    - Beattyville is located in an area of topographically rugged relief. Hillsides are steep and there is a lack of level, developable ground where communities can gather. The popularity of the recently developed Happy Top Park, a mountain top removal project converted into a community park, indicates the demand and enthusiasm for community areas. However, the Kentucky River shoreline is underutilized and is not functioning at its full potential as a place for the community to gather, enjoy recreational activities, and create connections to the river. This objective seeks to establish more resilient and sustainable connections to the Kentucky River and shoreline.
    - Silver Creek and Crystal Creek, tributaries of the Kentucky River that run through Beattyville, experience backwater flooding when the Kentucky River is high. This, combined with the buildup of debris and sediment, creates obstacles for

connection to the creeks. This objective seeks to improve access to and maintenance of Silver Creek and Crystal Creek.

1.8.2 Planning Constraints/Considerations

A constraint is a restriction that limits the extent of the planning process. Successful identification of study constraints helps to avoid undesirable outcomes. The following study specific constraint and considerations were identified:

Constraint

Avoid / minimize disproportionate impacts to economically disadvantaged and socially vulnerable populations in the study area from proposed Flood Risk Management (FRM) features.

Considerations

- Impacts to CSX Transportation (CSXT) rail, which follows an east-west path through the northern portion of Beattyville, or using the raised rail line as a levee requires considerable work with CSXT (time and resource intensive)
- Any suggested changes to downstream or upstream locks and dams would need to involve the Kentucky River Authority and may involve historic properties.
- Minimize/avoid negative environmental impacts.
- Measures that impact the floodway may present difficulties with permitting (such as FEMA); in Kentucky, the only nonstructural measure allowed in the floodway are buyouts (which must be mandatory)
- Local resources to fund the construction and to operate and maintain the project are limited.
- Avoid / minimize inducing flooding in the surrounding communities.

1.9 STUDY SCOPE

This General Investigation Feasibility Study will research all available flood reduction measures and methods, evaluate measures and generate alternatives that meet the objectives of the study, conduct financial analysis, and provide recommendations for the optimal solutions for the City of Beattyville to alleviate flooding from the Kentucky River.

1.10 RELEVANT PRIOR STUDIES AND REPORTS

U.S. Army Corps of Engineers - Booneville Lake, Kentucky, Condition of Improvement, 30 September 1995 – Project Maps and Data Sheets, Volume 2 – Multiple Purpose Projects. This proposed multipurpose project was originally designed to be located on the South Fork Kentucky River, 7.5 miles upstream from Booneville, Kentucky. The project was designed to operate as a unit in the comprehensive plan for flood risk mitigation in the Ohio River Basin, featuring over 403,000 acre-feet of storage capacity. This project was never constructed.

2 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

This chapter outlines the existing conditions and provides a forecast for the "Future Without Project" (FWOP) condition. The existing conditions encompass the general environment,

including relevant factors such as climate, flooding, and socioeconomic conditions that could influence or be impacted by the potential project alternatives. The FWOP condition represents the expected state if no federal action is taken (the "No Action Alternative"). The information presented in this chapter establishes the baseline for evaluating the alternatives.

2.1 PERIOD OF ANALYSIS

The planning horizon encompasses the planning study period, project implementation, period of economic analysis, and the effective life of the project. The period of analysis for this feasibility study is 50 years as required by ER 1105-2-103, Chapter 2, Section 2-4.

2.2 GENERAL SETTING

2.2.1 Climate

The climate within the project area is continental in nature and characterized by a wide range of temperature and precipitation totals. The average annual temperature is in the upper 50s with temperature extremes above 100 degrees Fahrenheit and below 0 degrees Fahrenheit. Precipitation primarily comes from storms distributed throughout the year, which generally move in an easterly or northeasterly direction. The most severe storm events occur in mid-winter or early spring (USACE, 1980; USACE, 1995).The USACE performed a synthesis of historic and projected climate trends for the project using the climate hydrology assessment tool (CHAT), time series toolbox (TST), and National Oceanic and Atmospheric Administration data sources, Civil Works Vulnerability Assessment Tool, and various scientific literature including the Fourth National Climate Assessment (USACE, 2023a). Analysis of historic trends were inconclusive, though a slight decrease in temperature and a slight increase in precipitation were indicated in certain historical data sets. It is hypothesized that the reason for the conflicting data is that the project area lies within a transition zone between northern and southern Appalachia, which are impacted by climate change in different, and often opposite ways. Projected trends indicate increases in temperature and precipitation. However, trends in projected streamflow are weaker and were not strongly supported in the analysis offering little consensus. While trends for typical streamflow were inconclusive, more consensuses exist for increases in extreme precipitation events. Therefore, project features impacted from extreme precipitation such as interior drainage structures may expect increase in the future. While project features impacted from increases in streamflow can be assumed to not be significantly impacted during its lifecycle. It should be noted that substantial uncertainty exists for projected conditions (USACE, 2023a. For the full detailed climate assessment, please refer to the Climate Change section within Appendix F and the Beattyville climate assessment in Section 2.7 below.

2.2.2 Soils and Geology

2.2.2.1 Geology and Physiography

The Kentucky Geologic map service, published by the Kentucky Geological Survey – University of Kentucky indicates that most of the site is underlain by alluvium. The information on the geology at the project site is based on the descriptions provided on the Beattyville geologic quadrangle.

The alluvium on-site consists of silt, clay, sand, and gravel, all intergrading and intertonguing chiefly on the flood plain of Kentucky River and its major tributaries. Alluvium predominantly

consists of yellowish brown clayey and sandy silt that contains lenses of light gray, very fine to fine quartz sand that commonly weathers grayish yellow. Pebbles, cobbles, and boulders of sandstone are locally common, especially in northern one-third of quadrangle. The formation includes older alluvium on terraces. Contacts are generally indistinct and are approximately located. The unit commonly grades into colluvium along valley walls.

The Grundy Formation of the Breathitt Group is mapped underlying the alluvium deposits. The Grundy Formation consists of siltstone (30-50%), shale (30-50%), sandstone (10-30%), coal, and underclay.

Artificial fill is mapped along the rail alignments and generally follows the interface of the Grundy Formation and the alluvium in the Beattyville area.

The topography of the area is that of rugged sandstone capped ridges with steep cliffs and shale-formed valleys with gentle slopes. The project area contains two stream valleys, Silver Creek, and Crystal Creek, that connect to the North Fork Kentucky River valley at the southern end of the project area, where Beattyville is located (UKY, 2023).

2.2.2.2 Soil Associations

Desktop analysis conducted via the National Resources Conservation Service's (NRCS) web soil survey application indicates there are seven soil map units and one miscellaneous unit within the project area (Table 1). Of the seven soil map units, none are defined as hydric or having hydric components. Of the seven soil map units, three are defined as prime farmland. For a full soil map and detailed soil descriptions, please refer to the NRCS soil report in Appendix B (NRCS, 2023).

Table 1. NRCS soil map units and their characteristics (NRCS, 2023)

Map Unit Symbol	Map Unit Name	Hydric	Prime Farmland	Acres in Project Area	Proportion of AOI
UuD	Urban land-Udorthents complex, 0-20% slopes	No	Not prime farmland	87.8	48.7%
W	Water	N/A	N/A	33.3	18.5%
GvB	Grigsby-Rowdy complex, 0-4% slopes, occasionally flooded	No	All areas prime farmland	28.8	16.0%
GyF	Shelocta-Gilpin complex, 20-65% slopes, sto	No	Not prime farmland	18.1	10.0%
SgF	Chagrin-Grigsby complex, 0-6% slopes, occasionally flooded	No	Not prime farmland	10.0	5.5%
EIA	Elk silt loam, 0-2% slopes, rarely flooded	No	All areas prime farmland	2.0	1.1%
GaD	Gilpin silt loam, 12-20% slopes	No	Not prime farmland	0.3	0.2%

uChgB	Chargin-Grigsby complex, 0-6% slopes, occasionally flooded	No	All areas prime farmland.	0.0[1]	0.0%
Totals for project area				**180.3**	**100.0%**

[1]Soil map unit is less than 0.1 acres and was rounded down to 0.

2.3 NATURAL ENVIRONMENT

2.3.1 Surface Water and Other Aquatic Resources

2.3.1.1 Surface Water

The project area falls within three distinct hydrologic units code (HUC) 12 watersheds, all of which drain into the Kentucky River. The western portion falls within the Contrary Creek-Kentucky River watershed (051002040503) and contains both Silver Creek and Crystal Creek. The eastern portion of the project area falls within the Hell Creek-North Fork Kentucky River (051002010707) watershed. The extreme southwestern portion falls within the Lower Buffalo Creek-South Fork Kentucky River watershed (051002030607; USGS, 2023b).

Section 303(d) of the Clean Water Act (CWA) requires States, Territories, and authorized Tribes to list and prioritize waters for which point source pollution control limits alone do not ensure attainment of water quality standards. The CWA and the United Sates Environmental Protection Agency (USEPA) regulations require that Total Maximum Daily Load (TMDL) be developed for all waters on the section 303(d) lists. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation or attribution of that amount to the pollutant's sources. Lists of 303(d) waters are submitted to the USEPA via a state monitoring program conducted by the Kentucky Department of Water (KDOW) and are made available to the public. The process of formulating TMDLs for specific pollutants is a method by which impaired water body segments are identified and restoration solutions are developed. Ultimately, the goal of TMDL process is full attainment of biological and chemical Water Quality Standards (WQS) and, subsequently, removal of water bodies from the 303(d) list (USEPA, 2009).

The USEPA “How’s my Waterway” web application has two stream water quality reports within the project area. Crystal Creek is a CWA listed 303(d) waterbody, which is impaired for warm water aquatic habitat due to high levels of organic enrichment. High levels of nitrates and phosphates indicates agricultural runoff or sewage discharge as possible sources (USEPA, 2023A; USEPA, 2023b). North Fork Kentucky River-river mile (RM) 0.0 to 2.3 is impaired for recreational use due to fecal coliform contamination, however, it is not currently listed under CWA 303 (d). This waterbody was removed from the 303(d) list after a TMDL was developed and implemented (USEPA, 2023a; USEPA, 2023b).

2.3.1.2 Groundwater

Within Lee County, approximately 75% of residents obtain their water from the North Fork Kentucky River. Of the remaining residents, 33% (approximately 650 people) make use of wells for their water needs. Within Beattyville, most residence obtain their water from Beattyville Water Works, which withdraws from the North Fork Kentucky River (KADD, 1999). Groundwater features within the project include two springs located along Silver Creek at the northwest end of the project

area and 30 monitoring wells. Groundwater quality varies but common issues in the region are high levels of iron and manganese, as well as salt contamination from abandoned oil/gas wells. In addition, groundwater within the area has historically been impacted by pollution stemming from runoff related contamination due to commercial mining, commercial logging, and other construction activities (UKY, 2023).

2.3.1.3 Floodplains

Executive Order (EO) 11988 later amended by EO 13690, requires Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. FEMA defines the floodway and floodplain as follows:

Regulatory Floodway: The regulatory floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height.

100-year Floodplain: Also known as the base flood, a flood having a one percent (1 in 100) chance of being equaled or exceeded in any given year.

500-Year Floodplain: A flood having a 0.2% (or 1 in 500) of being equaled or exceeded in any given year. Analysis of the USEPA NEPAssist website and Federal Emergency Management Agency (FEMA) floodplain maps indicate that the majority of the project area is within the floodway of Silver Creek, Crystal Creek, and North Fork Kentucky River. The remaining project area falls within the 100-year and 500-year floodplain. (USEPA, 2023c; FEMA, 2023a). Within the project area, 127 structures are located in the 100-year floodplain, with a total value of approximately $131 million.

2.3.1.4 Wetlands

Wetlands are considered for Federal projects under CWA Section 404 and Executive Order 11990. Wetlands are defined as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances, do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps marshes, bogs, and similar areas.” (USACE, 1987).

Desktop analysis conducted via the United States Fish and Wildlife Service’s (USFWS) National Wetland Inventory (NWI) web mapper indicates that palustrine emergent (PEM) wetland habitat exists along the fringe of North Fork Kentucky River near its confluence with Crystal Creek. NWI designated palustrine scrub-shrub (PSS) habitat exists along portions of Silver Creek and Crystal Creek near the CSX Transportation (CSXT) rail line (USFWS, 2023a). PEM wetlands are defined as freshwater wetland habitat consisting of less than 30% aerial coverage of woody tree and shrub species. Common species within a PEM wetland include cattails (*Typha spp.*), sedges (*Carex spp.*), bulrushes (*Scirpus spp.*), and other semi aquatic species. PSS wetlands are defined as having greater than 30% aerial coverage of woody shrub species and immature tree species. Common woody species within PSS include buttonbush (*Cephalantus occidentalis*), immature water oak (*Quercus nigra*), and immature red maple (*Acer rubrum*) (FGDC, 2013). For a full overview of NWI mapped wetlands, their size, and location related to the proposed project, please refer to the USFWS NWI map in Appendix B.

2.3.2 Fish and Wildlife Habitats

2.3.2.1 Terrestrial Habitats and Fauna

Given that the project area is urban, there is no significant or otherwise outstanding terrestrial habitat found in the project area, and the surrounding region contains much higher quality terrestrial habitat. The project falls within the Ohio/Kentucky Carboniferous Plateau level 4 ecoregion, which is within the Western Allegheny Plateau level 3 ecoregion (USEPA, 2023d). Historically, the area was mostly forested with mixed oak forests on slopes with mixed mesophytic forests in river valleys. The region is still mostly forested with mixed oak forests. Low lying areas in the region contain hemlock-hardwood forests and red maple-ash swamps (bplant, 2023). The project area primarily contains urban development within the North Fork Kentucky River valley. Due to this, ornamental trees, invasive species, and cultivated grass species are expected to be common, along with the remnants of species that inhabited the area prior to the creation of Beattyville.

Since the project area falls in and around the Beattyville city boundary, the terrestrial fauna is limited to those species typically found in an urban rural environment within the region, including various songbirds, raptors, grey squirrels (*Sciurus carolinensis*), mice, whitetail deer (*Odocoileus virginianus*), coyotes (*Canis latrans*), and other common urban species. Various species of bats also likely use the stream corridors for feeding and there is potential that listed bat species use the project area in some way (See Section 2.3.3.1 for a discussion of listed species). Otherwise, riparian habitat within the project area could have various turtle, snake, and lizard species that are associated with the streams in the area, although none are of conservation concern (City of Beattyville, 2023). These include the eastern fence lizard (*Sceloporus undulatus*) and the timber rattlesnake (*Crotalus horridus*) (HerpAtlas, 2024).

2.3.2.2 Aquatic Habitats and Fauna

The project area contains the North Fork Kentucky River, the South Fork Kentucky River, and the headwaters of the Kentucky River after the former pair's confluence. The North Fork Kentucky is a medium sized stream that contains species like muskellunge (*Elox masquinongy*), spotted bass (*Micropterus punctulatus*), smallmouth bass (*Micropterus dolomieu)*, channel catfish (*Ictalurus punctatus*), and rock bass (*Ambloplites rupestris*) (KDFWR, 2023a). It is a modified stream with historical uses for barge traffic, however, with the closure of multiple downstream dams, it is no longer used for this purpose (Christensen, 2022). Local areas within Lee County have habitat for the spotted salamander (*Ambystoma maculatum*) (HerpAtlas, 2024).

Crystal Creek and Silver Creek are two perennial streams that empty into North Fork Kentucky River and flow through the project area. Crystal Creek is known to suffer from nutrient contamination, as described in Section 2.3.1.1 (USEPA, 2023a). However, Silver Creek is classified as designated critical habitat (defined in Section 2.3.3.2) for the Kentucky Arrow Darter, which is typically observed as upland streams with cool, sluggish pools and riffle habitat (NatureServe 2023). For further discussion of this designated critical habitat and the Kentucky arrow darter, refer to Sections 2.3.3.1 and 2.3.3.2. In addition to stream habitat, USFWS NWI mapping indicates PEM and PSS habitat as being present within the project area (USFWS, 2023a). For detailed discussion of wetland habitat, refer to Section 2.3.1.4.

2.3.3 Endangered and Threatened Species

2.3.3.1 Federal and State Listed Species

Desktop analysis conducted via the USFWS's Information for Planning and Consultation (IPaC) web tool indicates that 12 endangered, threatened, proposed endangered, and candidate species have ranges that intersect the project area (Table 2). The Kentucky Department of Fish and Wildlife Resources' (KDFWR) Threatened & Endangered species list for Lee County indicates that 20 state endangered, threatened, and special concern species are within the same county as the project area (KDFWR, 2023b)

Table 2. Federal and State Listed Species with potential to occur within the project area.

Type	Scientific Name	Common Name	US Status	KY Status
Fish	Etheostoma spilotum	Kentucky Arrow Darter	T	T
Fish	Lethenteron appendix	American Brook Lamprey	-	T
Salamander	Cryptobranchus alleganiensis alleganiensis	Eastern Hellbender	-	S
Bird	Accipiter striatus	Sharp-shinned Hawk	-	S
Bird	Certhia americana	Brown Creeper	-	T
Bird	Junco hyemalis	Dark-eyed Junco	-	S
Freshwater mussel	Cyprogenia stegaria	Fanshell	E	-
Freshwater mussel	Epioblasma triquetra	Snuffbox	E	E
Freshwater mussel	Fusconaia subrotunda	Longsolid	T	S
Freshwater mussel	Obovaria subrotunda	Round Hickorynut	T	T
Freshwater mussel	Pleurobema clava	Clubshell	E	-
Freshwater mussel	Quadrula cylindrica cylindrica	Rabbitsfoot	E	-
Freshwater mussel	Simpsonaias ambigua	Salamander Mussel	PE	-
Insect	Danaus Plexippus	Monarch Butterfly	C	-
Insect	Dryobius sexnotatus	Sixbanded Longhorn Beetle	-	T
Crayfish	Cambarus guenteri	Redbird Crayfish	-	S
Crayfish	Cambarus taylori	Cutshin Crayfish	-	S
Mammal	Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	-	S
Mammal	Corynorhinus townsendii virginianus	Virginia Big-eared Bat	E	E
Mammal	Myotis austroriparius	Southeastern Myotis	-	S
Mammal	Myotis grisescens	Gray Myotis	E	T
Mammal	Myotis leibii	Eastern Small-footed Myotis	-	T
Mammal	Myotis lucifugus	Little Brown Bat	-	T
Mammal	Myotis septentrionalis	Northern Long-Eared Bat	T	E
Mammal	Myotis sodalis	Indiana Bat	E	E

E=Endangered, T=Threatened, S=Special Concern, C=Candidate, PE=Proposed Endangered

The gray bat was listed as endangered by the USFWS in 1976. The gray bat is a cave obligate species that occurs in areas of the southeastern and midwestern United States with limestone karst. Unlike some Myotis species in the Midwest and Southeast, gray bats roost on the ceilings

of caves and rear young in places where humans can disturb them with their presence through physical touch, noise, and artificial lighting. At the time of listing, the main threats to the gray bat were human disturbance to roosting bats, environmental contamination, impoundment of waterways, and roost modification or destruction. The species is also negatively impacted by cave commercialization, improper gating, and natural calamities like cave-ins and flood events (USFWS, 1997).

The Indiana bat was listed by USFWS as endangered in 1967. Indiana bats hibernate during winter in caves. For hibernation, they require cool, humid caves with stable temperatures under 50° F but above freezing. Very few caves within the range of the species have these conditions. If bats are disturbed or cave temperatures increase during hibernation, more energy is needed, and hibernating bats may starve (USFWS, 2006). In the spring, Indiana bats emerge from hibernation and migrate to summer roost sites where they usually roost under loose tree bark of dead or dying trees. During summer, males roost alone or in small groups, while females roost in larger groups of up to 100 bats or more. Indiana bats forage in or along the edges of forested areas. Indiana bats are found over most of the eastern half of the United States. Almost half of all Indiana bats (207,000 in 2005) hibernate in caves in southern Indiana. The 2005 population estimate was about 457,000 Indiana bats, half as many as when the species was listed as endangered in 1967 (USFWS, 2006). Loss and fragmentation of forest habitat are among the major threats to Indiana bat populations. Other threats include white-nose syndrome, winter disturbance, and environmental contaminants (USFWS, 2006).

The Virginia big-eared bat was listed by USFWS as endangered in 1979. It Is a colonial species that congregates in cave and cave like habitats during the summer. This species specializes in foraging moth species, which make up more than 80% of their prey. Forage activities occur within a few miles of roost sites and normally include forested habitat interspersed with open fields, cliff lines, and outcrops. Individuals can make use of different hibernacula during different seasons and can migrate upwards of 40 miles between sites. This species hibernates during the winter months, with the vast majority hibernating in 10 hibernacula, largely due to the narrow band of climatic conditions necessary for this species. Threats to this species include fragmentation of foraging areas, barriers to migration, and direct mortality from predation, wind turbine strikes, and brine pits. Of note, this species is particularly susceptible to disturbance within hibernacula, which can lead to increased mortality and abandonment of hibernacula (USFWS, 2019). This species ranges within Virginia, North Carolina, Kentucky, and West Virginia. Within Kentucky and within Lee County, Stillhouse Cave is one of the 10 major hibernacula for this species (CBD, 2023). While within the county, Stillhouse Cave is not within or nearby the project area.

The northern long-eared bat was listed as threatened by USFWS in 2015 and later reclassified as endangered on November 30, 2022. The bats spend the winter months hibernating in caves and mines. During the summer months, the bats roost singly or in colonies underneath bark or in cavities or crevices of both snags and live trees (USFWS, 2015). The primary threat to this species is white nose syndrome, which caused severe population losses in all hibernacula that were infected. Additional threats include loss of summer habitat, which includes roosting trees and other forested areas, and wind turbine strikes (USFWS, 2015).

The Kentucky arrow darter is a small benthic fish that typically occupies rocky pools in headwater streams of the upper Kentucky River drainage in eastern Kentucky. The species once occurred in small streams throughout the drainage, but it has now been eliminated from large portions of

its historical range, including 35 of 74 historical streams (HUC 4 watersheds). The Kentucky arrow darter currently occupies 52 small stream systems across 10 Kentucky counties (USFWS, 2022). However, most remaining populations are isolated and restricted to short stream reaches and, of the species' 52 extant streams, USFWS considers 27 of these populations to be "vulnerable" to extirpation. The species faces ongoing threats from poor water quality and altered habitats caused by coal mining, oil and gas exploration, logging, agriculture, poor land use practices, and development (USFWS, 2022). The species' fragmented distribution, lack of gene flow, and low genetic diversity increases its vulnerability to extirpation from chemical spills, habitat disturbance, and catastrophic weather events (e.g., drought, floods). Catastrophic flooding in the summer of 2022 across the upper Kentucky River drainage caused a great deal of damage to many streams occupied by the arrow darter but the effect on the species is currently unknown.

Listed as endangered by USFWS in 1993, the clubshell prefers clean, loose sand and gravel in medium to small rivers and streams and will bury itself in the bottom substrate to depths of up to four inches. Reproduction requires stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. Once found all over the eastern United States, it is now only known to occur in 13 streams (Haag and Cicerello, 2016). Reasons for its decline in the upper Ohio and Wabash watersheds are mainly due to pollution from agricultural run-off and industrial wastes, as well as extensive impoundments for navigation (USFWS, 1997). The only surviving natural population in Kentucky is in the upper Green River (Green County) where it is rare (Haag and Cicerello, 2016). While the project area exists outside of the surviving population's range, USFWS still protects suitable habitat within historical ranges for the potential reintroduction of the species. In addition, much of this species' original reach has not been surveyed and populations may still exist in areas where data is lacking.

The fanshell, listed as endangered in 1990, is found in medium to large rivers. It buries itself in sand or gravel in deep water of moderate current, with only the edge of its shell and its feeding siphons exposed. Reproduction requires a stable, undisturbed habitat and a sufficient population of fish hosts to complete the mussel's larval development. The species is known to be reproducing in the Clinch River in Tennessee and Virginia, as well as the Green and Licking Rivers in Kentucky. The damming of rivers has degraded most of this mussel's habitat, reducing its gravel and sand habitat and affecting the distribution of its fish hosts. Impoundment of larger river habitat, dredging for channel maintenance, and erosion caused by strip mining, as well as logging and farming have been known to destroy or degrade fanshell habitat. Other threats include pollution from agricultural and industrial runoff (USFWS, 1997). The largest populations of the fanshell occur in the Green and Licking rivers. Small, isolated populations of this species are known from the Barren River (Haag and Cicerello, 2016).

The longsolid was listed as threatened by USFWS on March 9, 2023. This species prefers sand and gravel within small rivers; however, it can also be found in coarse gravel and cobble in larger rivers. It is typically found in small streams at a depth of less than 2 ft but can be found at depths of over 20 ft in larger streams. Similar to most other mussel species, it relies on a host fish for glochidia to mature into adult mussels. Host species are currently unknown but likely candidates include minnow species within the genera *Campostoma*, *Cyprinella*, *Notropis*, and *Luxilus*, as well as sculpins within the genus *Cottus*. This species is currently found in the Ohio River, Cumberland River, and Tennessee River basins. Known threats to this species include habitat fragmentation from dams and other barriers, degraded water quality from chemical contamination due to poorly

managed development, direct mortality from dredging, and the proliferation of invasive mussel species like the zebra mussel (*Dreissena polymorpha*; USFWS 2023d).

The rabbitsfoot was listed as threatened by USFWS in 2013. Historically, the rabbitsfoot occurred in 137 streams in 15 states, including the following watersheds: the lower Great Lakes sub-basin, Ohio River system, Cumberland River system, Tennessee River system, lower Mississippi River sub-basin, White River system, Arkansas River system, and Red River system. It is found throughout the Ohio River drainage from headwaters in Pennsylvania to the mouth of the Ohio River (Cummings and Mayer, 1992). Based on historical and current data, the rabbitsfoot is declining range-wide and is now extant only in 46 of 137 streams of historical occurrence, representing a 66% decline. Further, in the streams where it is extant, populations with few exceptions are highly fragmented and restricted to short reaches (Butler, 2005). The chief causes of this species' decline are impoundments, channelization, chemical contaminants, mining, and sedimentation (Haag and Cicerello, 2016).

The round hickorynut was listed as threatened by USFWS on March 9, 2023. It is typically found in sand or gravel in riffle, run, and pool habitats within medium to large streams. They also thrive in shallow habitats with a depth of less than 1 foot with abundant American water-willow (*Dianthera americana*). In larger streams, they are commonly found in depths up to 6.5 ft. The primary threats to this species are habitat loss, degraded water quality from chemical contamination/erosion, and direct mortality from dredging activities (USFWS, 2023e).

The salamander mussel was proposed as endangered on August 21, 2023. As a proposed endangered species, it does not currently have protection under the Endangered Species Act (ESA). This species ranges throughout Kentucky drainages including the Ohio River, Green River, and Kentucky River basins. No records of this species have been reported from the Tennessee and Cumberland River drainages (Haag and Cicerello, 2016). This species is found in upland streams ranging in size from the largest river to small creeks. It is restricted to streams that support its only host, the mudpuppy (*Necturus maculosus*). It prefers habitat within fine sediments under large non-embedded flat rocks in deeper water or slow current areas. It can also be found in gravel riffles within beds of water willow (*Justicia americana*; Haag and Cicerello, 2016).

The monarch butterfly is a candidate species, and therefore has no formal protections under the ESA. Monarch butterflies are an iconic species with an annual, multigenerational, migratory life cycle and a cross-continental migratory range covering portions of Canada, the United States, and Mexico. To complete their life cycle, monarch caterpillars must feed on milkweed plants (*Asclepias* spp.) while adults feed on nectar from a variety of blooming plants. Monarch butterfly populations are in decline and are threatened by habitat loss, climate change, pesticide applications, natural enemies, and other abiotic and biotic stressors (USFWS, 2023c). This species migrates to its breeding locations in Mexico and California starting November and lasting until early March (Monarch Joint Venture, 2023).

2.3.3.2 Designated Critical Habitat

The USFWS defines designated critical habitat as the specific areas within the geographic area, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Designated critical habitat may also include areas that were

not occupied by the species at the time of listing but are essential to its conservation (USFWS, 2024).

Silver Creek is designated critical habitat from its headwaters to its confluence with the Kentucky River for the Kentucky Arrow Darter (USFWS, 2022).

2.4 PHYSICAL ENVIRONMENT

2.4.1 Recreational, Scenic, and Aesthetic Resources

2.4.1.1 Local Resources

Beattyville is situated alongside the North Fork Kentucky River, which provides opportunities for wildlife viewing, fishing, and boating. Beattyville has a public launch ramp on the northern side of the North Fork Kentucky River (KDFWR, 2023a). Beattyville is characterized as having primarily masonry architecture with a prevalent use of yellow brick with smooth-face textures for building walls and cut-stone blocks for foundations. Beattyville is home to multiple shopping opportunities and local restaurants. At the northeastern end of the project area, the Three Forks Historical Center provides insight into the region's history (Google Earth, 2023).

2.4.1.2 Regional Resources

The region around Beattyville has a wealth of recreational opportunities. Tourism is important in the area and ziplining, horseback riding, paddling, fishing, and other tourist attractions are common. The region is also a hotspot for rock climbing with approximately 1000 acres set aside for the sport. In addition to recreational resources, the region also has a wealth of scenic beauty with the valleys of Red River Gorge and the land bridge at Natural Bridge State Park, north of Beattyville (City of Beattyville, 2023). Additionally, Beattyville is near the Daniel Boone National Forest, offering views of deciduous forests and opportunities for camping (City of Beattyville, 2023). As a whole, the region has rugged topography with steep cliffs capped by sandstone peaks, with river valleys in between. The region is largely forested when not developed, consisting mostly of mixed oak with red maple understories (bplant, 2023). River views are common throughout the region as most development occurred nearby the Kentucky River and its tributaries.

2.4.2 Cultural Resources

Several steps were taken to identify cultural resources within the project area. USACE searched the online database of the National Register of Historic Places (NRHP) maintained by the National Park Service, the Kentucky Heritage Council (KHC), the Kentucky Office of State Archaeology, and USACE Geographic Information System (GIS) files to identify any previously recorded archaeological sites and above ground structures located within the project area. Currently, there have been six (n=6) archaeological surveys (Table 3) within portions of the project area and fifteen (n=15) identified archaeological sites (Table 4) within two kilometers radius. The KHC above-ground resource database identifies 34 (n=34) cultural-historic buildings within the project area that are considered historic structures (Table 5). All but one of these structures are considered unevaluated for the NRHP and the other is considered not-eligible due to being demolished.

Beattyville is currently developing a NRHP form for the downtown commercial area as a historic district eligible under Criterion A (associated with events that have made a significant contribution

to the broad patterns of history). This form identifies 39 structures as contributing to the Historic District's eligibility and lists 34 non-contributing (20 buildings and 14 sites). This recommendation has not been formally approved by the State Review Board and KHC due to concerns with the district's boundary and the overall inclusion of non-historic buildings.

USACE has initiated consultation with the Kentucky State Historic Preservation Office (KY-SHPO), and federally recognized Tribal Nations (Appendix F). An Interagency and Stakeholder meeting was held on August 7, 2023, and the KY-SHPO and federally recognized Tribal Nations were invited to participate in this meeting. Representatives from the Osage Nation were present during this meeting and requested that multiple avenues of communication should be considered for future Tribal consultation and that USACE should not assume that no response means the Tribes are not interested in the project. On December 21, 2023, the KY-SHPO requested that once an alternative has been selected to consult on the project area. On March 15, 2025, USACE provided updated letters on the area of potential effect (APE) and level of effort (LOE) to KY-SHPO and Tribal Nations. The APE consisted of the 500-year flood-plain and identified above-ground structured assessed for this study. The KY-SHPO concurred with the APE and LOE on April 15, 2024, and the Osage Nation was the only Tribal Nation that responded. They requested to be provided any future cultural survey reports for their review and USACE will comply with this request once these reports are completed.

Table 3. Previous Archaeological Investigations that occurred within the project area of the Beattyville Flood Risk Management General Interest Study

Author	Date	Title
Sheldon, Gregory A.	1990	A Phase One Archeological Assessment of the Proposed Falcon Ridge Apartments Near Beattyville, Lee County Kentucky
Uecker, Steve P. and Steven A Creasman	2002	An archaeological Survey of 3.8 Linear Miles (Targeting Areas of High Archaeological Potential) within the proposed KY 11 Relocation Project Boundaries in Lee and Owsley Counties Kentucky.
Bundy, Paul D.	2003	Assessment of Archaeological Potential for the KY 11 Relocation Project in Lee and Owsley Counties, Kentucky
Crider, Andrea	2003	
Moore, Rose G.	2004	An Archaeological Survey of the Beattyville and Heidelberg Tipples and Barge Loading Facility
Loughlin, Michael	2007	Phase I Archaeological Survey of a 2,100-foot Segment of a Project Electrical Power Transmission Line.

Table 4. Previously recorded archaeological sites located within or adjacent to the project area. Data taken from Kentucky Office of State Archaeology, database accessed January 24, 2024

Site Number	Cultural Affiliation/ Site Type	NRHP Status
15Le30	Indeterminant Precontact / Rockshelter	Unevaluated
15Le31	Woodland Period / Rockshelter	Unevaluated
15Le216	Historic Euro-American / Cemetery	Unevaluated
15Le247	Historic Euro-American / Historic farm; residence	Unevaluated
15Le248	Historic Euro-American / Historic farm; residence	Unevaluated
15Le250	Indeterminant Precontact / Rockshelter	Unevaluated

15Le251	Historic Euro-American / Historic farm; residence	Unevaluated
15Le252	Indeterminant Precontact / Open habitation without mounds	Not Eligible
15Le253	Indeterminant Precontact / Rockshelter	Unevaluated
15Le254	Historic Euro-American / Cemetery	Not Eligible
15Le259	Historic Euro-American / Historic farm; residence	Unevaluated
15Le276	Historic Euro-American / Other	Not Eligible
15Le30	Indeterminant Precontact / Rockshelter	Unevaluated
15Le31	Woodland Period / Rockshelter	Unevaluated
15Le216	Historic Euro-American / Cemetery	Unevaluated

Table 5. Identified Cultural-Historic Structures within the project area.

Site No.	Type	NRHP	Description
LE 108	House	Undetermined	Single Dwelling house (1925-1949)
LE 109	Stone Garage and Wall	Undetermined	Res Out Bldg/Dependency (1925-1949)
LE 110	House	Undetermined	Single Dwelling house (1925-1949)
LE 111	House	Undetermined	Craftsman; Single Dwelling (1925-1949)
LE 112	House	Undetermined	Single Dwelling house (1950-1974)
LE 113	House	Undetermined	Craftsman; Single Dwelling (1925-1949)
LE 114	Mill	Undetermined	Process/Manufacturing Facility (1900-1924)
LE 13	House	Undetermined	Vernacular Victorian; Demia Thomas Place (1850-1874)
LE 47	School	Undetermined	Beattyville Elementary School (1925-1949)
LE 9	House	Undetermined	Hampton-Flannery House; Single Dwelling (1887-1899)
LE 11	House	Undetermined	Darch House; Single Dwelling (1875-1899)
LE 10	House	Undetermined	Concrete Block House; Single Dwelling (1900-1924)
LE 6	Railroad Station	Undetermined	L&N Railroad State (1925-1949)
LE 14	Courthouse	Not Eligible	Demolished (1976); Lee County Court house (1850-1874)
LE 1	Bank	Undetermined	Lee County Deposit Bank (1900-1924)
LE 12	House	Undetermined	Colonel James Madison Beatty House; Single Dwelling (1875-1899)
LE 2	City Hall	Undetermined	Beattyville City Hall; Town Hall (1925-1949)
LE 25	House	Undetermined	Single Dwelling house (1875-1899)
LE 24	House	Undetermined	Single Dwelling house (1875-1899)
LE 23	House	Undetermined	Single Dwelling house (1875-1899)
LE 3	Bank	Undetermined	National Bank of Beattyville (1875-1899)
LE 5	BLDG	Undetermined	Jackson Building; (1900-1924)

Site No.	Type	NRHP	Description
LE 31	Office Building	Undetermined	Office Building (1925-1949)
LE 30	Service Station	Undetermined	Service Station (1925-1949)
LE 32	Commercial Building	Undetermined	Commercial Building (1925-1949)
LE 29	Commercial Building	Undetermined	Commercial Building (1925-1949)
LE 33	House	Undetermined	Single Dwelling house (1925-1949)
LE 34	House	Undetermined	Single Dwelling house (1900-1924)
LE 35	House	Undetermined	Craftsman; Single Dwelling (1900-1924)
LE 36	House	Undetermined	Single Dwelling house (1900-1924)
LE 39	House	Undetermined	Single Dwelling house (1925-1949)
LE 37	House	Undetermined	Single Dwelling house (1900-1924)
LE 38	House	Undetermined	Craftsman; Single Dwelling house (1900-1924)
LE 4	Commercial Building	Undetermined	Com/Prof/Office - Unknown (1900-1924)

2.4.3 Air Quality

The Clean Air Act (CAA) mandates that the USEPA set air quality standards for pollutants considered harmful to public health and welfare. The National Ambient Air Quality Standards (NAAQS) set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. These standards have been established for six criteria pollutants including carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particulate matter (PM10 and PM2.5), and sulfur dioxide (SO2), and each state is required to develop implementation plans for each pollutant. Areas are generally designated as being either in “attainment” of the standards for the pollutants listed above or in “nonattainment.”

Nonattainment areas are required by the CAA to comply with the NAAQS standards through the evaluation and development of a maintenance plan. The USEPA makes a conformity determination to assure that the actions within the maintenance plan conform to the respective state’s implementation plan for each nonattainment pollutant.

Desktop analysis conducted via the USEPA’s Green Book web application indicates that Lee County is in attainment for all criteria pollutants (USEPA 2023e).

2.4.4 Invasive species

Invasive species possess characteristics that allow them to spread easily into native communities and often displace and outcompete native flora and fauna (Kentucky Exotic Pest Plant Council, 2013). The Kentucky Exotic Pest Plant Council provides a list of exotic plant species’ that pose a significant threat to native plant communities (Table 6). The proposed project site does not have an existing site-specific inventory of invasive species and their presence is not well known; however, it is anticipated that invasive species will be abundant due to the urbanized nature of the project area.

Table 6. Invasive Species listed as Severe Threat for Kentucky (Kentucky Exotic Pest Plant Council 2013)

Scientific Name:	Common Name:
Achyranthes japonica	Japanese chaff flower
Ailanthus altissima	Tree-of-heaven
Alliaria petiolata	Garlic mustard
Ampelopsis brevipedunculata	Porcelain berry
Arthraxon hispidus	Hairy jointgrass
Carduus nutans	Musk thistle
Celastrus orbiculatus	Oriental bittersweet
Cirsium arvense	Canada thistle
Clematis terniflora	Leatherleaf clematis
Conium maculatum	Poison hemlock
Securigera varia	Crown vetch
Dioscorea polystachya	Chinese yam
Elaeagnus umbellata	Autumn olive
Euonymus alatus	Burning bush
Euonymus fortunei	Wintercreeper
Festuca arundinacea	Kentucky 31 fescue
Glechoma hederacea	Ground ivy
Lespedeza cuneata	Sericea lespedeza
Kummerowia stipulacea	Korean lespedeza
Ligustrum sinense, L. vulgare	Privet
Lonicera japonica	Japanese honeysuckle
Lonicera maackii, L. fragrantissima, L. standishii	Bush honeysuckles
Lysimachia nummularia	Moneywort
Lythrum salicaria	Purple loosestrife
Melilotus alba	White sweet clover
Melilotus officinalis	Yellow sweet clover
Microstegium vimineum	Japanese stiltgrass
Miscanthus sinensis	Chinese silver grass
Paulownia tomentosa	Princess tree
Phragmites australis	Common reed
Polygonum cuspidatum	Japanese knotweed
Pyrus calleryana	Callery pear
Pueraria lobata	Kudzu
Ranunculus ficaria	Lesser celandine
Rhamnus cathartica	European buckthorn
Rosa multiflora	Multiflora rose
Sorghum halepense	Johnson grass
Stellaria media	Chickweed

2.4.5 Noise

Noise in the vicinity of the project area is generated by a variety of sources including light traffic along Kentucky Highway (KYHWY) 11 and 52, noise generated from lawncare equipment and household power tools, and noise generated from local businesses.

Noise is measured as Day Night average noise levels in "A-weighted" decibels (dBA) that the human ear is most sensitive to. There are no Federal standards for allowable noise levels. The USACE Safety and Health Requirements Manual provides criteria for short-term permissible noise exposure levels for consideration of hearing protection or the need to administer sound reduction controls, which is concurrent with Occupational Safety and Health Administration (OSHA) standards (USACE 2014) (Table 7).

Table 7. Non-Department of Defense Continuous Noise Exposures (OSHA Standard)

Duration/day (hours)	Noise level (dBA)
8	85
4	88
2	91
1	94
0.5	97
0.25	100

2.4.6 Transportation and Traffic

Two two-lane highways cross the project area. KYHWY 11 bisects the project running north and south while KYHWY 52 runs west from its intersection with KYHWY 11. The rest of the project area contains urban city streets for both business and residential use. It is anticipated that traffic levels would be light, even at peak hours, due to the rural nature of the project area. The KYHWY 11 bridge at the southern end of the project area is one of the few methods of crossing the North Fork Kentucky River with the closest alternative crossing being approximately 4 miles west by southwest of the project area at Heidelberg. In addition to vehicular traffic, a CSXT class 1 rail line crosses the southern end of the project area running from east to west (Google Earth 2023, Kentucky.gov 2017). Class 1 rail lines are classified as freight rail lines owned and operated by companies with an operation revenue of more than 272.0 million dollars (SCMEDU 2023). Finally, the north Fork Kentucky River is not currently used for commercial navigation, though it is used for recreational boating with one boat launch ramp being present within the project area (Kentucky.gov, 2023b; KDFWR, 2023a).

2.4.7 Hazardous and Toxic Substances

The Hazardous and Toxic Substances section of this environmental assessment addresses the identification and assessment of Hazardous, Toxic, and Radioactive Waste (HTRW) resources within the project area. HTRWs encompass a wide array of substances that pose significant risks to human health and the environment due to their inherent toxicity, flammability, corrosiveness, or potential for contamination. These substances are subject to stringent regulations aimed at safeguarding public health and the environment.

At the federal level, the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, are the primary legislative frameworks governing the management and cleanup of hazardous substances. RCRA regulates the generation, transportation, treatment, storage, and disposal of hazardous waste, while CERCLA provides the authority and funds for the cleanup of hazardous waste sites, including those posing imminent threats to public health or the environment.

Additionally, state regulations play a crucial role in overseeing HTRW management and remediation efforts. In Kentucky, the Department for Environmental Protection (KDEP) administers regulations and programs related to hazardous waste, contaminated sites, and underground storage tanks. These regulations complement federal laws and ensure that HTRW resources are properly managed and remediated to protect human health and the environment.

A comprehensive search of applicable Federal and state databases revealed the presence of various HTRW resources within the vicinity of the project area. These resources include RCRA hazardous waste generators, and facilities, as well as KDEP Superfund sites (Table 8). Additionally, according to the KDEP underground storage tank statewide report, there are active underground storage tanks present at the IGA grocery store, Valero gas station, and Shell gas station which are located at the following Beattyville, KY addresses respectively: 285 Main St.; 79 Main St.; and 17 KYHWY 11 South. For a complete list of underground storage tanks, including removed storage tanks see appendix B.

Table 8. Federal and State HTRW Records search results (KDEP 2023a-b, kentucky.gov 2023b, USEPA 2023l)

Site Type	Location	Notes	Latitude	Longitude
RCRA Generator List	Family Dollar 484	Very small quantity generator	37.571203	-83.706515
RCRA Generator List	Omnicare Beattyville	Very small quantity generator	37.582797	-83.701277
RCRA Generator List	Beattyville Asphalt Plant	Used oil program	37.568451	-83.707051
KDEP Superfund Site	Lee County State Maintenance Garage	Managed petroleum spill cleanup	37.55278	-83.71250
KDEP Superfund Site	Lee County Maintenance Garage	Minor petroleum release cleanup	37.57977	-83.71957
KDEP Superfund Site	White Ash Road Dump	Abandoned drums, closed	37.56856	-83.72790
KDEP Superfund Site	Beattyville Housing Development Property	Meth lab cleanup, closed	37.59815	-83.70750

Site Type	Location	Notes	Latitude	Longitude
RCRA Hazardous Waste Facility	Former City Hall	Engineering Controls in place. Also, on Brownfield list for lead-based paint and asbestos	37.573707	-83.711176

2.5 Economic Environment

2.5.1 Socioeconomic and Environmental Justice

Beattyville is located in the heart of Appalachia, a region of the United States that has been subjected to over a century of resource extraction in support of the overall economic vitality of the country. Resource extraction, particularly coal mining, has deeply impacted Appalachian communities in several ways. Economically, it has been a double-edged sword, providing jobs and economic stability while also creating cycles of boom and bust. The industry's decline has left many communities, including Beattyville, struggling with unemployment and poverty. Mountaintop removal mining has resulted in significant changes to landscapes, including deforestation, water quality impacts, and alterations to habitats. Additionally, health issues like black lung disease and other respiratory ailments are prevalent among miners and communities suffer from higher rates of poverty, substance abuse, and inadequate infrastructure as a result of the industry's dominance and decline.

2.5.2 Executive Order 13045 Protection of Children

Executive Order 13045 “Protection of Children from Environmental Health Risks and Safety Risks” was issued in 1997. This order applies to economically significant rules under Executive Order 12866 “Regulatory Planning and Review” that concerns an environmental health or safety risk that the USEPA has reason to believe may disproportionately affect children. Environmental health risks or safety risks refer to risks to health or to safety that are attributable to products or substances that children are likely to come in contact with or ingest (such as the air we breathe, the food we eat, the water we drink or use for recreation, the soil we live on, and the products we use or are exposed to).

2.5.3 Executive Order 12898 Environmental Justice

Under Executive Order 12898 “Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations,” Federal agencies are directed to identify, address, and avoid disproportionately high and adverse human health or environmental effects on minority and low-income populations.

2.5.4 Socioeconomic Data

First issued in January 2021, Executive Order 14008 directed the Council on Environmental Quality (CEQ) to develop a new tool that characterizes environmental justice (EJ) considerations. This tool – the Climate and Economic Justice Screening Tool (CEJST) – provides indicators of burdens in eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. A community is highlighted as disadvantaged on the CEJST map if it is in a census tract that is (1) at or above the threshold for one or more environmental, climate, or other burdens, and (2) at or above the threshold for an associated socioeconomic burden.

The CEJST identified census tract 21129950100 in Lee County, which encompasses the entire project area, as an economically underserved or disadvantaged community. This community is at or above the threshold for the socioeconomic burdens shown in Figure 3 (CEQ, 2023). Percentile thresholds are denoted in blue and Beattyville percentiles are presented in orange (with corresponding value above).

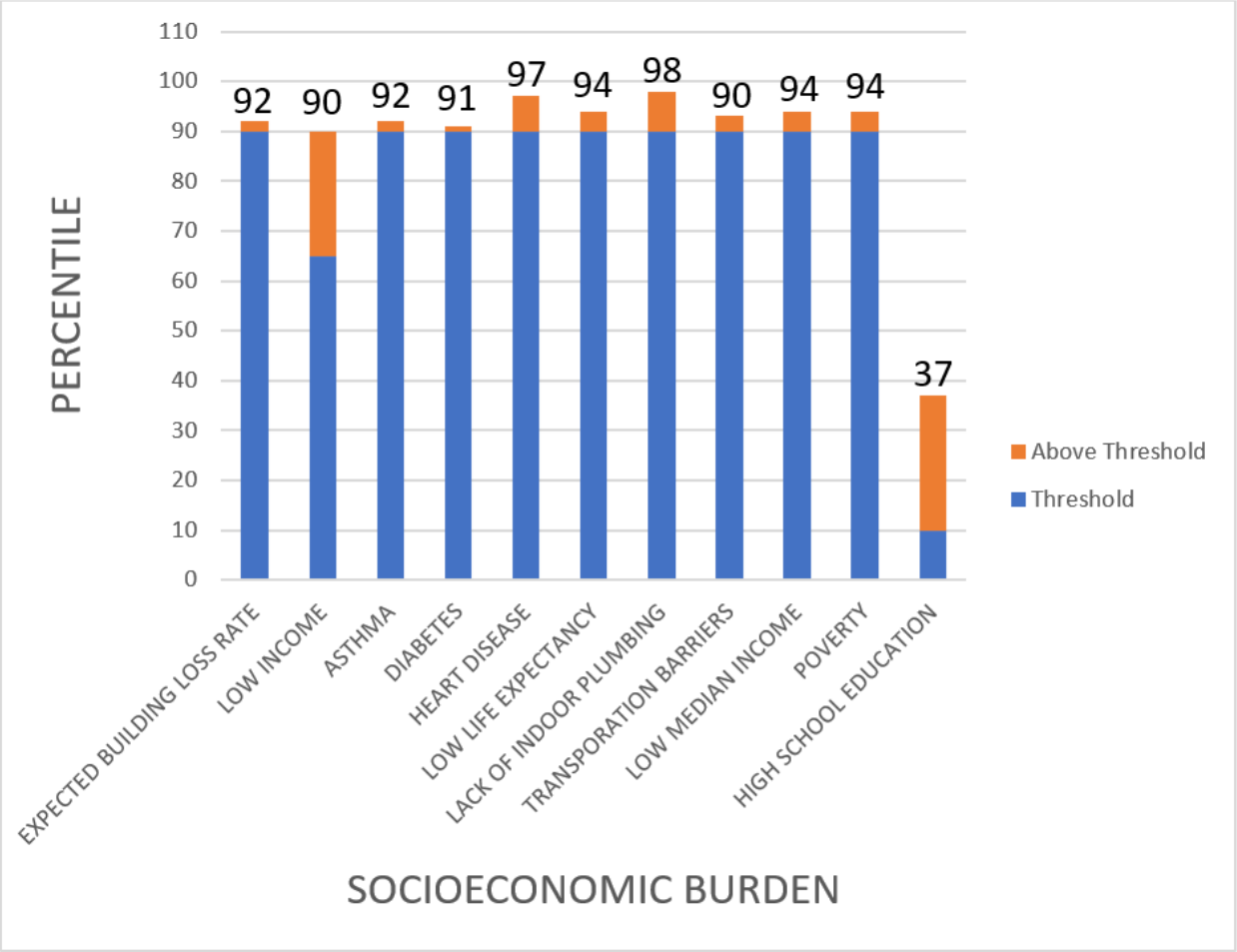


Figure 3. Socioeconomic Burdens in Lee County, KY (CEQ, 2023)

The unemployment rate in Lee County is among the highest in the state of Kentucky and is above the current nation rate of 3.5.

The USEPA's Environmental Justice Screening (EJScreen) tool is another mapping and screening application that provides a nationally consistent dataset and approach for combining environmental and demographic socioeconomic indicators into indices that provide an assessment of EJ. The EJScreen tool was utilized for census tract 21129950100 and an EJScreen Community report was generated (Table 9). The area ranks significantly higher than state and national averages with respect to low-income metrics, education, percentage of the population with less than a high school diploma, and low life expectancy (USEPA 2023m).

Table 9. EJScreen Environmental and Socioeconomic Indicators for census tract 21129950100 in Lee County, Kentucky (USEPA, 2023m)

SELECTED VARIABLES	VALUE	STATE AVERAGE	PERCENTILE IN STATE	USA AVERAGE	PERCENTILE IN USA
POLLUTION AND SOURCES					
Particulate Matter (µg/m^3)	7.56	8.54	12	8.08	33
Ozone (ppb)	56.9	59.3	20	61.6	18
Diesel Particulate Matter (µg/m^3)	0.0754	0.203	4	0.261	9
Air Toxics Cancer Risk* (lifetime risk per million)	20	26	0	25	5
Air Toxics Respiratory HI*	0.3	0.32	2	0.31	31
Toxic Releases to Air	480	7,500	35	4,600	46
Traffic Proximity (daily traffic count/distance to road)	0.068	78	0	210	0
Lead Paint (% Pre-1960 Housing)	0.13	0.24	39	0.3	39
Superfund Proximity (site count/km distance)	0.014	0.039	26	0.13	8
RMP Facility Proximity (facility count/km distance)	0.021	0.33	1	0.43	2
Hazardous Waste Proximity (facility count/km distance)	0.03	0.78	13	1.9	4
Underground Storage Tanks (count/km^2)	0.25	1.1	45	3.9	33
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.00067	0.48	52	22	45
SOCIOECONOMIC INDICATORS					
Demographic Index	31%	26%	69	35%	52
Supplemental Demographic Index	23%	16%	82	14%	84
People of Color	9%	16%	49	39%	20
Low Income	52%	37%	76	31%	83
Unemployment Rate	4%	6%	55	6%	54
Limited English-Speaking Households	0%	1%	0	5%	0
Less Than High School Education	29%	13%	91	12%	91
Under Age 5	5%	6%	45	6%	47
Over Age 64	16%	17%	47	17%	50
Low Life Expectancy	26%	22%	88	20%	94

2.6 MOST PROBABLE FUTURE WITHOUT PROJECT (FWOP) CONDITION

In the absence of a Federal project, Beattyville will experience flood events similar to and greater than the March 2021 event. If similar flooding occurs, Beattyville will have difficulty retaining citizens and businesses due the frequency and amount of damages incurred, cleanup costs from multiple inundations, and risk of potential imminent flood events. It is assumed that as a result of neglecting these risks, insurance rates will increase, and current and potential residents and business owners will be less inclined to remain and/or relocate in Beattyville. If Beattyville loses residents and long-standing businesses, visitation, and economic activity in and surrounding the study area will decrease. A reduction in population, commerce, and tourism would be expected to cause a concomitant reduction in the local tax base which would make it difficult for Beattyville to maintain infrastructure and quality of life for its citizens. This instability will adversely impact the recreational tourism industry of the area and would contribute to continued economic struggles for the already disadvantaged community.

2.7 CLIMATE ASSESSMENT

As part of a literature review of projected climate trends, The National Climate Assessment 5, Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Ohio Region, and NCEI Kentucky State Climate Summary were reviewed. The literature presents conflicting evidence regarding the hydrologic trends which can be expected in the future. In general, the following statements represent the probable hydrologic future that can be expected within the Kentucky River Basin:

- Winter and spring precipitation could potentially increase while future trends of summer and fall precipitation are uncertain (Runkle, 2022). Projected increases fall during the typical flood season, which is likely to further increase peak streamflow and reservoir levels. This projection emphasizes the continued need flood risk management projects into the future. The associated increases in flows on the rivers in the Kentucky River Basin may lead to more frequent and higher loading of levees and other flood infrastructure in the region during the winter and spring flood season.
- The frequency and intensity of extreme precipitation events could potentially increase, making current infrastructure that is designed for historical climate conditions more vulnerable for future flood events (National Climate Assessment 5, 2023).
- Projected future temperatures are anticipated to increase moderately over historic norms. This has various hydrologic implications including increased atmospheric moisture, evapotranspiration rates, frequency of droughts, and water supply demand (National Climate Assessment 5, 2023).

Based on the Beattyville Climate Assessment, the PDT determined that nonstructural measures should be designed to withstand increased 100-year inundation extents and depths, and to accommodate inundation rises at a quicker rate than existing conditions. The floodwall height should increase in order to accommodate potential streamflow increase. Table 10 provides a summary of recommendations and Appendix H contains the complete Beattyville Climate Assessment.

Table 10. Beattyville Climate Assessment Recommendations

Measure	Trigger	Hazard	Harm	Qualitative Likelihood (Frequent, Occasional, Likely, Seldom, Unlikely)	Consequence (Catastrophic, Critical, Marginal, Negligible)	Adaptation
Levee / Floodwall (Structural)	Increased streamflow from precipitation	Levee/Floodwall have a greater probability of overtopping	Levee/floodwall is overtopped leading to loss of structure and protected side of the levee/floodwall gets inundated	Likely or Seldom (Depends on conservatism in crest design height)	Earthen Levee – Catastrophic Floodwall - Marginal	Increase crest design height for projected streamflow increase
Interior Drainage (Structural)	Increased precipitation	Pump and pipes are undersized	Low lying structures would be inundated from interior ponding	Likely or Seldom (Depends on conservatism in interior drainage design)	Pump Station - Marginal Gravity Drains - Negligible	Design for larger pump and pipe sizes
Relocation/ Acquisition (Non-Structural)	Increased streamflow from precipitation	Increased 100-year inundation extents and depths	Structures that are near but not in the current 100-year floodplain may be at a higher risk of flooding in the future but may not be relocated or acquired during this project	Likely or Seldom (Depends on sensitivity of structure inundation near the 100-year floodplain extents)	Critical to Negligible (Depends on sensitivity of structure inundation near the 100-year floodplain extents)	Buyout structures at an increased floodplain extent
Floodproofing Wet/Dry (Non-Structural)	Increased streamflow from precipitation	Increased 100-year inundation extents and depths	Floodproofing efforts are not done to a high enough elevation	Likely or Seldom (Depends on conservatism in floodproofing design height)	Marginal	Increase floodproofing elevation

FWEEP (Inundation Mapping, Evacuation Planning, Flood Plain Management Plan)	Increased precipitation intensity (rate of inundation depth rise)	Inundation rises at a quicker rate than existing conditions	Warning times are reduced leading to individuals not evacuating in time	Seldom	Critical or Marginal (Depends on sensitivity of warning times)	Earlier warning notification in FWEEP, triggered with lower elevations
Floodway Acquisition Ecosystem Restoration Features	Increase in extreme temperatures	Increase in droughts frequency and extreme heat waves	Increase in temperature and drought stresses ecosystem restoration features	Likely	Critical of Marginal (Depends on design of ecosystem restoration features)	Include vegetation which is more resilient to drought and extreme temperatures.
Floodway Acquisition Recreational Features	Increased magnitude and frequency of extreme precipitation	Increases in localized flooding	Drainage features in recreation features are not capable of resulting in minimal flooding	Likely (Depends on selected project features and location)	Marginal to Negligible (Depends on recreation features)	Add recreational features which are resilient to extreme events

3 PLAN FORMULATION AND EVALUATION

This chapter describes the development, evaluation, and selection of alternative plans that address the study objectives. Alternative plans are made up of individual or combinations of management measures. Management measures help prevent or reduce flood risk by using either structural or non-structural means or a combination of the two.

3.1 PLANNING FRAMEWORK

A general overview of the plan formulation sequence and strategy for this study is presented in the following approach.

1. Management Measure Identification – Initial management measures were identified through collaboration between project stakeholders and the study team. These measures were initially developed to address flood risk along shorelines, leveraging the expertise of USACE while adhering to policy and authority constraints. The following measures have been implemented in past floodplain management projects within the USACE Great Lakes and Ohio River Division (LRD) and were developed such that rough order of magnitude costs could be applied for plan formulation purposes.
    - **Structural Measures** reduce or avoid damages by modifying the nature and/or extent of the flood hazard.
    - **Nature Based Solutions** protect, conserve, restore, sustainably use, and manage natural or modified ecosystems to enhance flood control systems.
    - **Nonstructural Measures** are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding and focus on reducing the consequences of flooding rather than reducing the probability of flooding (see Appendix A for additional descriptions and information on nonstructural measures).
    - **Flood Warning & Emergency Evacuation Plan (FWEEP)** is a plan to improve flood emergency response.
2. Management Measure Screening – Screening determined which management measures should be included in the preliminary array based on their completeness, effectiveness, efficiency, and acceptability, as outlined by PR&G (USACE, 2013). Additional considerations for screening included whether the measure effectively reduced flood risk, the rough order of magnitude cost, whether there were environmental concerns, and any other factor that was determined to be an important consideration.
3. Preliminary Array Formulation and Evaluation – The remaining measures were combined into a preliminary array of alternatives—combinations of management measures that aim to reduce risk throughout the study area. The initial array was evaluated based on the following evaluation criteria: effectiveness, efficiency, completeness, acceptability, identified planning objectives (Section 1.8.1), operation and maintenance (O&M) costs, and environmental effects/sustainability. Alternatives in the preliminary array were either retained for further consideration/reformulation in the expanded array or screened from further consideration.

4. Expanded Array Formulation and Evaluation – The remaining alternatives were combined into an expanded array of alternatives—variations of alternatives presented in preliminary array that expanded scope to include multiple target elevations for both structural and nonstructural alternatives. The expanded array was evaluated based on the following evaluation criteria: effectiveness, efficiency, completeness, acceptability, environmental effects, and social considerations. Alternatives were also evaluated with respect to the four accounts as outlined in the PR&G. The four accounts are National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). Alternatives in the expanded array were either retained for further consideration/reformulation in the final array or screened from further consideration.
5. Final Array Formulation and Comparison – Alternatives retained for further consideration were reformulated into the final array of alternatives. Alternatives within the final array were then evaluated and compared using the same criteria and accounts discussed in step 4. The final array was also evaluated for the extent to which alternatives met the planning objectives, as well as remaining risk and uncertainty.

3.1.1 Preliminary Structural and Nonstructural Measures

With the non-Federal sponsor and stakeholders, the PDT considered both local and regional solutions to the flood risk problem and defined 12 distinct measures for consideration.

1. Booneville Dam/Reservoir to impound water on the South Fork of the Kentucky River to control downstream flow
2. Cut-through to create a new channel so water bypasses a specific area prone to flooding
3. Levee at Silver Creek consisting of a compacted earthen berm that acts as a flood barrier
4. Floodwall that acts as a flood barrier
5. Pump Station utilizing pump(s) to move interior water beyond a flood barrier
6. Pressure Pipe used to pass water through a leveed area
7. Change in operation of upstream USACE dams to reduce flooding in the project area
8. Channel widening to cut back the riverbanks to allow more flow
9. Dredging to deepen the channel to allow more flow
10. Restoring the Kentucky River channel to remove fill placed near the shoreline by the CSXT railroad
11. Nonstructural measures including some combination of elevation, relocation, acquisition, dry floodproofing, and wet floodproofing
12. FWEEP consisting of inundation mapping, evacuation planning, floodplain management plan, flood sensors/gage, and flood sirens

The team performed a Qualitative Assessment of these 12 measures and screened based on whether the measure effectively reduced flood risk, the rough order of magnitude cost, whether there were environmental concerns, and any other factor that was determined to be an important consideration. The nine measures shown in Table 11 were screened out.

Five measures were screened due to their ineffectiveness with flood risk mitigation (cut-through, restoring the Kentucky River channel, channel widening, dredging, and change in operation of USACE dams upstream) and three were considered to not be effective as a standalone measure (levee at Silver Creek, pump station, and pressure pipe). Notably, a reservoir was considered, and while it was determined that flood risk could be substantially reduced, it was also understood to involve extremely high cost to construct, high cost to operate and maintain, generated serious environmental concerns, and created real estate acquisition concerns associated with the subsequent displacement of a community.

Table 11: Measures screened from further consideration

Measures	Flood Risk Reduction	Cost	Environmental	Notes
Dam	Yes	$$$$$	Extreme concerns – habitat, endangered species	Real estate acquisitions, displacement of community
Cut-through	No	$$$$	Presence of abandoned mine	
Restoring the Kentucky River channel	No	$$$	Fill material would likely have to be disposed of (not reusable)	
Channel widening	No	$$$$$	Potential habitat and endangered species	
Dredging	No	$$$$	Potential habitat and endangered species	Would have to be repeated, material would have to be disposed of
Levee at Silver Creek	Not as a standalone measure	$$	Silver Creek is critical habitat for threatened and endangered species	Only targets structures in a specific area
Pump Station	Not as a standalone measure	$$$$	No	The NFS has limited resources available for O&M
Pressure Pipe	Not as a standalone measure	$	High concern; would turn Crystal Creek into a tunnel/pipe	
Change in operation of USACE dams upstream	No	$$$$	Potential changes to riverine habitat	

Ultimately, the PDT carried forward three potential measures for further consideration as alternatives: Structural, Nonstructural, and FWEEP.

Structural: Floodwall

Nonstructural: Elevation, fill (compacted), relocation, acquisition, dry floodproofing, wet floodproofing

Flood Warning and Emergency Evacuation Plan (FWEEP): Inundation mapping, evacuation planning, floodplain management plan, flood sensors/gage, and flood sirens

3.2 Formulation and Comparison of Preliminary Array of Alternatives

3.2.1 Alternative Plans Descriptions

Each of the measures carried forward meets the objectives of the study and is likely to reduce flood risk. The measures carried forward were combined into four alternative plans (including No Action) as the preliminary array of alternatives.

Alternative 1: No Action

Alternative 1 is the No Action Alternative (NAA). USACE planning policy (Engineering Regulation 1105-2-103) and NEPA require consideration of a NAA. The NAA is the basis for the FWOP and assumes no measures would be implemented by the federal government to achieve the planning objectives. The FWOP serves as a baseline for future conditions assumed to take effect in the study area in the absence of federal action. This baseline serves as the foundation of comparison against which all subsequent alternatives are evaluated.

The NAA would not reduce flood risk within the study area, including economic damages associated with inundation of structures and impacts to commerce, and it also has no impact with respect to the life safety risk currently experienced in the community. No action would result in Beattyville being less resilient to potential increases in precipitation and streamflow that are projected to occur as a result of climate change impacts to hydrology in the region. Repetitive inundation within this socially vulnerable community could contribute to continuing decline of population in Beattyville and a loss of community cohesion.

Alternative 2: Floodwall Alignment

Alternative 2 includes two floodwall segments that do not cross either Silver Creek or Crystal Creek. Nonstructural measures would be applied in areas where the floodwall does not reduce damages. Figure 4 shows the floodwall segments with structures identified for nonstructural applications. This alternative also includes a FWEEP.

The floodwall alignments were chosen to prioritize protection of as many structures as possible while also avoiding the Kentucky River Regulatory Floodway, utilities, and minimizing demolition of existing structures. A floodwall is more desirable than a levee in this downtown project area due to its reduced footprint which results in fewer property acquisitions. In addition, when compared to levees, floodwalls also involve relatively less intrusion into the public space, which produces less negative impact on the area's visual aesthetics, such as viewshed and overall character. This alternative avoids environmental concerns (endangered species and designated critical habitat in Silver Creek) and does not require costly pump stations.

With no loss of life resulting from the March 2021 event, at this point in the plan formulation process, it was difficult to determine if certain measures and alternatives create or mitigate life

safety risk. The flooding occurred during the night in an area which is largely commercial, so fewer people would be expected downtown as opposed to an event taking place during the day or in a residential area.

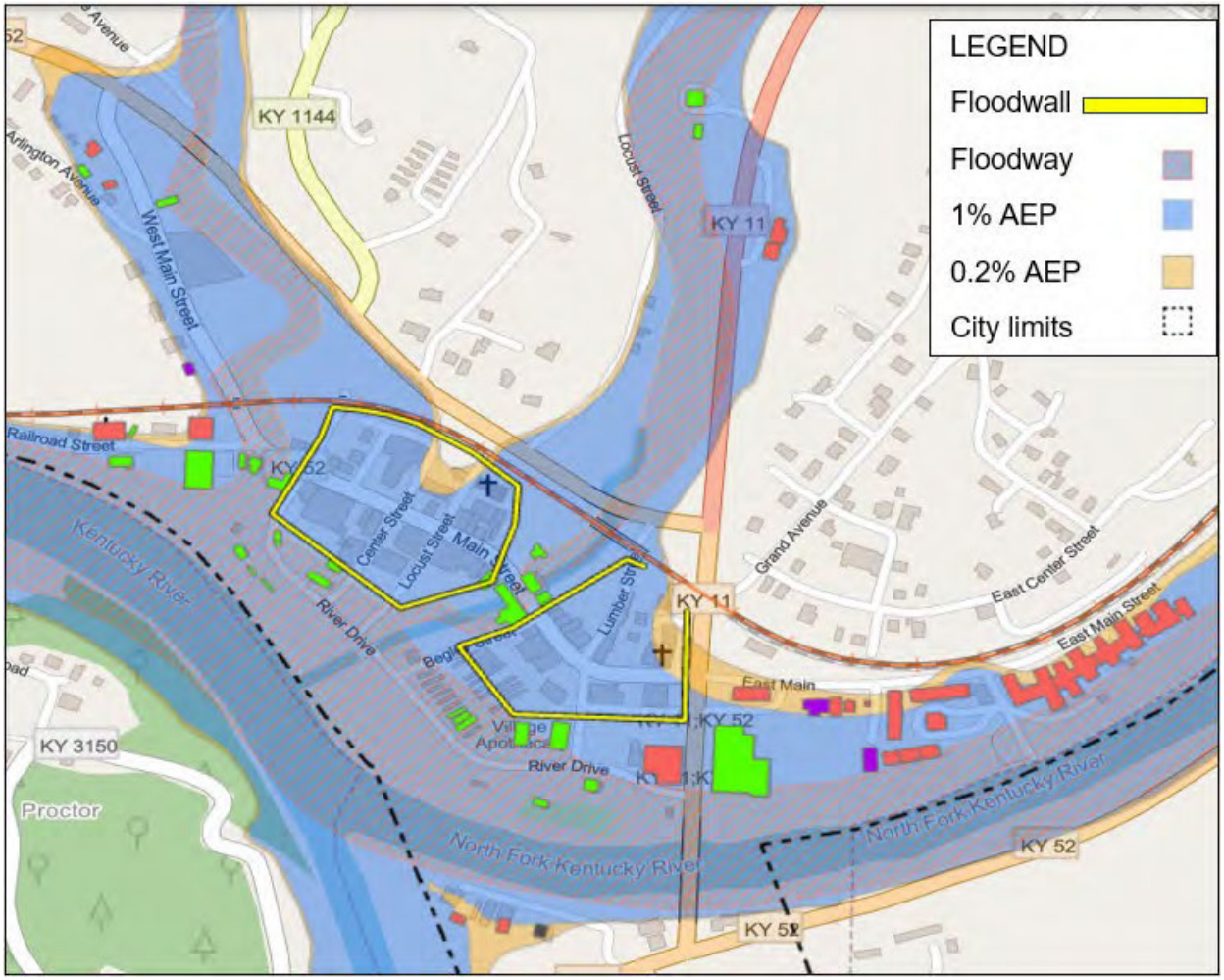


Figure 4. Alternative 2: Floodwall Alignment

Alternative 3: Complete Nonstructural

A project consisting entirely of nonstructural measures, listed in Section 3.2.1, was also carried forward for consideration (inclusive of a FWEEP). Due to a lack of parametric costs, there is tremendous uncertainty associated with the cost for nonstructural measures. The PDT aggregated the nonstructural measures by grouping the structures in Beattyville into seven geographical areas delineated by features such as flooding, site, building, and economic characteristics. This aggregation is presented in the following Figure 5.



Figure 5. Alternative 3: Complete Nonstructural Plan Showing Agglomeration of Seven Geographical Groups

Preliminary Nonstructural Aggregation Grouping

Group 1: Formed and bound by the Kentucky River, Silver Creek, and the railroad. Each structure in this group is located west of Silver Creek and impacted by its associated hydrology.

Group 2: Formed and bound by the Kentucky River, Silver Creek, Crystal Creek, and the railroad. Each structure in this group is positioned in between Silver and Crystal Creek and impacted by the hydrology of each stream.

Group 3: Formed and bound by the Kentucky River, Crystal Creek, and the railroad. Each structure in this group is located east of Crystal Creek and impacted by its associated hydrology.

Group 4: The easternmost group of structures consists of similar types of buildings (apartments) that were not flooded during the 2021 flood event. Group 4 is bound by the Kentucky River and the railroad.

Group 5: This group is on the opposite bank and is separated from the other structures in Beattyville by the North Fork Kentucky River.

Group 6: This group of structures located along West Main Street (Kentucky Route 52) experiences flooding as a result of backflow up Silver Creek.

Group 7: The structures in this group are located north of the railroad along Crystal Creek and Broadway (Kentucky Route 11).

Alternative 4: FWEEP

A project consisting of only a FWEEP. This alternative would provide the NFS with a plan to support emergency management and evacuation efforts, as well as suggested improvements to local development and zoning regulations.

The primary goals of the FWEEP are:

- Identification of flooding threat
- Dissemination of information to residents as a warning or advisory
- Signal need for emergency services
- Promote better understanding of flood risks
- Plans for response, inclusive of an evacuation plan, are known in advance

The following are descriptions of potential FWEEP components:

- *Flood Inundation Mapping (FIM)*: FIM maps show the spatial extent and depth of flooding at specific stage intervals along an individual stream section. USACE will acquire the data, existing conditions hydrologic analysis, and hydraulic modeling to support the development of flood inundation maps in a format that is best suited to the NFS's intended use. Potential uses of the maps are for local Emergency Management response, or for uploading on a third-party website such as the U.S. Geological Survey (USGS).
- *Evacuation planning*: This provides a safe exit strategy for those in flood prone areas. USACE will provide supporting technical data and information for the development of an evacuation plan. Examples of data include identifying flood water levels at various stages that would create ingress and egress issues (road blockages) and determining exit routes for designated areas of Beattyville. Development of the evacuation plan will be contracted to a qualified vendor.
- *Flood Plain Management Plan (FPMP):* The FPMP is a plan for implementing measures, practices, and policies to reduce loss of life, injuries, damages to property and facilities, public expenditures, and other adverse impacts associated with flooding. It also preserves and enhances natural flood plain values and should also address measures which will help preserve levels of protection provided by the USACE flood damage reduction project (USACE 1997). Policy Guidance Letter (PGL) No. 52, Flood Plain Management Plans (USACE 1997) provides policy on Section 202 (c), Flood Plain Management Plans, of the Water Resources Development Act (WRDA) of 1996. USACE policy is to promote flood plain management at the non-Federal level by encouraging a NFS to develop its FPMP during the preparation of the feasibility study. This ensures compatibility of the FPMP with the USACE project.
- *Flood sensors/gages*: These are stream gage monitors to detect changes to a certain parameter, usually precipitation volume and/or water level. Flood sensors and gages pose

funding concerns due to the cost of ongoing operation and maintenance after installation. Sensors and gages must be maintained and read by a qualified professional, typically USGS, for which there is an annual fee.

- *Flood sirens*: Flood sirens are simply audible flood warning devices. While flood sirens might not provide early enough warning to protect property (compared to the warning time provided by flood sensors and gages), they would provide life safety benefits. The PDT will evaluate the benefits versus the costs of installing flood sirens.

3.2.2 Principles, Requirements & Guidelines Criteria Comparison

The PDT performed an analysis of the preliminary array of alternatives by comparing the alternatives against the objectives and the PR&G criteria. The team also compared alternatives based on two criteria specific to this project: the NFS constraint of a lack of funding for ongoing operations and maintenance (O&M) after project completion and the alternative's level of environmental effect and sustainability.

PR&G criteria comparisons:

- Completeness: A measure of the extent to which the necessary investments and actions, both Federal and non-Federal, have been considered and provided for.
- Effectiveness: The extent to which each alternative plan contributes to achieving the planning objectives.
- Efficiency: A measure of the cost effectiveness of each alternative to meet the project objectives.
- Acceptability: The extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies.

The PDT developed the following matrix (Table 12. Alternatives PR&G Criteria Screening Matrix) to develop systematic, relative comparisons between the four preliminary alternatives. The screening criteria were assigned a qualitative score from 0-3 to differentiate between alternative plans:

1 – Does not meet the objective / criteria

2 – Meets the objective / criteria with some limitations / concerns

3 – Meets the objective / criteria

Table 12. Alternatives PR&G Criteria Screening Matrix

FORMULATION		OBJECTIVES			PR&G CRITERIA				OTHER	
Alternative	Description	1	2	3	Complete	Effective	Efficient	Acceptable	O&M	Env/Sust
1. No Action Alternative	No Federal action taken	1	1	1	2	1	2	2	1	2
2. Floodwall Alignment	Two floodwall segments that do not cross either creek + NS + FWEEP	2	3	1	3	2	2	2	2	2
3. Complete Nonstructural	A project consisting of only the nonstructural measure carried forward for consideration + FWEEP	3	2	2	2	2	1	3	2	3
4. FWEEP	A project consisting of only the FWEEP	3	2	2	2	2	3	3	2	3

Alternative 4 FWEEP scored highest on the PR&G criteria comparison. The inclusion of a FWEEP in each alternative is likely affecting the scores of Alternatives 2 and 3.

3.2.3 Comprehensive Benefits - Four Accounts Comparison

In a memorandum dated January 5, 2021, USACE Headquarters issued direction on the comprehensive assessment and documentation of benefits in the conduct of USACE water resources development project planning. In compliance with this memorandum, USACE conducted an evaluation of alternatives based on NED, RED, Environmental Quality (EQ), and Other Social Effects (OSE) accounts.

NED:

1. Recreation – losses in recreation river or lake area due to riverine flooding
2. Property – damages to property, roads, vehicles, and infrastructure from riverine flooding
3. Emergency Response – cost of emergency response due to damage from riverine flooding

RED:

1. RED Changes – changes to employment, income, the value of output due to property damages and/or business losses, businesses revenue, and indirect business taxes due to property damages and/or losses from riverine flooding

OSE:

1. Life Safety – estimation of lives lost from the riverine flood hazard

2. Connectedness – potential impact from riverine flooding on number of civic and community organizations/members, community vision and outlook for the future, community improvements underway and/or the number of community improvements underway, views of quality of life, and views of equity and diversity
3. Community Identity – potential impact from riverine flooding on core values, key traditions, and sources of group pride and honor
4. Leisure and Recreation – potential impact from riverine flooding on inventory of local recreational areas, sizes, and features, and local/nonlocal visitation and recreation sites

EQ:

1. Environmental Resource Loss – habitat changes due to shoreline change from riverine flooding, risk to threatened and endangered species due to habitat change from riverine flooding
2. Cultural Resource Sites – risk to cultural resource sites from riverine flooding
3. Cultural Resource Buildings – risk to cultural resource buildings from riverine flooding
4. Habitat Creation – designated critical habitat can be designated for listed species and is identified through "essential features"; if our project is creating those essential features then we are contributing to the recovery of the species

3.3 ADDITIONAL ALTERNATIVES DEVELOPMENT AND ANALYSIS

The three preliminary action alternatives were further developed based on elevations at approximately three-foot intervals, which coincided with four flood elevations relevant to Beattyville. These different design elevations were applied to Alternatives 2 and 3 to provide a standardized way for the team to develop and analyze project design options and identify the most optimal plan. The elevations are:

- 663.0 ft NAVD88 (lowest elevation where damages still occur)
- 666.5 ft NAVD88 (reoccurrence of the March 2021 flood event)
- 669.2 ft NAVD88 (FEMA Base Flood Elevation)
- 672.2 ft NAVD88 (FEMA Base Flood +3 feet)

Terminology for the flood elevations is provided in Section 3.3.1, below:

3.3.1 Terminology

Base Flood Elevation (BFE): FEMA established the BFE for most of Beattyville as the elevation 669.1 ft NAVD88. However, as the model moves upstream, this elevation increases. For the purposes of this study, a BFE of 669.2 ft NAVD88 was selected for all of Beattyville for consistency. Based on hydrological analysis, the USACE H&H modeling determined the 100-year flood for Beattyville as 672.08 ft NAVD88, which was rounded for simplicity and the purposes of this report to match the BFE plus 3 ft elevation of 672.2 ft NAVD88. In summary, for the purposes of this study, FEMA's BFE for the study area was assumed to be 669.2 ft NAVD88, and the BFE plus 3 feet was assumed to be 672.2 ft NAVD88. See Section 3.3.2, 4.1.4, and 4.9.3 for more information on the various elevations used for this study.

Design Flood Elevation (DFE): DFE determines the stage at which structures are allowed to be built to within the community. Traditionally, the DFE is set to at least match the BFE. Some

communities increase the elevation by 1 or 2 feet. The non-Federal sponsor (NFS) will develop the flood plain management plan prior to design of the recommended plan for this study. The DFE will establish the elevation the USACE project will elevate a structure and the height utilities and building materials will be mitigated against in a wet floodproof measure. The DFE will be a maximum for dry flood proofing benefits but will not be a minimum for dry floodproofing, because dry flood proofing will be limited by the structural capacity for holding back floodwaters.

3.3.2 Additional Alternatives Development

Alternative 2 Floodwall Alignment: The PDT performed hydraulic analysis of four potential floodwall heights based on the flood elevations described previously in Section 3.2.1, all with the same horizontal floodwall alignment (see Figure 4). This created three additional floodwall alternatives (Figure 6):

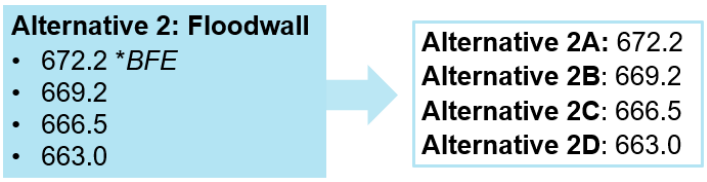


Figure 6. Floodwall Alternatives 2A, 2B, 2C, 2D

Alternative 3 Complete Nonstructural: Alternative 3 was also evaluated at the same four flood elevations (above), creating three additional nonstructural alternatives (Figure 7):



Figure 7. Nonstructural Alternatives 3A, 3B, 3C, 3D

3.3.3 Expanded Array of Alternatives Evaluation

This exercise resulted in four variations of floodwall alternatives and four variations of nonstructural alternatives, with the expanded array of alternatives now representing a total of ten alternatives. Aside from the No Action Alternative, each of the ten alternatives listed below includes a FWEEP as a component.

- No Action Alternative
- 2A. Floodwall Alignment 672.2 ft NAVD88
- 2B. Floodwall Alignment 669.2 ft NAVD88
- 2C. Floodwall Alignment 666.5 ft NAVD88
- 2D. Floodwall Alignment 663.0 ft NAVD88
- 3A. Complete Nonstructural 672.2 ft NAVD88
- 3B. Complete Nonstructural 669.2 ft NAVD88
- 3C. Complete Nonstructural 666.5 ft NAVD88
- 3D. Complete Nonstructural 663.0 ft NAVD88
- FWEEP

In compliance with the aforementioned USACE Headquarters memorandum on comprehensive benefit analysis, the PDT conducted an evaluation of the expanded array of alternatives based on NED, RED, EQ and OSE. These ten alternatives were evaluated both quantitatively (Hydrologic Engineering Center - Flood Damage Analysis 2.0 and LifeSim 2.1.3 programs) and qualitatively (low, medium, and high) across each of the four accounts as shown in the following table.

Table 13. Expanded Array Alternatives Evaluation

	NED				RED	EQ		OSE		
Alternatives	Total Investment Cost ($M)	Annual NED Benefits	BCR	Net Benefits	RED Benefits ($M)	Environmental	Cultural	Average Annual Life Loss	Social Connectedness	Communal Identity
1. No Action	0	0	N/A	0	LOW	MED	MED	0.135	LOW	LOW
2A. Floodwall Alignment 672.2	149	467,817	0.08	-5,039,097	HIGH	LOW	LOW	HIGH	LOW	LOW
2B. Floodwall Alignment 669.2	120	260,250	0.06	-4,173,278	HIGH	LOW	LOW	HIGH	LOW	LOW
2C. Floodwall Alignment 666.5	81	224,659	0.07	-2,787,202	MED	LOW	LOW	HIGH	MED	MED
2D. Floodwall Alignment 663.0	45	61,579	0.04	-1,621,358	MED	LOW	MED	MED	MED	MED
3A. Complete Nonstructural 672.2	89	291,909	0.09	-3,007,659	145.9	MED	LOW	0.092	MED	MED
3B. Complete Nonstructural 669.2	75	265,741	0.10	-2,528,354	121.0	MED	LOW	0.094	MED	MED
3C. Complete Nonstructural 666.5	54	218,496	0.11	-1,783,439	83.4	MED	LOW	0.097	MED	MED
3D. Complete Nonstructural 663.0	24	81,479	0.09	-816,888	35.3	MED	MED	0.114	MED	MED
4. FWEEP	3	N/A	N/A	N/A	5.3	LOW	MED	0.125	MED	LOW

FY24 price levels

3.3.4 Evaluation Observations

Not one of the ten alternatives in the expanded array scored above unity (or 1.0) within the Benefit Cost Ration (BCR) metric of the NED account. Alternatives with a BCR below unity are not considered to be economically viable. Additional information relating to the economic analysis of the expanded array of alternatives can be found in Appendix D - Economics.

Subsequent evaluation of the expanded array of alternatives yielded three significant observations.

1. The floodwall alternatives, when compared to the nonstructural alternatives, were not as efficient or effective at each increment across the NED, OSE, and EQ accounts. In a head-to-head evaluation with similarly affected inventory and similar levels of flood risk mitigation, the performance of the nonstructural alternatives was superior across the board. For this reason, the PDT decided to screen floodwall from further consideration. As this screening decision was clear, the PDT has sound reason to only use a qualitative approach for the RED and Life safety evaluations of the four floodwall alternatives.
2. The FWEEP positively impacted life safety in the nine alternatives it was included in. However, standing as its own alternative, it scored poorly in the NED, RED, and EQ accounts.

3. The initial nonstructural alternative variations were formulated with floodwalls in mind and eligibility was based on elevation only. This approach lent itself to nonstructural plans which were too large in scope to accommodate the significant costs associated with them.

Based on poor economic performance and these additional observations, a strategy for development of a new alternative with an incremental approach was established. To properly and logically aggregate the structure inventory, the PDT decided to rethink the eligibility criteria and how the nonstructural alternative could have a more targeted approach. Alternative 3A was considered the best plan of the expanded array as it maximized life safety (benefiting the OSE account), yielded the highest annual NED benefits of all NS plans, and scored highest of all NS plans in the RED account.

Alternative 4, a stand-alone FWEEP, and Alternative 3A were carried forward for further consideration.

3.4 ALTERNATIVE 5 INCREMENTAL NONSTRUCTURAL

In addition to the alternatives based on elevations, an Incremental Nonstructural alternative (Alternative 5) was developed using an incremental approach as depicted in the graphic below. The incremental plan allowed an alternative to be built from the ground up to tailor a plan which aligned with Beattyville's vision and values. This vision is represented most clearly through the study objectives, which were developed in concert by all parties at the Beattyville charette in April 2023. These objectives, in order of significance, are:

1. Life and community safety
2. Flood damage reduction (buildings, contents, infrastructure)
3. Enhance community cohesion (physical and cultural)

These objectives were continually referred to and remained explicitly in mind as the PDT began to identify and put together each subsequent increment. The PDT was deliberate and intentional with both the order of selection and the evaluation of each increment considered. Partners and stakeholders from the community alike collaborated with the team and contributed focused, personal input which allowed the PDT to scale and scope iterations which tightly aligned with that aforementioned shared vision.

It should also be noted that as Alternative 5 was constructed one increment at a time, the PDT considered each increment to serve as its own standalone alternative. Each increment presented is inclusive of the features highlighted in the previous increments. Figure 8 displays the overall logic, or roadmap, behind the incremental approach. Immediately following this roadmap, each increment will be discussed in further detail in the following sections. This discussion will be inclusive of a summary of annual benefits and costs associated with each individual increment will be presented. For comparative purposes, a cumulative summary of annual benefits and costs will be presented after all increments have been discussed.

Incremental nonstructural logic, or roadmap, is presented in Figure 8.

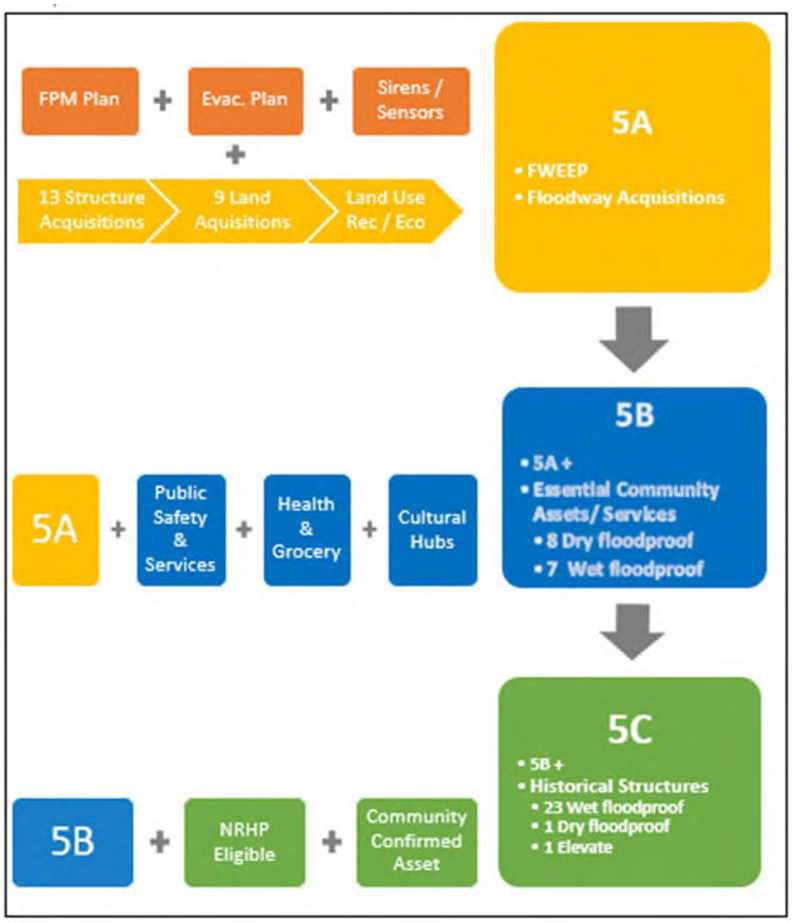


Figure 8. Incremental Nonstructural Alternative Roadmap

3.4.1 Increment 1 – FWEEP (Alternative 4)

A base plan utilizing applicable and appropriate FWEEP elements. With a significant objective being life and community safety, it is clear how important a FWEEP would be for the community of Beattyville. It would provide improved warning time with respect to when flood conditions are likely to occur, and this awareness allows citizens to take steps to ensure their own safety and minimize potential damages to their home, businesses, and personal property. This is the base plan because it provides the greatest improvement to life safety and supports resiliency through floodplain management and improved response to flood events.

A summary of annual benefits and costs for this increment only (independent of all other increments considered) is shown in the table below. It serves as a quick look at the economic performance of the increment itself. Economic analysis on the FWEEP only alternative was not performed as its impact on the NED account is anticipated to be negligible; however, it can reasonably be expected that some FRM benefits would exist as citizens will have more warning time to remove valuable contents and vehicles from the threatened area. Additional discussion of the FWEEP analysis can be found in the Economics appendix.

Table 14. Increment 1 Summary of Annual Benefits and Costs

Investment Cost	Increment 1 FWEEP
Construction First Cost	2,466,750
Interest During Construction	68,146
Total Investment Cost	2,534,896
Annual Charges	
Interest & Amortization	93,895
Operation & Maintenance	5,000
Total Annual Charges	98,895
Annual Benefits	
Flood Risk Management	0
Recreation	0
Total Annual Benefits	0
Benefit vs. Cost Ratio	**N/A**
Net Benefits	-98,895

3.4.2 Increment 2 – Acquisitions in the Kentucky River floodway (Alternative 5A)

With a FWEEP in place and the life and community safety objective being significantly improved, the PDT then began to focus on the remaining objectives (flood risk management and community cohesion) to determine the next increment to be considered in the tailored approach. Logically, due to the floodway being the area where most flood damages naturally occur in any given floodplain, the PDT began to focus on floodway acquisitions along the Kentucky River as the next variation of this incremental approach. Simply put, acquiring structures, and removing them from the floodway, in particular, is typically the most straight-forward nonstructural approach that can be taken to alleviate existing condition flood damages. In addition, acquisitions along the floodway also support components of the FWEEP that restrict future development in the frequently inundated floodway.

In pursuit of the most effective, efficient, and acceptable floodway acquisition strategy, members of the PDT traveled to Beattyville for an in-person meeting with city and county officials, historic preservation representatives, and additional key community stakeholders to discuss this incremental strategy. During this meeting the PDT and all Beattyville stakeholders present went through the entire structure inventory on an individual basis. PDT and stakeholders determined that if a structure's footprint was at least 50% in the FEMA regulatory floodway, then the decision was made to either acquire the property or take no action. The take no action option was applied if the property was found to have specific local significance or importance and would cause a detriment if acquired or removed. With this deliberate approach, the PDT was able to suggest, discuss, and confirm acquisition decisions with the support and advisement from Beattyville stakeholders in real time. As a result of this approach, the PDT and Beattyville confirmed 13 structures and 9 land parcels to be acquired. These structures are highlighted in red and shown on the map below in Figure 9.

Some acquired structures are eligible to be relocated, and some parcels may also be partially acquired as long as the remaining parcel is still of benefit to the owner.

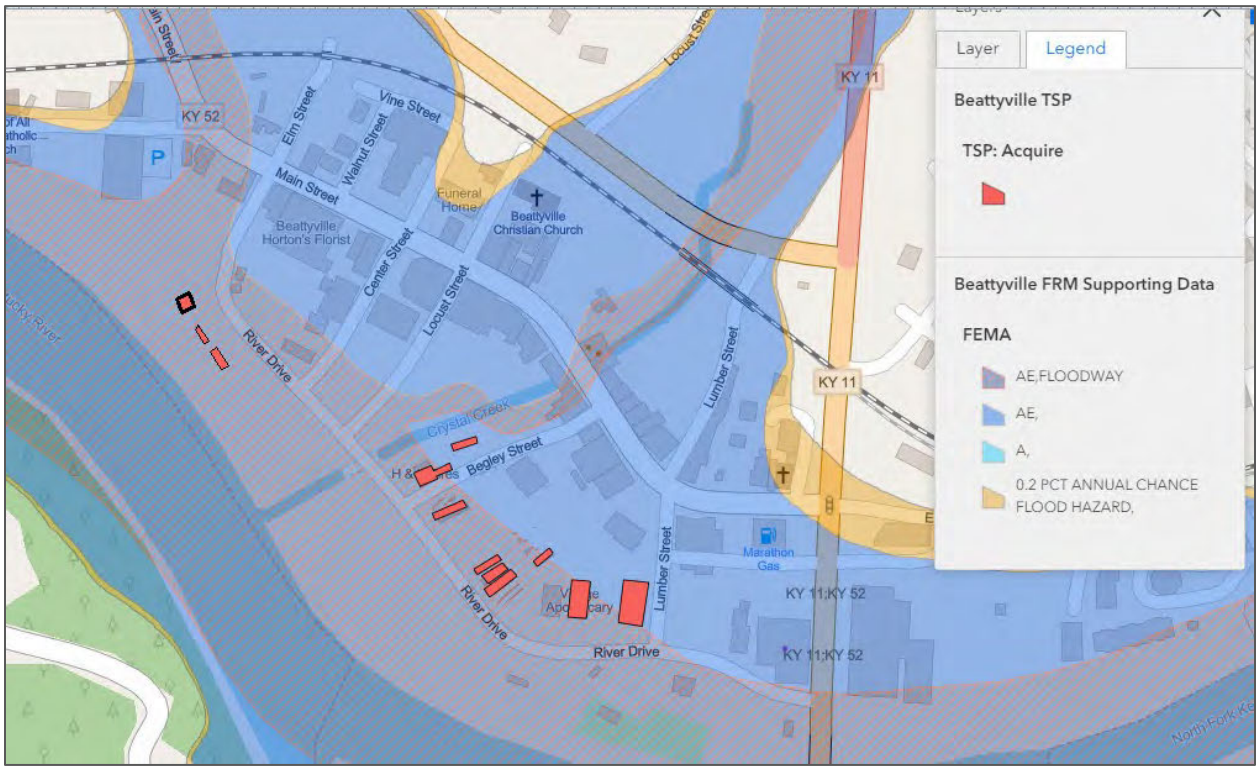


Figure 9. Increment 2 Acquisitions in the Kentucky River Floodway

Recreation Component

An additional and ultimately substantial benefit associated with the floodway acquisitions identified in Alternative 5A is that once these structures are removed, the open area left behind serves as a large, uninhabited, contiguous land area that is available for beneficial re-use. According to ER 1105-2-103, Para. 4-7.b.(2), “Alternative use of land is an integral part in planning for acquisition or permanent relocations of structures. USACE policy allows for inclusion of aquatic ecosystem restoration and recreation benefits when justifying permanent relocations or evacuations. Further, unlike structural alternatives, incrementally justified recreation use in conjunction with permanent relocation or evacuations may account for more than 50% of project justification. All permanent acquisition or relocation or evacuation recommendations must give proper consideration and documentation to alternative use of land.” Section 8-4.f of the ER provides that USACE may participate in recreation facilities at non-reservoir FRM projects if the recreation activities have a strong, direct relationship to the proposed FRM measures, such as trails along the channel or levee right-of-way.”

The PDT identified two opportunities for beneficial re-use of the floodway - Recreation and Ecosystem Restoration.

Beginning with the recreation component, the PDT and Beattyville stakeholders identified a number of recreation features that could be included in the development of our incremental

approach through the beneficial re-use of the floodway. Those features include, but aren't necessarily limited to:

- Walking/exercise trail (mixture of both an elevated boardwalk and asphalt path)
- Relocation of a frequently flooded playground (existing playground elevation is too low and too close to KY River and, as such, incurs extremely frequent inundation)
- Picnic tables.
- Historical markers and educational/point of interest signs
- Parking lot

These features align with city's own pre-existing vision for this specific area exactly, as depicted in their "Riverside Park Master Plan" (which was drafted in Feb 2023, by Bell Engineering) and the NFS desire to maintain a "walkable" Downtown. Additionally, these initiatives also align with the strategic goals identified in the 2020 Kentucky Statewide Comprehensive Outdoor Recreation Plan (SCORP), wherein respondents to a public participation survey indicated that they had visited a beach, lake, or river (89.3%); walked for pleasure, exercised, or leisurely enjoyed the outdoors (84.2%); or visited parks or historical sites (80.1%). Roughly two out of every three respondents indicated that they viewed scenery (67.5%), attended an outdoor fair or festival (62.7%), or went swimming or hiked on trails (56.0%). Other notable activities that respondents listed included driving for pleasure (49.5%) and fishing in freshwater from the bank or from a pier (47.8%)."

The PDT has considered mostly passive recreation features in an effort to keep long-term operation and maintenance costs as low as possible and to provide opportunity for aquatic ecosystem restoration. The proximity of the proposed trail(s) to the Kentucky River will support the community's desire to positively re-engage Beattyville with the Kentucky River, as opposed to merely fearing its next inundation.

Recreation benefits for Increment 5A were captured via utilization of the Unit Day Value (UDV) Methodology presented in ER 1105-2-103 and values as presented in Economic Guidance Memorandum (EGM) 24-02 – Unit Day Values for Recreation for FY2024.

Figure 10 presents the highly disturbed and barren existing condition of the Kentucky River Floodway in Beattyville where the proposed acquisitions and beneficial re-use components are planned.



Figure 10. Existing Conditions of the Kentucky River Floodway

A depiction of the proposed location of some of these recreation features is provided in Figure 11.

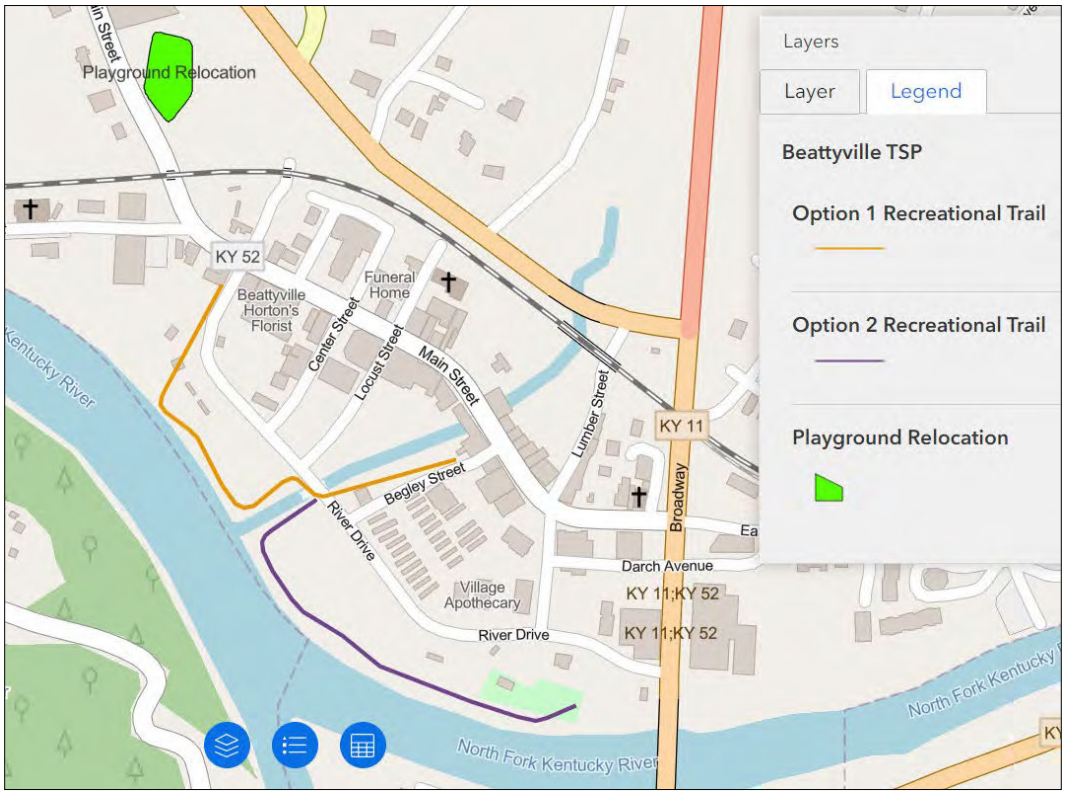


Figure 11. Proposed Locations of Recreation Features

Ecosystem Restoration Component

To build upon recreational aspects of the project as presented, the PDT has planned to stabilize the general area surrounding the proposed new walking trail with various native grasses, plantings, and riparian trees. This work includes, but is not necessarily limited to, approximately 6 acres of park land creation and tree, shrub, and native grasses planted in bare areas along the Kentucky River. The expectation of the PDT is that this ecosystem restoration work will have a positive aesthetic and environmental impact on the surrounding area, but creation of new, significant habitat units with this effort is not anticipated or intended. Conceptually, the intent is to strictly support and build upon the recreation features mentioned previously. As such, the PDT does not foresee any additional quantifiable benefits, but the qualitative impact is clear and apparent.

A depiction of the proposed location of some of these ecosystem restoration features is provided in Figure 12.

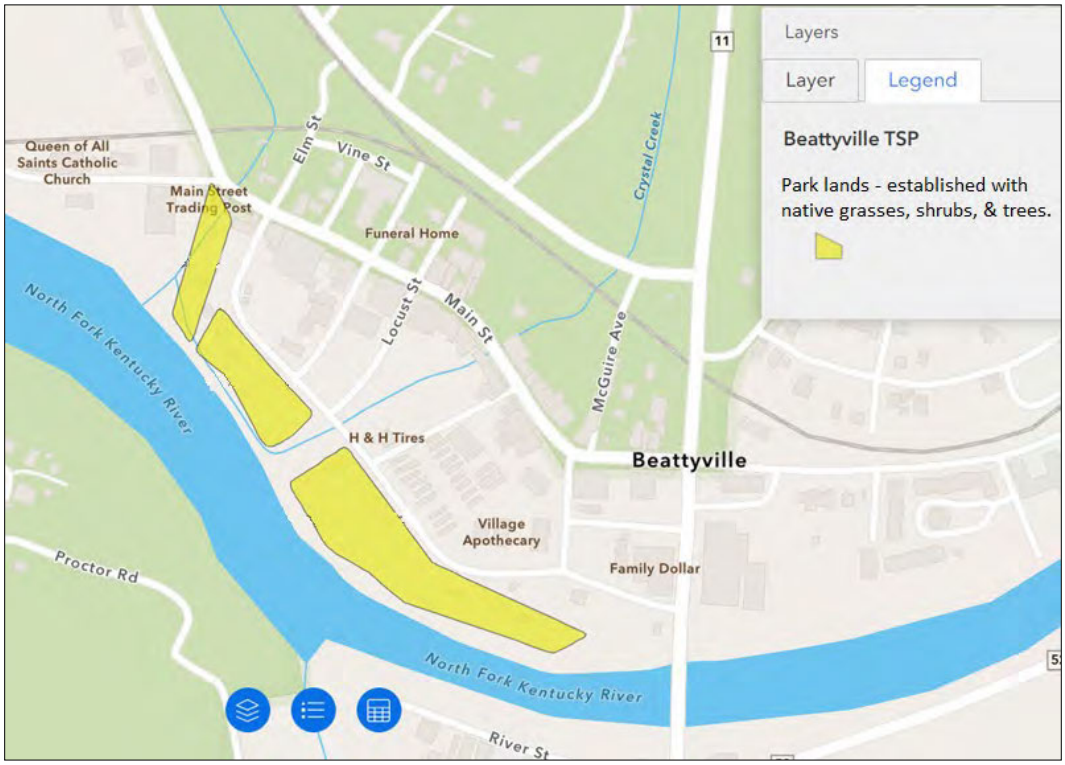


Figure 12. Proposed Locations for Ecosystem Restoration Features

The following table displays a summary of annual benefits and costs associated with this increment only (independent of all other increments considered). Increment 2, including acquisitions, FWEEP, recreation, and ecosystem restoration components (unquantified) via beneficial re-use of land acquisition yields $232,774 in annual net benefits and a BCR of 1.55.

Table 15. Increment 2 Summary of Annual Benefits and Costs

	Increment 2
Investment Cost	**5A - Floodway Aq**
Construction First Cost	10,851,756
Interest During Construction	299,789
Total Investment Cost	11,151,545
Annual Charges	
Interest & Amortization	413,063
Operation & Maintenance	10,000
Total Annual Charges	423,063
Annual Benefits	
Flood Risk Management	59,428
Recreation	596,410
Total Annual Benefits	655,838
Benefit vs. Cost Ratio	**1.55**
Net Benefits	232,774

3.4.3 Increment 3 – Essential/Anchor Assets and Services (Alternative 5B)

Beattyville is commonly referred to as the "Birthplace of the Kentucky River." Beattyville was incorporated in 1872 and has served as the County Seat of Lee County ever since. With an estimated population of approximately 2,176 residents, Beattyville also represents the largest city in all of Lee County. Further, according to stakeholders from Kentucky River Area Development District (KRADD), "Beattyville's identity is Lee County's identity." So, in effect, the heart of the entire county resides on Main Street in downtown Beattyville. The heart of any city, much less a county seat in a rural region of the state, requires the existence and reliable availability of essential structures or anchor establishments for basic functionality and community viability. The PDT considers these buildings to serve as the community anchors: grocery store (IGA), police station, city hall, health services, senior center, museum, and multiple churches.

With this increment, the tentatively selected plan involves dry floodproofing 8 structures (to protect exterior and contents) and wet floodproofing 7 additional structures (primarily for exterior protection). These structures are highlighted in light and dark green on the Figure 13. Floodproofing these structures will support community resiliency by protecting the services and providing consistency that will allow the town to bounce back after a flood event. The selected mitigation measure for each structure was first identified by the PDT based on building type and function and was coordinated with several members of the community during an in-person meeting between USACE and representatives of the NFS.

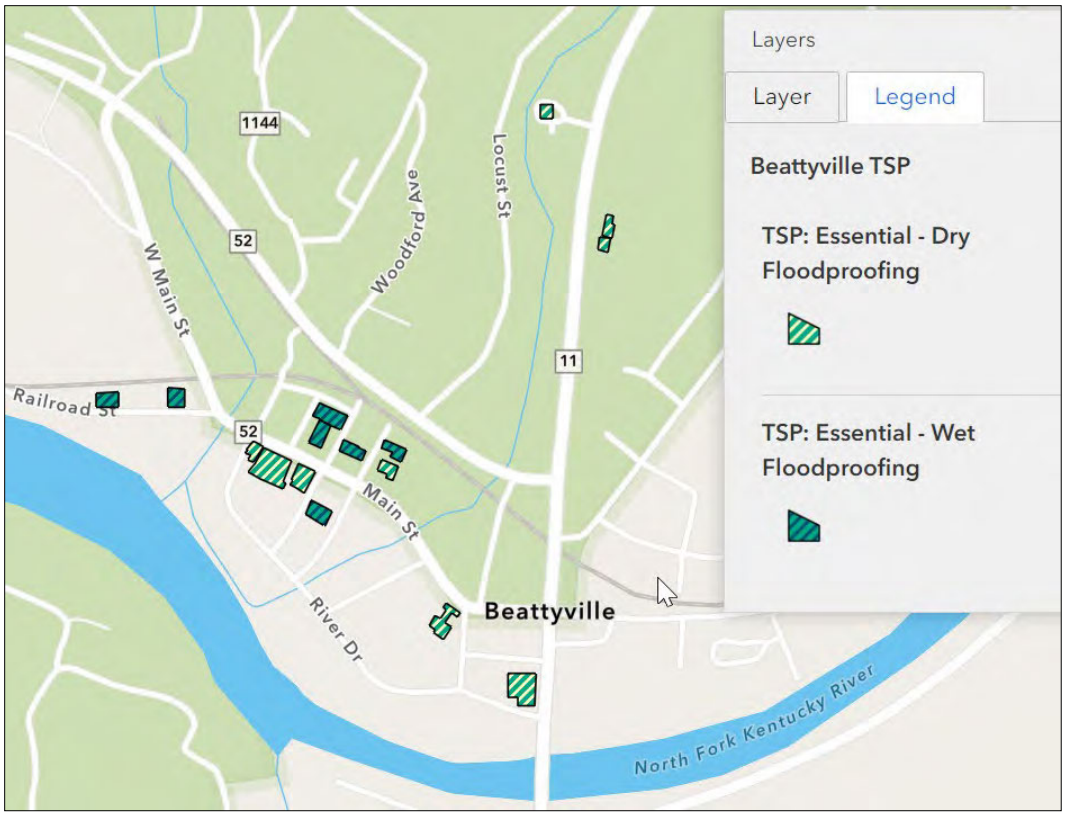


Figure 13. Increment 3 Essential/Anchor Assets and Services

A summary of annual benefits and costs for this increment only (independent of all other increments considered) is shown in the table below. It serves as a quick look at the economic performance of the increment itself. For this increment alone, benefits were below unity with a BCR of 0.25.

Table 16. Increment 3 Summary of Annual Benefits and Costs

Investment Cost	Increment 3 5B - Essential
Construction First Cost	9,038,549
Interest During Construction	249,697
Total Investment Cost	9,288,246
Annual Charges	
Interest & Amortization	344,045
Operation & Maintenance	0
Total Annual Charges	344,045
Annual Benefits	
Flood Risk Management	85,476
Recreation	0
Total Annual Benefits	85,476
Benefit vs. Cost Ratio	**0.25**
Net Benefits	-258,569

3.4.4 Increment 4 – Historical Structures (Alternative 5C)

Beattyville's Main Street is a state and nationally accredited Main Street Program, and it is currently pursuing historic designation for multiple properties located downtown. With several historic sites already listed in the NRHP and a regional history museum, Beattyville has a deep connection to the history of Eastern Kentucky. This iteration is intended to preserve and maintain the framework of downtown Beattyville. The structures included on Beattyville's NRHP submission for the downtown commercial area as a historic district will be either dry or wet floodproofed. Floodproofing these structures supports community identity by helping to preserve Beattyville's aesthetic characteristics and sense of community pride and history. Beattyville's submission of this NRHP form indicates that these structures are a priority.

Alternative 5C improves upon 5B by applying nonstructural FRM measures to 25 historical structures, the majority of which will be wet floodproofed (23). Of the two remaining historical structures, one will be dry floodproofed and the final structure will be elevated. This wet floodproofing is viewed to be a critical component to increase resilience of the community and reduce the recovery time long term from future inundation events.

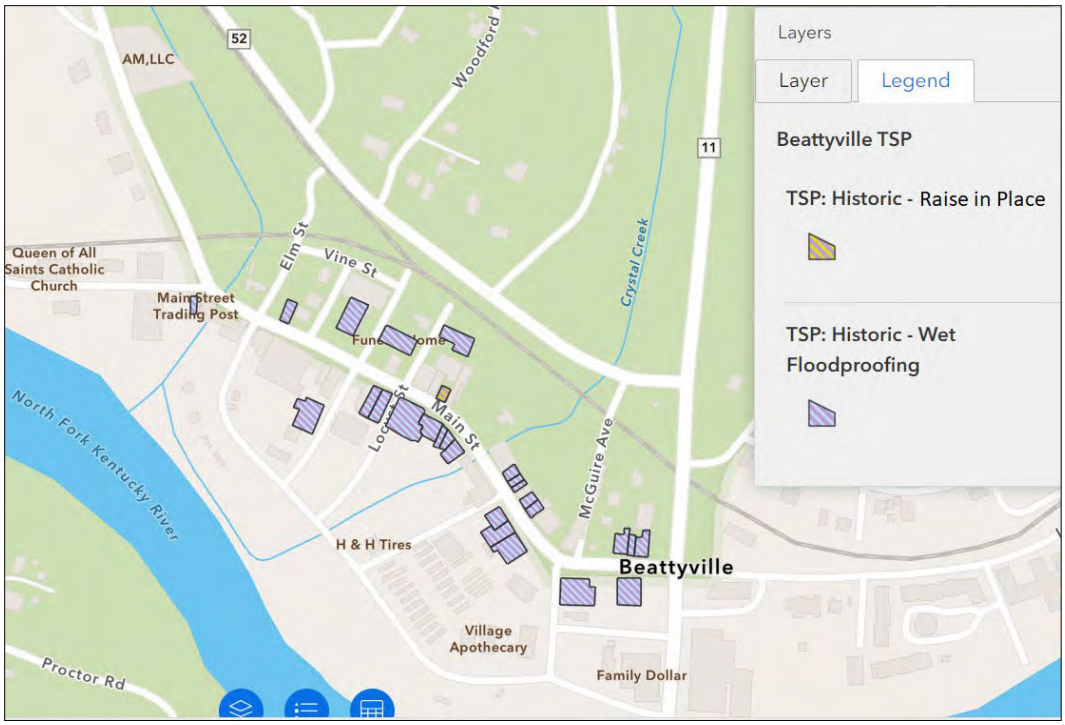


Figure 14. Increment 4 Historical Structures

The following table displays a summary of annual benefits and costs associated with this increment only (independent of all other increments considered). For this increment alone, benefits were below unity with a BCR of 0.08.

Table 17. Increment 4 Summary of Annual Benefits and Costs

Investment Cost	**Increment 4 5C - Historic**
Construction First Cost	13,419,639
Interest During Construction	370,729
Total Investment Cost	13,790,368
Annual Charges	
Interest & Amortization	510,808
Operation & Maintenance	0
Total Annual Charges	510,808
Annual Benefits	
Flood Risk Management	43,336
Recreation	0
Total Annual Benefits	43,336
Benefit vs. Cost Ratio	**0.08**
Net Benefits	-467,472

3.4.5 Summary of Annual Benefits and Costs

This table displays the summary of annual benefits and costs across each of the four increments in a cumulative fashion. FWEEP is FWEEP only. 5A is inclusive of the FWEEP. 5B is inclusive of 5A. 5C is inclusive of 5B.

Table 18. Summary of Annual Benefits and Costs for Incremental Analysis

Beattyville, KY
General Investigation
Summary of Annual Benefits and Costs
FY 2024 Price Levels
2.75% Interest Rate

Investment Cost	4 FWEEP	5A FW AQ	5B Essential	5C Historic
Construction First Cost	2,466,750	13,318,506	22,357,055	35,776,694
Interest During Construction	68,146	367,935	617,632	988,360
Total Investment Cost	2,534,896	13,686,441	22,974,687	36,765,054
Annual Charges				
Interest & Amortization	93,895	506,958	851,004	1,361,811
Operation & Maintenance	5,000	15,000	15,000	15,000
Total Annual Charges	98,895	521,958	866,004	1,376,811
Annual Benefits				
Flood Risk Management	0	59,428	144,903	188,239
Recreation	0	596,410	596,410	596,410
Total Annual Benefits	0	655,838	741,313	784,649
Benefit vs. Cost Ratio	**N/A**	**1.26**	**0.86**	**0.57**
Net Benefits	-98,895	133,879	-124,690	-592,162

3.4.6 Increment Impacts to Project Objectives

The following table displays the impact of each increment on the aforementioned project objectives, along with the alternative's cumulative impact on damages, benefits, and residual risk. This increment impact table is structured to present not only what we are gaining with the addition of each increment, in terms of objective impact, but also to display the risk that will still exist within the community if the incremental approach is cut short at any particular increment.

Table 19. Increment Impacts on Project Objectives

Iteration/Description	Objective Impact 1 Life and community safety	2 Reduce flood damages	3 Enhance community connection	Total Damages	Total Benefits (inc REC)	Residual Risk
Future Without Project	None	None	None	$795,674	$0	$795,674
FWEEP ONLY	Significant	Minor	Minor	N/A	Minor	Significant
Floodway Acquistion	Minor	Significant	Significant	N/A	$655,838	$736,247
Essential Structures	Minor	Significant	Significant	N/A	$741,313	$650,771
Historical Structures	None	Minor	Significant	N/A	$784,649	$607,435

As depicted in the table above, the FWEEP yields significant improvement to Objective 1, Life and Community Safety, with minor (yet uncalculated) positive improvements to Objectives 2 and 3 (Reduce Flood Damages and Enhance Community Connection).

With the addition of the floodway acquisition increment, the PDT has added significant impacts to Objectives 2 and 3, while producing minor, yet positive, impacts to Objective 1. In addition, total benefits (inclusive of recreation), have seen a significant jump from uncalculated, but minor, to over $650,000 annually. Finally, and somewhat unexpectedly, flood risk has been reduced, but only by $60,000 and annual residual risk is still well above $700,000.

As for the addition of the Essential Structures increment, significant impacts were added to Objectives 2 and 3 again, while producing minor, yet positive, impacts to Objective 1. Additionally, total benefits (inclusive of recreation), have seen another jump from $655,000 to $741,000 annually. Flood risk has been reduced by an additional $80,000 and annual residual risk has been lowered to $650,000.

Finally, with the addition of the Historical Structures increment, the PDT has added significant impacts to Objective 3 again, while producing minor, yet positive, impacts to Objective 2. In addition, total benefits (inclusive of recreation), have seen another jump from $741,000 to $785,000 annually. Finally, flood risk has been reduced by an additional $40,000 and annual residual risk has been lowered to $607,000, which represents a 24% decrease from Future Without Project Conditions.

4 ENVIRONMENTAL EFFECTS AND CONSEQUENCES

The CEQ's NEPA Implementing Regulations require that an EA identify the likely environmental effects of a proposed project and that the agency determine whether those impacts may be significant. Effects (or impacts) are changes to the human environment from the final array of alternatives that are reasonably foreseeable and include direct effects, indirect effects, and/or cumulative effects, as defined by 40 C.F.R. § 1508.1(g). Effects may include ecological, aesthetic, historic, cultural, economic, social, or health effects, and can be either beneficial or adverse.

In considering whether the effects are significant, agencies shall analyze the potentially affected environment and degree of the effects of the action (40 C.F.R. § 1501.3(b)). In considering the potentially affected environment, agencies should consider the affected area and its resources, understanding that significance varies with the setting of the proposed project. Agencies should

consider connected actions including actions that automatically trigger other actions, that cannot or would not proceed unless other actions are taken previously or simultaneously or are independent parts of a larger action and depend on the larger action for their justification (40 C.F.R. § 1501.9(e)). In considering the degree of the effects of the action, agencies should consider both short-term and long-term effects, both beneficial and adverse effects, effects on public health and safety, and effects that would violate laws protecting the environment. The term "degree" is not defined in the governing regulations, but generally refers to the magnitude of change that would result from the alternatives evaluated herein.

All potentially relevant resource areas were initially considered for analysis in this EA. Some resource topics are not discussed, or the discussion is limited in scope, due to the lack of anticipated effect from the alternatives on the resource or because that resource is not located within the affected environment, including wild and scenic rivers.

This section presents the adverse and beneficial environmental effects of the NAA and the final array of alternatives as described in Section 5.1.1. Other alternatives considered were screened from further consideration during the planning process that is presented in Section 3. This section is organized by resource topic, with the effects of the NAA and action alternatives discussed under each resource topic. Impacts are quantified whenever possible. Qualitative descriptions of impacts are explained by accompanying text where used.

Qualitative definitions/descriptions of impacts as used in this section of the EA include:

Degree:

- No Effect, or Negligible – a resource would not be affected, or the effects would be at or below the level of detection, and changes would not be of any measurable or perceptible consequence.
- Minor – effects on a resource would be detectable, although the effects would be localized, small, and of little consequence to the sustainability of the resource. Mitigation measures, if needed to offset adverse effects, would be simple and achievable.
- Moderate – effects on a resource would be readily detectable, localized, and measurable. Mitigation measures, if needed to offset adverse effects, would be extensive and likely achievable.
- Significant – effects on a resource would be obvious and would have substantial consequences. The resource would be severely impaired so that it is no longer functional in the project area. Mitigation measures to offset the adverse effects would be extensive, and success of the mitigation measures would not be guaranteed.

Duration:

- Short-term – temporary effects caused by the construction and/or implementation of a selected alternative.
- Long-term – caused by an alternative after construction has been completed and/or when it is in full and complete operation.

4.1 AFFECTED ENVIRONMENT (40 CFR 1502.15) AND ENVIRONMENTAL CONSEQUENCES (40 CFR 1502.16)

4.1.1 Climate

The USACE has developed numerous policies that require civil works projects to consider climate change during the planning and selection of projects. This includes the 2024-2027 Climate Adaptation Plan (USACE 2024a) as well as a Climate Preparedness and Resilience Policy Statement (USACE 2024b). These policies represent the USACEs commitment to increase the nations resilience to climate change related effects as well as reduce greenhouse gas (GHG) emissions, where possible, in supply chains, workforce operations, and construction projects.

4.1.1.1 Climate-Affected Hydrology

A climate assessment of Beattyville was conducted to satisfy the requirements of ECB 2018-14 and provide helpful information to the decision-making process about current and projected climatological trends in the project area. A summary of the Beattyville Climate Assessment is presented in Section 2.7. and the complete assessment can be found in Appendix H.

No Action

It is expected that the NAA would result in Beattyville being less resilient to potential increases in precipitation and streamflow that are projected to occur as a result of climate change impacts to hydrology in the region. As discussed in Section 2.6, repeated flooding is resulting in economic decline and social hardship to an already underserved and disadvantaged community, as well as presenting potential life safety risks to the community. The result of the NAA would be that Beattyville would be less resilient to the risk of flooding, flooding could potentially be more frequent, and flood depths could be potentially deeper.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

It is expected that Alternative 5C would result in significant long-term beneficial impacts to climate change resiliency for Beattyville. Up to 13 structures would be removed from the floodway, up to nine structures would be dry floodproofed, up to 30 structures would be wet floodproofed, and one structure would be raised in place, in addition to a FWEEP being implemented. These actions would increase flood resiliency and thus climate change resiliency as it relates to increased potential for flooding.

4 - FWEEP Only

It is expected that Alternative 4 would improve life safety to residence in Beattyville by providing advance warning of flood events, however, it would not address vulnerabilities to infrastructure, leaving Beattyville less resilient to future flood events, which could potentially be more frequent and with greater flood depths.

5A - FWEEP and Acquisitions in Kentucky River Floodway

It is expected that Alternative 5A would result in significant long-term beneficial impacts to climate change resiliency for Beattyville. Up to 13 structures would be removed from the floodway and a FWEEP would be implemented. These actions would increase flood resiliency and thus climate change resiliency as it related to increased potential for flooding.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

It is expected that Alternative 5B would result in significant long-term beneficial impacts to climate change resiliency for Beattyville. Up to 28 structures would either be removed from the floodway, dry floodproofed, wet floodproofed, or raised in place, in addition to a FWEEP being implemented. These actions would increase flood resiliency and thus climate change resiliency as it related to increased potential for flooding.

3A - Complete Nonstructural 672.2 ft NAVD88

It is expected that Alternative 3A would result in significant long-term beneficial impacts to climate change resiliency for Beattyville. Up to 120 structures below 672.2 ft NAVD88 would either be removed from the floodway, dry floodproofed, wet floodproofed, or raised in place, in addition to a FWEEP being implemented. These actions would increase flood resiliency and thus climate change resiliency as it is related to increased potential for flooding.

4.1.1.2 Greenhouse Gas Emissions

The CEQ's NEPA Implementing Regulations require that, where applicable, climate change-related effects, including, where feasible, quantification of greenhouse gas emissions, from the proposed action and alternatives and the effects of climate change on the proposed action and alternatives (40 C.F.R. § 1502.16(a)6).

Climate change is inherently a cumulative global issue. This means that one molecule of a greenhouse gas (GHG) released anywhere on Earth has been assumed to have the same impact on climate regardless of its location. Consequently, the geographic scope for analyzing the effects of GHG emissions is vast, and it is best to evaluate these effects in relation to state and Federal GHG emission goals and standards. The state of Kentucky currently has no GHG emission goals or standards. Executive Order (EO) 14057: *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*, sets specific Federal goals for GHG emissions including:

- 100% carbon pollution-free electricity on a net annual basis by 2030, including 50% 24/7 carbon pollution-free electricity.
- 100% zero-emission vehicle acquisitions by 2035, including 100% zero-emission light-duty vehicle acquisitions by 2027.
- A net-zero emissions building portfolio by 2045, including a 50% emissions reduction by 2032.
- A 65% reduction in scope 1 and 2 greenhouse gas emissions, as defined by the Federal Greenhouse Gas Accounting and Reporting Guidance, from Federal operations by 2030 from 2008 levels.
- Net-zero emissions from Federal procurement, including a Buy Clean policy to promote use of construction materials with lower embodied emissions.
- Climate resilient infrastructure and operations
- A climate- and sustainability-focused Federal workforce.

According to the EPA (2024), there are four sectors of the U.S. economy produce the majority of the GHG's that are emitted each year. They include:

1. Energy – The energy sector, particularly the combustion of fossil fuels for electricity generation, is a major contributor to GHG emissions. This includes emissions from power

plants and other energy-related activities necessary to power commercial and residential buildings for lighting, heating, cooling, and operation of appliances.
2. Transportation – The transportation sector is a significant source of GHG emissions, primarily from the combustion of gasoline and diesel fuels in cars, trucks, airplanes, ships, and trains.
3. Industry – Industrial processes, including manufacturing, construction, and chemical production, release GHGs through activities such as burning fossil fuels for energy, chemical reactions, and the use of industrial equipment.
4. Agriculture – Agricultural activities contribute to GHG emissions through practices such as livestock digestion, manure management, use of gas- and diesel-powered machinery, and the use of synthetic fertilizers.

The relative amounts of GHG emissions produced by each sector can vary depending on the methodology of the analysis, as well as factors such as changes in technology and policy over time. However, as of recent assessments, a rough breakdown of GHG emissions by sector in the United States is as follows (EPA, 2024):

- Energy: Approximately 28-30%
- Transportation: Approximately 27-29%
- Industry: Approximately 22-24%
- Agriculture: Approximately 9-10%

No Action and Alternative 4 – FWEEP Only

Since the NAA and Alternative 4 do not address the protection of structures within the project area and do not have construction elements, it can be assumed that their GHG emissions will be the same. While no GHG emissions are anticipated with the NAA or Alternative 4 due to construction, it has been assumed that a moderate flood event would occur sometime within the 50-year study period. Due to this, the NAA and Alternative 4's GHG emissions were based on a single moderate flood cleanup event within the study area. To estimate emissions, total mileages or total hours for each component were calculated and multiplied by an average gallons per hour/mile for a given vehicle category. This produced the total gallons of diesel and gasoline needed for the cleanup effort. These numbers were then converted to tons/grams of carbon dioxide (C02), methane (CH4), and nitrous oxide (N2O). These numbers were then run through USACE's Net Emissions Analysis Tool (NEAT) to calculate social costs of the projected GHG emissions. Assumptions made for the NAA and Alternative 4's analysis and the calculations can be found in Appendix B. Results of the NEAT tool analysis can be found in Table 20.

The results of the GHG analysis were that the NAA and Alternative 4 would produce 129 metric tons of CO2, 5,740 grams of CH4, and 1,148 grams of N20. The NAA would create $16,797 of social costs to the community of Beattyville, Kentucky. These reflect a minor adverse impact to the climate and the American people.

In addition to the cleanup effort, 13 structures would remain in the floodway and consume electricity. The exact amount of electricity consumption is unknown but is expected to be minor.

Action Alternatives

Analysis of the remaining four Action Alternative's emissions was separated into two parts, construction emissions and carbon sequestration. For the construction emissions calculation, the

USACE estimated total fuel usages for gasoline and diesel from projected necessary equipment anticipated hours of use. These totals were then converted to tons/grams of C02, CH4, N20. The NEAT tool was then utilized to calculate social costs for the Action Alternatives based on the projected GHG emissions. For the carbon sequestration calculation, the United States Forest Service's (USFS) Standard Estimates of Forest Ecosystem Carbon for Forest Types of the United States was consulted, which outlines carbon bank totals for different regional tree groupings. This document evaluates carbon sequestered in tons per acre over a time period ranging from 0-120 years for a variety of tree associations, with the amount of carbon sequestered at 50 years being chosen to represent the 50-year study period (Hoover et al. 2022). The chosen tree association used to represent the proposed plantings was the oak-hickory association within the south-central region. While the USFS document was made for natural regeneration and not plantings, USACE determined it could be used since it would naturally account for any risks associated with replanting, natural mortality, and other issues encountered during the study period. The total estimated carbon sequestration from the USFS document was converted to tons/grams of carbon dioxide and included in the NEAT analysis of the applicable action alternatives as benefits. Carbon sequestration benefits were not applied to Alternative 3A as the ecosystem restoration component was not part of that plan. For a summary of the NEAT tool results and a comparison of the NAA and Action Alternatives, please refer to Table 20. For a full view of calculations done, please refer to Appendix B.

Table 20. Net Emissions Analysis Tool (NEAT) results.

Construction Gross Totals (Action Alternatives)					
	C02	Ch4	N20	C02[e]	Social Costs (2020 dollars)
TSP	568 metric tons	23,213 grams	4,643 grams	570 metric tons	$78,154
Alternative 4	129 metric tons	5,740 grams	1,148 grams	129 metric tons	$16,797
Alternative 5A	49 metric tons	1,971 grams	394 grams	49 metric tons	$6, 678
Alternative 5B	118 metric tons	7,201 grams	1,440 grams	119 metric tons	$16,260
Alternative 3A	2,983 metric tons	121,089 grams	24,218 grams	2,993 metric tons	$410, 360
Carbon Sequestration	-699 metric tons[1]	0	0	-699 metric tons[1]	-$158, 318[1]
Action Alternative Overall Total (Construction-Sequestration) *** no sequestration applied**					
TSP Overall	-131 metric tons[1]	23,213 grams	4,643 grams	-129 metric tons[1]	-80,164[1]

Alternative 4*	129 metric tons	5,740 grams	1,148 grams	129 metric tons	$16, 797
Alternative 5A	-650 metric tons[1]	1,971 grams	394 grams	-650 metric tons[1]	-$151,641[1]
Alternative 5B	-581 metric tons[1]	7,201 grams	1,440 grams	-580 metric tons[1]	-$142, 059[1]
Alternative 3A*	2,983 metric tons	121, 089 grams	24,218 grams	2,993 metric tons	$410, 360[1]
No Action Alternative	129 metric tons	5,740 grams	1,148 grams	129 metric tons	$16,797
Net Totals (AA-NAA)					
TSP	-260 metric tons[1]	17,473 grams	3,495 grams	-258 metric tons[1]	-$96,961[1]
Alternative 4	0 metric tons	0 grams	0 grams	0 metric tons	$0
Alternative 5A	-779 metric tons[1]	-3,769 grams[1]	-754 grams[1]	-779 metric tons[1]	-$168,437[1]
Alternative 5B	-709 metric tons[1]	1,461 grams	292 grams	-709 grams[1]	-$158,856[1]
Alternative 3A	2,854 metric tons	115,349 grams	23,070 grams	2,864 metric tons	$393, 563

[1] Negative numbers indicate sequestration of GHG or a beneficial social cost

For comparison of the NAA and Action Alternatives, all GHG's were converted to carbon dioxide equivalents ($CO2^e$) via the NEAT tool so a direct comparison could be made. The results of the NEAT analysis of Alternative 5C showed that the project would create a net sequestration of 258 metric tons of $CO2^e$ when compared to the NAA. Alternative 5C would create $96,961 worth of social costs benefits over the 50-year study period. These results indicate a moderate beneficial impact to GHG and broader climate goals. Alternative 4 is functionally identical to the NAA in terms of GHG emissions. Alternative 5A would create a net sequestration of 779 metric tons of $CO2^e$ and would create $168,437 in social costs benefits, representing a moderate beneficial impact. Alternative 5B would create a net sequestration of 709 metric tons of $CO2^e$ and would create $158,856 in social costs benefits, reflecting a moderate beneficial impact. Alternative 3A would produce 2,864 metric tons of $CO2^e$ and would incur $393,563 in social costs, representing a moderate adverse impact.

While small amounts of O&M would be needed for maintenance of the plantings and hiking trail associated with Alternative 5C, 5A, and 5B during the 50-year study period, emissions amounts for these activities are likely too low to be calculable and are not covered in this GHG analysis.

4.1.2 Soils and Geology

4.1.2.1 Geology and Physiography

No Action

The NAA would have no effect on geology and physiography. These resources are relatively stable and take long-term geologic processes for significant change to be realized, unless otherwise impacted by large scale earth moving activities.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These actions would have no effect on geology or physiography, as they do not involve altering bedrock or landforms from their existing condition.

4 - FWEEP Only

As the FWEEP involves the installation of sirens and the production of an evacuation plan, no impacts to geology or physiography are anticipated.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These actions would have no effect on geology or physiography, as they do not involve altering bedrock or landforms from their existing conditions.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These actions would have no effect on geology or physiography, as they do not involve altering bedrock or landforms from their existing conditions.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These actions would have no effect on geology or physiography, as they do not involve altering bedrock or landforms from their existing conditions.

4.1.2.2 Soil Associations

No Action

The NAA would have no effect on soils or prime farmland as no large-scale disturbance of soils would be expected to occur. While a small amount of erosion and deposition would be expected

to occur within certain areas of the impact area during high flow events, ongoing flooding is not expected to negatively impact soil profiles or farmlands within the project area.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. The demolishing of structures would cause minor disturbances to soil due to heavy equipment operations and regrading. However, best management practices (BMPs) would be employed to limit impacts to local soils. Additionally, because land being disturbed for nonstructural measures would be within and immediately surrounding the foundations of structures, the project would have no effect to prime farmland. Construction impacts related to restoration activities, as well as the proposed hiking trail, would not permanently alter prime farmland soil map units, and therefore, would have no effect on them.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. Since no ground would be disturbed, no impacts to soil associations are anticipated.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. The demolishing of structures would cause minor disturbances to soil due to heavy equipment operations and regrading. However, best management practices (BMPs) would be employed to limit impacts to local soils. Additionally, because land being disturbed for nonstructural measures would be within and immediately surrounding the foundations of structures, the project would have no effect to prime farmland. Construction impacts related to restoration activities, as well as the proposed hiking trail, would not permanently alter prime farmland soil map units, and therefore, would have no effect on them.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. The demolishing of structures would cause minor disturbances to soil due to heavy equipment operations and regrading. However, best management practices (BMPs) would be employed to limit impacts to local soils. Additionally, because land being disturbed for nonstructural measures would be within and immediately surrounding the foundations of structures, the project would have no effect to prime farmland. Construction impacts related to restoration activities, as well as the proposed hiking trail, would not permanently alter prime farmland soil map units, and therefore, would have no effect on them.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. The demolishing of structures would cause minor disturbances to soil due to heavy equipment operations and regrading. However, best management practices (BMPs) would be employed to limit impacts to local soils. Additionally, because land being disturbed for nonstructural measures would be within and immediately surrounding the foundations of structures, the project would have no effect to prime farmland.

4.1.3 Surface Water and Other Aquatic Resources

4.1.3.1 Surface Water

No Action

The NAA would have moderate, negative impacts to surface waters over the long-term. Structures in the floodway and floodplain would continue to be inundated with water during flood events. These events cause damage to structures and release debris and other pollutants into the environment. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville, and would be expected to enter the waterway during a flooding event.

Additionally, impacts to surface water could be worsened if streamflow magnitude increases in the future due to climate change. The review of projected climate trends found little consensus regarding the projected streamflow trends, but the review noted substantial uncertainties regarding projected changes of streamflow due to climate change. As such, climate change is not expected to significantly further the impact to surface water.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 building, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. As such, it would be expected that Alternative 5C would have long-term moderate positive impacts to surface waters. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed ecosystem restoration activities within the floodway would further filter sedimentation and other runoff, leading to long term moderate beneficial effects on nearby surface waters.

No activities are expected to occur below the Ordinary High-Water Mark. As such, the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a National Pollution Discharge Elimination System (NPDES) stormwater discharge permit be acquired prior to construction.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. The implementation of a FWEEP itself would not directly impact surface water resources, however, the lack of protection for structures would cause similar moderate adverse impacts to those spelled out in the NAA.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 5A would have long-term moderate positive impacts to surface waters. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed ecosystem restoration activities within the floodway would further filter sedimentation and other runoff, leading to long term moderate beneficial effects on nearby surface waters.

No activities are expected to occur below the Ordinary High-Water Mark. As such, the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a National Pollution Discharge Elimination System (NPDES) stormwater discharge permit be acquired prior to construction.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 5B would have long-term moderate positive impacts to surface waters. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed ecosystem restoration activities within the floodway would further filter sedimentation and other runoff, leading to long term moderate beneficial effects on nearby surface waters.

No activities are expected to occur below the Ordinary High-Water Mark. As such, the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a National Pollution Discharge Elimination System (NPDES) stormwater discharge permit be acquired prior to construction.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 3A would have long-term moderate positive impacts to surface waters. These positive impacts would be realized by the removal of structures from the floodway and via the utilization

of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

No activities are expected to occur below the Ordinary High-Water Mark. As such, the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a National Pollution Discharge Elimination System (NPDES) stormwater discharge permit be acquired prior to construction.

4.1.3.2 Groundwater

No Action

The NAA would have moderate, negative impacts to ground water over the long-term. Structures in the floodway and floodplain would continue to be inundated with water following current and future trends. These flooding events cause damage to structures and have the potential to release debris and other pollutants into the environment that would degrade groundwater quality, including household chemicals, lead based paint, asbestos, plastics, and other substances.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These construction and demolition activities would be expected to have no effect on groundwater. Potential runoff during construction and demolition would be expected to be mitigated through an erosion control plan outlined in Appendix A. As such, it would be expected that Alternative 5C would have long-term moderate positive impacts to ground water. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into the environment which could eventually leach into groundwater resources.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. While the development of a FWEEP would have no direct impacts to groundwater, the lack of protection for buildings would cause similar long term adverse impacts to the NAA.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These construction and demolition activities would be expected to have no effect on groundwater. Potential runoff during construction and demolition would be expected to be mitigated through an erosion control plan. As such, it would be expected that Alternative 5A would have long-term moderate positive impacts to ground water. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into the environment which could eventually leach into groundwater resources.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These construction and demolition activities would be expected to have no effect on groundwater. Potential runoff during construction and demolition would be expected to be mitigated through an erosion control plan. As such, it would be expected that Alternative 5B would have long-term moderate positive impacts to ground water. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into the environment which could eventually leach into groundwater resources.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These construction and demolition activities would be expected to have no effect on groundwater. Potential runoff during construction and demolition would be expected to be mitigated through an erosion control plan. As such, it would be expected that Alternative 5B would have long-term moderate positive impacts to ground water. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into the environment which could eventually leach into groundwater resources.

4.1.3.3 Floodplains

No Action

The NAA would be expected to have significant long-term negative impacts to the floodplain. At least 45 structures would remain within the regulated floodway, leaving a high risk that these structures would continue to flood regularly. This maintains a scenario where there is an ongoing risk to life and property, as well as potential impacts to the floodplain environment caused by the release of debris and other pollutants during flooding disasters.

Tentatively Selected Plan

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. The removal of structures would allow the floodplain to function more naturally, allowing increased floodplain area for water to disperse during high water mark events. There would be a significant reduction in the risk to life and property, due to the removal of structures in the floodway, and the protection of structures in the floodplain. This would also reduce environmental impacts to the floodplain caused by the release of debris and other pollutants during flooding disasters. Furthermore, ecosystem restoration activities within the floodplain would further restore natural floodplain function by adding native riparian species, which would also increase resiliency via the reduction of erosion. There would be negligible short-term adverse impacts to the environment during construction and demolition. However, these impacts would be expected to be successfully mitigated by the erosion control plan outlined in Appendix A. Further, applicable floodplain construction permits would be acquired from the KDOW.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. While the development of a FWEEP itself would not directly impact the floodplain, significant long-term negative impacts would occur for the same reasons spelled out in the NAA's analysis.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. The removal of structures would allow the floodplain to function more naturally, allowing increased floodplain area for water to disperse during high water mark events. There would be a significant reduction in the risk to life and property, due to the removal of structures in the floodway. This would also reduce environmental impacts to the floodplain caused by the release of debris and other pollutants during flooding disasters. Furthermore, ecosystem restoration activities within the floodplain would further restore natural floodplain function by adding native riparian species, which would also increase resiliency via the reduction of erosion. There would be negligible short-term adverse impacts to the environment during construction and demolition. However, these impacts would be expected to be successfully mitigated by an erosion control plan. Further, applicable floodplain construction permits would be acquired from the KDOW.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. The removal of structures would allow the floodplain to function more naturally, allowing increased floodplain area for water to disperse during high water mark events. There would be a significant reduction in the risk to life and property, due to the removal of structures in the floodway, and the protection of structures in the floodplain. This would also reduce environmental impacts to the floodplain caused by the release of debris and other pollutants during flooding disasters. Furthermore, ecosystem restoration activities within the floodplain would further restore natural floodplain function by adding native riparian species, which would also increase resiliency via the reduction of erosion. There would be negligible short-term adverse impacts to the environment during construction and demolition. However, these impacts would be expected to be successfully mitigated by an erosion control plan. Further, applicable floodplain construction permits would be acquired from the KDOW.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. The removal of structures would allow the floodplain to function more naturally, allowing increased floodplain area for water to disperse during high water mark events. There would be a significant reduction in the risk to life and property, due to the removal of structures in the floodway, and the protection of structures in the floodplain. This would also reduce environmental impacts to the floodplain caused by the release of debris and other pollutants during flooding disasters. There would be negligible short-term adverse impacts to the environment during construction and demolition. However, these impacts would be expected to be successfully mitigated by an erosion control plan. Further, applicable floodplain construction permits would be acquired from the KDOW.

4.1.3.4 Wetlands

No Action

Although wetland resources within Beattyville are minor, the NAA would be expected to have long-term significant negative impacts to wetlands. Structures in the floodway and floodplain would continue to be inundated with water on a routine basis. These flooding events cause damage to structures and release debris and other pollutants into the environment. Household chemicals, lead based paint, asbestos, plastics, and other substances that may occur in structures in Beattyville have the potential to enter wetland habitats during flooding events and cause harm to aquatic organisms.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse impact on wetlands due to increased turbidity caused by the disturbance and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. As such, it would be expected that Alternative 5C would have long-term significant positive impacts to wetlands. These positive impacts would be realized by the removal of structures from the floodway via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby wetlands. Furthermore, restoration activities would provide further buffer to riparian wetland habitat by filtering runoff from Beattyville, producing a minor long term beneficial effect.

No activities are expected to occur within the boundaries of existing wetlands. As such the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a NPDES stormwater discharge permit be acquired prior to construction.

4 - FWEEP Only

While the development of a FWEEP would not directly impact wetlands, long term significant negative impacts are anticipated for similar reason spelled out in the NAA's analysis due to the lack of protections to structures.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse impact on wetlands due to increased turbidity caused by the disturbance and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that the Alternative 5A would have long-term significant positive impacts to wetlands. These positive impacts would be realized by the removal of structures from the floodway via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash,

household chemicals, lead based paint, asbestos, and plastics into nearby wetlands. Furthermore, restoration activities would provide further buffer to riparian wetland habitat by filtering runoff from Beattyville, producing a minor long term beneficial effect.

No activities are expected to occur within the boundaries of existing wetlands. As such the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a NPDES stormwater discharge permit be acquired prior to construction.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse impact on wetlands due to increased turbidity caused by the disturbance and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that the Alternative 5B would have long-term significant positive impacts to wetlands. These positive impacts would be realized by the removal of structures from the floodway via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby wetlands. Furthermore, restoration activities would provide further buffer to riparian wetland habitat by filtering runoff from Beattyville, producing a minor long term beneficial effect.

No activities are expected to occur within the boundaries of existing wetlands. As such the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a NPDES stormwater discharge permit be acquired prior to construction.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse impact on wetlands due to increased turbidity caused by the disturbance and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that the Alternative 3A would have long-term significant positive impacts to wetlands. These positive impacts would be realized by the removal of structures from the floodway via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby wetlands.

No activities are expected to occur within the boundaries of existing wetlands. As such the project would occur outside the jurisdiction of the CWA and would not require permitting for compliance with sections 401 or 404 of the act. Land disturbance would occur over an area that is larger than one acre, and as such would require that a NPDES stormwater discharge permit be acquired prior to construction.

4.1.4 Fish and Wildlife Habitats

4.1.4.1 Terrestrial Habitats and Fauna

No Action

The NAA would be expected to have no effect on terrestrial habitats and fauna. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. Therefore, the reoccurrence of flooding within the area would not be expected to impact these resources.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have no effect on terrestrial habitats and fauna. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. As such, the short-term disturbance caused by construction and demolition would not be expected to impact any habitats.

4 - FWEEP Only

Alternative 4 would have no effect on terrestrial habitat and fauna as it lacks a construction component. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. Therefore, the reoccurrence of flooding within the area would not be expected to impact these resources.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have no effect on terrestrial habitats and fauna. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. As such, the short-term disturbance caused by construction and demolition would not be expected to impact any habitats.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have no effect on terrestrial habitats and fauna. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. As such, the short-term disturbance caused by construction and demolition would not be expected to impact any habitats.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have no effect on terrestrial habitats and fauna. The project area is urban and there is a lack of significant or otherwise outstanding terrestrial habitat within the proposed project area. As such, the short-term disturbance caused by construction and demolition would not be expected to impact any habitats.

4.1.4.2 Aquatic Habitats and Fauna

No Action

The NAA would be expected to have significant adverse long-term negative impacts to aquatic habitats and fauna including the those of the Kentucky River, Crystal Creek, and Silver Creek.

Structures in the floodway and floodplain would continue to be inundated with water on a routine basis. These flooding events cause damage to structures and have the potential to release debris and other pollutants into the environment. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville, and would be expected to enter the water way during a flooding disaster event.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance of soils and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. As such, it would be expected that Alternative 5C would have long-term moderate positive impacts to aquatic habitats and fauna. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures within the floodplain. This would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed native plantings in the floodway would cause significant long-term beneficial impacts to aquatic habitats by providing habitat and acting as a filter for runoff from Beattyville.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. While the development of a FWEEP would not impact aquatic habitats directly, significant adverse long-term impacts, as spelled out in the analysis of the NAA, would occur due to the lack of protection for structures within the floodplain.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance of soils and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 5A would have long-term moderate positive impacts to aquatic habitats and fauna. These positive impacts would be realized by the removal of structures from the floodway. This would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed native plantings in the floodway would cause significant long-term beneficial impacts to aquatic habitats by providing habitat and acting as a filter for runoff from Beattyville.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance of soils and run-

off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 5B would have long-term moderate positive impacts to aquatic habitats and fauna. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures within the floodplain. This would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, proposed native plantings in the floodway would cause significant long-term beneficial impacts to aquatic habitats by providing habitat and acting as a filter for runoff from Beattyville.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance of soils and run-off of sediment. However, these impacts would be expected to be successfully mitigated through an erosion control plan. As such, it would be expected that Alternative 3A would have long-term moderate positive impacts to aquatic habitats and fauna. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures within the floodplain. This would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

4.1.5 Endangered and Threatened Species

4.1.5.1 Federally Listed Species

No Action

The NAA would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project footprint and continued flooding of Beattyville would not be expected to impact bat habitat or bat populations. Additionally, the NAA would have *no effect* on the monarch butterfly, as little habitat for this species is within the project area and continued flooding of Beattyville would not be expected to impact monarch habitat or populations.

The NAA has the potential to have significant, long-term adverse impacts to aquatic species that have ranges which overlap with the project area, including the Kentucky arrow darter and the seven listed mussel species (Table 2). The Kentucky arrow darter is known to occur in Silver Creek. While it is not clear if there are extant populations of listed mussels within the Kentucky River downstream of the project area, the project area is included in the historical ranges of these species, and it is assumed that they could occur where suitable habitat is present. Impacts to these species would occur from the pollution caused during regularly reoccurring flooding disasters. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and would be expected to enter the water way during a flooding disaster event. The species listed are sensitive to pollution and impacts to water quality are known to impact all of the mussel species as well as the Kentucky arrow darter.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

The USACE has determined under Section 7 of the ESA that Alternative 5C would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project area and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5C would have *no effect* on the monarch butterfly, as little habitat for this species is present within the project area.

The USACE has determined under Section 7 of the ESA that Alternative 5C *may affect but is not likely to adversely affect* the Kentucky arrow darter and the seven listed mussel species that have ranges which overlap with the project area (Table 2) caused by the expected moderate long-term positive improvements to water quality as well as the enhancement of riparian habitat in the floodway. The USFWS will be consulted for concurrence on this determination prior to the finalization of this IFR/EA [PENDING].

It is expected that Alternative 5C would have significant long-term, positive impacts to federally listed aquatic species. Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would reduce potential impacts to the federally listed aquatic organisms within the watershed.

4 - FWEEP Only

Alternative 4 would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project footprint and continued flooding of Beattyville would not be expected to impact bat habitat or bat populations. Additionally, Alternative 4 would have *no effect* on the monarch butterfly, as little habitat for this species is within the project area and continued flooding of Beattyville would not be expected to impact monarch habitat or populations.

Alternative 4 has the potential to have significant, long-term adverse impacts to aquatic species that have ranges which overlap with the project area, including the Kentucky arrow darter and the seven listed mussel species (Table 2). The Kentucky arrow darter is known to occur in Silver Creek. While it is not clear if there are extant populations of listed mussels within the Kentucky River downstream of the project area, the project area is included in the historical ranges of these species, and it is assumed that they could occur where suitable habitat is present. Impacts to these species would occur from the pollution caused during regularly reoccurring flooding disasters. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and

would be expected to enter the water way during a flooding disaster event. The species listed are sensitive to pollution and impacts to water quality are known to impact all of the mussel species as well as the Kentucky arrow darter.

5A - FWEEP and Acquisitions in Kentucky River Floodway

The USACE has determined that Alternative 5A would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project area and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5A would have *no effect* on the monarch butterfly, as little habitat for this species is present within the project area.

The USACE has determined that the Alternative 5A *may affect but is not likely to adversely affect* the Kentucky arrow darter and the seven listed mussel species that have ranges which overlap the project area (Table 2) caused by the expected moderate long-term positive improvements to water quality as well enhancement of riparian habitat in the floodway.

It is expected that Alternative 5A would have significant long-term, positive impacts to federally listed aquatic species. Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would reduce potential impacts to the federally listed aquatic organisms within the watershed.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

The USACE has determined that Alternative 5B would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project area and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5B would have *no effect* on the monarch butterfly, as little habitat for this species is present within the project area.

The USACE has determined that the Alternative 5B *may affect but is not likely to adversely affect* the Kentucky arrow darter and the seven listed mussel species that have ranges which overlap the project area (Table 2) caused by the expected moderate long-term positive improvements to water quality as well enhancement of riparian habitat in the floodway.

It is expected that Alternative 5B would have significant long-term, positive impacts to federally listed aquatic species. Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These construction and demolition activities could have a negligible adverse short-term impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by

the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would reduce potential impacts to the federally listed aquatic organisms within the watershed.

3A - Complete Nonstructural 672.2 ft NAVD88

The USACE has determined that Alternative 3A would have *no effect* on federally listed bat species that have ranges which overlap with the project area (Table 2). There is little habitat for these species within the project area and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 3A would have *no effect* on the monarch butterfly, as little habitat for this species is present within the project area.

The USACE has determined that the Alternative 3A *may affect but is not likely to adversely affect* the Kentucky arrow darter and the seven listed mussel species that have ranges which overlap the project area (Table 2) caused by the expected moderate long-term positive improvements to water quality as well enhancement of riparian habitat in the floodway.

It is expected that Alternative 3A would have significant long-term, positive impacts to federally listed aquatic species. Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. The long-term improvement of water quality in the area would reduce potential impacts to the federally listed aquatic organisms within the watershed.

4.1.5.2 State Listed Species

No Action

The NAA would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). No state-listed bird or bat species are known from the project footprint and there is little habitat for these species within the project area. Because the project footprint is primarily urban, the continued flooding of Beattyville would not be expected to impact bird or bat habitat or populations. Additionally, the NAA would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project area.

It is expected that the NAA could have significant long-term negative impacts to state listed aquatic species (Table 2). While the Kentucky Arrow Darter is known to occur in Silver Creek, it is not clear if there are extant populations of the other state listed species within the project area or downstream. However, the historical range includes the project area and without formal survey data, it is assumed that they could occur where suitable habitat is present. Impacts to these species would occur from the pollution caused during regularly reoccurring flooding disasters.

Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and would be expected to enter the water way during a flooding disaster event. The species listed are sensitive to pollution and impacts to water quality are known to cause negative impacts.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). Due the urban nature of Beattyville site, there is little habitat for these species within the project footprint and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5C would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project footprint.

It is expected that Alternative 5C would have long-term significant positive impacts to state listed aquatic species (Table 2). Alternative 5C entails demolishing up to 13 structures and regrading soils to match natural conditions, dry floodproofing up to 9 structures, wet floodproofing up to 30 structures, and the raising of one residential structure currently in the project footprint. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. The positive impacts to listed species would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would result in a long-term beneficial impact to the state listed aquatic organisms within the watershed.

4 - FWEEP Only

Alternative 4 would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). No state-listed bird or bat species are known from the project footprint and there is little habitat for these species within the project area. Because the project footprint is primarily urban, the continued flooding of Beattyville would not be expected to impact bird or bat habitat or populations. Additionally, Alternative 4 would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project area.

It is expected that Alternative 4 could have significant long-term adverse impacts to state listed aquatic species (Table 2). While the Kentucky Arrow Darter is known to occur in Silver Creek, it is not clear if there are extant populations of the other state listed species within the project area or downstream. However, the historical range includes the project area and without formal survey data, it is assumed that they could occur where suitable habitat is present. Impacts to these species would occur from the pollution caused during regularly reoccurring flooding disasters. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and would be expected to enter the water way during a flooding disaster event. The species listed are sensitive to pollution and impacts to water quality are known to cause negative impacts.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). Due the urban nature of Beattyville site, there is little habitat for these species within the project footprint and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5A would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project footprint.

It is expected that Alternative 5A would have long-term significant positive impacts to state listed aquatic species (Table 2). Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts to listed species would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would result in a long-term beneficial impact to the state listed aquatic organisms within the watershed.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). Due the urban nature of Beattyville site, there is little habitat for these species within the project footprint and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 5B would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project footprint.

It is expected that Alternative 5B would have long-term significant positive impacts to state listed aquatic species (Table 2). Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts to listed species would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The long-term improvement of water quality in the area would result in a long-term beneficial impact to the state listed aquatic organisms within the watershed.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have no effect on state listed bird or bat species that have ranges which overlap with the project area (Table 2). Due the urban nature of Beattyville site, there is little

habitat for these species within the project footprint and no trees greater than 3-inches in diameter would be removed during construction or demolition activities. Additionally, Alternative 3A would have no effect on the six-banded longhorn beetle, as little habitat for this species is present within the project footprint.

It is expected that Alternative 3A would have long-term significant positive impacts to state listed aquatic species (Table 2). Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These short-term construction and demolition activities could have a negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts to listed species would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. The long-term improvement of water quality in the area would result in a long-term beneficial impact to the state listed aquatic organisms within the watershed.

4.1.5.3 Designated Critical Habitat

No Action

The NAA has the potential to negatively impact Kentucky Arrow Darter designated critical Habitat within Silver Creek. It is expected that the NAA could have long-term significant negative impacts to aquatic environments via the pollution caused during regularly reoccurring flooding disasters. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and would be expected to enter the water way during a flooding disaster event. The Kentucky Arrow Darter is sensitive to pollution and impacts to water quality are known to cause negative impacts.

Tentatively Selected Plan

Alternative 5C has the potential to have a negligible short-term adverse impact on Kentucky arrow darter designated critical habitat due to construction runoff. However, it is expected that Alternative 5C would have significant long-term positive impacts to aquatic environments. Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. These construction and demolition activities could have a short-term negligible impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan outlined in Appendix A. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The improvement of local and regional water quality would have a long-term positive impact to Kentucky arrow darter Habitat.

The USACE has determined under Section 7 of the ESA that Alternative 5C *may affect but is not likely to adversely affect* the Kentucky arrow darter caused by positive impacts to designated critical habitat through the long-term improvement in water quality as well as enhancement of riparian habitat in the floodway. The USFWS will be consulted for concurrence on this determination prior to the finalization of this IFR/EA [PENDING].

4 - FWEEP Only

Alternative 4 has the potential to negatively impact Kentucky arrow darter critical habitat within Silver Creek. It is expected that Alternative could have long-term significant adverse impacts to aquatic environments via the pollution caused during regularly reoccurring flooding disasters. Household chemicals, lead based paint, asbestos, plastics, and other substances likely to cause harm to aquatic organisms, would be expected to occur in structures in Beattyville and would be expected to enter the water way during a flooding disaster event. The Kentucky Arrow Darter is sensitive to pollution and impacts to water quality are known to cause adverse impacts.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A has the potential to have a negligible short-term adverse impact on Kentucky arrow darter designated critical habitat due to construction runoff. However, it is expected that Alternative 5A would have significant long-term positive impacts to aquatic environments. Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. These construction and demolition activities could have a short-term negligible adverse impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The improvement of local and regional water quality would have a long-term positive impact to Kentucky arrow darter Habitat.

The USACE has determined that Alternative 5A *may affect but is not likely to adversely affect* the Kentucky arrow darter caused by positive impacts to designated critical habitat through the long-term improvement in water quality as well as enhancement of riparian habitat in the floodway.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B has the potential to have a negligible short-term adverse impact on Kentucky arrow darter designated critical habitat due to construction runoff. However, it is expected that Alternative 5B would have significant long-term positive impacts to aquatic environments. Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. These construction and demolition activities could have a short-term negligible adverse impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead

based paint, asbestos, and plastics into nearby surface waters. Furthermore, the proposed native riparian plantings within the floodway would provide improved bank resiliency as well as would improve water quality by acting as a natural buffer to pollutants. The improvement of local and regional water quality would have a long-term positive impact to Kentucky arrow darter Habitat.

The USACE has determined that Alternative 5B *may affect but is not likely to adversely affect* the Kentucky arrow darter caused by positive impacts to designated critical habitat through the long-term improvement in water quality as well as enhancement of riparian habitat in the floodway.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A has the potential to have a negligible short-term adverse impact on Kentucky arrow darter designated critical habitat due to construction runoff. However, it is expected that Alternative 3A would have significant long-term positive impacts to aquatic environments. Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. These construction and demolition activities could have a short-term negligible adverse impact on surface waters due to increased turbidity caused by the disturbance and run-off of soil. However, these impacts would be expected to be successfully mitigated through an erosion control plan. The positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters. The improvement of local and regional water quality would have a long-term positive impact to Kentucky arrow darter Habitat.

The USACE has determined that Alternative 3A *may affect but is not likely to adversely affect* the Kentucky arrow darter caused by positive impacts to designated critical habitat through the long-term improvement in water quality as well as enhancement of riparian habitat in the floodway.

4.1.6 Recreational, Scenic, and Aesthetic Resources

4.1.6.1 Local Resources

No Action

The NAA would have significant long-term adverse impacts to local recreational, scenic, and aesthetic resources. Flooding of the town would be expected to continue to occur, and buildings would continue to be damaged during disaster events. Many structures that have been recently flooded remain dilapidated and unoccupied, resulting in further degradation of the local aesthetic quality of Beattyville. Structures that are flooded again would release debris into the surrounding environment and would also degrade the local aesthetics of Beattyville as well as degrade wildlife viewing opportunities on the Kentucky River. Additionally, the Three Forks Historical Center would remain unprotected and would continue to experience damage, disrupting a local recreation opportunity.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have long-term significant beneficial impacts to local recreational, scenic, and aesthetic resources. Alternative 5C entails demolishing up to 13 structures, regrading soils

to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. While the demolition of structures would cause short-term minor adverse impacts to the aesthetics of the project footprint, the long-term aesthetic character of the area would be improved by returning the impacted sites to a natural grade and their utilization as green space or for other appropriate community functions that align with proper use of floodplains. The riparian zone plantings and new hiking trail would provide new recreational opportunities as well as restore the floodplain to a more natural state. Additionally, this would tie into regional themes of natural tourism by providing natural floodplain habitat. Alternative 5C would improve the overall aesthetic of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. While the development of a FWEEP would have no direct impacts to local aesthetic resources, the lack of protections for town structures would cause significant long-term adverse impacts spelled out in the analysis of the NAA.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have long-term significant beneficial impacts to local recreational, scenic, and aesthetic resources. Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. While the demolition of structures would cause short-term minor adverse impacts to aesthetics of the project footprint, the long-term aesthetic character of the area would be improved by returning the impacted sites to a natural grade and their utilization as green space or for other appropriate community functions that align with proper use of floodplains. The riparian zone plantings and new hiking trail would provide new recreational opportunities as well as restore the floodplain to a more natural state. Additionally, this would tie into regional themes of natural tourism by providing natural floodplain habitat. Alternative 5A would improve the overall aesthetic of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have long-term significant beneficial impacts to local recreational, scenic, and aesthetic resources. Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. While the demolition of structures would cause short-term minor adverse impacts to aesthetics of the project footprint, the long-term aesthetic character of the area would be improved by returning the impacted sites to a natural grade and their utilization as green space or for other appropriate community functions that align with proper use of floodplains. The riparian zone plantings and new hiking trail would provide new recreational opportunities as well as restore the floodplain to a more natural state. Additionally, this would tie into regional themes of natural tourism by providing natural floodplain habitat. Alternative 5B would improve the overall aesthetic of the community by removing dilapidated

structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have long-term significant beneficial impacts to local recreational, scenic, and aesthetic resources. Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. While the demolition of structures would cause short-term minor adverse impacts to aesthetics of the project footprint, the long-term aesthetic character of the area would be improved by returning the impacted sites to a natural grade and their utilization as green space or for other appropriate community functions that align with proper use of floodplains. Alternative 5B would improve the overall aesthetic of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville.

4.1.6.2 Regional Resources

No Action

The NAA could have long-term minor adverse impacts to regional recreational, scenic, and aesthetic resources. As nature-based tourism continues to grow in the Red River Gorge and Natural Bridge State Park, long-term adverse impacts to Beattyville caused by flooding could prevent the community contributing to aspects of regional tourism. Degradation of the community as described in 4.6.1 would discourage visitation from regional recreators and discourage the development of recreation-based businesses within Beattyville.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have long-term minor positive impacts to regional recreational, scenic, and aesthetic resources Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. The demolition of structures would cause temporary minor impacts to aesthetics while the area remains disturbed. However, the areas would be returned to a natural grade and would be utilized as green space or for other appropriate community functions that align with proper use of floodplains. This would improve the long-term aesthetic character of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville. The native plantings and hiking trail would provide incentive for regional visitors to visit the area, increase its alignment with regional tourism values, and encourage the development of recreation-based businesses within Beattyville.

4 - FWEEP Only

Alternative 4 entails the development of a FWEEP for the town of Beattyville. While the development of a FWEEP would have no direct effect on regional aesthetics, the lack of structural protection would lead to minor long-term adverse impacts as spelled out by the NAA's analysis.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have long-term minor positive impacts to regional recreational, scenic, and aesthetic resources Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. The demolition of structures would cause temporary minor impacts to aesthetics while the area remains disturbed. However, the areas would be returned to a natural grade and would be utilized as green space or for other appropriate community functions that align with proper use of floodplains. This would improve the long-term aesthetic character of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, and providing the opportunity for more recreation opportunities within the project area. The native plantings and hiking trail would provide incentive for regional visitors to visit the area, increase its alignment with regional tourism values, and encourage the development of recreation-based businesses within Beattyville.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have long-term minor positive impacts to regional recreational, scenic, and aesthetic resources Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. The demolition of structures would cause temporary minor impacts to aesthetics while the area remains disturbed. However, the areas would be returned to a natural grade and would be utilized as green space or for other appropriate community functions that align with proper use of floodplains. This would improve the long-term aesthetic character of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville. The native plantings and hiking trail would provide incentive for regional visitors to visit the area, increase its alignment with regional tourism values, and encourage the development of recreation-based businesses within Beattyville.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have long-term minor positive impacts to regional recreational, scenic, and aesthetic resources. Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. The demolition of structures would cause temporary minor impacts to aesthetics while the area remains disturbed. However, the areas would be returned to a natural grade and would be utilized as green space or for other appropriate community functions that align with proper use of floodplains. This would improve the long-term aesthetic character of the community by removing dilapidated structures, reducing the debris deposited in Beattyville during flooding disasters, providing the opportunity for more recreation opportunities within the project area, and floodproofing existing commercial buildings that already provide local recreation opportunities and contribute to the aesthetic quality of Beattyville.

4.1.6.3 Cultural Resources

No Action

The NAA would have no effect to cultural resources. No construction or demolition activities would occur that would impact the potential Historic District or other known cultural resources within the community.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have long-term minor positive impacts to cultural resources. Alternative 5C entails demolishing up to 13 structures and regrading soils to match natural conditions, dry floodproofing up to 9 structures, wet floodproofing up to 30 structures, and the raising of one residential structure currently in the project footprint. Of these total structures 33 are currently being considered as part of the Beattyville Downtown Historic District. Of these 33 structures, 27 have been identified for wet floodproofing, 1 has been identified for dry floodproofing and the remaining 5 will have no action. The effects associated with wet and dry floodproofing will be considered and consulted on during the continuation of the Section 106 process; however, these are unlikely to be considered adverse effects and will ultimately provide historic benefits to the community of Beattyville by ensuring minimal loss of historic integrity to the community.

4 - FWEEP Only

A FWEEP-only plan would not minimize or avoid adverse effects to the Beattyville Historic District related to future flooding and would have little to no beneficial effects to the historic district.

5A - FWEEP and Acquisitions in Kentucky River Floodway

This alternative would have little to no beneficial effects to the Beattyville Historic District or other cultural resources and would not minimize or avoid adverse effects to other cultural resources due to future flooding.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

This alternative would have little to no beneficial effects to the Beattyville Historic District or other cultural resources and would not minimize or avoid adverse effects to other cultural resources due to future flooding.

3A - Complete Nonstructural 672.2 ft NAVD88

This alternative would result with several historic buildings to be demolished which could be considered an adverse effect to the Beattyville Historic District. Furthermore, this alternative would have little to no beneficial effects to other cultural resources due to future flooding.

4.1.7 Air Quality

No Action

The NAA would have no effect on air quality. No construction activities would occur that could release ozone, carbon monoxide, or other particulates into the atmosphere. Additionally, it would not be expected that the continued flooding of Beattyville would result in impacts to air quality.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would cause short-term minor impacts to air quality. Temporary construction and demolition activities, including the operation of heavy equipment with diesel engines, would release carbon monoxide and ozone into the atmosphere. Additionally, it would be expected that some dust and other particulate matter would be released during implementation of Alternative 5C. However, activities would only occur during daylight hours, allowing air quality return to baseline during off hours. Given that Lee County is in attainment for all criteria pollutants, it is not expected that impacts to air quality would be significant or require mitigation.

4 - FWEEP Only

Alternative 4 would have no effect on air quality. No construction activities would occur that could release ozone, carbon monoxide, or other particulates into the atmosphere. Additionally, it would not be expected that the continued flooding of Beattyville would result in impacts to air quality.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would cause short-term minor impacts to air quality. Temporary construction and demolition activities, including the operation of heavy equipment with diesel engines, would release carbon monoxide and ozone into the atmosphere. Additionally, it would be expected that some dust and other particulate matter would be released during implementation of Alternative 5A. However, activities would only occur during daylight hours, allowing air quality return to baseline during off hours. Given that Lee County is in attainment for all criteria pollutants, it is not expected that impacts to air quality would be significant or require mitigation.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would cause short-term minor impacts to air quality. Temporary construction and demolition activities, including the operation of heavy equipment with diesel engines, would release carbon monoxide and ozone into the atmosphere. Additionally, it would be expected that some dust and other particulate matter would be released during implementation of Alternative 5B. However, activities would only occur during daylight hours, allowing air quality return to baseline during off hours. Given that Lee County is in attainment for all criteria pollutants, it is not expected that impacts to air quality would be significant or require mitigation.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would cause short-term minor impacts to air quality. Temporary construction and demolition activities, including the operation of heavy equipment with diesel engines, would release carbon monoxide and ozone into the atmosphere. Additionally, it would be expected that some dust and other particulate matter would be released during implementation of Alternative 3A. However, activities would only occur during daylight hours, allowing air quality return to baseline during off hours. Given that Lee County is in attainment for all criteria pollutants, it is not expected that impacts to air quality would be significant or require mitigation.

4.1.8 Invasive Species

No Action

The NAA would have no effect on invasive species. The project area is urban and invasive species are present. However, it is not expected that continued flooding would exacerbate invasive species issues above the level they are currently at. Additionally, the project area is not a natural area where it would be expected that invasive species could damage natural plant or wildlife communities.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have minor beneficial effects on invasive species. The project area is urban, and invasive species are already present. Temporary construction activities would cause ground disturbance. However, all disturbed ground would be promptly reseeded or repaired to the appropriate asphalt or concrete condition. Given that the project area is urban, seed mixtures would likely consist of common lawn species that would be most appropriate for the setting and routine maintenance expected for the area. Therefore, construction activities would have no effect to this resource. The native plantings in the floodway would cause a minor long term beneficial effect to this resource as invasive species would be replaced or displaced by native species.

4 - FWEEP Only

Alternative 4 would have no effect on invasive species. The project area is urban and invasive species are present. However, it is not expected that continued flooding would exacerbate invasive species issues above the level they are currently at. Additionally, the project area is not a natural area where it would be expected that invasive species could damage natural plant or wildlife communities.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have minor beneficial effects on invasive species. The project area is urban, and invasive species are already present. Temporary construction activities would cause ground disturbance. However, all disturbed ground would be promptly reseeded or repaired to the appropriate asphalt or concrete condition. Given that the project area is urban, seed mixtures would likely consist of common lawn species that would be most appropriate for the setting and routine maintenance expected for the area. Therefore, construction activities would have no effect to this resource. The native plantings in the floodway would cause a minor long term beneficial effect to this resource as invasive species would be replaced or displaced by native species.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have minor beneficial effects on invasive species. The project area is urban, and invasive species are already present. Temporary construction activities would cause ground disturbance. However, all disturbed ground would be promptly reseeded or repaired to the appropriate asphalt or concrete condition. Given that the project area is urban, seed mixtures would likely consist of common lawn species that would be most appropriate for the setting and routine maintenance expected for the area. Therefore, construction activities would have no effect to this resource. The native plantings in the floodway would cause a minor long term beneficial effect to this resource as invasive species would be replaced or displaced by native species.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have no effect on invasive species. The project area is urban, and invasive species are already present. Temporary construction activities would cause ground disturbance. However, all disturbed ground would be promptly reseeded or repaired to the appropriate asphalt or concrete condition. Given that the project area is urban, seed mixtures would likely consist of common lawn species that would be most appropriate for the setting and routine maintenance expected for the area. As such, Alternative 3A is not expected to impact invasive species.

4.1.9 Noise

No Action

The NAA would have no effect on noise. No construction or demolition activities associated with the action alternatives would occur that would impact the current noise level of the community.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have short-term minor impacts to noise. Construction and demolition activities would create higher levels of noise for the community. However, it is not expected that noise levels would be significantly higher than typical noises found in urban communities and construction activities would only occur during daylight hours, thus limiting the disturbance caused to community members. Siren installation and testing would also create short-term adverse impacts but would be short in duration and limited to areas directly around the siren.

4 - FWEEP Only

Alternative 4 would have short-term minor impacts to noise. Power tools and other equipment used to install the sirens would create localized raised noise levels. However, it is not expected that noise levels would be significantly higher than typical noises found in urban communities. Occasional siren testing would create short term impacts, however these would be short in duration and limited to areas directly around the siren.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have short-term minor impacts to noise. Construction and demolition activities would create higher levels of noise for the community. However, it is not expected that noise levels would be significantly higher than typical noises found in urban communities and construction activities would only occur during daylight hours, thus limiting the disturbance caused to community members. Siren installation and testing would also create short-term adverse impacts but would be short in duration and limited to areas directly around the siren.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have short-term minor impacts to noise. Construction and demolition activities would create higher levels of noise for the community. However, it is not expected that noise levels would be significantly higher than typical noises found in urban communities and construction activities would only occur during daylight hours, thus limiting the disturbance caused to community members. Siren installation and testing would also create short-term adverse impacts but would be short in duration and limited to areas directly around the siren.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have short-term minor impacts to noise. Construction and demolition activities would create higher levels of noise for the community. However, it is not expected that noise levels would be significantly higher than typical noises found in urban communities and construction activities would only occur during daylight hours, thus limiting the disturbance caused to community members. Siren installation and testing would also create short-term adverse impacts but would be short in duration and limited to areas directly around the siren.

4.1.10 Transportation and Traffic

No Action

The NAA would have no effect on transportation and traffic, as there would be no construction activities that would impact traffic.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C would have short-term negligible impacts to transportation and traffic. Minor detours or flaggers may be used to safely control traffic around temporary demolition and construction activities. However, given that heavy traffic is not an issue in Beattyville, it would not be expected to cause noticeable impacts to local transportation or traffic flow.

4 - FWEEP Only

Alternative 4 would have no effect on transportation and traffic, as there would be no construction activities that would impact traffic.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A would have short-term negligible impacts to transportation and traffic. Minor detours or flaggers may be used to safely control traffic around temporary demolition and construction activities. However, given that heavy traffic is not an issue in Beattyville, it would not be expected to cause noticeable impacts to local transportation or traffic flow.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B would have short-term negligible impacts to transportation and traffic. Minor detours or flaggers may be used to safely control traffic around temporary demolition and construction activities. However, given that heavy traffic is not an issue in Beattyville, it would not be expected to cause noticeable impacts to local transportation or traffic flow.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A would have short-term negligible impacts to transportation and traffic. Minor detours or flaggers may be used to safely control traffic around temporary demolition and construction activities. However, given that heavy traffic is not an issue in Beattyville, it would not be expected to cause noticeable impacts to local transportation or traffic flow.

4.1.11 Hazardous and Toxic Substances

Section 2.4.7 outlines the known sites in the project area that constitute Recognized

Environmental Conditions (RECs) that would correspond with hazardous and toxic substances. However, a complete Phase I Environmental Site Assessment for Beattyville has not been completed due to the limited ability to access all buildings and properties at this point in the planning phase of the study. Therefore, all RECs are not known. However, it can be assumed, given the typical age and type of structures in Beattyville, that lead-based paint and asbestos is present in many of the buildings. There is also potential for onsite storage of petroleum products that are currently unknown, as well as storage of household cleaners, pesticides, and other chemicals commonly used for routine maintenance of vehicles and facilities.

No Action

It would be expected the NAA would have long-term moderate adverse impacts to hazardous and toxic substances. Impacts would result from hazardous and toxic substances being dispersed into the environment during flooding disasters along with other trash and debris.

Tentatively Selected Plan

Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. As such, it would be expected that Alternative 5C would have moderate long-term, positive impacts to hazardous and toxic substances. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

Prior to any construction or demolition activities a Phase I Environmental Site Assessment would be performed to fully identify any potential RECs at each structure that is included in Alternative 5C. All appropriate actions would be taken to remove or abate RECs prior to demolition or activities that could otherwise cause hazardous and toxic substances to be released into the environment.

4 - FWEEP Only

It would be expected that Alternative 4 would have long-term moderate adverse impacts to hazardous and toxic substances due to the lack of protection for town structures. Impacts would result from hazardous and toxic substances being dispersed into the environment during flooding disasters along with other trash and debris.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. As such, it would be expected that Alternative 5A would have moderate long-term, positive impacts to hazardous and toxic substances. These positive impacts would be realized by the removal of structures from the floodway which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

Prior to any construction or demolition activities a Phase I Environmental Site Assessment would be performed to fully identify any potential RECs at each structure that is included in Alternative 5A. All appropriate actions would be taken to remove or abate RECs prior to demolition or

activities that could otherwise cause hazardous and toxic substances to be released into the environment.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B entails nonstructural measures being implemented on up to 28 structures and the implementation of a FWEEP. As such, it would be expected that Alternative 5B would have moderate long-term, positive impacts to hazardous and toxic substances. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

Prior to any construction or demolition activities a Phase I Environmental Site Assessment would be performed to fully identify any potential RECs at each structure that is included in Alternative 5B. All appropriate actions would be taken to remove or abate RECs prior to demolition or activities that could otherwise cause hazardous and toxic substances to be released into the environment.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. As such, it would be expected that Alternative 3A would have moderate long-term, positive impacts to hazardous and toxic substances. These positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures in the floodplain, which would significantly reduce the risk of the release of debris, trash, household chemicals, lead based paint, asbestos, and plastics into nearby surface waters.

4.1.12 Socioeconomic and Environmental Justice

No Action

It would be expected the NAA would have significant long-term negative impacts to socioeconomics and EJ. Resource extraction, particularly coal mining, has had a dramatic impact on the community resulting in boom-and-bust cycles that have left Beattyville with inadequate infrastructure to support the existing community. This is exhibited by the area being classified as a disadvantaged community by the CEQ which outlines 11 socioeconomic burdens that the community faces (Figure 3). The NAA would result in the community, already struggling with poverty, to continue to have to clean up destroyed buildings and debris after each flooding disaster. Many structures that have a high likelihood of containing lead-based paint and asbestos would remain in the floodway and would regularly be flooded and damaged during disaster events. All 65 commercial buildings representing much of the local economy of the area would continue to experience damage during flooding disasters, resulting in lost business and costly cleanups. Finally, risks to life and safety would remain elevated, as a flood warning system and emergency management plan would not be created for the community.

5C – FWEEP, Acquisitions in Kentucky River Floodway, Essential/Anchor Structures, and Historical Structures

Alternative 5C is expected to have significant long-term positive impacts to socioeconomics and EJ. Alternative 5C entails demolishing up to 13 structures, regrading soils to match natural conditions, dry floodproofing up to 9 buildings, wet floodproofing of up to 30 structures, raising one structure in place, and the implementation of a FWEEP. Positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of structures being damaged regularly during flooding events. By removing structures, this plan would remove a significant amount of potential lead-based paint and asbestos from the community. Through reducing the risk of damages this plan would reduce the risk of lost business for the community and costly cleanups. The plantings and hiking trail would provide recreational opportunities for residents, increase business development within Beattyville, and increase community cohesion by providing common space for residents. Furthermore, the plantings would create a natural buffer for erosion as well as improve local water quality through its buffer effect. Finally, the development of the FWEEP would result in lower risks to life and safety for the community.

4 - FWEEP Only

It would be expected that Alternative 4 would have moderate long-term beneficial impacts and significant long-term adverse impacts to socioeconomics and EJ. The implementation of a FWEEP would provide the population with advance warning and a plan during flood events, producing a moderate long-term beneficial impact in terms of the reduction of life loss. The FWEEP, however, would not address the damage done by flood events to businesses and residents. Resource extraction, particularly coal mining, has had a dramatic impact on the community resulting in boom-and-bust cycles that have left Beattyville with inadequate infrastructure to support the existing community. This is exhibited by the area being classified as a disadvantaged community by the CEQ which outlines 11 socioeconomic burdens that the community faces (Figure 3). Alternative 4 would result in the community, already struggling with poverty, to continue to have to clean up destroyed buildings and debris after each flooding disaster. Many structures that have a high likelihood of containing lead-based paint and asbestos would remain in the floodway and would regularly be flooded and damaged during disaster events. All 65 commercial buildings representing much of the local economy of the area would continue to experience damage during flooding disasters, resulting in lost business and costly cleanups.

5A - FWEEP and Acquisitions in Kentucky River Floodway

Alternative 5A is expected to have significant long-term positive impacts to socioeconomics and EJ. Alternative 5A entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. Positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of structures being damaged regularly during flooding events. By removing structures, this plan would remove a significant amount of potential lead-based paint and asbestos from the community. Through reducing the risk of damages this plan would reduce the risk of lost business for the community and costly cleanups. The plantings and hiking trail would provide recreational opportunities for residents, increase business development within Beattyville, and increase community cohesion by providing common space for residents. Furthermore, the plantings would create a natural buffer for erosion as well as improve local water quality through its buffer effect. Finally, the development of the FWEEP would result in lower risks to life and safety for the community.

5B - FWEEP, acquisitions in Kentucky River Floodway, and Essential/Anchor Structures

Alternative 5B is expected to have significant long-term positive impacts to socioeconomics and EJ. Alternative 5B entails demolishing up to 13 structures within the floodway, regrading soils to match natural conditions, and the implementation of a FWEEP. Positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of structures being damaged regularly during flooding events. By removing structures, this plan would remove a significant amount of potential lead-based paint and asbestos from the community. Through reducing the risk of damages this plan would reduce the risk of lost business for the community and costly cleanups. The plantings and hiking trail would provide recreational opportunities for residents, increase business development within Beattyville, and increase community cohesion by providing common space for residents. Furthermore, the plantings would create a natural buffer for erosion as well as improve local water quality through its buffer effect. Finally, the development of the FWEEP would result in lower risks to life and safety for the community.

3A - Complete Nonstructural 672.2 ft NAVD88

Alternative 3A is expected to have significant long-term positive impacts to socioeconomics and EJ. Alternative 3A entails nonstructural measures being implemented on up to 120 structures below 672.2 ft NAVD88 and the implementation of a FWEEP. Positive impacts would be realized by the removal of structures from the floodway and via the utilization of nonstructural measures, which would significantly reduce the risk of structures being damaged regularly during flooding events. By removing structures, this plan would remove a significant amount of potential lead-based paint and asbestos from the community. Through reducing the risk of damages this plan would reduce the risk of lost business for the community and costly cleanups. Finally, the development of the FWEEP would result in lower risks to life and safety for the community.

4.2 Mitigation, Monitoring, and Adaptive Management

Mitigation can include avoiding, minimizing, rectifying, reducing over time, and/or compensating for impacts to the human environment.

During early scoping it was identified that designated critical habitat for the Federally threatened Kentucky Arrow Darter occurred within the limits of Beattyville. Avoidance was determined to be the best method to mitigate impacts, and measures that resulted in direct impacts to critical habitat were screened from consideration.

It is expected that Alternative 5C would result in construction and demolition activities that would disturb greater than one acre of land. This disturbance could result in runoff that could impact surface waters, wetlands, and aquatic habitat. Minimization has been determined to be the best method to mitigate these impacts and a Storm Water Pollution Prevention Plan (SWPPP) has been developed to detail erosion control measures and best management practices that would be employed to reduce erosion to a point that impacts are not significant.

5 PLAN COMPARISON AND SELECTION

5.1 PLAN COMPARISON

The result was a Final Array of Alternatives with a total of six alternatives including the NAA. The following criteria for comparison was developed and informed with the CBEST tool:

- Number of Structures eligible:
  - This category does not evaluate the alternatives across the four accounts it is just a quick access point to display the data.
- NED Benefits (additional information included in Appendix D - Economics):
  - Project Total First Cost (in FY24 dollars) which includes the cost of design and management during construction.
  - BCR – a measure of the annualized benefits (AB) of the project compared to the annualized cost (AC) =AB/AC
  - Net Benefits – The difference between annualized benefits (AB) and annualized cost (AC) =AB-AC
- RED Benefits (additional information included in Appendix D - Economics):
  - Registers changes in the distribution of regional economic activity that result from each alternative plan. In addition to the benefits accounted for within the NED account, the implementation of the TSP would result in local economic activity which is accounted for within the RED account. The regional economic impact modeling tool, RECONS, was used to calculate RED benefits.
- EQ Benefits:
  - Environmental: a measure of the degree to which the alternative impacts the environmental habitat
  - Cultural: a measure of the degree to which the alternative impacts the area's cultural resources
- OSE Benefits:
  - Average Annual Life Loss (additional information included in Appendix D - Economics): the degree to which the alternative reduces life loss.
  - Social Connectedness: a measure of the degree to which the alternative supports community cohesion and opportunities for connection
  - Community Identity: a measure of the degree to which the alternative supports community traditions, lifestyle, and values

The qualitative criteria were compared using a relative value of HIGH to LOW on the analysis of the final array of alternatives.

5.1.1 Final Array Alternatives Evaluation

This table below presents the final array alternative evaluation. Six alternatives in total were considered in this final evaluation across the four accounts (NED, RED, EQ, and OSE).

Table 21. Final Array Alternatives Evaluation

		NED			RED	EQ		OSE		
Alternatives	Number of Structures Eligible	Total Investment Cost ($M)	BCR	Net Benefits (including REC)	RED Benefits ($M)	Environmental	Cultural	Average Annual Life Loss	Social Connectedness	Communal Identity
1. No Action	0	0	N/A	0	0	MED	MED	0.135	LOW	LOW
3A. Complete Nonstructural 672.2	120	89	0.09	-3,007,659	145.9	MED	LOW	0.092	MED	MED
4. FWEEP	0	3	N/A	N/A	5.3	LOW	MED	0.125	MED	LOW
5A. Incremental NS (FWEEP + FW AQ)	13	13.7	1.26	133,879	22.8	MED	MED	0.095	HIGH	MED
5B. FWEEP + FW AQ + ES	28	23	0.86	-124,690	41.1	MED	MED	0.095	HIGH	HIGH
5C. FWEEP + FW AQ + ES + HS	53	36.8	0.57	-592,162	67.4	MED	HIGH	0.095	HIGH	HIGH

FY24 price levels

NED Plan
Total Net Benefits Plan
Nonstructural Plan

Alternative 3A represents the complete nonstructural alternative, but this alternative yields a BCR of 0.09 and over $3 million in negative net benefits.

Alternative 4, FWEEP, stands out as the plan with the lowest cost to save a statistical life; however, it alone does not provide the greatest reduction to life safety risk. As such, the benefits of the FWEEP are clear, but as a standalone alternative it fails to deliver a complete project.

The NED plan is alternative 5A (Incremental nonstructural plan, including FWEEP, recreation, and an eco-system restoration component via beneficial re-use of land acquisition). Alternative 5A produces $133,879 in net benefits and a BCR of 1.26. In addition to the positive contributions to the NED and RED accounts, 5A produces the largest total reduction to average annual life loss and has a high score for social connectedness by integrating the numerous new recreation features into the downtown area.

Alternative 5B improves upon 5A by adding nonstructural floodproofing measures to 15 structures considered to be essential and/or anchor points for the community. The heart of any city requires the existence and reliable availability of anchor establishments for basic functionality.

Finally, Alternative 5C is presented as the Total Net Benefits Plan from amongst the array. It further improves upon 5B with its application of nonstructural FRM measures to 25 historical structures, the majority of which will be wet floodproofed. This wet floodproofing is viewed to be as a critical component to allow Beattyville to bounce back from future inundation events. Alternative 5C provides all the benefits of 5A and 5B, but it is the only plan which will increase resilience of the community and reduce recovery time long term. Additionally, 5C offers the highest impact to the EQ account. 5C best represents Beattyville's vision for the floodplain while also celebrating and preserving its identity for long term resilience.

These additional benefits, particularly increased resilience, and community cohesion among socially vulnerable and disadvantaged communities in the face of continued and worsening flood risk, justify the selection of the TSP over the NED plan.

5.1.2 Final Array Criteria Evaluation

The following describes how the criteria were evaluated:

- Total Investment Cost: This was included for reference and is in FY24 dollars.
- BCR: Alternative 5A yields the highest BCR with 1.26 and is the only BCR above unity (1.0).
- Net Benefits: Alternative 5A produces the highest net benefits of $133,879 and is the only positive net benefits. The NAA does not provide any NED benefits, so it is valued at "0".
- RED Benefits: Alternative 4 FWEEP had the lowest RED benefits ($5.3 million) and Alternative 3A Complete Nonstructural 672.2 had the highest ($145.9 million). The NAA did not provide any RED benefits. In general, RED benefits increase as construction costs increase.
- Environmental: While the NAA and the FWEEP are both less environmentally invasive, the nonstructural alternatives were valued more highly due to their potential to create open space due to acquisitions. Alternatives 5A, 5B, and 5C Floodway Acquisitions have the potential to create a contiguous space along the Kentucky River shoreline or Silver and Crystal Creek which would lend itself to development of recreation or ecosystem restoration benefits. Silver Creek is classified as Kentucky arrow darter designated critical habitat and ecosystem restoration efforts in that area could provide environmental benefits.
- Cultural Resources: At the time of this report, Beattyville was developing a NRHP form for the downtown commercial area as a historic district. Even though the decision of this report is unknown at this time, it seems likely that this designation will be approved. The values for the cultural resources criteria assume the historic district designation is approved and in place. On May 17, 2024, members of the PDT met with the NFS and KHC to discuss what structures will be included and what specific non-structural measure may apply. Thirty-four historic structures were identified and of these 34 structures, 26 were identified for wet-floodproofing, 1 for dry-floodproofing, and the remaining 7 will have no action. These measures/actions were determined to facilitate the historic preservation of the historic district once formally nominated.
- Average Annual Life Loss: The NAA does nothing to prevent potential life loss during future flood events, and the expected life loss under the NAA is 0.1354 lives per year – nearly 7 individuals whose lives are expected to be lost due to direct contact with flood waters over the 50-year period of analysis. These figures do not include indirect life loss; that is, life loss that occurs due to other effects of a flood, such as a power outage, exposure to extreme weather conditions, or lack of access to emergency services.
  All proposed alternatives reduce the expected annual life loss, several of them by 25-30%. However, the cost of the proposed measures must be considered. While USACE does not place a monetary value on human life, the cost per statistical life saved can be a useful measurement to compare the cost-effectiveness of the proposed alternatives. Alternative 3A Nonstructural 672.2 reduces life loss by 32% and Alternative 3B Nonstructural 669.2 reduces life loss by 31%, however they are the costliest per life saved ($58,990,000 for Alternative 3A and $51,770,000 for Alternative 3B). Alternative 4, FWEEP only, has the lowest cost to save a statistical life ($10,230,000), followed by Alternative 5, Floodway Acquisition ($20,160,000).

- Social Connectedness and Community Identity: The NAA would allow the possibility for future flood damages to disrupt the social fabric of the Beattyville, and negatively impact the overall community cohesion and sense of unity. Alternatives 5A, 5B, and 5C Floodway Acquisitions have the potential to create a contiguous space along the Kentucky River shoreline or up Silver and Crystal Creek which would lend itself to development of recreation or ecosystem restoration benefits. These developments would enhance not only the local economy, but the local sense of pride and improved lifestyle, and availability of outdoor recreation opportunities for both locals and visitors.

5.2 IDENTIFICATION OF THE NED PLAN

NED Plan: Reasonably maximizes NED benefits.

Alternative 5A is the NED Plan.

Nonstructural Plan: A primarily nonstructural alternative considered for FRM projects.

Alternative 3A is the nonstructural plan as it includes benefits for all structures in the base flood structure inventory.

Life Safety/Tolerable Risk Guidelines (TRG) Plan: An alternative that addresses life safety concerns and TRG1 and TRG 4 (from PB 2019-04) for studies that involved existing or proposed dams and levees.

Alternative 4 - FWEEP is the Life Safety Plan because components such as the Evacuation Plan and FPMP promote flood awareness and safety without the risks of overtopping or failures caused by floodwall and nonstructural measures.

Maximum Total Net Benefits Plan: The plan that maximizes total net benefits across all benefit categories.

Alternative 5C is the Maximum Total Net Benefits Plan. It provides all the benefits of 5A and 5B but is the only plan which will increase resilience of the community and reduce the recovery time long term. It further improves upon 5B with its application of nonstructural FRM measure to 25 historical structures, the majority of which will be wet floodproofed. Additionally, 5C offers the highest impact to the EQ account. 5C best represents Beattyville's vison for the floodplain while also celebrating and preserving its identity for long term resilience.

Least Damaging Environmentally Practicable Alternative (LEDPA): Consistent with Section 404 of the CWA.

The LEDPA is not applicable because no proposed alternative impacts Waters of the United States.

Locally Preferred Plan: If requested by the NFS, and not in one of the other listed plans in the guidance.

The NFS has indicated that they are in support of Alternative 5C, and a Locally Preferred Plan was not developed.

5.3 PLAN SELECTION

The TSP is Alternative 5C - Incremental Nonstructural Plan as it is the alternative which provides the most comprehensive benefits. Alternative 5C is not the plan with the highest NED benefits, therefore a NED waiver will be required (see Section 5.4). Alternative 5C is a nonstructural plan consisting of acquisitions, recreation components, dry floodproofing, wet floodproofing, and raising in place at the BFE elevation plus 3 ft. of 672.2 ft. NAVD88, paired with a FWEEP.

5.4 DEVIATION FROM THE NED

The Louisville District plans to request a policy exception from Engineer Regulation (ER) 1105-2-103, which states: “The National Economic Development, or NED, Plan for all project purposes except ecosystem restoration, the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment, the NED plan, shall be selected. The Assistant Secretary of the Army for Civil Works (ASA/CW) may grant an exception when there are overriding reasons for selecting another plan based upon comprehensive benefits or other Federal, State, local and international concerns.” This policy exception will be requested to allow for a Recommended Plan justified by comprehensive net benefits as captured in the EQ and OSE account—in this case, benefits that would increase resilience, reduce risk to life safety, protect culturally and historically significant structures, promote community cohesion, and support communal identity within the economically disadvantaged and socially vulnerable community of Beattyville.

The ‘Comprehensive Documentation of Benefits in Decision Document’ Memorandum, dated 5 January 2021, directs study teams to consider the total net benefits of project alternatives, including equal consideration of economic, environmental, and social benefits when making decisions and recommendations. The ‘Implementation of Environmental Justice and the Justice40 Initiative’ Memorandum, dated 15 March 2022 directs USACE studies and planning efforts to put disadvantaged communities front and center in the planning process to implement EJ initiatives. Through the comprehensive accounting of benefits and a thorough assessment of EJ considerations, the Louisville District is recommending a plan that incorporates comprehensive benefits and provides a significantly disadvantaged community with much needed flood risk management assistance.

Selection of the TSP, based on the calculation of comprehensive benefits, is consistent with current guidance. It is recommended that a policy exception from ER 1105-2-100 2-3(f)(1) be granted for the Beattyville, KY Flood Risk Management Study to provide a recommendation that adds significant value to the Nation while also maximizing value to the region by utilizing comprehensive benefits and promoting EJ principles within a socially vulnerable and economically disadvantaged community.

- Alternative 5A is the NED plan (Annual net benefits: $134,000)
- The team is not recommending the plan with the highest NED benefits.
- The TSP is not the plan with the highest BCR.
- Waiver allows focus on Total Net Benefits
- Highest Total Net Benefit Plan is 5C.
- TSP has BCR which is less than 1.0 (0.57)

- The implementation plan will state individual nonstructural solutions will not need to be economically justified as almost every measure will cost more than the benefits attributed to the action.

At the time this report was written, it is unknown to the PDT if the waiver request will be approved. According to the Interim Environmental Justice Guidance for Civil Works Planning Studies, "the District Planning Chief will indicate the potential need for a policy exception to recommend a plan other than the National Economic Development plan." This risk is captured in the project risk register.

6 THE TENTATIVELY SELECTED PLAN

6.1 PLAN ACCOMPLISHMENTS

The PDT has put forward a comprehensive plan which maximizes total net benefits and includes the following:

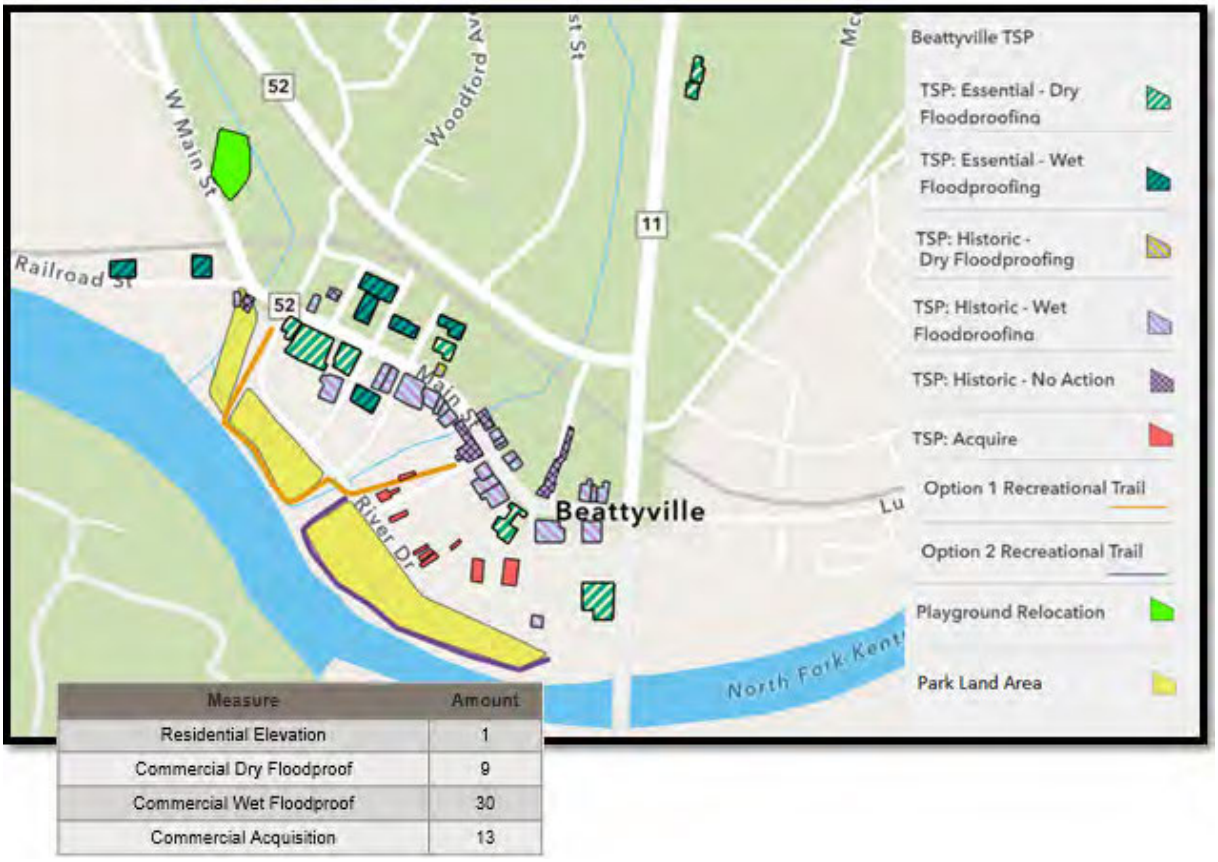
FWEEP: A base plan utilizing applicable and appropriate FWEEP elements. This is the base plan because it provides a cost-effective improvement to life safety and supports resiliency through floodplain management and improved response to flood events.

5A – Incremental Nonstructural/Floodway Acquisitions in the Kentucky River floodway: Floodway acquisitions are the next increment as the floodway is the area where most flood damages naturally occur, and acquisitions will support the components of the FWEEP that restrict development in the floodway. If a structure's footprint is at least 50% in the FEMA regulatory floodway, then the decision was made to acquire the property or do nothing. The do-nothing option was applied if the property has specific local significance or importance and would cause a detriment if acquired or removed. The floodway acquisitions identified in Alternative 5A also provide a contiguous space where recreational features such as a walking trail, playground area, parking, and a kayak launch area for access to the Kentucky River will provide additional project benefits. Additionally, ecosystem restoration benefits may be captured in certain areas to improve habitat and aesthetic qualities of the riverfront, although they have not been quantified for this effort. As of now, these ecosystem components (native grasses, plantings, and riparian trees) serve only to support the recreation features under consideration.

5B – Essential/Anchor Assets and Services: Structures supporting local services, assets, and anchor businesses such as police stations, courthouses, health centers, groceries, and cultural hubs were considered essential/anchor community assets and services. These structures will be dry (8) or wet (7) floodproofed. Floodproofing these structures will support community resiliency by protecting the services that will allow the town to bounce back after a flood event.

5C – Historical Structures: The structures included on Beattyville's NRHP form, for the designation of the downtown commercial area as a historic district, will be either dry (1) or wet (27) floodproofed, with five s structures with no action. Floodproofing these structures supports community cohesion by helping to preserve Beattyville's aesthetic characteristics

as well as its sense of community pride and history. With Beattyville currently working diligently on a historic district designation, this complete alternative aligns with the community's long-term vision.



Measure	Amount
Residential Elevation	1
Commercial Dry Floodproof	9
Commercial Wet Floodproof	30
Commercial Acquisition	13

Figure 15. Tentatively Selected Plan - Alternative 5C Incremental Nonstructural Plan

6.2 NONSTRUCTURAL COMPONENT DESCRIPTIONS

The nonstructural portion of the TSP will involve acquisitions of 13 structures (9 tracts) and floodproofing of 40 structures. The structures identified as acquisitions under this plan will be mandatory buyouts.

Modeling results assume 100% participation of voluntary nonstructural measures. Were the actual participation rate to be less than 100%, both benefits and costs would decrease. Notably, the NED plan includes only acquisitions among its proposed nonstructural measures, which are mandatory and thus, by their nature, would have 100% participation.

Acquisitions (also commonly referred to as buyouts) involve obtaining the at-risk structure and land that the structure sat upon. The structure is demolished Dry Floodproofing is a measure primarily designed to prevent water from entering a structure or to minimize damages once water has entered a structure. Dry floodproofing may include the use of one or more of the following methods:

- Backflow valves
- Temporary or permanent closures or watertight shields on doors, windows, stairwells, and/or vents
- Rearranging or protecting damageable property, including relocating, or raising utilities.
- Sump pumps, sub-drains, and floor drains
- Water resistant material, including waterproof membranes, adhesives, and sealants to reduce seepage of floodwater through walls.
- Installing measures to prevent sewer backup.
- Constructing veneer walls or dikes around structures

Dry floodproofing occurs at the finished floor elevation (FFE) and protects up to 3 ft.

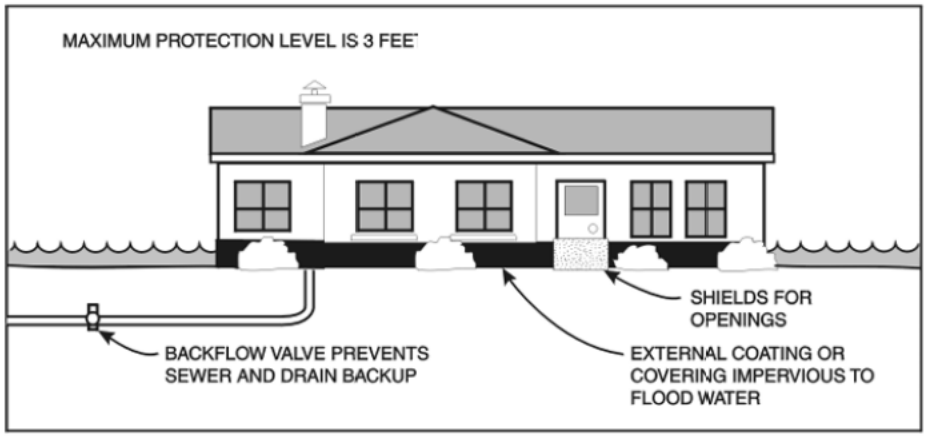


Figure 16. Depiction of Dry Floodproofing

Wet floodproofing is a measure taken by raising all utilities above the DFE. All construction materials and finishing materials within the flood elevation need to be water resilient.

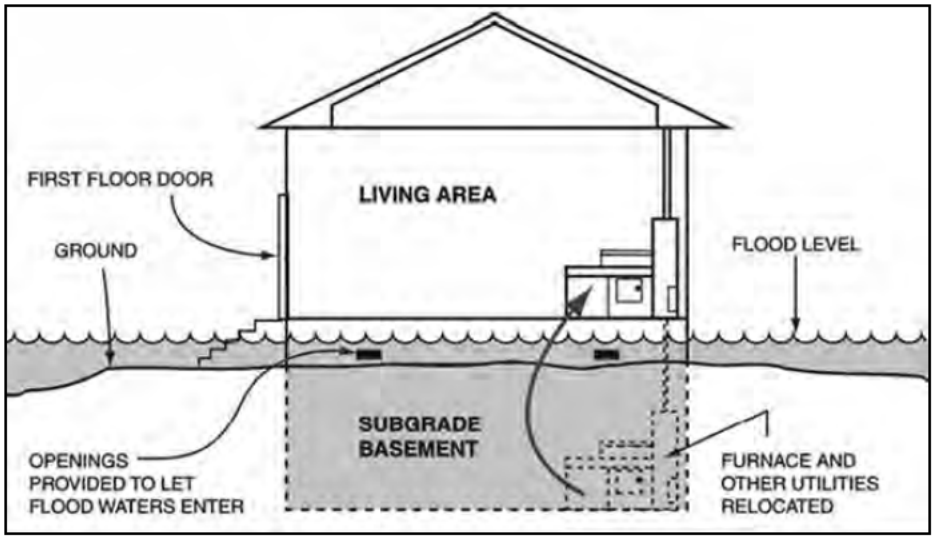


Figure 17. Depiction of Wet Floodproofing

Raising in Place (also commonly referred to simply as Elevation) is elevating a structure's contents above flood heights and allowing it to flood. Raising a structure creates a "basement area" that is designed to allow intentional flooding to equalize hydrostatic pressures. Structures are to be raised to the DFE (Section 3.3.1). Ultimately, the DFE will be determined by Beattyville. If the DFE differs from the BFE at any point before the study is implemented, USACE will update their terms for eligibility of the specifics of raising a structure in place.

The entire foundation of the structure will be lifted and placed on a new foundation (i.e., columns, piers, posted or raised foundation walls) so that the lowest habitable finished floor is at or above the target design elevation. All utilities and mechanical equipment, including air conditioners and hot water heaters, will also be raised to the required elevation. Flood vents will be installed, as appropriate, on elevated structures, as well as structures for which the first floor is already above the target design elevation but lack appropriate flood venting. This area must be kept free of items that could be damaged during a flood. The final elevation should place the first floor and associated ductwork, plumbing, mechanical and electrical systems above the projected water surface elevation.



Figure 18. Depiction of Raising in Place

FWEEP flood warning and preparedness planning relies upon stream gages, rain gages, and hydrologic computer modeling to determine the impacts of flooding for areas of potential flood risk. A flood warning system, when properly installed and calibrated, is able to identify the amount of time available for residents to implement emergency measures to protect valuables or to evacuate the area during serious flood events. Local officials are encouraged to develop and maintain a flood EAP that identifies hazards, risks, and vulnerabilities, and encourages the development of local flood risk mitigation. The EAP should include the community’s response to flooding, location of evacuation centers, evacuation routes, and flood recovery processes. The individual components of the FWEEP will be further developed and provided in detail at the ADM milestone.

Construction laydown is expected for this project. Determination for the location and size of laydown is to be provided at the ADM milestone.

6.3 COST ESTIMATE

A Federal Cost Share Agreement (FCSA) was signed on January 3, 2023. Table 22. Estimated Project First Cost presents a breakdown of the estimated project first cost in FY24 dollars. Table 23. Estimated Project Costs and Apportionment presents the estimated first cost and apportionment for design and construction in FY24 dollars. The Cost Certification in Appendix C provides a breakdown of the Project First Cost.

Note that the following cost share estimates do not account for the ability-to-pay criteria and resulting adjustment, described in Section 6.7.

Table 22. Estimated Project First Cost

Feature	Project First Cost (FY24)
Fish & Wildlife Facilities	$252,000
Cultural Resource Preservation	$266,000
Lands and Damages	$4,285,000
Nonstructural + FWEEP	$24,803,000
Planning Engineering & Design	$4,657,000
Construction Management	$1,514,000
TOTAL PROJECT COST (FY2024)	$35,777,000
TOTAL Federal (85.75%)	$30,672,775
TOTAL Non-Federal (14.25%)	$5,097,225

Table 23. Estimated Project Costs and Apportionment

	FY2024	FY2025	FY2026	FY2027	FY2028	FY2029	FY2030	
Feasibility Study Costs								
FED share	$563,458	$531,862						
Non-FED	$563,458	$531,862						
Design & Implementation Costs								
Design Analysis, Plans and Specs			$931,400	$931,400	$931,400	$931,400	$931,400	
S&A				$378,500	$378,500	$378,500	$378,500	
Construction				$6,200,750	$6,200,750	$6,200,750	$6,200,750	
LERRDs			$857,000	$857,000	$857,000	$857,000	$857,000	
Fish & Wildlife Facilities			$50,400	$50,400	$50,400	$50,400	$50,400	
Cultural Resource Preservation			$53,200	$53,200	$53,200	$53,200	$53,200	Total
FED share (85.75%)			$1,622,390	$5,506,313	$5,506,313	$5,506,313	$5,506,313	$23,647,640
Non-FED (14.25%)			$269,610	$2,964,938	$2,964,938	$2,964,938	$2,964,938	$12,129,360
Non-FED cash (5% Min)			$94,600	$423,563	$423,563	$423,563	$423,563	$1,788,850
Non-FED LERRD			$857,000	$857,000	$857,000	$857,000	$857,000	$4,285,000
Total Project Cost	$1,126,916	$1,063,724	$1,892,000	$8,471,250	$8,471,250	$8,471,250	$8,471,250	$35,777,000

Feasibility is funded 50/50

6.4 LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND DISPOSAL AREAS

The NFS is expected to exercise their power of eminent domain to ensure all acquisitions are complete. Floodproofing measures will be voluntary. Owners of floodproofed structures will be required to grant the NFS a permanent real estate interest in the property, whether that is a restrictive covenant or permanent easement is to be determined. (See Appendix E for discussion of this real estate interest.) Should the FWEEP portion of the TSP include installation of sirens and sensors, the NFS would need to acquire a permanent real property interest anywhere such FWEEP infrastructure is constructed.

Public Law 91-646 Relocation Assistance benefits are authorized for residents and businesses that are permanently displaced by mandatory acquisitions. Residential tenants that are temporarily displaced by the construction of floodproofing measures on their residence are also eligible for temporary relocation assistance benefits. Owner-occupants and non-residential landowners and tenants that are temporarily displaced by the implementation of floodproofing measures are not eligible for relocation assistance benefits.

Utility and facility relocations are expected to be negligible. Most utility impacts will not rise to the level of a relocation as they will involve either the permanent disconnection of utilities from structures being demolished or temporary service interruption to individual structures during implementation of floodproofing measures. Should any utilities be impacted in such a way as to rise to the level of relocation, the NFS will be responsible for acquiring any real estate necessary to support such a relocation and for performance of the relocation.

6.5 OPERATION, MAINTENANCE, REPAIR, REPLACEMENT, AND REHABILITATION

OMRR&R costs associated with this TSP are considered ‘de-minimis’ (requiring only periodic surveillance by the NFS). Ultimately, each individual property owner will be responsible for maintenance of their elevated or floodproofed structure/home.

An Operation and Maintenance Manual will be developed by USACE at the completion of construction and all operation and maintenance responsibilities will be given to the NFS in perpetuity after completion of construction. The NFS should reserve an estimated amount of $12,000 annually for the continued maintenance of the project to be used on an as-needed basis with the assumption that this amount exceeds the cost of typical yearly maintenance, and any surplus should be reserved in case of future larger repairs. It should be noted that this annual amount includes the cost to operate and maintain gages. The project site should be maintained in accordance with Chapter 3 of the Flood Control Operations & Maintenance Policies (ER-1130-2-350).

6.6 PROJECT RISKS

All risks are recorded in the Risk Register; those identified as High risk are detailed below:

1. Applicability and cost of nonstructural measures (scope risk)

   Risk: The process of optimizing nonstructural measures will likely determine that many structures in Beattyville (specifically, those in fair-poor condition) will not be eligible for

application of certain nonstructural measures; in this case mandatory buyouts might be the only nonstructural option (if the structure is in the floodway, buyouts are always the only nonstructural option). Additionally, cost estimates for nonstructural measures are limited, and mostly apply to residential structures; in Beattyville the structures are primarily commercial.

Risk Management: Reduction. 1) Prepare the NFS for mandatory buyouts. 2) Evaluation of individual structures during D&I phase

2. NED Waiver (scope risk)

   Risk: The PDT has determined that an NED (National Economic Development) waiver may be needed because it is unlikely that the project will yield a BCR above unity. The risk is that the NED waiver will not be approved, resulting in the need to identify alternatives with positive BCRs. According to the Interim Environmental Justice Guidance for Civil Works Planning Studies paragraph 5, iv. "The District Planning Chief will indicate the potential need for a policy exception from the (ASA(CW)) to recommend a plan other than the National Economic Development plan."

   Risk Management: Reduction. 1) Gather examples of other NED waivers 2) Provide evidence of the other accounts to balance out the negative BCR.

3. Participation Rates in Nonstructural Measures (cost risk)

   Risk: Per the implementation plan, participation in the nonstructural measures would be voluntary on the part of each property owner. There is risk and uncertainty surrounding how many property owners would agree to participate. Low participation rates would reduce the total project cost, thus reducing benefits.

   Risk Management: Reduction. 1) Outreach efforts to individual property owners to gauge interest in participation. 2) Sharing information with the NFS and local property owners prior to design phase.

6.7 COST SHARING

An ability-to-pay analysis was conducted in accordance with EGM 19-04 (USACE, Directorate of Civil Works, 2019). The first step in determining eligibility is to determine the benefits-based floor (BBF). The BBF determines the maximum possible reduction in the level of non-Federal cost-sharing and is calculated by dividing the project's BCR by four and expressing that factor as a percentage. If the factor determined is less than the standard level of cost-sharing, projects may be eligible for either a reduction in the non-Federal share to the BBF, or for a partial reduction to a share between the standard level and the BBF, as determined by the eligibility factor in the second step below. In no case, however, will the non-Federal cost-share be less than five percent. The BBF for Beattyville is 0.57 (project BCR) divided by four which equals 0.1425. Expressed as a percentage the BBF is 14.25%.

For step two, the eligibility factor (EF) is determined as per the method outlined in EM 19-04 (USACE, Directorate of Civil Works, 2019). The EF is calculated using the formula below:

$$EF = a - (b_1 * state\ income\ index) - (b_2 * county\ income\ index)$$

Where:

State income index = the average over three years of the state per-capita income index (state per capita income divided by the national per capita income) for the state in which the project is located

County income index = is the average over three years of the county per-capita income index (county per capita income divided by national per capita income) for the county in which the project is located

a=18.22

b_1=0.079

b_2=0.158

The values of the parameters a, b_1, and b_2 are determined by HQUSACE (USACE, Directorate of Civil Works, 2019).

Using these parameters, the calculation for Kentucky River, Beattyville, Flood Risk Management Feasibility Study was determined as follows:

$$EF = 18.22 – (0.079 * 79.61) – (0.158 * 53.79) = 3.43$$

If the EF is one or more, the project is eligible for the full reduction in cost-share to the BBF Using this methodology, the EF for the Beattyville study was determined to be greater than one, therefore, the project was eligible for the full reduction in cost-share to the BBF of 14.25%.

All estimates are at the 2024 price level and may change due to inflation prior to construction. The non-Federal sponsor must provide self-certification of financial capability as required by USACE policy. Use of funds from other federal programs, including any non-federal contribution required as a matching share, to meet financial obligations of the non-federal sponsor is not permitted unless USACE authorizes use of those funds in writing.

Project design and implementation costs are shared. Based on the ability-to-pay analysis, the cost share for this project was determined to be 85.75 percent federal and 14.25 percent non-Federal. The non-Federal sponsor is required to provide all LERRDs. Based on these requirements, the estimated non-Federal contribution for the recommended plan is $5,098,000.

Table 24. Federal and non-Federal cost share for the TSP

	Cost ($000s)		
Construction Item	**Federal Cost**	**Non-Federal Cost**	**Total Cost**
PED*	$3,993 *(85.75%)*	$664 *(14.25%)*	$4,657
LERRDs	$0	$4,285	$4,285
Construction Costs*	$24,684	$4,102	$26,834
Subtotal	$26,685 *(85.75%)*	$4,397 *(14.25%)*	$31,119
Total Project	**$30,679 *(85.75%)***	**$5,098 *(14.25%)***	**$35,777**
*Construction costs include construction, FW, CR, and construction management			

6.8 Design and Construction

Details related to design and construction will be added after the TSP is confirmed as the Recommended Plan at the Agency Decision Milestone. The plans for design and implementation are discussed in Appendix G Nonstructural Implementation Plan.

6.9 Environmental Commitments

Mitigation can include avoiding, minimizing, rectifying, reducing over time, and/or compensating for impacts to the human environment.

During early scoping it was identified that designated critical habitat for the Federally threatened Kentucky Arrow Darter occurred within the limits of Beattyville. Avoidance was determined to be the best method to mitigate impacts, and measures that resulted in direct impacts to designated critical habitat were screened from consideration.

It is expected that the TSP would result in construction and demolition activities that would disturb greater than one acre of land. This disturbance could result in runoff that could impact surface waters, wetlands, and aquatic habitat. Minimization has been determined to be the best method to mitigate these impacts and a Storm Water Pollution Prevention Plan (SWPPP) has been developed to detail erosion control measures and best management practices that would be employed to reduce erosion to a point that impacts are not significant.

6.10 Project Specific Considerations

6.10.1 Description of Work for In-Kind Crediting

The local NFS may provide work as in-kind credit towards design and implementation costs. Work may include geotechnical investigations, cultural investigations, engineered designs, and specification writing. In-kind work will be described in the future PPA.

6.10.2 Sponsor Led Contracting

The authority in Section 204 of WRDA 1986, as amended (“Section 204”) allows the NFS to carry out water resource projects and be reimbursed by the USACE for the Federal share of the Project costs, when Federal funds are made available. The voluntary nonstructural measures included in the tentatively selected plan will be executed through this authority. See the Nonstructural Implementation Plan for more information.

6.11 Environmental Operating Principals

6.11.1 Environmental Justice

Like many communities in Appalachia, Beattyville and Lee County struggle with unemployment and poverty, devastated landscapes, health issues like black lung disease and other respiratory ailments, higher rates of poverty, substance abuse, and inadequate infrastructure.

According to the CJEST tool (Section 2.13), Lee County is an economically underserved or disadvantaged community as it is at or above the threshold for the socioeconomic burdens in eleven different categories.

Additionally, median household income is significantly lower than both the state and national averages, and nearly half of the residents of Beattyville are in poverty, notably including 68% of children under the age of 5 years. The number of persons with a disability is more than twice the national rate. The community also has a deficit of connectivity, with 68% of households having a broadband connection, compared to 88% nationally, and 2.2% of households have no telephone service, more than double the national proportion.

Potential benefits of the TSP for the EJ Community include:

- Decrease in expected building loss rate.
- Increased income due to improved community stability and job availability (both from the regional economic benefits of the TSP as well as expected future investments)
- Improved quality of life and positive health impacts (particularly life expectancy and heart disease) associated with convenient access to green space and multiple outdoor recreational activities.
- Improved quality of life due to removal of abandoned structures
- Improved quality of life and life expectancy due to removal of lead-based paint and asbestos in structures where nonstructural measures are applied.
- Selecting the floodwall alternative as the TSP would have had a negative impact on public transportation due to its intrusiveness into the roads and public access. The TSP prevents this occurrence throughout the community.

6.11.2 Community Growth and Demographics

Beattyville is striving to ignite growth within the city by working to raise funds for downtown developments such as a $1.25M land grant for improvements to the town square, a $499K grant to restore a historically significant Works Progress Administration (WPA) building, and a grant to update and rejuvenate Main Street. Additionally, in 2023, Beattyville created a plan for the riverfront which includes many recreational components that will be included in the TSP. A depiction of their plan can be seen in Figure 19.



Figure 19. Beattyville's Conceptual Plan for the Riverfront between Crystal Creek and Silver Creek (February 2023)

Beattyville has experienced an average of 13% increase in the lodging industry since the creation of the local tourism commission in December 2011. In 2014, there were three (3) inns offering 44 rooms and 24 cabins for a total of 68 units. By year's end 2023, there were 52 rooms, seven (7) campgrounds, and around 170 cabins/rental homes for a total of 229 units. The graph below shows gross annual sales from rentals in Lee County from 2012-2023 (Beattyville/Lee County Tourism, 2024). This growth in rentals indicates an influx of tourism in the area which will be supported by the TSP through improved community resiliency and sense of stability, preservation of historic structures which add aesthetic appeal and interest and increased recreational opportunities in downtown Beattyville.

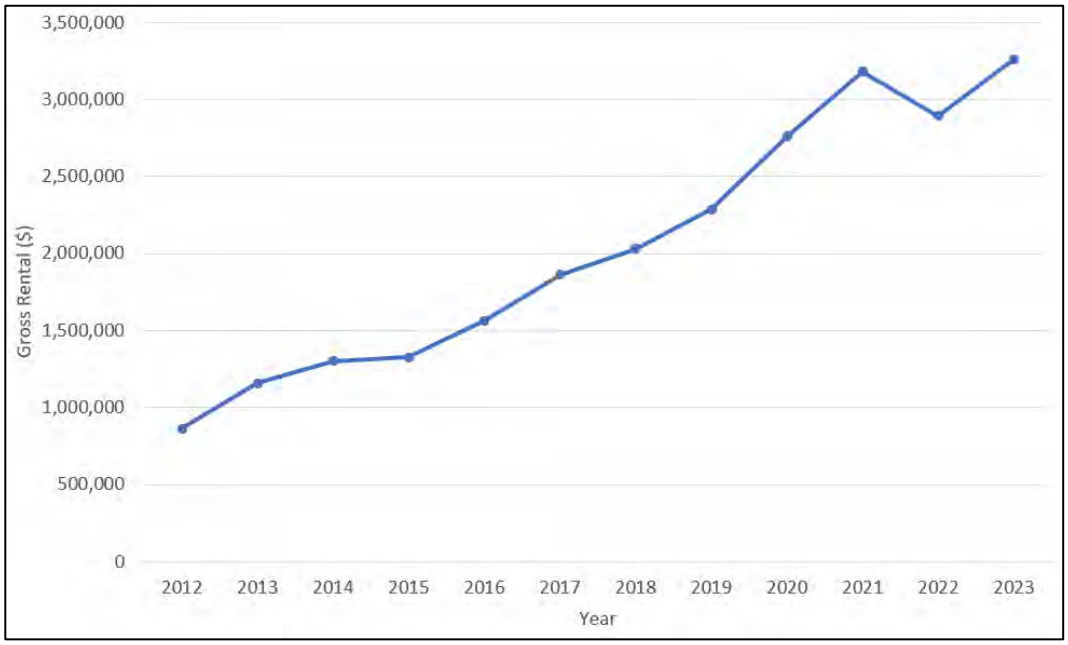


Figure 20. Gross Rental Revenue (in dollars) in Lee County, 2012-2023 (Beattyville/Lee County Tourism, 2024)

Between 2010 and 2022, Lee County has experienced a growth in the elderly population. Among six age groups (0 to 4, 5 to 19, 20 to 34, 35 to 49, 50 to 64, and 65 and older, the 65+ age group was the fastest growing between 2010 and 2022 with its population increasing 25.9% (USA Facts, 2024). The 35 to 49 age group declined the most dropping 20.7% between 2010 and 2022 (USA Facts, 2024).

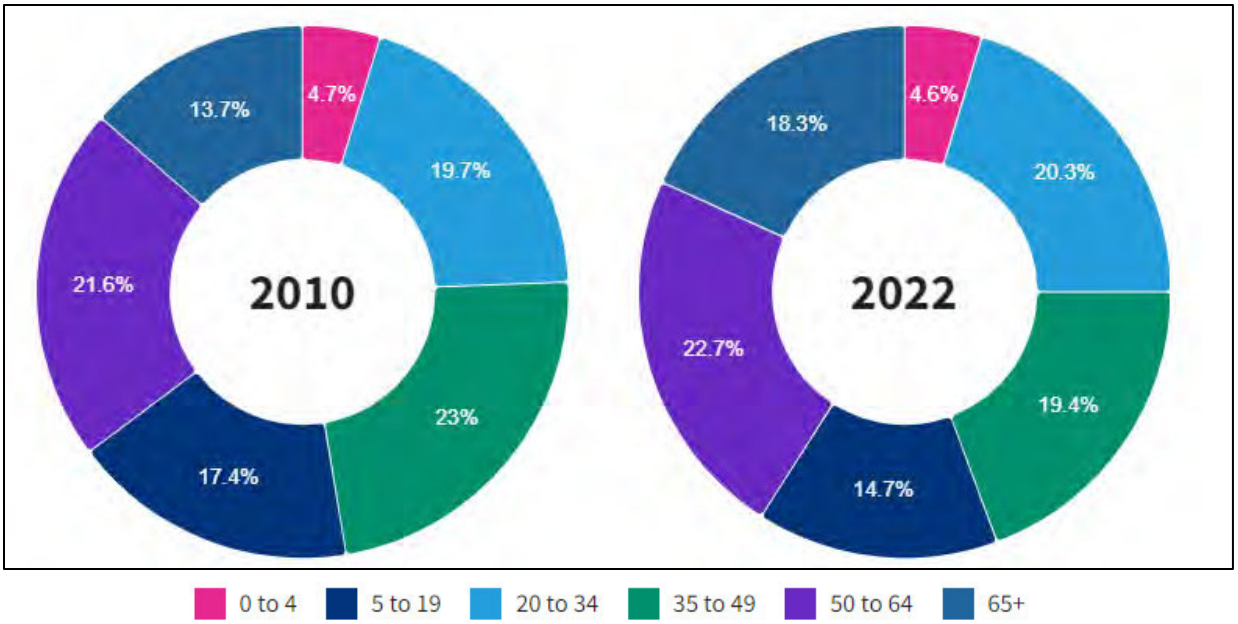


Figure 21. Change in Age in Lee County, 2010 to 2022 (USA Facts, 2024)

According to the World Health Organization (WHO), city planners should foster active ageing by creating an age-friendly physical environment including but not limited to outdoor spaces and buildings, civic participation and employment, and social participation (WHO, 2007) (Figure 22Figure 22: Age-friendly City Topic Areas (WHO, 2007)). The physical environment influences personal mobility and injury, crime, health behavior and social participation (WHO, 2007). Additionally, the entire community and local economy benefits from the patronage of older adult consumers and their participation in volunteer or paid work (WHO, 2007).

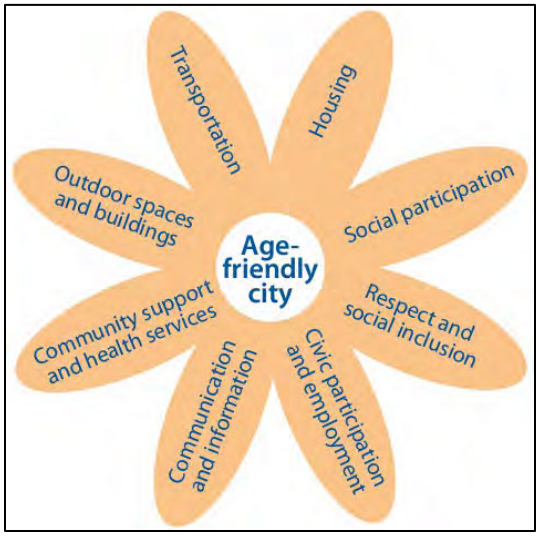


Figure 22: Age-friendly City Topic Areas (WHO, 2007)

The TSP will improve outdoor spaces and buildings for all of Beattyville's visitors and inhabitants. For the elderly population in particular, the TSP will positively impact mobility, independence, quality of life and the ability to "age in place."

6.11.3 Project Schedule

Execution of the Project Partnership Agreement (PPA) and completion of subsequent project phases are contingent upon available funding. Separable elements to be implemented by the NFS through the authority in Section 204 of WRDA 1986 will be implemented utilizing design-build contracts between the NFS and contractors. Depending on funding availability, structures will be made eligible based on each structure's flood risk. Design-build contracts will be utilized for each separable element. General request for proposal and contract and construction guidance documents for the NFS will be generated with the first available General Investigation (GI) or Construction General (CG) funding and provided for their implementation. For separable elements to be implemented in a traditional fashion, design is expected to take one year from receipt of GI or CG funding and the receipt of matching NFS funds. Implementation will be completed over a 5-year period starting when CG funds become available.

Table 25. Project Feasibility Schedule provides the actual and future estimated schedule for the remaining key milestones for the feasibility phase.

Table 25. Project Feasibility Schedule

Activity	Milestone	Scheduled	Actual
Feasibility Cost Sharing Agreement	CW130	3 Jan 2023	03 Jan 2023
Planning Charette	CW142	19 April 2023	19 April 2023
Alternatives Milestone Meeting	CW261	13 Sept 2023	13 Sept 2023
Tentatively Selected Plan Milestone Meeting	CW262	1 May 2024	14 June 2024
Draft Feasibility Report Release	CW250	13 Aug 2024	13 Aug 2024
Agency Decision Milestone Meeting	CW283	21 Jan 2025	TBD
Final Report Transmittal	CW160	22 May 2025	TBD
30-Day S&A Review start		22 May 2025	TBD
30-Day S&A Review end		23 June 2025	TBD
Signed Chief's Report	CW270	12 Dec 2025	TBD

6.12 Views of the Non-Federal Sponsor and Responsibilities

Lee County, Kentucky, the NFS, expresses continued interest in participating in the proposed project and has acknowledged their responsibilities as outlined below.

The NFS will perform all necessary steps to complete and execute a PPA for the design and implementation phase of the project. In addition, the NFS will provide the required non-Federal contribution. The County is working to secure non-Federal cost share funds from grants and loans. The NFS is also working to clarify potential in-kind contribution opportunities.

The NFS actively participated in the development of alternatives and the selection of the TSP. Louisville District has actively reached out to the NFS throughout the duration of the feasibility

phase. In addition, the NFS met with representatives from Louisville District at the project site to discuss alternatives.

Once the project has been completed, the NFS will accept the project, along with their O&M responsibilities, including monitoring and performing routine maintenance to maintain its function.

The total project costs for design and construction of the project will be shared 85.75% Federal and 14.25% non-Federal, as presented in the Section 6.7. Additionally, during the design and implementation phase, the NFS shall:

- Provide all lands, easements, rights-of-way, relocations, and disposal areas.
- Provide, during construction, any additional costs as necessary to make the total non-Federal contributions equal to 14.25% of the total project costs. The NFS may provide work in-kind during final design and construction. The non-Federal share is estimated at $5,098,000 which does not include the estimated value of the Lands, Easements, Right of Ways, Relocations, and Disposals.
- Operate, maintain, repair, replace, and rehabilitate the completed project or functional portion of the completed project at no cost to the Federal government, in accordance with the applicable Federal and State laws and any specific directions prescribed by the Federal government for so long as the project is authorized.
- Hold and save the Federal government harmless from damages due to the construction and operation and maintenance of the project, except where such damages are due to the fault or negligence of the Federal government or its contractors.
- Grant the Federal government a right to enter, at reasonable times and in a reasonable manner, upon land which the NFS owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purposes of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.
- Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs for a minimum of three years after completion of the project construction for which such books, records, documents, and other evidence are required.
- Perform, or cause to be performed, any investigations for hazardous substances regulated under CERCLA, 42 USC 9601-9675, as amended, that may exist in, on, or under lands, easements, or rights-of-way necessary for construction, operation, and maintenance of the project; except that the NFS shall not perform such investigations on lands, easements, or rights-of-way that the Federal Government determines to be subject to the navigation servitude without prior specific written direction by the Federal Government.
- Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines are necessary for construction, operation, and maintenance of the project.
- Agree that, as between the Federal government and the NFS, the NFS shall be the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.
- Prevent obstructions of, or encroachments on, the Project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) that might reduce

the TSP, hinder its operation and maintenance, or interfere with the proper function such as any new development on project lands or the addition of facilities that would degrade the benefits of the project.

- Not use Federal funds to meet the NFS's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.
- Assume the financial responsibility for the construction, operation, maintenance, repair, replacement, and rehabilitation of the completed betterments outside of the project area.

7 ENVIRONMENTAL COMPLIANCE

7.1 CUMULATIVE EFFECTS OF TSP

The USACE must consider the cumulative effects of the proposed project on the environment as stipulated by NEPA. Formally defined, cumulative effects are "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions". Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 C.F.R. Part 1508.7).

The cumulative effects analysis is based on the potential effects of the proposed project when added to similar impacts from other projects in the region. An inherent part of the cumulative effects analysis is the uncertainty surrounding actions that have not yet been fully developed. The CEQ regulations provide for the inclusion of uncertainties in the analysis and states that "when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment… and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking" (40 C.F.R. 1502.21).

Temporal and geographical limits for this project must be established to frame the analysis. The temporal limits for assessment of impacts would initiate in 1970 with the passing of the NEPA and would end 50 years after the completion of Alternative 5C. The geographical extent considered is the census tract (21129950100) that Beattyville is within, which encompasses the most immediate community that relies on the infrastructure found within Beattyville.

Section 2.0 of this integrated EA documents the existing environment within the area, and Section 4.0 documents potential environmental effects of the final array of alternatives and the NAA. As outlined in the analysis provided in Section 4.0, the effects of Alternative 5C would be largely beneficial by reducing the risk of the most damaging impacts that would occur during flooding disasters. Long-term positive impacts to surface waters, wetlands, aquatic habitat, aquatic threatened and endangered species, hazardous and toxic waste, and socioeconomics and EJ would be expected to be realized over the entire 50-year planning horizon. The overall lack of adverse effects associated with Alternative 5C, as documented in this EA, demonstrates both the benign nature and limited ability of Alternative 5C to impact the environment based on relatively small environmental footprint that is mostly based within an urban setting. The only identified adverse effect that would be seen during the implementation of this project are short-term, construction-related impacts. Potential impacts to the Kentucky arrow darter and its designated critical habitat were mitigated through an avoidance strategy developed during scoping. Potential impacts to surface waters caused by construction related activities is expected to be mitigated through a minimization strategy outlined in a SWPPP.

Currently, no other construction related projects are known to be planned in the area of analysis. This limits the ability to forecast if the impacts of Alternative 5C would cumulate to a significant impact when combined with potential future actions. However, given the benign nature of the project it can be reasonably assumed that Alternative 5C would not result in cumulative impacts when and if future projects are undertaken.

Impacts to the area that have occurred historically in this period of analysis would include several coal mining operations. Including the former Happy Top mine just northwest of downtown and the abandoned mine located southwest of downtown across the Kentucky River (Figure 7). Beattyville has historically relied on industries such as coal mining, which have undergone significant decline, leading to economic instability and high poverty rates. Limited access to quality education, healthcare, and employment opportunities exacerbates socioeconomic challenges in the area. Cumulative effects of past and ongoing economic hardships contribute to a cycle of poverty and limited social mobility. Additionally, the region has experienced environmental degradation due to coal mining activities, including mountaintop removal and strip mining, as well as deforestation activities, leading to habitat destruction, water pollution, and soil erosion. This has cumulated in an overall loss of biodiversity have further impacted the ecosystem and natural resources upon which the community historically depended.

This analysis of historical actions highlights the interconnected nature of socioeconomic and environmental factors impacting Beattyville. Understanding and addressing these cumulative effects are essential for fostering sustainable development, improving community resilience, and enhancing the overall quality of life for residents. This historical context was at the forefront of the planning of Alternative 5C and the plan is expected to produce overall positive impacts regarding the socioeconomic sustainability of Beattyville. Although historical impacts to the environment in this region from human activities have been severe, the implementation of Alternative 5C is not expected to cause additional harm to the environment. Impacts from Alternative 5C would not further alter aquatic habitats that have been severely degraded due to regional mine and logging operations in the watershed. The project would also only have minimal impacts to terrestrial environments and are short-term in nature. As such it has been determined that the project would not cause significant cumulative effects to the environment.

7.2 Environmental Compliance Table

The TSP is in compliance with all local, state, and Federal statutes as well as Executive Orders. No local zoning laws or public planning ordinances are in place in the project area that would impact the TSP. Compliance is documented below in .

Table 26. Environmental Compliance Status

Statute/Executive Order	Full	Partial	N/A
National Environmental Policy Act (considered partial until the FONSI is signed) *		X	
Fish and Wildlife Coordination Act*		X	
Endangered Species Act*		X	
Clean Water Act**	X		
National Historic Preservation Act*		X	

Wild and Scenic Rivers Act			X
Clean Air Act	X		
Comprehensive, Environmental Response, Compensation and Liability Act	X		
Bald and Golden Eagle Protection Act	X		
Migratory Bird Treaty Act	X		
Resource Conservation and Recovery Act	X		
Toxic Substances Control Act	X		
Quiet Communities Act	X		
Farmland Protection Act	X		
Executive Order 11988 Floodplain Management**	X		
Executive Order 11990 Protection of Wetlands	X		
Executive Order 12898 Environmental Justice in Minority Populations and Low-Income Populations	X		
Executive Order 13045 Protection of Children from Environmental Health Risks and Safety Risks	X		
Executive Order 13122 Invasive Species	X		
Executive Order 14008 Tackling the Climate Crisis at Home and Abroad	X		

7.3 PUBLIC INVOLVEMENT

The Integrated Feasibility Report (IFR) and Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) was made available for public review and comment for a period of 30 days beginning on [PENDING]. All Federal, state, and local agencies, as well as non-governmental organizations (NGO's), and Tribes contacted for public review are listed in Table 27. All public review comments received will be included in Appendix H. Additionally, the public was involved during EJ outreach efforts as described in Section 7.2.2.1.

Table 27. Stakeholders Contacted for Public Review

Stakeholder Type	Stakeholder
Federal	U. S. Fish and Wildlife Service, Frankfort Field Office
	U. S. Environmental Protection Agency, Region 4 Office
	U. S. Geological Survey, Kentucky Water Science Center
State	Kentucky Department of Fish and Wildlife Resources
	Kentucky Department for Energy and Environment
	Office of Kentucky State Nature Preserves
	Kentucky Heritage Council

Local	Lee County Judge Executive
NGO	The Nature Conservancy of Kentucky
Federally Recognized Indian Tribes	Shawnee Tribe
	Cherokee Nation
	Eastern Shawnee Tribe of Oklahoma
	Osage Nation
	Absentee Shawnee Tribe of Oklahoma
	United Keetoowah Band of Cherokee Indians in Oklahoma
	Eastern Band of Cherokee Indians
	The Delaware Nation
	The Delaware Tribe of Indians Oklahoma

7.3.1 Feasibility Charette

The feasibility study charette was held on April 18-19, 2023, in Beattyville, Kentucky. For a feasibility study applying the principles of SMART (Specific, Measurable, Attainable, Risk Informed, Timely) Planning, a charette allows the convening of the PDT and the Vertical Team (VT), along with local and agency stakeholders, to make decisions critical to the study. The purpose of the charette was to establish a common understanding of the planning process used by USACE to study Civil Works projects. The underlying objective of the charette is to help the PDT move towards completion of a SMART feasibility study and ensure that the VT and the NFS are aligned with the proposed direction. The charette attendees also visited the project site and were able to assess the existing condition and gather information that might inform the future with project condition for Beattyville. Below are the charette's goals and objectives as presented at the charette:

Goals:

- Initiate the first iteration of the planning process for the study.
- Begin formation of a collaborative and effective PDT by strengthening relationships with stakeholders.
- Set expectations and establish a constructive approach to this study.
- Provide a solid foundation for subsequent iterations of the planning process, scheduling of study milestones, and robust stakeholder engagement and public communication.

Objectives:

- Establish joint understanding of planning process.
- Define existing conditions and POOCs.
- Generate possible management measures.
- Identify significant study risks and uncertainties.
- Brainstorm opportunities to justify potential plans using decision criteria.

The charette participants included the PDT at the time of the charette, which was comprised of the Louisville District staff and the NFS. Local stakeholders assisted as possible (Lee County and Beattyville employees). State and federal organizations also assisted as much as possible (Kentucky Division of Water, Kentucky State Hazard Mitigation Officer, KDFWR, State and Congressional Representatives, U.S. Geological Survey, Kentucky River Area Development District, etc.).

The VT included representatives from LRD, the Policy, and Legal Compliance Review (PLC&R) team, and the Flood Risk Management Planning Center of Expertise (FRM-PCX). The complete list of attendees with names appears in Appendix H.

7.3.1.1 Outcomes of Key Charette Discussions

While important discussion occurred on many topics, and is captured in the charette products, summary outcomes of some of the key conversations are the following:

- Mutual understanding that all are committed to the flood risk management purpose.
- VT and stakeholder concurrence on the POOCs (finalized in Sections 1.7 and 1.8).
- Discussion on decision criteria and metrics for identifying and screening measures and alternatives, and an overview of the PR&G criteria and the four accounts.
- The team presented project risks and uncertainties and requested feedback and additional input from the attendees.
- Overview and discussion on the types of measures (structural, non-structural, and a combination of the two) and the current specific measures the team was evaluating, and an outline of items to consider such as cost, real estate, environmental impacts, downstream impacts, etc.
- Development of project benefits
- Discussion about opportunities for continued outreach
- Site visit

7.3.2 Environmental Justice

7.3.2.1 Outreach

The strategy for EJ outreach was developed according to the Interim Environmental Justice Guidance for Civil Works Planning Studies (January 2023). During the scoping process, the PDT conducted EJ analysis and stakeholder mapping. This included using the CEJST (Section 2.6.4) to gain a better understanding of the community, and spending time during the planning charette to identify potential groups and strategies for outreach. Additionally, the team developed a Communication Plan which outlines the objectives of outreach efforts and is included as an appendix in the Project Management Plan (PMP).

This strategy involves continuing to develop an understanding of the community landscape outside of the local stakeholders that have already participated in the Planning charette and are involved with the project. The PDT will consider how the study could impact existing/further vulnerability in the community.

Operationalizing the EJ strategy includes identifying community concerns after conducting more engagement. Additionally, the feasibility report documents existing conditions and FWOP with respect to social, economic, and environmental health conditions.

The PDT and the NFS developed the following specific EJ outreach efforts and activities, some of which are already utilized by the Sponsor, to reach a broad public:

- Facebook/social media outreach: Lee County Judge Executive Steve Mays (NFS Representative) agreed to post information developed by the PDT and the USACE Public Affairs Office (PAO) including a brief description of the project and a project-specific email for questions and comments.
- Farmers Market: a booth at the local farmers market where key members of the PDT will be available to answer questions and interact with the local community.
- Signs: the PDT plans to create large signs (approximately 3ft x 5ft) to post in Beattyville with the USACE logo, a brief description of the project, the project email and/or a QR code; the sign could direct people to a website with additional information

The objectives and constraints provide benefits and avoid disproportionate impacts to the community. The final array of alternatives considers environmental factors, health and safety, social vulnerability and resilience, and economic vitality. Outreach efforts will be ongoing throughout the life of the project.

7.3.2.2 Benefits of the TSP

Expected benefits of the TSP on the EJ Community (refer to Section 2.6):

- Decrease in expected building loss rate.
- Increased income due to improved community stability and job availability (both from the regional economic benefits of the TSP as well as expected future investments)
- Improved quality of life due to removal of abandoned structures
- Improved quality of life and life expectancy due to removal of lead-based paint and asbestos in structures where nonstructural measures are applied.
- Selecting the floodwall alternative as the TSP would have had a negative impact on public transportation.

7.3.3 Stakeholder Agency Coordination

7.3.3.1 State and Federal Agencies

Coordination with state and Federal resource agencies was conducted in conjunction with the preparation of the draft IFR and EA. Initial scoping letters initiating NEPA and Section 106 were sent on July 18, 2023, to agencies listed in Table 27 to kickoff scoping activities and invite participating agencies to an interagency meeting. An interagency meeting was held on August 7, 2023, to discuss known project details and to acquire agency specific knowledge of the potential project area. Follow-up scoping letters were sent to agencies on March 12, 2024, to communicate the final array of alternatives being considered and to acquire any additional information prior to selection of the TSP. Subsequent Section 106 letters were provided to the KY-SHPO on March 15, 2024, to formally consult on the APE and level of effort (LOE) KHC concurred with the APE and LOE on April 15, 2024, all correspondence can be found in Appendix B.

7.3.3.2 Local Agencies

Local agencies listed in Table 27 will be provided with the draft DPR/EA for review on [PENDING]. Any correspondence received from local agencies will be provided in Appendix B and responded to in the final DPR/EA. Additionally, local agencies were contacted during the feasibility charette (Section 7.2.1) for input on planning and scoping.

7.3.3.3 Non-Governmental Organizations

NGOs listed in Table 27 will be provided with the draft DPR/EA for review on [PENDING]. Any correspondence received from NGOs will be provided in Appendix B and responded to in the final DPR/EA.

7.3.3.4 Federally Recognized Indian Tribes

Federally recognized Indian Tribes (see Table 27 above) were invited to participate in the initial scoping meeting that was held on August 7, 2023. The Osage Nation was the only Tribal Nation that participated in this engagement. Subsequent Section 106 letters were provided to Tribal Nations on March 15, 2024, to formally consult on the APE and level of effort (LOE). The Osage Nation provided a letter on April 22, 2024, requesting USACE to provide any draft cultural reports for their review. The archaeological and cultural historic surveys are currently in progress and will be provided to consulting Tribal Nations for their review and concurrence. All correspondence to date can be found in Appendix B. Furthermore, Section 106 Letters were provided to Tribal Nations on March 15 specifically to consult for their indigenous knowledge of the project area on 29 April 2024 (see Appendix B for example). On May 6, 2024, the Delaware Nation responded with a letter stating Lee County is not within their area of interest and deferred future involvement. No other Tribal responses have been received.

8 DISTRICT ENGINEER RECOMMENDATION

After considering the engineering, economic, environmental, and social aspects relative to the construction of the proposed floodplain management project in Beattyville, Lee County, Kentucky, I approve this report and recommend that the TSP be authorized and constructed as a Federal project under the authority of Section 6 of the Flood Control Act of 1939, PL 76-396 and Section 105(a) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2215(a).

The estimated total project cost is $35,777,000 (not including feasibility costs). The estimated Federal share of 85.75% is $30,679,000 and the non-Federal 14.25% share is $5,098,000. The estimated value of the LERRD required for the project is approximately $4,285,000 and is creditable towards the Sponsor's share of total project costs. I further recommend that the project be funded and constructed subject to cost-sharing and financing arrangements acceptable to the Chief of Engineers and the Secretary of the Army.

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 national civil works construction program nor the perspective higher review levels within the Executive Branch. Consequently, these recommendations may be modified before implementation. However, the NFS, the State, interested Federal agencies, and other parties would be advised of any modifications and would be afforded an opportunity to comment further.

_____ _____

Date

[redacted]
Colonel, U.S. Army
District Commander

9 REFERENCES AND LIST OF PREPARERS

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9.2 List of Preparers

Table 28. Project Delivery Team

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Lauren Alexander	Risk	3 Years USACE Experience Responsible reviewer for HEC-SSP
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Appendix A
Engineering

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 INTRODUCTION

1.1 BACKGROUND

In late February and early March of 2021, a series of heavy rainstorms collectively caused major flooding in the Kentucky River basin as well as other parts of central and eastern Kentucky (NWS). The City of Beattyville (Beattyville), Kentucky, experienced one of the worst and most damaging floods in its history. The flood crested at approximately 666.5 Ft. NAVD88. Though there were no fatalities, most if not all businesses in downtown Beattyville had five feet of water and were closed for some time after the event (WKYT).

1.2 SCOPE OF STUDY

The Beattyville General Investigation was launched around January 2023. The objective is to analyze all available flood risk reduction measures and provide a recommendation for the optimal measure for Beattyville.

2 GENERAL

2.1 TENTATIVELY SELECTED PLAN

The Tentatively Selected Plan least cost alternative proved to be a nonstructural plan consisting of acquisition (13 structures), floodproofing (10 structures dry floodproofed and 31 wet floodproofed) and raising in place (1 structure) paired with providing the Beattyville with a Flood Warning Emergency Evacuation Plan (FWEEP). The FWEEP will be further developed and provided in detail at the ADM milestone. See the first volume of this report for further breakdown of how this plan was selected.

2.1.1 Nonstructural Plan

Objectives prioritized for the Nonstructural plan included life safety, risk of structures and community cohesion. See Section 9.1 Nonstructural of this report for more information.

2.1.2 Flood Warning Emergency Evacuation Plan (FWEEP)

Flood warning and preparedness planning (referred to as Increment 1 in the Feasibility Report) will be further investigated in this study. See Section 9.2 FWEEP for further information to be included and explored.

2.2 TERMINOLOGY

2.2.1 Base Flood Elevation (BFE)

FEMA established the BFE for most of Beattyville as the elevation 669.1 ft NAVD88. However, as the model moves upstream, this elevation increases. For the purposes of this study, a BFE of 669.2 ft NAVD88 was selected for all of Beattyville for consistency. Based on hydrological analysis, the USACE H&H modeling determined the 100-year flood for Beattyville as 672.08 ft NAVD88, which was rounded for simplicity and the purposes of this report to match the BFE plus 3 ft elevation of 672.2 ft NAVD88. In summary, for the purposes of this study, FEMA's BFE for

the study area was assumed to be 669.2 ft NAVD88, and the BFE plus 3 feet was assumed to be 672.2 ft NAVD88. See Section 3.6.5, 4.1.4, and 4.9.3 for more information on the various elevations used for this study.

2.2.2 Design Flood Elevation (DFE)

DFE determines the stage at which structures are allowed to be built to within the community. Traditionally, the DFE is set to at least match the BFE. Some communities increase the elevation by 1 or 2 feet. The Non-Federal Sponsor (NFS) will develop the flood plain management plan prior to design of the recommended plan for this study. The DFE will establish the elevation the USACE project will elevate a structure and the height utilities and building materials will be mitigated against in a wet floodproof measure. The DFE will be a maximum for dry flood proofing benefits but will not be a minimum for dry floodproofing, because dry flood proofing will be limited by the structural capacity for holding back floodwaters.

3 HYDROLOGIC HAZARDS

3.1 INTRODUCTION

This chapter requires development of several data sets to assist in best estimates of hydrologic loading to be used in the evaluation of potential Flood Risk Management (FRM) Projects. FRM's include potential new levee systems which require hydrologic loading to help establish initial levee elevation estimates. Hydrologic loading was reviewed for the Beattyville, Kentucky as well as the three contributing forks, the North Fork Kentucky River (North Fork), Middle Fork Kentucky River (Middle Fork), and South Fork Kentucky River (South Fork). Flow-frequency and stage-frequency curves were developed for the Kentucky River at Beattyville and for each of the three Kentucky River forks. Hydrologic loadings were reviewed in the North, Middle, and South Fork because additional reservoirs were initially investigated in the upper forks. The hydrologic loadings are documented for the upper forks, but additional reservoirs are not anticipated at the time of report completion.

Elevation data provided in this report on stream conditions and structural aspects are in North American Vertical Datum of 1988 (NAVD88) unless otherwise stated. The conversion from NVGD29 to NAVD88 used was -0.54 ft for the vicinity of the project area based on https://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html.

3.2 BACKGROUND DATA

Beattyville is the county seat of Lee County and lies at the confluence of the North Fork and South Fork. The North Fork and South Fork are both tributaries of the Kentucky River and the Middle Fork is a tributary of the North Fork.

Hydrologic loading data used in this evaluation was primarily taken from the United States Geological Survey (USGS) gages summarized in Table 1. USGS gages at Lock 6 and Lock 8 are shown in Table 1 as they are referenced in this chapter but no systematic data from either gage was used in the development of the final flow-frequency and stage-frequency curves.

Table 1: USGS Reference Gages

Gage No.	Gage ID	Location	Gage Elevation (ft)	Drainage Area (sq. mi.)
03280000	North Fork Kentucky River	Jackson, KY	697.70	1,101
03281000	Middle Fork Kentucky River	Tallega, KY	641.55	537
03281500	South Fork Kentucky River	Booneville, KY	641.91	722
03282000	Kentucky River Lock 14	Heidelberg, KY	625.39	2,657
03284000	Kentucky River Lock 10	Winchester, KY	556.10	3,955
03284500	Kentucky River Lock 8	Camp Nelson, KY	503.25	4,414
03287000	Kentucky River Lock 6	Salvisa, KY	487.02	5,102
03287500	Kentucky River Lock 4	Frankfort, KY	461.58	5,411

Data from Kentucky River Lock (Lock) 14 USGS gage 03282000 at Heidelberg, KY (Heidelberg) was the primary gage used for the development of flow- and stage-frequency curves due to the proximity of the gage to Beattyville, which is approximately 3.5 miles west of Beattyville. Data from Lock 10 USGS gage 03284000 at Winchester, KY (Winchester) and Lock 4 USGS gage 03287500 at Frankfort, KY (Frankfort) was used in various capacities as transposed and perception threshold (PT) data depending on correlation between USGS sites. Data transposition and the PT are discussed in further detail later in the report. The North Fork at Jackson, KY (Jackson), Middle Fork at Tallega, KY (Tallega), and South Fork at Booneville, KY (Booneville) each have a USGS gage and were also individually reviewed in coordination with Lock 14 as part of this study. See Section 4.4 for additional details on the data used.

Flows in the headwater area of the Kentucky River Basin are controlled by two primary flow regulation structures: (1) Carr Creek Dam located in the North Fork Basin and (2) Buckhorn Dam located in the Middle Fork Basin. The South Fork currently has no flow regulation. It should be noted that Carr Creek Dam is on a tributary of North Fork and regulates a drainage area of 58 square miles. The North Fork USGS gage 03280000 at Jackson has a contributing drainage area of 1,101 square miles. Therefore, Carr Creek Dam has a minor impact on inflow at the North Fork USGS gage. Conversely, Buckhorn Dam regulates a drainage area of approximately 408 square miles, which compared to the Middle Fork USGS gage 03281000 at Tallega drainage area of 537 square miles has a much larger impact on inflows at the Middle Fork USGS gage.

Points of regulation downstream of Lock 14 include Lock 10 at Winchester, Lock 8 at Camp Nelson, Lock 6 at Salvisa, and Lock 4 at Frankfort. The Kentucky River ends at its confluence with the Ohio River at Carrollton, KY. The Dix Dam (also noted as Herrington Lake), placed into operation in 1926, is located on the Dix River approximately 2.2 miles upstream of its confluence with the Kentucky River and has a drainage area of 439 square miles. The Dix River confluence with the Kentucky River is located upstream of the Lock 6 USGS gage 03287000 at Salvisa and downstream of the Lock 8 USGS gage 03284500 at Camp Nelson.

Figure 3.1 shows the location of Beattyville, USGS gages, and other pertinent project features referenced in this chapter.

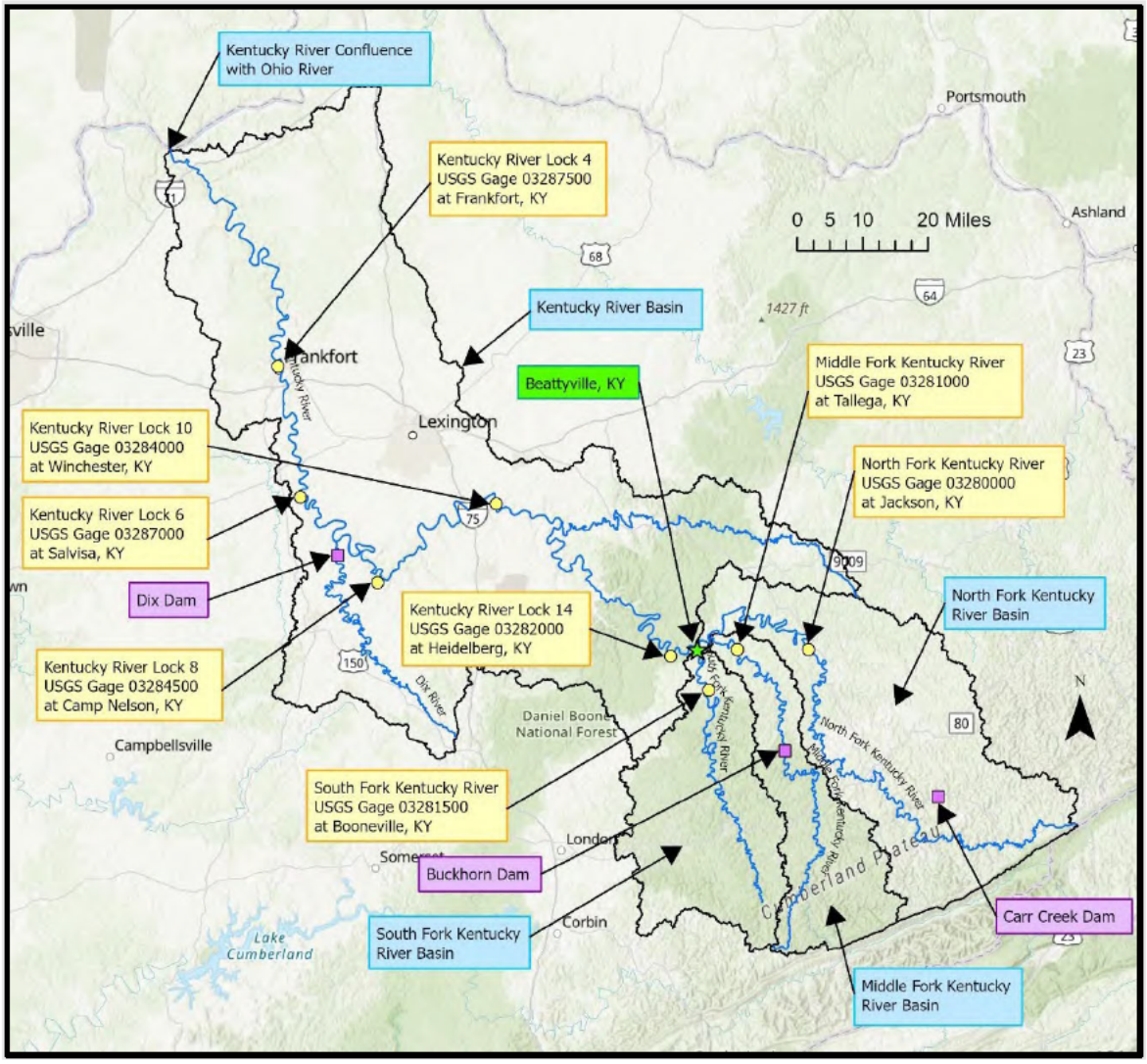


Figure 3-1: Project Vicinity Map

Prior to the establishment of the above mentioned USGS gages, there was generally no reliable data for floods occurring at Lock 14 or in the North, Middle, or South Fork. Consistent USGS gage data collection began in 1921 for Lock 14 and in 1939 for North, Middle, and South Fork.

3.3 HYDROLOGY

3.3.1 Kentucky River Basin Hydrology

Information regarding the climate and hydrology of the North, Middle, and South Fork basins was primarily taken from the Buckhorn and Carr Creek WCMs. The North, Middle, and South Fork basins are designated as humid subtropical climates according to the Koppen Climate Classification, which is characterized by hot, humid summers and cool to mild winters. The area

is subject to frequency temperature changes, high humidity, and periods of intense precipitation. The basins lie in the Eastern Kentucky Coal Field physiographic region, which is dominated by forested hills and highly dissected by V-shaped valleys. The Kentucky River basin extends northwest through the Bluegrass physiographic region until its confluence with the Ohio River.

Storms of 2.0 to 3.0 inches per 24-hour period are not uncommon and total annual rainfall generally varies between approximately 44 to 49 inches. Records indicate precipitation is fairly well distributed through the year with approximately 56 percent of total annual precipitation occurring between March and August with July being the month of great precipitation contribution. Minimum months of rainfall varied but usually occur in October.

Storms that produce the most intense rainfall are typically formed in the southwestern United States or in the Gulf of Mexico and move northeasterly toward the north Atlantic coast. Cyclonic storms are the most frequent cause of excess runoff in these basins. Storms of this type generally occur mid-winter to early spring when conditions are conducive to high runoff, and many have produced severe flooding in the North, South, and Middle Fork basins. Convective storms which produce rainfall of high intensity generally occur during the summer months and seldom cause important flooding since they are usually have smaller area coverage and transpiration losses and infiltration rates are high. Topography of the basins are such that orographic rainfall does not occur.

3.3.2 Major Floods

Flooding in the basins has been experienced at some point in every month of the year. Summer and fall season floods generally have less coverage than those occurring during the winter and spring. The principal cause of floods in the basins is excessive rainfall. Snow melt can aggravate flood conditions but is not a direct cause of flooding. The headwater areas of the Kentucky River often have characteristic steep, rugged terrain. This terrain along with the periods of intense precipitation make for conditions of extremely rapid runoff and high susceptibility to flash flooding. Table 2 summarizes the three largest flood events recorded by USGS gages referenced.

Table 2: Major Flood Events

Date	***Peak Inflow (cubic feet per second [cfs])***	***Elevation (ft)***	***Gage Height (ft)***
USGS Gage 03280000 – North Fork			
July 29, 2022*	54,400	739.70	42.00
May 8, 1984*	53,500	739.67	41.97
January 30, 1957	53,500	738.11	40.41
USGS Gage 03281000 – Middle Fork			
January 30, 1957	52,700	684.88	43.33
February 1939	37,300	682.05	40.50

February 2, 1951	35,300	681.62	40.07
USGS Gage 03281500 – South Fork			
January 30, 1957	66,100	685.31	43.40
February 28, 1962	54,700	682.65	40.74
May 8, 1984	51,600	683.03	41.12
USGS Gage 03282000 – Kentucky River Lock 14			
February 04, 1939	120,000	660.99	35.60
January 30, 1957	116,000	660.39	35.00
March 24, 1929	113,000	659.79	34.40
USGS Gage 03284000 – Kentucky River Lock 10			
December 10, 1978*	101,000	596.25	40.15
February 05, 1939	92,400	590.90	34.80
March 01, 1962*	91,500	592.17	36.07
USGS Gage 03287500 – Kentucky River Lock 4			
December 09, 1978*	118,000	510.05	48.47
January 25, 1937	115,000	509.04	47.46
February 16, 1989*	105,000	505.75	44.17

**Events occurred after regulation of the respective USGS gage*

The February 1939, January 1957, and March 2021 flood events are discussed further below. The 1939 and 1957 events are discussed in further detail because they are the two floods of record at Lock 14 and were large events that also impacted the three upper forks. The March 2021 event is discussed in further detail because it was the most significant flooding the Beattyville area had seen in 50 years and was the event that prompted this study.

3.3.3 Storm and Flood of February 1939

The storm and flood of February 1939 is the flood of record at Lock 14. There is limited data available regarding the February 1939 flood. Precipitation data could not be found in eastern Kentucky dating back to the event and the flood appears to be overshadowed by the July 4-5 floods of 1939, which caused catastrophic flash flooding across much of eastern Kentucky. It is possible the February 1939 floods were more localized to the Kentucky River basin and did not cause the as much overall damage or flooding as the July 1939 flood event. The storm and flood of February 1939 resulted in a flow of 120,000 cubic feet per second (cfs) and stage elevation of 660.99 feet according to the Lock 14 USGS gage 03282000 at Heidelberg. Both floods are shown below in Figure 3.2.

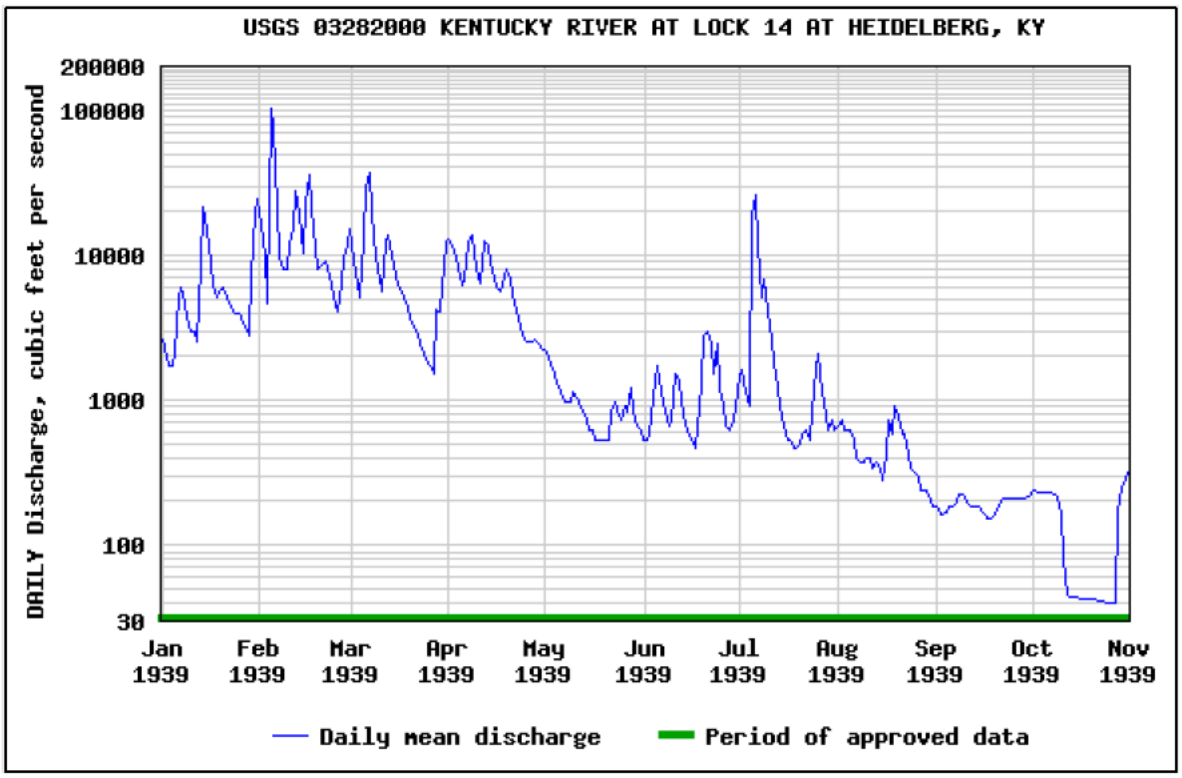


Figure 3-2: Daily Discharge for the Kentucky River at Lock 14 for 1939

3.3.4 Storm and Flood of January 1957

Heavy rains over an extensive area on January 27 to February 2, 1957, caused extreme flooding in southeastern Kentucky and adjacent areas in West Virginia, Virginia, and Tennessee. Total rainfall for the storm period ranged from 6 to 9 inches over most of the reported area and was estimated to be around 12 inches at the eastern end of the Virginia-Kentucky State line. The principal basins affected by the storm were those of the Big Sandy, Kentucky, Cumberland, and Tennessee Rivers. Maximum discharge of record occurred in many streams. The 1957 flood was the second largest flood of record at Lock 14, the flood of record for the Middle Fork and South Fork, and the third largest flood of record for the North Fork according to the respective USGS gages. Refer to Table 2 above for the recorded flow values and stages at each of the gage locations.

3.3.5 Storm and Flood of March 2021

Several rounds of heavy rain moved across eastern Kentucky from late Friday, February 26, 2021, through early Monday, March 1, 2021. The first round of heavy rain came through late Friday, February 26 and in the morning of Saturday, February 27. The second round of heavy rain occurred late Saturday night as a warm front lifted northward across eastern Kentucky. The heavy rain stalled over portions of eastern Kentucky, leading to flash flooding in the early morning hours. The third and final round of heavy rain came late Sunday afternoon through Sunday night. Due to the antecedent moisture conditions from the first two rounds of rainfall, the third round caused widespread flash flooding across much of eastern Kentucky and ultimately led to larger river and creek flooding.

The combination of all the heavy rainfall led to significant flooding across a good portion of central and east Kentucky, including the project area. For some areas, this was the most significant

flooding in the last 50 years or more. 72-hour rainfall totals at Heidelberg were approximately 6.5 inches according to the National Weather Service.

3.4 Overall Systematic, Regional, and Historical Data

3.4.1 Source Data Overview

As previously noted, the USGS gages in Table 1 were the primary data sources used in this analysis. Annual peak inflow data from each of the gages was obtained and used to develop the hydrologic loading curves. Table 3 summarizes the various annual peak inflow data available at each of the USGS gages in Table 1.

Figure 3.3 show a visual representation of the available annual peak inflow data at Lock 4, Lock 10, Lock 14, North Fork, Middle Fork, and South Fork USGS gages. Table 4 summarizes the drainage area ratios between the USGS gages in Table 1.

Table 3: USGS Annual Peak Inflow Source Data Summary

Gage No.	*Gage ID*	*Historic Data*	*Unregulated Data*	*Regulated Data*
03281500	South Fork	N/A	1926 – 1931, 1937, 1939 – Present	N/A
03281000	Middle Fork	N/A	1929, 1931 – 1932, 1935, 1937, 1939 - 1960	1961 – Present
03280000	North Fork	N/A	1917 – 1921, 1927 – 1931, 1935 – 1975	1976 – Present
03282000	Lock 14	N/A	1921 - 1960	1961 – Present
03284000	Lock 10	N/A	1908 – 1960	1961 – 2010, 2012 – Present
03287500	Lock 4	1817, 1847, 1854, 1880, 1883	1895 – 1926	1927 - Present

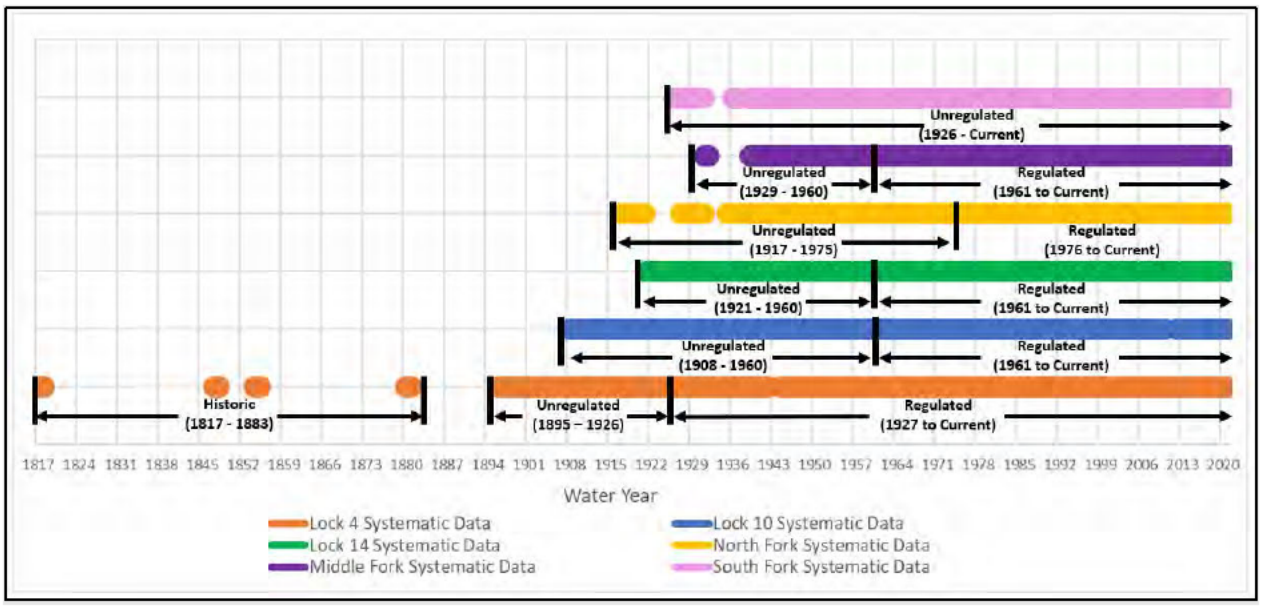


Figure 3-3: USGS Peak Inflow Source Data Summary Visualization

Table 4: USGS Source Data Drainage Area Ratio Summary

To / From	North Fork (1,101 sq mi)	Middle Fork (537 sq mi)	South Fork (722 sq mi)	Lock 14 (2,657 sq mi)	Lock 10 (3,955 sq mi)	Lock 4 (5,411 sq mi)
North Fork (1,101 sq mi)	1.00	0.49	0.66	2.41	3.59	4.91
Middle Fork (537 sq mi)	2.05	1.00	1.34	4.95	7.36	10.08
South Fork (722 sq mi)	1.52	0.74	1.00	3.68	5.48	7.49
Lock 14 (2,657 sq mi)	0.41	0.20	0.27	1.00	1.49	2.04
Lock 10 (3,955 sq mi)	0.28	0.14	0.18	0.67	1.00	1.37
Lock 4 (5,411 sq mi)	0.20	0.10	0.13	0.49	0.73	1.00

3.4.2 Systematic Data Record Extensions

Several different methods of systematic data record extension were reviewed and used as part of this study for Beattyville and the associated headwater drainage areas. These methods are summarized below and the priority that was placed on their use.

1. The Maintenance of Variance Extension (MOVE.3) function as described in *Guidelines for Determining Flood Flow Frequency, Bulletin 17C*, 2019 (B17C). This is the recommended method to extend records based on B17C and was therefore the highest priority for record extension if applicable between two gages.

2. Concurrent annual peak flows between two gages were compared and best fit trendlines created. R squared values associated with the trendline were reviewed to determine if there was sufficient correlation for record extension. Generally, if the trendline yielded an r squared value of 0.8 or more, correlation was considered sufficient. This method was reviewed if drainage areas between the two gages were similar, and the MOVE.3 function was not applicable.

3. Concurrent annual peak flow between two gages were compared on a log-log basis and best fit linear trendline created. R squared values associated with the trendline were reviewed to determine if there was sufficient correlation for record extension. Generally, if the trendline yielded an r squared value of 0.8 or more, correlation was considered sufficient. This method was reviewed if drainage areas between the two gages were similar, and the MOVE.3 function was not applicable. The use of direct flow comparisons or log-log comparisons was determined based on whichever method yielded a higher r squared value of the trendline created.

4. If the above three options did not yield sufficient correlation, scaling factors were reviewed for flows from concurrent peak annual events between locations. This type of analysis was used to review perception thresholds since the r squared value and drainage area ratios between compared locations did not yield sufficient correlation to use as direct systematic data extension.

3.4.3 Lock 14 Rating Curve

Figure 3.4 shows the Lock 14 USGS gage 03282000 at Heidelberg developed rating curve using recorded systematic flow and stage data from the gage over its period of record with a linear trendline, overlay of the rating curve from the Buckhorn Lake WCM, and overlay from the current published USGS rating curve. The developed rating curve was used based on the high r squared value of 0.9903 when correlating the flow and stage data and a visual review of the data in Figure 3.4. The current USGS published rating curve typically yields lower flows at the same stage value compared to the developed curve and the previously established rating curve in the Buckhorn WCM. It is unknown when or why the current USGS published rating curve was updated to its current state. The developed rating curve based on the linear trendline was used as discussed in Section 4.5.4 as part of the spreadsheet tool provided by the LRL Water Management Section. Observed and modeled flood stages were converted to flow values utilizing the developed rating curve linear trend line shown in this figure.

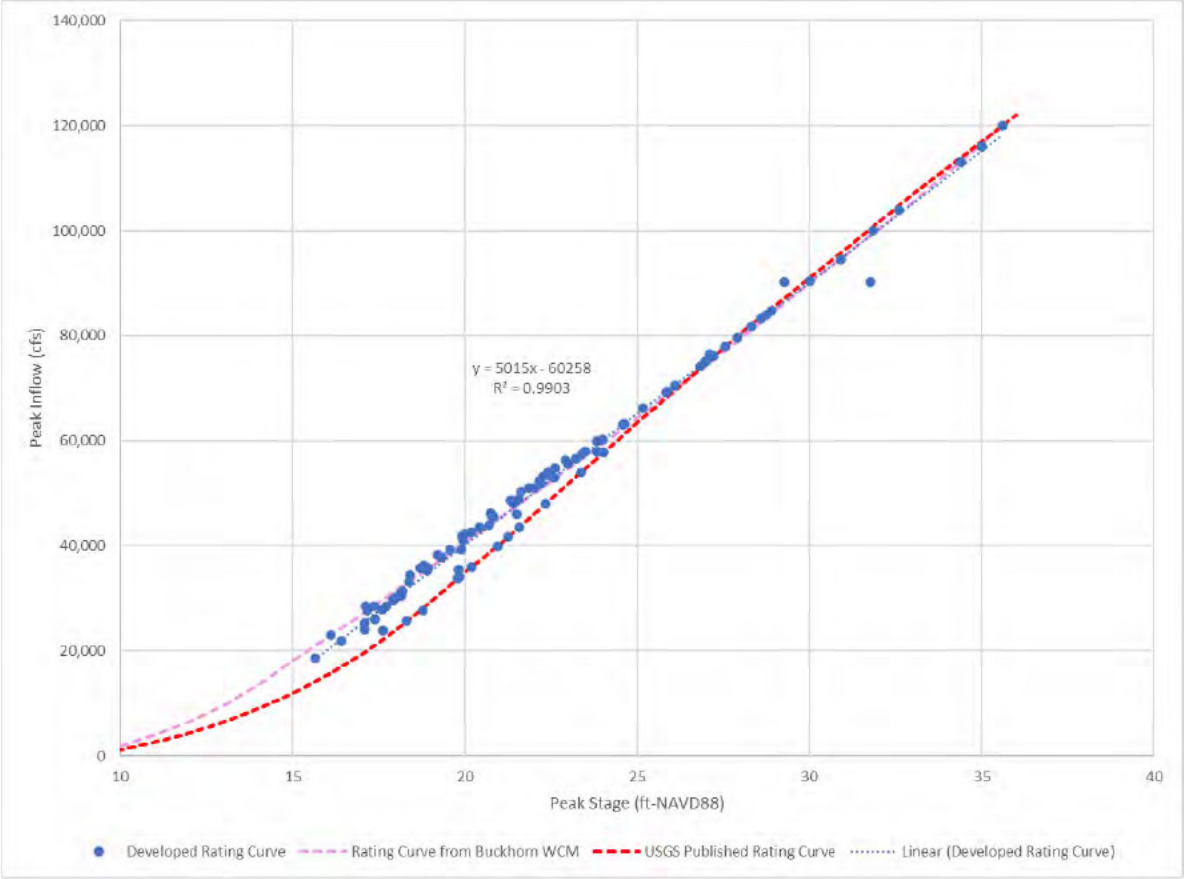


Figure 3-4: Lock 14 Rating Curves – Buckhorn WCM and USGS Published Rating Curves

As part of the hydraulic modeling effort for Beattyville, the Project Delivery Team (PDT) coordinated with the USGS on the potential of a sloped rating curve for the Kentucky River upstream of Lock 11. Backwater effects along the Kentucky River have influenced stages at Lock 14, and subsequently at Beattyville. Figure 3.5 shows the sloped rating cure that was observed for the 2021 event along with field measurements performed by the USGS. Discussions with USGS staff indicated USGS trusted their peak inflow data and sloped rating curve but did not have the additional data or availability yet to review the data further to determine how and when the sloped rating curve occurs. The Hydrologic Engineering Center's River Analysis System (HEC-RAS) model created for this study used the 2021 event for calibration purposes, which partially reflected the sloped rating curve as the final rating curve created a hysteresis loop. A composite rating curve was created from the hysteresis loop and used for the final stage frequency curve analysis at Beattyville, see Section 4.6.4 for additional details. Since the composite rating curve partially incorporates the sloped rating curve, it is slightly more conservative when considering calculated stage values based on flows.

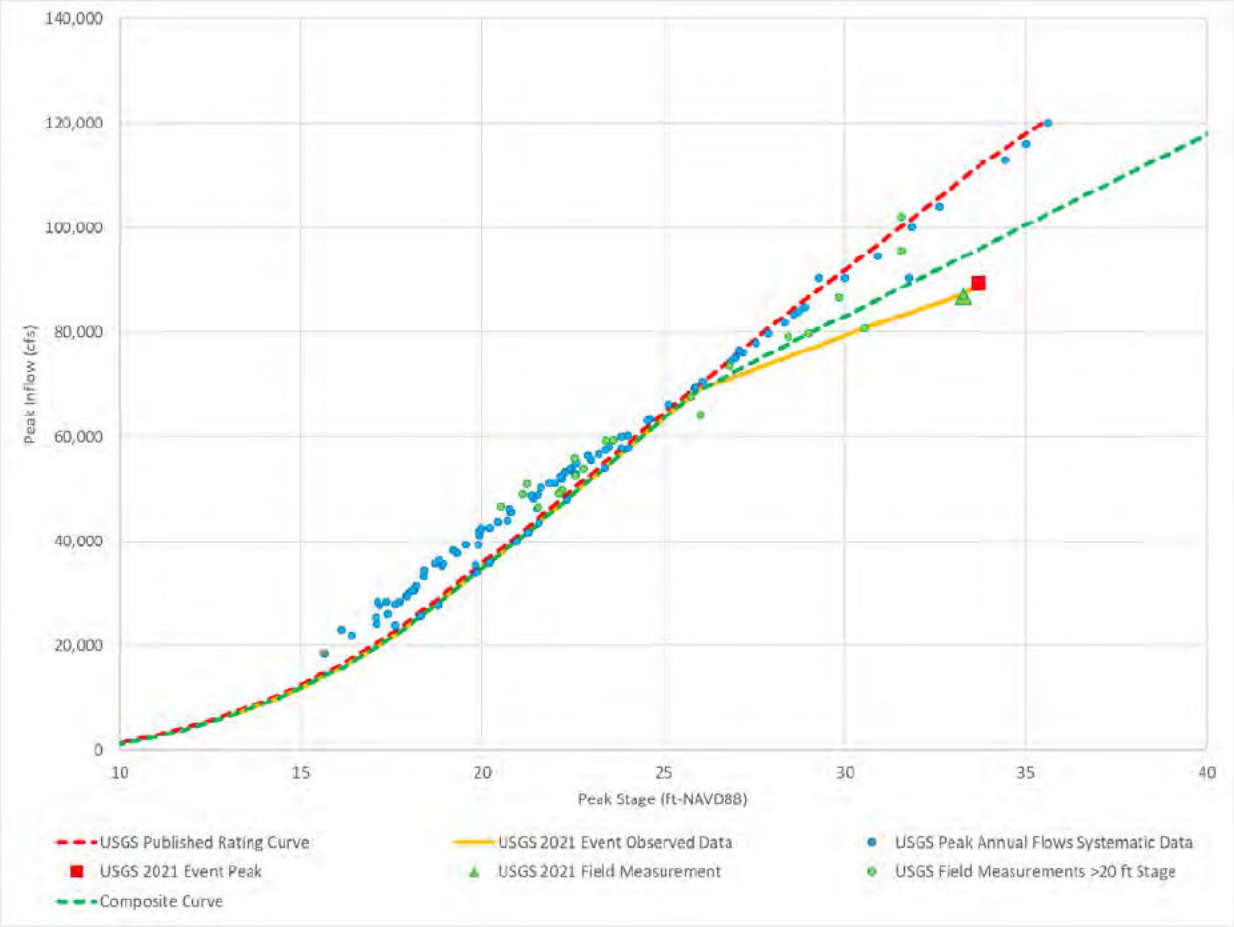


Figure 3-5: Lock 14 Sloped Rating Curve Data

3.5 LOCK 14 AT HEIDELBERG

3.5.1 Period of Record Extension Lock 10 to Lock 14

Unregulated annual peak flow data was used to calculate the instantaneous unregulated peak inflow frequency curve. USGS gages at Lock 14 (drainage area of 2,657 square miles) and Lock 10 (drainage area of 3,955 square miles) were compiled to create the composite period of record (POR). Instantaneous peak inflow is available at Lock 14 from 1921 to present and available at Lock 10 from 1908 to present. The Lock 14 and Lock 10 gages are listed as unregulated through 1960 and regulated from 1961 to present after the construction and operation of Buckhorn Lake. The unregulated POR at Lock 14 was extended between 1908 to 1920 by transposing Lock 10 data to Lock 14 data.

To transpose Lock 10 USGS Gage 03284000 at Winchester data to extend the Lock 14 POR, the MOVE.3 function as described in B17C was used. The transposition is based on observed correlation between the base-10 logarithms of the annual maximum series available at two sites. Several primary conditions should be met before use of the MOVE.3 function, which include:

- A minimum of 10 concurrent years of record between the two sites
- A correlation coefficient $\rho > 0.80$

- Slope of the linear regression model $b > 0$

The Lock 10 USGS gage 3284000 at Winchester has unregulated annual peak flow data from 1908 to 1960 and the Lock 14 USGS gage 03282000 at Heidelberg has unregulated annual peak flow data from 1921 to 1960. This yields 40 years of concurrent similar observed data between the two sites and 13 potential years of record extension. Calculation of the correlation coefficient for the two data sets from MOVE.3 yields a value of $\rho = 0.92$ and the slope yielded a value of $b = 1.21$. Therefore, the above conditions were met, and the MOVE.3 function was used for record extension. The MOVE.3 function also generates the estimated extended record length for the most recent non-overlapping years, which in this instance was an extension of 8 years. The drainage area ratio between the Lock 10 USGS gage 03284000 at Winchester and the Lock 14 USGS gage 03282000 at Heidelberg is 1.49, which is a reasonable drainage area ratio for systematic data transposition. Therefore, the Lock 14 USGS gage 03282000 at Heidelberg annual peak flow data was extended 8 years between 1913 to 1920 by transposing Lock 10 USGS gage 3284000 at Winchester annual peak flow data via the MOVE.3 function.

Figure 3.6 shows the results of the MOVE.3 function with 1 to 1 ratio line, concurrent period data, extend period data, and linear best fit line for the concurrent period data on a log-log scale. Table 5 shows the record extension values at the Lock 14 USGS gage 03282000 at Heidelberg via the MOVE.3 function.

It should be noted that the Lock 14 transposed annual peak flows shown in Table 5 can exceed the corresponding annual peak flows at Lock 4 which has a larger drainage area. It is believed that flows attenuate as they move down the Kentucky River where the floodplain is substantially wider at Lock 4. This can result in longer periods of elevated flows at Lock 4 but also mitigates the peak flow. The steep, rugged terrain contributing to Lock 14 results in the opposite conditions where the flashy nature of the floods result in high peak values but shorter durations. These conditions cause higher peak flows at Lock 14 compared to Lock 4 but the duration and total volume of flow at Lock 4 is still considerably higher compared to Lock 14.

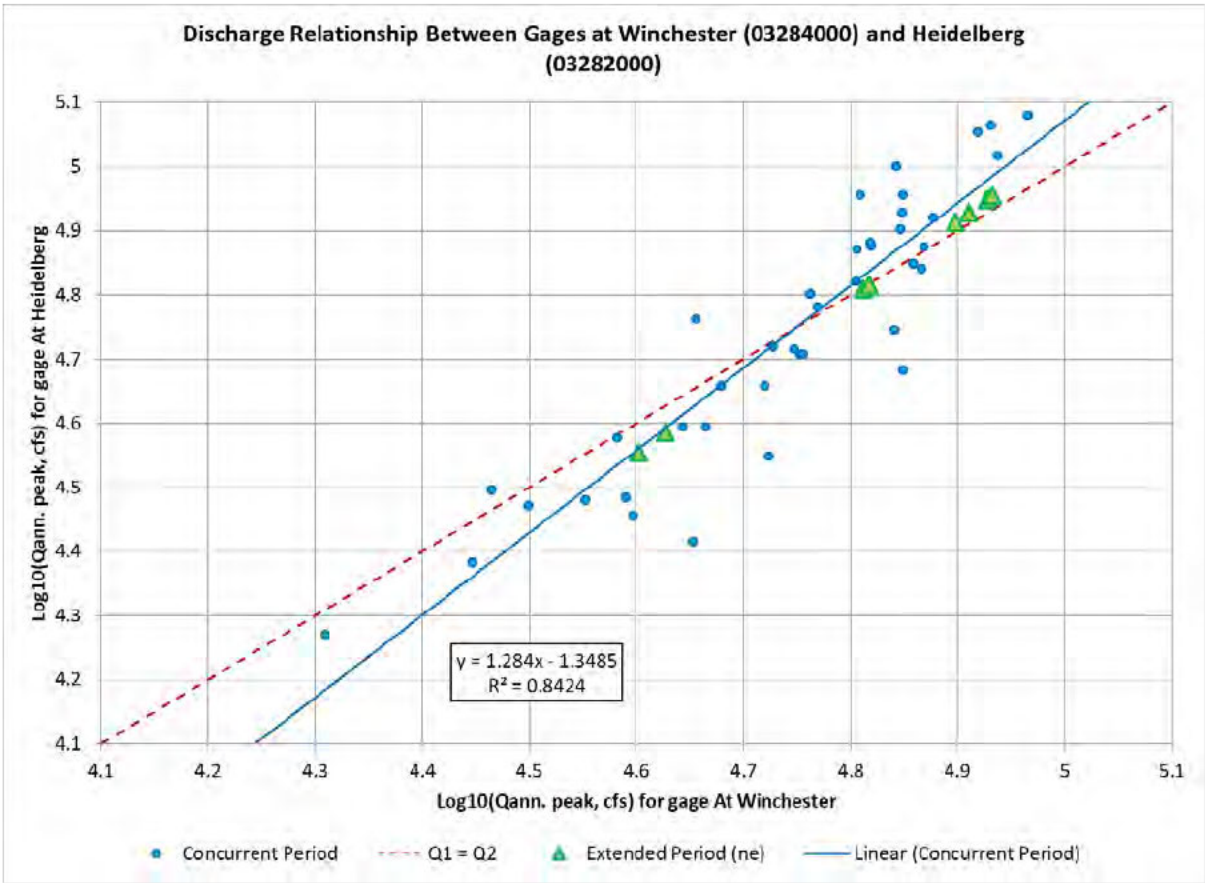


Figure 3-6: Lock 14 and Lock 10 Inflow Correlation with MOVE.3 Extension (Log-Log Scale)

Table 5: Lock 14 MOVE.3 Function Record Extension

Year	***Lock 10 Flow (cfs)***	***Lock 14 Transposed MOVE.3 Flow (cfs)***
1913	84,600	88,900
1914	40,000	35,900
1915	42,400	38,600
1916	85,600	90,100
1917	64,800	64,400
1918	81,300	84,700
1919	65,600	65,300
1920	79,100	81,900

3.5.2 Period of Record Extension Lock 4 to Lock 14

USGS gage data at Lock 4 was also used to supplement the data set with historic flows. Lock 4 USGS gage 03827500 at Frankfort has annual flood and gage data dating back to 1895 and has historic flood gage heights from 1817, 1847, 1854, 1880, and 1883. Therefore, Lock 4 data was reviewed for correlations to see if the POR for Lock 14 could be extended using transposed data.

Lock 4 has a drainage area of 5,292 square miles and Dix Dam has a drainage area of 439 square miles, which is approximately 8% of the drainage area for Lock 4. Due to the small percentage of regulation impact, flows between Lock 4 and Lock 14 were reviewed neglecting the impacts of regulation of the Dix Dam to see if a correlation could be identified. Concurrent annual peak flow data from 1921 through 1960 from Lock 4 USGS gage 03284500 at Frankfort was plotted against Lock 14 USGS gage 03282000 at Heidelberg and various trendlines were fit to the data based on unregulated conditions for Lock 14 to see if a correlation could be made. The same data was also plotted and compared on a log-log scale with a linear trendlines fit to the data. Figure 3.7 and Figure 3.8 show the Lock 4 to Lock 14 direct flow and log-log flow comparisons, respectively. Direct flow comparisons show the drainage area ratio, 1 to 1 ratio line, and exponential trendline. Log-log comparisons show a linear trendline.

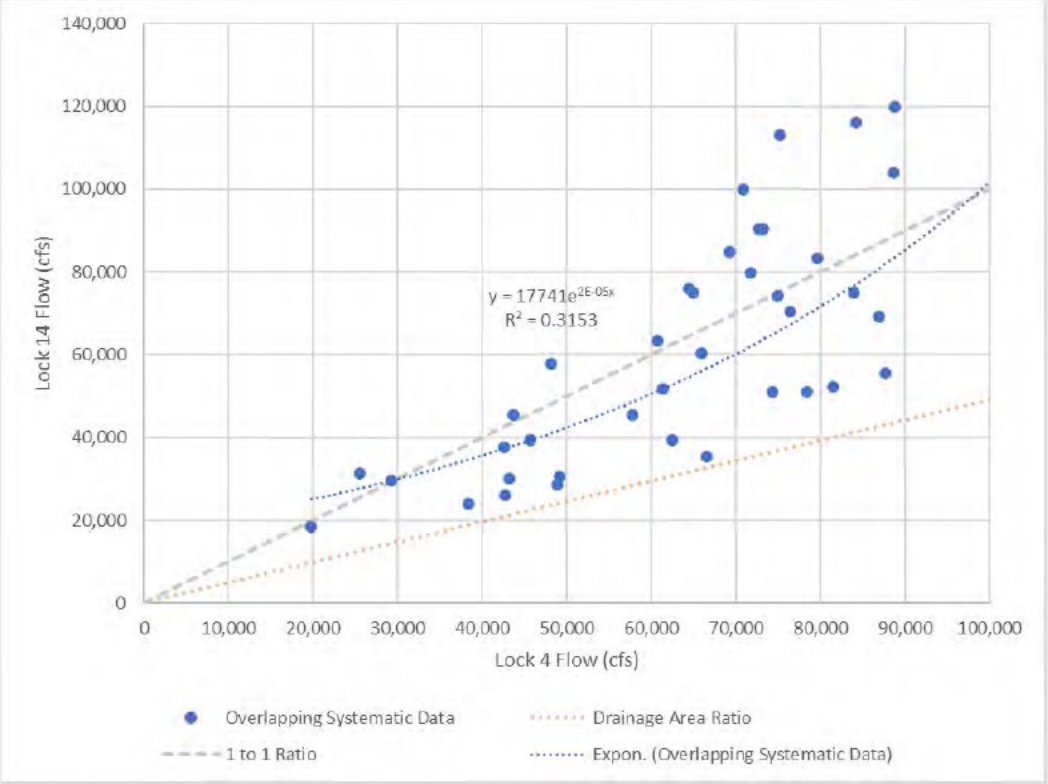


Figure 3-7: Lock 4 and Lock 14 Annual Peak Flow Data Comparison

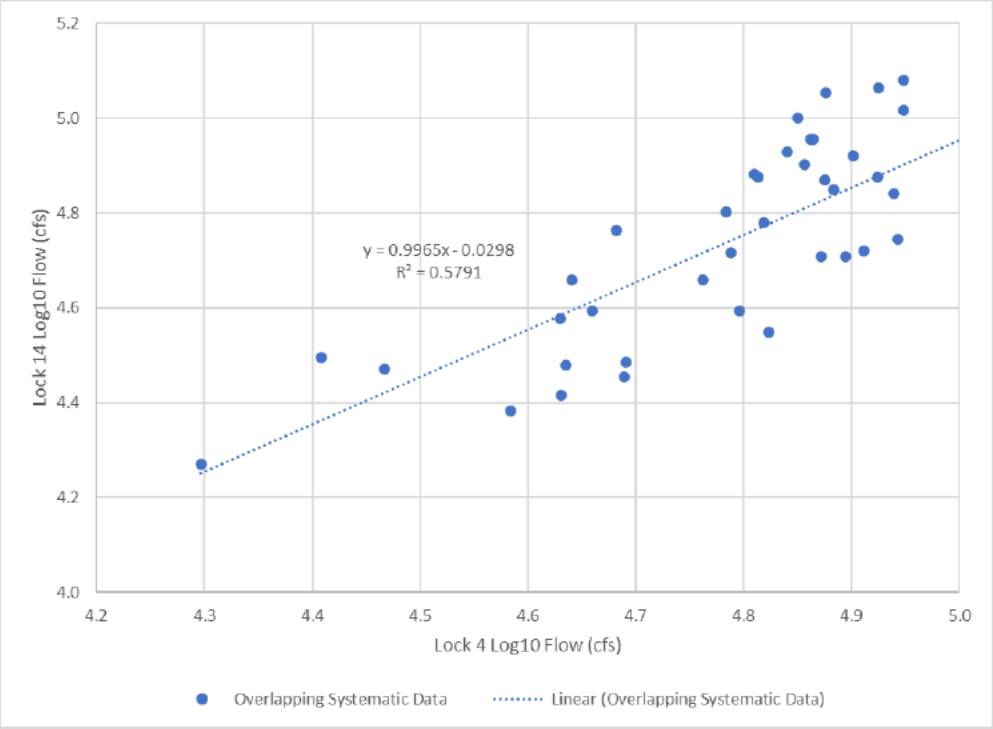


Figure 3-8: Lock 4 and Lock 14 Annual Peak Flow Data Comparison (Log-Log)

All r squared values were below 0.6, therefore correlation was not considered high enough for including this data as systematic data in the composite period of record. Although r squared values resulted in a value where systematic record extension was not considered feasible, events between Lock 4 and Lock 14 for annual peak inflows between 1921 and 1960 were reviewed to identify if peak flow values occurred from the same precipitation event at each location. Table 6 summarizes the events and corresponding annual unregulated peak inflows. Events shaded in green indicate peak flow values that occurred from the same precipitation event.

Table 6: Lock 4and Lock 14 Corresponding Event Comparison

	Lock 14		***Lock 4***	
Water Year	***Date***	***Peak Flow (cfs)***	***Date***	***Peak Flow (cfs)***
1921	4/17/1921	29,600	4/19/1921	29300
1922	2/21/1922	75,100	2/23/1922	65,000
1923	2/4/1923	84,800	2/6/1923	69,300
1924	1/4/1924	55,600	1/4/1924	87700
1925	2/16/1925	51,000	12/9/1924	74400

1926	1/22/1926	51,900	1/24/1926	61400
1927	12/23/1926	90,400	12/26/1926	72,700
1928	6/29/1928	35,300	7/1/1928	66500
1929	3/24/1929	113,000	3/27/1929	75,200
1930	11/18/1929	24,100	2/5/1930	38400
1931	4/23/1931	45,500	4/25/1931	43700
1932	1/31/1932	79,700	2/2/1932	71,800
1933	2/21/1933	45,500	2/23/1933	57800
1934	3/4/1934	76,100	3/6/1934	64,500
1935	3/13/1935	83,300	3/13/1935	79,700
1936	4/7/1936	60,300	4/10/1936	65900
1937	1/26/1937	48,200	1/25/1937	115000
1938	7/15/1938	26,000	7/16/1938	42700
1939	2/4/1939	120,000	2/7/1939	88,800
1940	4/21/1940	39,300	4/23/1940	45700
1941	7/6/1941	31,300	7/7/1941	25600
1942	7/10/1942	30,200	8/24/1942	43200
1943	3/20/1943	66,200	-	-
1944	4/12/1944	52,400	12/31/1943	81500
1945	3/6/1945	51,000	3/7/1945	78400
1946	1/9/1946	90,300	1/12/1946	73,200
1947	6/29/1947	57,900	7/1/1947	48100
1948	2/15/1948	104,000	2/17/1948	88,700
1949	3/19/1949	39,300	2/16/1949	62500
1950	2/2/1950	69,200	2/2/1950	87000
1951	2/2/1951	100,000	2/5/1951	70,900
1952	3/24/1952	70,500	3/26/1952	76,400

1953	5/7/1953	30,500	3/4/1953	49100
1954	1/17/1954	18,600	3/5/1954	19800
1955	3/1/1955	75,000	3/6/1955	84,000
1956	2/19/1956	74,200	2/19/1956	75,000
1957	1/30/1957	116,000	2/3/1957	84,200
1958	5/8/1958	63,300	5/11/1958	60800
1959	1/23/1959	37,700	1/22/1959	42600
1960	3/18/1960	28,500	6/24/1960	48900

As shown in Table 6, the same precipitation event caused the annual peak inflow at Lock 4 and Lock 14 for 28 years out of the total 40 years of overlapping unregulated data. Therefore, annual peak inflows from Lock 14 to Lock 4 are typically caused by the same precipitation event. In years where the annual peak inflows do not align between Locks 4 and Lock 14 (12 of 40 years), it is believed this may be due to storm orientation and placement. For these events, the storms may be centered below Lock 14 within the Kentucky River Basin, resulting in higher peak flows at Lock 4 that do not correlate back to Lock 14.

Numerous overlapping annual peak inflow data points in Table 6 show that Lock 14 flows can exceed the corresponding flows at Lock 4, which has a larger drainage area. As previously noted, this is believed to be a result flow attenuation as flow moves downstream and the flashy nature of the headwater basins. Due to uncertainty in the Lock 4 to Lock 14 transposition, it was determined that the Lock 4 data should not be utilized as systematic or flow interval data as part of the inflow frequency analysis. However, since peak flows at Lock 14 generally coincide with the same precipitation event at Lock 4, it was used to develop perception threshold data as discussed further in Section 4.6.1.

3.5.3 Period of Record Extension Lock 6 and Lock 8 to Lock 14

Both Lock 6 USGS gage 03287000 at Salvisa and Lock 8 USGS gage 03284500 at Camp Nelson were reviewed to potentially extend the POR for Lock 14 USGS gage 03282000 at Heidelberg. Lock 8 USGS gage has annual peak flow data dating back to 1911. A MOVE.3 function review indicated annual peak flow data from Lock 8 could only extend the POR by 4 years, which is less than Lock 10. Therefore, Lock 8 data was not used to further supplement the Lock 14 POR.

A MOVE.3 function review was also performed for Lock 6 correlations were not high enough to warrant record extension. Similar analysis was performed on Lock 6 gage data as described for Lock 4 in Section 4.5.2, but correlations were found to be substantially lower. Therefore, Lock 6 data was not used to further supplement the Lock 14 POR.

3.5.4 Period of Record Extension at Lock 14 From 1960 to the Present

Three data sources were reviewed to establish the regulated-unregulated flow relationship at Lock 14. These sources include:

- Spreadsheet model provided by LRL Water Management
- The Buckhorn Lake WCM
- Modified HEC Hydrologic Modeling System (HMS) analysis of the Kentucky River Basin

The spreadsheet model provided by LRL Water Management includes estimated unregulated stage heights and stage height reductions of numerous regulation structures in Kentucky and Indiana for major storm events from 2015 to 2022, including reductions at Lock 14 based on the regulation of Buckhorn Lake. Stage heights at Lock 14 from the spreadsheet model were converted to estimated flow values using a rating curve developed based on Lock 14 USGS gage 03282000 at Heidelberg, which is included previously in Figure 3.4. As noted in Section 4.4.2, this rating curve does not account for the uncertainty in the sloped rating curve that has been developed based on field measurements performed by the USGS.

Table 7 summarizes the spreadsheet model storm events, estimated unregulated stage height, estimated regulated stage height, and estimated flows based on the Lock 14 rating curve. The unregulated and regulated flow estimates in this analysis are plotted in Figure 3.11 at the end of this section.

Table 7: Spreadsheet Model Lock 14 Impacts from Buckhorn Lake Regulation

Date	*Unregulated Stage (ft)*	*Regulation Stage (ft)*	*Regulation Reduction (ft)*	*Unregulated Flow (cfs)*	*Regulated Flow (cfs)*
2/23/2015	22.4	20.3	2.1	52,100	41,500
3/6/2015	26.2	23.3	2.9	71,100	56,600
4/4/2015	21.7	20.4	1.3	48,600	42,000
4/15/2015	22.2	20.7	1.5	51,100	43,600
7/16/2015	24.0	21.5	2.5	60,100	47,600
12/26/2015	20.0	18.2	1.8	40,000	31,000
2/4/2016	20.4	19.0	1.4	42,000	35,000
2/17/2016	23.1	20.9	2.2	55,600	44,600
5/2/2016	22.4	20.9	1.5	52,100	44,600
7/16/2015	24.0	21.5	2.5	60,100	47,600
4/24/2017	21.3	19.8	1.5	46,600	39,000

2/12/2018	24.4	22.3	2.1	62,100	51,500
2/18/2018	20.0	19.3	0.7	40,000	36,500
3/26/2018	20.6	19.8	0.8	43,100	39,100
12/16/2018	20.4	19.9	0.5	42,000	39,500
2/21/2019	22.8	21.5	1.3	54,100	47,600
2/24/2019	25.5	23.9	1.6	67,600	59,600
12/18/2019	22.1	21.5	0.7	50,600	47,300
12/31/2019	20.5	20.2	0.3	42,500	41,000
2/7/2020	23.9	21.6	2.4	59,600	47,800
2/14/2020	22.0	20.8	1.2	50,100	43,900
3/22/2020	20.8	20.1	0.8	44,100	40,300
3/2/2021	36.0	33.6	2.4	120,300	108,200
3/29/2021	22.9	21.3	1.6	54,600	46,600
7/29/2022	27.1	26.2	0.9	75,600	71,100

Table 5 from the Buckhorn Lake WCM shows a summary of flood frequency data, including a relationship between unregulated and regulated flows for the 2-, 5-, 10-, 25-, 50-, and 100-year events for Lock 14. Figure 3.9 shows Table 5 from the Buckhorn WCM.

TABLE 4-5

SUMMARY OF FLOOD FREQUENCY DATA

USGS Station Number	Stream Name and Location	Type of Flow	Peak Discharge in cfs 2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	Record No. of Years	Record Period	Max. Known Discharge Date	Max. Known Discharge cfs
03280600	Middle Fork Kentucky River nr Hyden	N *	14,800	23,200	31,000	42,600	53,600	64,800	28	1957-84	1957	60,000
03281000	Middle Fork Kentucky River at Tellega	N *	15,400	23,700	35,000	49,500	61,000	70,000	14	1939-53	1957	52,700
		M **	4,660	5,900	7,040	9,260	11,100	13,400				
03282000	Kentucky River @ Lock 14 @ Heidelberg	N *	63,000	82,500	96,700	114,000	127,000	139,000	59	1921-79	1939	120,000
		M ***	53,400	69,700	81,300	96,200	118,000	119,300				
		M ***	53,400	69,000	80,200	95,000	116,600	118,300				

* Natural
** Modified by Buckhorn Lake
*** Modified by Buckhorn lake + Carr Fork Lake

Figure 3-9: Buckhorn Lake WCM Table 5

The unregulated values for Lock 14 and the regulated values noted as 'Modified by Buckhorn Lake + Carr Fork Lake" were plotted in Figure 3.11. It should be noted that two rows in the Buckhorn Lake WCM Table 5 are designated with "***" for Lock 14 flows. The row second from the bottom in the Buckhorn Lake WCM Table 5 is assumed to be a typo and should be designated as "**", which based on the footnote means values are "Modified by Buckhorn Lake".

Additionally, the modified Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) model used a calibrated HEC-HMS CWMS model of the entire Kentucky River basin created in 2016 by the USACE Louisville District as a basis. No further calibration or validation was performed on the model as part of this analysis. The following modifications were made to the model for the purposes of this assessment:

- All nodes and reaches downstream of Lock 14 removed.
- All nodes and reaches upstream of Buckhorn Lake removed.
- All nodes and reaches in North Fork upstream of the North Fork and Middle Fork confluence removed.
- All nodes in the South Fork removed.

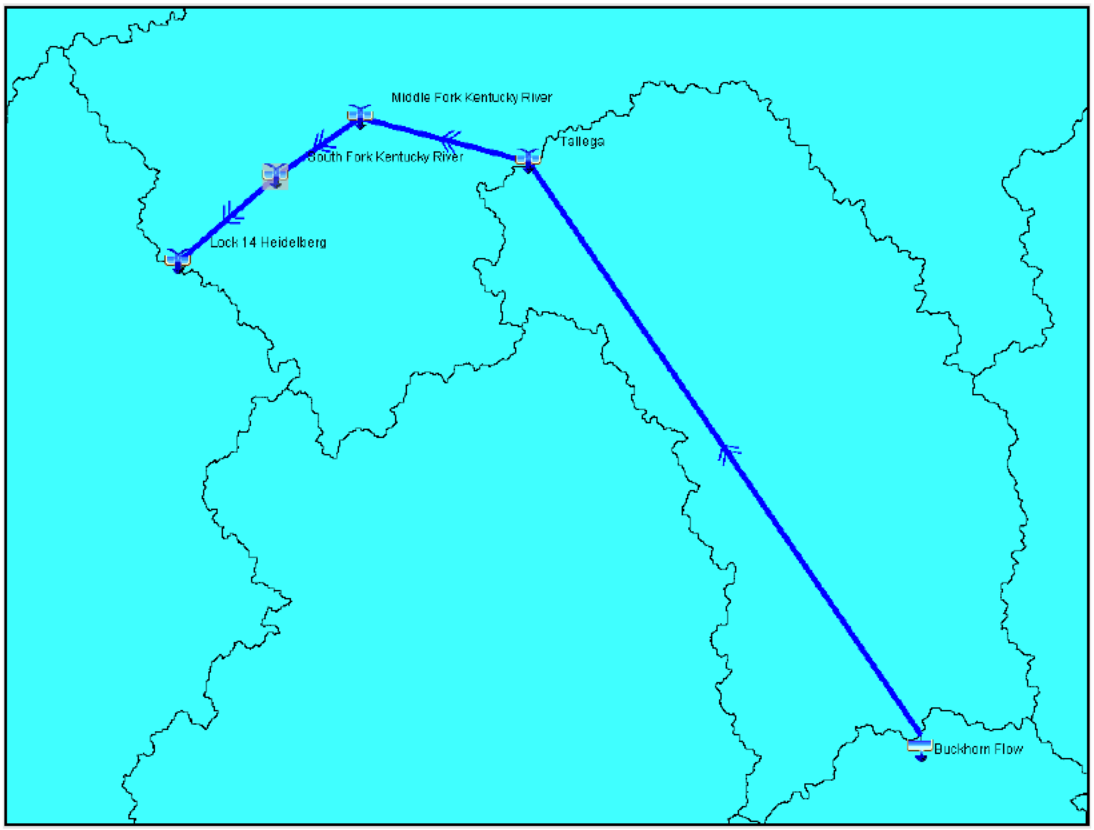


Figure 3-10: HEC-HMS Modified Model for Lock 14 and Buckhorn Lake

These edits created a model representing only the nodes and reaches between Buckhorn Lake and Lock 14. The North Fork and Carr Creek Lake were removed from the model to simplify the modeling due to the fact that Carr Creek provides minimal regulation compared to Buckhorn Lake.

Operational data from Buckhorn Lake was obtained from the Louisville District Water Management section, which included the following data between November 24, 1982, through May 2022 for Buckhorn Lake in 6-hour time increments. Operational data included:

- Buckhorn Lake stage height (ft)
- Buckhorn Lake outflow (cfs)
- Buckhorn Lake inflow (cfs)

A new 6-hour increment time series was created by subtracting the Buckhorn Lake outflow data from the inflow data during storm events. This time series represents the amount of flow stored, or regulated, by Buckhorn Lake during storm events.

The flow stored time series was then routed through the modified model as a specific discharge gage at the Buckhorn Lake location. This analysis created an estimated 6-hour time series of the reduction in flows in Middle Fork at the Tallega gage and at Lock 14 by the regulation of Buckhorn Lake.

Detailed USGS data was then downloaded at Lock 14 and Tallega. Detailed data included discharge values in hourly increments for Lock 14 USGS gage 03282000 at Heidelberg from October 1987 to February 2004 and for Middle Fork USGS gage 03281000 at Tallega from October 1987 to May 2004, after which both gage locations had 15-minute increment discharge data available through the present. The discharge data from the Lock 14 and Tallega gages were converted to 6-hour time increments to align with the operational data for Buckhorn Lake. Output results at Lock 14 and Tallega from the modified HEC-HMS simulation using the Buckhorn Lake flow stored time series were added to corresponding converted 6-hour time increment peak discharges from the USGS gage to estimate flow in the unregulated condition. Annual peak flow events from 1988 to 2014 and corresponding major flow events between 2015 and 2021 in the spreadsheet model were analyzed in this way to develop the unregulated to regulated flow relationship. Table 8 summarizes the results at Lock 14 of these events for the modified HEC-HMS model analysis.

Table 8: HEC-HMS Lock 14 Regulation Analysis Results

Date	***Lock 14 Regulated Flow (cfs)***	***HEC-HMS Flow Stored (cfs)***	***Estimated Unregulated Flow (cfs)***
1/20/1988	22,667	389	23,056
6/16/1989	55,317	707	56,023
10/18/1989	52,233	21,018	73,251
2/20/1991	41,667	9,351	51,018
12/4/1991	53,633	10,082	63,716
3/5/1993	34,250	3,025	37,275

3/29/1994	54,417	9,116	63,533
5/19/1995	41,667	676	42,342
5/29/1996	42,300	202	42,502
3/4/1997	35,800	4,531	40,331
4/20/1998	53,900	16,029	69,929
1/10/1999	38,300	636	38,936
4/5/2000	28,233	7,453	35,686
2/17/2001	35,883	3,887	39,770
3/19/2002	45,717	19,381	65,098
2/17/2003	76,500	5,784	82,284
2/7/2004	59,867	3,528	63,394
5/1/2005	45,708	8,969	54,677
1/24/2006	27,450	6,310	33,760
4/16/2007	35,154	13,628	48,782
4/5/2008	23,608	1,379	24,987
5/9/2009	52,454	3,497	55,951
1/25/2010	40,450	10,154	50,604
4/17/2011	35,500	9,860	45,360
1/21/2012	25,117	1,918	27,035
1/17/2013	35,458	11,619	47,078
12/7/2013	33,546	4,496	38,042
2/23/2015	34,621	10,357	44,978
3/6/2015	51,542	19,695	71,237
4/4/2015	35,608	700	36,308
4/15/2015	37,958	4,399	42,357
7/16/2015	41,054	12,863	53,917
12/26/2015	24,567	3,785	28,352

2/4/2016	28,483	4,012	32,495
2/17/2016	39,496	13,106	52,602
5/2/2016	37,867	5,358	43,224
7/16/2015	41,054	12,863	53,917
4/24/2017	33,063	12,443	45,506
2/12/2018	47,617	24,112	71,728
2/18/2018	30,254	7,378	37,632
3/26/2018	33,258	10,667	43,926
12/16/2018	33,604	4,685	38,289
2/21/2019	42,808	10,695	53,504
2/24/2019	57,425	13,452	70,877
12/18/2019	41,325	6,969	48,294
12/31/2019	34,642	5,710	40,352
2/7/2020	43,167	24,491	67,658
2/14/2020	39,046	11,599	50,644
3/22/2020	33,904	8,143	42,047
3/2/2021	88,400	24,667	113,067
3/29/2021	41,492	20,228	61,719

The three data sources were plotted overlapped to select the regulated-unregulated flow relationships for Lock 14. Figure 3.11 shows the regulated-unregulated flow relationships from the three data sources with linear trendlines of each. Trendlines for each source had good correlation and plotted similarly against one another. The spreadsheet model and Buckhorn Lake WCM data trendlines were very similar with the modified HEC-HMS analysis plotting only slightly below. The Buckhorn Lake WCM relationship was used as the final regulated-unregulated flow relationship for Lock 14. This was the original estimated relationship when Buckhorn Lake was constructed, incorporates the regulation of North Fork based on the construction of Carr Creek Lake, and the other two data sources plotted similarly against it, indicating it is still a valid relationship for current conditions. A 10% upper and lower uncertainty bound is also shown on Figure 3.11 for reference.

Utilizing this relationship, the unregulated POR at Lock 14 was extended between 1961 to 2022 by transposing regulated flows with an established regulated-unregulated flow relationship for Lock 14.

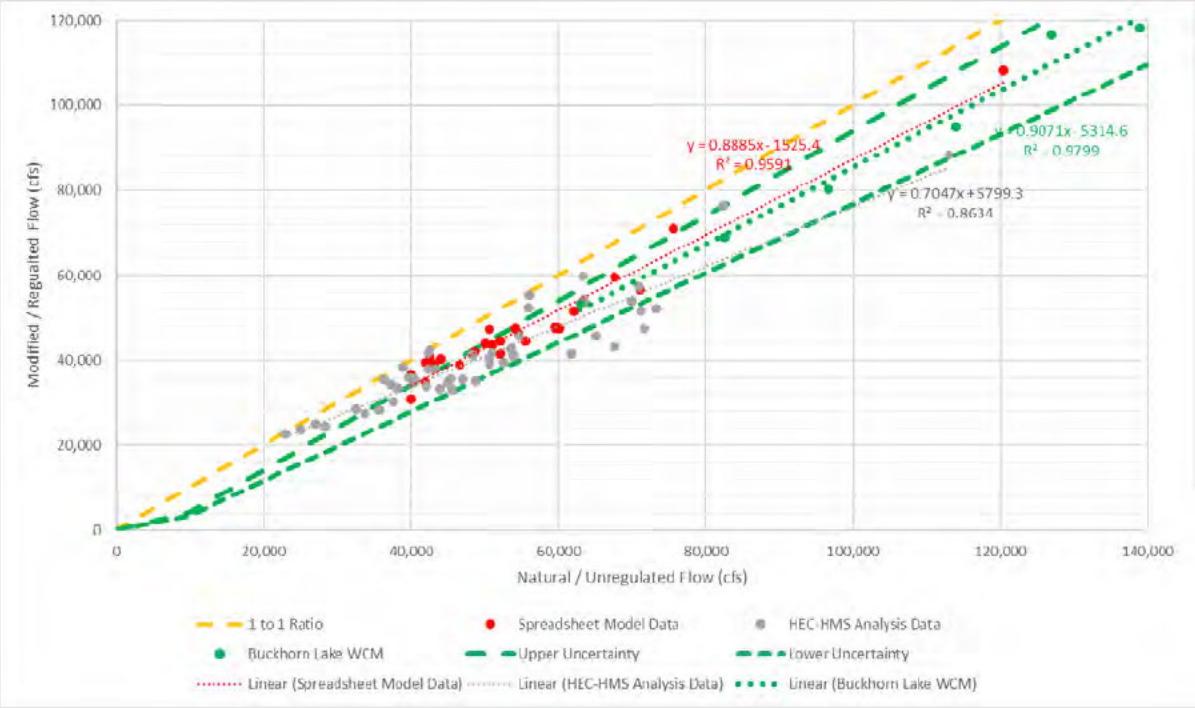


Figure 3-11: Lock 14 Regulated-Unregulated Relationship Review

3.6 HYDROLOGIC HAZARD CURVES – LOCK 14 AT HEIDELBERG

3.6.1 Perception Thresholds

Historic flood data dating back as far as 1817 at Lock 4 was also used to supplement the POR using PTs. In lieu of including direct systematic data transpositions from the Lock 4 USGS gage 03287500 at Frankfort, PTs were developed. Two PTs for Lock 14 were established, one based on the historic data between 1817 and 1894, and one for the annual peak inflow data at the Lock 4 USGS gage between 1895 and 1912 available at the Lock 4 USGS gage 03287500 at Frankfort.

For the historic data PT, a rating curve for Lock 4 was used to approximate the historic flood peak flows from 1817, 1847, 1854, 1880, and 1883 which only included gage heights. Figure 3.12 shows the Lock 4 USGS rating curve developed best on USGS data with linear best fit line and the current published USGS rating curve. The best fit line was used in this analysis to calculate Lock 4 flows as the current published USGS rating curve appears to be slightly overestimating flows based on the gage data. Those values are displayed below in Table 9.

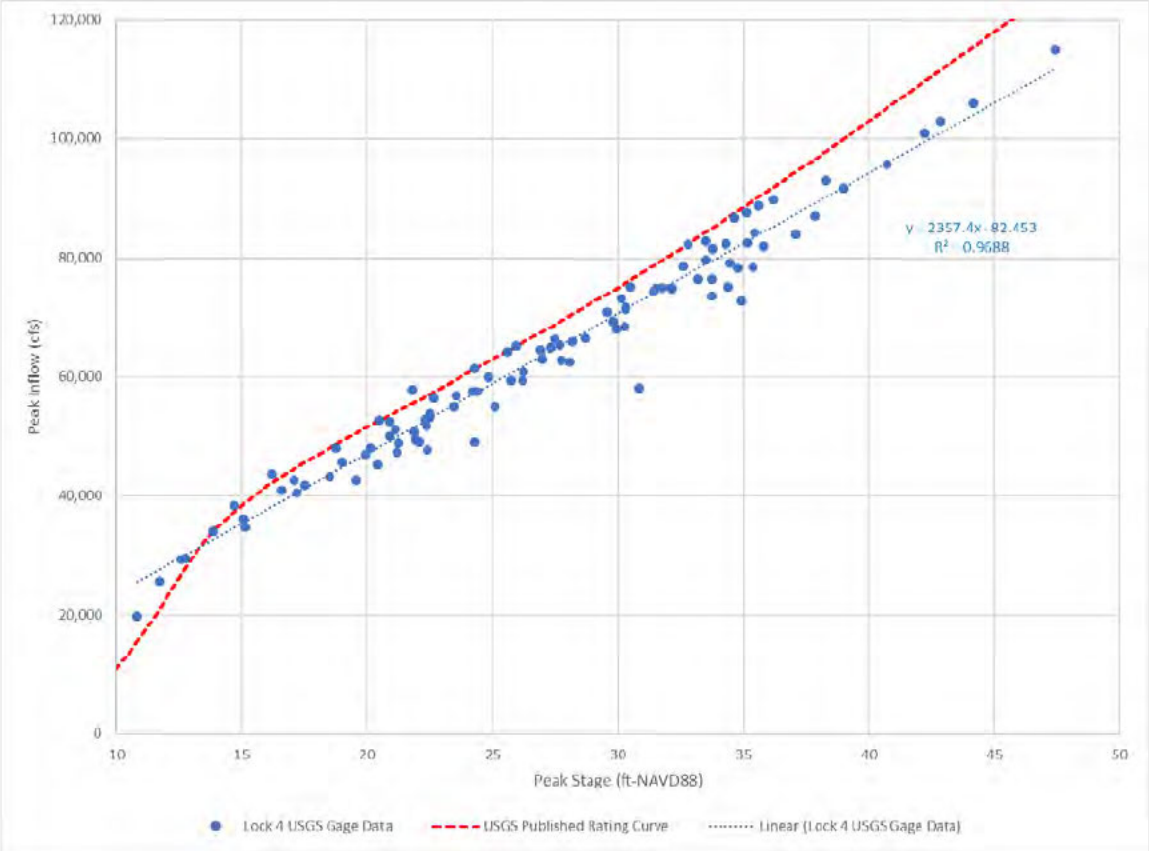


Figure 3-12: Lock 4 Rating Curve

Table 9: Peak Flows Calculated from Lock 4 Historic Stages

Water Year	***Lock 4 Peak Flow (cfs)***
1817	88,300
1847	87,100
1854	86,000
1880	87,100
1883	98,900

Next, scaling factors for unregulated annual peak flows for corresponding events from Lock 4 to 14 were developed. Table 10 shows a summary of the calculated scaling factors from corresponding annual peak inflow events between 1921 and 1960 that caused annual peak flows at Lock 14 USGS gage 03282000 at Heidelberg and Lock 4 USGS gage 03287500 at Frankfort.

Table 10: Lock 14 and Lock 4 Inflow Scaling Factors

Date	*Lock 14 Peak Flow (cfs)*	*Lock 4 Peak Flow (cfs)*	*Scaling Factor*
4/17/1921	29,600	29,300	1.01
2/21/1922	75,100	65,000	1.16
2/4/1923	84,800	69,300	1.22
1/4/1924	55,600	87,700	0.63
1/22/1926	51,900	61,400	0.85
12/23/1926	90,400	72,700	1.24
6/29/1928	35,300	66,500	0.53
3/24/1929	113,000	75,200	1.50
4/23/1931	45,500	43,700	1.04
1/31/1932	79,700	71,800	1.11
2/21/1933	45,500	57,800	0.79
3/4/1934	76,100	64,500	1.18
3/13/1935	83,300	79,700	1.05
4/7/1936	60,300	65,900	0.92
7/15/1938	26,000	42,700	0.61
2/4/1939	120,000	88,800	1.35
4/21/1940	39,300	45,700	0.86
7/6/1941	31,300	25,600	1.22
3/6/1945	51,000	78,400	0.65
1/9/1946	90,300	73,200	1.23
2/15/1948	104,000	88,700	1.17
2/2/1950	69,200	87,000	0.80
2/2/1951	100,000	70,900	1.41

3/24/1952	70,500	76,400	0.92
3/1/1955	75,000	84,000	0.89
2/19/1956	74,200	75,000	0.99
1/30/1957	116,000	84,200	1.38
5/8/1958	63,300	60,800	1.04
1/23/1959	37,700	42,600	0.88
		Mean	1.02
		Minimum	0.53
		Maximum	1.50

Based on Table 10, maximum, mean, and minimum scale factors were calculated to be 1.5, 1.02, and 0.50, respectively. Table 11 summarizes the Lock 4 USGS gage 03287500 at Frankfort historic data converted to Lock 14 based on the minimum, maximum and average scale factors.

Table 11: Lock 4 Historic Scaled Data for Lock 14

Water Year	***Lock 4 Peak Flow (cfs)***	***Lock 14 Flow, Minimum Scale Factor (cfs)***	***Lock 14 Flow, Mean Scale Factor (cfs)***	***Lock 14 Flow, Maximum Scale Factor (cfs)***
1817	88,300	46,800	90,100	132,500
1847	87,100	46,200	88,800	130,700
1854	86,000	45,600	87,700	129,000
1880	87,100	46,200	88,800	130,700
1883	98,900	52,400	100,900	148,400

Based on the maximum scale factor flows in Table 10, a rounded PT of 150,000 cfs was selected based on historic data from Lock 4 USGS gage 03287500 at Frankfort between 1817 and 1894.

For the PT for annual peak flow data from 1895 to 1912, a similar process to the historic data was used. Table 12 summarizes the Lock 4 USGS data 03287500 at Frankfort from 1895 to 1912 converted to Lock 14 data based on the maximum and average scale factors.

Table 12: Lock 4 1895 to 1912 Scaled Data for Lock 14

Water Year	*Lock 4 Peak Flow (cfs)*	*Lock 14 Flow, Minimum Scale Factor (cfs)*	*Lock 14 Flow, Mean Scale Factor (cfs)*	*Lock 14 Flow, Maximum Scale Factor (cfs)*
1895	41,600	22,000	42,400	62,400
1896	47,800	25,300	48,800	71,700
1897	76,900	40,800	78,400	115,400
1898	59,800	31,700	61,000	89,700
1899	76,400	40,500	77,900	114,600
1900	29,600	15,700	30,200	44,400
1901	57,600	30,500	58,800	86,400
1902	68,000	36,000	69,400	102,000
1903	70,800	37,500	72,200	106,200
1904	33,400	17,700	34,100	50,100
1905	50,200	26,600	51,200	75,300
1906	50,800	26,900	51,800	76,200
1907	63,400	33,600	64,700	95,100
1908	71,300	37,800	72,700	107,000
1909	82,400	43,700	84,000	123,600
1910	52,900	28,000	54,000	79,400
1911	52,400	27,800	53,400	78,600
1912	64,200	34,000	65,500	96,300

Based on the maximum scale factor flows in Table 12, a rounded PT of 125,000 cfs was selected based on the annual peak unregulated flow data from Lock 4 USGS gage 03287500 at Frankfort between 1895 and 1912.

Data Summary

To summarize, the following information was used to develop the final unregulated POR data used for Lock 14.

- PTs were used for on historic data from 1817 to 1894 and annual peak inflow data from 1895 to 1912 based on Lock 4 USGS gage 0327500 at Frankfort data using scaling factors established between consistent events at Lock 4 and Lock 14.
- Unregulated Lock 10 USGS gage 03284000 at Winchester peak inflow data between 1913 to 1920 was transposed to Lock 14 based on the MOVE.3 function.
- Unregulated flows from Lock 14 USGS gage 03282000 at Heidelberg from 1921 to 1960 were directly used.
- The Buckhorn Lake WCM unregulated to regulated flow relationship was used to transpose Lock 14 USGS gage 03282000 at Heidelberg regulated flows to unregulated flows between 1961 and 2022.

Figure 3.13 shows a visual of the final composite POR used in the assessment.

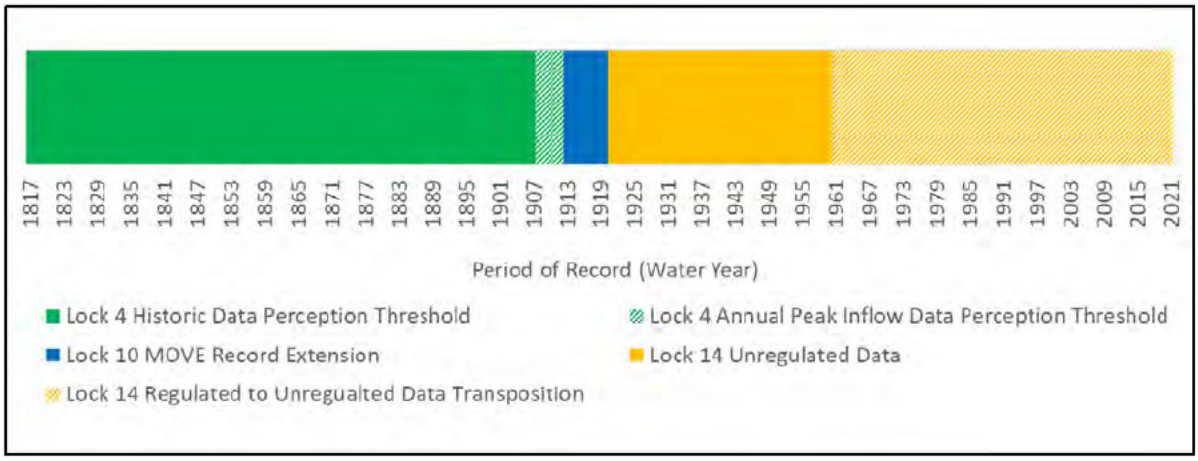


Figure 3-13: Lock 14 Final POR Visualization

3.6.2 Unregulated Flow-Frequency Curve

The composite unregulated annual peak flow POR was used to calculate the peak unregulated flow frequency curve using a B17C analysis in the Hydrologic Engineering Center's (HEC) Statistical Software Package (SSP). The final POR included systematic and transposed data from 1817 to 2022 as previously discussed. Figure 3.14 shows the HEC-SSP expected moment algorithm (EMA) data for the unregulated POR.

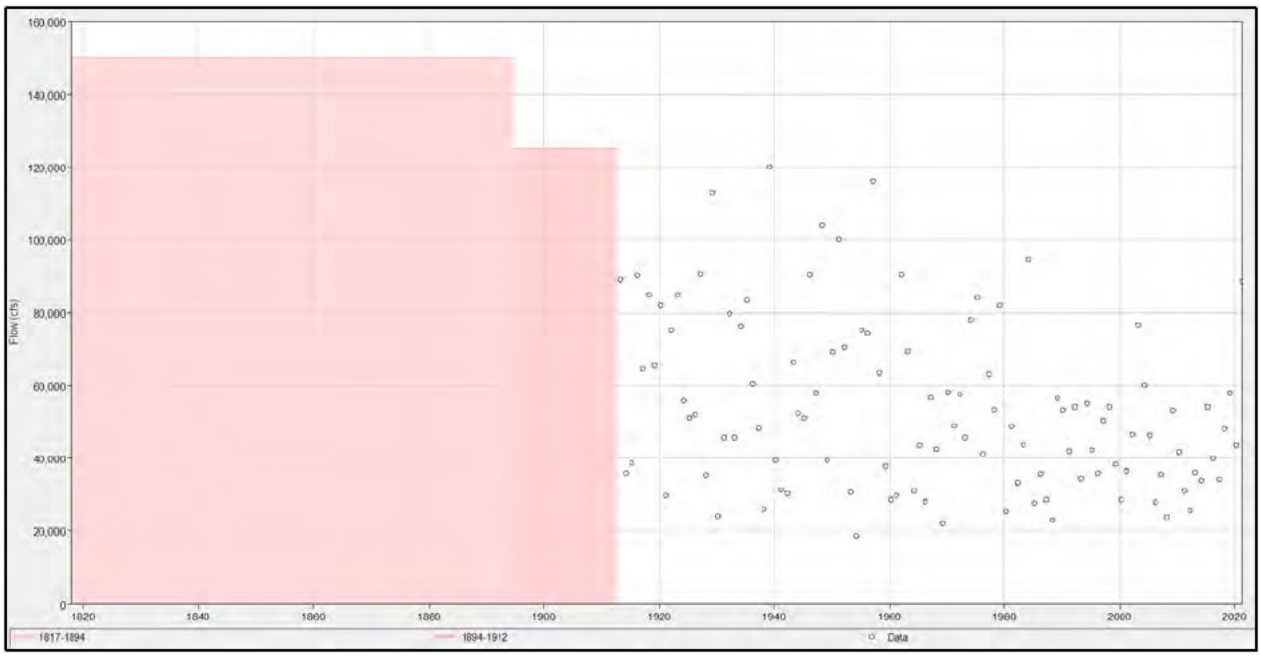


Figure 3-14: Lock 14 Unregulated POR HEC-SSP EMA Data

Regional Skew Information

Regional skew information was available from an existing study published by the USGS in cooperation with the Kentucky Transportation Cabinet. The study is titled "*Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals*" and was published in 2003. The regional skew values for peak flows for the state of Kentucky is 0.011 with a standard error and mean square error of 0.52 and 0.27, respectively. The regional skew was applied to the B17C analysis to develop a weighted skew, which was the final adopted skew for all flow frequency analyses.

Potentially Influential Low Outliers

The Multiple Grubbs-Beck Test was performed on the data to determine if the POR contained any potentially influential low flood (PILF) values. PILF's are reviewed to confirm that small observed inflows do not have an inappropriately large impact on the inflow frequency analysis. The test identified no PILF values.

Unregulated Flow Frequency Sensitivities

To determine how sensitive the analysis is to the inclusion of additional data sources, multiple sensitivities were reviewed by plotting overlapping data from the various data sets. Flow-frequency curves for the following data sets were developed using a B17C analysis in HEC-SSP:

- Lock 14 Unregulated Only – includes unmodified unregulated flow data from Lock 14 USGS gage 03282000 at Heidelberg from 1921 to 1960
- Lock 10 and Lock 14 Combined Unregulated Only – includes transposed unregulated Lock 10 USGS gage 03284000 at Winchester to Lock 14 USGS gage 03282000 at Heidelberg

data via the MOVE.3 function from 1913 to 1920 and unmodified unregulated flow data from Lock 14 from 1921 to 1960.

- Lock 14 Transposed Unregulated – includes unmodified regulated flow data from Lock 14 USGS gage 03282000 at Heidelberg from 1921 to 1960 and transposed regulated to unregulated Lock 14 data from 1961 to 2022.
- Lock 10 Combined and Lock 14 Transposed Unregulated – includes transposed unregulated Lock 10 USGS gage 03284000 at Winchester to Lock 14 USGS gage 03282000 at Heidelberg data from 1913 to 1920 via the MOVE.3 function, unmodified regulated flow data from Lock 14 from 1921 to 1960 and transposed regulated to unregulated Lock 14 data from 1961 to 2022.
- Final POR – includes the final period of record as previously discussed with PTs.

Figure 3.15 show a plot of the curves for the above data sets along with the 1939 unregulated flood of record at 120,000 cfs and the final POR systematic data points.

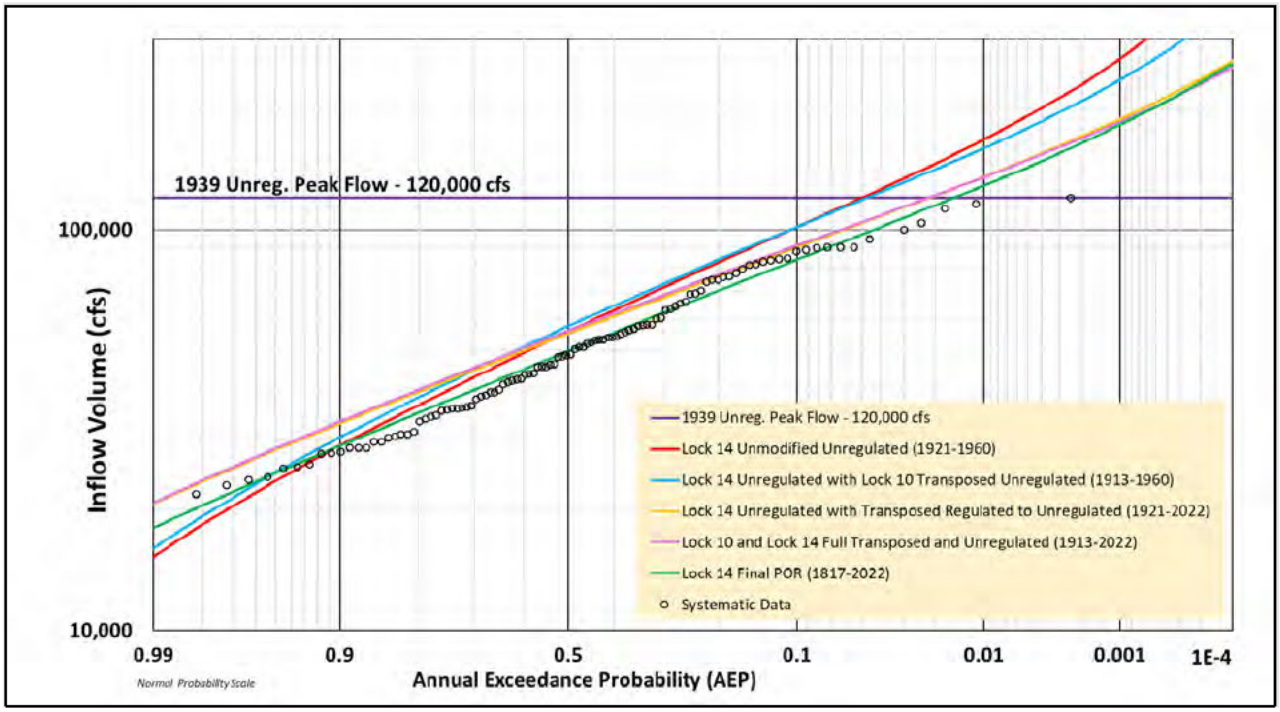


Figure 3-15: Lock 14 Unregulated Inflow Frequency Sensitivities

Table 13 summarizes the mean, standard deviation, and skew of the sensitivities plotted in Figure 3.15, which were similar between the sensitivities reviewed. All plot more frequent for the 1939 flood value compared to the POR final curve.

Table 13: Lock 14 Statistical Summary of Bulletin 17C Sensitivities

Data Set Description	*Mean (of log) (μ)*	*Std. Dev. (of log) (σ)*	*Skew (of log) (γ)*
Lock 14 Unmodified Unregulated (1921-1960)	4.740	0.208	-0.192
Lock 14 Unregulated with Lock 10 Transposed Unregulated (1913-1960)	4.752	0.201	-0.269
Lock 14 Unregulated with Transposed Regulated to Unregulated (1921-2022)	4.739	0.170	-0.098
Lock 10 and Lock 14 Full Transposed and Unregulated (1913-2022)	4.744	0.169	-0.138
Lock 14 Final POR (1817-2022)	4.685	0.179	-0.022

Figure 3.16 shows the final unregulated flow-frequency curve for Lock 14 using the B17C analysis in HEC-SSP.

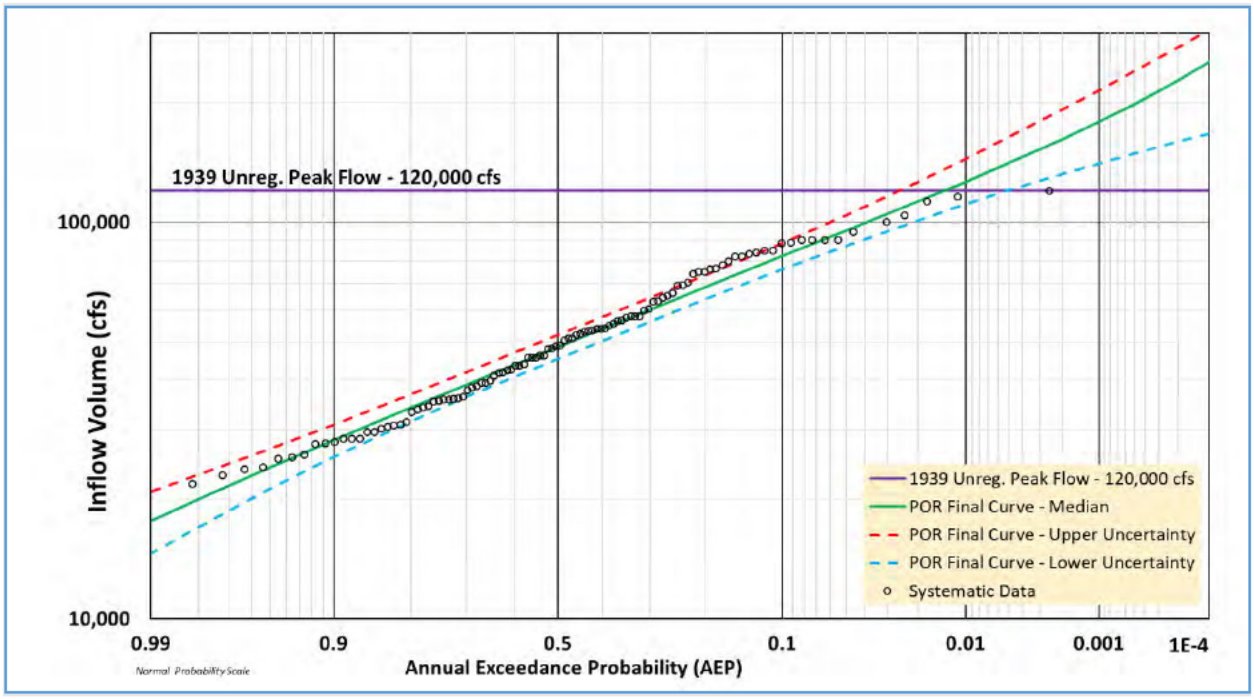


Figure 3-16: Lock 14 Unregulated Flow Frequency Curve

3.6.3 Regulated Flow-Frequency Curve

The previously established regulated-unregulated relationship shown in Figure 3.11 was used to develop the regulated flow frequency curve from the final unregulated flow frequency curve. A sensitivity analysis was performed transposing the unregulated flow frequency curve to a regulated flow frequency curve by directly transposing the data using the best estimate and by also using the upper and lower uncertainty bounds. The comparison of the two transpositions is shown in Figure 3.17.

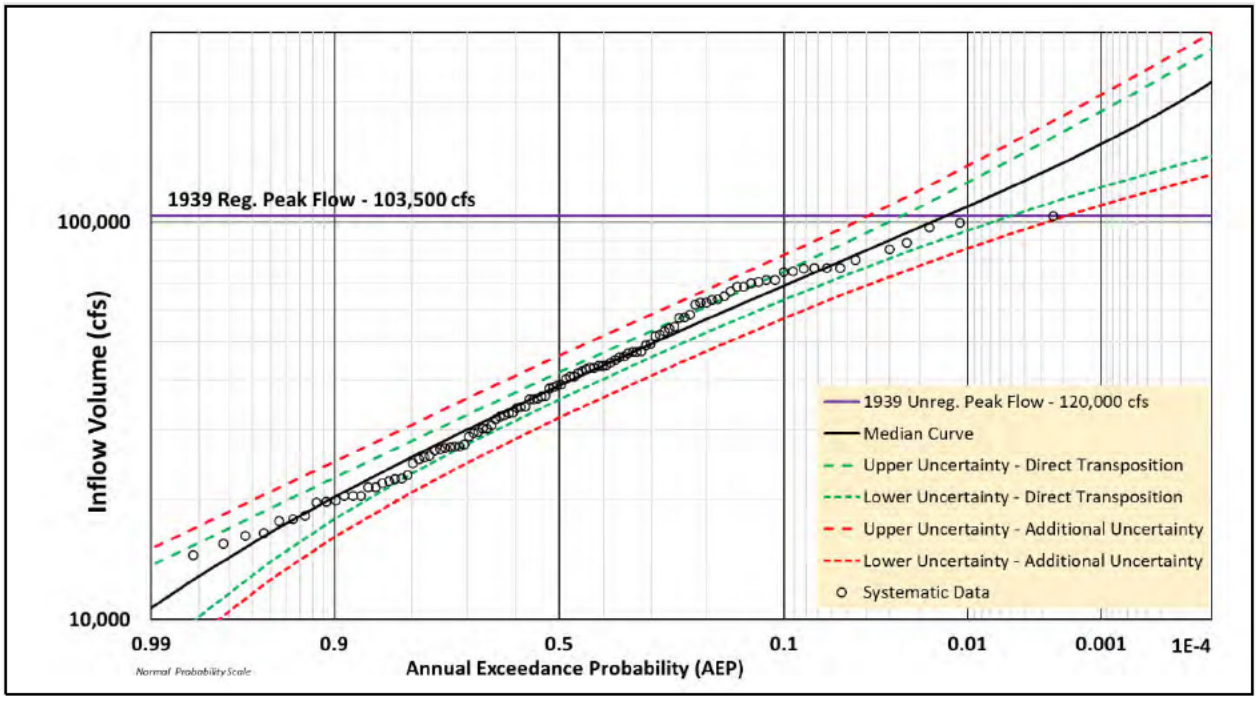


Figure 3-17: Lock 14 Transposed Regulated Flow Frequency Comparison

To incorporate the uncertainty associated with the regulated-unregulated transposition, the transposition using the upper and lower uncertainty bounds was selected.

Figure 3.18 shows the final regulated flow frequency curve for Beattyville.

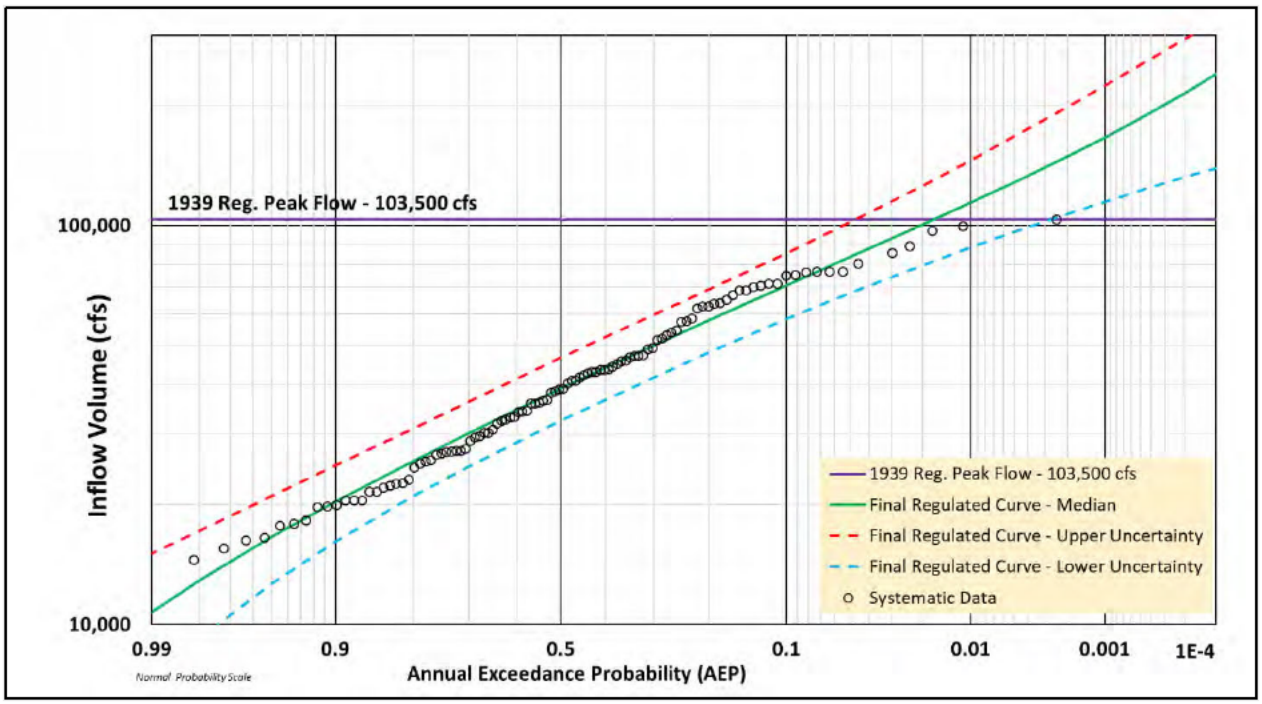


Figure 3-18: Lock 14 Final Regulated Flow-Frequency Curve

The final POR unregulated and regulated flow-frequency curves are plotted in Figure 3.19. The unregulated and regulated systematic data points are shown for reference.

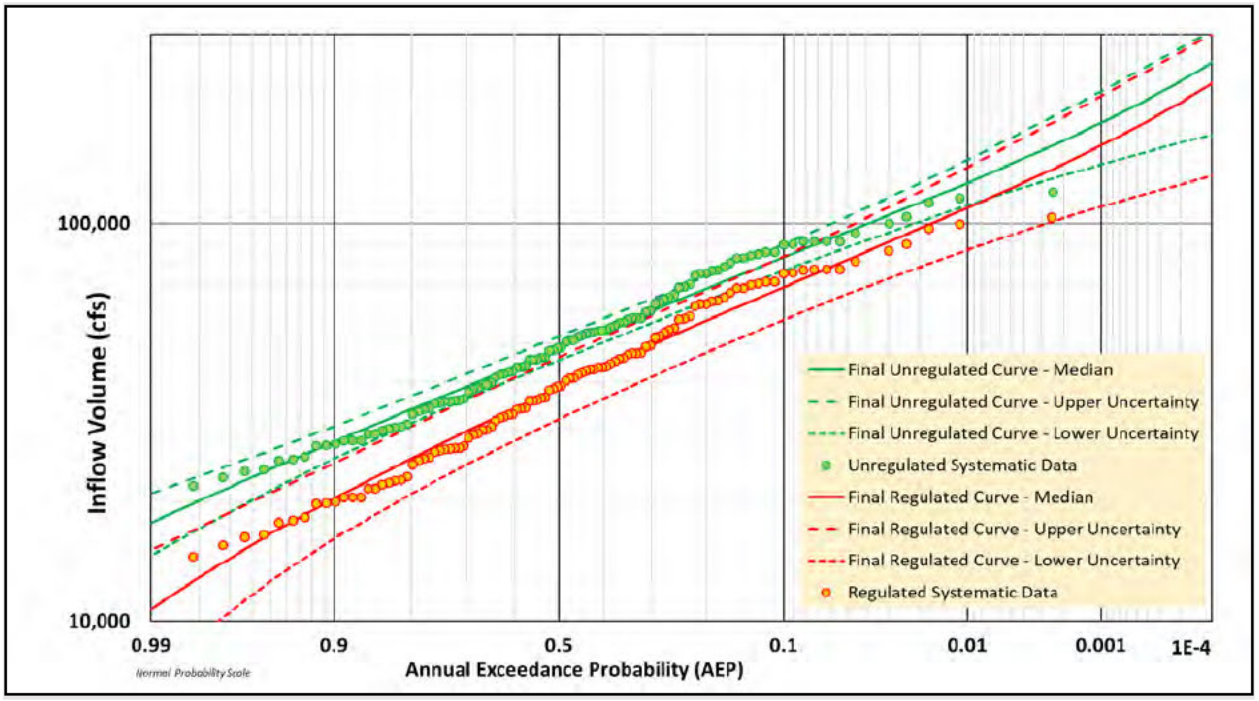


Figure 3-19: Lock 14 Regulated and Unregulated Flow Frequency Curve Comparison

3.6.4 Regulated Stage-Frequency Curve

To develop the final stage-frequency curve for Beattyville, a composite rating curve was developed based on the 500-year AEP event at Cross Section 257.5170 of the HEC-RAS model

developed for the planning study. Cross Section 257.5170 is on the Kentucky River at Beattyville immediately downstream of the confluence of the North Fork and South Fork. Figure 3.20 shows the location of Cross Section 257.5170 from the HEC-RAS model. Figure 3.21 shows the rating curve at Cross Section 257.5170 for the 500-year AEP event with 15% upper and lower uncertainty bounds and the composite curve used to create the stage-frequency curve at Beattyville.



Figure 3-20: Beattyville HEC-RAS Cross Section 257.5170

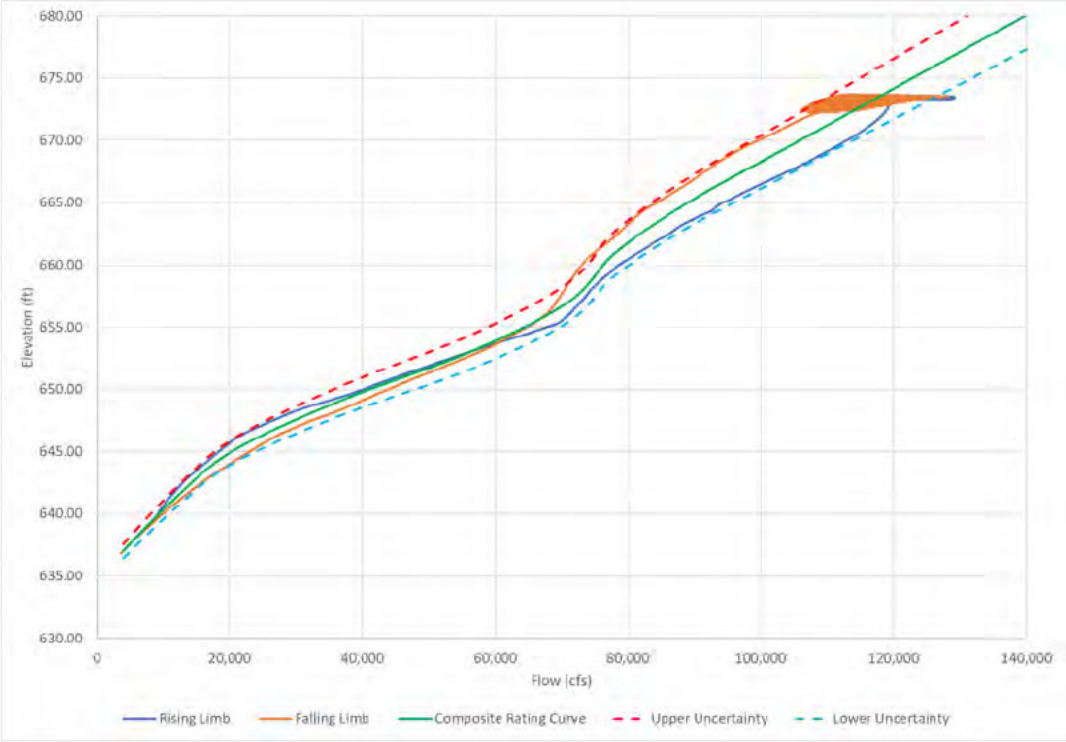


Figure 3-21: HEC-RAS Model Cross Section 257.5170 Rating Curve

As shown in Figure 3.21, the rating curve from the HEC-RAS model creates a hysteresis loop. There is not enough information available with the annual peak flow data to determine if peak inflows occurred during the rising or falling limbs. Therefore, a composite curve was created and used for the development of the stage-frequency curve at Beattyville. For the purposes of creating the composite curve, the noise at the top of the hysteresis loop was simplified.

Annual peak inflows at Cross Section 257.5170 at Beattyville used for the development of the stage frequency curve were adjusted based on a drainage area ratio between the Lock 14 USGS gage 03282000 at Heidelberg drainage area and the Cross Section 257.5170 drainage area. Cross Section 257.5170 is immediately downstream of the confluence of North and South Fork, therefore the total drainage area of the three headwater basins of 2,631 square miles was used for the Beattyville drainage area. The listed drainage area of Lock 14 USGS gage 03282000 at Heidelberg drainage area is 2,657 square miles, therefore a drainage area ratio of 0.99 was used.

To select the degree of uncertainty to incorporate into the final stage frequency curve, a sensitivity analysis was performed. A series of data set conversions for the unregulated to regulated transposition and the transposition from regulated flow to stage were plotted. The data sets compare various stage frequency curves using direct transpositions and using the upper/lower uncertainty bounds shown in Figure 3.11 for the unregulated/regulated relationship and Figure 3.21 for the stage transposition. Four different comparisons were made, which are described below and shown in Figure 3.22.

1. Data set 1 shows the upper/lower stage frequency curve based on a direct transposition of the unregulated/regulated relationship and direct transposition of stage using the composite rating curve.

2. Data set 2 shows the upper/lower stage frequency curve based on using the upper/lower uncertainty bounds shown in Figure 3.11 for the unregulated/regulated relationship and direct transposition of stage using the composite rating curve.

3. Data set 3 shows the upper/lower stage frequency curve based on using the upper/lower uncertainty bounds shown in Figure 3.11 for the unregulated/regulated relationship and the upper/lower uncertainty bounds shown in Figure 3.21 for the stage transposition.

4. Data set 4 shows the upper/lower stage frequency curve based on a direct transposition of the unregulated/regulated relationship and the upper/lower uncertainty bounds shown in Figure 3.21 for the stage transposition.

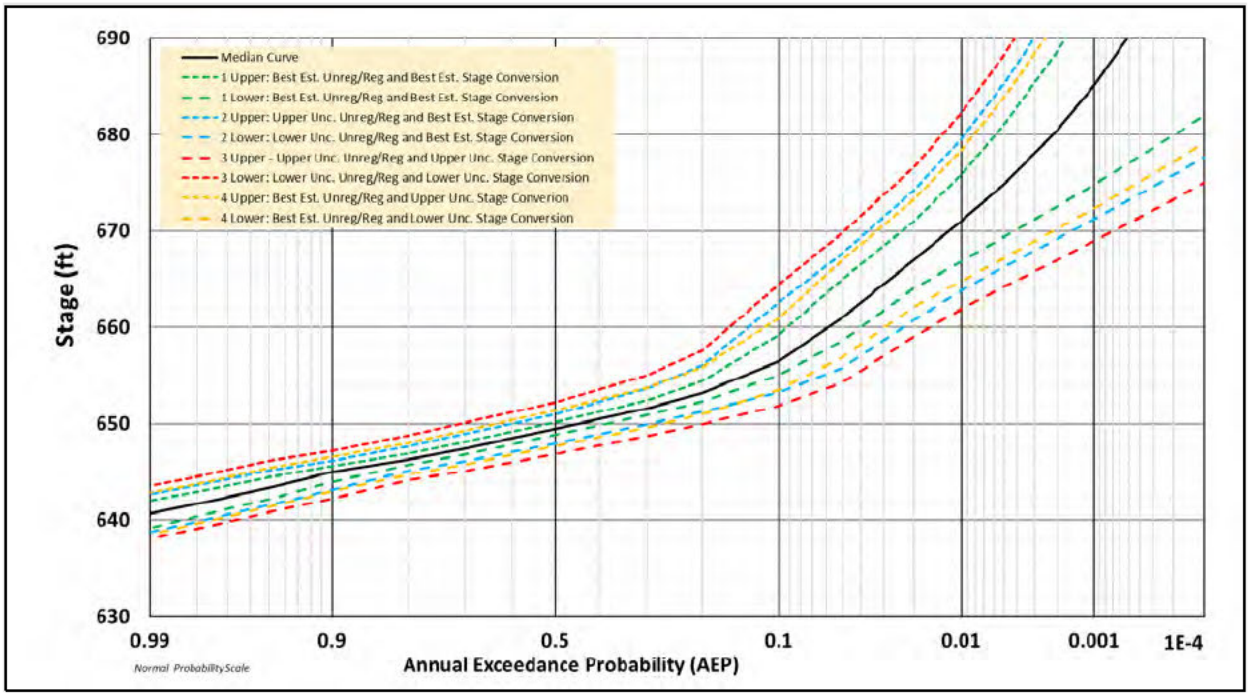


Figure 3-22: Beattyville Stage Frequency Sensitivity Analysis

Data set 2 was selected for the final stage frequency curve to incorporate some uncertainty into the analysis. Data set 1 does not incorporate any additional uncertainty and Data set 4 was considered to incorporate too much uncertainty. Data set 2 and 3 yielded similar results, but Data set 2 was selected based on engineering judgement.

Figure 3.23 shows the final regulated stage frequency curve for Beattyville.

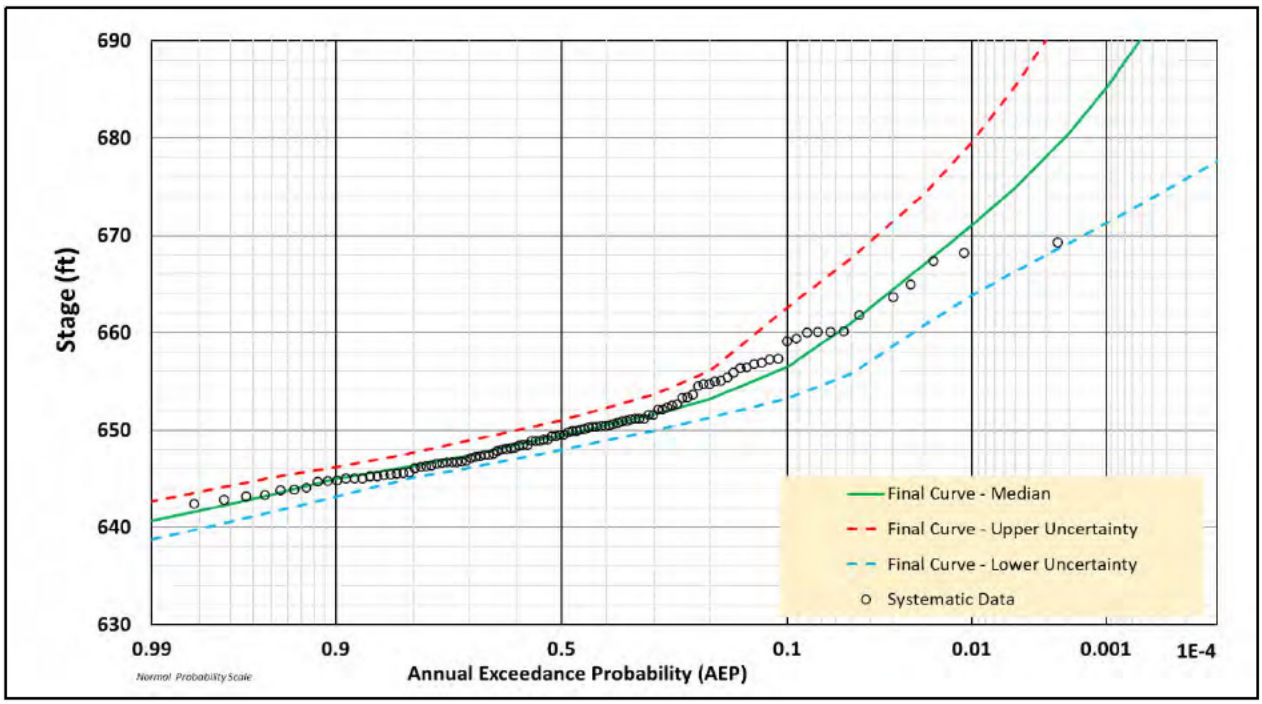


Figure 3-23: Final Beattyville Regulated Stage Frequency Curve

3.6.5 Hydrologic Hazard Curve Summary Tables

Table 14 and Table 15 summarize the final regulated flow and stage frequency curve for Lock 14 USGS gage 03282000 at Heidelberg at various AEPs. The published USGS rating curve shown in Figure 3.4 was used to develop the stage frequency curve for Lock 14.

Table 14: Lock 14 Final Regulated Flow Frequency Curve Summary Table

AEP	*Return Period (Years)*	*95% Confidence Interval (cfs)*	*5% Confidence Interval (cfs)*	*Expected [Mean] Curve (cfs)*	*Computed [Median] Curve (cfs)*
0.002	500	198,293	106,880	148,998	141,811
0.01	100	145,696	88,107	114,086	111,842
0.04	25	105,933	69,718	86,338	85,723
0.1	10	85,225	58,249	70,846	70,604
0.2	5	69,158	48,056	57,975	57,864
0.5	2	46,568	32,416	39,069	39,054
0.99	1	15,043	7,265	11,218	10,712

Table 15: Lock 14 Final Regulated Stage Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (ft)	5% Confidence Interval (ft)	Expected [Mean] Curve (ft)	Computed [Median] Curve (ft)
0.002	500	676.55	658.37	666.75	665.32
0.01	100	666.10	654.84	659.81	659.36
0.04	25	658.19	651.51	654.51	654.39
0.1	10	654.30	649.50	651.71	651.67
0.2	5	651.41	647.74	649.46	649.44
0.5	2	647.49	644.95	646.18	646.17
0.99	1	641.29	638.72	640.16	639.99

Table 16 and Table 17 summarize the final regulated flow and stage frequency curve for Beattyville at various AEPs.

Table 16: Beattyville Final Regulated Flow Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	196,353	105,834	147,540	140,423
0.01	100	144,270	87,245	112,970	110,748
0.04	25	104,896	69,036	85,493	84,884
0.1	10	84,391	57,679	70,153	69,913
0.2	5	68,481	47,586	57,408	57,298
0.5	2	46,112	32,099	38,686	38,672
0.99	1	14,896	7,194	11,108	10,607

Table 17: Beattyville Final Regulated Stage Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (ft)	5% Confidence Interval (ft)	Expected [Mean] Curve (ft)	Computed [Median] Curve (ft)
0.002	500	696.66	669.98	682.27	680.17
0.01	100	681.31	664.34	672.08	671.43
0.04	25	669.70	656.46	663.69	663.47
0.1	10	663.29	653.38	656.77	656.70
0.2	5	656.31	651.26	653.31	653.28
0.5	2	650.96	647.94	649.47	649.47
0.99	1	642.59	638.77	640.90	640.62

3.6.6 Levee Assurance and Accreditation

The planning study requires the development and review of alternatives to reduce flood risks and flood impacts to Beattyville. This includes levee system alternatives that could potentially be accredited to protect the Special Flood Hazard Areas (SFHA) from being inundated with reasonable assurance by the 1-percent-annual-chance flood, or the 100-year flood event. Reasonable assurance may vary but typically includes 65 to 85 percent assurance protection from the 100-year flood event or a minimum freeboard of 3 feet above the 100-year 50 percent (median) assurance protection flood event.

Figure 3.24 shows the 50 percent (median) stage frequency curve at Beattyville with the 85 percent and 65 percent assurance upper credible limits. 85 and 65 percent assurance credible limits for Beattyville were developed using the same process discussed Section 3.6.4 except the 85 and 65 upper confidence limits were used for the HEC-SSP analyses.

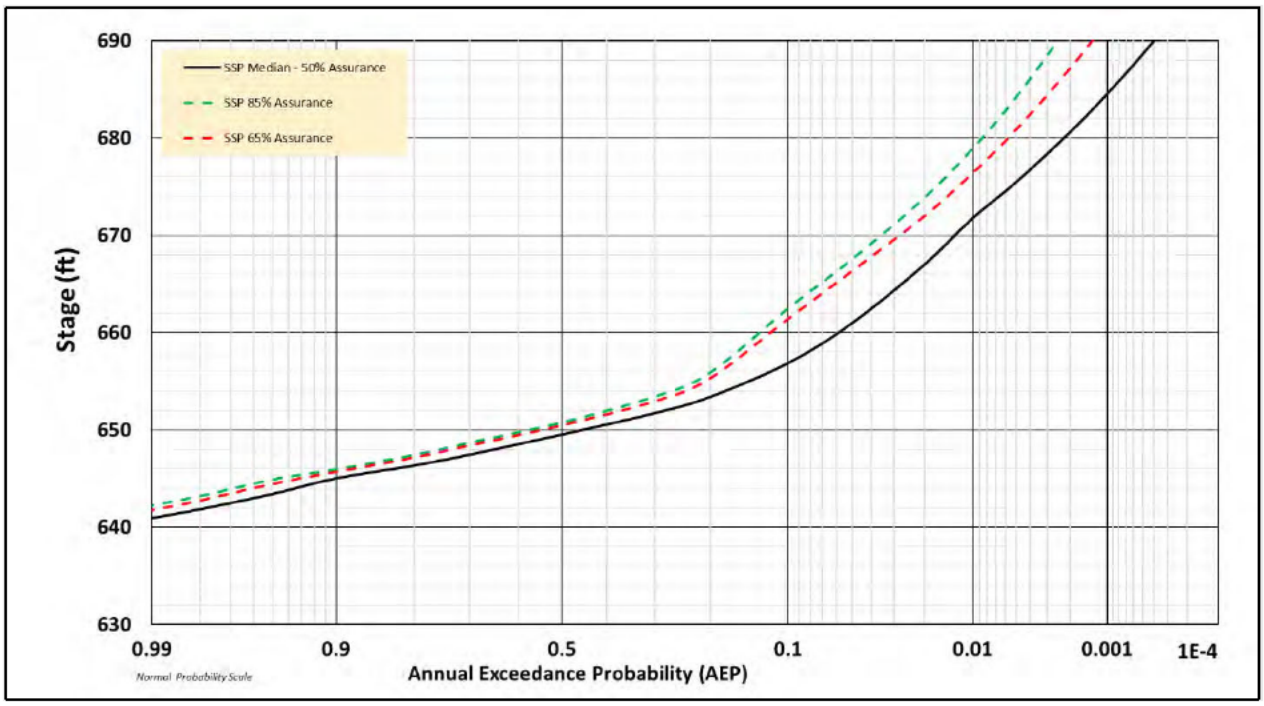


Figure 3-24: Beattyville Assurance Stage Frequency Plot

Table 18 summarizes the estimated flow and BFE values based on 85 percent assurance, 65 percent assurance, and 50 percent assurance plus 3 ft of freeboard.

Table 18: Beattyville Levee Assurance Summary

Data Set Description	*Flow – 0.01 AEP Event (cfs)*	*BFE – 0.01 AEP Event (ft)*
Beattyville 85 Percent Assurance	134,754	678.50
Beattyville 65 Percent Assurance	126,232	675.99
Beattyville 50 Percent Assurance	110,748	674.43*

*Includes 3 feet of freeboard

3.7 Coincident Loading and Hydrologic Loading Analysis upstream of Beattyville

The main hydrologic loading analysis utilized for Beattyville is the loading at Kentucky River Lock 14 outlined above in Section 3.6. This analysis accounts for observed flooding downstream of the confluence of the North, Middle and South Forks of the Kentucky River. The PDT considered the potential for looking at coincident loading for the 3 forks of the Kentucky River, however as noted

below, determined it was not appropriate based on correlation of the forks to the main stem of the Kentucky River as well as the lack of available data within the system.

Lock 14 is approximately 6 miles downstream of Beattyville and has a similar drainage area to Beattyville (2,657 square miles compared to 2,631 square miles). Flooding at Lock 14, and subsequently Beattyville, has historically been caused by floods that occurred on all 3 forks of the Kentucky River. Peak annual unregulated inflow data for Lock 14 was compared to peak annual unregulated inflow data for the 3 forks for the period or record that was available for each gage between 1921 and 1960. There is a total of 25 years where all gages have peak floods recorded that are summarized below in Figure 3-25 . Sorted by peak flow observed at Lock 14, 17 of the 25 years the observed peak flood on each fork aligned with the peak flow at Lock 14. Based on this data, the PDT believes that for damaging floods to occur at Beattyville, there needs to be significant contribution from all three forks of the Kentucky River.

	Lock 14		North Fork		Middle Fork		South Fork	
WY	Date	Peak Flow	Date	Peak Flow	Date	Peak Flow	Date	Peak Flow
1939	2/4/1939	120,000	2/4/1939	46,800	2/4/1939	37,300	Feb 1939	48,100
1957	1/30/1957	116,000	1/30/1957	53,500	1/30/1957	52,700	1/30/1957	66,100
1929	3/24/1929	113,000	3/24/1929	46,000	3/24/1929	24,400	3/23/1929	37,900
1948	2/15/1948	104,000	2/14/1948	44,000	2/14/1948	20,700	2/14/1948	40,500
1951	2/2/1951	100,000	2/2/1951	45,400	2/2/1951	35,300	2/2/1951	41,000
1946	1/9/1946	90,300	1/8/1946	41,800	1/8/1946	25,700	1/8/1946	42,100
1955	3/1/1955	75,000	2/28/1955	37,500	3/1/1955	14,600	2/22/1955	26,700
1956	2/19/1956	74,200	2/19/1956	34,900	2/19/1956	19,400	2/18/1956	39,600
1952	3/24/1952	70,500	3/23/1952	32,600	3/24/1952	14,300	3/23/1952	31,900
1950	2/2/1950	69,200	2/3/1950	35,800	2/3/1950	15,200	2/2/1950	21,300
1943	3/20/1943	66,200	3/20/1943	26,500	12/31/1942	14,200	3/20/1943	23,900
1958	5/8/1958	63,300	5/7/1958	32,200	5/8/1958	15,400	5/8/1958	23,800
1947	6/29/1947	57,900	8/6/1947	22,000	6/29/1947	17,600	6/29/1947	50,700
1944	4/12/1944	52,400	3/1/1944	21,500	2/19/1944	14,600	4/12/1944	22,300
1945	3/6/1945	51,000	3/6/1945	24,900	2/18/1945	9,610	3/6/1945	19,300
1937	1/26/1937	48,200	1/25/1937	23,700	1/25/1937	8,770	1/25/1937	16,100
1931	4/23/1931	45,500	4/22/1931	21,400	4/23/1931	9,820	4/23/1931	9,540
1940	4/21/1940	39,300	4/20/1940	18,000	4/21/1940	7,910	4/20/1940	13,800
1949	3/19/1949	39,300	3/19/1949	17,900	3/19/1949	11,500	3/19/1949	16,800
1959	1/23/1959	37,700	1/22/1959	18,300	1/23/1959	8,990	1/22/1959	18,900
1941	7/6/1941	31,300	7/5/1941	7,820	7/6/1941	8,750	7/6/1941	16,600
1953	5/7/1953	30,500	5/20/1953	16,900	5/8/1953	8,440	5/7/1953	12,600
1942	7/10/1942	30,200	7/9/1942	27,300	8/10/1942	7,390	8/9/1942	12,400
1960	3/18/1960	28,500	3/17/1960	11,000	3/18/1960	6,100	6/24/1960	24,600
1954	1/17/1954	18,600	1/17/1954	9,050	1/17/1954	5,480	1/16/1954	8,230

Figure 3-25 Summary of Unregulated Peak Floods on All Three Forks of the Kentucky River

Additionally, the three forks showed a strong degree of correlation with Lock 14 as can be seen below in Figure 3-26 to Figure 3-28. Typically, coincident frequency analyses are performed on streams that are considered independent variables. USGS peak annual streamflow data indicates that the three forks are generally caused by the same rainfall events.

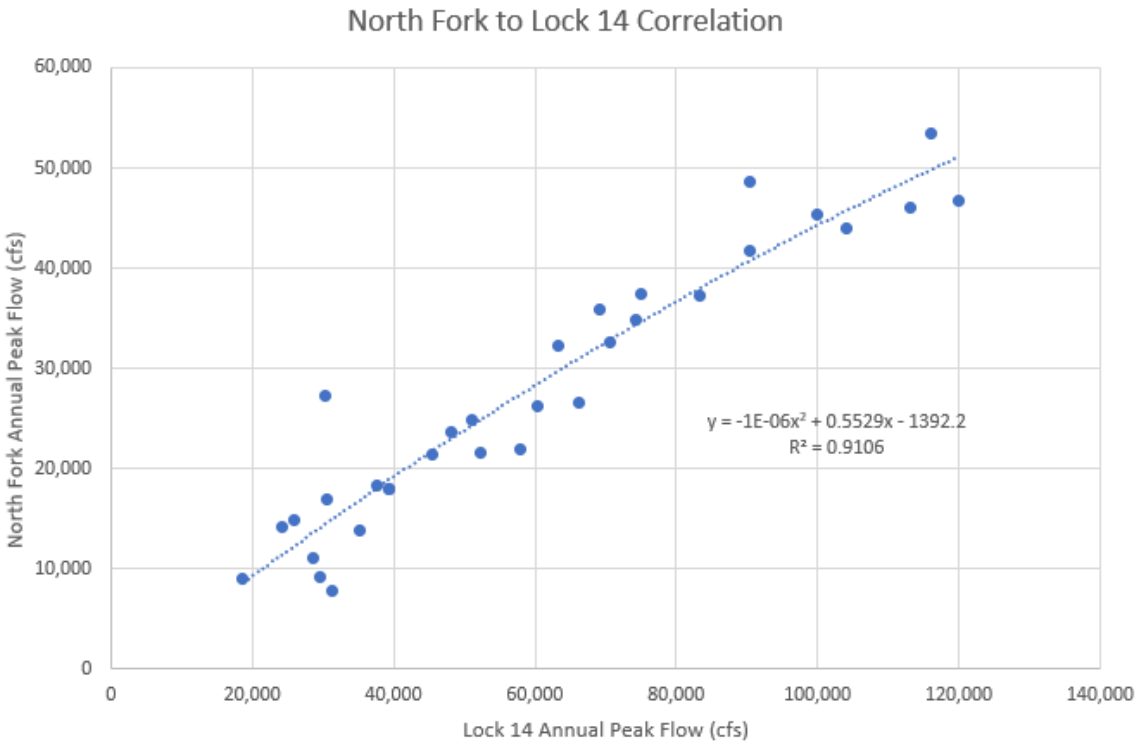


Figure 3-26 North Fork Correlation to Lock 14 for Annual Peak Flows

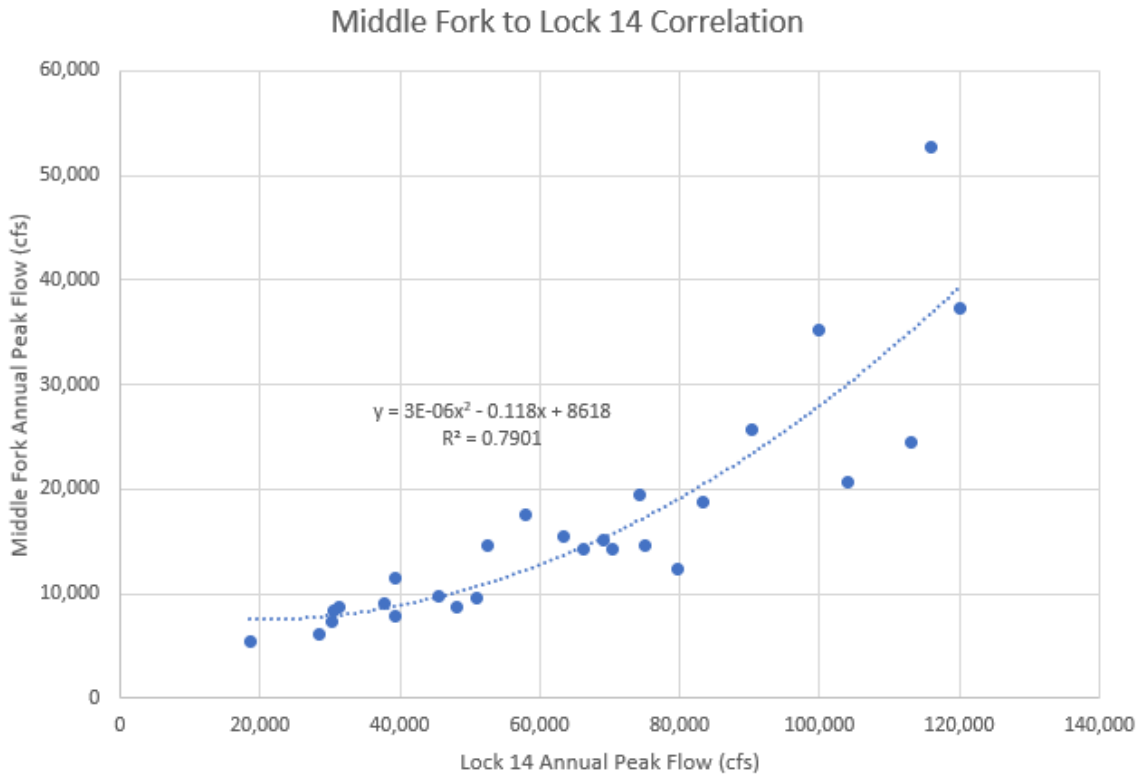


Figure 3-27 Middle Fork Correlation to Lock 14 for Annual Peak Flows

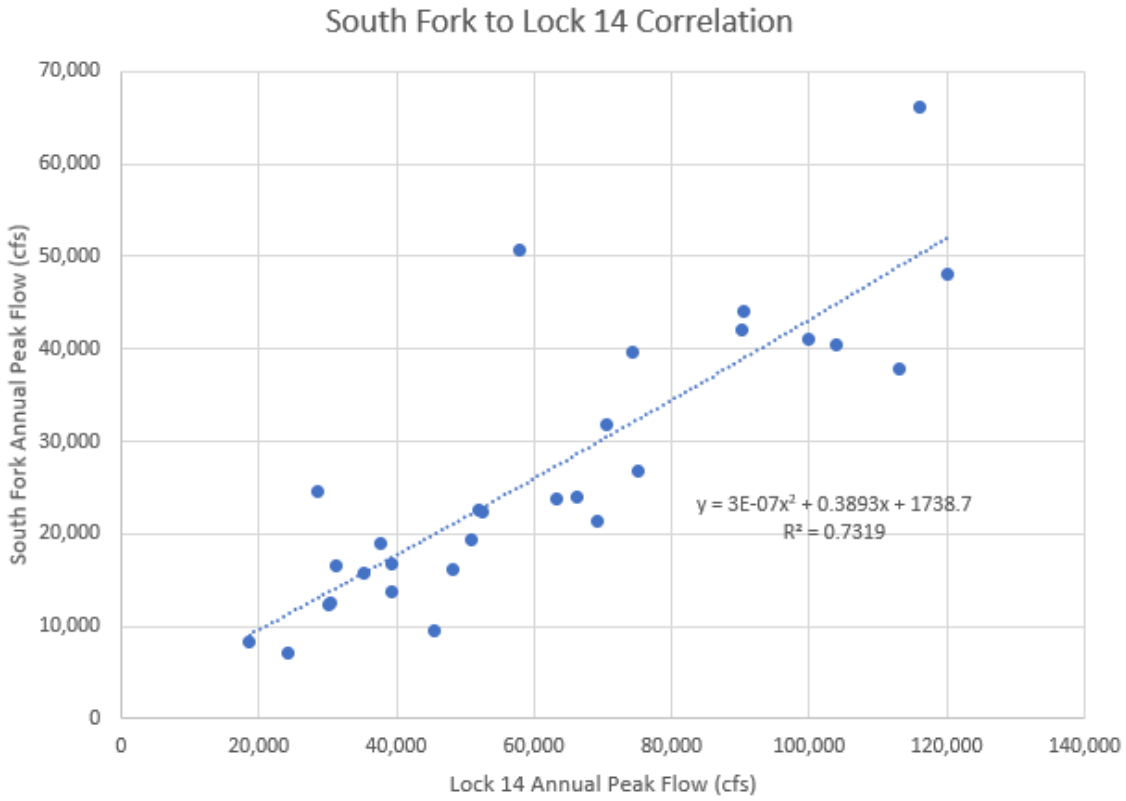


Figure 3-28 South Fork Correlation to Lock 14 for Annual Peak Flows

The PDT also believes that adequate data was not available to properly perform a coincident loading analysis for the 3 forks of the Kentucky River without significant modeling and assumptions. For a simplified application, the dominant variable would need to be the Kentucky River downstream of the confluence with the North and Middle forks. However, there is no gage data available at this location. To perform a coincident loading analysis, period of record modeling would have to be performed combining flows from the North and Middle forks to develop flows at this location, which would then need to be converted to stages so that exceedance stages could be developed. This could also be performed utilizing precipitation data which should be available dating back to 1915.

Lastly, there is significant uncertainty in the rating curve at Lock 14, and subsequently at Beattyville, as noted in Figure 3-5. This uncertainty may be due to the timing of when floods occur on the three forks of the Kentucky River and is included in the final stage frequency curve provided for Beattyville.

Analyses of the North, Middle and South Forks of the Kentucky River is included below. These analyses were completed in case potential flood protection measures were identified on the forks that could have an effect on Beattyville as well as other communities within the region.

Future studies should consider performing a coincident frequency analysis to potentially reduce these sources of uncertainty and to potentially gain a better understanding of the hydraulics related to the Kentucky river, specifically at Beattyville.

3.8 HYDROLOGIC HAZARD CURVES – NORTH FORK

3.8.1 Overall Systematic, Regional and Historical Data

Systematic Data Overview

Refer to Section 4.2 and 4.4 for general background and summary information on the USGS gages used as part of this analysis. Unregulated peak flow data from several sources was used to calculate the instantaneous peak inflow frequency curve for North Fork. The North Fork USGS gage 03280000 at Jackson was the primary gage used which includes unregulated data in 1905 to 1907, 1917 to 1921, 1927 to 1931, and 1935 to 1975. Regulation in the North Fork began in 1976 with the operation of Carr Creek Lake and regulated peak flow data is available from 1976 to present.

Record Extension – Lock 14 to North Fork

The MOVE.3 function was reviewed to transpose Lock 14 USGS gage 03282000 at Heidelberg to North Fork USGS gage 03280000 at Jackson systematic data. The linear regression slope yielded a negative value of b = -0.466, indicating extension of the data set with the MOVE.3 function is not possible.

In lieu of using the MOVE.3 function to transpose Lock 14 flow data to North Fork, the concurrent annual peak unregulated data from 1921 to 1960 was plotted and a distribution was fit to the data, which is shown in Figure 3.25. A drainage area ratio line, a 1:1 ratio line, and a polynomial trendline were added to the figure for reference. Figure 3.26 shows the same systematic flow data plotted on a log-log basis.

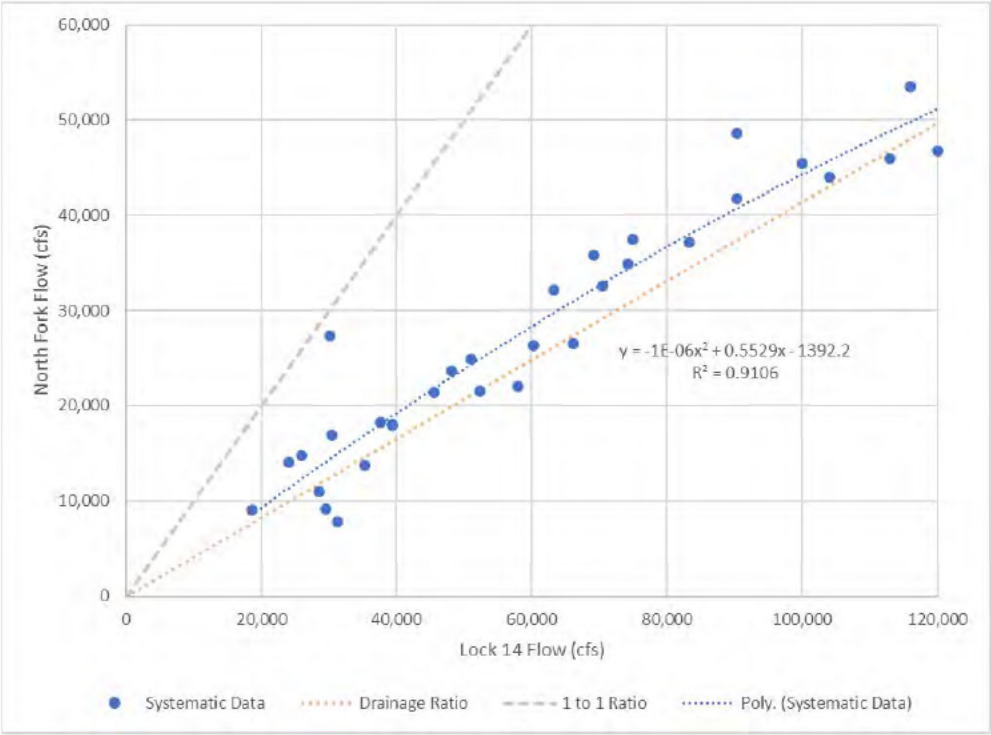


Figure 3-29: North Fork and Lock 14 Unregulated Annual Peak Flow Data Comparison

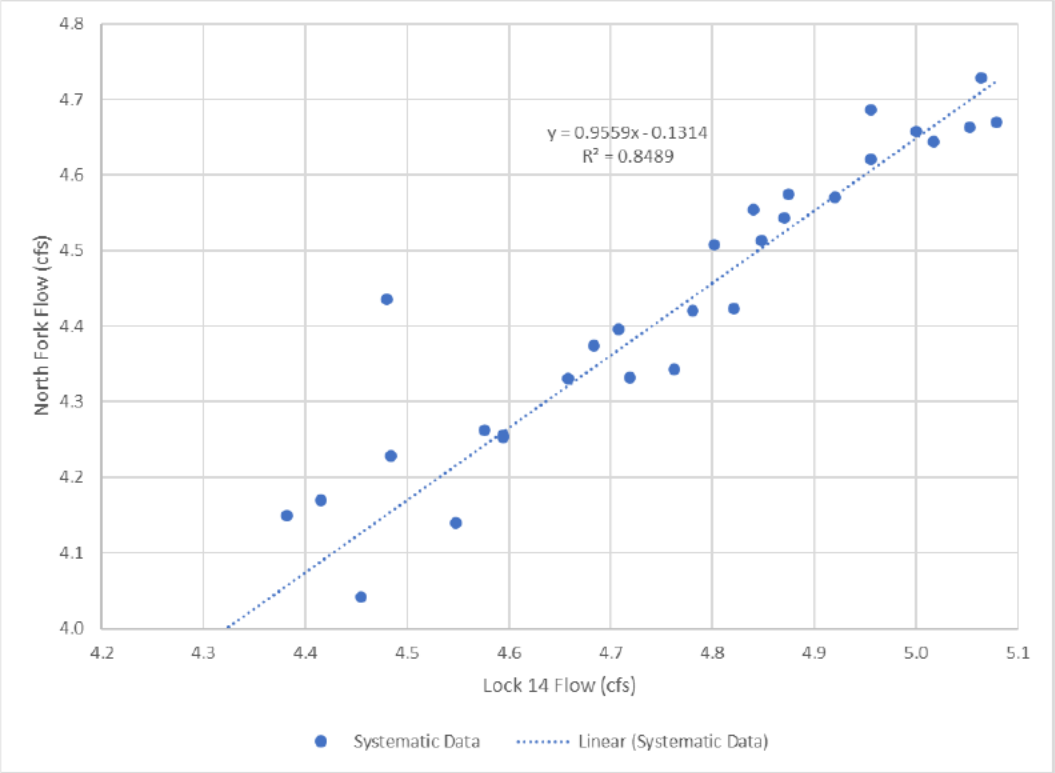


Figure 3-30: North Fork and Lock 14 Unregulated Log-Log Annual Peak Flow Data Comparison

The polynomial trendline of the direct flow data comparisons resulted in an r squared value of 0.9106 which indicates a good correlation. A linear trendline fit to the log-log distribution of the data yielded an r squared value of 0.8489. Since the polynomial trendline of the direct comparisons resulted in a higher r squared value, it was used to transpose Lock 14 USGS gage 03282000 at Heidelberg data to North Fork data for the years 1922 to 1926 and 1932 to 1934.

Record Extension – Lock 4 and Lock 6 to North Fork

Locks 4 (drainage area of 5,411 square miles) USGS gage 03287500 at Frankfort and Lock 6 USGS gage 03287000 at Salvisa, KY (drainage area of 5,102 square miles) flow data were reviewed for potential transposition to North Fork (drainage area of 1,101 square miles) because they have annual flood and gage data dating back to 1895. Lock 4 also has historic gage heights from 1817, 1847, 1854, 1880, and 1883.

Overlapping flow data from Lock 4 and 6 was plotted against North Fork and polynomial trendlines were fit to the data. The same data was also plotted and compared on a log-log scale with linear trendlines fit to the data. Table 19 summarizes the r squared values of the direct and log-log scale data comparisons.

Table 19: Lock 4 and Lock 6 Annual Peak Flow Data Comparison to North Fork

Location Comparisons	***Direct Data Comparison R Squared***	***Log-Log Scale Data Comparison R Squared***
Lock 6 to North Fork	0.0459	0.0261
Lock 4 to North Fork	0.5369	0.6379

All r squared values were below 0.70, indicating there was poor correlation. In addition, drainage area ratios for the North Fork USGS gage 03280000 at Jackson compared to the Lock 4 USGS gage 03287500 (drainage area ratio of 4.91) at Frankfort and Lock 6 USGS gage 03287000 at Salvisa (drainage area ratio of 4.63) exceeds a factor of 2. Therefore, gages at Lock 4 and Lock 6 were not used for record extension at North Fork.

Unregulated-Regulated Transposition

The unregulated POR at North Fork USGS gage 03280000 at Jackson was extended between 1976 to 2022 by transposing flows with an established regulated-unregulated relationship for North Fork. Two data sources were compared to establish the regulated-unregulated relationship. These sources include:

- Spreadsheet model provided by the LRL Water Management section.
- The Carr Creek Lake WCM

The spreadsheet model also includes stage reductions in North Fork USGS gage 03280000 at Jackson based on the regulation of Carr Creek Lake for various events between 2015 to 2022. Stage heights at Jackson from the spreadsheet model were converted to estimated flow values using a rating curve developed based on USGS flow data at the North Fork gage. Figure 3.27 shows the North Fork at Jackson rating curve developed from USGS with systematic data and10 percent upper and lower uncertainty bounds. The USGS published rating curve was used for the purposes of this analysis.

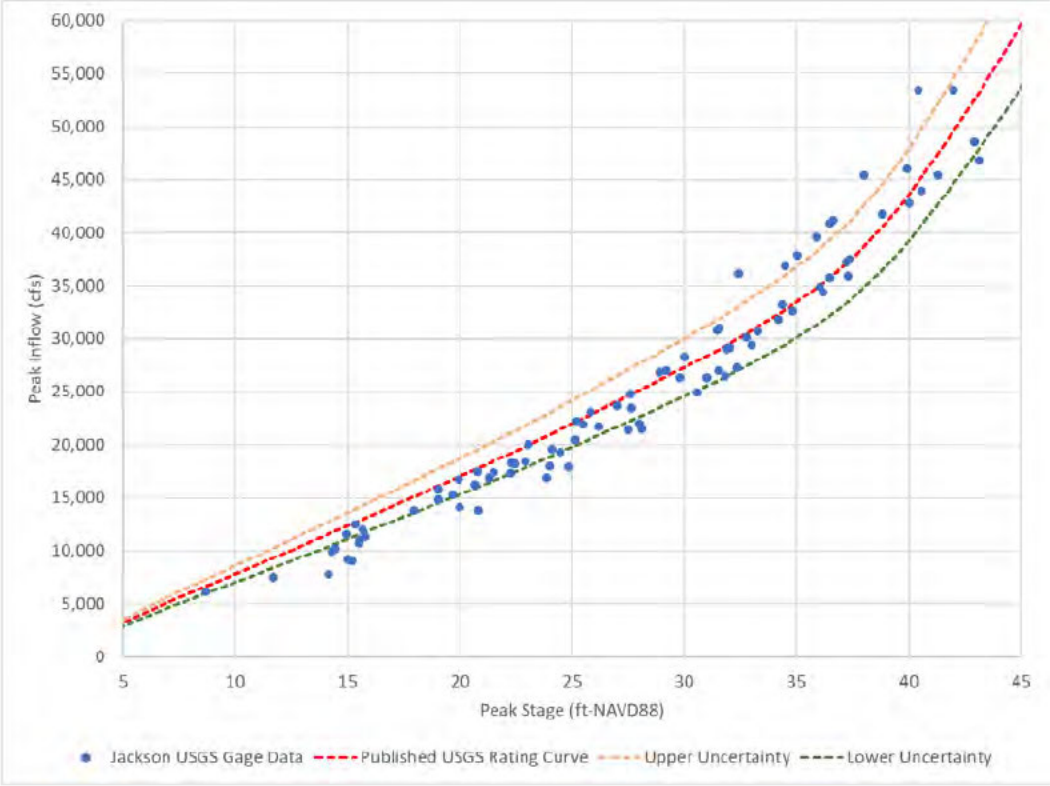


Figure 3-31: North Fork at Jackson USGS Rating Curve with Uncertainty

Table 20 summarizes the events and stage height results from the spreadsheet model for Carr Creek Lake regulation impacts on the North Fork USGS gage 03280000 at Jackson with estimated flows based on the Jackson rating curve.

Table 20: Spreadsheet Model for North Fork Impacts from Carr Creek Lake Regulation

Date	*Unregulated Stage (ft)*	*Regulated Stage (ft)*	*Regulated Reduction (ft)*	*Unregulated Flow (cfs)*	*Regulated Flow (cfs)*
3/5/2015	32.4	29.7	2.7	30,000	27,000
7/15/2015	27.2	24.7	2.5	24,300	21,700
5/1/2016	24.7	22.0	2.7	21,700	18,900
2/12/2018	32.5	29.0	3.5	30,200	26,200
2/21/2019	26.0	23.5	2.5	23,000	20,400
2/25/2019	31.4	28.1	3.3	28,800	25,300
2/8/2020	27.5	25.0	2.5	24,600	22,000
3/2/2021	43.0	39.0	4.0	52,800	41,000

3/29/2021	26.7	24.2	2.5	23,800	21,100
½/2022	26.8	24.4	2.4	23,900	21,400
7/29/2022	46.4	43.5	2.9	64,700	54,500

Plate 16 from the Carr Creek Lake WCM shows a natural and modified flow frequency curve for North Fork, which is shown in Figure 3.28. Plate 16 data was plotted and shown on Figure 3.29 to develop the regulated-unregulated flow relationship.

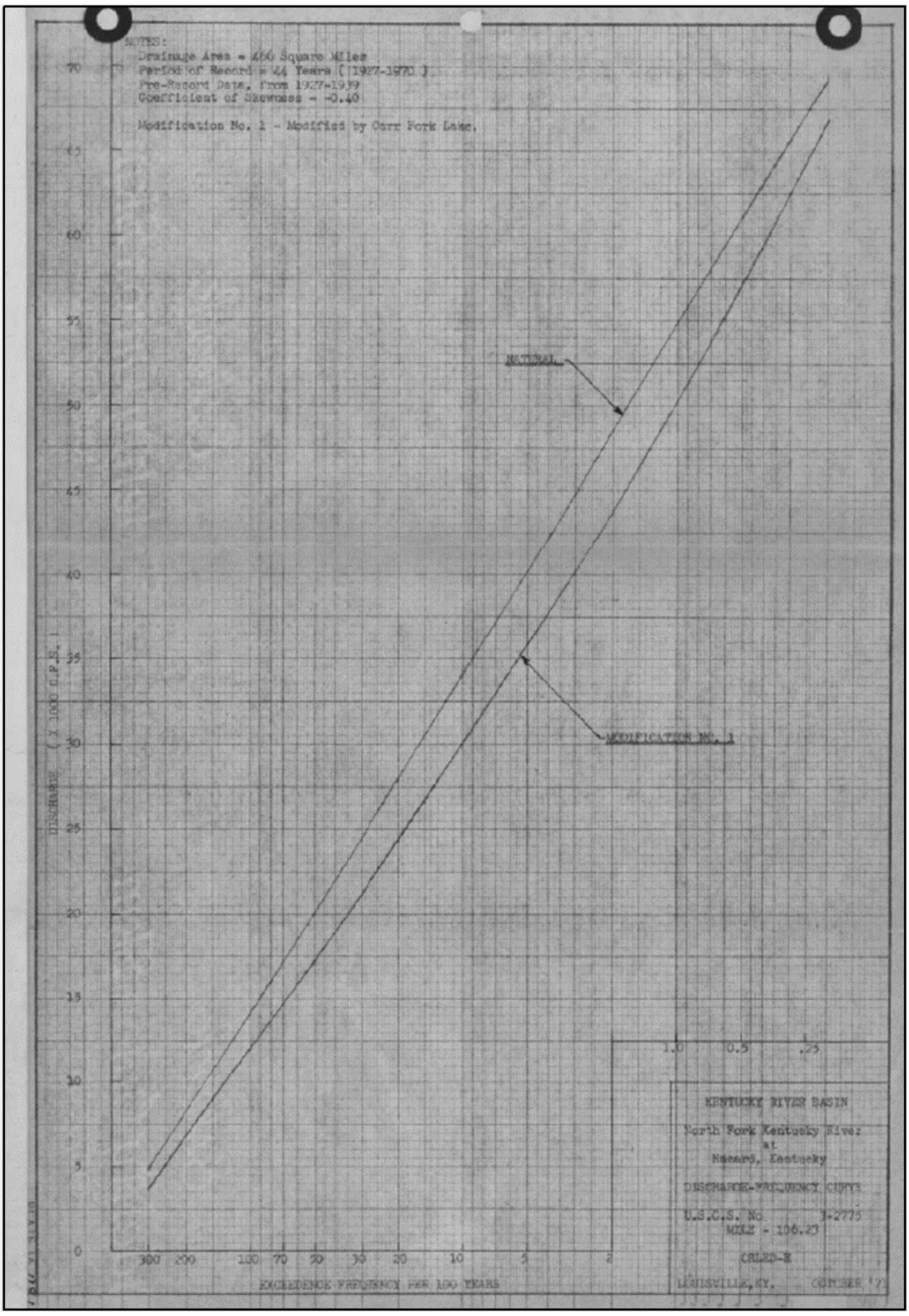


Figure 3-32: Carr Creek Lake WCM Plate 16

The two data sources were plotted overlapped to select the unregulated to regulated flow relationships at North Fork USGS gage 03280000 at Jackson. Figure 3.29 shows the overlapping plot from the two data sources with linear trendlines of each and 5 percent upper and lower uncertainty for the Carr Creek Lake WCM relationship, which was the selected unregulated-regulated relationship for this analysis. Five percent upper uncertainty and 15 percent lower uncertainty were selected for this analysis. A 5 percent upper uncertainty was selected because any higher percent uncertainty results in calculated upper uncertainty values exceeding the 1 to 1 flow ratio at higher flows, which is not possible. Each data source is discussed in further detail below.

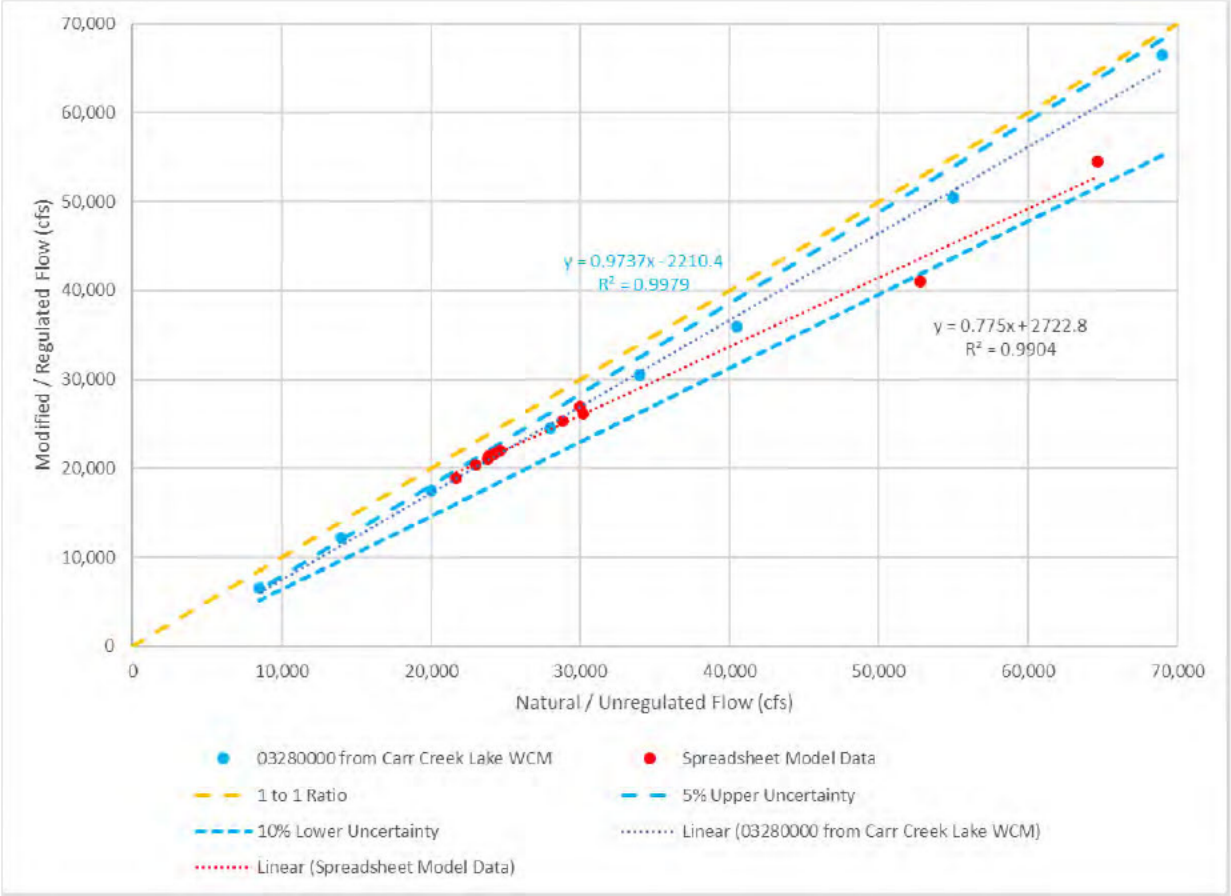


Figure 3-33: North Fork Regulated-Unregulated Relationship

As seen in Figure 3.29, trendlines for each source had good correlation. The Carr Creek Lake WCM relationship was used as the final relationship for North Fork. This was the original estimated relationship when Carr Creek Lake was constructed, and the spreadsheet model plots similarly against it. This indicates it is still a valid relationship for current conditions. Therefore, this relationship was used to convert the regulated flows from 1976 to the present to unregulated values and utilized as part of the unregulated inflow frequency analysis.

Perception Thresholds

As previously noted, annual peak flow data at Lock 4 USGS gage 03287500 and Lock 6 USGS gage 03287000 at Salvisa were reviewed for record extension at the North Fork USGS gage 03280000 at Jackson. A comparison of the flow data indicated poor correlations and drainage

area ratios that exceed a factor of 3. Therefore, the data at the Lock 4 and Lock 6 USGS gages was not used. Missing annual peak inflow data in the POR between 1908 and 1916 was assigned a PT of 53,500 cfs, which is the unregulated flood of record.

Data Summary

To summarize, the following information was used to develop the final unregulated POR data used for Lock 14.

- A PT of 53,500 cfs was used between 1908 and 1916 to supplement data gaps in the unregulated POR. The PT was based on the flood of record.
- Unregulated Lock 14 USGS gage 03287000 at Heidelberg flow data between 1922 to 1926 and 1932 to 1934 was transposed to North Fork USGS gage 03280000 at Jackson based on good correlations of the annual peak flows.
- Unregulated flows from North Fork USGS gage 03280000 at Jackson from 1905 to 1907, 1917 to 1921, 1927 to 1931, and 1935 to 1975 were directly used.
- The Carr Creek Lake WCM unregulated to regulated flow relationship was used to transpose North Fork USGS gage 03280000 at Jackson regulated flows to unregulated flows between 1975 to 2016.

Figure 3.30 shows a visual of the final composite North Fork POR used in the assessment.

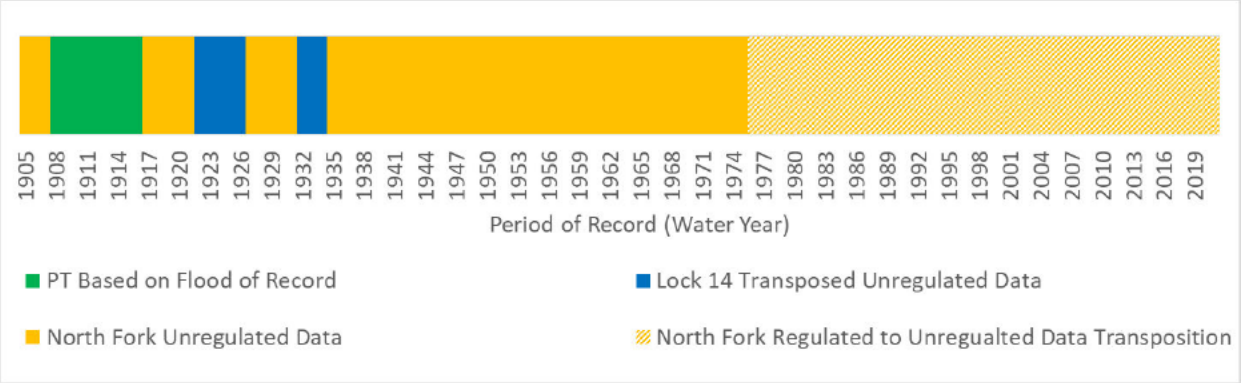


Figure 3-34: North Fork Final POR Visualization

3.8.2 Unregulated Flow-Frequency Curve

The composite unregulated annual peak flow POR was used to calculate the peak flow frequency curve using a B17C analysis in HEC-SSP. The final POR included systematic and transposed data from 1905 to 2022 as previously discussed. Figure 3.31 shows the HEC-SSP EMA Data for the unregulated POR for North Fork.

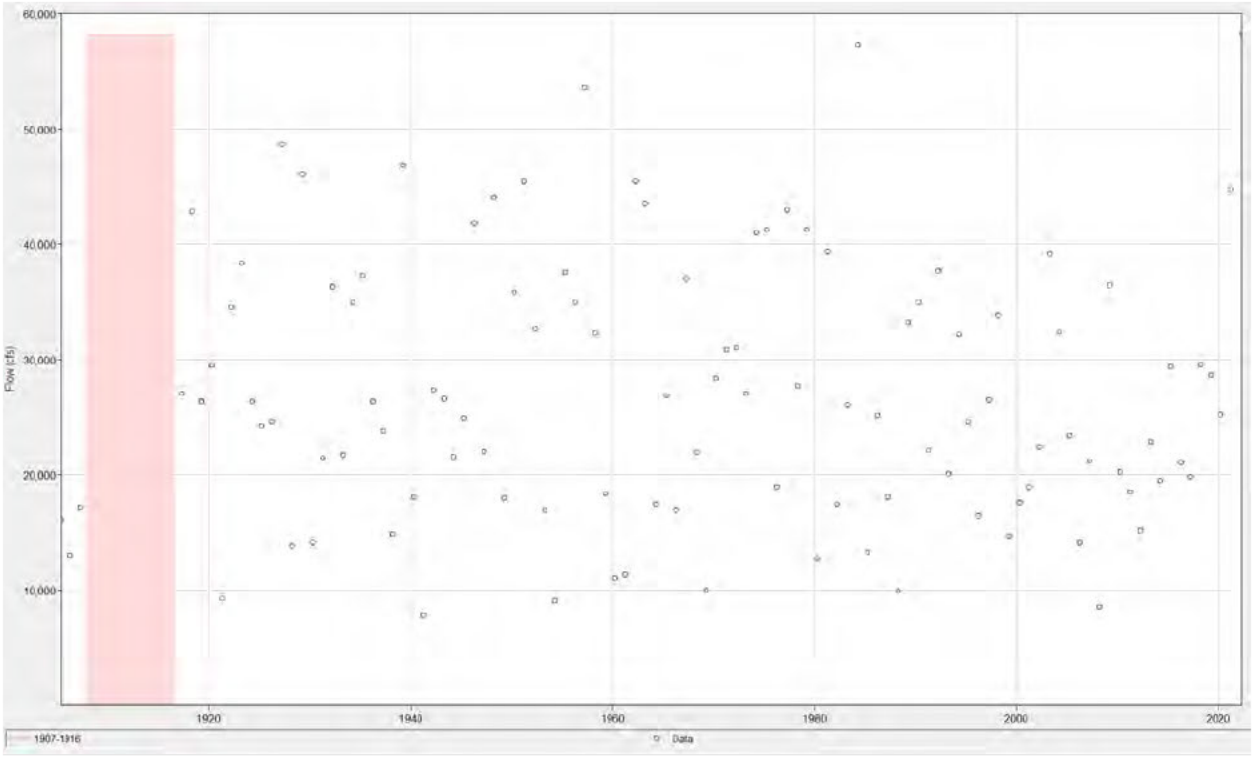


Figure 3-35: North Fork Unregulated POR HEC-SSP EMA Data

Regional Skew Information

Regional skew information was available from an existing study published by the USGS in cooperation with the Kentucky Transportation Cabinet. The study is titled "*Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals*". The regional skew values for peak flows for the state of Kentucky is 0.011 with a standard error and mean square error of 0.52 and 0.27, respectively. The regional skew was applied to the B17C analysis, and the weighted skew was used as the final adopted skew.

Potentially Influential Low Outliers

The Multiple Grubbs-Beck Test was performed on the data to determine if the POR contained any PILF values. PILF's are reviewed to confirm that small observed inflows do not have an inappropriately large impact on the inflow frequency analysis. The test identified no PILF values.

Unregulated Flow Frequency Sensitivities

To determine how sensitive the analysis is to the inclusion of additional data sources, multiple sensitivities were modeled with various data sets. Flow-frequency curves for the following data sets were developed using a B17C analysis in HEC-SSP:

- North Fork Unregulated Only – includes unmodified unregulated flow data from North Fork from 1905 to 1907, 1917 to 1921, 1927 to 1931, and 1935 to 1975.
- North Fork Transposed Unregulated – includes unmodified unregulated flow data from North Fork from 1905 to 1907, 1917 to 1921, and 1927 to 1975 and transposed regulated to unregulated flow data from 1976 to 2022.

- Final POR – includes the final period of record as previously discussed.

Figure 3.32 show a plot of the curves for the above data sets.

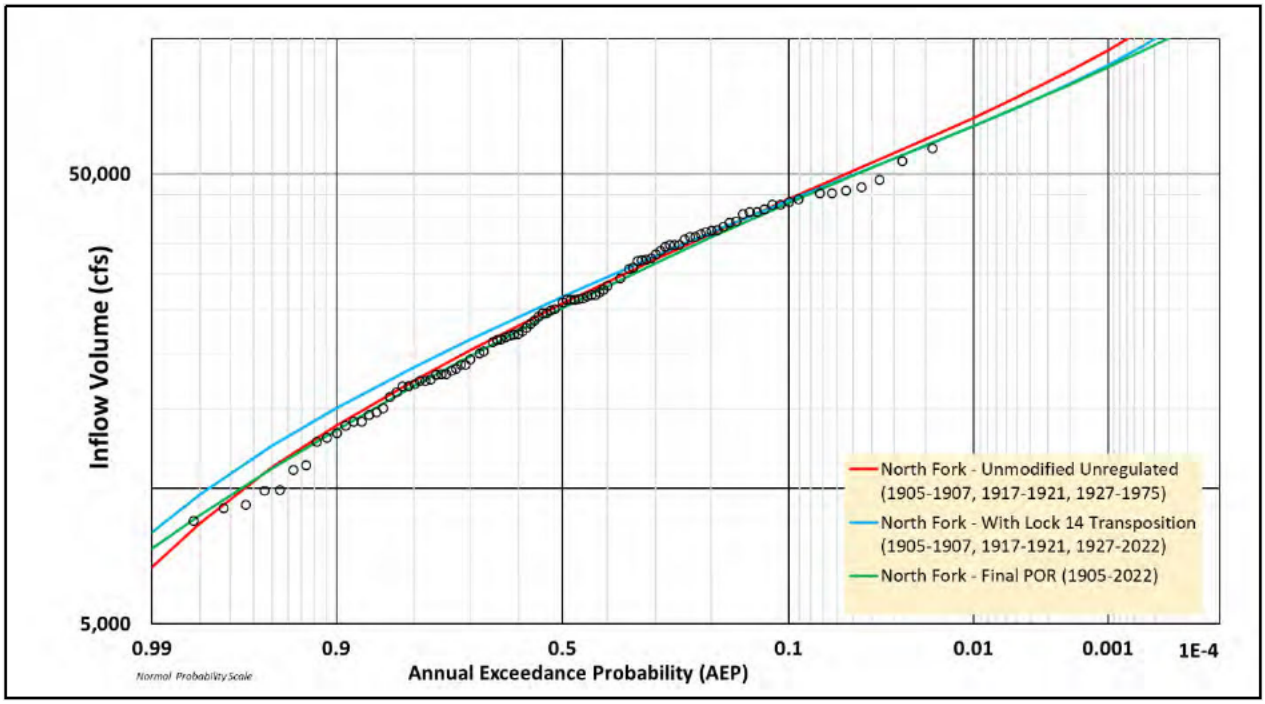


Figure 3-36: North Fork Unregulated Inflow Frequency Sensitivities

Table 21summarizes the mean, standard deviation, and skew of the sensitivities plotted in Figure 3.32, which were similar between the sensitivities reviewed.

Table 21: North Fork at Jackson Statistical Summary of Bulletin 17C Sensitivities

Data Set Description	***Mean (of log) (μ)***	***Std. Dev. (of log) (σ)***	***Skew (of log) (γ)***
North Fork Unmodified Unregulated (1905-1907, 1917-1921, 1927-1975)	4.408	0.186	-0.237
North Fork with Unregulated Lock 14 Transpositions (1905-1907, 1917-1921, 1927-2022)	4.419	0.178	-0.397
North Fork Final POR (1905-2022)	4.391	0.196	-0.337

Figure 3.33 shows the final unregulated flow-frequency curve for North Fork using the B17C analysis in HEC-SSP.

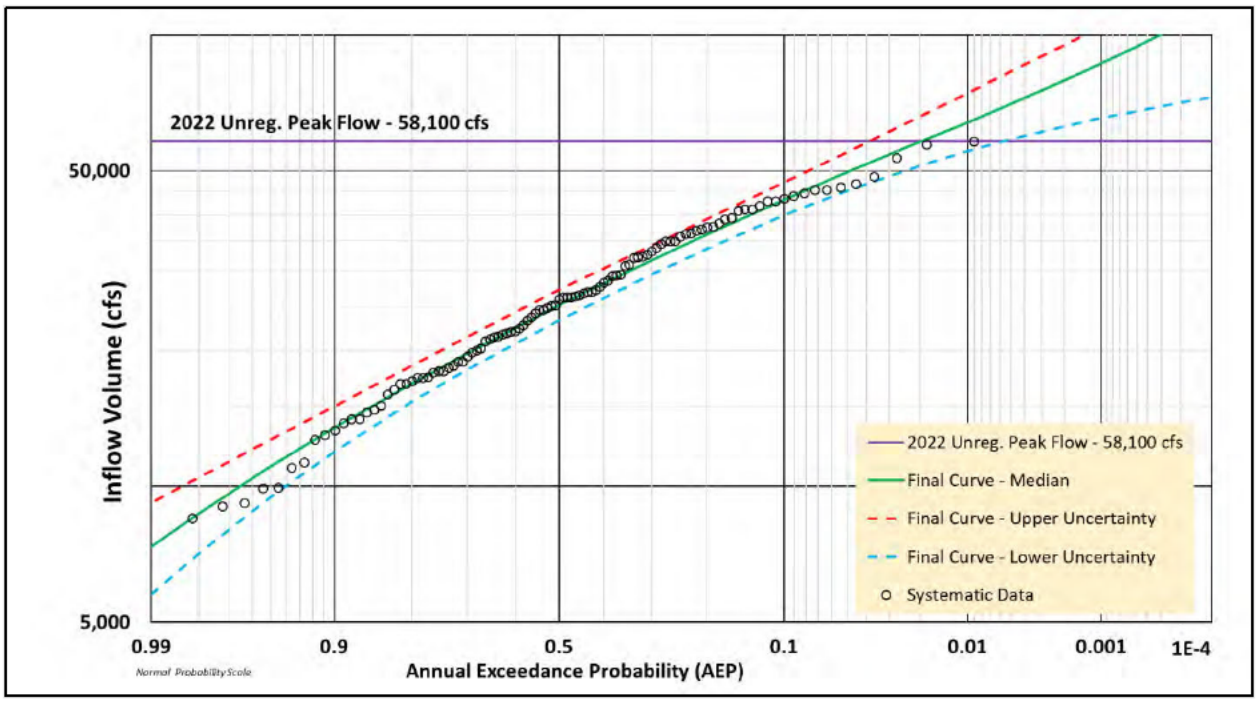


Figure 3-37: North Fork Final Unregulated Flow Frequency Curve

3.8.3 Regulated Flow-Frequency Curve

The previously established regulated-unregulated relationship shown in Figure 3.11 was used to develop the regulated flow frequency curve from the final unregulated flow frequency curve. A sensitivity analysis was performed transposing the unregulated flow frequency curve to a regulated flow frequency curve by directly transposing the data and by using the upper and lower uncertainty bounds. The comparison of the two transpositions is shown in Figure 3.34.

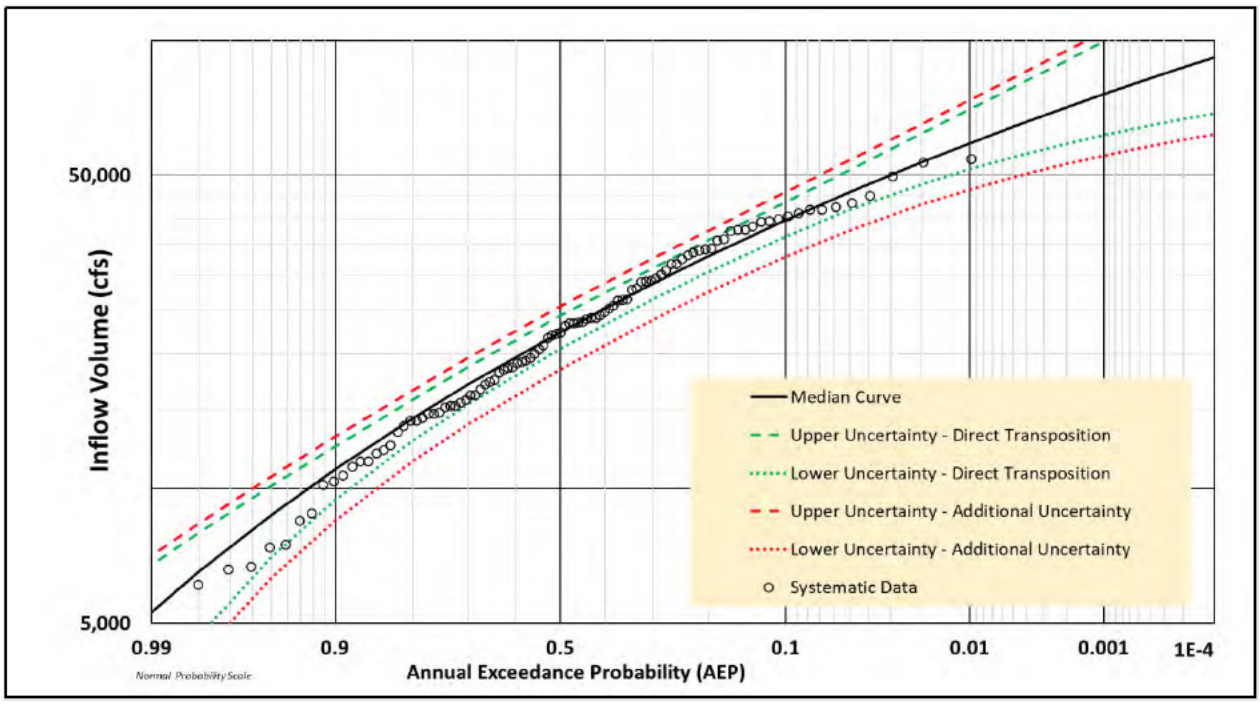


Figure 3-38: North Fork Transposed Regulated Flow Frequency Comparison

To incorporate the uncertainty associated with the regulated-unregulated transposition, the transposition using the upper and lower uncertainty bounds was selected. Figure 3.35 shows the final regulated flow frequency curve for North Fork.

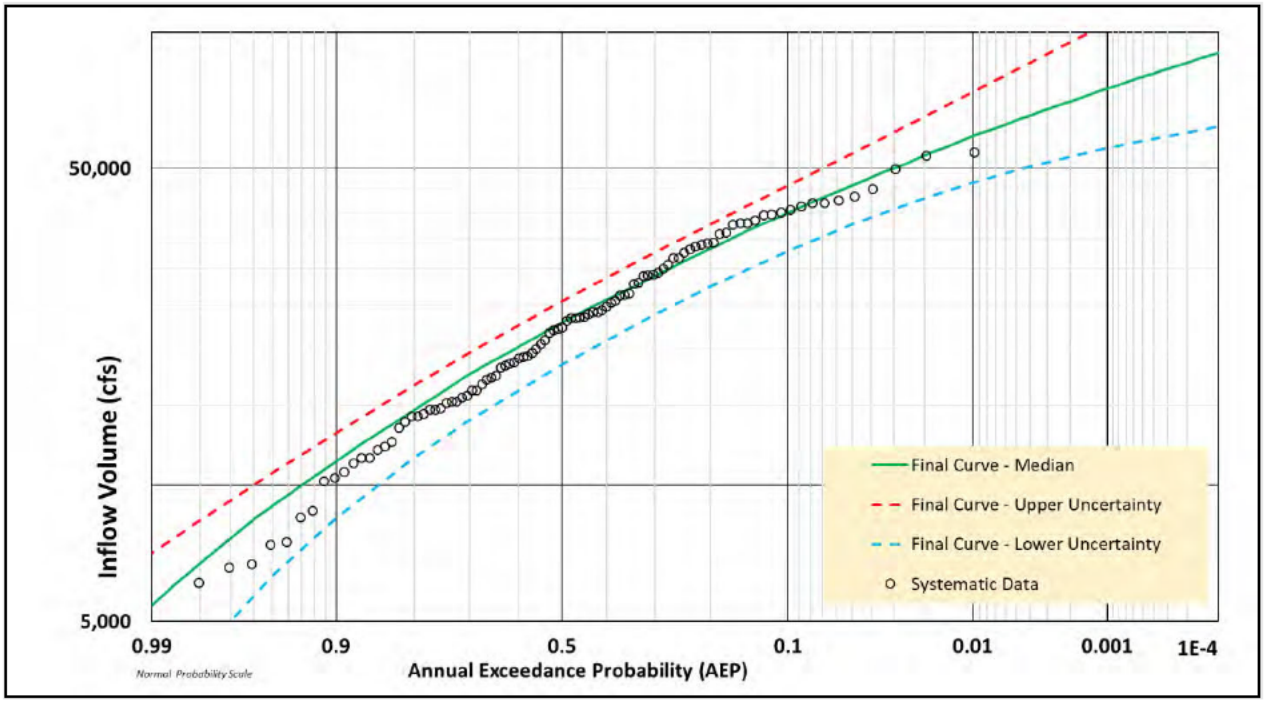


Figure 3-39: North Fork Final Regulated Flow Frequency Curve

The final unregulated and regulated flow-frequency curves are plotted in Figure 3.36. The unregulated and regulated systematic data points are shown for reference.

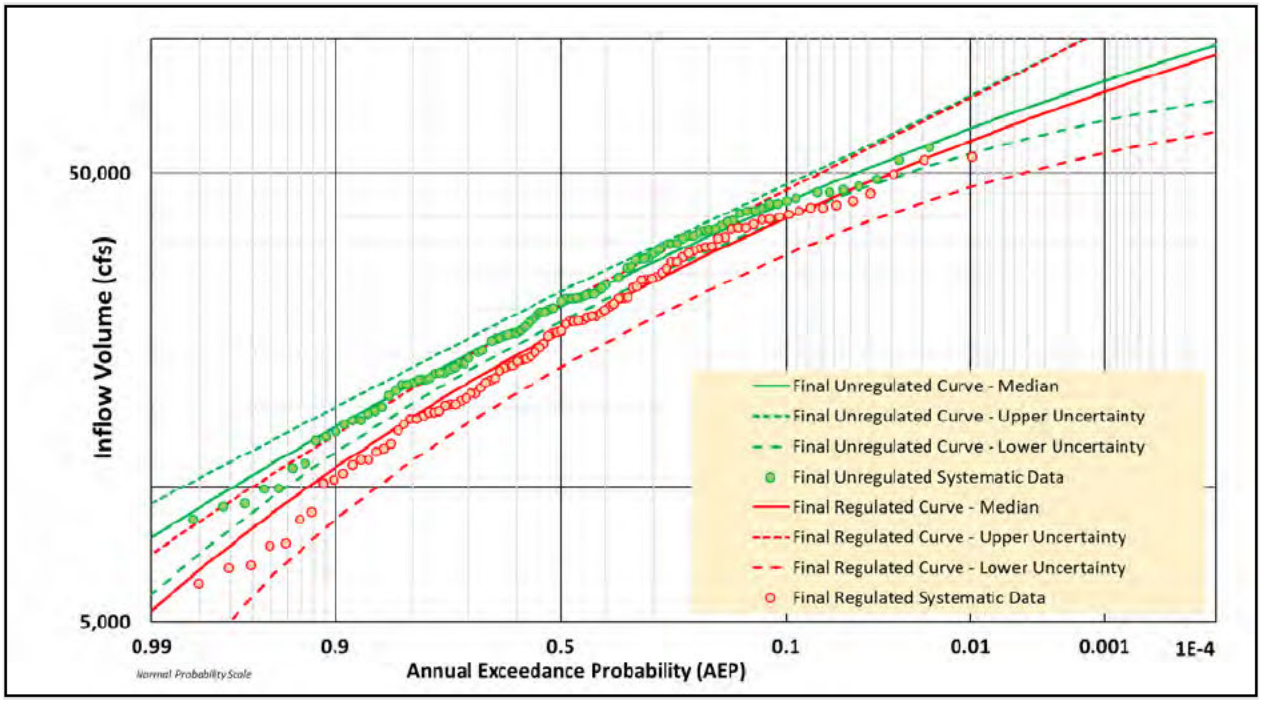


Figure 3-40: North Fork Regulated and Unregulated Flow Frequency Curve Comparison

3.8.4 Regulated Stage-Frequency Curves

The stage frequency curve for North Fork was developed using the same process discussed in Section 4.6.4 using the additional uncertainty in the regulated-unregulated relationship and a direct transposition using the published North Fork USGS rating curve shown in Figure 3.27. Figure 3.37 shows the final regulated stage frequency curve for the North Fork.

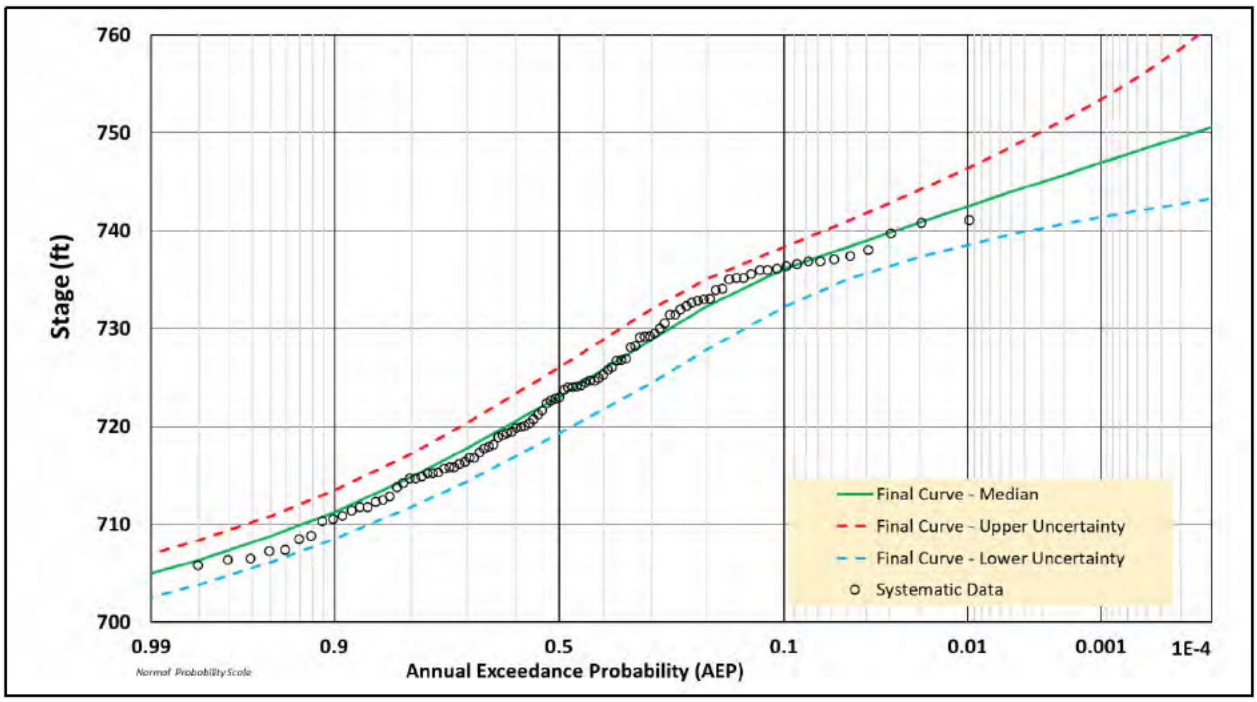


Figure 3-41: North Fork at Jackson Final Stage Frequency Curve

3.8.5 Hydrologic Hazard Curve Summary Tables

Table 22 and Table 23 summarize the final regulated flow and stage frequency curves for North Fork at Jackson for various AEPs, respectively.

Table 22: North Fork at Jackson Final Regulated Flow Frequency Curve Summary Table

AEP	*Return Period (Years)*	*95% Confidence Interval (cfs)*	*5% Confidence Interval (cfs)*	*Expected [Mean] Curve (cfs)*	*Computed [Median] Curve (cfs)*
0.002	500	94,802	53,038	74,963	71,017
0.01	100	73,681	46,475	60,191	58,988
0.04	25	55,875	38,572	47,505	47,169
0.1	10	45,831	32,921	39,854	39,735
0.2	5	37,631	27,447	33,031	33,019
0.5	2	25,520	18,479	22,305	22,361
0.99	1	7,081	3,052	4,945	5,292

Table 23: North Fork at Jackson Final Regulated Stage Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (ft)	5% Confidence Interval (ft)	Expected [Mean] Curve (ft)	Computed [Median] Curve (ft)
0.002	500	751.30	740.70	746.72	745.71
0.01	100	746.39	738.54	742.81	742.46
0.04	25	741.53	735.45	738.87	738.75
0.1	10	738.30	732.21	736.12	736.08
0.2	5	735.05	727.82	732.27	732.26
0.5	2	726.03	719.24	722.99	723.04
0.99	1	706.97	702.50	704.63	705.01

3.9 HYDROLOGIC HAZARD CURVES – MIDDLE FORK

3.9.1 Overall Systematic, Regional and Historical Data

Systematic Data Overview

Refer to Section 4.2 and 4.4 for general background and summary information on the USGS gages used as part of this analysis. Unregulated peak flow data from several sources was used to calculate the instantaneous peak flow frequency curve for Middle Fork. The Middle Fork USGS gage 03281000 at Tallega was the primary gage used which includes unregulated data in 1929, 1931, 1932, 1935, 1937, and 1939 to 1960. South Fork USGS gage 03281500 at Booneville was transposed to supplement unregulated data in 1926 and North Fork USGS gage 03280000 at Jackson was transposed to supplement unregulated data in 1927 to 1928, 1930, 1936, and 1938.

Regulated data was reviewed separately based on not being able to establish a consistent regulated-unregulated flow relationship. This is discussed in further detail in Section 4.8.3.

Record Extension – North Fork to Middle Fork

The overlapping unregulated data from 1917 to 1960 for North Fork USGS gage 03280000 at Jackson and Middle Fork USGS gage 03281000 at Tallega were plotted and a distribution was fit to the data, which is shown in Figure 3.38. A drainage area ratio line, a 1:1 ratio line, and a polynomial trendline were added to Figure 3.38 for reference. Figure 3.39 shows the same information in Figure 3.38 on a log-log basis.

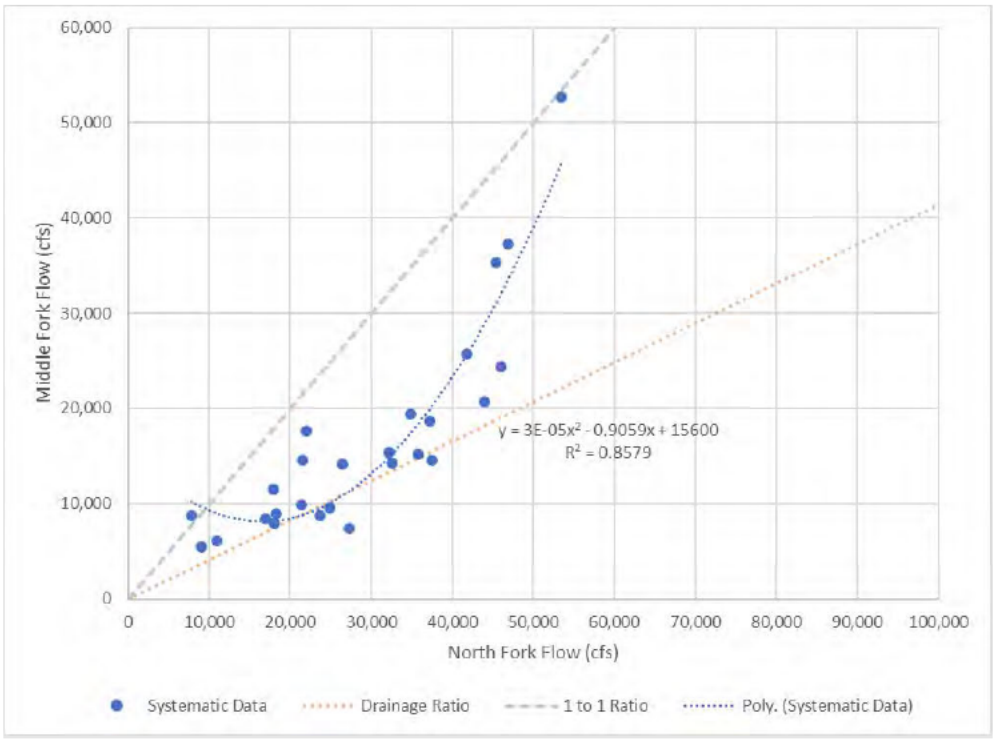


Figure 3-42: North Fork Regulated and Middle Fork Unregulated Data Comparison

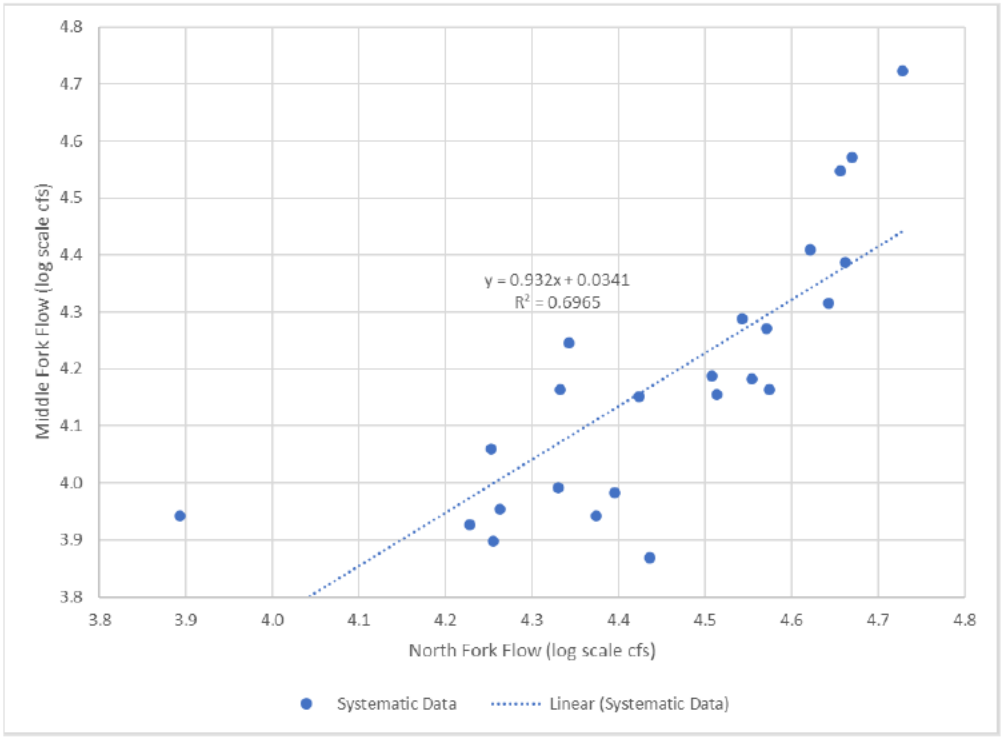


Figure 3-43: North Fork Regulated and Middle Fork Unregulated Data Comparison (Log-Log Basis)

As shown in Figure 3.38, the polynomial trendline resulted in an r squared value of 0.8579 which indicates a good correlation. The linear trendline fit to a log-log distribution of the above data yielded an r squared value of 0.6965. The drainage area ratio between the two gages is 2.05, which is a reasonable ratio for data transposition. Since the polynomial trendline resulted in a higher r squared value, it was used to transpose North Fork USGS gage 03280000 at Jackson to Middle Fork USGS gage 03281000 at Tallega.

Record Extension – South Fork to Middle Fork

The overlapping unregulated data from 1921 to 1960 for South Fork and Middle Fork gages were plotted and a distribution was fit to the data, which is shown in Figure 3.40. A drainage area ratio line, a 1:1 ratio line, and a polynomial trendline were added to Figure 3.40 or reference. Figure 3.41 shows the same information in Figure 3.40 on a log-log basis.

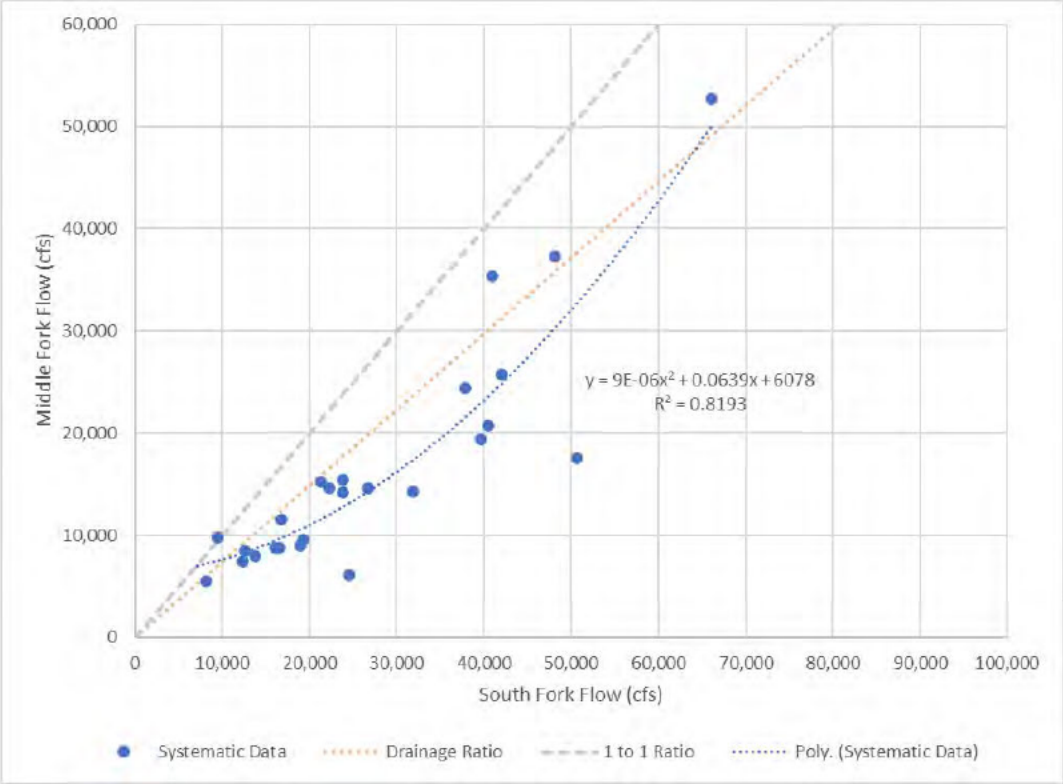


Figure 3-44: South Fork Regulated and Middle Fork Unregulated Data Comparison

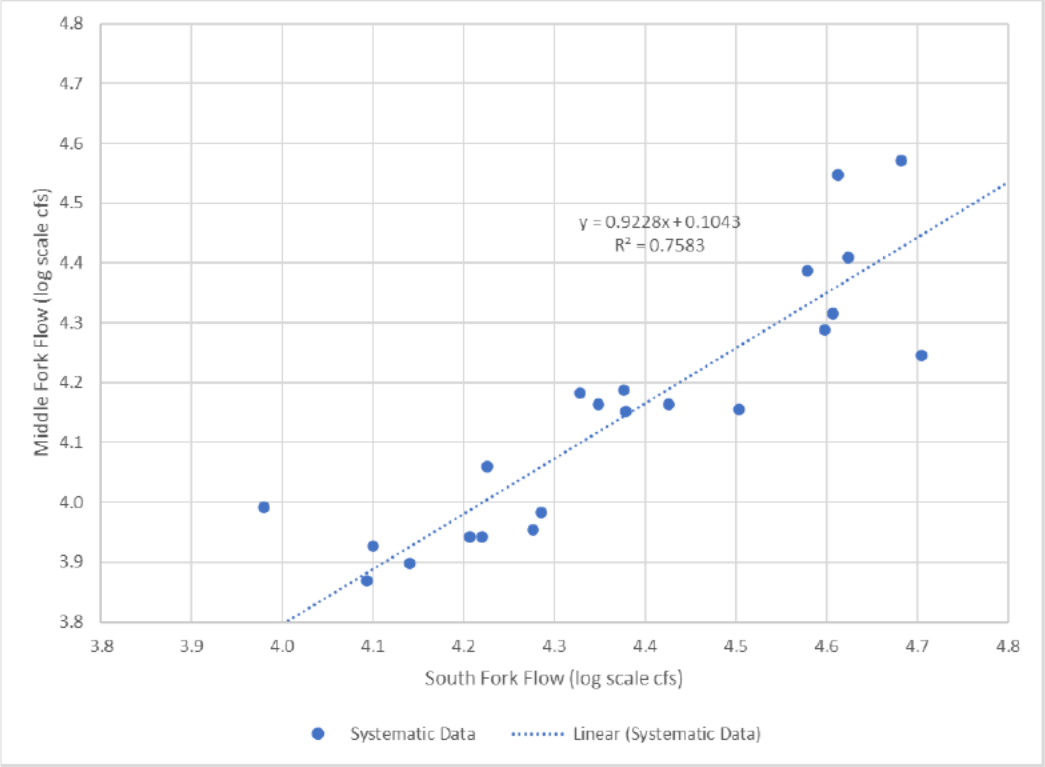


Figure 3-45: South Fork Regulated and Middle Fork Unregulated Data Comparison (Log-Log Basis)

As shown in Figure 3.40, the polynomial trendline resulted in an r squared value of 0.8193 which indicates a good correlation. The linear trendline fit to a log-log distribution of the above data yielded an r squared value of 0.7583. The drainage area ratio between the two gages is 1.34, which is a reasonable ratio for data transposition. Since the polynomial trendline resulted in a higher r squared value, it was used to transpose South Fork USGS gage 03281500 at Booneville to Middle Fork USGS gage 03281000 at Tallega.

Perception Thresholds

Missing annual peak inflow data in the POR between 1922 and 1925 was assigned a PT of 52,700 cfs, which is the unregulated flood of record at the Middle Fork USGS gage 03281000 at Tallega.

Data Summary

To summarize, the following information was used to develop the final unregulated POR data used for Middle Fork:

- A PT of 52,700 cfs was used between 1922 and 1925 to supplement data gaps in the unregulated POR. The PT was based on the flood of record.
- Unregulated North Fork flow data between 1917 to 1921, 1927 to 1928, 1930, 1936, and 1938 was transposed to Middle Fork based on good correlations of the annual peak flows.
- Unregulated South Fork flow data from 1926 was transposed to Middle Fork based on good correlations of the annual peak flows.

- Available unregulated Middle Fork flow data was used from 1929 to 1960.

Figure 3.42 shows a visual of the final composite unregulated POR for Middle Fork used in the assessment.

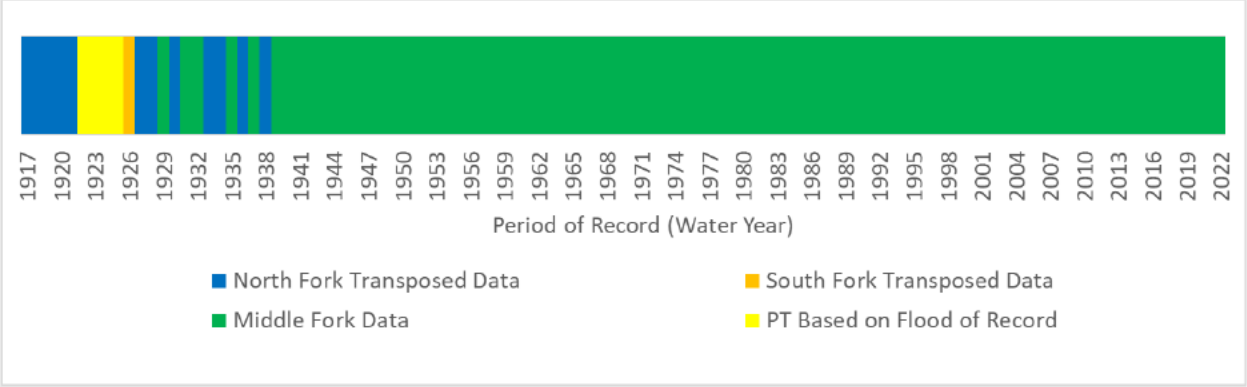


Figure 3-46: Middle Fork Final Unregulated POR Visualization

3.9.2 Unregulated Flow-Frequency Curve

The composite unregulated peak flow POR was used to calculate the peak flow frequency curve using a B17C analysis in HEC-SSP. Figure 3.43 shows the HEC-SSP EMA Data for the unregulated POR.

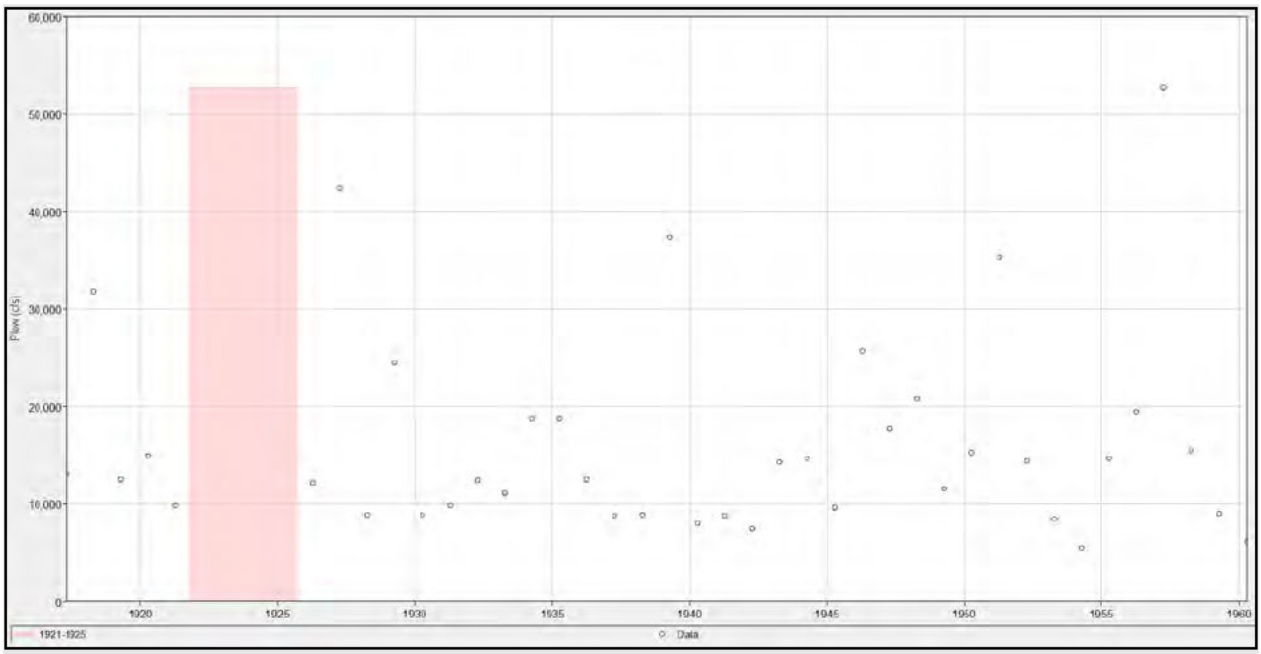


Figure 3-47: Middle Fork Final Unregulated POR HEC-SSP EMA Data

Regional Skew Information

Regional skew information was available from an existing study published by the USGS in cooperation with the Kentucky Transportation Cabinet. The study is titled “Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals”. The regional skew values for peak flows for the state of Kentucky is 0.011 with a standard error and

mean square error of 0.52 and 0.27, respectively. The regional skew was applied to the B17C analysis, and the weighted skew was used as the final adopted skew.

Potentially Influential Low Outliers

The Multiple Grubbs-Beck Test was performed on the data to determine if the POR contained any PILF values. PILF's are reviewed to confirm that small observed inflows do not have an inappropriately large impact on the inflow frequency analysis. The test identified no PILF values.

Unregulated Flow Frequency Sensitivities

To determine how sensitive the analysis is to the inclusion of additional data sources, flow-frequency curves for the following data sets were developed and compared using a B17C analysis in HEC-SSP:

- Middle Fork unmodified unregulated – includes unmodified unregulated flow data from Middle Fork between 1929 to 1960
- Middle Fork unregulated POR – includes the final period of record as previously discussed.

Figure 3.44 show a plot of the curves for the above data sets along with the POR systematic data.

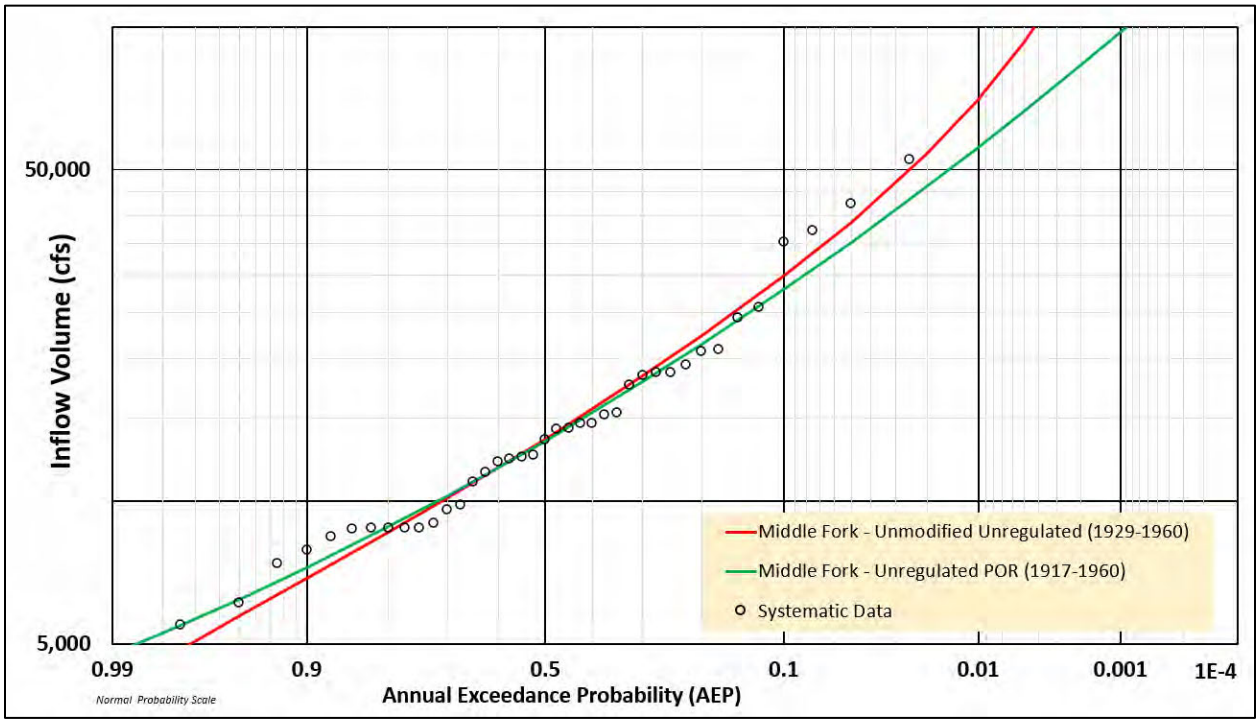


Figure 3-48: Middle Fork Unregulated Inflow Frequency Sensitivities

Table 24 summarizes the mean, standard deviation, and skew of the sensitivities plotted in Figure 3.44, which were similar between the sensitivities reviewed.

Table 24: Middle Fork at Tallega Statistical Summary of Bulletin 17C Sensitivities

Data Set Description	*Mean (of log) (μ)*	*Std. Dev. (of log) (σ)*	*Skew (of log) (γ)*
Middle Fork Unmodified Unregulated (1929-1960)	4.145	0.241	0.273
Middle Fork Final POR (1917-1960)	4.144	0.230	0.408

Figure 3.45 shows the final unregulated flow-frequency curve for Middle Fork using the B17C analysis in HEC-SSP.

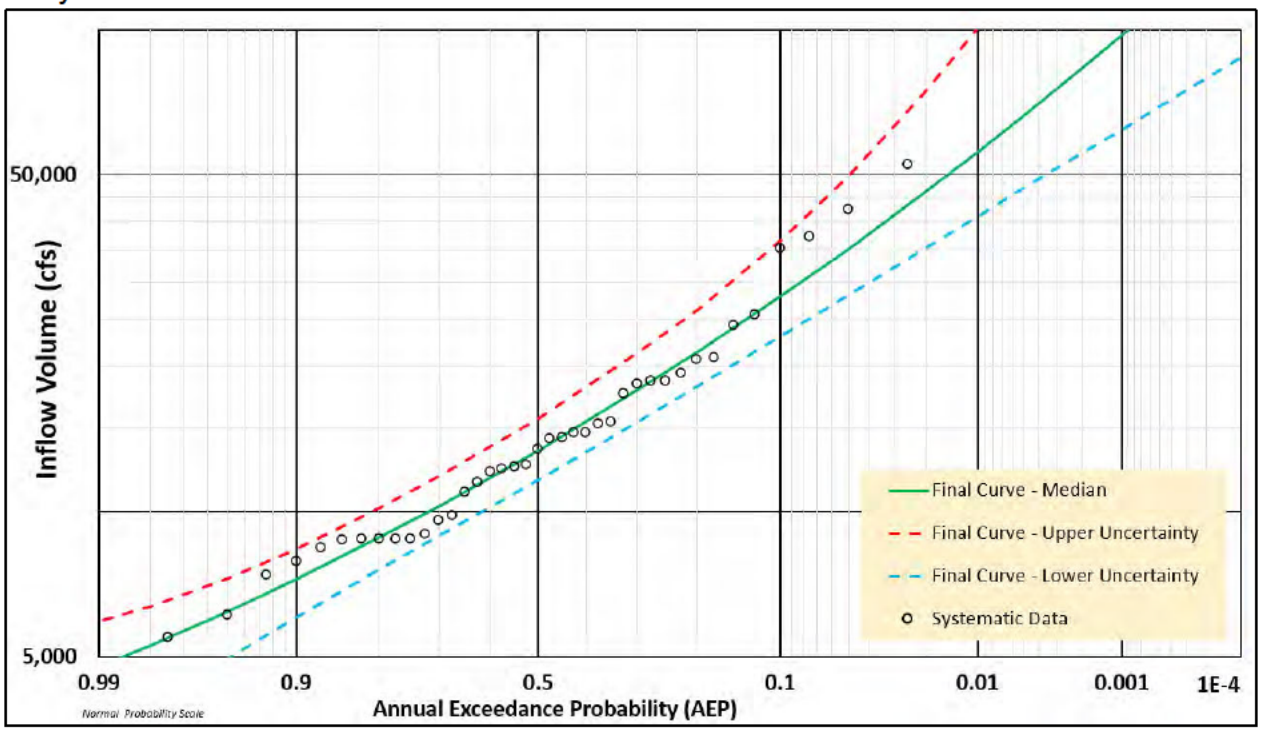


Figure 3-49: Middle Fork Final Unregulated Flow Frequency Curve

3.9.3 Regulated Flow-Frequency Curve

A regulated-unregulated relationship for Middle Fork with good correlation could not be established as part of this study. Therefore, regulated systematic data from the Middle Fork USGS gage 0328100 at Tallega from 1961 to 2022 was used directly to develop the regulated flow frequency curve. Figure 3.46 shows the HEC-SSP EMA Data for the regulated POR.

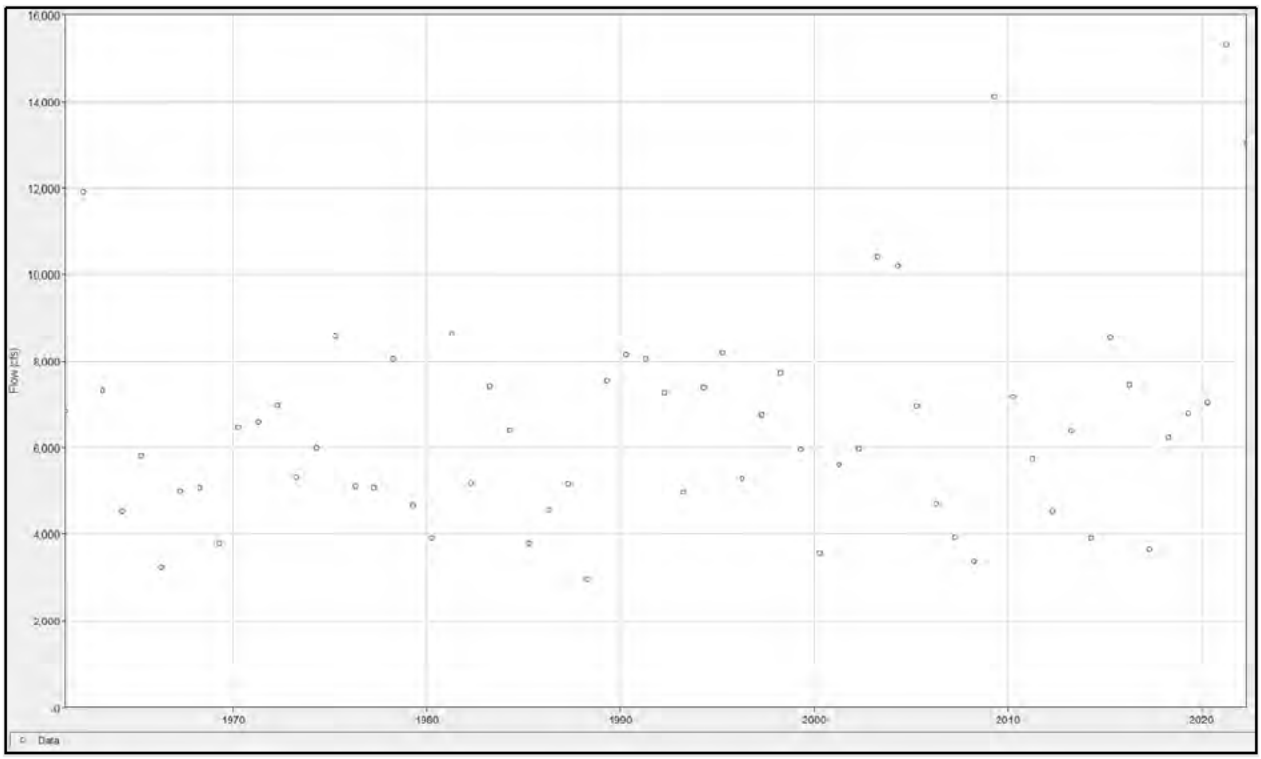


Figure 3-50: Middle Fork Regulated POR HEC-SSP EMA Data

Regional Skew Information

Regional skew information was available from an existing study published by the USGS in cooperation with the Kentucky Transportation Cabinet. The study is titled "Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals". The regional skew values for peak flows for the state of Kentucky is 0.011 with a standard error and mean square error of 0.52 and 0.27, respectively. The regional skew was applied to the B17C analysis, and the weighted skew was used as the final adopted skew.

Potentially Influential Low Outliers

The Multiple Grubbs-Beck Test was performed on the data to determine if the POR contained any PILF values. PILF's are reviewed to confirm that small observed inflows do not have an inappropriately large impact on the inflow frequency analysis. The test identified no PILF values.

Regulated Flow Frequency Sensitivities

The final POR unregulated and regulated flow frequency curves are plotted in Figure 3.47.

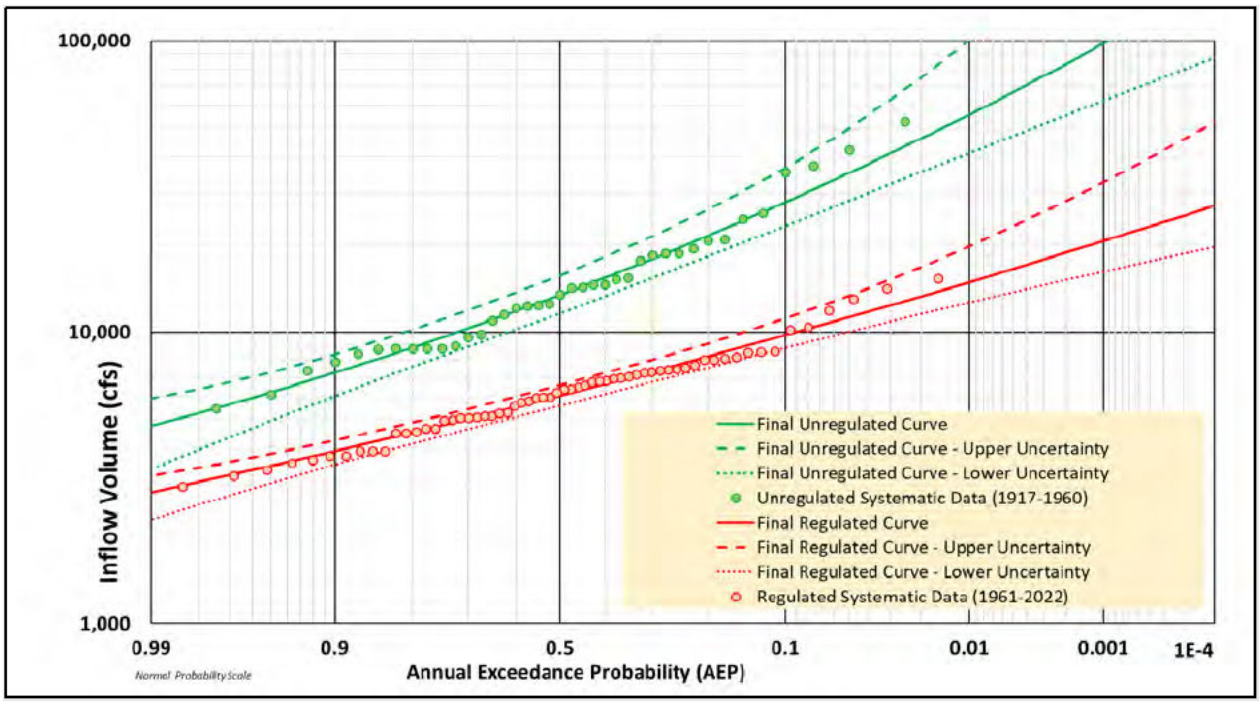


Figure 3-51: Middle Fork Regulated and Unregulated Flow Frequency Curve Comparison

It should be noted that systematic regulated flow data is typically not used to generate regulated flow frequency curves. Systematic regulated data when plotted in a flow frequency analysis can create 'steps', where flows are consistent over a series of AEPs and then steps up for another series of AEPs. This is a result of the operation of regulated infrastructure controlling outflow conditions and is not as well suited for Log-Pearson Type III (LP3) distributions as unregulated data. LP3 curves fit through systematic regulated data can result in a highly positive skew that cause the regulated flow frequency curve to cross and exceed the unregulated flow frequency curve for less frequent events. Graphical peak flow frequencies are often used for regulated data in these instances but as shown in

Figure 3.47, this is not the case with the Middle Fork systematic regulated data and the LP3 distribution fits the data reasonably well. Because a regulated-unregulated relationship could not be established and the two frequency curves do not cross, the LP3 distribution was considered acceptable for this study to use the systematic regulated data for the regulated flow frequency curve.

Figure 3.48 shows the final POR regulated flow frequency curve with systematic data and 90 percent upper and lower credible interval.

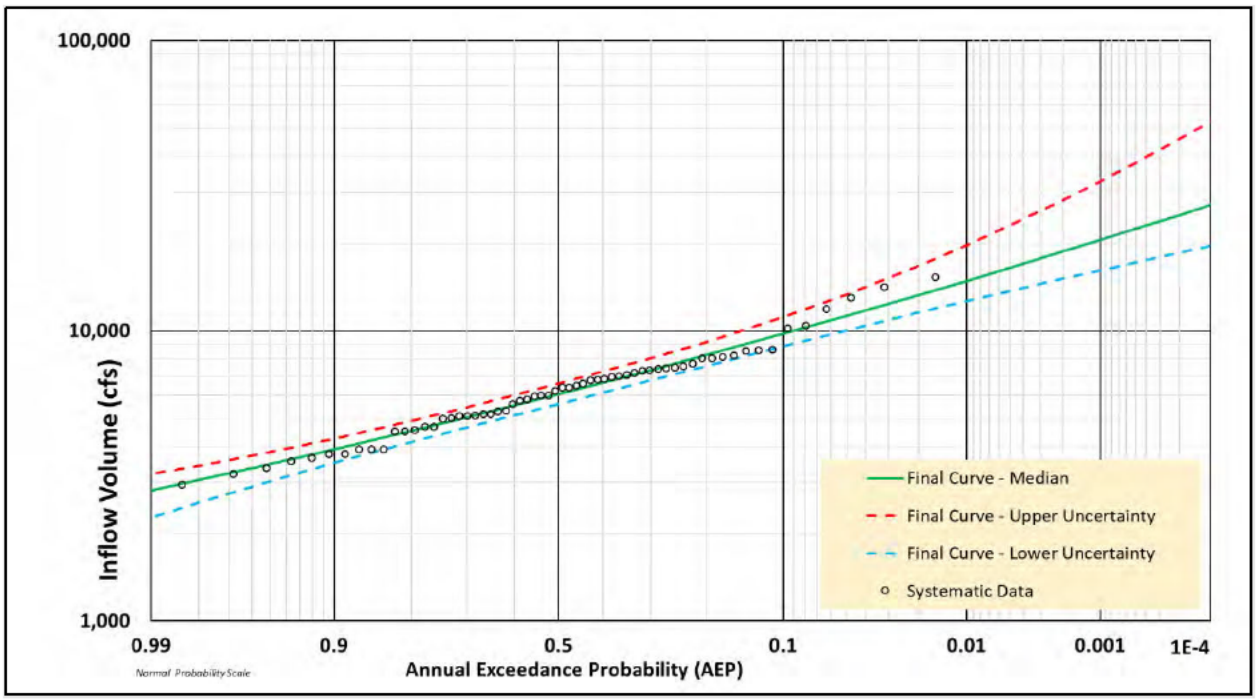


Figure 3-52: Middle Fork Final Regulated Flow Frequency Curve

Regulated-Unregulated Relationship

As previously noted, a regulated-unregulated relationship was not established for Middle Fork. Numerous attempts were made to develop a flow relationship, but values were deemed too variable and had poor data correlation. The following data sources were reviewed to establish a regulated-unregulated flow relationship at Middle Fork:

- Spreadsheet model provided by the LRL Water Management Section
- The Buckhorn Lake WCM
- Modified HEC-HMS analysis of the Kentucky River Basin at 1-hour time step from 2008 to 2022 based on available 1-hour data at Buckhorn Lake.
- Modified HEC-HMS analysis of the Kentucky River Basin at 6-hour time step from 1988 to 2022 based on available 6-hour data at Buckhorn Lake.

Figure 3.49 shows the data from the above sources, associated trendlines, and 1 to 1 ratio for the Middle Fork.

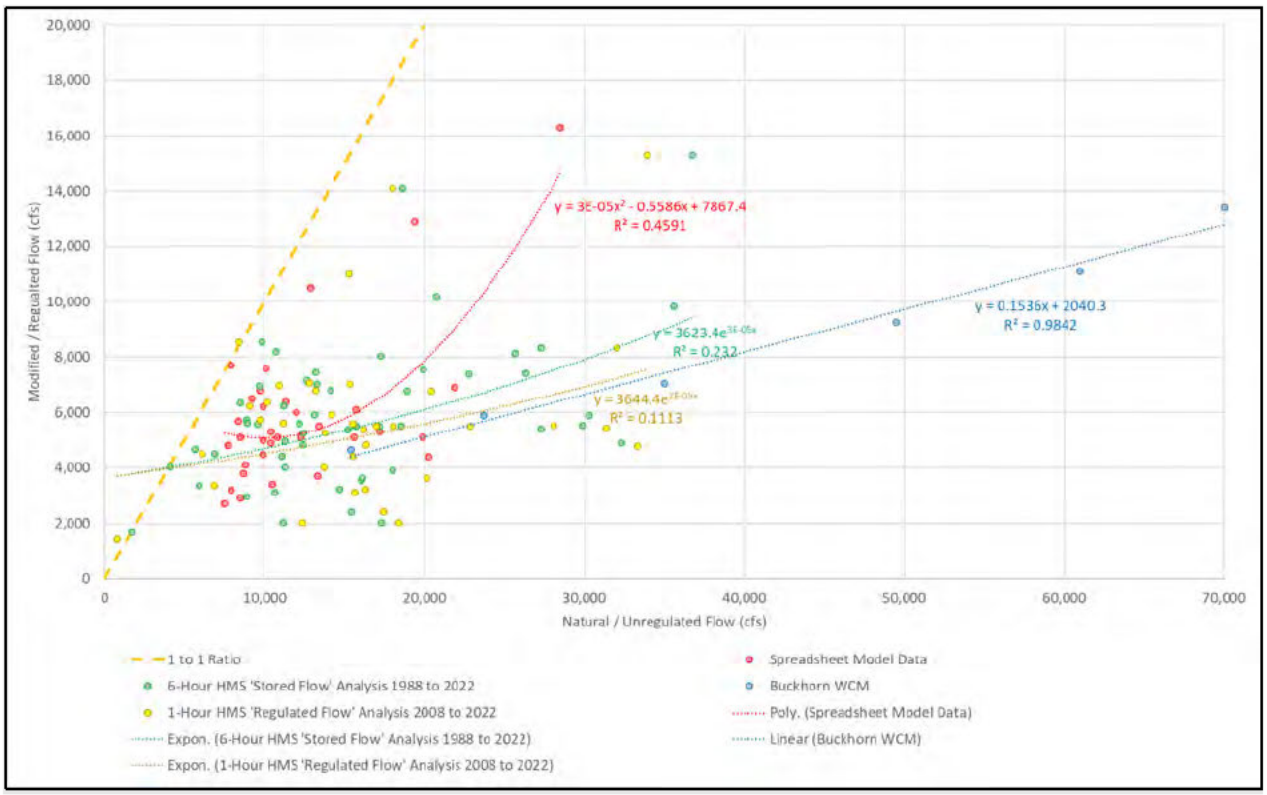


Figure 3-53: Middle Fork Regulated-Unregulated Relationship Comparisons

The HMS analyses used a similar process as previously described for Lock 14. Different time steps were used based on the availability of data at the referenced time step. As shown in Figure 3.49, the various analyses produced a wide range of results that did not have good data correlations.

It is unknown exactly why attempts to create a regulated-unregulated relationship for Middle Fork were unsuccessful. One possibility is the combination of the high amount of regulation Buckhorn Lake provides compared to the basin area, the orientation of storm events, and the generally flashy conditions of the upper Kentucky River Basins. If a storm event is centered at/or upstream of Buckhorn Lake, the Middle Fork USGS gage will show a significant reduction in natural flow based on the amount of regulation Buckhorn Lake provides. Conversely, if a storm event is centered downstream of Buckhorn Lake, the flashy conditions of the basin could result in near natural flow conditions at the Middle Fork USGS gage because Buckhorn Lake is not able to provide any regulation. This could result in a wide range of regulated flow conditions. Additional analyses on the effects of precipitation on the Middle Fork basin could be performed to refine the regulated-unregulated relationship but it was not deemed necessary at the time of this planning study.

3.9.4 Regulated Stage-Frequency Curve

Figure 3.50 shows the published Middle Fork USGS gage 003282000 at Tallega rating curve. Systematic data at the Middle Fork USGS gage 003282000 at Tallega rating curve as well as 10 percent upper and lower uncertainties are also shown for reference.

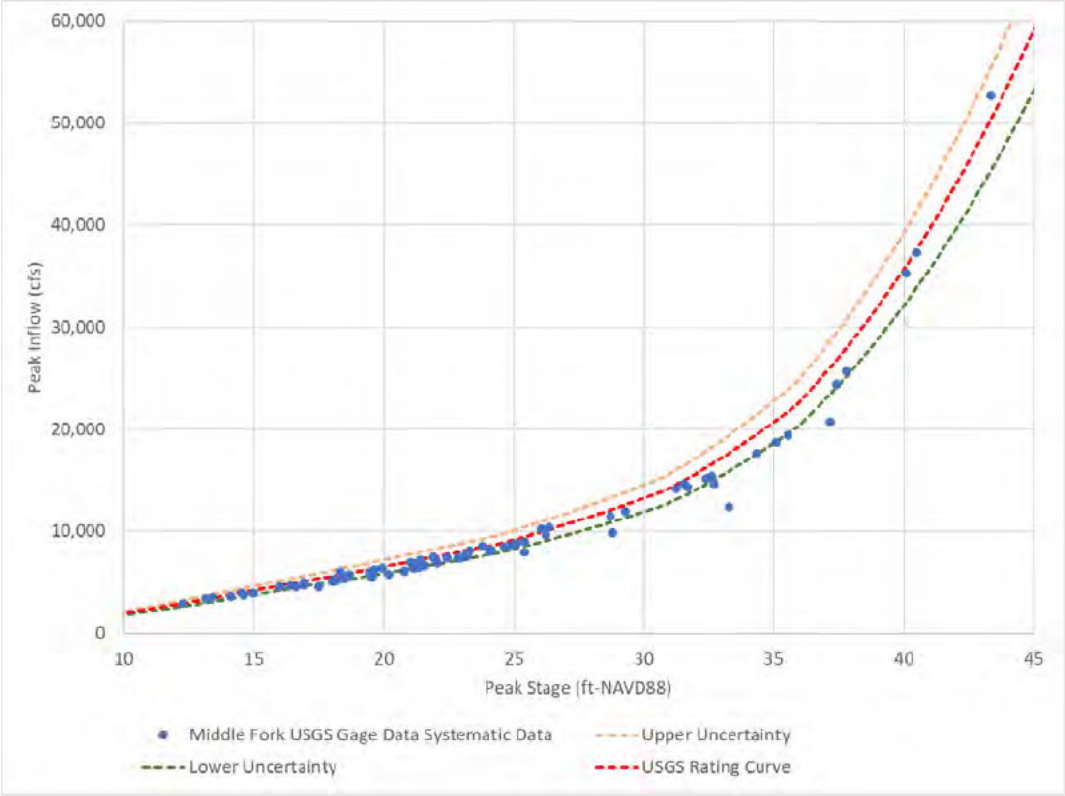


Figure 3-54: Middle Fork at Tallega USGS Published Rating Curve

The stage frequency curve for Middle Fork was developed by directly transposing the regulated flow frequency curve in Figure 3.48 with the rating curve shown in Figure 3.50.

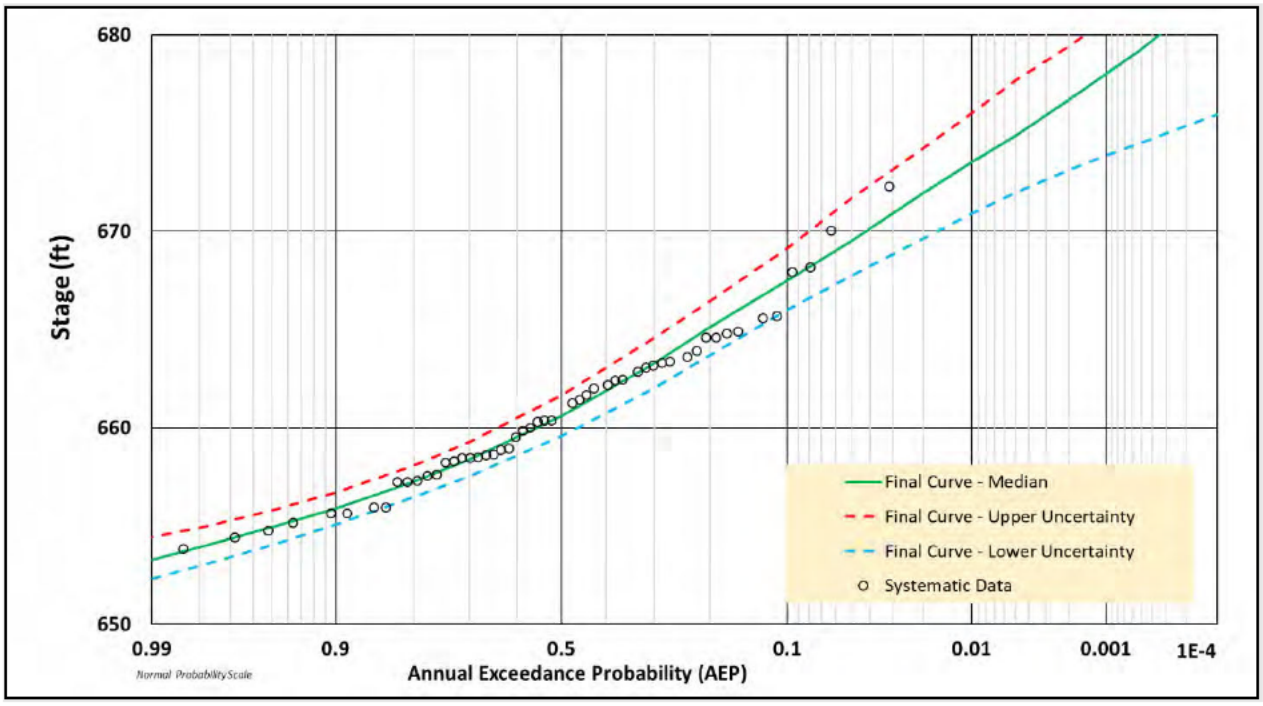


Figure 3-55: Middle Fork Final Regulated Stage-Frequency Curve

3.9.5 Hydrologic Hazard Curve Summary Tables

Table 25 and Table 26 summarize the final regulated flow and stage frequency curves for Middle Fork at Tallega for various AEPs, respectively.

Table 25: Middle Fork at Tallega Final Regulated Flow Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	28,250	15,110	21,049	18,748
0.01	100	19,730	12,637	15,591	14,856
0.04	25	13,932	10,289	11,817	11,601
0.1	10	11,138	8,844	9,854	9,766
0.2	5	9,137	7,564	8,294	8,252
0.5	2	6,568	5,595	6,057	6,067
0.99	1	3,207	2,272	2,813	2,698

Table 26: Middle Fork at Tallega Final Regulated Stage Frequency Curve Summary Table

AEP	Return Period (Years)	95% Confidence Interval (ft)	5% Confidence Interval (ft)	Expected [Mean] Curve (ft)	Computed [Median] Curve (ft)
0.002	500	676.68	675.46	679.42	673.12
0.01	100	673.52	672.91	675.99	670.88
0.04	25	669.93	669.68	672.10	668.05
0.1	10	667.49	667.36	669.13	666.01
0.2	5	665.10	665.02	666.44	663.67
0.5	2	660.56	660.58	661.65	659.58
0.99	1	653.55	653.29	654.43	652.31

3.10 HYDROLOGIC HAZARD CURVES – SOUTH FORK

3.10.1 Overall Systematic, Regional and Historical Data

Systematic Data Overview

Refer to Section 4.2 and 4.4 for general background and summary information on the USGS gages used as part of this analysis. South Fork USGS gage 03281500 at Booneville was the primary gage used for the development of stage and flow frequency curves. The South Fork USGS gage 03281500 includes annual peak streamflow data from 1926 to 1931, 1937 and 1939 to the present. The POR was also supplemented with data from the Middle Fork USGS gage 03281000 at Tallega for annual peak flows in 1932 and 1935 (the Middle Fork USGS gage 03281000 also does not include data from 1933, 1934, 1936 or 1938). There is no regulation in the South Fork and there are no current plans to include regulation, therefore only the unregulated peak flow frequency curve was created as part of this assessment.

Record Extension

Inflow correlations were reviewed to supplement South Fork data by plotting overlapping flow data between South Fork and Middle and North Forks. Inflow correlations were also reviewed between South Fork for and Locks 14, 10, 8, 6, and 4 but all the Locks have a drainage area ratio in excess of 3.5 compared to the South Fork USGS gage and were therefore considered not suitable for data transposition. The drainage area ratio between Middle Fork to South Fork and North Fork to South Fork are approximately 0.74 and 1.52, respectively, which indicates it is suitable for data transposition.

Direct overlapping data and log-log scale data was reviewed. Table 27 summarizes the r squared values of the direct and log-log scale data comparisons.

Table 27: South Fork Annual Peak Inflow Data Comparisons

Location Comparisons	***Direct Data Comparison Polynomial Trendline R Squared***	***Log-Log Scale Data Comparison R Squared***
North Fork to South Fork	0.7314	0.6447
Middle Fork to South Fork	0.8193	0.6965

As shown in Table 27, South Fork USGS gage 03281500 at Booneville had a better correlation with Middle Fork USGS gage 03281000 at Tallega. Therefore, the Middle Fork USGS gage 03281000 at Tallega was used for record extension. Figure 3.52 shows the direct flow comparison with drainage area ratio, 1 to 1 ratio, and polynomial trendline between South Fork and Middle Fork USGS gages.

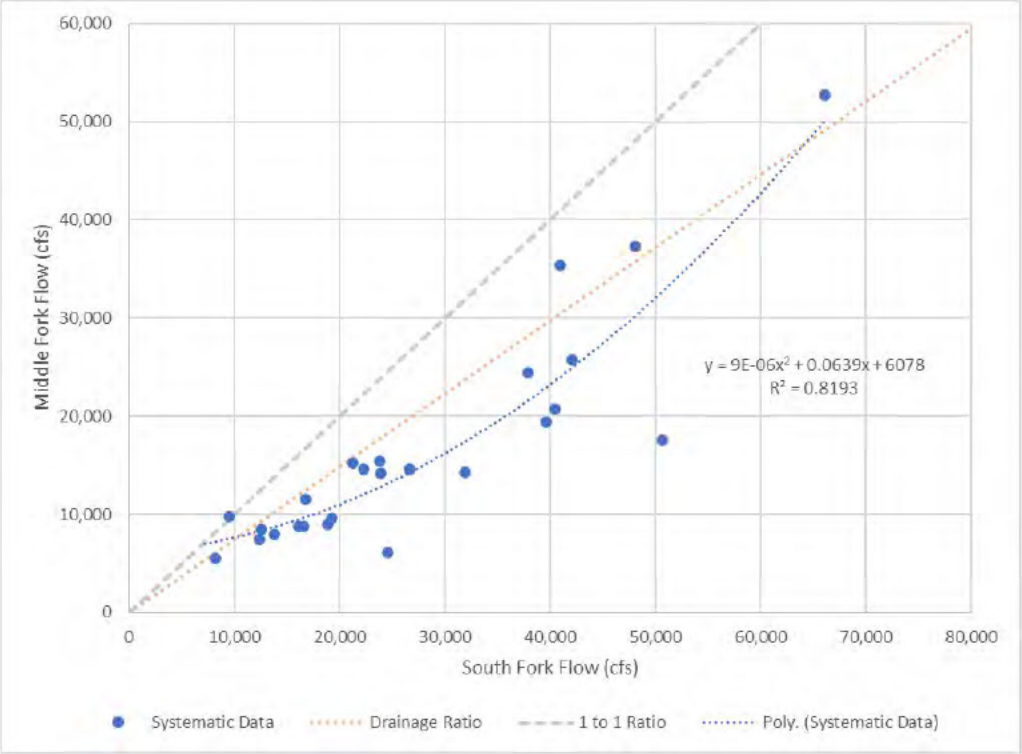


Figure 3-56: South Fork and Middle Fork Flow Data Comparison

Perception Thresholds

Missing annual peak inflow data in the POR between 1933 to 1934, 1936, and 1938 was assigned a PT of 66,100 cfs, which is the unregulated flood of record for the South Fork.

Data Summary

To summarize, the following information was used to develop the final unregulated POR data used for South Fork.

- A PT of 66,100 cfs was used between 1933 to 1934, 1936, and 1938 to supplement data gaps in the unregulated POR. The PT was based on the flood of record.
- Transposed unregulated data from Middle Fork to South Fork was used for 1932 and 1935.
- Unregulated flows from South Fork from 1926 to 1931, 1937, and 1939 to present were directly used.

Figure 3.53 shows a visual of the final composite South Fork POR used in the assessment.

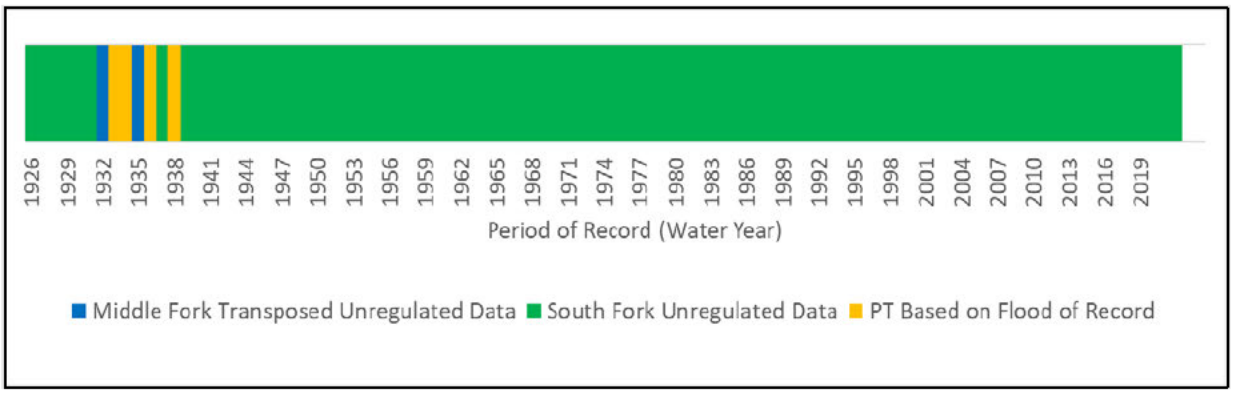


Figure 3-57: South Fork Final POR Visualization

3.10.2 Unregulated Flow-Frequency Curve

The composite unregulated peak flow POR was used to calculate the peak flow frequency curve using a B17C analysis in HEC-SSP. The final POR included systematic and transposed data from 1908 to 2022 as previously discussed. Figure 3.54 shows the HEC-SSP EMA Data for the unregulated POR for South Fork.

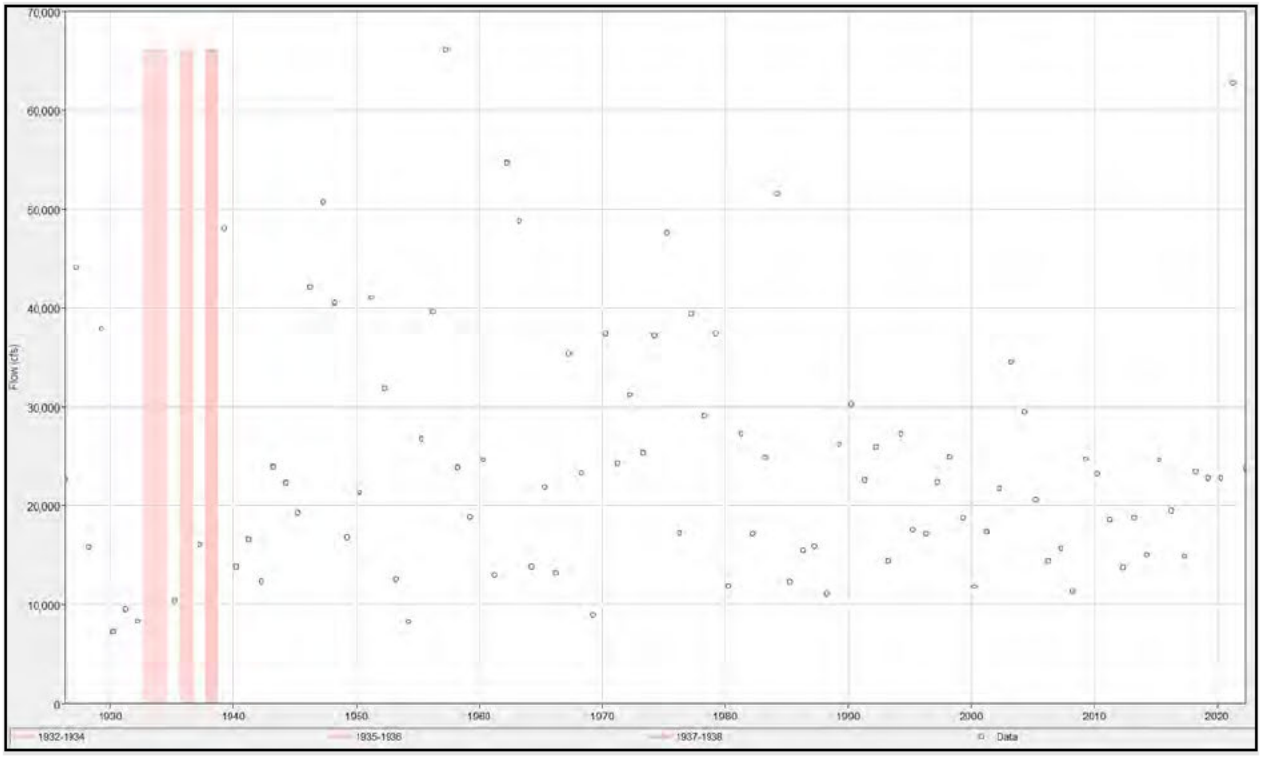


Figure 3-58: South Fork Unregulated POR HEC-SSP EMA Data

Regional Skew Information

Regional skew information was available from an existing study published by the USGS in cooperation with the Kentucky Transportation Cabinet. The study is titled “Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals”. The regional skew values for peak flows for the state of Kentucky is 0.011 with a standard error and

mean square error of 0.52 and 0.27, respectively. The regional skew was applied to the B17C analysis, and the weighted skew was used as the final adopted skew.

Potentially Influential Low Outliers

The Multiple Grubbs-Beck Test was performed on the data to determine if the POR contained any PILF values. PILF's are reviewed to confirm that small observed inflows do not have an inappropriately large impact on the inflow frequency analysis. The test identified no PILF values.

Unregulated Flow Frequency Sensitivities

To determine how sensitive the analysis is to the inclusion of additional data sources, sensitivities were modeled with various data sets. Flow-frequency curves for the following data sets were developed using a B17C analysis in HEC-SSP:

- South Fork Unmodified Unregulated – includes unmodified unregulated flow data from 1926 to 1931, 1937, and 1939 to present.
- Final POR – includes the final period of record as previously discussed with interval data and PTs.

Figure 3.55 show a plot of the curves for the above data sets using a B17C analysis in HEC-SSP.

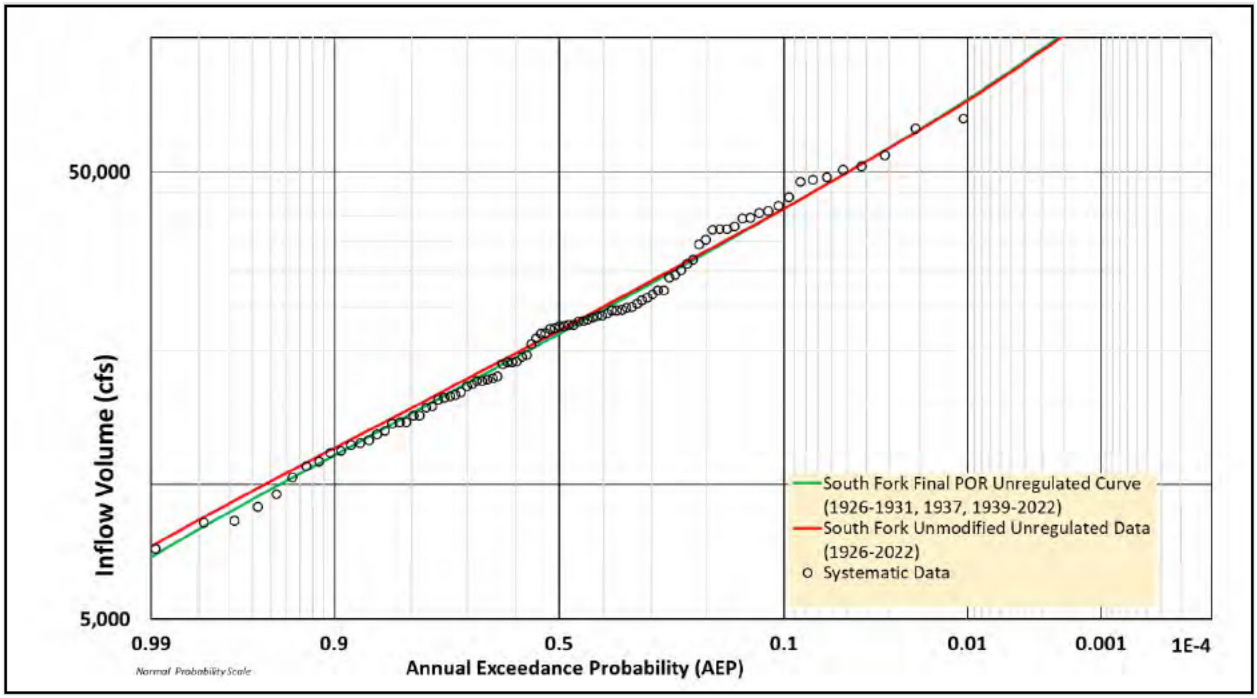


Figure 3-59: South Fork Unregulated Inflow Frequency Sensitivities

Table 28 summarizes the mean, standard deviation, and skew of the sensitivities plotted in Figure 3.55. Both sensitivities are similar in terms of mean, standard deviation, and skew.

Table 28: South Fork at Booneville Statistical Summary of Bulletin 17C Sensitivities

Data Set Description	*Mean (of log) (μ)*	*Std. Dev. (of log) (σ)*	*Skew (of log) (γ)*
South Fork Unmodified Unregulated (1926-1931, 1937, 1939-2022)	4.348	0.207	0.084
South Fork Final POR (1926-2022)	4.340	0.212	0.066

Figure 3.56 shows the unregulated POR final curve with systematic and B17C analysis in HEC-SSP.

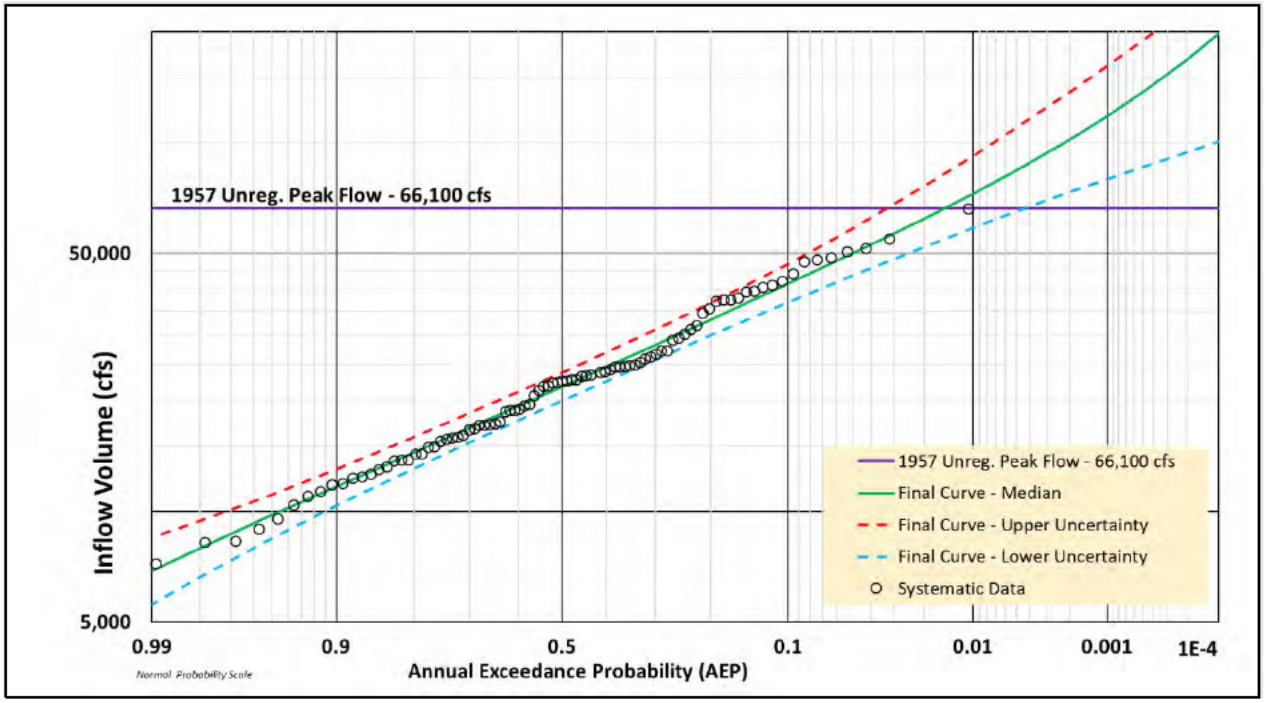


Figure 3-60: South Fork Final Unregulated Flow Frequency Curve

3.10.3 Regulated Flow-Frequency Curve

South Fork flows are currently not regulated and as of the time of this analysis, there were no plans to incorporate regulation within the South Fork basin. Therefore, regulated flow-frequency curves for South Fork were not developed.

3.10.4 Stage-Frequency Curves

Figure 3.57 shows the published South Fork USGS gage 003281500 at Booneville rating curve. Systematic data at the South Fork USGS gage 003281500 at Booneville rating curve as well as a best fit exponential trendline through the systematic data and 10 percent upper and lower uncertainties for the best fit trendline are also shown for reference.

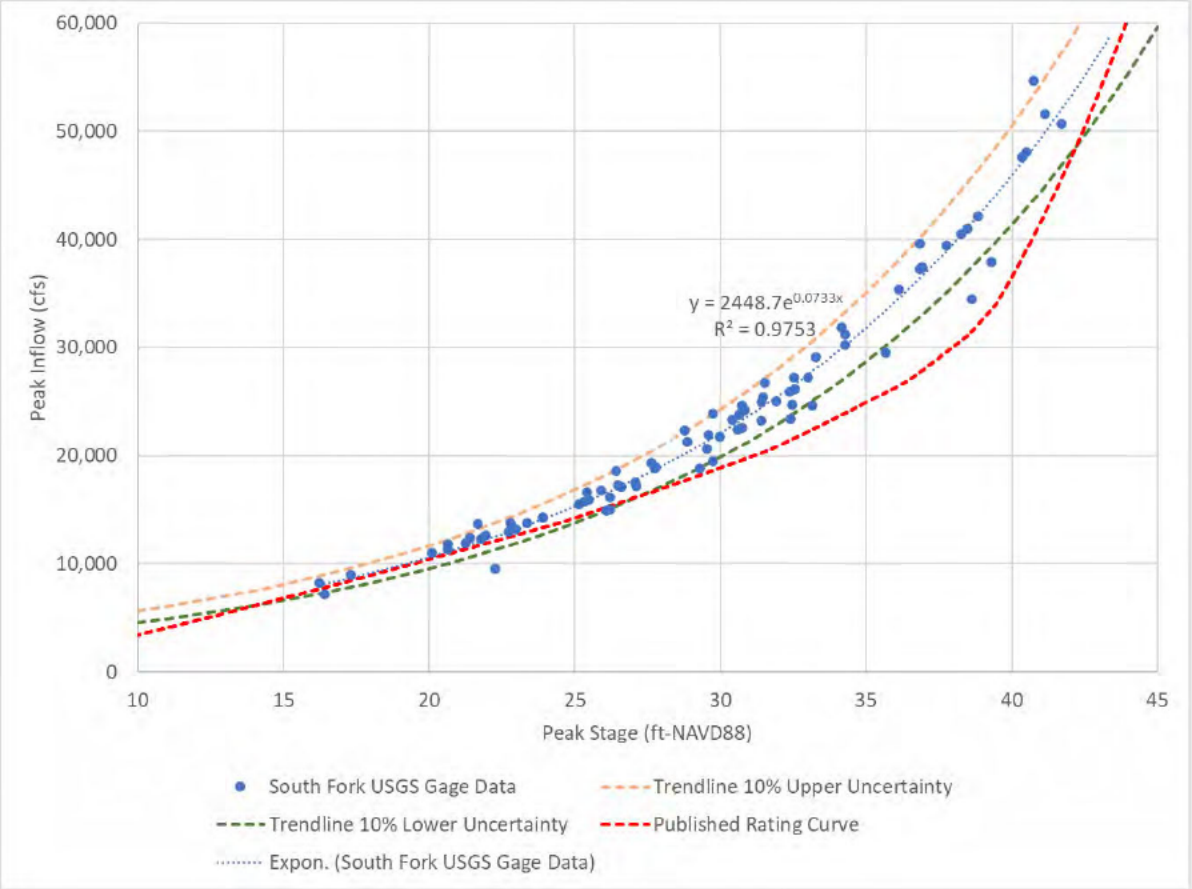


Figure 3-61: South Fork at Booneville USGS Published Rating Curve

As shown in Figure 3.57, the published USGS rating curve does not match the systematic data as well as the exponential trendline fit through the systematic data. It is not certain why the published USGS curve appears shifted from the systematic data. The best fit trendline was used to develop the South Fork stage frequency curve, which is shown in Figure 3.58.

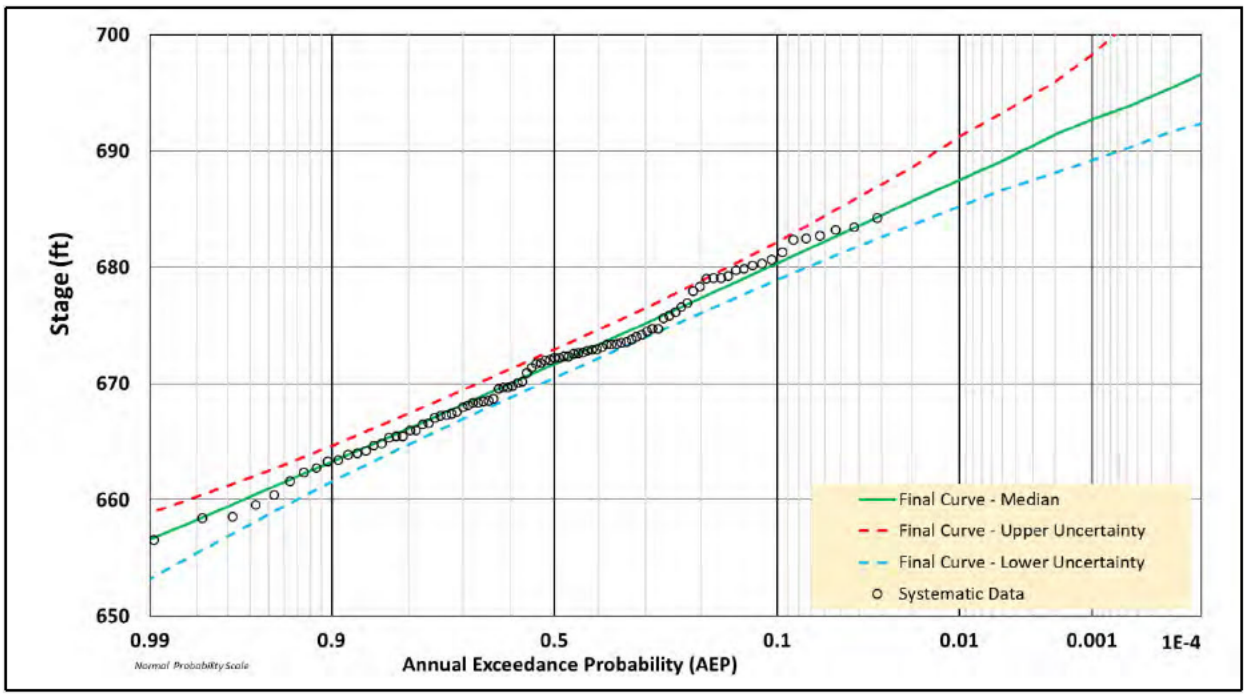


Figure 3-62: South Fork Final Unregulated Stage-Frequency Curve

3.10.5 Hydrologic Hazard Curve Summary Tables

Table 29 and Table 30 summarize the final unregulated flow and stage frequency curves for South Fork at Booneville for various AEPs, respectively.

Table 29: South Fork at Booneville Final Unregulated Flow Frequency Curve Summary Table

AEP	*Return Period (Years)*	*95% Confidence Interval (cfs)*	*5% Confidence Interval (cfs)*	*Expected [Mean] Curve (cfs)*	*Computed [Median] Curve (cfs)*
0.002	500	137,285	73,299	101,973	92,877
0.01	100	91,801	58,604	72,572	69,817
0.04	25	61,320	45,016	51,975	51,207
0.1	10	46,835	36,890	41,338	41,046
0.2	5	36,602	29,957	33,063	32,937
0.5	2	23,782	19,889	21,756	21,746
0.99	1	8,471	5,589	6,883	7,181

Table 30: South Fork at Boonville Final Unregulated Stage Frequency Curve Summary Table

AEP	*Return Period (Years)*	*95% Confidence Interval (ft)*	*5% Confidence Interval (ft)*	*Expected [Mean] Curve (ft)*	*Computed [Median] Curve (ft)*
0.002	500	695.94	688.10	692.52	691.44
0.01	100	691.26	685.22	687.98	687.51
0.04	25	685.73	681.59	683.54	683.34
0.1	10	682.16	678.91	680.46	680.36
0.2	5	678.80	676.07	677.41	677.36
0.5	2	672.92	670.48	671.70	671.70
0.99	1	658.84	653.16	656.01	656.58

3.11 UNCERTAINTY

This section discusses potential points of uncertainty within the data or previously discussed analyses beyond standard inaccuracies in gage data. As part of the SMART planning guidance, the risk associated with the assumptions made in this report, and subsequently the uncertainty outlined below is also noted.

Lock 14 Rating Curve

As previously noted, the USGS published data at Lock 14 is based on a non-sloped rating curve. Discussions with USGS and review of their field measurements captured during the March 2021 event indicate that the Lock 14 rating curve reacts as a sloped rating curve during certain sustained high flow and downstream conditions that create backwater effects. The HEC-RAS model was calibrated and validated based on the March 2021 event, which yielded a rating curve at Beattyville that created a hysteresis loop in the model. USGS noted there is insufficient observed data to determine how and when Lock 14 reacts to flow based on a sloped rating curve. Therefore, a composite rating curve created from the model rating curve with additional uncertainty was used for the final transform of the flow frequency curve to stage frequency curve at Beattyville. Not knowing which events react based on the sloped and non-sloped rating curves introduces additional uncertainty to the analyses.

If deemed necessary as the study continues, additional sensitivities could be evaluated comparing the impacts of using the various rating curves to develop the final stage frequency curve at Beattyville. This would help quantify the level of uncertainty and sensitivity between the various rating curves.

Beattyville HEC-RAS Rating Curve

The final Beattyville stage frequency curve was created using a rating curve developed in HEC-RAS. There is no gage or significant field data at cross section 257.5170 where the rating curve was developed to calibrate to or determine the level of uncertainty in the HEC-RAS rating curve. As noted above, the HEC-RAS rating curve created a hysteresis loop, which was simplified to a composite rating curve for the purposes of this report.

Middle Fork

As previously noted, an unregulated-regulated relationship was not established for Middle Fork USGS gage 03281000 at Tallega. Several methods and data sources were used in an attempt to establish a relationship, but none were deemed accurate or consistent enough to use. Therefore, the regulated flow data set was input directly into HEC-SSP to develop the regulated flow frequency curve and fit to a Log-Pearson type III (LP3) distribution. This results in some uncertainty because regulated data is typically not fit to an LP3 distribution for the creation of flow frequency curves.

Coincident Loading

Uncertainty related to timing on the North, Middle and South Forks of the Kentucky River and how that coincident loading affects stages at Beattyville is documented in Section 4.7. This study accounts for flooding on all 3 forks by performing the Bulletin 17C Study at Lock 14 which is located downstream of Beattyville.

SMART Planning Risk

The risk associated with assumptions made as part of this analysis affect the final stage frequency results utilized to determine the 0.01 AEP flood event. The stage frequency curve accounts for these sources of uncertainty, which subsequently affects the level of assurance calculations. The PDT believes that adequate analysis has been performed to quantify the uncertainty, and therefore the risk, associated with the development of the stage frequency curve at Beattyville. Future studies should consider if additional analysis is warranted to further reduce uncertainty, and therefore further reduce planning risk, associated with the hydrologic analysis. The key sources of uncertainty that affect the final stage frequency curve are summarized in the following list.

- The final POR was extended to include data from Lock 4 and Lock 10. Extending the period of record can reduce the uncertainty in the Bulletin 17C analysis. However, there is also uncertainty in the relationship between Lock 14 and the downstream Locks used to extend the POR.
- The final regulated inflow frequency curve utilizes a regulated-unregulated relationship to convert the unregulated inflow frequency curve to a regulated flow frequency curve. Uncertainty in this relationship was incorporated as part of the final analysis but could be further investigated in future studies to try to reduce the uncertainty in that relationship.
- The rating curve at Beattyville was utilized to convert the regulated inflow frequency curve to a regulated stage frequency curve. This is the largest source of uncertainty and is also accounted for in the final results. Additional modeling could be performed to better understand the rating curve at both Lock 14 and Beattyville.

4 HYDROLOGY

4.1 PROJECT DESCRIPTION

4.1.1 Project Site

Beattyville is considered a city and is the county seat of Lee County, Kentucky. Beattyville is situated at the confluence of the North Fork and South Fork Kentucky Rivers which forms the Kentucky River mainstem. The community is on the North bank of the confluence on flat terrain that rises quickly with the steep topography away from the river. About 6 miles downstream is Lock 14 on the Kentucky River at Heidelberg, Kentucky. See Figure 4.1.

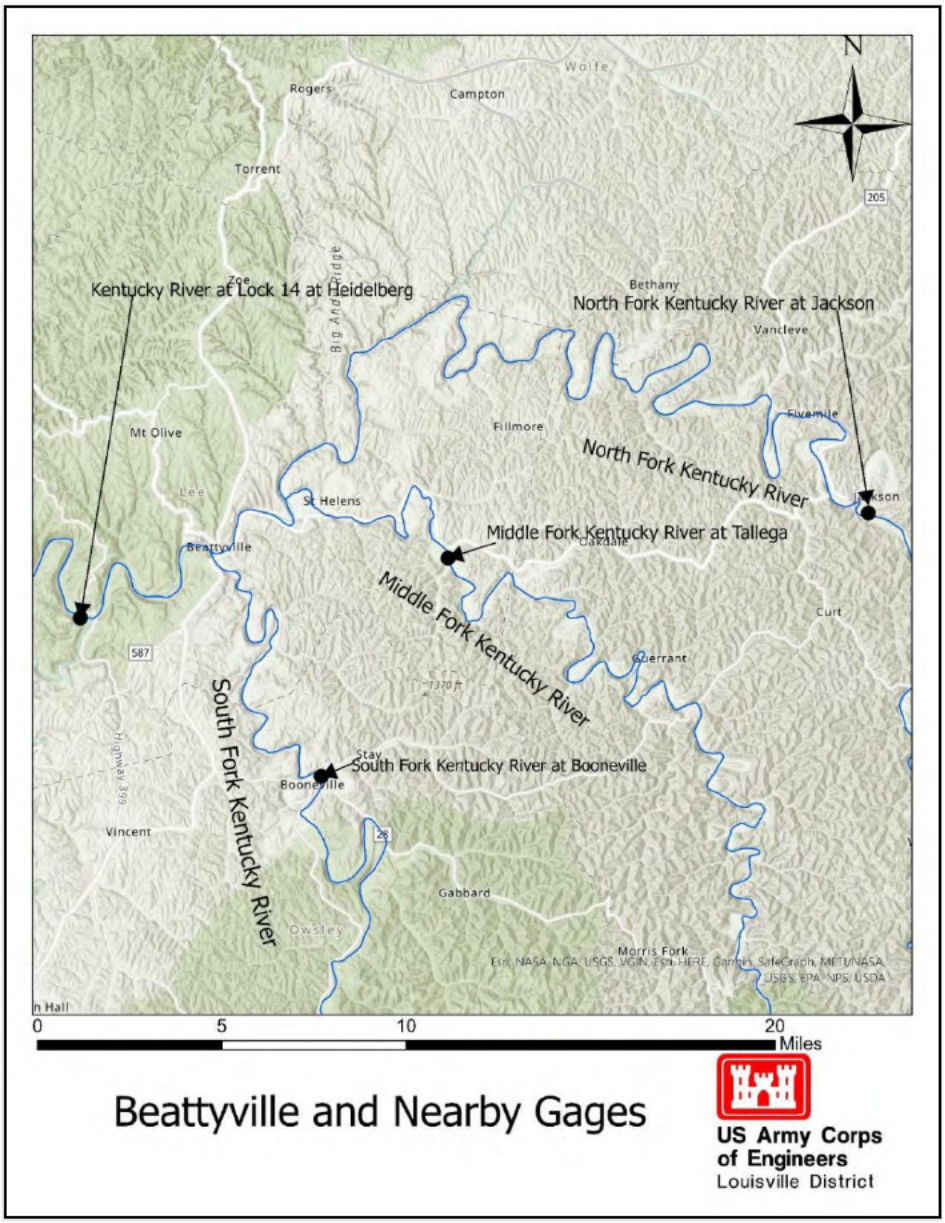


Figure 4-1: Beattyville and Surrounding Area

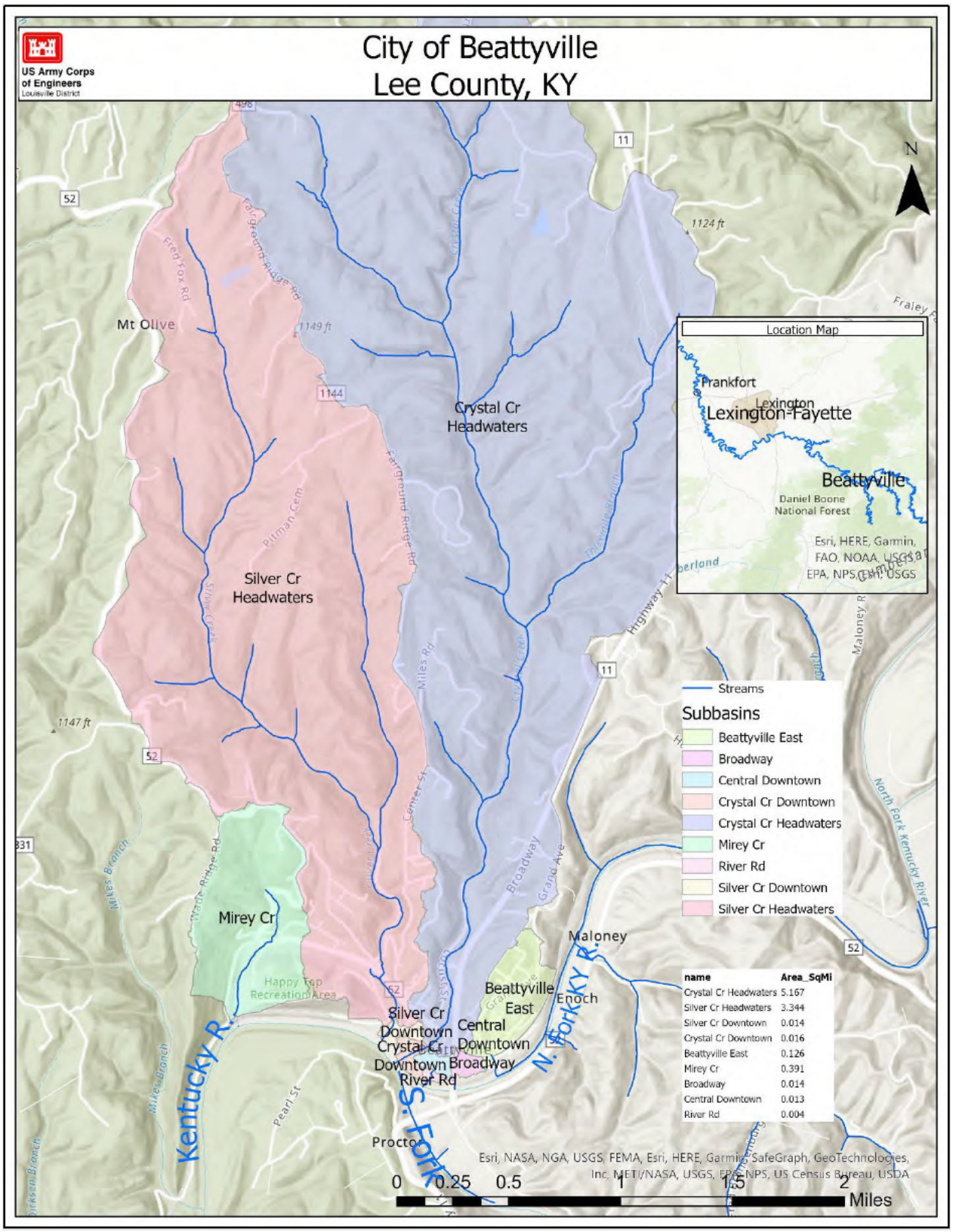
The climate is typical of the Commonwealth of Kentucky characterized by hot, humid summers and mild to cool winters. The steep terrain is prone to flash flooding because intense storms can produce high runoff rates, particularly in the winter to early spring when vegetation is dormant, and soils have higher moisture content.

4.1.2 Primary Flooding Source

Two local streams pass through downtown Beattyville. Crystal Creek flows south on the east side of downtown (drainage area of 5.2 mi^2) and Silver Creek flows south on the west side (drainage area of 3.3 mi^2), both terminating at the Kentucky River. Mirey Creek is third stream that flows enters the Kentucky River west of downtown Beattyville (drainage area of 0.4 mi^2). See Figure 4.2 for interior drainage watersheds.

Existing information does not indicate principal flooding is caused by any of the Crystal and Silver Creeks (the Creeks). The contributing drainage areas are relatively small, and the overall basins slopes are steep. The streams are likely very flashy, but not such as to contribute to damaging floods. The time of concentrations for the watersheds are small relative to the entire uncontrolled Kentucky River watershed at Beattyville (2,164 mi^2). Coincident flooding of the Creeks and the Kentucky River is not likely. The significance of coincidence is discussed later in Section 4.9.7 during the evaluation of a floodwall alternative.

The primary flooding is due to the Kentucky River backwater, as stated in previous reports such as the Flood Insurance Study (FIS). The FIS indicates that although flashy with high stream velocities, the Creeks do not flood Beattyville when the Kentucky River is at normal stage and scour is not an issue. There is no evidence to suggest the Creeks are a flooding concern in downtown Beattyville. Currently, flooding from the Creeks is not being investigated further as a flooding source and the study focus remains on the Kentucky River.



name	Area_SqMi
Crystal Cr Headwaters	5.167
Silver Cr Headwaters	3.344
Silver Cr Downtown	0.014
Crystal Cr Downtown	0.016
Beattyville East	0.126
Mirey Cr	0.391
Broadway	0.014
Central Downtown	0.013
River Rd	0.004

Figure 4-2: Beattyville Interior Watersheds Map

4.1.3 Flood Insurance Study

The current Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Lee County contains peak discharges that have been in effect since 1976. The preliminary FIS Number 211219CV000B is dated 27-October-2022, where the Beattyville Community Number is 210136 and the unincorporated areas of Lee County is Community Number 210135. See the Summary of Discharges from the preliminary FIS in Figure 4.3.

Flooding Source	Location	Drainage Area (Square Miles)	Peak Discharge (cfs)				
			10% Annual Chance	4% Annual Chance	2% Annual Chance	1% Annual Chance	0.2% Annual Chance
Crystal Creek	Mile 0.31 (above mouth)	5.1	2,500	*	4,100	5,200	7,400
Kentucky River	Heidelberg Gage	2,657	79,500	*	105,000	115,000	138,800
Mirey Creek	Mile 0.26 (above mouth)	0.3	520	*	850	1,060	1,500
Mirey Creek	Kentucky Highway 52	0.1	285	*	460	580	800
North Fork Kentucky River	140 feet downstream of Broadway	1,883	60,000	*	79,300	86,800	105,000
Silver Creek	Mile 0.14 (above mouth)	3.3	1,940	*	3,200	4,000	5,800

*Not calculated for this Flood Risk Project

Figure 4-3: Summary of Discharges from the Preliminary FIS

4.1.4 Regulatory Floodway Established

A Regulatory Floodway has been established for Beattyville (shown in blue and red hatch marks in Figure 4.4). The Regulatory Floodway marks the calculated location where farther riverside encroachment into the floodplain increases the water surface of the base flood elevation (BFE) greater than the regulated limit of 1.0 feet. The local regulator is the Kentucky Division of Water (KYDoW). The effective BFE for Beattyville is 669.1 Ft. NAVD88 see section 2.2.1 for discussion on the identified BFE.



Figure 4-4: Current Flood Hazard Mapping of Beattyville Established by Regulators

4.1.5 Watershed Regulation

The Kentucky River is formed at Beattyville where the North and South Forks merge. The South Fork Kentucky River flows generally north from southern headwaters encompassing a 748-mi^2 unregulated drainage area. The North Fork Kentucky River near the mouth accounts for 1883 mi^2, which captures also includes the Middle Fork Kentucky River. The Middle Fork enters the North Fork about 2.6 miles upstream of Beattyville. The Middle Fork is regulated by Buckhorn Lake Dam (operated by USACE LRL beginning in 1961) regulating 73% of the Middle Fork watershed. The North Fork is regulated by Carr Creek Lake Dam (also operated by USACE LRL beginning in 1976) controlling 58 mi^2 of the watershed. The total drainage area at Beattyville is approximately 2,630 mi^2 with 2,164 mi^2 unregulated. The total percentage of upstream drainage area regulated by the two dams is 18% at Beattyville. See Table 31 below.

Table 31: Natural and Regulated Drainage Areas of the Kentucky River

		Drainage Area Regulated (Mi^2)		% Drainage Area Controlled by Year	
		408	58		
Location	Natural conditions	Buckhorn (1961)	Carr Creek (1976)	1961	1976
	Drainage Area NOT Regulated				
Heidelberg Gage	2657	2249	2191	15%	18%
Beattyville @ Fork Confluence	2630	2222	2164	16%	18%
North Fork Mouth	1883	1475	1417	22%	25%
South Fork Mouth	748	748	748	0%	0%
Middle Fork Mouth	559	151	151	73%	73%
North Fork U/S of Middle Fork	1320	1320	1262	0%	4%

Carr Creek Dam mostly benefits Hazard, Kentucky, and has little impact on the flood stage at Beattyville. Also, note the March 2021 event that initiated this study was marked by high discharges from the unregulated South Fork and a near 1% AEP event at the Tallega gage on the Middle Fork despite the storm largely missing Buckhorn Lake itself. For all intents and purposes, the Buckhorn Dam is the only significant regulation structure upstream of Beattyville. See Figure 4.5.

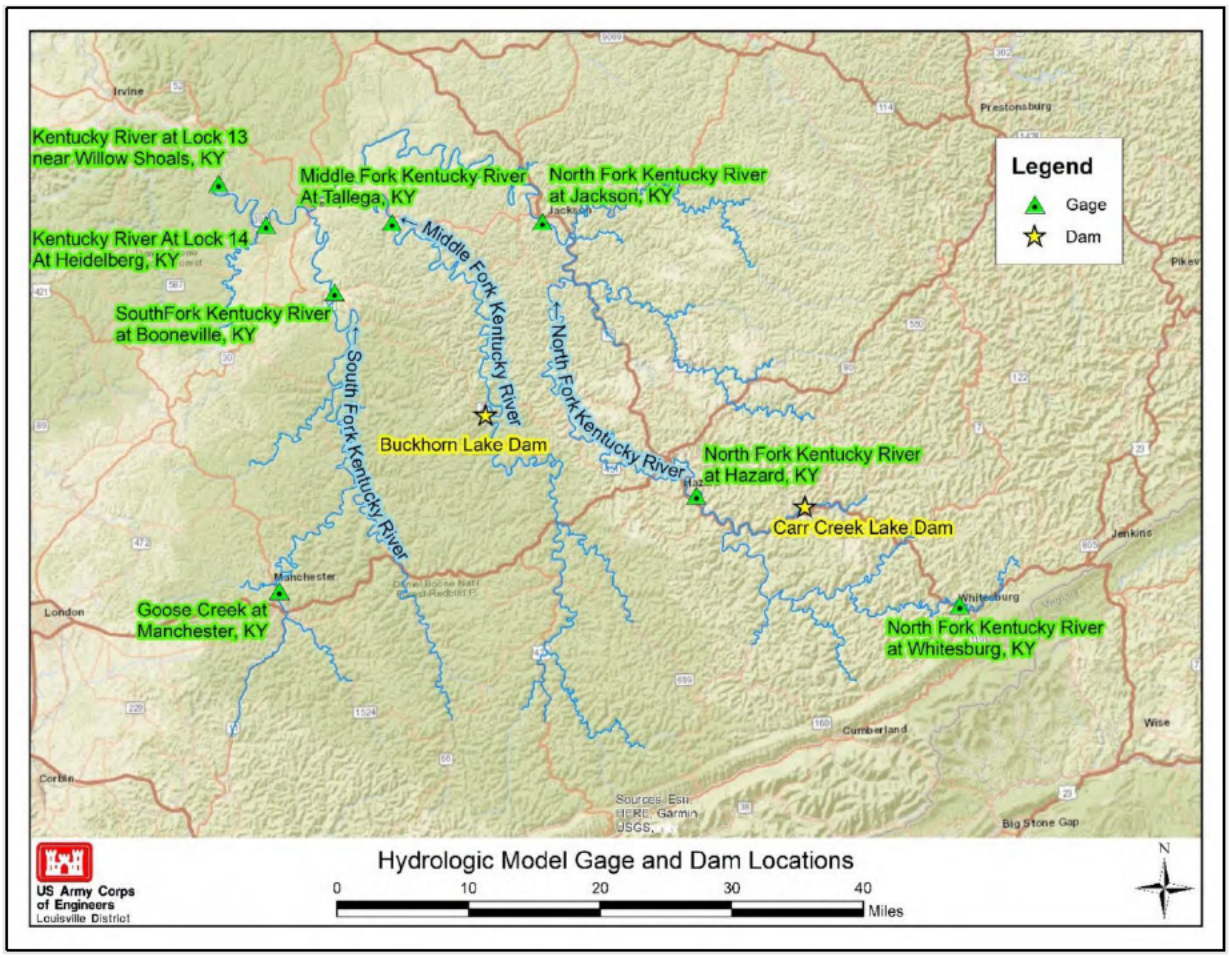


Figure 4-5: Location of Upper Kentucky River Basin Stream Gages and Reservoirs

4.1.5.1 USACE Reservoir Operations

Buckhorn and Car Creek Dams are USACE projects authorized for flood control. Water Management (WM) oversees the flood control strategy written in the Water Control Manuals (WCM) of the respective projects. In general, when heavy precipitation arrives, the Dams decrease water releases to a prescribed outflow until downstream flooding (if any) recedes. The WCM contains the Schedule of Regulation which is the primary instruction for reservoir operations. The Schedule of Regulation prescribes the reservoir releases given the reservoir pool elevation and the gage readings at downstream control points. The Dams share the same downstream control point that impacts Beattyville, which is Lock 14 at Heidelberg, KY.

The Schedules of Regulation cite control stages at Lock 14(shown in Figure 4.6 and Figure 4.7), which corresponds roughly to just below the National Weather Service 'action' and flood stages for the stream gage. The reservoirs are operated to this control point as to not worsen flooding according to the Schedule.

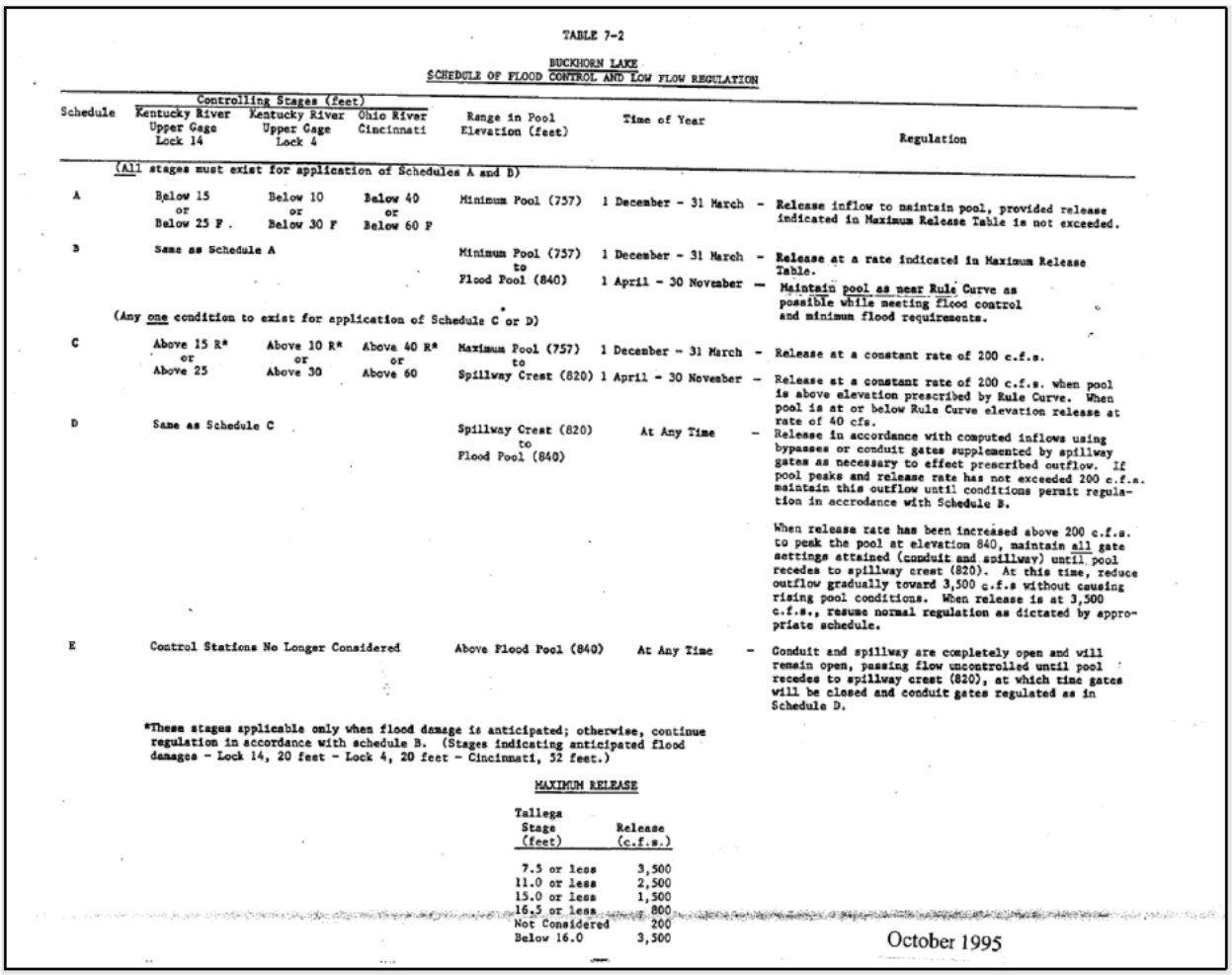


TABLE 7-2

BUCKHORN LAKE
SCHEDULE OF FLOOD CONTROL AND LOW FLOW REGULATION

Schedule	Controlling Stages (feet) Kentucky River Upper Gage Lock 14	Kentucky River Upper Gage Lock 4	Ohio River Cincinnati	Range in Pool Elevation (feet)	Time of Year	Regulation
	(All stages must exist for application of Schedules A and B)					
A	Below 15 or Below 25 F.	Below 10 or Below 30 F	Below 40 or Below 60 F	Minimum Pool (757)	1 December - 31 March	- Release inflow to maintain pool, provided release indicated in Maximum Release Table is not exceeded.
B	Same as Schedule A			Minimum Pool (757) to Flood Pool (840)	1 December - 31 March 1 April - 30 November	- Release at a rate indicated in Maximum Release Table. - Maintain pool as near Rule Curve as possible while meeting flood control and minimum flood requirements.
	(Any one condition to exist for application of Schedule C or D)					
C	Above 15 R* or Above 25	Above 10 R* or Above 30	Above 40 R* or Above 60	Maximum Pool (757) to Spillway Crest (820)	1 December - 31 March 1 April - 30 November	- Release at a constant rate of 200 c.f.s. - Release at a constant rate of 200 c.f.s. when pool is above elevation prescribed by Rule Curve. When pool is at or below Rule Curve elevation release at rate of 40 cfs.
D	Same as Schedule C			Spillway Crest (820) to Flood Pool (840)	At Any Time	- Release in accordance with computed inflows using bypasses or conduit gates supplemented by spillway gates as necessary to effect prescribed outflow. If pool peaks and release rate has not exceeded 200 c.f.s. maintain this outflow until conditions permit regulation in accordance with Schedule B. When release rate has been increased above 200 c.f.s. to peak the pool at elevation 840, maintain all gate settings attained (conduit and spillway) until pool recedes to spillway crest (820). At this time, reduce outflow gradually toward 3,500 c.f.s without causing rising pool conditions. When release is at 3,500 c.f.s., resume normal regulation as dictated by appropriate schedule.
E	Control Stations No Longer Considered			Above Flood Pool (840)	At Any Time	- Conduit and spillway are completely open and will remain open, passing flow uncontrolled until pool recedes to spillway crest (820), at which time gates will be closed and conduit gates regulated as in Schedule D.

*These stages applicable only when flood damage is anticipated; otherwise, continue regulation in accordance with schedule B. (Stages indicating anticipated flood damages - Lock 14, 20 feet - Lock 4, 20 feet - Cincinnati, 52 feet.)

MAXIMUM RELEASE

Tallega Stage (feet)	Release (c.f.s.)
7.5 or less	3,500
11.0 or less	2,500
15.0 or less	1,500
16.5 or less	800
Not Considered	200
Below 16.0	3,500

October 1995

Figure 4-6: Buckhorn Lake Schedule of Regulation

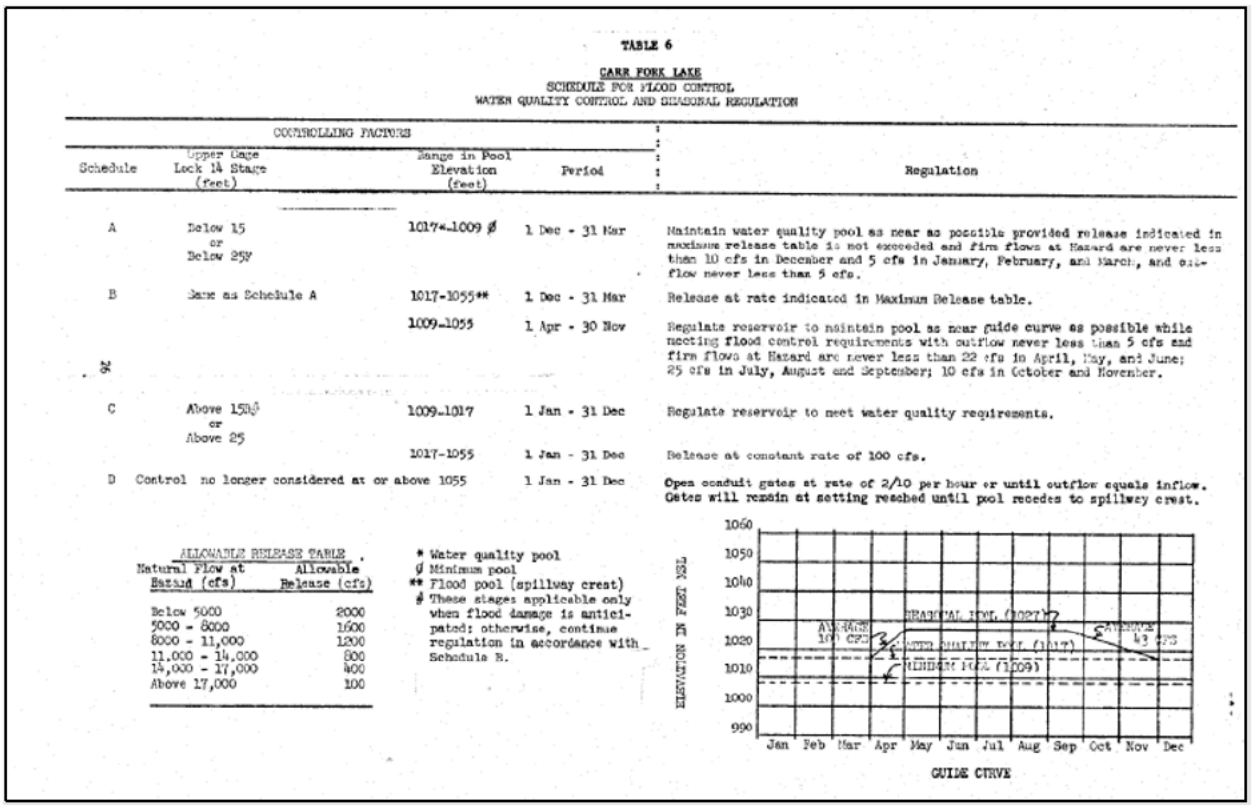


TABLE 6

CARR FORK LAKE
SCHEDULE FOR FLOOD CONTROL
WATER QUALITY CONTROL AND SEASONAL REGULATION

Schedule	CONTROLLING FACTORS: Upper Gage Lock 14 Stage (feet)	Range in Pool Elevation (feet)	Period	Regulation
A	Below 15 or Below 25Y	1017-1009 ø	1 Dec - 31 Mar	Maintain water quality pool as near as possible provided release indicated in maximum release table is not exceeded and firm flows at Hazard are never less than 10 cfs in December and 5 cfs in January, February, and March, and outflow never less than 5 cfs.
B	Same as Schedule A	1017-1055**	1 Dec - 31 Mar	Release at rate indicated in Maximum Release table.
		1009-1055	1 Apr - 30 Nov	Regulate reservoir to maintain pool as near guide curve as possible while meeting flood control requirements with outflow never less than 5 cfs and firm flows at Hazard are never less than 22 cfs in April, May, and June; 25 cfs in July, August and September; 10 cfs in October and November.
C	Above 15ø or Above 25	1009-1017	1 Jan - 31 Dec	Regulate reservoir to meet water quality requirements.
		1017-1055	1 Jan - 31 Dec	Release at constant rate of 100 cfs.
D	Control no longer considered at or above 1055		1 Jan - 31 Dec	Open conduit gates at rate of 2/10 per hour or until outflow equals inflow. Gates will remain at setting reached until pool recedes to spillway crest.

ALLOWABLE RELEASE TABLE

Natural Flow at Satan (cfs)	Allowable Release (cfs)
Below 5000	2000
5000 - 8000	1600
8000 - 11,000	1200
11,000 - 14,000	800
14,000 - 17,000	400
Above 17,000	100

* Water quality pool
ø Minimum pool
** Flood pool (spillway crest)
ø These stages applicable only when flood damage is anticipated; otherwise, continue regulation in accordance with Schedule B.

Figure 4-7: Carr Creek Lake Schedule of Regulation

4.1.5.2 Reservoir Re-Operation

Both Carr Creek and Buckhorn Dams utilize Heidelberg (Lock 14) as a downstream control point located about 6 miles downstream of Beattyville. WCMs specify the control point stage at 15 feet and 25 feet (falling/rising) to regulate releases. Heidelberg stage 25 feet gives an approximate discharge of 65,000 cfs which equates to about a stage 5 feet below the damage stage at Beattyville. Considering the long travel times and large unregulated areas between the reservoirs and Beattyville there is currently no need to re-examine the operation of the reservoirs.

4.1.6 Kentucky River Navigation Dams

The Kentucky River was dammed with a series of 14 low-head dams in the early 1900's for the purpose of navigation. The dams were constructed by USACE and have since been removed from the project portfolio. The Kentucky River Authority owns and operates Locks 5 through 14. Beattyville lies within the upper pool of Lock 14 at Heidelberg, KY. Under normal conditions, the Kentucky River water surface elevation at Beattyville is approximately the same as at Lock 14 (~634 Ft. NAVD88).

4.2 Flow Frequency Analysis

The Risk Cadre support team was engaged early in the study to perform a comprehensive flow frequency analysis (FFA) using the methods employed in risk analysis of flood risk management projects. Such analysis was necessary as the flow frequency analysis results will likely be applied to additional upcoming studies in the watershed.

Current guidance requires a Bulletin 17C flow frequency analysis, which recommends the analysis be performed on unregulated flow data. Regulation in the Kentucky River watershed complicates the analysis. The Risk support team utilizes multiple data sources to develop an unregulated-to-regulated relationship where an unregulated flow record is assembled for analysis with Bulletin 17C methodology. The Risk support team provides more accounting for uncertainties in data, flow to stage conversions, etc. than typical flood risk management study efforts. The results are then converted to regulated flows for use in the study. See the Risk Report on hydrology for more information.

Frequency flows at Beattyville were calculated by drainage area ratio using the Heidelberg flow frequency values. The Beattyville flow frequencies are included in this report for reference, but the modeling only targets the Heidelberg gage peak discharges.

Table 32 through Table 36 present the regulated frequency flows for the USGS gages at Heidelberg, Jackson, Tallega, and Booneville, KY.

Table 32: Regulated Frequency Flows on the Kentucky River at Heidelberg (Lock 14)

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	198,293	106,880	148,998	141,811
0.01	100	145,696	88,107	114,086	111,842
0.02	50	125,888	78,781	100,568	99,337
0.04	25	105,933	69,718	86,338	85,723
0.1	10	85,225	58,249	70,846	70,604
0.2	5	69,158	48,056	57,975	57,864
0.5	2	46,568	32,416	39,069	39,054
0.99	1	15,043	7,265	11,218	10,712

Table 33: Regulated Frequency Flows on the Kentucky River at Beattyville

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	196,353	105,834	147,540	140,423
0.01	100	144,270	87,245	112,970	110,748
0.02	50	124,656	78,010	99,584	98,365
0.04	25	104,896	69,036	85,493	84,884
0.1	10	84,391	57,679	70,153	69,913
0.2	5	68,481	47,586	57,408	57,298
0.5	2	46,112	32,099	38,686	38,672
0.99	1	14,896	7,194	11,108	10,607

Table 34: Regulated Frequency Flows on the North Fork at Jackson, KY

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	94,802	53,038	74,963	71,017
0.01	100	73,681	46,475	60,191	58,988
0.02	50	65,082	43,025	54,174	53,515
0.04	25	55,875	38,572	47,505	47,169
0.1	10	45,831	32,921	39,854	39,735
0.2	5	37,631	27,447	33,031	33,019
0.5	2	25,520	18,479	22,305	22,361
0.99	1	7,081	3,052	4,945	5,292

Table 35: Regulated Frequency Flows on the Middle Fork at Tallega, KY

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	28,250	15,110	21,049	18,748
0.01	100	19,730	12,637	15,591	14,856
0.02	50	16,761	11,540	13,700	13,281
0.04	25	13,932	10,289	11,817	11,601
0.1	10	11,138	8,844	9,854	9,766
0.2	5	9,137	7,564	8,294	8,252
0.5	2	6,568	5,595	6,057	6,067
0.99	1	3,207	2,272	2,813	2,698

Table 36: Regulated Frequency Flows on the South Fork at Booneville, KY

AEP	Return Period (Years)	95% Confidence Interval (cfs)	5% Confidence Interval (cfs)	Expected [Mean] Curve (cfs)	Computed [Median] Curve (cfs)
0.002	500	137,285	73,299	101,973	92,877
0.01	100	91,801	58,604	72,572	69,817
0.02	50	76,126	52,196	6,253	60,711
0.04	25	61,320	45,016	51,975	51,207
0.1	10	46,835	36,890	41,338	41,046
0.2	5	36,602	29,957	33,063	32,937
0.5	2	23,782	19,889	21,756	21,746
0.99	1	8,471	5,589	6,883	7,181

4.3 The March 2021 Flooding of Beattyville

4.3.1 The March 2021 Event

The storm event of March 2021 flooded Beattyville and was described by city officials as the worst seen in a generation in the downtown business area. City officials recall the river stage climbing so quickly that flow appeared to be rushing through the downtown from multiple directions at times. The event spurred investigative action from U.S. Congressional Representative Hal Rogers to evaluate flooding issues and reduction measures.

The flood began in late February of 2021 and extended into early March. The USGS gage at Heidelberg recorded a steep hydrograph rising limb with a measured peak discharge of 89,100 cfs and a peak water surface elevation of 659.1 Ft. NAVD88. See the event flow hydrograph in Figure 4.8. Surveys of highwater marks (HWMs) in Beattyville indicate an approximate peak water surface elevation (WSE) of 666.5 Ft. NAVD88.

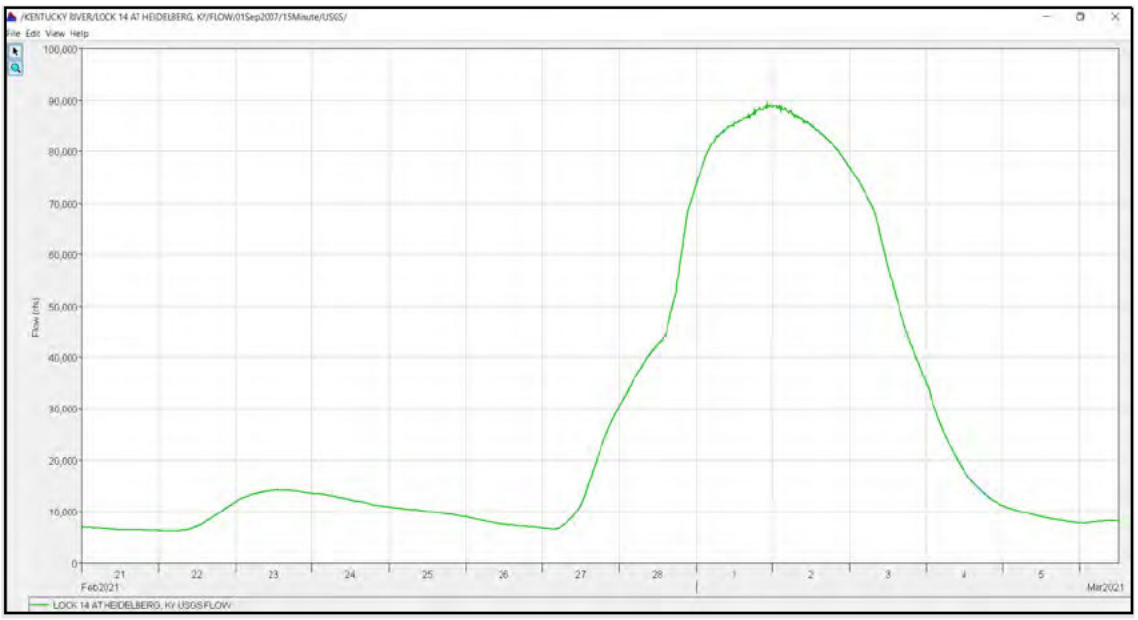


Figure 4-8: March 2021 Observed Flood Hydrograph at Heidelberg, KY

4.3.2 Discharge-Stage Discrepancy Identified

The March 2021 flood event inundated Beattyville to an approximate elevation of 666.5 Ft. NAVD88 (surveyed HWMs): however, the HEC-RAS model indicated the peak stage to be about 5 feet lower for the flow recorded downstream at Heidelberg, KY. The HEC-RAS model was calibrated to the USGS gage rating curves during HEC-CWMS model development and has held up well over years of use by Water Management. However, the March 2021 flood event recorded flow did not produce the recorded stage at the gage.

4.3.3 The USGS on the March 2021 Event

Discussions with the USGS Louisville Office gave more insight into the discharge-stage issues with the March 2021 high-flow event. USGS field personnel took flow measurements during the March 2021 event and stated the published data is accurate.

4.3.3.1 Slope Rating Curve on the Kentucky River

The USGS is confident in the published rating curve at Heidelberg (Lock 14) under normal circumstances. However, the gage at Lock 14 experiences a significant shift in the rating curve during high flows because of backwater. In general, most of the gages on the upper end of the Kentucky River main channel seem to begin showing deviation from the normal stage-discharge rating in the 40,000-50,000 cfs range.

The source of backwater on the Kentucky River is primarily the flow obstruction of the series of fourteen low-head dams themselves, but there are other factors. The lack of bed slope gradient, inflow tributaries, and overbank return flow are all likely sources that contribute to the backwater affect. At approximately 60,000 cfs, the rating curve transitions to a sloped rating. This forces a rating shift up then back down along the pro-rated curve.

The pro-rated curve refers a rating curve in development that will over time be used to finalize an updated rating curve for publishing. The pro-rated curve was applied to the March 2021 event using flow measurements taken at Lock 14 during the flood event. The pro-rated curve was used by the USGS in publishing the gage data for the event. That is, the observed March 2021 event

curve (the published observed stage and flow hydrographs plotted together stage vs flow) captures the published rating curve and pro-rated curve together (see Figure 4.9). If the observed hydrograph data points (data from the USGS website) were converted to stage using only the published rating curve (the black plotted line), the pro-rated portion departing from the curve would not be captured (the red plotted line), and the converted higher flows would instead follow the black line yielding an incorrect stage. The is the case for the stage-flow discrepancy in Section 4.3.2 and explains why the HEC-RAS model failed to capture both the flow and stage at Lock 14 as well as the Beattyville highwater mark stage (recall the HEC-RAS model was originally calibrated to the published rating curve).

The USGS applied the pro-rated curve to the March 2021 event so the recorded data would be accurate for publishing. The sloped ratings have been typically developed using the upstream and downstream hydraulic structures (the low-head locks and dams) along the Kentucky River. A sloped rating is difficult to establish at Lock 14 because it is the most upstream low-head dam. The closest published slope-rated gage on the Kentucky River is at Lock 11 (which is being used as the downstream boundary condition in the HEC-RAS model update). For the March 2021 event, the USGS applied the measured flow/stage at Lock 14 and estimated the sloping water surface from Lock 11 through Locks 12 and 13 to produce the pro-rated curve at Lock 14.

As further validation, the USGS estimated the March 2021 event stage at Beattyville at 666.0 Ft. NAVD88 (within 0.5 feet of the surveyed HWMs) by extending the estimated slope from Lock 11 through Lock 14 to Beattyville.

Figure 4.9 shows rating curves at Lock 14. The black plotted line represents the published USGS rating curve while the red line shows the observed rating curve for the March 2021 event. The observed rating curve depicts the shift used by the USGS to capture the transition to the pro-rated slope rating for the March 2021 event. The transition appears abrupt, but this is understood to be a representation of a single event. Any future developed slope rating curve would likely be a best fit line for multiple events where the transition would be more gradual or completely blended into a new rating curve entirely, like the established slope rating curve at Lock 11 (shown later in Figure 4.22).

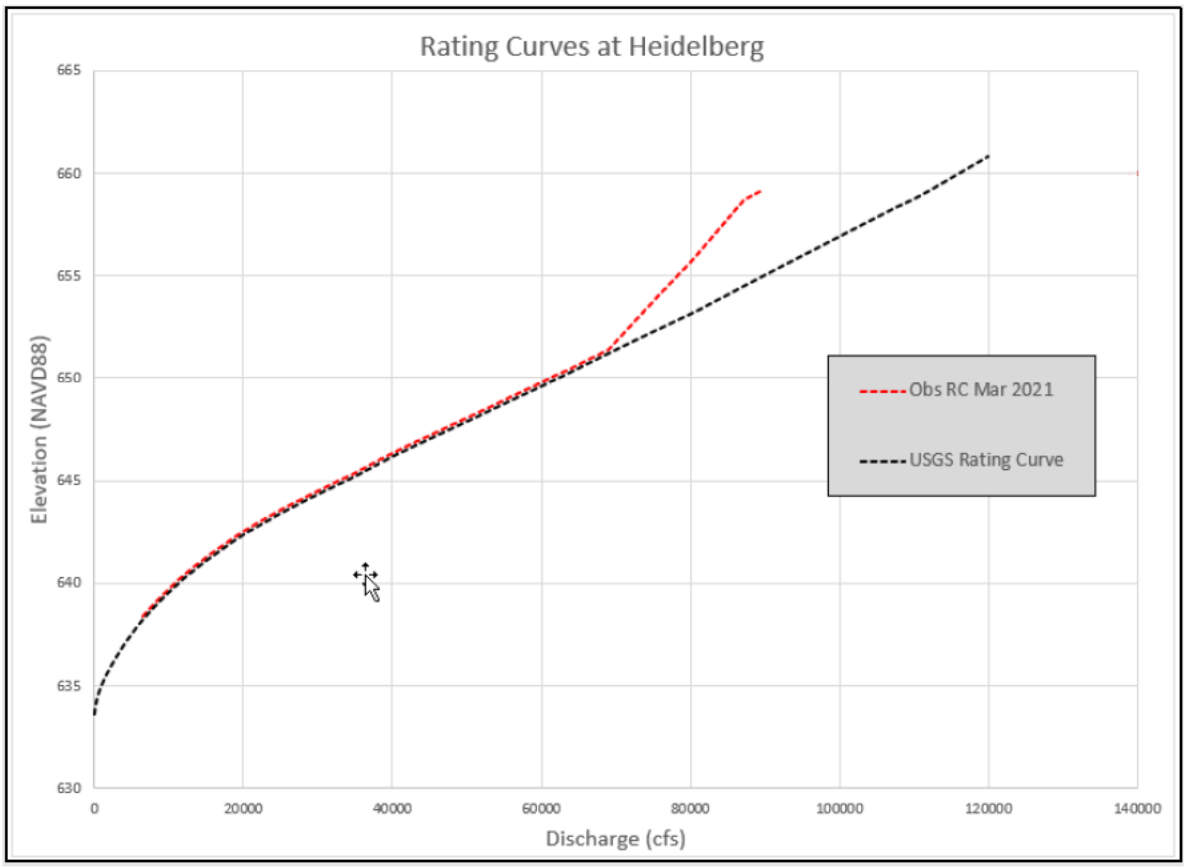


Figure 4-9: Lock 14 USGS Published Rating Curve and the Slope-Rated Curve for March 2021

4.4 Modeling Considerations and Version History

The Kentucky River Basin HEC-CWMS model was developed in 2016. The modeling component software (HEC-RAS, HEC-HMS, etc.) versions have been updated with the HEC-CWMS versions over time. However, software developers added Geographic Information System (GIS) features to HEC-HMS in 2021. While the current HEC-HMS version used with the HEC-CWMS model is version 4.10, it was originally developed with an HEC-HMS version that did not have GIS capabilities. That is, the ArcGIS was used outside HEC-HMS.

4.4.1 The HEC-CWMS Hydrologic Model

The HEC-HMS component of the HEC-CWMS model was developed to work with HEC-CWMS for daily Water Management use. HEC-CWMS is an application that links the modeling components which inherently complicates the modeling setup and data requirements. HEC-CWMS users (Water Management) prefer simplicity in the modeling for reliability reasons. Reasonably accurate results in most situations are sought for making daily reservoir release decisions.

For HEC-CWMS reliable functionality, the HEC-HMS and HEC-ResSim components require the use of the same routing routines for identical routing reaches within the models. The HEC-CWMS components use Muskingum routing routines for simplicity. However, natural parameter-based routing routines are more typical of detailed flood risk management projects. The HEC-HMS

model for this project uses Muskingum-Cunge where channel slope, generalized shape, and roughness contribute to the attenuation of peak flows during reach routing.

4.4.2 HEC-ResSim Usage Excluded from Study

HEC-HMS is required to transform precipitation into runoff to assess local flows upstream and downstream of the reservoir because HEC-ResSim cannot. Positioning multiple storm events for assessing optimal storm position, or even creating a randomness for statistical analysis is not possible in HEC-ResSim. Such an analysis requires an HEC-WAT model development, which is outside the current scope and likely unnecessary. While HEC-ResSim boasts capabilities of making reservoir release decisions based on rule settings, those same rules would capture reservoir operations at minimum flow during large storm events. Minimum flow can be set in HEC-HMS for simulations of the storm events to adequately capture the reservoir discharges.

HEC-HMS and HEC-ResSim employ the same reach routing routines, and because of this, both fall short of detail required for this study. While the software programs serve adequately for daily Water Management reservoir operation decisions with the HEC-CWMS application, both fail to capture the backwater affects in the system due to the downstream low-head locks and dams.

HEC-ResSim can incorporate rating curve that gives a stage for a given flow/downstream pool combination. However, such a rating curve would need to be developed through HEC-RAS simulations thus extending the analysis already completed by the HEC-HMS/RAS combination. The use of modified Puls could be employed in the HEC-HMS or HEC-ResSim models, but again require the use of HEC-RAS to develop the proper stage-discharge curves, also additional calibration would be required. When HEC-HMS is used in conjunction with HEC-RAS, a solid case for the HEC-HMS/HEC-RAS combination is made versus HEC-ResSim.

4.4.3 Watershed Re-Delineation

The delineation process was repeated to further delineate (or break up) watersheds and recalculate basin parameters for the study. Prior to the Alternative Milestone Meeting (AMM), alternative dam sites were investigated within the watershed which required the full capabilities of the current HEC-HMS version. The HEC-HMS component of the HEC-CWMS model was updated by re-delineating the watershed using the same subbasin outlets. The subbasins were then further broken down to provide inflows at areas of interest for this study (such as the flows at Beattyville from the North and South Forks separately). Further delineation of smaller subbasins for added detail means few subbasins remain the same as the original HEC-CWMS model component making direct parameter comparison cumbersome. For anticipated future studies, the subbasin above the Whitesburg gage was added. Routing reach routines were changed to Muskingum-Cunge, as stated in Section 4.4.1. This became the new base HEC-HMS model from which frequency storms were modeled and the alternative dam sites were investigated.

4.4.3.1 Dam Sites Investigated

The alternative dam sites basin models are not included in the existing conditions HEC-HMS model. Dam sites were investigated on the North Fork at St. Helens, Jackson, Hazard, and on Troublesome Creek; all sites were ineffective at preventing the 1% AEP flood at Beattyville.

The previously authorized reservoir project at Booneville on the South Fork was modeled and was shown to prevent flooding at Beattyville (project classified inactive in 1976). Regulating the large South Fork drainage area approximately 7.5 miles upstream of Beattyville effectively

prevents the development of the sloped water surface at Heidelberg for the 1% AEP frequency flow where the published rating curve shifts upward along the pro-rated curve as discussed in Section 4.3.3.1. The Booneville Dam was hydrologically modeled in HEC-HMS and then discharges routed in the HEC-RAS model as part of the investigation.

The PDT screened out reservoir alternatives prior to the AMM. The dam site modeling is not included as part of this report.

4.4.4 Overall Modeling Approach

The updated HEC-HMS model was calibrated to the March 2021 flood event (discussed in Section 4.6.1). No reliable high peak flow validation event was available with both stream gage records and precipitation. Hydrologic modeling efforts proceeded to frequency storm simulations using Atlas 14 annual maximum series precipitation data.

The calibration and frequency storm events were applied to the HEC-RAS hydraulic model. The inflow hydrographs were scaled to reach the calibration and frequency flow targets at Lock 14. It should be noted that while the March 2021 flood was used for calibration event, calibration was focused on the Lock 14 rating curve with provisional rating (pro-rated) and the highwater marks surveyed at Beattyville (discussed in Section 4.3.3.1). There is more confidence in rating curve up to the peak discharge of the March 2021 event, after which uncertainty in stage-discharge relationship increases.

For this General Investigation, the HEC-HMS model supplies inflow hydrographs from the Forks for the area of interest (Beattyville). It is reasonable to simply the modeling simulations by targeting the FFA peak discharges at Lock 14 because the analysis is based on streamflow records at that gage, regardless upon which Forks contributed to the annual peak discharges in the historical record.

Two approaches were considered for frequency storm modeling. Approach 1 involved adjusting the HEC-HMS loss parameters targeting the computed FFA 1% AEP peak discharges at the four gages nearest Beattyville (at Jackson, Tallega, Booneville, and Lock 14). The HEC-HMS results were then applied to the HEC-RAS model. The inflow hydrographs above each gage were scaled in HEC-RAS targeting the 1% AEP peak discharges.

Approach 2 was to simplify efforts by applying uniform loss parameters across the entire watershed in HEC-HMS, then scaling the inflows in HEC-RAS uniformly only targeting the 1% AEP peak discharge at Lock 14 gage. This approach simplifies the task of iterating HEC-RAS simulations to ascertain the correct inflow hydrograph scaling factor, where the first approach iterates simulations for each gage individually.

The two approaches were compared for sensitivities near the study area. The difference in stage between the two approaches did not exceed +/-0.25 feet, which is within the margin of error of the hydraulic modeling software (see Table 37).

Table 37: Stage Sensitivity in Modeling Approaches for the 1% AEP Simulation

Stream	River Station	Approach 1 Stage (Ft.)	Approach 2 Stage (Ft.)	Difference Stage (Ft.)
North Fork Kentucky River	0.101	672.42	672.29	-0.13
North Fork Kentucky River	0.262	672.65	672.55	-0.10
South Fork Kentucky River	0.105	672.42	672.29	-0.13
South Fork Kentucky River	0.183	672.58	672.37	-0.21
Kentucky River	257.5170	663.90	663.96	0.06
Kentucky River	251.6741	672.42	672.29	-0.13

Approach 2, scaling the uniform loss inflows was chosen for simplicity. The effort in additional simulation iterations is not warranted given such small potential improvements in results.

More discussion of the HEC-HMS uniform loss parameters can be found in Section 4.7.1.1.

4.5 DATA COLLECTION

4.5.1 Vertical Datum

The vertical datum referenced in this report are in the North American Vertical Datum of 1988 (NAVD88) in units of feet (Ft).

USACE dams still reference their native project datum using the National Geodetic Vertical Datum of 1929 (NGVD29). Consult the National Geodetic Survey for site-specific conversions to NAVD88. For the Beattyville study area, use the following formula to convert to NAVD88:

Ft. NAVD88 = Ft. NVGD29 + (-0.54 feet)

4.5.2 GIS Terrain and Layers

Terrain data for the model is a 10-foot resolution DEM resampled KY from Above statewide 5-foot DEM dataset.

4.5.3 Existing Data and Supporting Analysis

4.5.3.1 Stream Gage Data

The stream gage data analyzed for this study was 15-minute and annual peak discharge data obtained from the USGS streamflow gages shown in Table 38.

Table 38: USGS Stream Gages Used

Gage Name	USGS Gage No.	NWS Gage Identification	Drainage Area (SQMI)
South Fork Kentucky River at Booneville, KY	03281500	BOOK2	722
Goose Creek at Manchester, KY	03281100	MCHK2	163
Middle Fork Kentucky River at Tallega, KY	03281000	TLLK2	537
North Fork Kentucky River at Jackson, KY	03280000	JKNK2	1,101
North Fork Kentucky River at Hazard, KY	03277500	HAZK2	466
North Fork Kentucky River at Whitesburg, KY	03277300	WHTK2	66
Kentucky River at Lock 13 Near Willow Shoals, KY	03282060	WLWK2	2,784
Kentucky River at Lock 14 at Heidelberg, KY	03282000	HLDK2	2,657

4.5.3.2 Dam Discharge Data

Discharges for Carr Creek Dam and Buckhorn Dam were estimated using two different approaches:

4.5.3.2.1 Calibration Event

Discharge flows from the USACE dams are maintained by Water Management (WM). Outflows are calculated based on the gate rating curves using the water surface elevation (WSE) at the lake and the recorded gate opening heights. The outflow records reside in the WM database and were used to estimate flows at Carr Creek Dam and Buckhorn Dam for the 2021 calibration event.

4.5.3.2.2 Frequency Storm Modeling

For the frequency storm modeling, minimum outflows from the dams were used for downstream flooding simulations, per the Water Control Manual Schedules of Regulation. See Figure 4.6 and Figure 4.7 for dam Schedules of Regulation.

4.5.3.3 Precipitation

Gridded precipitation data was used for calibration events of the model due to its availability and to provide better temporal and spatial accuracy. Gridded radar precipitation is in 1-hour increments and was provided from the Hydrologic Engineering Center's Corps Water Management System (HEC-CWMS) database, which is Stage 3 data ingested from the National Weather Service (NWS).

Atlas 14 gridded precipitation-frequency data based on the annual maximum series (AMS) were used for this study. Atlas 14 is an official peer-reviewed record of precipitation frequency estimates produced by the National Weather Service (NWS) Office of Water Prediction, part of Hydrologic Modeling Efforts.

The Water Management team utilizes the Hydrologic Engineering Center's (HEC) Corps Water Management Software (CWMS) in daily reservoir operations. The HEC-CWMS model contains three main components, all part of the HEC software suite: Hydrologic Modeling Software (HEC-HMS) for watershed modeling, River Analysis System (HEC-RAS) for hydraulic modeling, and Reservoir System Simulator (HEC-ResSim) for reservoir simulations.

The Kentucky River Basin HEC-CWMS model was developed for the Kentucky River basin in 2016, with the report completed in 2018.

The respective components of HEC-HMS and HEC-RAS were used as the base for the Beattyville General Investigation hydrologic and hydraulic models.

The hydrologic component of the HEC-CWMS model is used by Water Management team is in earlier versions of HEC-HMS. The study effort prior to the Alternative Milestone Meeting (AMM) called for exploring various potential locations for reservoirs. The HEC-HMS version was upgraded to v4.10 for the dam site exploration and general ease of compatibility for the remainder of the study. The upgrade required the re-delineation of the watershed using the subbasins already established in the original HEC-HMS model.

4.5.4 General Hydrologic Methodology for Basin Analysis

The purpose of this section is to describe the efforts performed to estimate the physical hydrologic parameters for the Kentucky River watershed. The proceeding sub-sections outlines efforts performed to delineate the watershed with subbasins and determine hydrologic elements within the watershed. HEC-HMS, version 4.10 was used during this effort.

The 8 gages from Table 38, Buckhorn Dam, and Carr Creek Dam are shown in Figure 4.10.

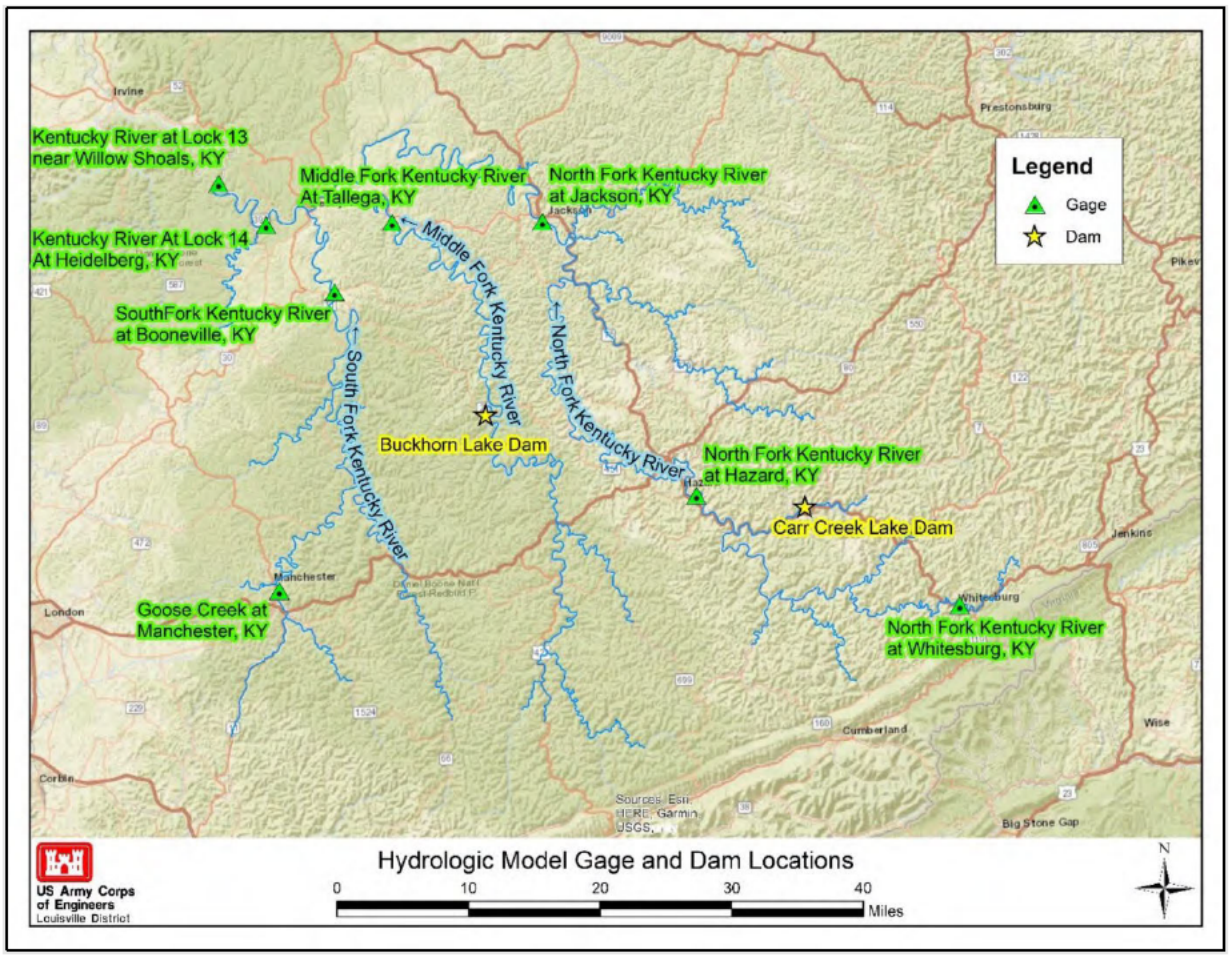


Figure 4-10: Hydrologic Model Gage and Dam Locations

4.5.5 General HEC-HMS Model Development

An HEC-HMS model was created using three main components: A basin model, a meteorologic model, and control specifications. The parameters used for the basin model is shown in Table 39 and Table 40.

Table 39: Summary of Parameters of Hydrologic Calibration Modeling

Modeling Method	Parameter	Description
Deficit and Constant Loss	Initial Deficit	The initial deficit defines the volume of water that is to be required to fill the soil layer at the start of the simulation.
	Constant Rate	The constant rate defines the rate at which precipitation will be infiltrated into the soil layer after the initial deficit has been satisfied in addition to the rate at which percolation occurs once the soil layer is saturated. Typically, this parameter is equated with the saturated hydraulic conductivity of the soil.
	Maximum Deficit	Maximum Deficit specifies the total amount of water the soil layer can hold.
	Percent Impervious Area	Impervious area directly connected to the channel network (no losses are computed).
ModClark Transform Method	Time of Concentration	Defines the maximum travel time within a subbasin.
	Storage Coefficient	The storage coefficient is used in the linear reservoir for each grid cell.
Recession Baseflow	Initial Discharge	Initial baseflow discharge
	Recession Constant	The recession constant describes the rate at which baseflow recedes between storm events. It is defined as the ratio of baseflow at the current time, to the baseflow one day earlier.
	Ratio to Peak	The baseflow is reset when the current flow divided by the peak flow falls to a specified ratio value.
Muskingum-Cunge Routing	Length	Total length of the reach element, computed within HEC-HMS.
	Slope	Average slope for the reach.
	Manning's "n"	Manning's "n" roughness coefficients were selected based on previous hydraulic modeling or judgment using aerial photography.
	Shape	The trapezoidal cross-section was selected as the shape of the reach, based on cross sections of the previous hydraulic modeling and/or survey data.

Table 40: Summary of Parameters for Hydrologic Frequency Flow Modeling in HEC-HMS

Modeling Method	Parameter	Description
Frequency Storm	Storm Duration	The storm duration determines how long the precipitation will last.
	Intensity Duration	The intensity duration specifies the shortest time period of the storm.
	Intensity Position	The intensity position determines where in the storm the period of peak intensity will occur, thus how the depth is distributed during a storm.
	Area Reduction	The area reduction determines the area-reduction curves for reducing point precipitation, precipitation at a gage, to precipitation over a storm area.

4.5.6 Delineation

Using GIS capabilities within HEC-HMS and the terrain from Section 4.5.2, the relatively larger subbasins along North Fork, Middle Fork, and South Fork were further delineated to reduce their drainage area.

This is to provide additional lateral inflow locations for the hydraulic model. The delineated subbasins are shown in Table 41 and Figure 4.11.

The CWMS HEC-HMS model was trimmed by approximately 2,950 square miles downstream so that the most downstream portion is at Kentucky River at Lock 13 near Willow Shoals, KY. Some HEC-CWMS subbasins were broken down into smaller subbasins where additional inflow information was needed for the Beattyville study.

Table 41: Subbasins Calibrated for the HEC-HMS Model

Subbasin	Drainage Area (SQMI)	Subbasin	Drainage Area (SQMI)
BOOK2	236.4	LOST	42.3
BUCK2	157.3	MCHK2	163.3
CFLK2	60.5	ODAK2	167.1
HAZK2	338.6	ODAK2E	155.1
HAZK2E	66.5	QUICK	162.1
HLDK2C	16.8	QUICK_SF	40.3
HLDK2E	218.4	TLLK2	120.2
HLDK2W	57.3	TRBLE	24.9
HYDK2	203.0	TRBLW	1.9
JKNK2	12.9	WLWK2	111.2
JKNK2E	176.8	WLWK2N	15.8
JKNK2S	173.6	WTNK2	62.0
		Total Area	2784.4

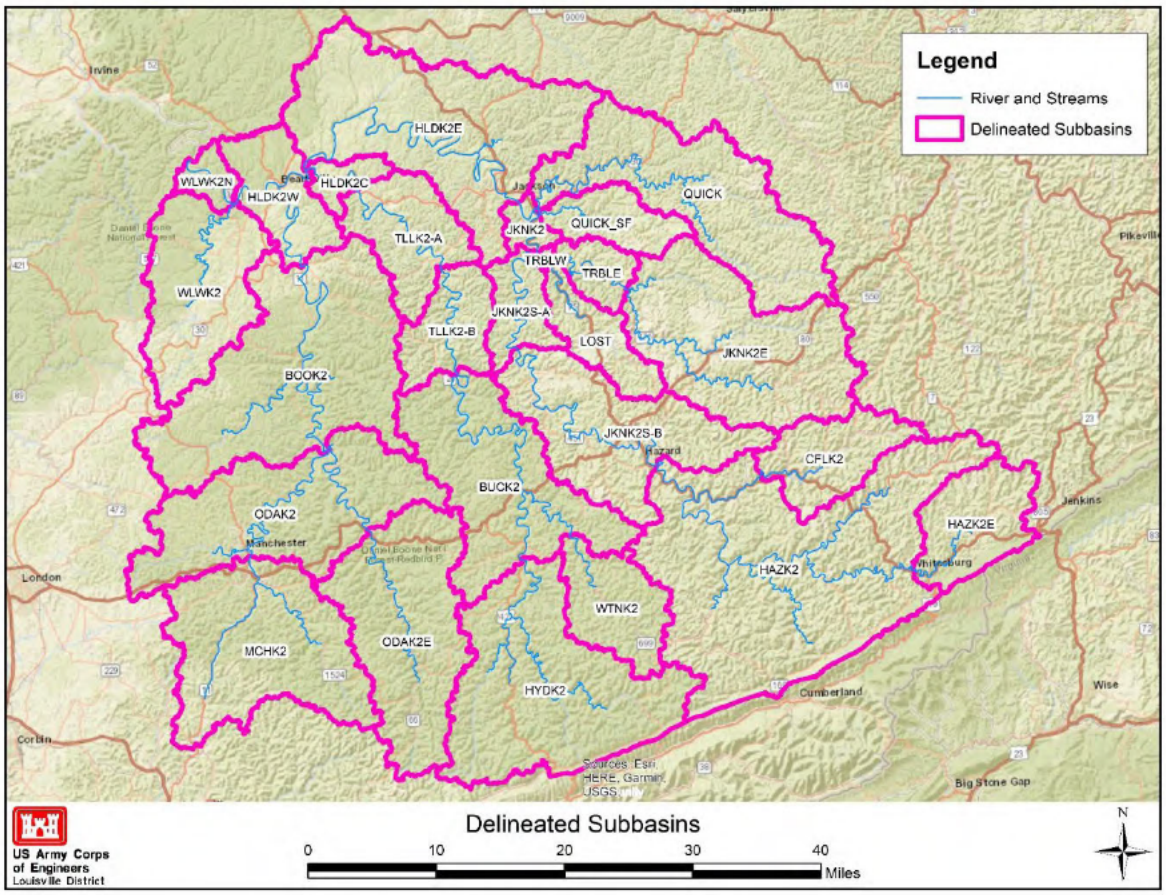


Figure 4-11: Subbasin Delineation

4.5.7 Estimated Loss Parameters

Loss rate parameters were computed using the Deficit and Constant Loss method. Initial estimates for subbasin losses were selected from the original HEC-CWMS subbasins and adjusted during calibration.

4.5.8 Clark Unit Hydrograph Parameters

Initial time of concentration (Tc) estimates for the new delineated subbasins were calculated from the Soil Conservation Service (SCS), now referred to as the Natural Resource Conservation Service (NRCS), curve number equation adopted from the NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15 Time of Concentration. The equations are shown in Equation 1 and Equation 2.

Equation 1: Estimated Time of Concentration

$$T_c = \left(\frac{L^{0.8} * (S+1)^{0.7}}{1,140Y^{0.5}}\right)^{0.3}$$

where,

$T_c = time\ of\ concentration (hours)$

$L = Longest\ flow\ path\ (ft)$

$S = maximum\ potential\ retention\ (in)$

$Y = average\ watershed\ land\ slope\ (\%)$

Equation 2: Maximum Potential Retention

$$\boldsymbol{S = \frac{1000}{CN} - 10}$$

where,
$S = maximum\ potential\ retention\ (in)$
$CN = SCS\ Curve\ Number$

A curve number raster was assembled using soil and land use data according to procedures from the HEC product online manuals. The USDA publishes soil data with the NRCS Soil Survey Geographic (SSURGO), from which the 2017 Kentucky dataset was used. The National Land Cover Dataset (2019) and Percent Impervious Surface (2019) raster files were obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium. The average values were computed in HEC-HMS for each subbasin using percent impervious area and curve number input raster files. The curve number raster was then used to calculate the Time of Concentration with Equations 1 and 2.

The Modified Clark (ModClark) unit hydrograph storage coefficient (R) is a calibration parameter that affects the shape of the runoff hydrograph and is derived using observed rainfall runoff data. The ratio of Clark's unit hydrograph parameters, as shown in Equation 3 tends to be a regional value (USACE, EM 1110-2-1417). The ratio value from the HEC-CWMS model was carried over to the newly delineated subbasins and the storage coefficient was updated respectively.

Equation 3: Clark Unit Hydrograph Ratio

$$\boldsymbol{\frac{R}{T_c + R} = Ratio}$$

4.5.9 Estimated Baseflow Parameters

In the HEC-HMS model, an approximation of the baseflow contribution to the total flow hydrograph is made using the recession method.

The recession baseflow method is designed to approximate the typical behavior observed in watersheds when channel flow recedes exponentially after a rain event. This method is appropriate for this modeling effort because it is primarily intended for use in event-based simulation. Three parameters were defined for baseflow recession computations in the HEC-HMS model: Initial discharge, recession constant, and a ratio to peak value. The initial discharge comes from the observed inflow. The recession constant and ratio to peak value carried over from the HEC-CWMS model.

4.5.10 Estimated Muskingum-Cunge Parameters

The HEC-CWMS model utilizes Muskingum routing methods for computational stability. When HEC-CWMS is in daily use, the HEC-ResSim and HEC-HMS routing routines must be the same for corresponding stream reaches and so Muskingum is favored for stability. For the Beattyville effort, the HEC-HMS routing routines were updated to Muskingum-Cunge to favor more natural parameters such as length, slope, and channel roughness. The Muskingum-Cunge routing method is based on the combination of the conservation of mass and the diffusion representation of the conservation of momentum.

The length and slope of the reach was computed through basin characteristics in HEC-HMS initially. The slopes were updated using the channel bottom survey from the Kentucky River Basin Profile for the Flood of January-February 1957 plans, dated 1967.

The Manning's n value was determined from either judgement using aerial imagery or the value within the current HEC-CWMS HEC-RAS model component.

An Index celerity of 5 ft/s was chosen for the index method.

The channel was defined using a trapezoidal channel. The data for the channel was obtained from representative cross-sections from the HEC-CWMS HEC-RAS model component. Where such data was not available, values were selected based on engineering judgement of the available data.

4.5.11 Time Zone Considerations

The gridded precipitation datasets are provided in Coordinated Universal Time (UTC) and the observed inflows are provided in local time, Eastern Standard Time (EST). The gridded precipitation was adjusted depending on the time of year relating to daylight savings time so that the simulated and observed data would be presented in the same time zone.

4.6 BASIN MODEL CALIBRATION

The purpose of this section is to describe the efforts for calibration and validation of the basin.

4.6.1 Selection of a Calibration Storm Event

The March 2021 storm event (shown in Table 42) was chosen for calibration based on the recent available precipitation gridded data, stream flow records, and availability of highwater marks. Note that the HEC-CWMS model was updated in 2016 and calibrated to the and April 2011, August 2011, and July 2015 events. In 2019, the HEC-HMS model component was re-calibrated using continuous calibration methods. The 2019 HEC-CWMS calibrations were leveraged to the validity of this model as a starting point for this study. The continuous calibration is preferred by Water Management due to suitability for most daily simulations.

4.6.1.1 Observed Inflows

The observed discharges from the USGS gages in Table 38 were used for this study. The observed discharges were compared against the discharges of the subbasin hydrologic elements in the model.

4.6.1.2 Observed Outflows

The observed outflows recorded for Carr Creek Dam and Buckhorn Dam, as mentioned in Section 4.5.3.2, were used for the respective Dams. Note that inflows upstream of the respective reservoirs were routed to their own sinks and not routed downstream into the project area. A source element was used as the dam outlet to route the observed discharge data into the project area.

Table 42: Period of Record Used for Calibration

Event Date	Observed Peak Discharge at Tallega, KY (CFS)	Observed Peak Discharge at Jackson, KY (CFS)	Observed Peak Discharge at Booneville, KY (CFS)	Control Specification	
				Start	End
Feb-March 2021	16,900	41,300	62,700	25FEB2021 00:00	10MAR2021 12:00

4.6.2 Calibration Techniques

Calibration was conducted by first optimizing transform, loss rates, and baseflow parameters against the observed inflows. The calibration for the model is based on single event modeling with emphasis on peak discharge as opposed to continuous simulation. The objectives of single-event modeling are better suited in determining the peak flow rate and timing, flow volume, and recession curve shape (Moriasi, 2007).

The gages listed in Table 38 were used for calibration. The model was calibrated until the model had a performance of "Satisfactory" or better, referencing Table 43 which shows the performance rating from Moriasi, 2007.

Table 43: Recommended Performance Ratings (Source: Moriasi, 2007)

Performance Rating	RSR	NSE	PBIAS for Streamflow (%)
Very Good	0.00 ≤ RSR ≤ 0.50	0.75 < NSE ≤ 1.00	PBIAS < ±10
Good	0.50 < RSR ≤ 0.60	0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15
Satisfactory	0.60 < RSR ≤ 0.70	0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25
Unsatisfactory	0.70 < RSR	NSE ≤ 0.5	±25 ≤ PBIAS

where,
$RSR = Root\ Mean\ Square\ of\ Observations\ Standard\ Deviation\ Ratio$
$NSE = Nash - Sutcliffe\ Efficiency$
$PBIAS = Percent\ Bias$

4.6.3 Calibration Results

The March 2021 storm event exhibited much higher flows in the watershed than what was assumed in the continuously calibrated HEC-CWMS modeling. The most significant change to watershed parameters were with the ModClark transform parameters. The calculated time of concentration discussed in Section 4.5.8 was reasonably close to the HEC-CWMS values (given the watershed drainage areas); however, no direct comparison could easily be made since the updated model further reduced the size of most subbasins. The final calibrated transform parameters used both the initial calculated and the HEC-CWMS values as range guides.

There was no validation storm event simulated for the calibration due to scarcity of data on such representative and infrequent events. The 2016 HEC-CWMS calibration of the HEC-HMS component attempted to validate with multiple events, few of which were satisfactory. The model has since been re-calibrated using the continuous calibration approach, which at best, inform Water Management decisions. Event validation is a moving target in general, but more so in this area where the time of concentration and storage coefficients can change significantly depend on season and antecedent conditions. The steep terrain of the Upper Kentucky River basin is a good candidate for variable time of concentration values touted in future HEC-HMS versions.

The final calibration results are summarized in Table 44 and the modeled calibrated graphs are shown in Figure 4.12 to Figure 4.19. Missing observed data for Lock 13 (Willow Shoals) is likely impacting performance ratings for that element. Note that the calibration for Middle Fork Kentucky River at Tallega, KY (Figure 4.15) did not meet the satisfactory performance ratings from Table 43; this is because Muskingum-Cunge routing in HEC-HMS cannot compute backwater. It is assumed that Middle Fork experienced backwater from the North Fork because the subbasin (TLLK2) fell well short of the observed peak discharge with zero constant losses applied, and therefore the performance ratings were ignored.

Negative values for Percent Bias performance rating indicates the observed discharge volume exceeds the calculated hydrograph discharge volume in the model. However, the rating takes in

to account the full period of simulation where variations in flow before and after the peak impacts the rating. The peak discharge, timing, and general shape indicate an otherwise good calibration. Note that HEC-HMS did not report volume for some locations and is denoted by 'n/a.'

Table 44: Summary of Calibration Results

	Unit	Whitesburg	Hazard	Jackson	Tallega	Manchester	Booneville	Lock 14 at Heidelberg	Lock 13 at Willow Shoals
Computed Peak	**CFS**	3,640	18,440	41,348	12,353	14,225	60,065	110,298	115,182
Observed Peak	**CFS**	3,680	18,400	41,300	16,900	13,100	62,700	89,400	88,900
Computed Volume	**IN**	3.80	n/a	n/a	n/a	5.05	6.19	n/a	n/a
Observed Volume	**IN**	4.57	n/a	n/a	n/a	6.44	7.06	n/a	n/a
Performance Ratings									
RMSE Std Dev:		0.3	0.4	0.3	1.1	0.3	0.2	0.4	0.3
Percent Bias:	**%**	-17.92	-27.46	-25.82	-68.79	-21.46	-12.29	-21.61	-25.17
Nash-Sutcliffe		0.915	0.855	0.910	0.177	0.922	0.943	0.851	0.893

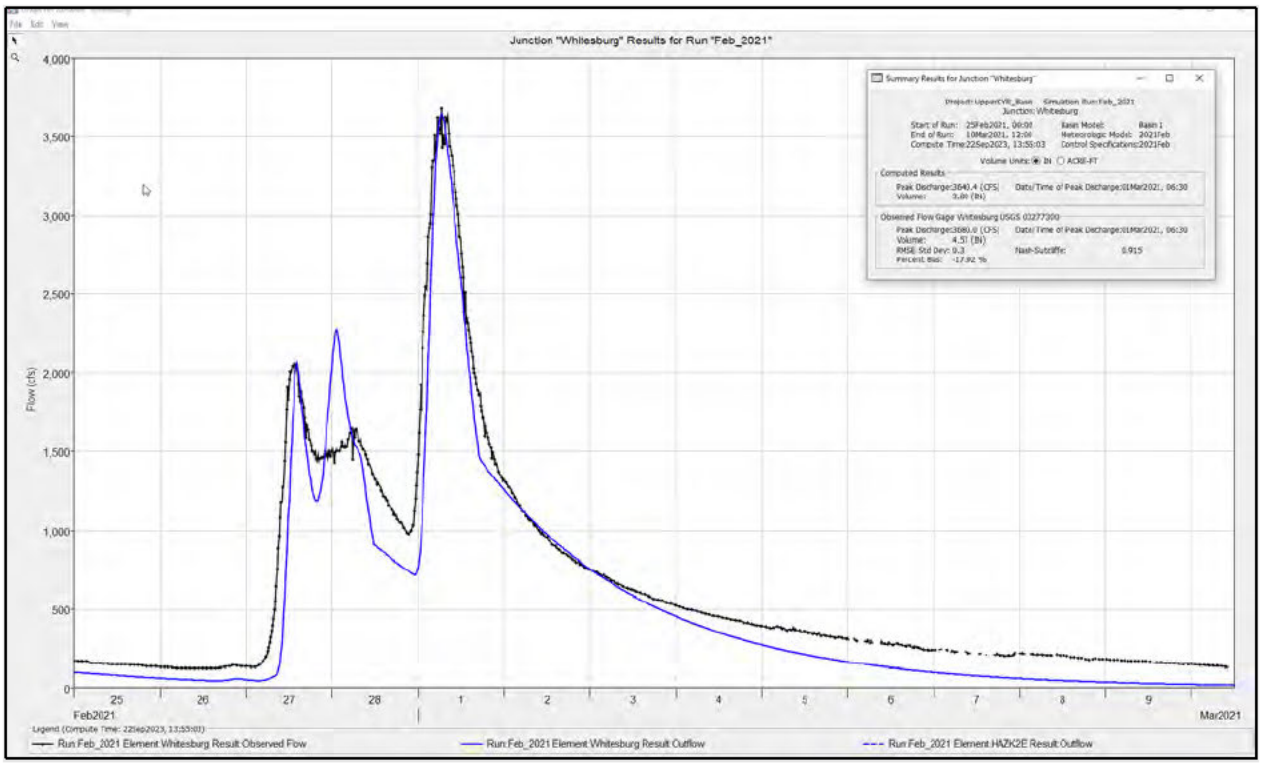


Figure 4-12: North Fork Kentucky River at Whitesburg, KY Calibration Results

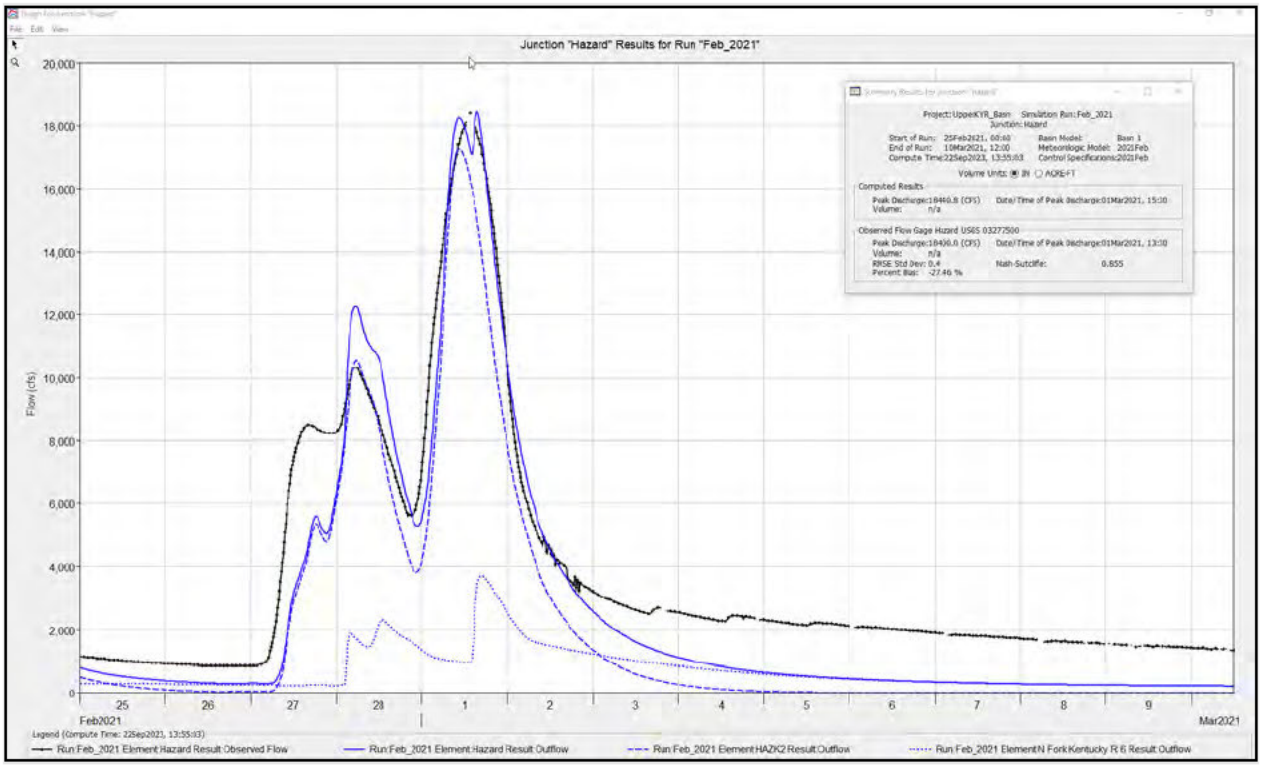


Figure 4-13: North Fork Kentucky River at Hazard, KY Calibration Results

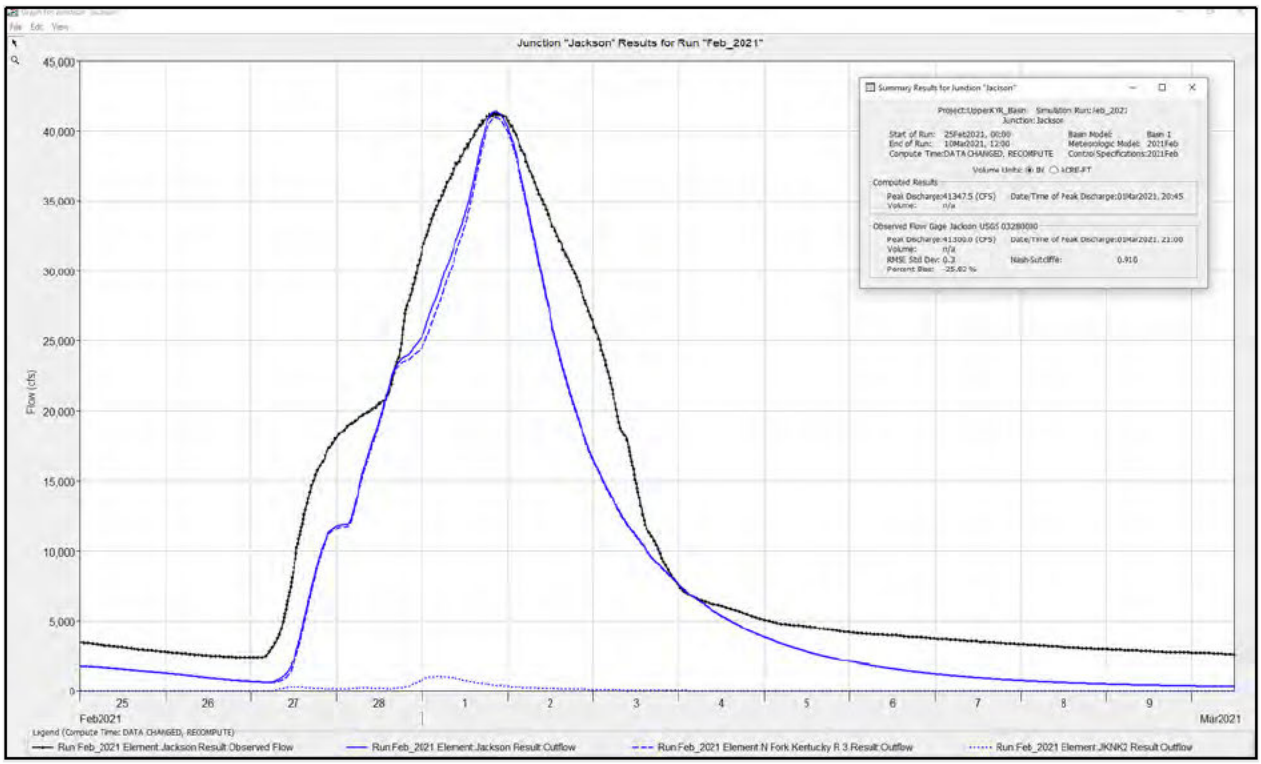


Figure 4-14: North Fork Kentucky River at Jackson, KY Calibration Results

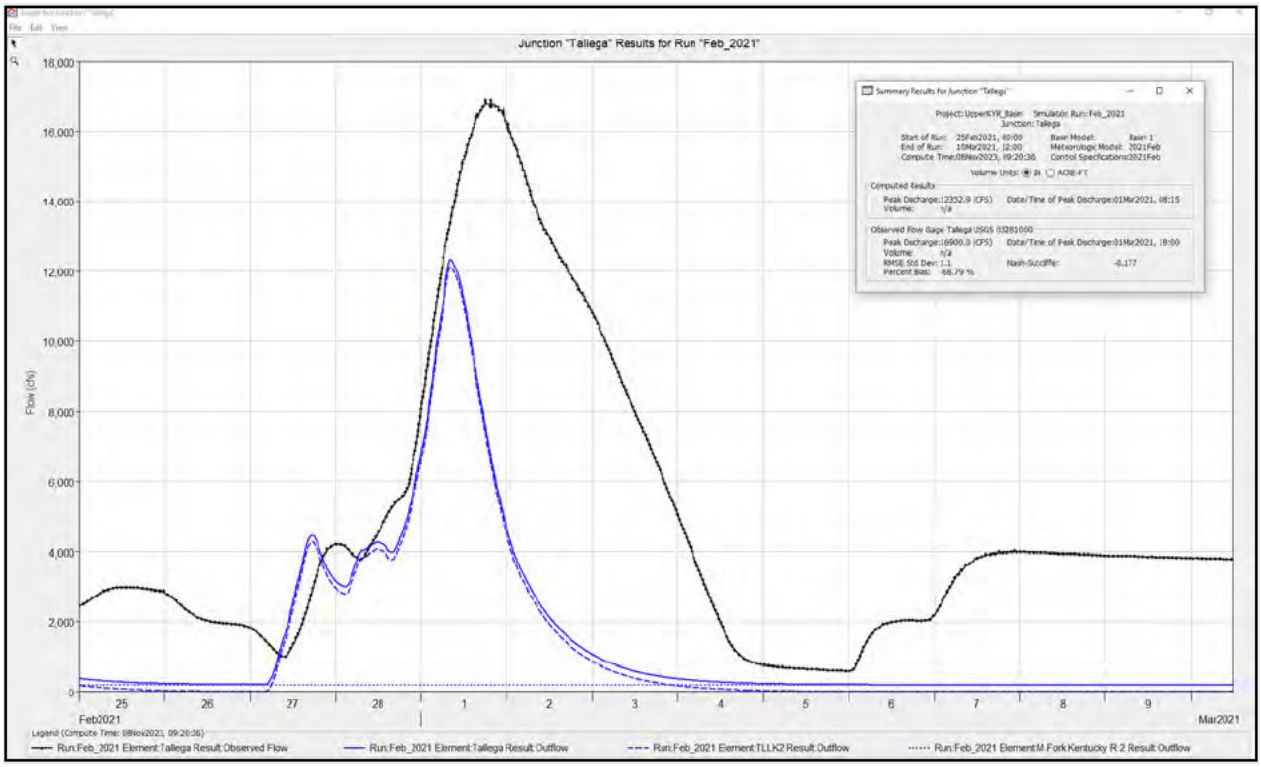


Figure 4-15: Middle Fork Kentucky River at Tallega, KY Calibration Results

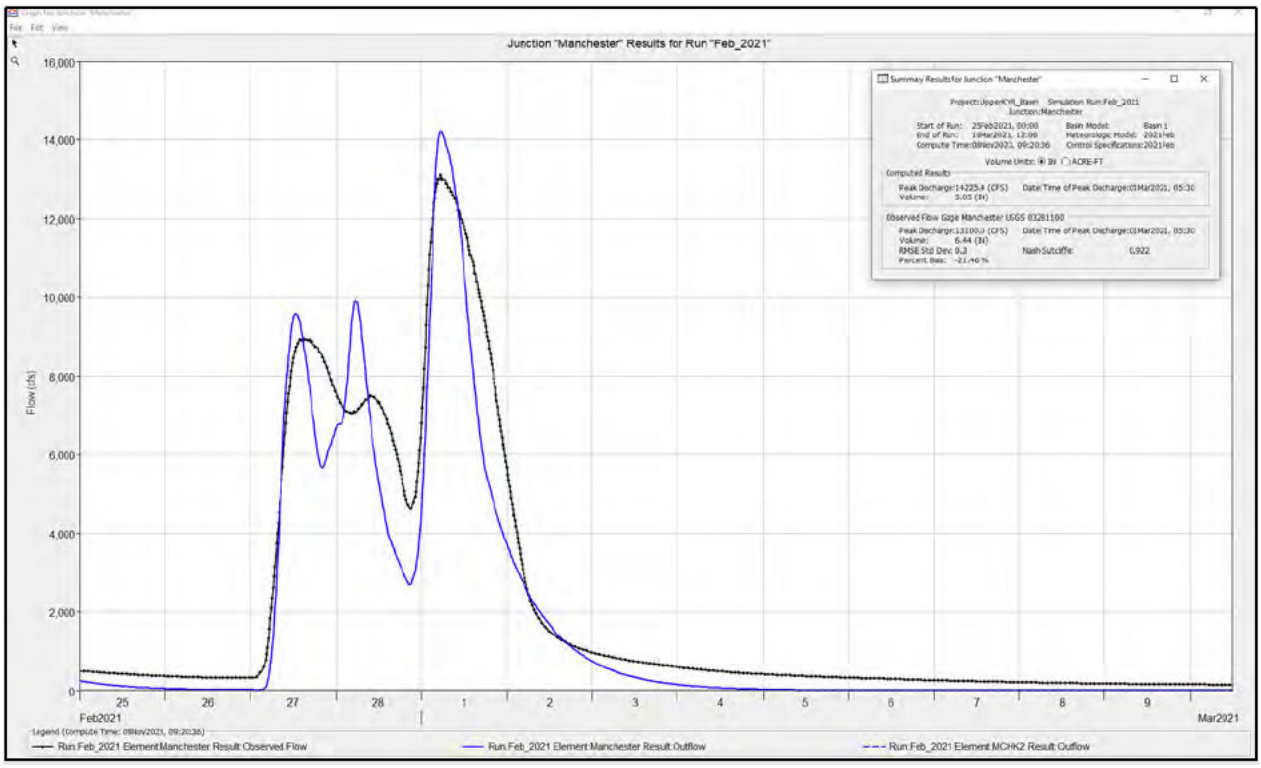


Figure 4-16: Goose Creek at Manchester, KY Calibration Results

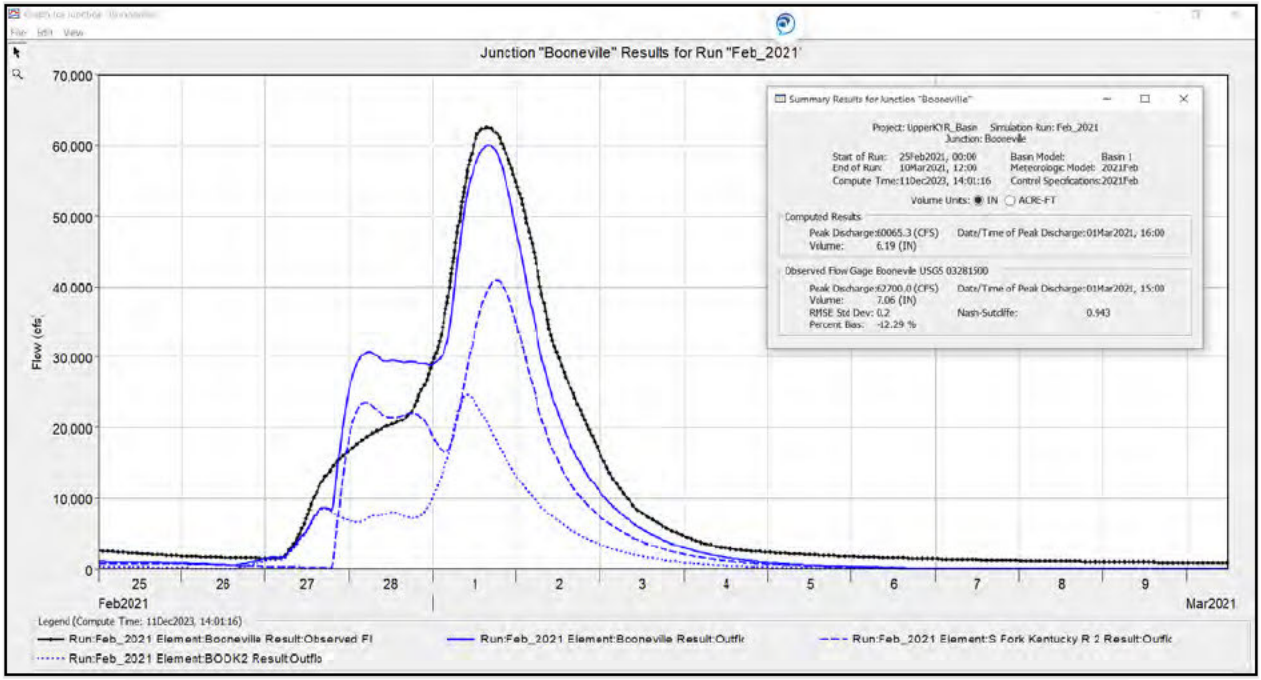


Figure 4-17: South Fork Kentucky River at Booneville, KY Calibration Results

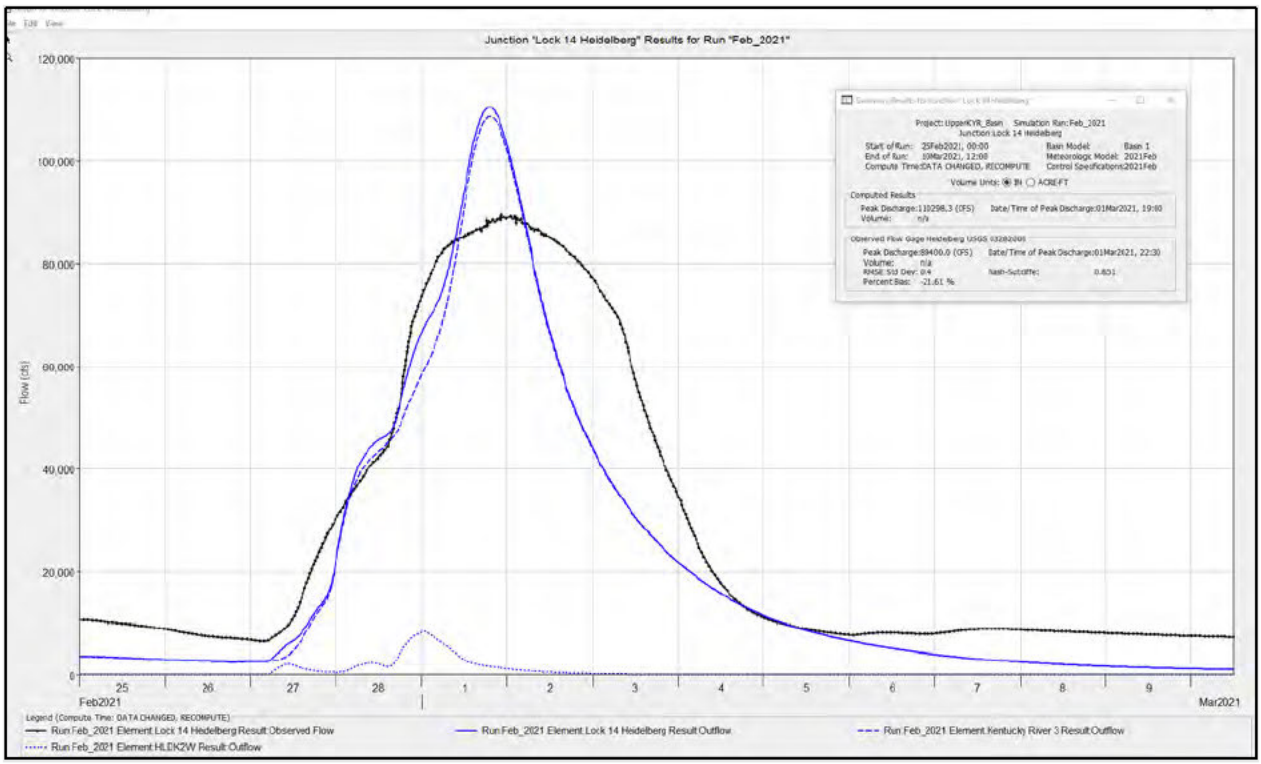


Figure 4-18: Kentucky River at Lock 14 at Heidelberg Calibration Result

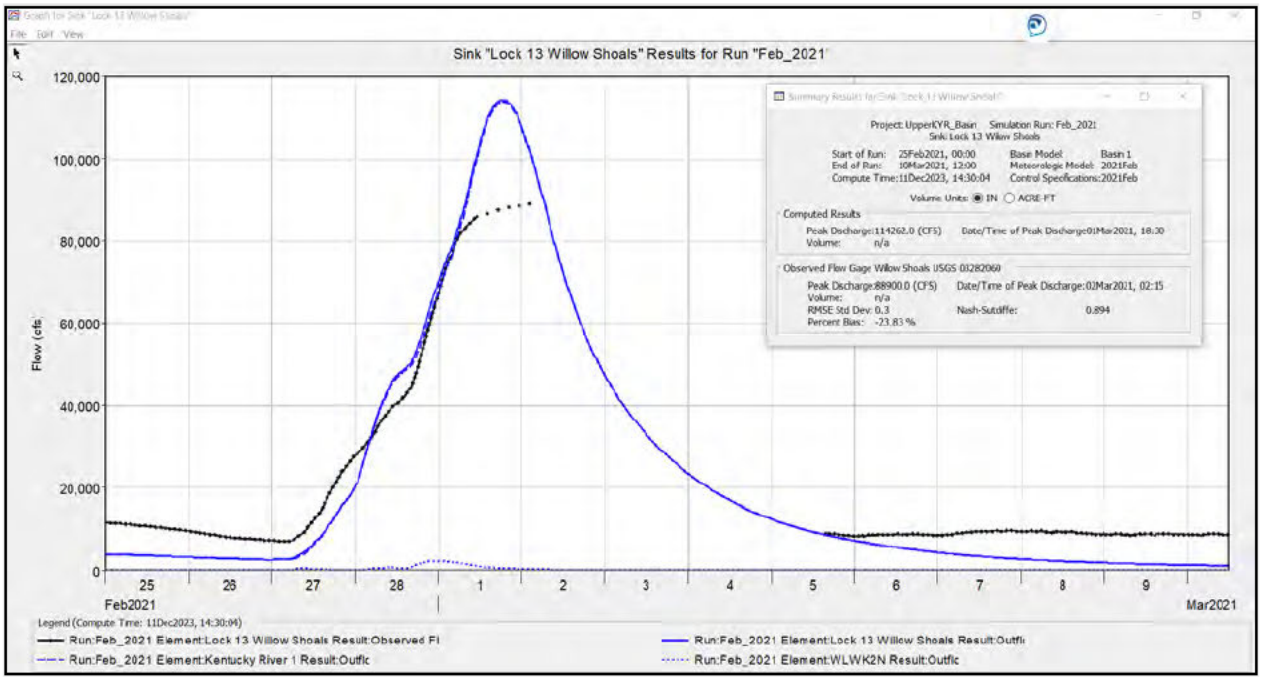


Figure 4-19: Kentucky River at Lock 13 Near Willow Shoals, KY Calibration Results

4.7 BASIN FREQUENCY MODELING

The purpose of this section is to describe the efforts performed to develop the 1% Annual Exceedance Probability (AEP) for the watershed. Note that the 1% AEP is analogous to the 100-year Average Recurrence Interval (ARI), which both refer to the probability that a given rainfall volume over a given duration will be exceeded in any one year. The computed 1% AEP flows will be used in phase 2 of this study for the hydraulic modeling.

The primary purpose of the HEC-HMS model was to investigate potential reservoir sites and provide an appropriate inflow hydrograph for frequency storm modeling. The PDT screened out reservoirs as an option for the study prior to the Alternatives Milestone Meeting (AMM). The calibrated hydrologic model was then used for developing the likely inflow hydrograph at Beattyville.

4.7.1 Storm Simulations

Initially, the 1% AEP storm event was modeled adjusting loss parameters beginning with upstream subbasins. The calibrated HEC-HMS model transformation, routing, and base flow parameters were retained for frequency storm modeling. Loss parameters were adjusted to target the frequency flow peak discharges in Section 4.2 at the Jackson, Tallega, and Booneville stream gages (where the flow frequencies were determined on the Forks).

Loss parameters for the 1% AEP storm were found to be reasonable across the basin. However, adjusting loss parameters per the same method for higher frequency storm varied widely. Some loss parameters were unreasonably high for subbasins between the lower Fork gages (Jackson, Tallega, and Booneville gages) and the downstream Heidelberg gage.

Furthermore, when HEC-HMS basin flows were applied to the HEC-RAS model, the differences in reach routing routines between the software made simulating the entire watershed for the full range of frequency flows difficult as inflows hydrographs would still need to be scaled in an iterative process to target the peak flows at Heidelberg (Lock 14).

4.7.1.1 Supplying an Inflow Hydrograph

For the Beattyville General Investigation study, the inflow hydrograph approaching the study area was the primary concern. It was more reasonable to simulate in HEC-HMS with uniform losses across the entire watershed because the computed flow frequency analysis peak discharges at the Heidelberg gage are based on the recorded peak flows regardless upon which upstream Fork the precipitation occurred (no discernable storm pattern could be determined between the Forks). While the upstream gage flow frequencies were calculated, those at Heidelberg are the primary concern for Beattyville. Relegating the losses to uniform values essentially makes the flows from each Fork a function of drainage area. Appropriate Atlas 14 storm (annual maximum series) precipitations and areal reduction factors were used in simulations for the designated frequency event.

4.7.1.1.1 Applying Concepts from Similar Terrain

The constant loss values for the initial 1% AEP simulations ranged from near zero to about 0.1 inches per hour upstream of Beattyville, and about 0.3 inches per hour downstream of Beattyville. As the inflow from upstream was the primary concern, experience from the Johnson County study was leveraged to assign typical loss values.

The low constant loss rates in the 1% AEP simulations are consistent with loss rates used for the Johnson County study (the nearest watershed East of the North Fork Kentucky River, just beyond the mountain ridge). The water control manual for Paintsville Lake Dam indicated an initial deficit of 0.3 inches and constant loss rates of 0.02 inches per hour were representative values for the terrain (Paint Creek watershed). Like the Paint Creek watershed, the Upper Kentucky River basin terrain is similar across the watersheds, for the most part. Low constant loss rates are typical for such terrain in winter and spring months when peak flows are highest.

As an additional validation, the HEC-HMS component of the HEC-CWMS model was re-calibrated in 2019. The final constant loss rates values using continuous calibration found that 0.02 inches per hour is typical for the watershed in winter/spring applications.

4.7.1.1.2 Applying Precipitation

Each frequency storm event was modeled in HEC-HMS with respective Atlas 14 precipitation data using uniform losses with soil infiltration values typical to the region when seasonal runoff is greatest (discussed above). Simulations were completed for the 0.2%, 1%, 2%, 4%, 10%, 20%, and 99% AEP events.

4.7.1.2 Applying Results to the Hydraulic Model

The HEC-HMS output files were placed in the HEC-RAS home folder then appropriately linked to the HEC-RAS unsteady flow files for simulations for ease of model transport.

The hydrographs were then scaled accordingly in the HEC-RAS model flow file until the desired flow at Heidelberg was achieved.

The inflow hydrographs for the frequency simulations are scaled uniformly in HEC-RAS across the contributing subbasins, with the respective frequency flow at Heidelberg as the target.

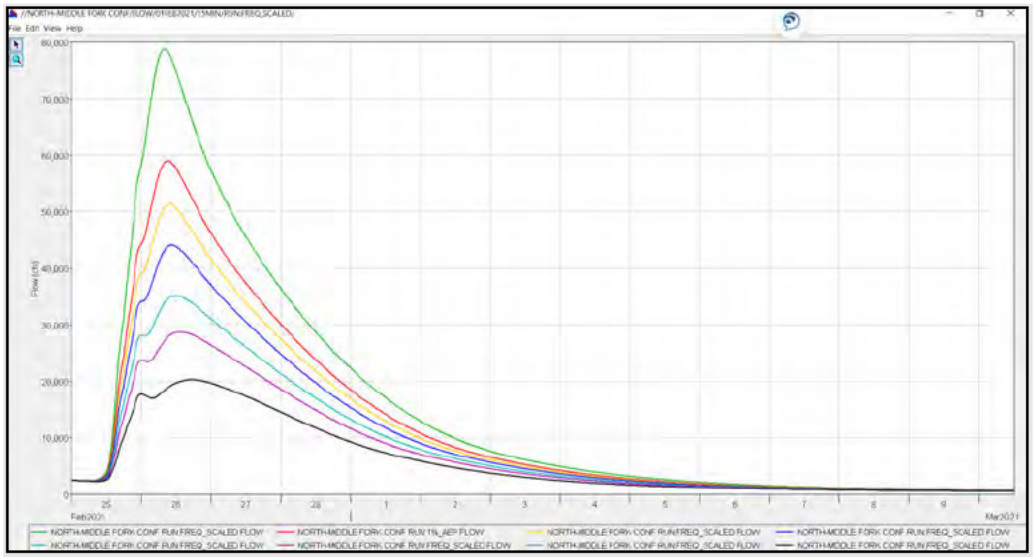


Figure 4-20: Inflow Hydrographs at the North-Middle Fork Confluence

4.8 HYDRAULIC MODEL DEVELOPMENT

4.8.1 General Hydraulic Methodology

The purpose of this section is to describe the existing conditions modeling effort. A one-dimensional (1D) unsteady state hydraulic model for Beattyville was developed using HEC-RAS version 6.3. The development began with the existing CWMS model for the Kentucky River Basin, which was updated for this project with new terrain, cross sections, and a two-dimensional (2D) flow area at Beattyville.

4.8.2 Hydraulic Model Setup

4.8.2.1 Terrain Data

The terrain was created by the aforementioned DEM. No bathymetry was available for the HEC-CWMS model upstream of Lock 11 on the Kentucky River at Irvine, KY. Existing bed profiles and aerial photography were used to estimate channel depth and width.

Bathymetry upstream of Lock 11 was adjusted based on a 1957 USACE study channel bottom (USACE Flood of January-February 1957). The channel bottom slopes of the main stem Kentucky River and the 3 Forks appeared to be the most consistent approaching the study area free of steep drops and inclines, which were present when applying separate data sources. The adjustment was made by approximating the channel bottom at various river mile stations to capture change in slope. The cross-sectional channel bottoms were adjusted using the Channel Design Modification Tool with a trapezoidal channel. The channel bathymetry was initially assumed using the estimated depth from Low Bank to the Thalweg from the 1957 study and estimated top width from satellite imagery and an assumed side slope of 2:1. The side slope and bottom width were then adjusted throughout the Kentucky River basin upstream of Lock 11 to better approximate the bathymetry using engineering judgement. The new channel was burned into the terrain and the cross sections recut to the new terrain.

4.8.2.2 Cross Section Data

The overbanks portions of the existing cross sections were recut based on the updated terrain. New cross sections were added in and around Beattyville to model the bridges more appropriately and to better capture flow and inundation in the area of interest (AOI).

Manning's "n" values were approximated with reference to the CWMS model and the 2019 National Land Cover Database (NLCD) land use layer. When the NLCD was used to approximate the Manning's "n" value, the Mapping, Modeling, and Consequence (MMC) recommendations from Figure 4.21 was referenced.

NLCD ID	Land Cover Description	Manning's "n" Value Range
11	Open Water	0.025–0.05
21	Developed, Open Space	0.03–0.05
22	Developed, Low Intensity	0.06–0.12
23	Developed, Medium Intensity	0.08–0.16
24	Developed, High Intensity	0.12–0.20
31	Barren Land	0.023–0.030
41	Deciduous Forest	0.10–0.20
42	Evergreen Forest	0.08–0.16
43	Mixed Forest	0.08–0.20
52	Shrub/Scrub	0.07–0.16
71	Grassland/Herbaceous	0.025–0.05
81	Pasture/Hay	0.025–0.05
82	Cultivated Crops	0.02–0.05
90	Woody Wetlands	0.045–0.15
95	Emergent Herbaceous Wetlands	0.05–0.085

Figure 4-21: MMC Recommended Manning's Roughness n-Value Ranges for Land Cover

4.8.2.3 Bridges and Culverts

A total of two bridges (both KY-11) were added to the model based on As-Builts from the Kentucky Transportation Cabinet (KYTC).

4.8.2.4 Stream Reaches

The Kentucky River reaches from Lock 11 up to Beattyville and the three Forks were included in the model. A new reach from the confluence of Carr Creek and North Fork Kentucky River to Whitesburg, KY was added from the Carr Creek SQRA hydraulic modeling effort.

4.8.2.5 Boundary Conditions

The HEC-CWMS model was trimmed to only include the basins upstream of Lock 11. The upstream boundaries were inflow hydrographs with lateral inflow hydrographs at the gage locations for Booneville, Tallega, and Jackson, KY. Hydrographs of the 2021 event were used as were the frequency storm inflow hydrographs from the Hydrologic Study.

For the downstream boundary, the USGS published rating curve was used (see Figure 4.22). This was done as part of the effort to calibrate the model to the 2021 event. See Section 4.8.3.2 for further discussion.

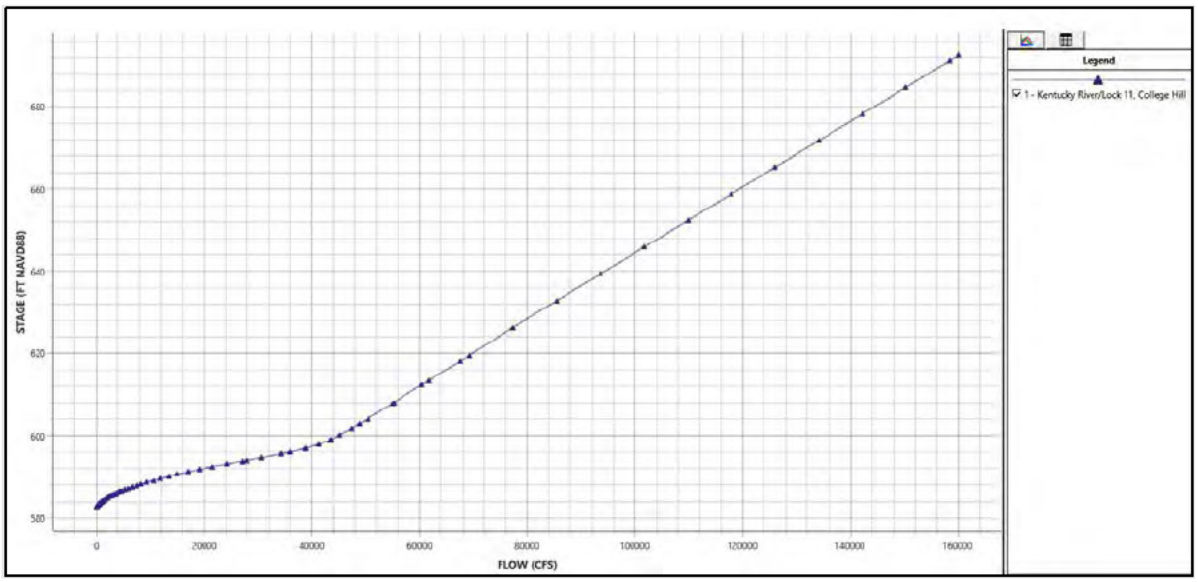


Figure 4-22: Published USGS Rating Curve at Lock 11 on the Kentucky River

4.8.2.6 Storage Areas

Storage areas from the HEC-CWMS model were used except for at Beattyville where the storage area was converted to a 2D flow area. This was done to provide better inundation modeling and mapping at Beattyville.

4.8.2.7 2D Flow Area

A 2D flow area was used at Beattyville to provide a better understanding of the inundation occurring as floodwaters rise on the Kentucky River.

Note that the 2D area is connected to lateral structure LS 275.5 on the Kentucky River reach which extends from just upstream of Crystal Creek to just downstream of Mirey Creek. The lateral structure was placed slightly behind intermediate high ground (a railroad embankment) at Mirey Creek, so the weir ground elevations appear low. This allows backwater to flow into the 2D area freely without the need to model the culvert/bridge opening under the railroad at Mirey Creek. Since no damageable structures are present in this area and no useable culvert/bridge data exists, the arrangement allows the inundation to properly map without affecting the study area results.

4.8.3 Calibration Efforts

In general, the channel roughness from the HEC-CWMS model was preserved because the model was calibrated to the USGS rating curves for each gaged reach. Flow roughness factors were used in calibration, which has held up well for years used by Water Management. The calibration was considered fit for use for nearly all stream reaches. The reach of the Kentucky River from approximate River Mile (RM) 242.8 upstream to Beattyville required calibration to adjust for the slope affects discussed in Section 4.3.3.1.

4.8.3.1 Existing Data

The USGS gage at Heidelberg and surveyed HWMs were used for the calibration effort. The observed rating curve for the March 2021 event was used for calibration due to the slope effect present in the Kentucky River, see Section 4.3.3.1 for further discussion. The observed flow and stage at Heidelberg were also used as additional references.

4.8.3.2 Lock 11 Gage Rating Curve as the Downstream Boundary Condition

The HEC-RAS model was truncated at Lock 11 (RM 203.8) on the Kentucky River to reduce computation times. The published USGS rating curve at Lock 11 was assigned as the downstream boundary condition (recall this is the most downstream gage with an established published slope rating).

4.8.3.3 Flow Roughness Factors

The reach of the Kentucky River from approximate RM 242.8 upstream (past Lock 14) to Beattyville was calibrated using flow roughness factors, which scale the Manning's 'n' roughness coefficients for the desired flows. The process is highly iterative because as flow roughness factors are increased, the stage increases but the flow decreases and vice versa.

The flow roughness factors were adjusted starting with the lowest flows working to the highest. After the flow roughness factors were altered, the simulation was computed and then the flow was adjusted by scaling entering flows in the reach within the unsteady flow file. Results were checked against the observed and published rating curves, then repeated. The iterative process continued for the full range of flows.

The Kentucky River system exhibits looped rating curves. Looped rating curves have a hysteresis effect that simply implies the conditions that occur before a given flow impact the associated stage, where a higher stage can be produced with less than the peak discharge. The hysteresis effect is present at the Lock 14 gage (Heidelberg). Note the purple loop plot in Figure 4.23.

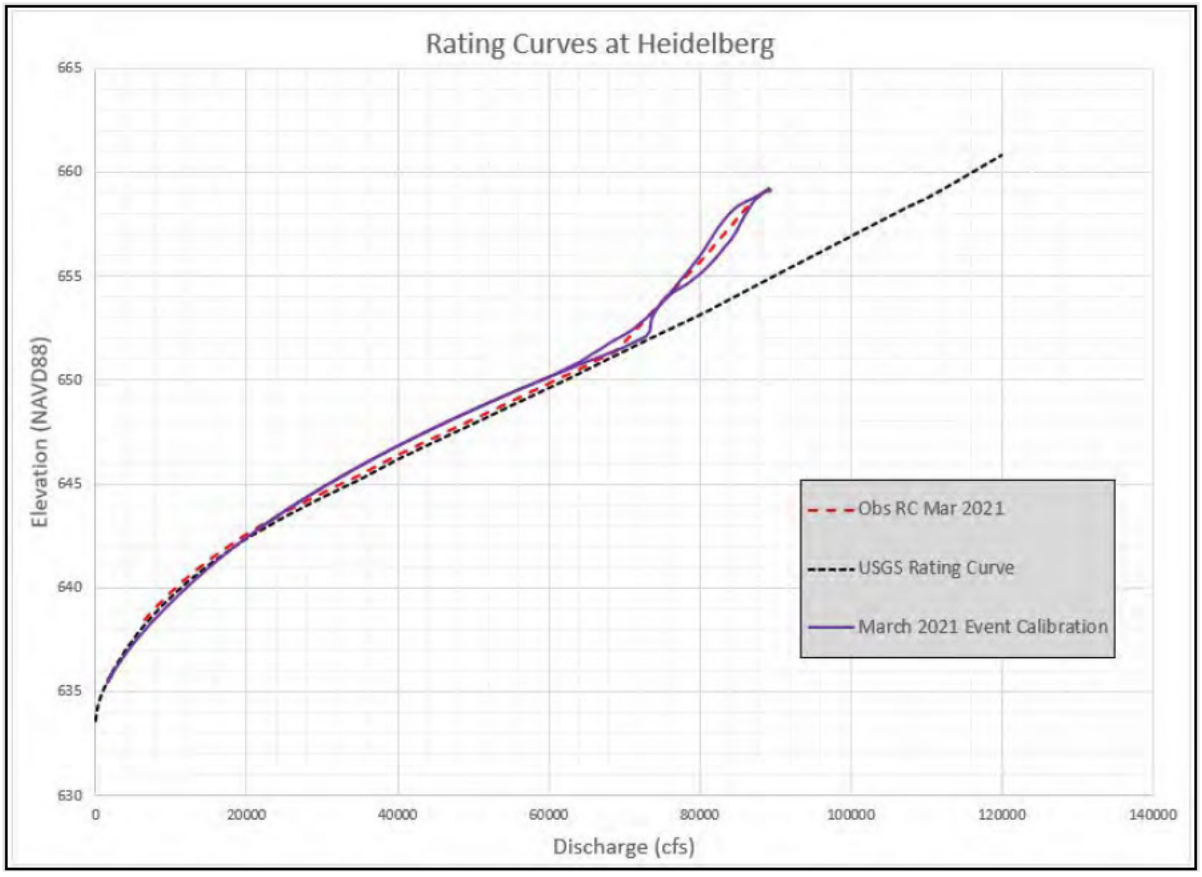


Figure 4-23: Calibration of March 2021 Event to the Observed Rating Curve

4.8.3.4 Calibration

Figure 4.23 represents the calibration effort for the March 2021 event. The inflow hydrographs were input from the HEC-CWMS forecast flow file (CWMS - RFC- Zero) of the event for local flows, and the observed gage data on the three river Forks (North Fork at Jackson, Middle Fork at Tallega, and South Fork at Booneville). The inflow hydrographs supplied by the observed gage data was scaled minor amounts to achieve the flows at Heidelberg during calibration.

The calibration targeted peak flows along the entire March 2021 event observed rating curve. That is, calibration began by scaling the event to lower peak flows on the observed rating curve, calibrating the flow roughness factor, then continuing up the observed rating curve to the next peak flow target. The objective is to utilize the flow roughness factors that track well with the computed hydrograph, with the peak stage close to the observed rating curve and the peak flow marking the end of the rising limb and beginning of the falling limb of the hydrograph. The higher the target peak flow is on the curve, the more pronounced the hysteresis effect which is visible in Figure 4.23 for the March 2021 event.

The March 2021 event was the first recorded event to utilize a pro-rated slope rating curve, therefore, higher peak flows were assumed to extend the sloped rating curve parallel to the observed, similar to the published slope rating curve at Lock 11 (see Figure 4.22). The assumption was necessary to calibrate flows beyond the observed event up to the calculated 0.2% AEP flow while maintaining continuity in the model simulations at higher flows.

The flow roughness factors are stored in the geometry file. However, additional flow roughness factors are stored in plan files for peak flows greater than 80,000 cfs at Heidelberg. This arrangement was necessary because the falling hydrograph limb at higher peak flows should track along the observed rating curve. When the higher peak flow roughness factors are stored in the geometry file, this causes the hydrographs of lower peak flow events to track further off the observed rating curve. Therefore, the solution was to store the higher peak flow roughness factors in the plan file for those peak flow simulations.

4.8.4 Calibration Results

Calibration effort resulted in a reasonable reproduction of the March 2021 hydrograph (see Figure 4.24). Additionally, the simulated rating curve plotted reasonably well at the peak stage and flow (presented above in Figure 4.23).

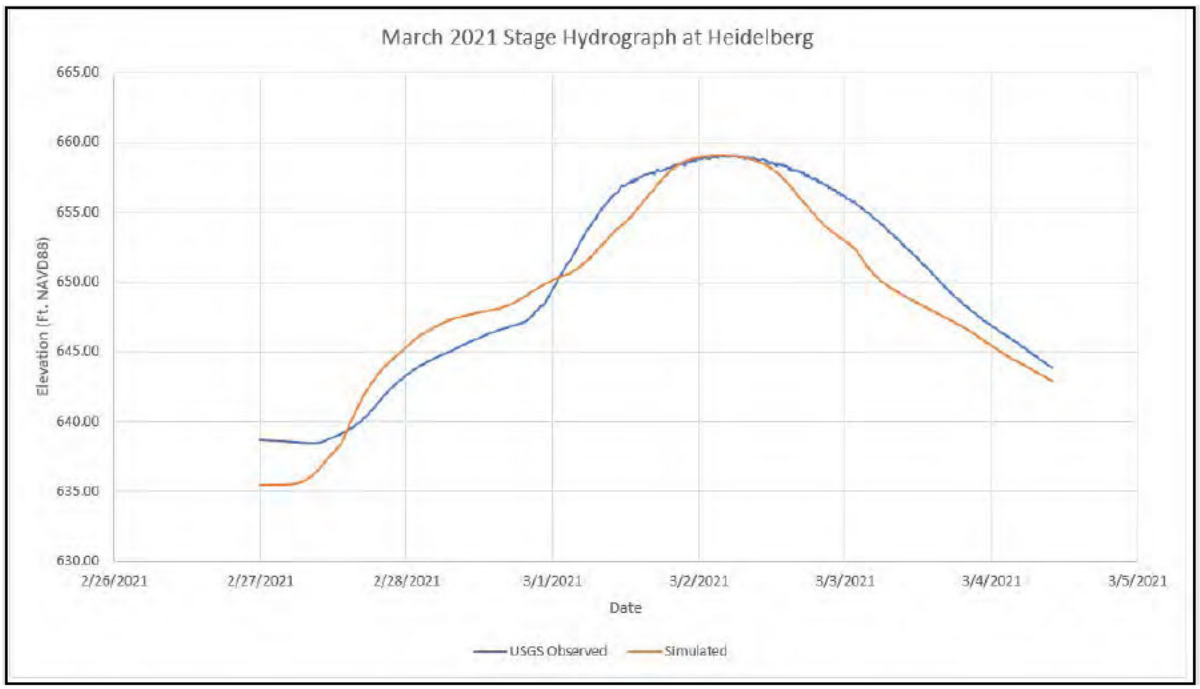


Figure 4-24: Observed and Simulated Stage Hydrograph

The March 2021 event is the only flood event with available highwater marks at Beattyville and a stream gage record at Heidelberg. It must be recognized that the observed rating curve developed by the USGS for the event record leverages measurements from a single event and slope ratings from downstream gages. The HEC-RAS model was calibrated to the same event, which implies there is likely higher uncertainty in the stage-discharge curve at Beattyville for events larger than the March 2021 flood.

4.8.5 General Approach to Modeling Frequency Storms

Each frequency storm was simulated in HEC-RAS using the respective HEC-HMS results output. The HEC-HMS output files were input into the HEC-RAS flow files. Upstream boundary condition flow hydrographs and subbasin outflows were linked in the unsteady flow files. Flows from Buckhorn Dam and Carr Creek Dam were set to their respective minimum flows for storm events.

HEC-RAS simulations were executed in an iterative process of uniformly scaling the upstream boundary condition flow hydrographs and subbasin outflows until the target flow was reached at Heidelberg, then the flow roughness factors were adjusted (recall Section 4.8.3.3), and then the process was repeated. In a sense, simulations for events greater than the March 2021 event were calibrated to the rating curve (see Figure 4.22) in the same process.

Each simulated event was checked against the observed rating curve for reasonableness. Figure 4.25 shows selected simulations plotted with the observed rating curve. Note the hysteresis effect.

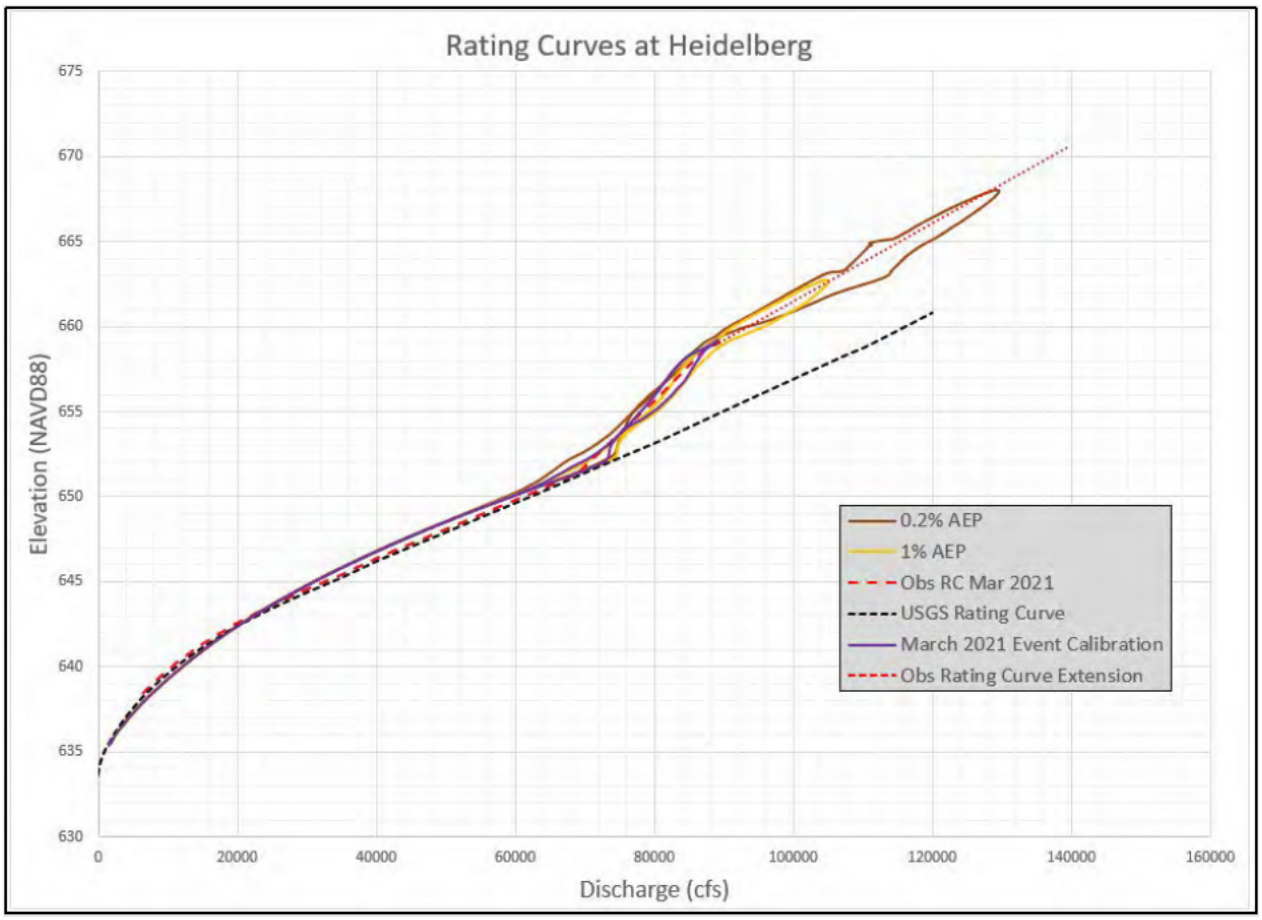


Figure 4-25: Rating Curves of Various Simulations

4.8.6 Conclusions for Existing Conditions

The existing conditions modeling is adequate for the study area. Future studies of upstream areas on the Forks should extend the HEC-RAS model scaling inflows to the Jackson, Tallega, and Booneville gages, then revisit the scaled inflows at the Heidelberg gage as it establishes the downstream condition for the Forks.

Note the lateral structures near the confluence in combination with the inflows from the Forks and the inflows from subbasin outlets all converge in this area. It causes peak discharges to vary quite a bit from the cross sections nearest the confluence to XS 256.9893 as flows computationally balance. Hydrograph plots tend to show iterations across the lateral structure as the difference in head attempt to equalize each computational time step. Attempts were made to resolve or lessen this affect by changing the weir overflow computation method. The normal 2D equation method produced the better results verses using the weir equation option. Adding time slices to the 2D flow area mostly resolved the issue.

4.8.6.1 Uncertainties and Risk Assumptions

Uncertainty exists in both hydrology and hydraulics, the terrain data, the channel bathymetry, and survey data.

4.8.6.1.1 Hydrologic Uncertainties

Hydrologic uncertainties in the flow frequency analysis are addressed in the Risk Report. The flow frequency analysis utilized Bulletin 17C methods intended to capture uncertainties in the stream flow record.

Hydrologic uncertainties also exist in rainfall patterns. No discernable pattern was found in the annual peak flow records indicating the percent of time each of the three Forks contributes to flooding at Beattyville. Uncertainty in storm event precipitation timing and patterns exists and may not be quantifiable without a more thorough analysis.

4.8.6.1.1.1 Frequency Storm Events and Fork Coincidence

The modeled frequency storm events are theoretical, and the drainage area above Beattyville exceeds the size of typical storm areas. The modeling utilizes watershed drainage areas as the primary distributor of flows converging into the Kentucky River, with the peak discharges targeting calculated values from the flow frequency analysis (also theoretical). The flow hydrographs from contributing subbasins are scaled to the calculated values associated with the frequency peak flows at Heidelberg (downstream of Beattyville). While North and South Fork peak hydrograph timing is within about a day at Beattyville for modeled storms, coincidence may be irrelevant as the resulting peak discharge would still be scaled to the frequency flow target at Heidelberg.

True historical coincidence is not only unknown, but the flow would have been recorded at the Heidelberg gage regardless. The risk of frequency storms not capturing increases in water surface elevations due to coincident peaks from the Forks appears low. However, if a floodwall alternative is considered part of the TSP, then some level of coincident frequency analysis may be warranted. The complexity of such analysis may result in an overly conservative water surface elevation value (in the simplest analysis) or an order of magnitude larger data requirement for a continuous record analysis. The most straightforward path to managing coincidence risk would incorporate additional uncertainty in the stage-discharge curve at Beattyville. See the Risk Report for such considerations.

4.8.6.1.2 Hydraulic Uncertainties

4.8.6.1.2.1 Channel Bathymetry

Recent channel bathymetry was not available for the Forks or the Kentucky River. Bathymetric data in the HEC-RAS model uses the most complete and best available albeit from the data is over 50 years old and acquisition methods were not well-documented. With residents complaining of sedimentation, the bathymetric data remains a source of uncertainty.

Channel bathymetry is based on historical data but is assumed to be adequate. Drop elevations taken from the Broadway Street (KY-52) bridge indicate the bathymetry used is within 1 to 2 feet of the channel data used. In-channel conveyance is hindered by the Kentucky River low-head dams, which contribute significantly to backwater effects. Early simulations assumed channel dredging 10 feet deeper showed the excavation provided an insignificant amount of in-channel storage lowering the water surface less than one foot, thus the backwater effects remain dominant. The risk to proceeding without current channel data appears low.

4.8.6.1.2.2 The Observed Rating Curve and Calibration Event

Uncertainty increases for higher stream discharges. The calibration event is the only event with both measured flow and stage at Heidelberg and highwater marks (also a source of uncertainty)

at Beattyville within the period of regulation. The observed rating curve, to which higher flows are calibrated, is a construct of the USGS best estimate as explained in Section 4.3.3.1. Uncertainties exist throughout entire rating curve, with higher uncertainty at flows exceeding the calibration event peak flow. Additional information can be found in the Risk Report addressing uncertainties in the flow to stage conversion at Heidelberg and Beattyville.

The observed rating curve is assumed to be conservative for higher flows; however, there is risk to underestimating or overestimating the stage for infrequent flood events (such as the 1% AEP flood) upon which project alternatives are evaluated.

4.8.6.2 Economic Analysis

Uncertainty in terrain and bathymetry has been conveyed for economic analysis. Engineering Manual 1110-02-1619 (EM 1619) Table 5-2 presents the minimum standard deviation of error in stage for economic analysis using HEC-FDA. The recommended minimum standard deviation of error is 0.9 for this study. The value provided is assumed adequate given the study data; however, this is the minimum value, and the true error is unknown.

4.8.6.3 Flood Control Reservoirs

Buckhorn and Carr Creek Dam are assumed to operate as prescribed in the Water Control Manuals. The Water Management and Lake Operations teams are well-seasoned, and the risk of mis-operation of the dams is assumed low.

4.8.6.4 The Creeks

Flooding from Crystal and Silver Creeks are not a driving factor in flooding Beattyville. Section 4.1.2 describes the Creeks and reasons for focusing on Kentucky River backwater flooding. The Creeks contribute a small drainage area and coincident flooding with the Kentucky River is unlikely. However, coincident timing of peak hydrographs is possible. Section 4.9.7 details an unlikely coincident flooding scenario where both creeks are peak discharging with Kentucky River backwater at peak stage. Uncertainty is present with the ungagged Creeks and streamflow data non-existent. However, the risk of significant increases in water surface elevation due to coincidence is low.

4.9 CONCEPTUAL ALTERNATIVES

This section describes efforts modeling the various improvement alternatives and analyzing the hydraulic impacts of proposed improvements at Beattyville.

Proposed conditions were modeled for the 0.2%, 1%, 2%, 4%, 10%, 20%, 50% and 99% AEP flow frequencies for economic analysis against the proposed condition.

As part of the Planning Process, the Future Without Project (FWOP) conditions must be considered. For the hydraulic engineering discipline, the FWOP and the existing conditions analyses are the same for this study. The hydraulic data for existing conditions will be used for the FWOP conditions during economic analysis. No further hydraulic analysis is anticipated for FWOP conditions.

4.9.1 Non-Structural and Structural Alternatives Considered

Both non-structural and structural alternatives were considered. Hydraulic data outputs for existing conditions were furnished to the PDT for analyzing non-structural solutions. Note that non-structural measures are not discussed in this report as they were not hydraulically modeled.

The PDT determined structural solutions would be limited to the analysis of a floodwall/levee system as the study advances toward the TSP. Collaboration between the hydraulics, geotechnical, and civil design disciplines defined the floodwall alignment with the highest likelihood of meeting study objectives. For example, the chosen alignment avoids the Floodway and minimizes the disruption of utility infrastructure while meeting flood mitigation goals.

The PDT chose four floodwall heights for feasibility-level analysis. Economic analysis will determine the floodwall height with most net economic benefits for consideration as the TSP. While the hydraulic analysis of proposed floodwall heights was performed on the forementioned annual exceedance probabilities, this report primarily deals with the 1% AEP given the FEMA emphasis on the flood reoccurrence. All data necessary for economic analysis was furnished to the PDT. Analyzed floodwall heights are addressed below in Section 4.9.3.

4.9.2 Structural Alternative: Floodwalls

The PDT geotechnical and civil design members provided recommended floodwall alignments for hydraulic analysis. Analysis prior to the AMM indicated the lack of storage in Crystal and Silver Creeks requiring high-capacity pump stations if the alignments crossed the streams.

The alignments were chosen to avoid the Kentucky River Regulatory Floodway (see Section 4.1.4). Note that in Figure 4.4, the Floodway includes the historical alignment of Crystal Creek which was established by the effective Kentucky River hydraulic analysis. The Floodway likely included the creek to discourage development, but the stream alignment has since been altered through downtown Beattyville.

There are two recommended floodwall alignments: one surrounding the central downtown between Crystal and Silver Creeks, and the other between Crystal Creek and Broadway Street. The alignments are visible in Figure 4.26.

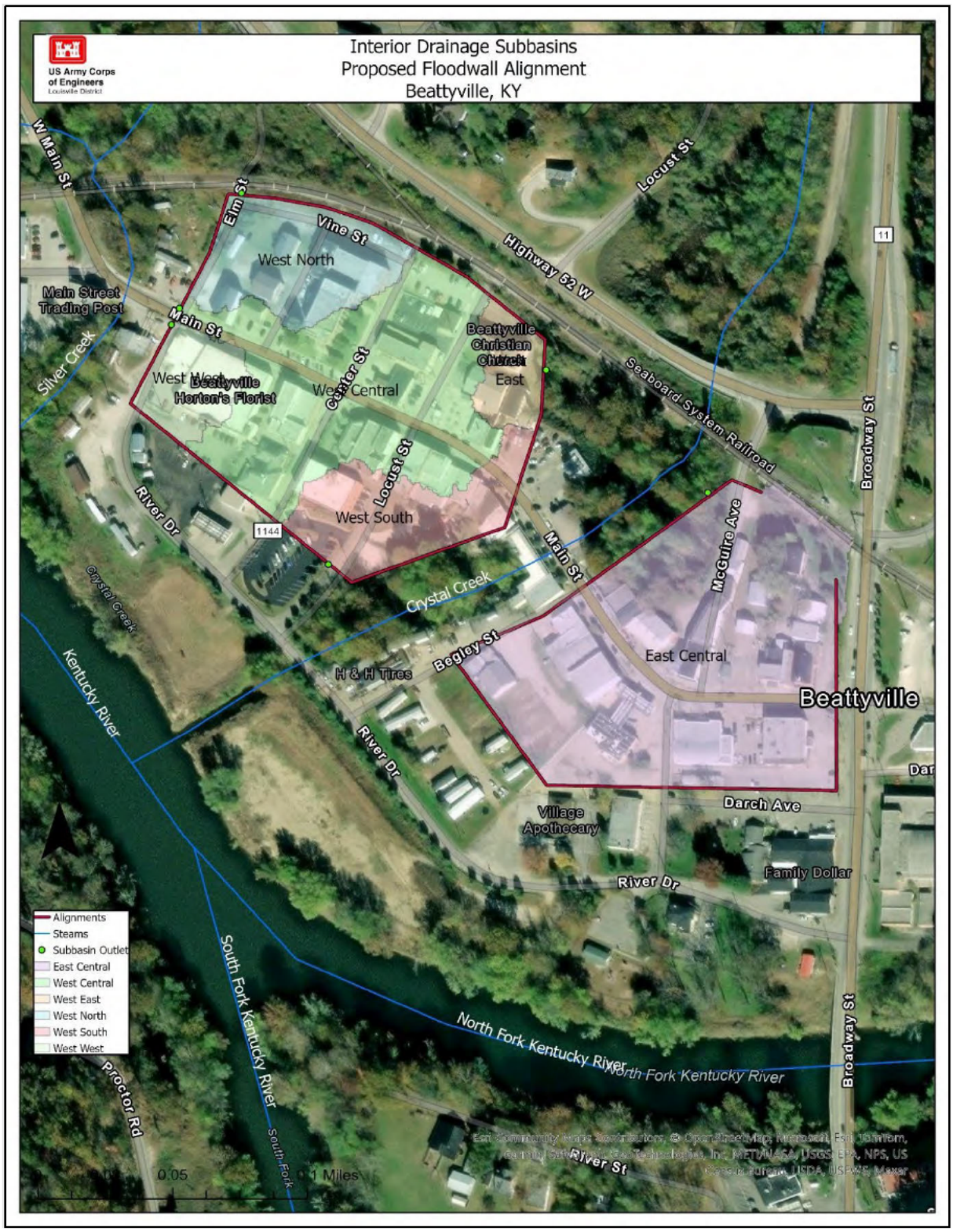


Figure 4-26: Floodwall Alignments and Interior Drainage Subbasins

4.9.3 Floodwall System Modeling Approach

The PDT requested hydraulic analysis of four potential floodwall heights, all with same horizontal alignment. Appropriate data from the hydraulic modeling results was supplied for economic analysis.

The floodwall elevations analyzed were 663.0 Ft. NAVD88, 666.5 Ft. NAVD88 (the reoccurrence of the March 2021 flood event), 669.2 Ft. NAVD88 (the effective base flood elevation), and 672.2 Ft. NAVD88 (the effective base flood elevation plus 3 feet of freeboard).

The HEC-RAS existing conditions model was adapted to these alternative floodwall heights by adding 2D flow area connections to the 2D flow area representing Beattyville. Each analyzed floodwall height has an associated HEC-RAS geometry file. Since the horizontal floodwall alignment is same for each height alternative, the floodwall geometry files are duplicates with different heights assigned to the 2D flow area connections within the associated geometric file.

HEC-RAS plans were created for each floodwall height geometry and the eight (8) frequency flows. The same flow files representing the existing conditions frequency flows were applied to each floodwall height geometry. Simulations were completed and results checked for reasonableness.

Flow data tables and mapping output files were furnished for economic analysis (HEC-FDA) and HEC-LifeSim modeling.

4.9.4 Impacts on River Stage

The maximum rise in river stage for the 1% AEP flood due to the presence of floodwalls would occur with the maximum floodwall height analyzed. The rise in river stage for the BFE plus 3 ft. with a floodwall elevation of 672.2 Ft. NAVD88 is less than 0.1 feet, well below the maximum 1-foot surcharge regulatory limit.

4.9.5 Duration above Damage Stage and Rate of Rise

Hydraulic modeling simulations of the 1% AEP frequency flood indicate the damage stage at Beattyville of 657 Ft. NAVD88 is exceeded for approximately 2.5 days (see Figure 4.27).

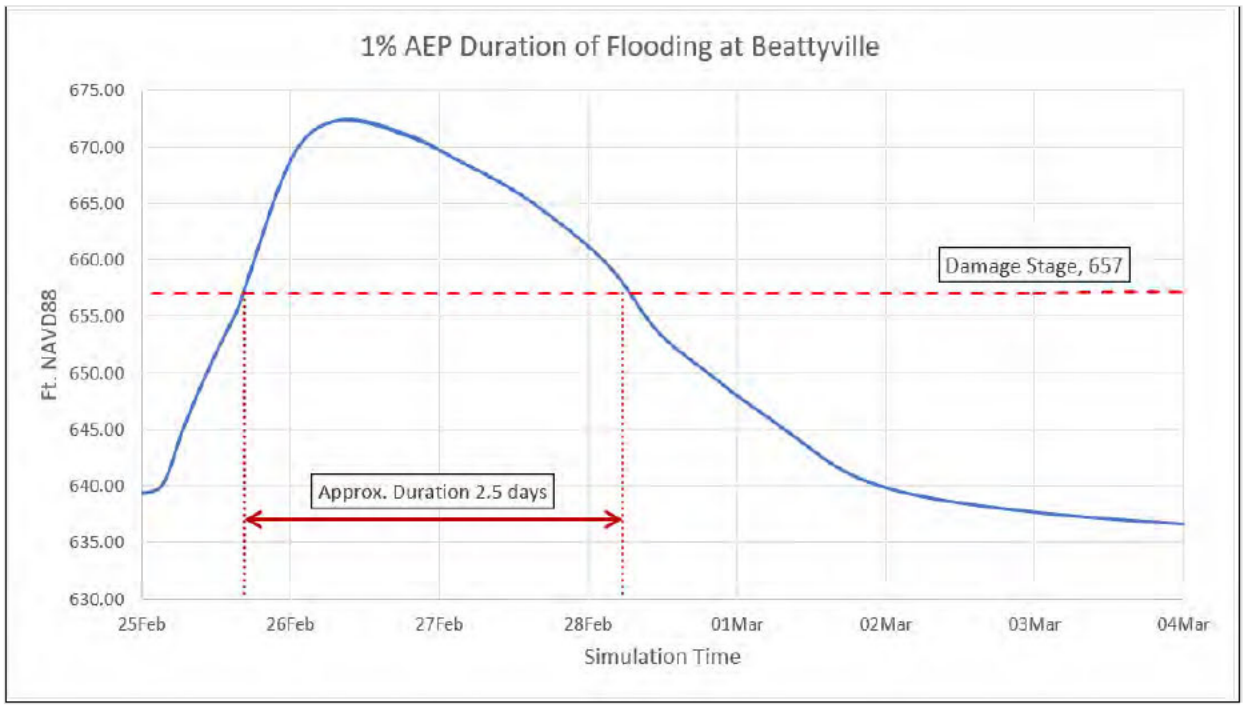


Figure 4-27: Simulated 1% AEP Duration of Flooding at Beattyville

Once at damage stage, the rate of rise for the 1% AEP frequency flood at Beattyville can be up to 1.7 feet per hour, approximately 130% faster than at the Heidelberg gage. This occurs as the gage discharge-stage rating shifts upward in the manner discussed in Section 4.3.3.

4.9.6 Overtopping Sections and Superiority

The overtopping sections were calculated using the HEC-RAS model. The overtopping sections were simulated in HEC-RAS with 1D storage areas to achieve initial estimates of overtopping section length and superiority increments height requirements. The estimates were then applied to the HEC-RAS geometry with 2D flow areas for detailed simulation.

Engineering and Construction Bulletin 2019-8 (ECB 2019-8) addresses the managed overtopping of levee systems. The intent of overtopping and superiority sections is to force an overtopping event into prescribed portion of the floodwall thus providing a controlled manner of leveed area inundation. Initial simulations indicate when the overtopping section is set to 673 Ft. NAVD88 (slightly higher than the 1% AEP stage), the required superiority increment is about 6.75 feet. This arrangement utilizes an overtopping length of about 1970 feet for the downstream floodwall alignment. The 0.2% AEP flood rises to 6 feet above the overtopping section inundating the leveed area in less than 1 hour, which may be unacceptable for life-safety parameters.

Designated overtopping sections may not be feasible with the floodwall alignment and targeted flood defense elevations for large flood events. The alignment may require the full length between high ground tie-ins be considered the overtopping section and reinforced accordingly.

4.9.7 Coincident Flooding of the Creeks

It is not impossible for coincident flooding to occur with Crystal/Silver Creeks and the Kentucky River; however, such coincidence in is highly unlikely given the relative difference in drainage areas.

Crystal and Silver Creek (the Creeks) do not cause flooding for storm events with a normal Kentucky River stage. Crystal Creek (5.2 mi^2) and Silver Creek (3.3 mi^2) have times of concentrations between 0.75 to 1.5 hours. The Kentucky River (and the Forks) above Beattyville encompasses 2,164 mi^2 of uncontrolled drainage area with times of concentration of 22-24 hours to Beattyville. Peak discharging of the Creeks would likely have already occurred prior to the Kentucky River flood wave arriving at Beattyville.

Completing a coincident frequency analysis poses several challenges. A lack of data makes establishing a correlation (an indicator of independence/dependence) difficult at best as the small watersheds are not gaged and a period of record is not available for analysis. It would then be reasonable to assume the watersheds are hydrologically independent given such differences in drainage area. Independence of variables would be the starting assumption in a coincident frequency analysis (CFA).

Regardless, the 1% AEP Kentucky River stage with 1% AEP Crystal and Silver Creek flows give a stage increase of 0.4 feet at Beattyville. This can be taken as a worst case with both Creeks reaching peak discharge when the Kentucky River flood wave arrives. The total chance 1% AEP using total probability will be less than a 0.4-foot increase in stage, which is not significant with HEC-RAS modeling.

If a floodwall alternative advances as the Tentatively Selected Plan (TSP), then a full CFA would be warranted.

4.9.8 Interior Drainage

A floodwall/levee system alternative requires an interior drainage analysis. Engineering Manual 1110-2-1413 (EM 1413) addresses hydrologic design and analysis of interior areas.

4.9.8.1 Minimum Facilities

For feasibility-level design, interior drainage is assessed for minimum facilities which determines the components required for the drainage system to operate as it did prior to project installation. Common components of interior drainage systems may include gratuity outlets, pump stations, detention storage, diversions, and pressure conduits.

When assessing minimum facilities, it is reasonable to use the design storm of the existing storm sewer system to determine the additional system components required. The analysis can be completed using the design storm for the sewer network in questions; however, if the design storm is unknown, then another appropriate design storm may be used. For this analysis, the interior drainage assumes a 100-year, 24-hour storm for comparing existing and proposed conditions. The indication of adequacy is the proposed condition ponding level is no higher than the existing condition ponding level.

4.9.8.2 Interior Drainage Modeling

The interior drainage was modeled using HEC-HMS. The interior subbasins were delineating using a high-resolution digital elevation model (from KY Above statewide 5-foot DEM dataset). Information from archived Kentucky Transportation Cabinet (KYTC) project plans, Google Earth

imagery, and field visits was used to assemble a rudimentary drainage network, which was then used in the subbasin delineation and identification of gravity outlet locations at the line of defense. Some basic sewer depths below grade were assumed and storage-elevation curves were assembled. The data was entered in HEC-HMS to represent each subbasin as a reservoir with outlet facilities.

Precipitation transformation was modeled using SCS unit hydrograph method. The interior areas are urban with connected impervious areas. Losses were estimated using SCS curve number methodology.

The 100-year, 24-hour storm was used for simulation and gravity outlets were sized to keep the ponding below damage elevations. A normal Kentucky River tail water elevation of 635.0 Ft. NAVD88 was used in simulations.

4.9.8.2.1 Gravity Drains

The initial interior drainage analysis indicates gravity outlets will be the primary means to convey interior runoff through the line of defense, each outlet equipped with a flap gate for backflow prevention. The existing storm sewer system will be utilized where possible matching or upsizing the existing storm sewer connections at the line of defense. The proposed floodwall alignment is situated such that the gravity pipes will likely drain to Crystal or Silver Creek. See the proposed gravity outlet locations in Figure 4.26. There is a potential need for basic collector storm sewer drains in some interior areas, but the need appears to be minimal.

4.9.8.2.2 Pumping Stations

The interior areas encompass relatively small drainage areas. Maximum precipitation runoff can be assumed for the nearly impervious leveed area without creating a need for pumping. The gravity outlets are shown to be adequate. If the floodwall/levee alignments are altered to cross Crystal or Silver Creek, then pump stations will likely be required. The current floodwall alignments, as analyzed, will not require pump stations.

4.9.8.2.3 Interior Detention Storage

In Figure 4.26, the interior area topography within the alignment east of Crystal Creek exhibits a low area in the northwest portion near the gravity outlet. This would be the likely location of designated detention storage if required. Based on available data, storm sewers may not outlet in this area. Collector sewers may be needed to move interior runoff efficiently to the outlet. The gravity outlet through the line of defense may require some detention storage. Field surveys are necessary to determine the need.

4.9.8.2.4 Diversions

For the current floodwall alignment, interior drainage areas are relatively small, and streams will not pass through the line of defense. There is no anticipated need for diversions.

4.9.8.2.5 Pressure Conduits

Prior to the AMM, a pressure conduit was considered, and analysis showed it was feasible for Crystal Creek. This analysis applies to an unfavorable alignment which crossed Crystal Creek. The pressure conduit was screened out prior to the AMM mainly for environmental and maintenance concerns. Pressure conduits are no longer being considered.

4.9.8.3 Minimum Facility Recommendations

For the proposed floodwall alignments, minimum facilities will likely include gravity outlets to move interior runoff through the line of defense. The modeled gravity outlets are 30 inches in diameter or less, thus avoiding the requirement for secondary means of closure. The eastern alignment may require minor detention storage, if any. Collector sewers are more likely to be needed in the eastern alignment. Field surveys of terrain and the locations and conditions of the existing storm sewer system will be required for more detailed analysis.

Precipitation runoff will enter the storm sewers incurring head losses and attenuating hydrograph peaks. However, the gravity outlets were modeled in HEC-HMS as outlet culverts exiting reservoirs, which assumes the runoff goes directly to the outlet. This is reasonable for assessing whether the proposed exiting gravity outlets through the line of defense hinder the existing storm sewer system with the floodwall system in place. The outlet will receive the hydrograph unattenuated by the storm sewer system and can be considered conservative for comparison with existing conditions.

Table 45 exhibits the anticipated gravity outlets required to move interior runoff through the line of defense. The calculated gravity outlets assume concrete pipes with Manning's roughness coefficients of 0.012, but other materials with similar roughness may be allowable pending Levee Safety review. Flap gates were assumed for all outlets.

Table 45: Anticipated Gravity Outlets Required

Interior Subbasin	Length (Ft)	Diameter (Ft)	Inlet Elevation (Ft)	Outlet Elevation (Ft)	Slope (Ft/Ft)
West N	193	1.0	645.0	639.2	0.030
West S	198	1.0	656.7	650.8	0.030
West E	200	1.0	649.6	643.6	0.030
West W	91	1.0	657.0	654.3	0.030
West Central	123	2.0	657.0	653.3	0.030
East Central	91	2.0	640.5	637.8	0.030
*Floodwall/levee penetrations with diameters greater than 2.5 feet require second means of closure.					

There is no need for pump stations, diversions, and pressure conduits currently. If the alignments are modified such that the line of defense crosses Crystal or Silver Creek, then such system components may be required.

4.9.9 Results Discussion

The hydraulic analysis is complete for feasibility-level design. By avoiding the Regulatory Floodway, the proposed floodwall alignments minimized water surface elevation increases due to presence of the project and avoid the FEMA 'zero rise' in base flood elevation mandate. The alignments do not cross the Creeks thus avoiding the need for costly pumping stations. Precipitation runoff within the small interior areas would be passed through the line of defense with gravity outlets.

Challenges with the proposed floodwall alignments remain, despite the above advantages. Superiority in overtopping may not be feasible with the alignments. Additional erosion armoring

may be required to reduce risk to floodwall foundations. Economic modeling with HEC-LifeSim may indicate increased life safety risk with egress. NFIP eligibility appears very unlikely.

Additional hydraulic analysis will be required if a floodwall alternative is carried forward as the TSP. Continue below for anticipated analysis and considerations in detailed design.

4.10 FUTURE ANALYSIS AND CONSIDERATIONS

4.10.1 Detailed Floodwall Analysis

Floodwall alternatives require a more in-depth analysis if carried forward as part of the Tentatively Selected Plan (TSP). It is not uncommon for efforts to be iterative in nature between engineering disciplines as a solution is sought.

4.10.1.1 Overtopping and Superiority Sections Detailed

Floodwall overtopping sections are typically flanked by a raised superiority increment designed to force larger flood events to overtop the floodwall in the designated locations. The larger flood events targeted are the next two larger frequency flows greater than for what the floodwall is designed. The overtopping sections are intended to allow the gradual filling of the leveed area as not to cause panic, serve as warning of inundation, and to allow the hydrostatic pressures on the floodwalls/levees to equalize thus lowering the risk of catastrophic failure.

When the flood mitigation system is overtopped and the leveed area inundated without catastrophic failure, the system design level will have been considered exceeded and has performed as intended.

Additional analysis will be required to establish effective overtopping sections. Overtopping and superiority section issues were previously discussed regarding the maximum floodwall height evaluated prior to the TSP. Carrying the floodwall option forward will require a collaborative effort with the PDT to determine if designated overtopping sections are desirable with the selected floodwall elevation, or if the entire floodwall length must be designed for overtopping. Superiority sections are not always feasible and further analysis must be completed to make a determination.

4.10.1.2 Plunging Force

Plunging force refers to the force exerted on the landside ground and the potential erosion of the floodwall/levee foundation. Plunging force is primarily driven by the approach velocities of overtopping flows, the water surface height above the overtopping section, and the fall from that elevation to the landside ground surface. It is a force per unit of floodwall length. The plunging force dictates the amount of surface armoring required to mitigate the eroding of floodwall foundations and reduce the risk of the subsequent collapse.

Plunging force analysis will be required for floodwall alternatives carried forward as the TSP. Geotechnical and structural engineers use the analysis to determine appropriate foundation armoring and erosion protection.

4.10.2 Interior Drainage

Cursory interior drainage has been completed to address minimum facilities. The analysis has indicated the relativity small, leveed areas (and thus small drainage areas) will likely drain well-ahead of the Kentucky River flood wave arrival. The basic interior drainage facilities consist of

gravity outlets and have shown to be adequate given assumptions regarding existing storm sewer networks.

Advancing the floodwall alternative as the TSP will require additional interior drainage analysis after survey data is acquired, including a complete Coincident Frequency Analysis (CFA) of gravity outlets. Collector sewers will likely be required to facilitate proper drainage within the leveed area. The process is iterative with the Civil Design engineers to select the optimal network configuration and outlet sizes. Field surveys of terrain and the locations and conditions of the existing storm sewer system will be required for more detailed analysis.

4.10.2.1 Outlet protection

Gravity outlets designed to evacuate interior runoff from the interior areas require erosion protection. Erosion is typically mitigated with riprap protection at the outlets. The US Federal Highway Administration (US FHWA) design manuals are used to size minimum riprap gradations.

The gravity outlet protection measures would be exposed to riparian forces nearly perpendicular to the outlet centerlines. The FIS report states that Crystal and Silver Creeks can generate high stream velocities in flash flood conditions. However, the report also indicates scour has not been an issue. Additionally, the initial gravity pipe configurations supporting the interior drainage analysis empty to Crystal and Silver Creeks located in the Kentucky River backwater influence where velocities are typically low. High stream velocities are not a concern for washing out riprap protection at the gravity outlets.

4.10.3 The Creek Hydraulic Models

Crystal and Silver Creeks have not been identified as the primary flooding source. Further analysis of the creeks has not been warranted. Survey data was obtained for the bridges along the creeks but have not been incorporated in HEC-RAS models for the individual streams. Creek channel bathymetry through downtown Beattyville was included in the main existing conditions HEC-RAS model terrain file.

Crystal and Silver Creeks will need to be modeled in HEC-RAS if the PDT requires hydraulic analysis. The effective steady flow HEC-RAS models obtained from KYDoW terminate just upstream of the KY-52 bridge crossings. The creek water surface elevations though downtown are controlled by the Kentucky River backwater. Updating and extending the Creek models would likely require no more than 2 weeks effort per creek.

4.10.4 Flood Inundation Mapping

The modeling applied to this study thus far could be used to develop flood inundation mapping (FIM). The resulting maps would carry forward with uncertainties already discussed with existing conditions. The level of processing effort would be about a 5-week effort. If Crystal and Silver Creeks are to be included as flooding sources, the effort nearly doubles. Such mapping may be useful to emergency management and planning officials.

4.10.5 Flood Warning Systems

A flood warning system for Beattyville would likely only provide riverine flood warning for the Kentucky River stage. The primary gage for detection would be the USGS gage at Heidelberg for which the National Weather Service (NWS) Ohio River Forecast Center (OHFC) issues stage forecasts. Warning time would be up to 24 hours and relies solely on the forecast for the event. Real-time warning from the Heidelberg gage may not provide sufficient warning time.

Beattyville floods when all three Forks provide significant flow contributions. For the March 2021 flood, the peak flows at the Fork gages could have provided some indication of the coming flood at Beattyville. However, configuring such a warning system based on the upstream gages would require significant effort to establish patterns and thresholds. The best estimate of potential warning time based on such a system is 6 to 12 hours. The required level of effort and likelihood of producing a usable product is unknown.

4.10.6 FEMA Flood Hazard Mapping Considerations

FEMA submittal processes can be lengthy, and many standards must be met. Typically, the effective models FEMA has on file must be used for mapping updates. Additionally, FEMA mandates the models be updated with the latest bridge and terrain data. If the model is not executable (such as the model on file being in paper form), then whole model replacement is an option. However, additional requirements apply such as water surface profiles at boundary tie-ins must be within +/-0.5 feet. Continue below for other hurdles to this approach.

4.10.6.1 The Effective Hydraulic Model

The effective model was reconstructed from HEC-2 files found in LRL digital archives. The model was verified to be the effective model by comparing the cross-section points with the scanned paper format PDF obtained from FEMA.

The effective FEMA hydraulic model includes the Kentucky River from Heidelberg through the confluence at Beattyville to approximately 1 mile upstream on the North Fork. The Kentucky River and the North Fork are combined in a single stream reach. The South Fork is represented by a flow change location. The model only contains 6 cross sections, and no bridges were included. The encroachment stations were not included in the model.

The model was converted to HEC-RAS and the cross sections were georeferenced using the effective lettered cross sections and river mileage from USGS quad sheets (long used in-house as ‘official’ river mileage). HEC-2 models converted to HEC-RAS do not produce the same results but were comparable to the results in the FEMA PDF file.

The simplicity of the steady flow model allowed for quick encroachment analyses. An encroachment analysis was completed on the original (now georeferenced) cross section geometry, then a second on the cross-section geometry re-cut from the current terrain model. The two encroachment analyses were compared and confirms the effective Floodway extents are reasonably correct along the Kentucky River and the North Fork. When the initial Floodway was submitted (prior to becoming effective), some ethics-guided leeway is permitted when drawing Floodway boundaries between the model cross sections. This is likely the reason for the effective Floodway not reflecting the current channel alignment of Crystal Creek. The old channel alignment is still intact on FEMA flood hazard maps (see Figure 4.4).

4.10.6.2 Updating the Effective FEMA Hydrologic and Hydraulic Analyses

The effective discharges and the updated flow frequency discharges (Section 4.2) are comparable. A submitted hydrologic analysis (updated peak discharges) must change the base flood effective peak discharges by at least 5% for FEMA to consider updating the effective peak discharges published in the current FIS. The updated flow frequency analysis does not meet that criterion for the base flood (1% AEP/100-yr flood). See Table 46 below.

Table 46: Comparison of Flow Frequency Analysis and FIS Effective Discharges at Heidelberg

AEP	Return Period (Years)	Flow Frequency Analysis (2023) (cfs)	Effective Discharges (1978) (cfs)	Percent Difference
0.002	500	141,811	140,000	1.3%
0.01	100	111,842	116,000	-3.6%
0.02	50	99,337	106,000	-6.3%
0.1	10	70,604	80,200	-12.0%

The flow to stage conversion differs noticeably for the 1% AEP and 0.2% AEP flows between the effective (converted HEC-2 model) and the updated (HEC-RAS unsteady flow model for this study). The difference can be explained by the slope effect that develops when flows at Heidelberg exceed 70,000 cfs (recall Section 4.3.3.1). The updated HEC-RAS model uses the pro-rated rating curve to capture the slope effect for these higher flows, where the effective model does not. The effective model (converted from HEC-2) utilizes a known water surface elevation as the downstream boundary condition. The known water surface elevation is dictated by the adjacent Kentucky River downstream effective HEC-RAS model.

The unsteady flow HEC-RAS model produces a 1% AEP stage approximately 1.9 feet higher than the effective model. However, leveraging the unsteady HEC-RAS model to update the effective FEMA hydraulic analysis is not recommended as this would result in a higher base flood elevation, even with the lower 1% AEP discharges. Also, use of the model would not satisfy the continuity in water surface requirements with the next downstream Kentucky River model. Updating the effective hydraulic modeling would not likely yield impactful results for Beattyville and would require a significant level of effort through FEMA acceptance.

4.10.6.3 Regulatory Floodway Revision

The effective Regulatory Floodway boundaries are likely to change very little with a Floodway Revision. The converted HEC-2 model encroachment analysis indicates the effective Floodway is reasonable for the main flooding source. An update would likely only impact the Floodway alignment of the Crystal Creek, which may not yield many benefits. A Floodway Revision is not currently recommended.

5 CONCEPT ALTERNATIVES NOT SELECTED

5.1 FLOODWALLS

The flood wall alignments shown in Figure 5.1 were selected with a priority to protect as many structures as possible while also avoiding the floodway, utilities and minimizing demolition impacts of existing structures. Further explanation on the screening process of the floodwall alignments can be found in Section 3.7 of the Integrated Feasibility Report and Environmental Assessment.

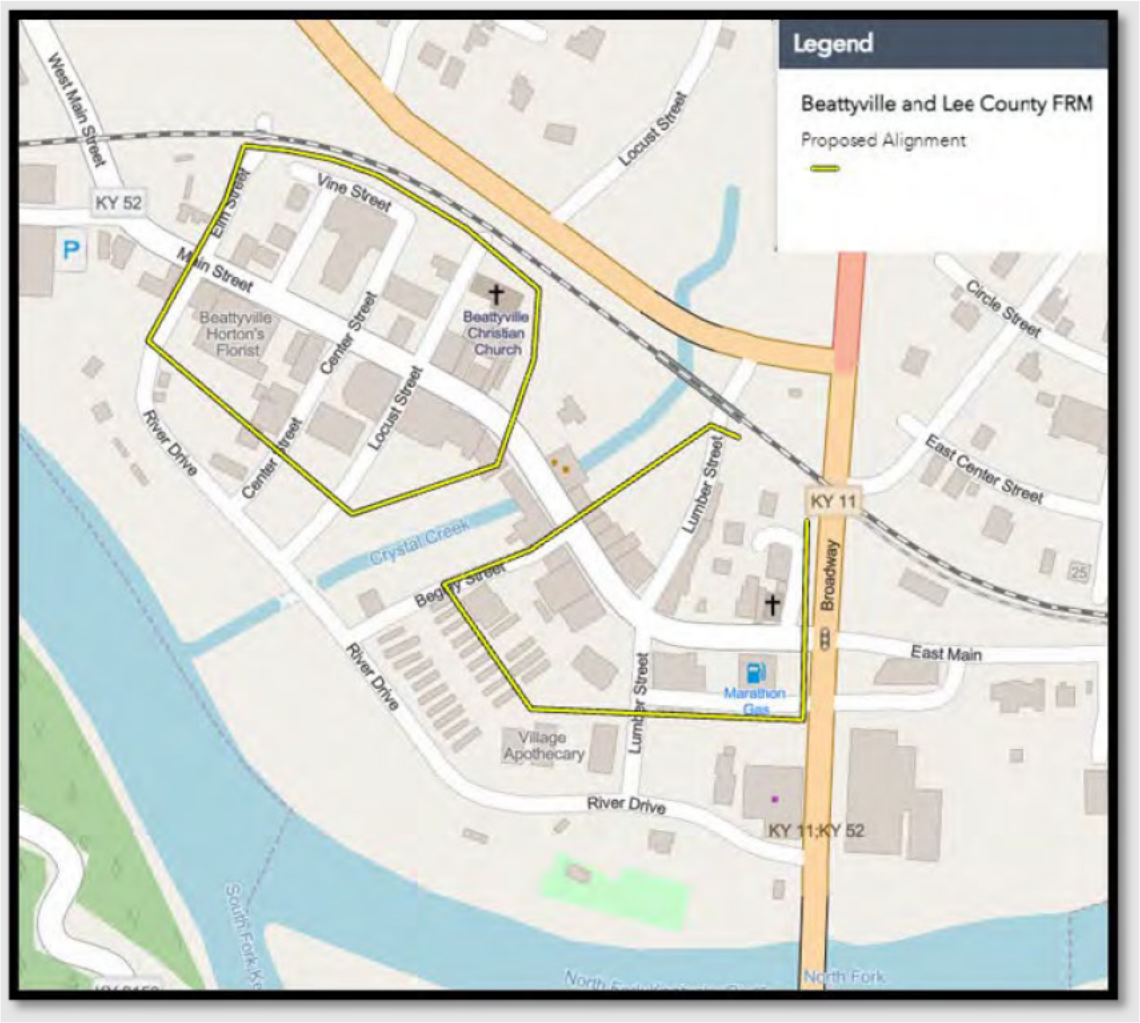


Figure 5-1: Floodwall Alignments

6 SURVEY, MAPPING AND OTHER GEOSPATIAL DATA REQUIREMENTS

6.1 OVERVIEW

Primary survey control consists of 3 semi-permanent control points set and adjusted utilizing least-squares adjustment of the primary network to achieve Second Class, First Order Horizontal accuracy (1:50,000). The 3 control points were levelled through to vertically tie them together utilizing differential levelling with a digital level with precision of 0.001 ft, achieving First Order, Class 1 Vertical Accuracy. Original elevations for the 3 primary control points were derived utilizing the National Geodetic Survey Online Position User Service (OPUS) to obtain NAD83 horizontal position and NAVD1988 elevations, then levels and adjustments were made as mentioned above. Horizontal/Vertical Positions to obtain Finished Floor Elevations and Lowest Adjacent Grade were measured utilizing a 1" Robotic Total Station from secondary control, achieving a horizontal and vertical accuracy of 0.01 ft. These secondary networks were tied back into the primary network with a horizontal accuracy of Second Class, Second Order (1:25,000) and vertical of First Order Class 1

6.1.1 Datum

- Horizontal Datum: NAD1983 (2011) SPC KY South (Zone 1602)
- Vertical Datum: NAVD1988
- Date of Survey: 03 – 28 April 2023

6.2 FIELD WORK DATA COLLECTION

Field work investigations consisted of determining the type of pavement surrounding the structure, the type of pavement (i.e., concrete, or asphalt), foundation type, construction material (vinyl siding, brick, masonry, or CMU), the number of openings at grade and the number of openings above grade. Using these metrics along with zoning data and the finished floor elevation (FFE), we were able to develop a plan of action on the best possible non-structural measure for each individual structure in our study area.

6.3 GIS DATA COLLECTION, MANAGEMENT AND DISTRIBUTION

Existing conditions geospatial data was gathered from various federal, state, and local sources. New geospatial data was developed using ESRI ArcGIS software, ArcGIS Pro. All geospatial data was compiled in a centralized ESRI geodatabase for data consistency and organization. Project geospatial data was shared among the PDT using ArcGIS Portal (see Figure 6-1), enabling collaboration, data-driven decision-making, and efficient workflows.

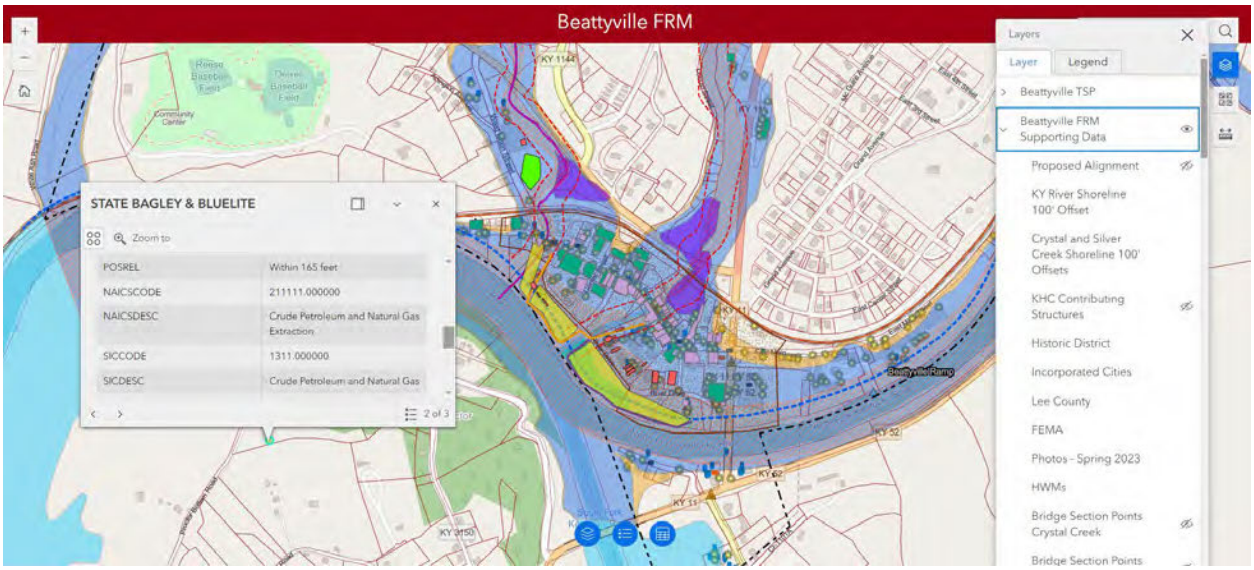


Figure 6-1: Beattyville FRM Web Mapping Application on ArcGIS Portal

7 GEOTECHNICAL

7.1 LOCAL GEOLOGY

The Kentucky Geologic map service, published by the Kentucky Geological Survey – University of Kentucky, indicates that most of the project is underlain by alluvium. The information on the geology at the project site is based on the descriptions provided on the Beattyville geologic quadrangle.

The alluvium on-site consists of silt, clay, sand, and gravel, all intergrading and intertonguing chiefly on the flood plain of the Kentucky River and its major tributaries (like the North Fork). Alluvium predominantly consists of yellowish brown clayey and sandy silt that contains lenses of light gray, very fine to fine quartz sand that commonly weathers grayish yellow. Pebbles, cobbles, and boulders of sandstone are locally common, especially in the northern one-third of the quadrangle. The formation includes older alluvium on terraces, and in abandoned meanders. Contacts are generally indistinct and are approximately located. The unit commonly grades into colluvium (not mapped) along valley walls. A veneer of alluvium may cover some terraces and parts of valleys shown as bedrock (small outcrops of bedrock surrounded by alluvium not mapped).

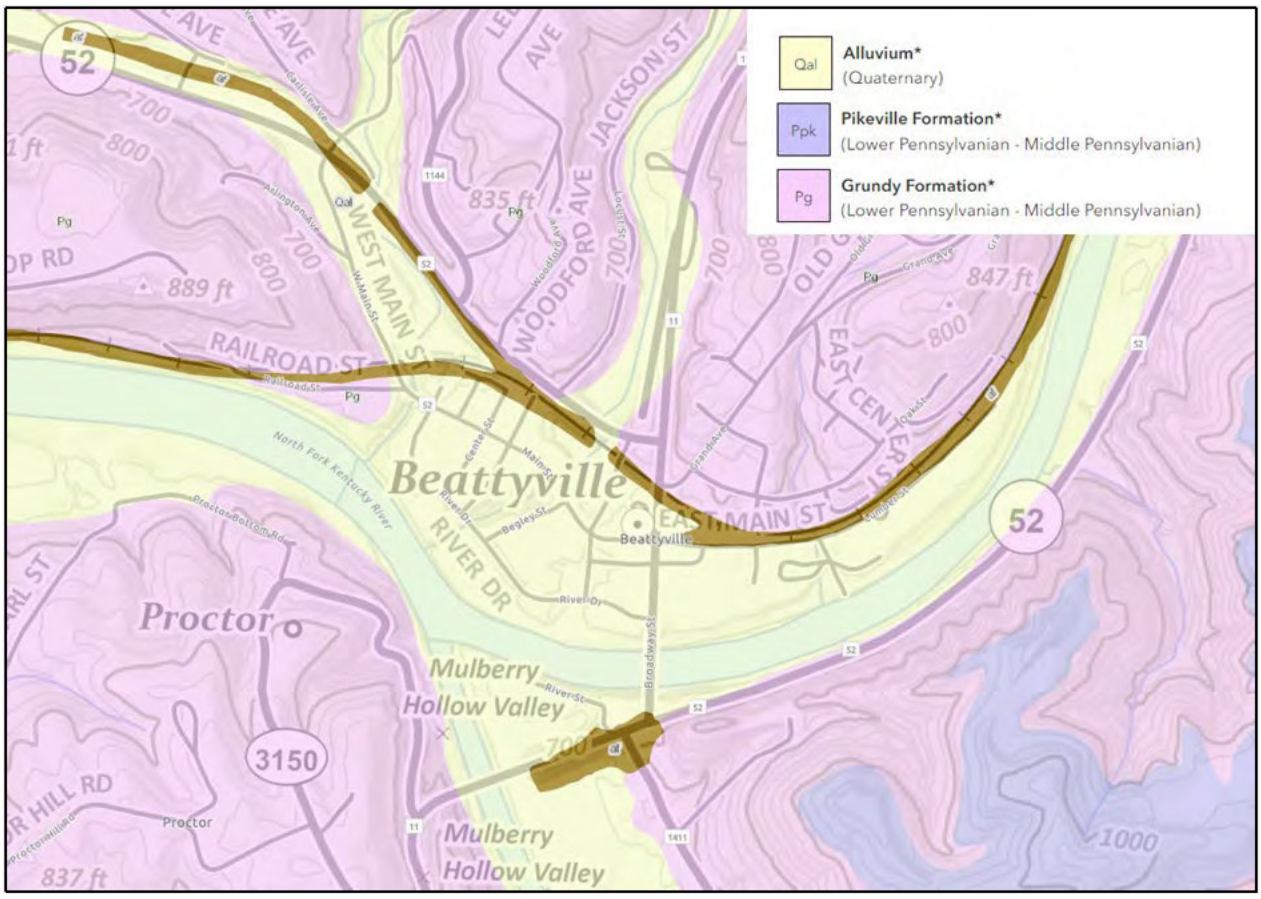


Figure 7-1: Local Geology of Beattyville (Source - UKY KGS website)

The Grundy Formation of the Breathitt Group is expected below the alluvium. The Grundy Formation consists of siltstone (30 to 50 percent), shale (30 to 50 percent), sandstone (10 to 30 percent), coal, and underclay.

The project site is in an area of Kentucky where the mining of coal can impact development. Surface mines have resulted in mountain top removal, as well as the filling of valleys, while the underground mining of coal has resulted in mines that have caused surface subsidence or otherwise impacted construction. The Gray Hawk coal zone contains two coal beds about 20 to 30 feet apart. The upper bed is traceable into the Gray Hawk coal bed of the Heidelberg and Sturgeon quadrangles. It is persistent and generally more than 12 inches thick. The lower bed is sporadic and is generally less than 12 inches thick. The upper bed of the Gray Hawk coal zone is probably the same as Lee No. 3 coal bed, the Barren Fork coal bed, and Travelers Rest coal bed. The Beattyville coal zone contains two coal beds about 10 to 25 feet apart. The upper coal bed is much more persistent and generally thicker than the lower. This upper bed is probably the same as Tattlers coal bed (Weir and Mumma, 1973), Lee No. 2 coal bed (Miller, 1910), and Hudson coal bed (Lyons, 1963). The Contrary coal bed on the Right Fork of Contrary Creek is projected from exposures in the adjoining Heidelberg quadrangle (Black, 1977). The strata below the Corbin Sandstone Member of the Lee Formation were named Beattyville Shale Member of Lee Formation by Miller (1917); but as noted by Weir (1973), these strata are not lithologically separable from Breathitt Formation.

Artificial fill is mapped along the rail alignments and generally follows the interface of the Grundy Formation and the alluvium in the Beattyville area.

7.2 GEOTECHNICAL CONSIDERATIONS/HAZARDS

The geotechnical considerations/hazards listed below were identified as the most likely to increase remediation costs and impact non-structural measure approaches, design, and cost.

7.2.1 Existing Fill

As indicated on the geologic maps, fill was placed for the railroad; however, to provide more area for development, fill is also often placed in roadways and in areas that are lower in elevation that are more prone to flooding. This fill may consist of materials dredged from the nearby river(s). Other sources of fill material include construction debris, waste materials generated by nearby manufacturing, and/or soils generated from nearby earthwork projects (i.e., rock cuts from highway projects, benching hillsides). In areas where coal mines are present, mine spoils are often a source of readily available fill material depending on the proximity of the mine to the town. Existing fill often is not placed in a controlled manner, resulting in elevated risks and increase design and construction costs.

Existing fill tends to be poor quality and irregular in content and quality. Often existing fill contains debris that can be difficult to penetrate. Depending on the depth of the existing fill, existing fill could be undercut and either replaced with controlled fill or foundations extended to suitable soils. If the fill extends too deep and undercutting is not feasible, deep foundation systems may be required. The presence of the existing fill must be considered and could significantly impact the design and implementation of the non-structural measures and other planned improvements. In addition, the presence of the existing fill may create a preferential seepage path that may impact slabs-on-grade in structures to be dry floodproofed.

It was reported by Beattyville officials that fill has been placed in areas between River Drive and the Kentucky River. The fill reportedly consisted of excess materials that were deposited during flood events (clays, silts, and sands). As the deposits were removed during flood clean-up, the materials were placed between River Drive and the Kentucky River as a disposal site. Additionally, fill was placed in the southern portion of Beattyville, generally north of River Drive, when Crystal Creek was re-routed. Based on available USGS topographic maps and aerial photography, Crystal Creek was re-routed to the south between 1961 and 1995. The former alignment of Crystal Creek flowed from the northeast to the southwest until it passed under Main Street. Crystal Creek then flowed generally west through the current location of several parking lots north of River Drive until it emptied into the Kentucky River at the same location as Silver Creek. The new alignment for Crystal Creek continued to the southwest after it passed under Main Street, passing under River Drive, and emptying into the Kentucky River approximately 625 feet south of the former exit with Silver Creek. Figure 7-2 and Figure 7-3 show both the general area of mass fill placement between River Drive and the Kentucky River and the former/current Crystal Creek Alignment.

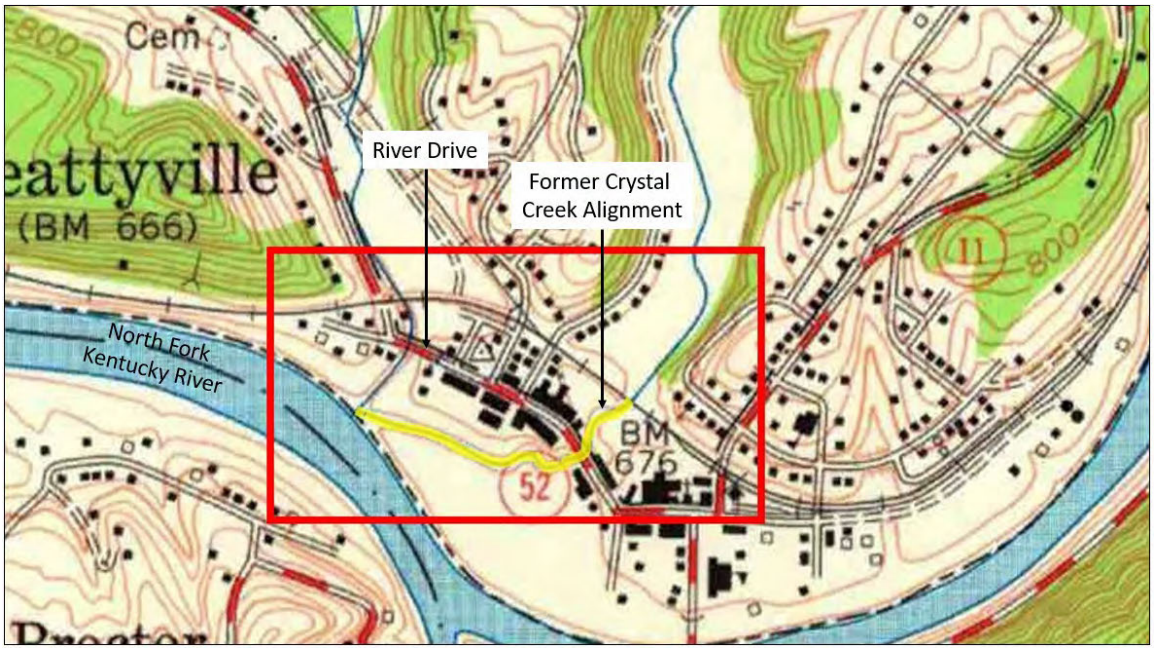


Figure 7-2: Former Crystal Creek Alignment (USGS Beattyville Topographic Map, 1961)

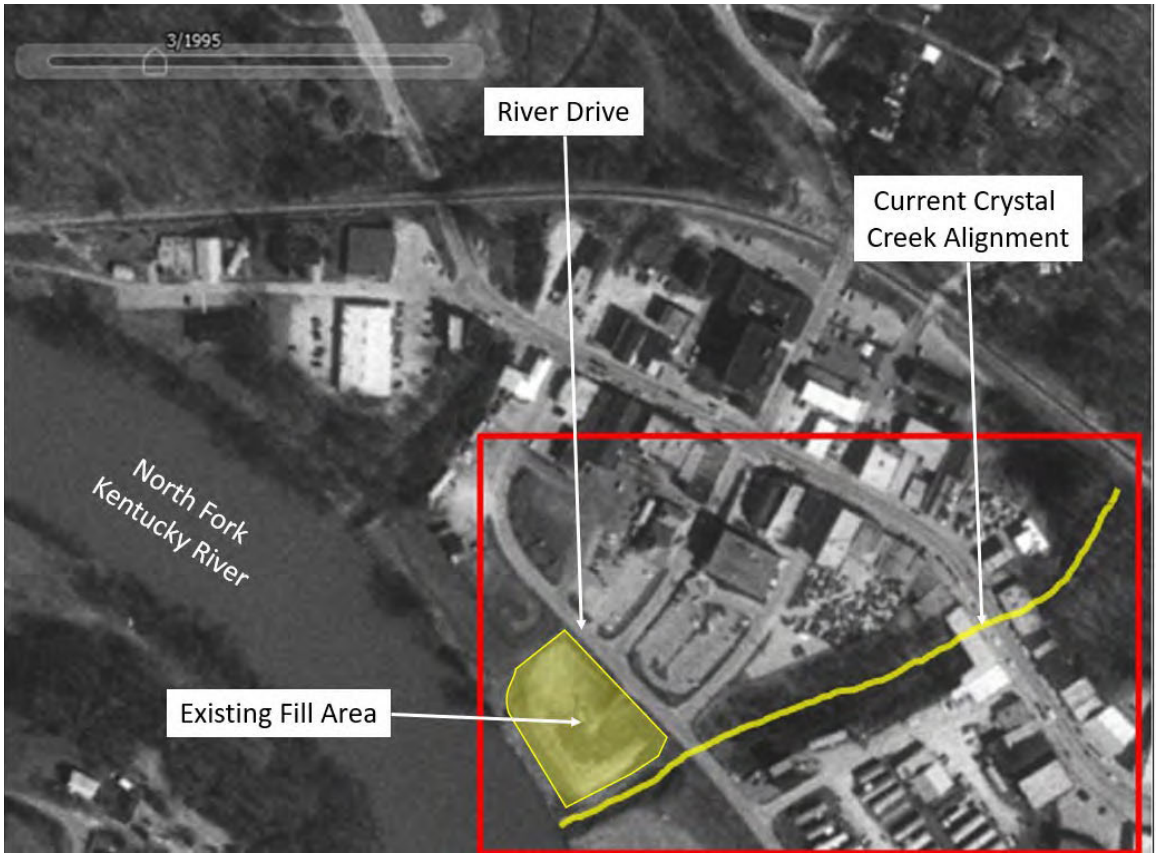


Figure 7-3: Current Crystal Creek Alignment and Existing Fill Area (Google Earth Aerial Photograph, 1995)

Available Sanborn fire insurance maps indicated that a sawmill and lumber yard and coal company (Day Lumber and Coal Company) were present to the east of Broadway and south of East Main Street until at least 1921. In the 1914 Sanborn map, there was a waste conveyor leading to a sawdust and refuse burner on the eastern portion of the property. In the 1908 map, this area was labeled as “Hell Dump” for sawdust and refuse. On the map, the area was an irregular shaped area that was approximately 110 feet by 60 feet. The location and size of the dump/burn area should be considered approximate. Often materials from former dump sites are still present, and the extents may be much larger than was mapped. The presence and location of these fill materials should be considered for any planned improvements or alterations in that area.

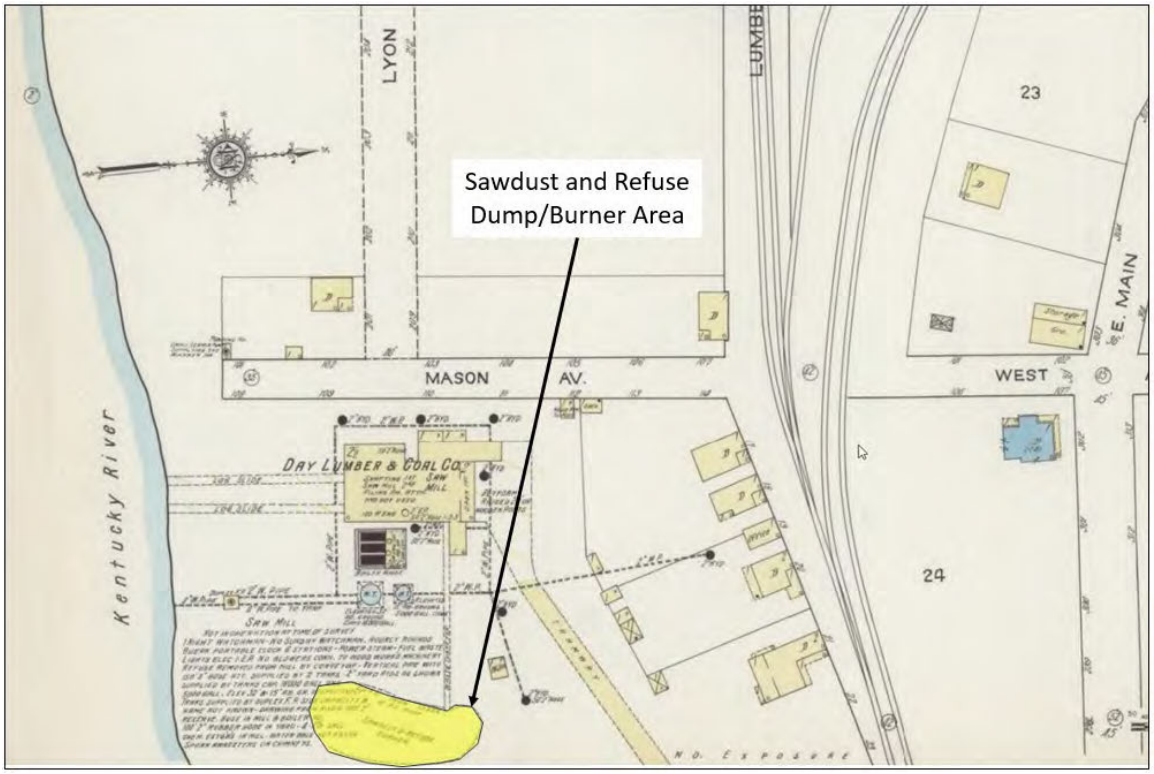


Figure 7-4: Approximate Location of Sawdust and Refuse Burner (Sanborn Map, 1914)

7.2.2 Soft Soils

As indicated on the geologic maps, alluvium is present across most of the project area. Soft soils are typically associated with alluvial deposition and can create a concern with new foundations or additional loading to existing foundations. Isolated undercut and replacement of soft soils and/or deep foundation systems may be required to address soft alluvial soils.

7.3 Future Exploration(s)

The tentatively selected plan will consist of an array of floodproofing measures throughout Beattyville. The measures planned primarily consist of dry floodproofing existing structures with a lesser number of structures being raised-in-place and wet floodproofed. Buildings that are not

structurally suitable for floodproofing and/or buildings within the floodway will be acquired and removed.

The bearing conditions and soils, foundation systems, and conditions under the floor slab must be evaluated for each building where dry floodproofing is planned. The exploration for each building will likely consist of a series of test pits and borings around the perimeter of the building with some form of limited exploration likely consisting of hand auger borings and/or test pits within or adjacent to the building. It is critical to understand the subsurface conditions (underlying soil types and soil strength) and the building construction (foundation size and bearing depth) to evaluate if dry floodproofing is feasible for the building; and if dry floodproofing is possible, to properly design a dry floodproofing system that will be effective for each structure. The exploration should be sensitive to identifying soils or materials that are present that would be susceptible to allowing seepage under the building foundations or any other conditions that would need to be addressed during design and construction of the selected dry floodproofing system (such as existing fill or soft soil).

8 ENVIRONMENTAL ENGINEERING

An Environmental Assessment (EA) is being developed to identify the likely environmental effects of a proposed project and its reasonable alternatives. Environmental effects analyzed include ecological, aesthetic, historic, cultural, economic, social, and human health. Impacts to the environment were considered throughout the feasibility planning phase and reduced to the extent practicable for all alternatives. The EA will outline compliance with all applicable environmental laws and regulations for implementation of the Tentatively Selected Plan.

9 CIVIL DESIGN

9.1 NONSTRUCTURAL

Data collection for the Tentatively Selected Plan was gathered through field investigations consisting of survey and fieldwork investigations. Details into the data collection regarding survey can be found in Section 6.2 Field Work Data Collection of this report.

Nonstructural measures are designed to reduce or avoid flood damages without directly controlling riverine waters; they are not designed to reduce or eliminate flood heights.

USACE divided the structures within Beattyville into two categories: Historic and Essential. An example of a Historic structure may be an old church. An example of an Essential structure may be a grocery store.

Within the Historic designation, there is one structure to be dry floodproofed. See Section 9.1.1 for more information on Dry floodproofing structures. 23 structures are to be wet floodproofed. See Section 9.1.2 for more information on Wet floodproofing structures. One structure is to be raised in place. See Section 9.1.3 for more information regarding raising a structure in place. Four structures under the Historic designation have been deemed “no action” meaning they will be left alone. See Figure 9-1: Historic Structures for an overview of the above breakdown.

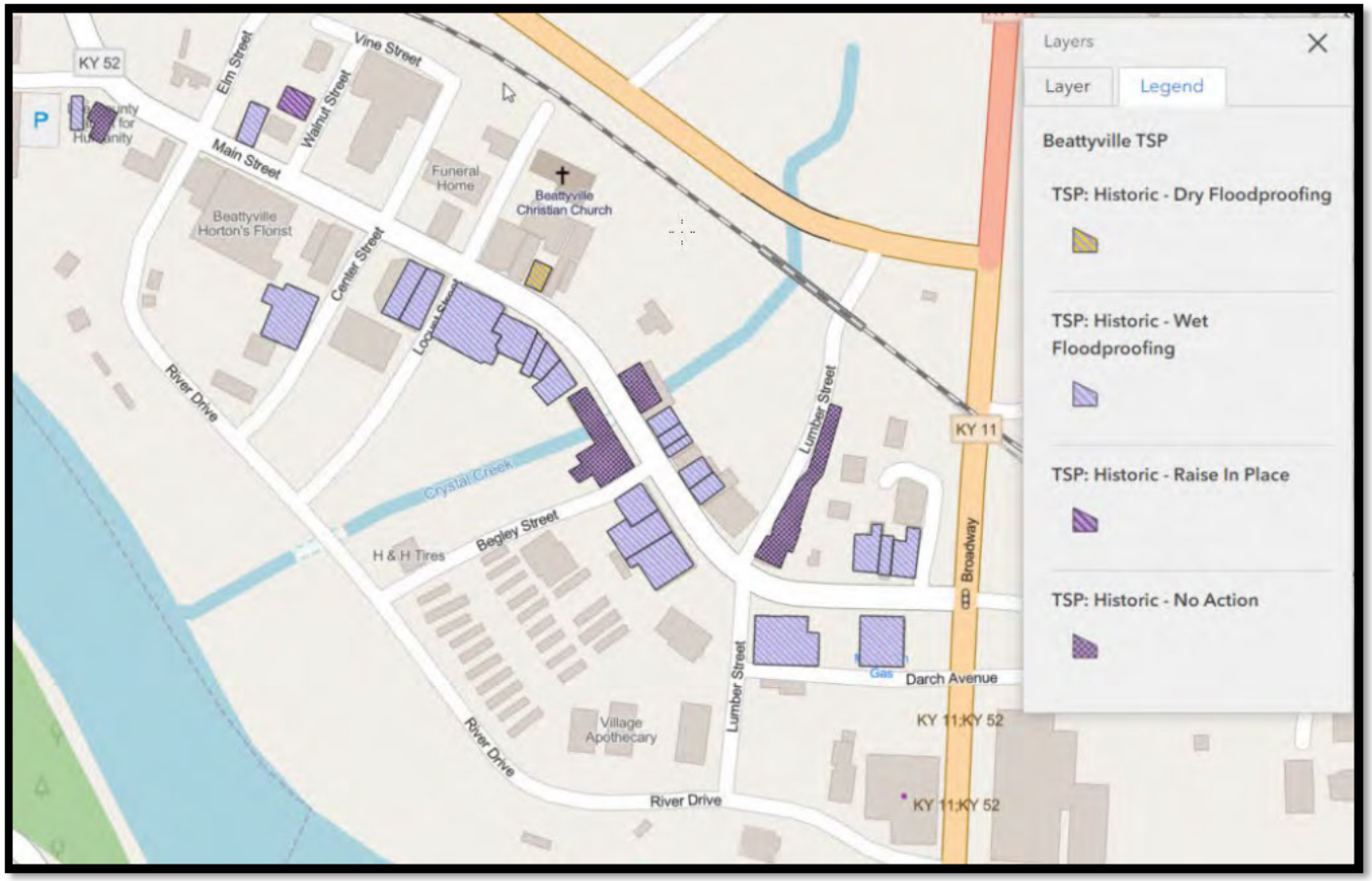


Figure 9-1: Historic Structures

Within the Essential designation, there are eight structures to be Dry floodproofed. See Section 9.1.1 for more information on Dry floodproofing structures. Seven structures are to be wet floodproofed. See Section 9.1.2 for more information on Wet floodproofing structures. No structures have been determined to be raised in place. One structure under the Essential designation have been deemed “no action” meaning it will be left alone. See Figure 9-2: Essential Structures for an overview of the above breakdown.

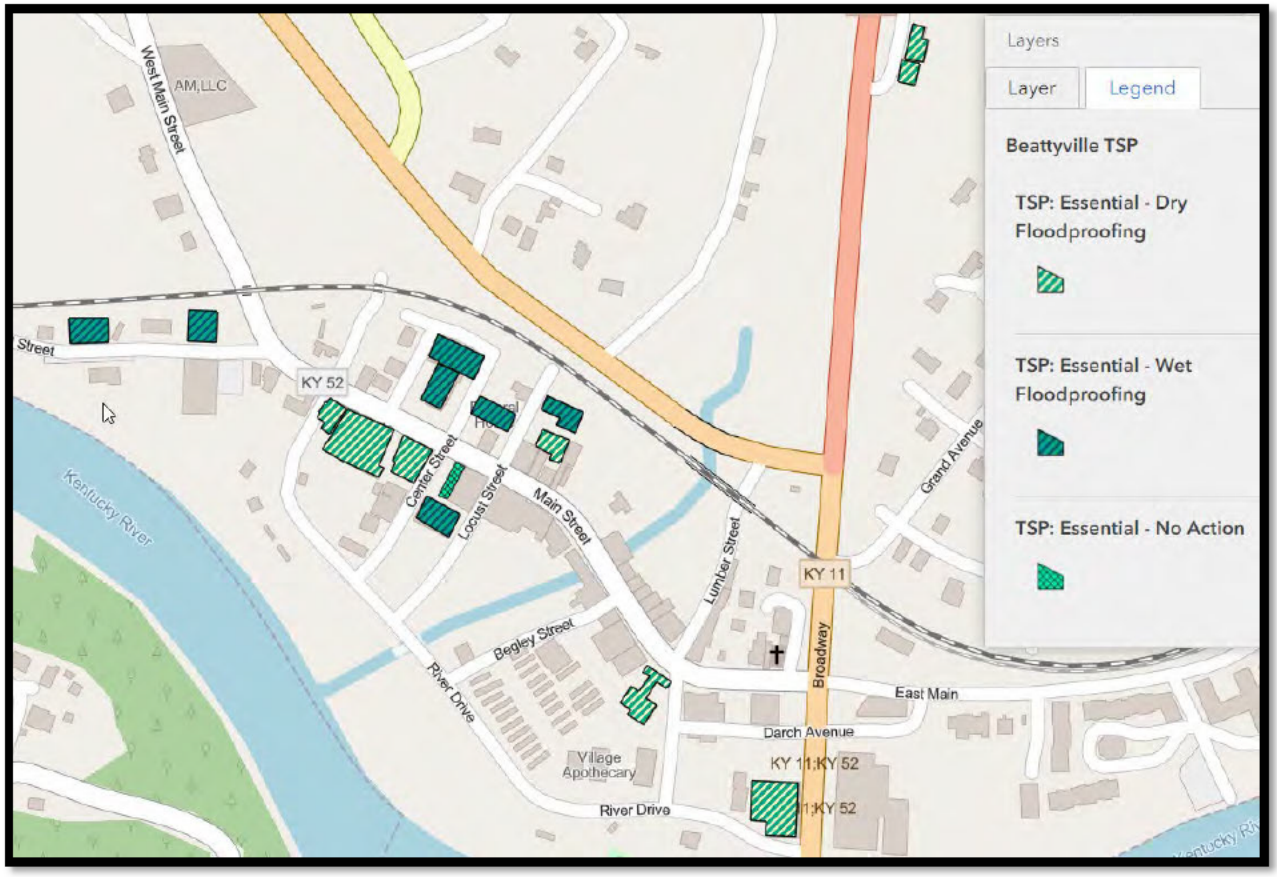


Figure 9-2: Essential Structures

While each eligible structure will be evaluated for the most cost-effective nonstructural measure, the federal government reserves the right to determine which measure shall be implemented for each structure.

After the Agency Decision Milestone, we will develop diagrams for each structure category to show what type of work is covered and what type of work isn't covered. The diagrams will be made for each structure type. Types may be Historic structures, wet floodproofing structures, dry floodproofing structures that are stick build, dry floodproofing structures that are CMU, and raising in place residential structures.

9.1.1 Dry Floodproofing

Dry Floodproofing is a measure primarily designed to prevent water from entering a structure up to the maximum allowable height. Structures zoned as Commercial are eligible while residential structures are not. Examples of dry floodproofing providing permanent and temporary water-tight covers for all openings; and constructing veneer walls around structures. Dry floodproofing occurs at each structure's finished floor elevation (FFE) and protects 3 ft. as a typical standard (see Figure 9-3: Dry Floodproofing Depiction). Dry flood proofing may extend up to the design flood elevation but is not required to. The height of the dry floodproofing will in most cases be limited by the structures ability to resist the forces of the floodwaters.

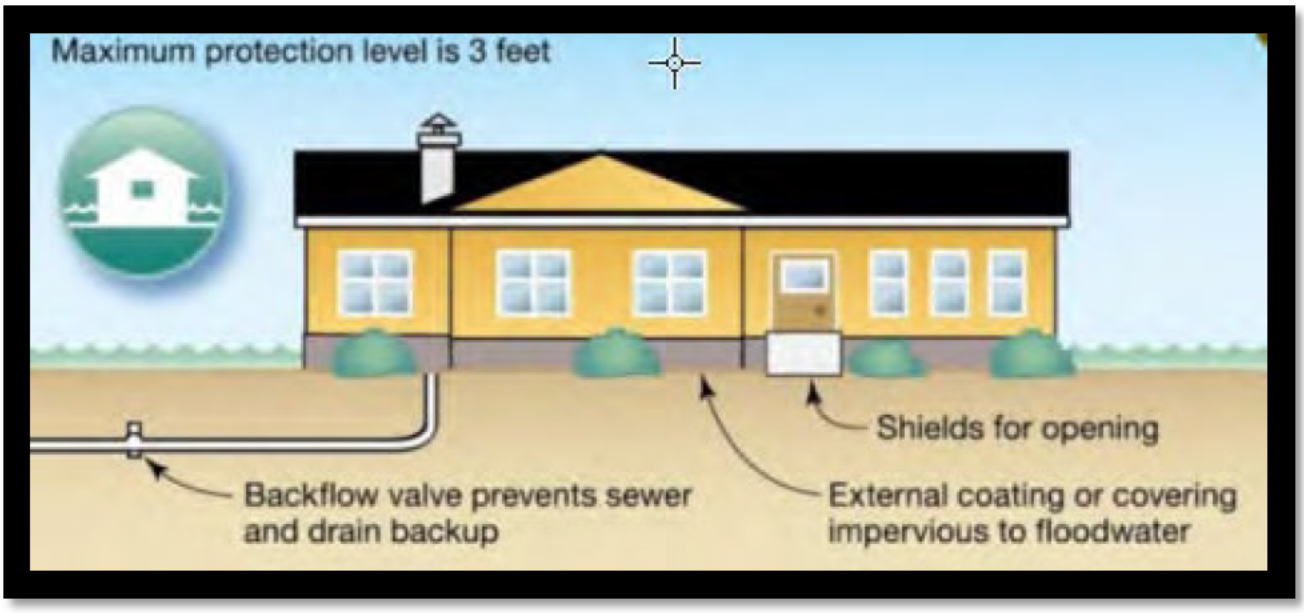


Figure 9-3: Dry Floodproofing Depiction

Dry floodproofing may include the use of one or more of the following methods: waterproof membranes or sealants to reduce seepage of floodwater through walls; watertight shields for doors and windows; and/or installing measures to prevent sewer backup. Common floodproofing measures include:

- Backflow valves
- Temporary or permanent closures on doors, windows, stairwells, and/or vents
- Rearranging or protecting damageable property, including relocating, or raising utilities
- Sump pumps, sub-drains, and floor drains
- Water resistant material, including waterproof adhesives and sealants

9.1.2 Wet Floodproofing

Wet floodproofing is a measure taken by raising all utilities above the design flood elevation. Structures zoned as Commercial or Residential are eligible. All construction materials and finishing materials need to be water resilient that are installed below the design flood elevation. (See Figure 9-4: Wet Floodproofing Depiction).

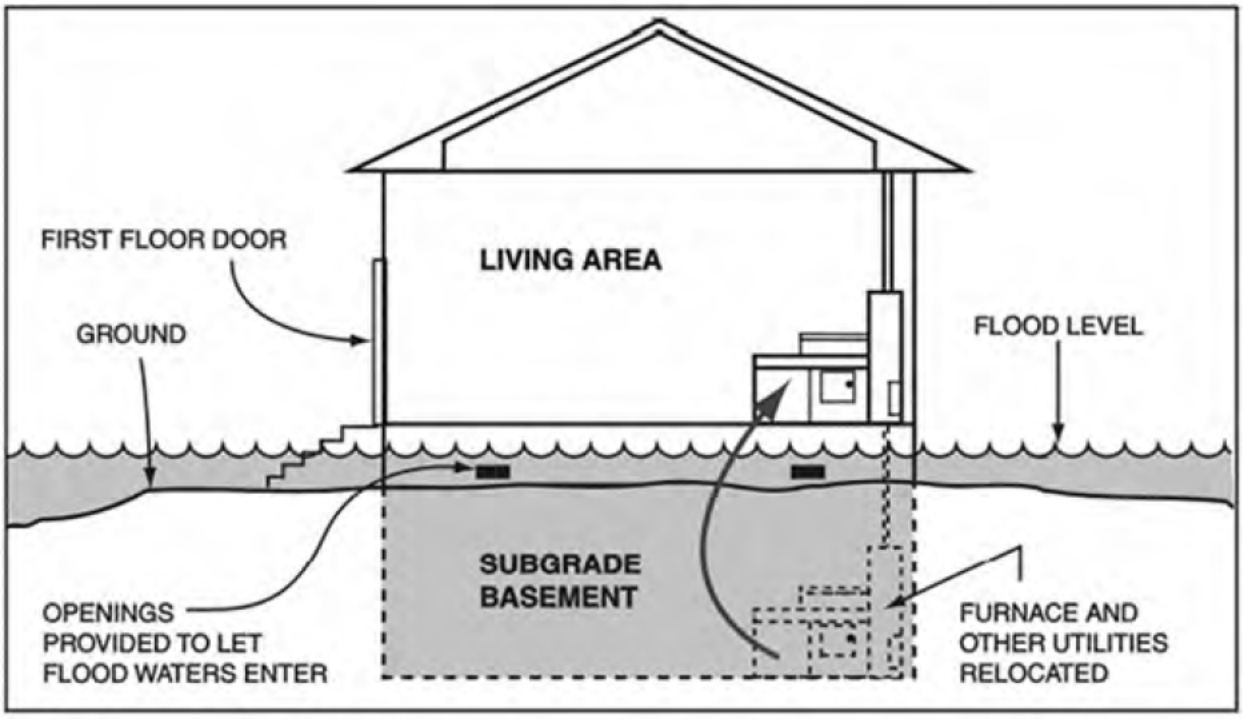


Figure 9-4: Wet Floodproofing Depiction

9.1.3 Raising Structure in Place

Raising a structure in place is done by elevating a structure's contents above flood heights and allowing it to flood. Only structures zoned as Residential are eligible to be raised. Raising a structure creates a "basement area" that is designed to allow intentional flooding to equalize hydrostatic pressures. Structures are to be raised to the Design Flood Elevation, discussed in Section 2.2 Design Flood Elevation (DFE). Ultimately, the Design Flood Elevation will be determined by the Beattyville. If the DFE differs from the BFE at any point before the study is implemented, USACE will update the allowable height a structure may be raised. The entire foundation of the structure will be lifted and placed on a new foundation (i.e., columns, piers, posted or raised foundation walls) so that the lowest habitable finished floor is at or above the design flood elevation. All utilities and mechanical equipment, including air conditioners and water heaters, will also be raised to the required elevation. Flood vents will be installed, as appropriate, on elevated structures, as well as structures for which the first floor is already above the design flood elevation but lack appropriate flood venting. This area must be kept free of items that could be damaged during a flood. Raising a structure in place to an elevation which is at least equal to the design flood elevation. The final elevation should place the first floor and associated ductwork, plumbing, mechanical and electrical systems above the design flood elevation.

9.2 FWEEP

Flood warning and preparedness planning (FWEEP) relies upon stream gages, rain gages, and hydrologic computer modeling to determine the impacts of flooding for areas of potential flood risk. A flood warning system, when properly installed and calibrated, can identify the amount of time available for residents to implement emergency measures to protect valuables or to evacuate the area during serious flood events. Local officials are encouraged to develop and maintain a flood emergency action plan (EAP) that identifies hazards, risks, and vulnerabilities, and

encourages the development of local flood risk mitigation. The EAP should include the community's response to flooding, location of evacuation centers, evacuation routes, and flood recovery processes.

9.3 CONSTRUCTION LAYDOWN

Construction laydown is expected for this project. Potential laydown area at the corner of Begley Street and River drive. Construction laydown will ultimately be coordinated with Beattyville during the Design and Implementation phase of this project to minimize the disturbance to the town.

9.4 RECREATION AND ECOSYSTEM RESTORATION

Recreational additions have been incorporated into the plan. A playground location with approximately 20 parking spaces and two options for concrete surfaced multipurpose trails. Ecosystem recreation including native grasses, shrubbery and trees will be incorporated. See Figure 9-5 for the proposed locations of these items.

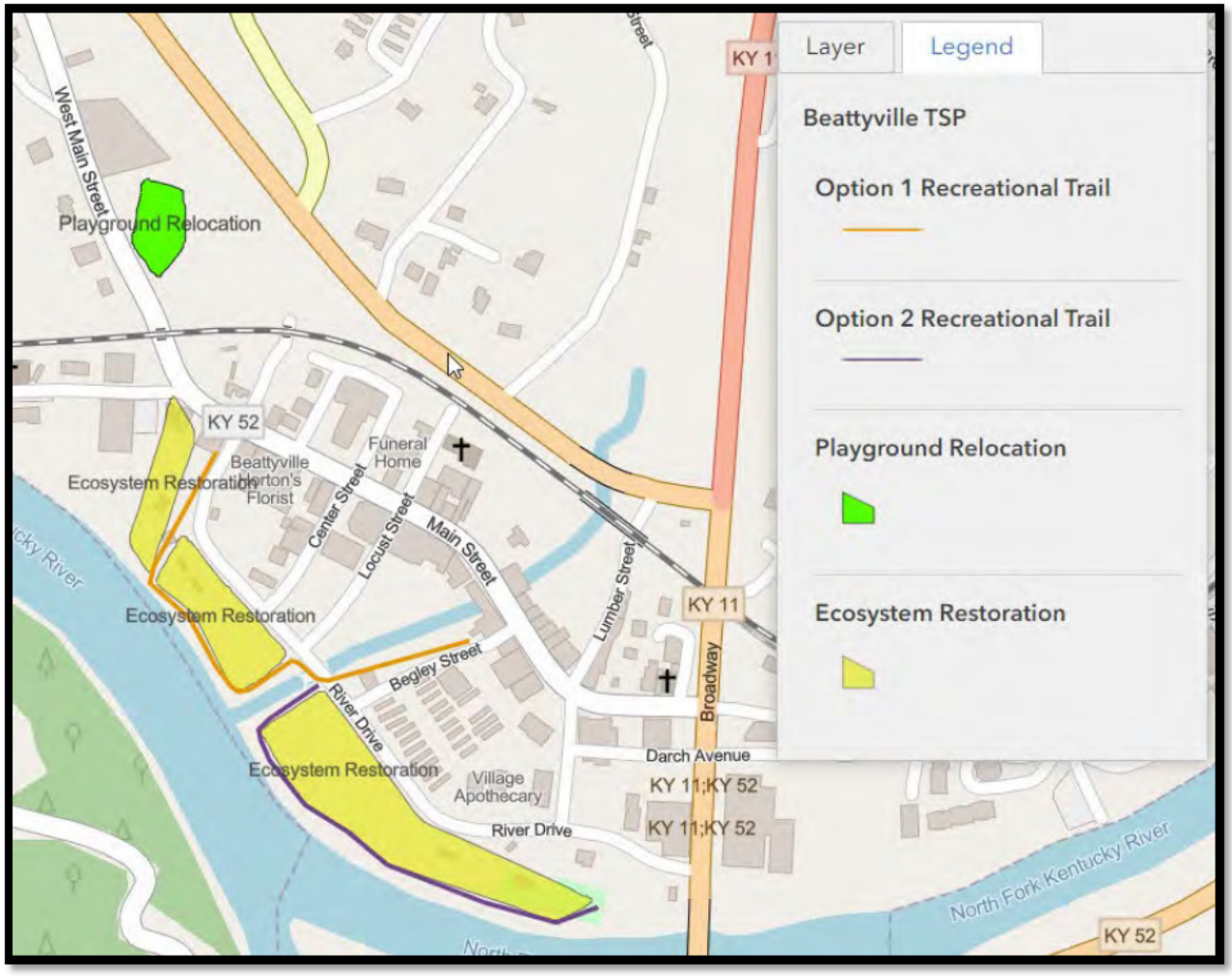


Figure 9-5: Recreational and Ecosystem Restoration Area

10 HAZARDOUS AND TOXIC MATERIALS

A search of applicable federal databases revealed the following hazardous, toxic, radioactive waste (HTRW) resources within their individual search radii around the project area; no National Priority List (NPL) sites, no Proposed NPL sites, No Delisted NPL sites, no comprehensive environmental response compensation, and liability information system (CERCLIS) sites, no CERCLIS no further remedial action planned (NFRAP) sites, no corrective action sites, no resource conservation and recovery act (RCRA) treatment, storage, and disposal facilities (TSDF), two RCRA very small quantity generators, one used oil program hazardous waste generator, 7 RCRA hazardous waste facilities, and no federal institutional controls.

A search of applicable state databased and open records requests (ORR) revealed the following HTRW resources within their individual search radii around the project area; five Kentucky Department of Environmental Quality (KDEP) Superfund sites, no KDEP Institutional Controls, No KDEP Environmental Covenant Sites, no KDEP Voluntary Remediation Program sites, one KDEP brownfield site, and 48 underground storage tanks sites.

According to the Kentucky Department of Environmental Quality (KDEP) underground storage tank (UST) statewide report, the following resources are in proximity to the project area: 3 active UST's, 24 storage tanks that were removed, ten active leaking underground storage tanks (LUST), 3 closed LUSTs, 5 duplicate LUSTs, and 3 LUSTs that were removed.

There is a high likelihood of lead-based paint and asbestos within the structures found in proximity to the project area. A Phase I Environmental Site Assessment will need to be performed for any property that will be acquired for project purposes to determine the potential presence of HTRWs. Appropriate measures will be taken to properly handle and dispose of HTRWs encountered.

11 ENVIRONMENTAL OBJECTIVES AND REQUIREMENTS

An EA is being developed with the feasibility report to determine compliance with all applicable environmental laws and regulations.

12 OPERATIONS AND MAINTENANCE

Structures acquired by the Lee County, along with recreational facilities and ecosystem features, are to be maintained in perpetuity.
Occupants in structures that have been floodproofed will be responsible for maintaining the integrity of the floodproofing and securing all enclosures when a flood event is forecast.

13 COST ESTIMATES

13.1 COST DETERMINATION

Using the metrics described in Section 13.1 Cost Determination of this Appendix, a cost estimate was developed providing quantities throughout the study area. See Appendix C for a detailed description of the cost estimate for this Study.

14 CLIMATE ASSESSMENT

See Appendix H for the Climate Assessment.

15 SCHEDULE FOR DESIGN AND CONSTRUCTION

15.1 ELIGIBILITY

The USACE and Non-Federal Sponsor will require additional structure-specific analysis during design to determine final eligibility, which could result in structures being removed and/or additional structures being added prior to implementation. Design of specific floodproofing on a structure-to-structure basis will rely on a third-party contractor.

15.1.1 Type 1 (Acquisition)

All structures in the project area in the floodway and structures that have been deemed structurally unsound, regarding their ability to be floodproofed (13 structures), are to be acquired.

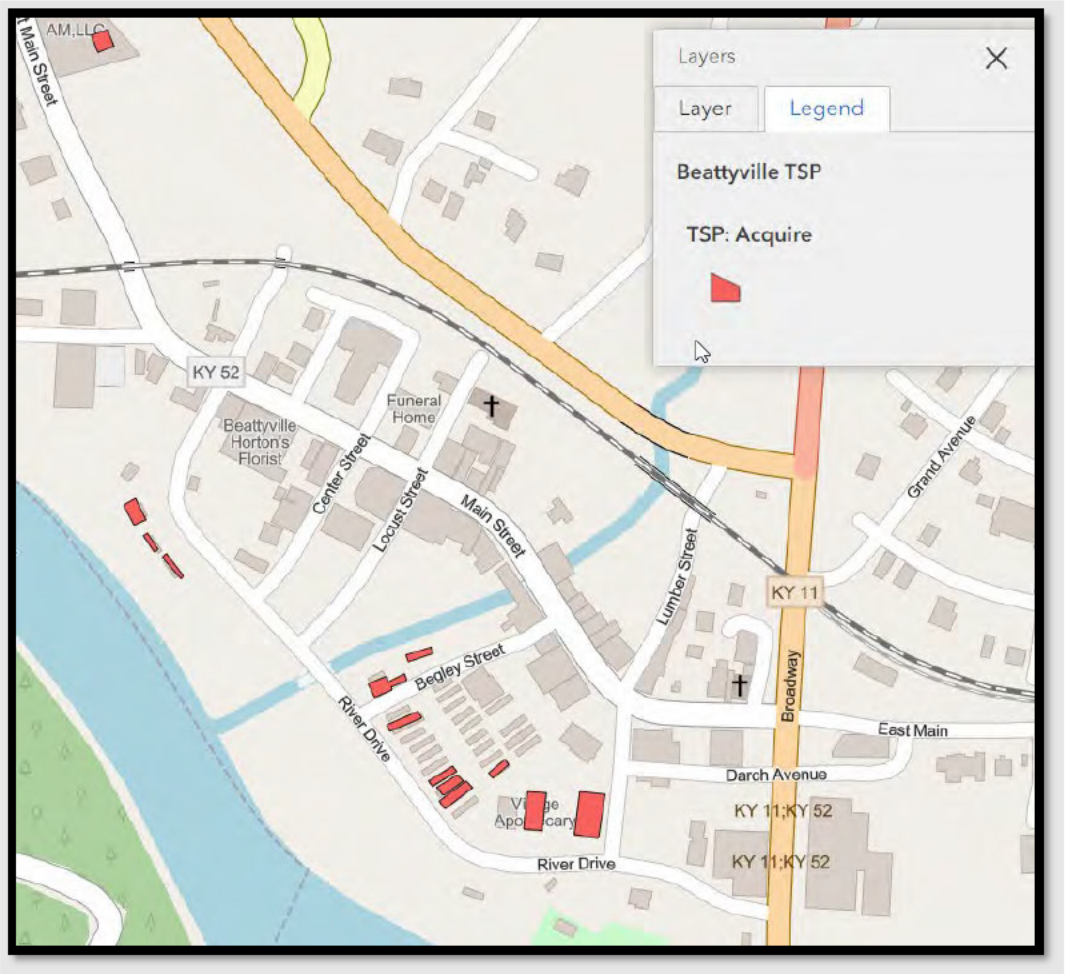


Figure 15-1: Type 1 Structures

15.1.2 Type 2 (Raise In-Place)

All structures in the project area zoned as “residential” are to be raised in place (1 structure).

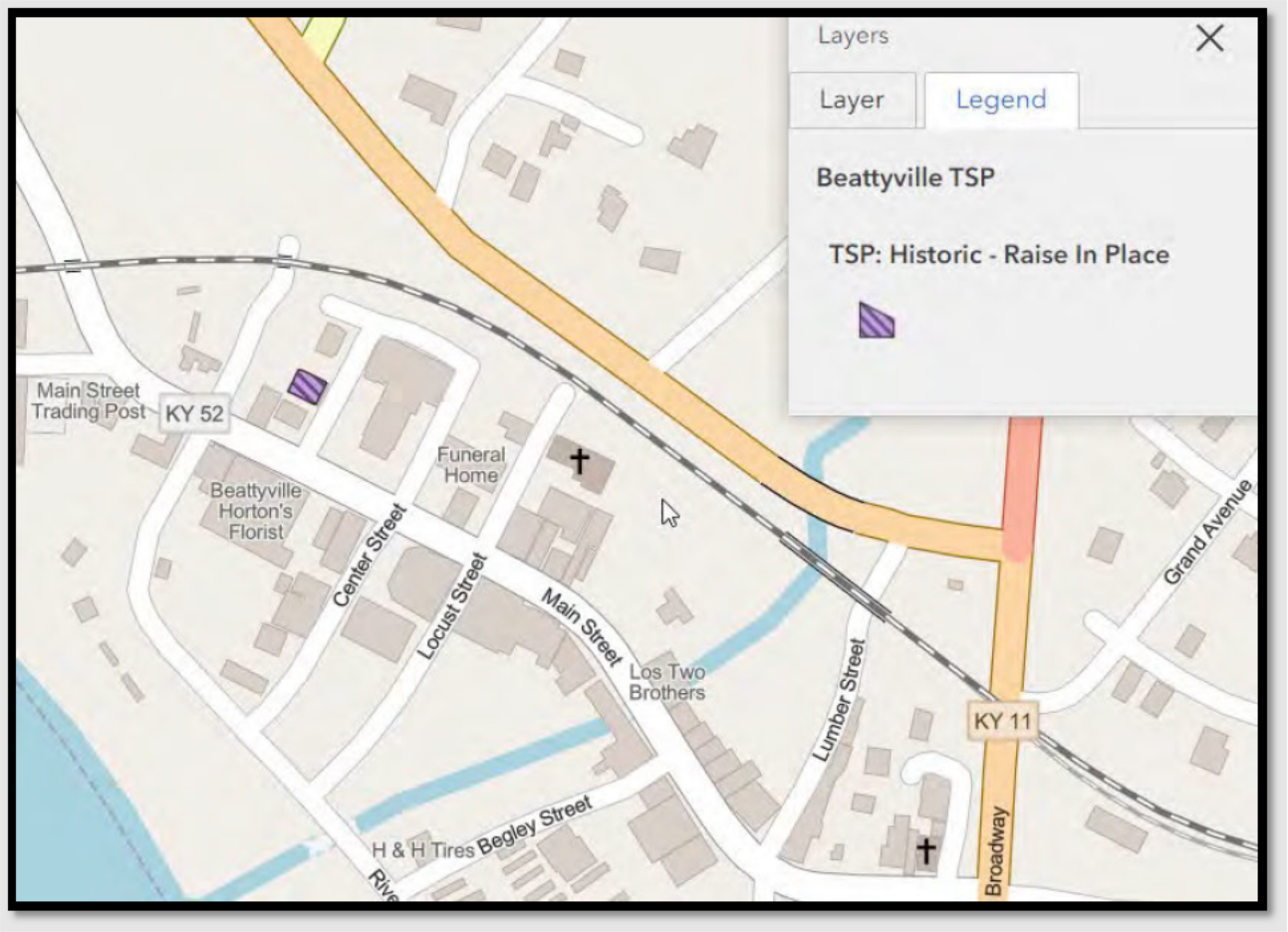


Figure 15-2: Type 2 Structures

15.1.3 Type 3 (Floodproofing)

All remaining structures in project area zoned "commercial" are to be dry floodproofed (9 structures) or wet floodproofed (30 structures).

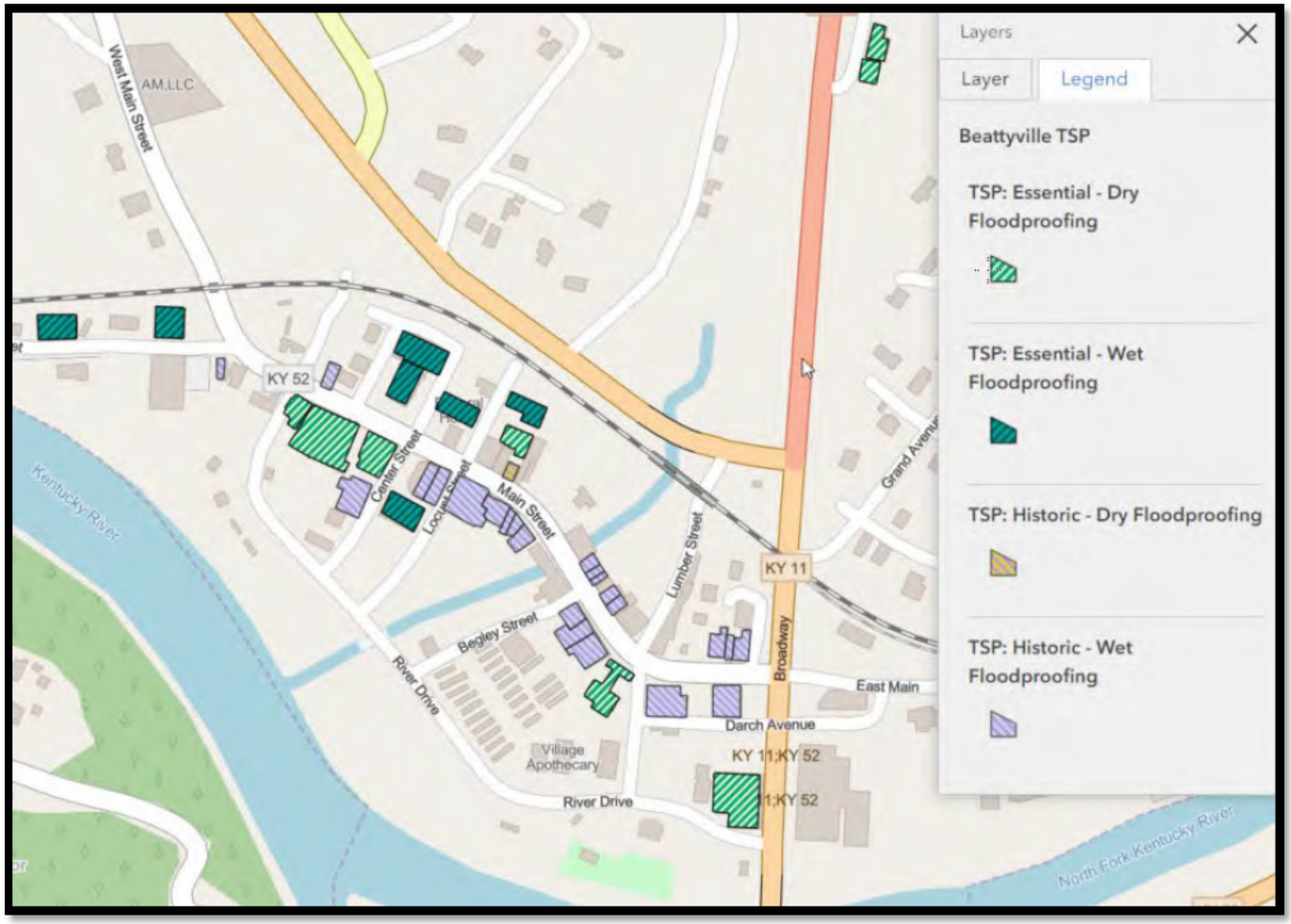


Figure 15-3: Type 3 Structures

16 REFERENCES

16.1 DATA

Digital Elevation Model:

- KY From Above: KY Aerial Photography & Elevation Data Program (KYAPED), 2017. https://kyfromabove.ky.gov/
- Land Use Data:
- NLCD 2019 Land Cover (CONUS). Accessed February 2023.
- https://www.mrlc.gov/data/nlcd-2019-land-cover-conus

16.2 SOFTWARE

- Environmental Systems Research Institute Inc (ESRI), ArcGIS Pro Software: http://www.esri.com/
- HEC-HMS, Version 4.10 Software: https://www.hec.usace.army.mil

- HEC-HMS, Version 4.11 Software: https://www.hec.usace.army.mil
- HEC-RAS, Version 6.3.1 Software: https://www.hec.usace.army.mil
- HEC-RAS, Version 6.4.1 Software: https://www.hec.usace.army.mil

HEC-SSP, Version 2.2 Software: https://www.hec.usace.army.mil

16.3 Reports, Manuals, and Bulletins

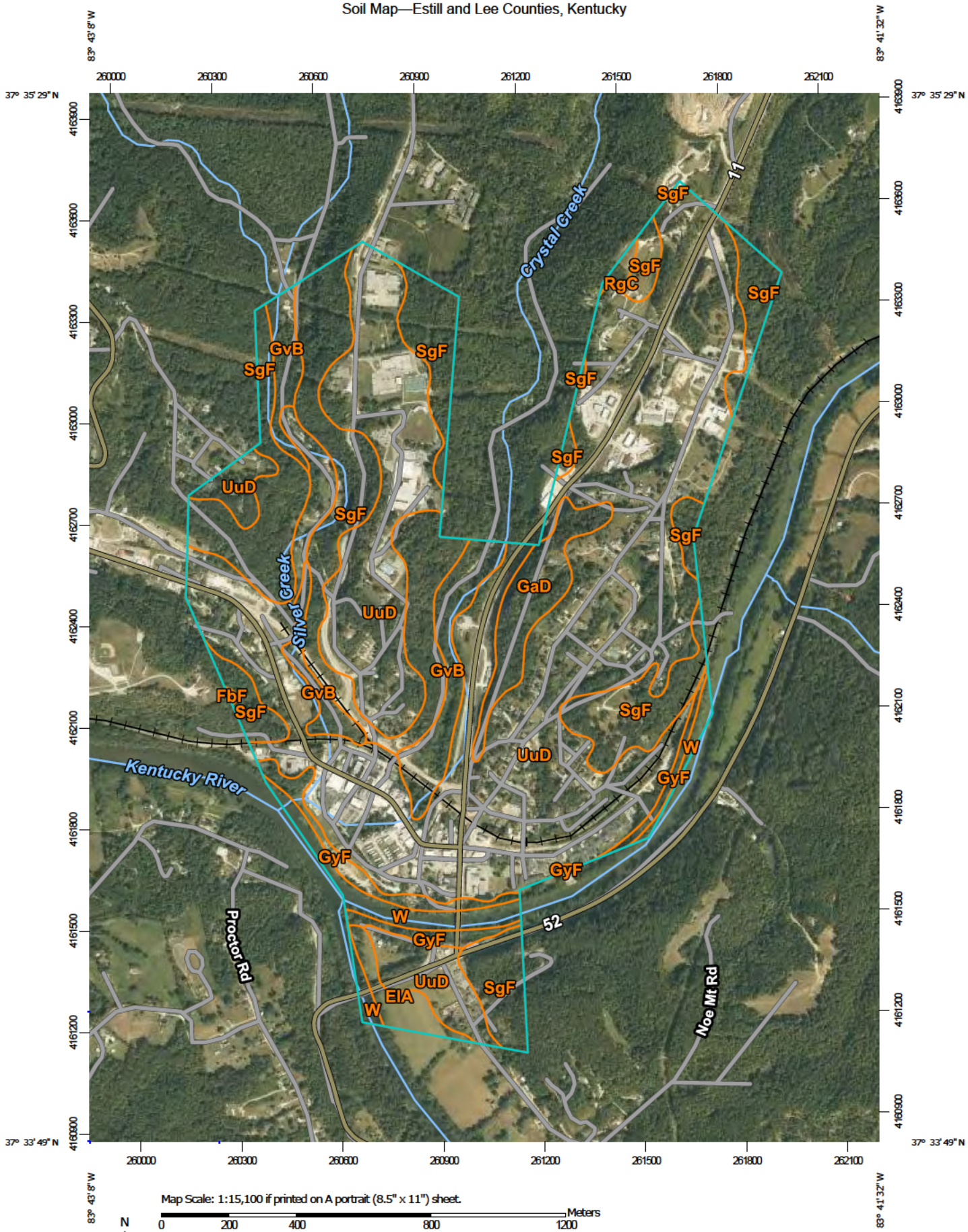
- E.C.B. 2019-8. Engineering and Construction Bulletin. “Managed Overtopping of Levee Systems.” Department of the Army, (24 April 2019) US Army Corps of Engineers, Washington, DC.
- E.M. 1110-2-1619. Engineering Manual. Engineering and Design: “Risk-Based Analysis for Flood Damage Reduction Studies.” Department of the Army, (1 August 1996), US Army Corps of Engineers, Washington, DC.
- E.M. 1110-2-1413. Engineering Manual. Engineering and Design: “Hydrologic Analysis of Interior Areas.” Department of the Army, (24 August 2018), US Army Corps of Engineers, Washington, DC.
- E.R. 1110-2-1150. Engineering Regulation. Engineering and Design: “Engineering and Design for Civil Works Projects.” Department of the Army, (31 August 1999), US Army Corps of Engineers, Washington, DC.
- Federal Emergency Management Agency, Flood Insurance Study: City of Beattyville, Lee County, Kentucky, and Incorporated Areas, (27 October 2022). Report No. 21129CV000B. Washington, D.C.
- Federal Emergency Management Agency, *Guidance for Flood Risk Analysis and Mapping: Levees,* (February 2018). Guidance Document 95. Washington, D.C.
- Federal Insurance Administration, Flood Insurance Study: City of Beattyville, Lee County, Kentucky, (January 1978). U.S. Department of Housing and Urban Development. Washington, D.C.
- HEC-HMS, Hydrologic Modeling System, Technical Reference Manual. Hydrologic Engineering Center, (March 2000), U.S. Army Corps of Engineers, Davis, CA.
- HEC-HMS, Hydrologic Modeling System, User’s Manual. Hydrologic Engineering Center, (February 2016), US Army Corps of Engineers, Davis, CA.
- HEC-RAS, River Analysis System, Hydraulic Reference Manual. Hydrologic Engineering Center, (February 2016), U.S. Army Corps of Engineers, Davis, CA.
- HEC-RAS, River Analysis System, User’s Manual. Hydrologic Engineering Center, (February 2016), U.S. Army Corps of Engineers, Davis, CA.
- HEC-SSP, Statistical Software Package, User’s Manual. Hydrologic Engineering Center, (June 2019), U.S. Army Corps of Engineers, Davis, CA.
- Paintsville Lake Dam Water Control Manual. Project Manual for Water Control Management: Paintsville Lake – Paint Creek Basin. U.S. Army Corps of Engineers, (February 2002) Huntington District, Huntington, WV.
- Technical Manual for Levees: Modeling, Mapping, and Consequences. Technical Manual. Modeling, Mapping, and Consequences Production Center, (January 2017). U.S. Army Corps of Engineers, Washington, D.C.

- USGS Water Supply-Paper 1651-A. “Floods of January-February 1957 in Southeastern Kentucky and Adjacent Areas: Floods of 1957. USGS Water Supply-Paper 1651-A.” Department of the Interior (1964). Washington, D.C.

Appendix B
Environmental

FY: 2024
Project Title: Beattyville, KY FRM
Project Project No.: 498982
Location: Lee County, Kentucky

Soil Map—Estill and Lee Counties, Kentucky



Soil Map—Estill and Lee Counties, Kentucky

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Estill and Lee Counties, Kentucky
Survey Area Data: Version 24, Sep 10, 2023

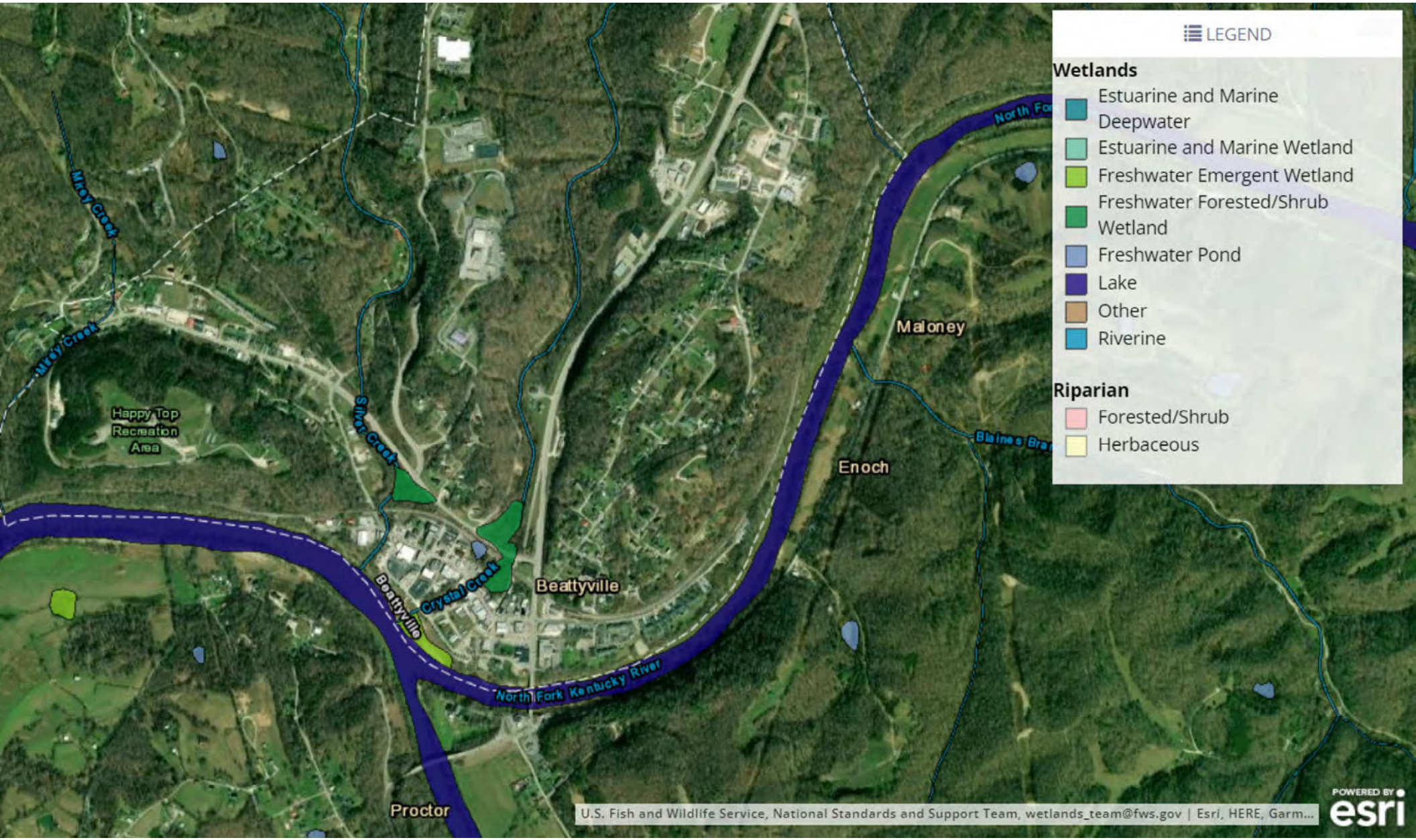
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 29, 2019—Sep 15, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ElA	Elk silt loam, 0 to 2 percent slopes, rarely flooded	7.7	1.2%
FbF	Fairpoint and Bethesda soils, 2 to 70 percent slopes, benched, stony	0.2	0.0%
GaD	Gilpin silt loam, 12 to 20 percent slopes	18.4	3.0%
GvB	Grigsby-Rowdy complex, 0 to 4 percent slopes, occasionally flooded	31.8	5.1%
GyF	Grigsby-Chavies-Yeager complex, 2 to 55 percent slopes, frequently flooded	15.9	2.6%
RgC	Rayne-Gilpin complex, 4 to 12 percent slopes	1.7	0.3%
SgF	Shelocta-Gilpin complex, 20 to 65 percent slopes, stony	145.3	23.4%
UuD	Urban land-Udorthents complex, 0 to 20 percent slopes	383.4	61.8%
W	Water	16.1	2.6%
Totals for Area of Interest		**620.5**	**100.0%**


LEGEND
Wetlands
Estuarine and Marine Deepwater
Estuarine and Marine Wetland
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Other
Riverine
Riparian
Forested/Shrub
Herbaceous
Mary Creek
Mary Creek
Happy Top Recreation Area
Silver Creek
Maloney
Enoch
Beattyville
Crystal Creek
Beattyville
North Fork Kentucky River
Proctor
U.S. Fish and Wildlife Service, National Standards and Support Team, wetlands_team@fws.gov | Esri, HERE, Garm...
POWERED BY esri

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Kentucky Ecological Services Field Office
J C Watts Federal Building, Room 265
330 West Broadway
Frankfort, KY 40601-8670
Phone: (502) 695-0468 Fax: (502) 695-1024
Email Address: kentuckyes@fws.gov

In Reply Refer To: October 02, 2023
Project Code: 2024-0000310
Project Name: Beattyville Kentucky FRM Study Project

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the

human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do..

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of

this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Kentucky Ecological Services Field Office
J C Watts Federal Building, Room 265
330 West Broadway
Frankfort, KY 40601-8670
(502) 695-0468

PROJECT SUMMARY

Project Code: 2024-0000310
Project Name: Beattyville Kentucky FRM Study Project
Project Type: Levee / Dike - New Construction
Project Description: Study of potential flood reduction measures for Beattyville, Kentucky.
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@37.57785285,-83.71285207062203,14z



Counties: Lee County, Kentucky

ENDANGERED SPECIES ACT SPECIES

There is a total of 12 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 2 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Gray Bat *Myotis grisescens*	Endangered

No critical habitat has been designated for this species.
This species only needs to be considered under the following conditions:
- The project area includes potential gray bat habitat.

Species profile: https://ecos.fws.gov/ecp/species/6329
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/6422.pdf

Indiana Bat *Myotis sodalis*	Endangered

There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
This species only needs to be considered under the following conditions:
- The project area includes known 'swarming 1' habitat.
- The project area includes known 'swarming 2' habitat.

Species profile: https://ecos.fws.gov/ecp/species/5949
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/6422.pdf

Northern Long-eared Bat *Myotis septentrionalis*	Endangered

No critical habitat has been designated for this species.
Species profile: https://ecos.fws.gov/ecp/species/9045
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/6422.pdf

Virginia Big-eared Bat *Corynorhinus (=Plecotus) townsendii virginianus*	Endangered

There is **final** critical habitat for this species. Your location does not overlap the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/8369
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/6422.pdf

FISHES

NAME	STATUS
Kentucky Arrow Darter *Etheostoma spilotum*	Threatened

There is **final** critical habitat for this species. Your location overlaps the critical habitat.
Species profile: https://ecos.fws.gov/ecp/species/9063
General project design guidelines:
https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/5224.pdf

CLAMS

NAME	STATUS
Clubshell *Pleurobema clava*	Endangered
Population: Wherever found; Except where listed as Experimental Populations No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/3789 General project design guidelines: https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/5639.pdf	
Fanshell *Cyprogenia stegaria*	Endangered
No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/4822 General project design guidelines: https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/5639.pdf	
Longsolid *Fusconaia subrotunda*	Threatened
There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/9880	
Rabbitsfoot *Quadrula cylindrica cylindrica*	Threatened
There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/5165 General project design guidelines: https://ipac.ecosphere.fws.gov/project/J4ZZZVB4INFXHM5WGC34MAA2YI/documents/generated/5639.pdf	
Round Hickorynut *Obovaria subrotunda*	Threatened
There is **final** critical habitat for this species. Your location does not overlap the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/9879	
Salamander Mussel *Simpsonaias ambigua*	Proposed Endangered
No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/6208	

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate
No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	

CRITICAL HABITATS

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
Kentucky Arrow Darter *Etheostoma spilotum* https://ecos.fws.gov/ecp/species/9063#crithab	Final

IPAC USER CONTACT INFORMATION

Agency: Army Corps of Engineers
Name: Micah Cothren
Address: 600 Martin Luther King Jr. Place, USACE 708
City: Louisville
State: KY
Zip: 40202
Email micah.v.cothren@usace.army.mil
Phone: 5023156130

Kentucky Underground Storage Tank Statewide Report Search Results.

UST ID	Address	Substance	Capacity in gallons	Status	Leak Detection	Lat.	Long.
54993	79 E Main St	Premium gasoline	6,000	Active	None	37.571283	-83.706774
54993	79 E Main St	Kerosene	3,000	Active	None	37.571283	-83.706774
54993	79 E Main St	Diesel	3,000	Active	None	37.571283	-83.706774
45223	144 Broadway	Empty	1,000	Removal Confirmed	None	37.570717	-83.706045
54043	309 Main St	Oil	550	Removal Confirmed	None	37.573673	-83.711185
66079	KY 11	Diesel	1,000	Removal Confirmed	None	N/A	N/A
66587	E Main St	Gasoline	1,000	Removal Confirmed	None	N/A	N/A
68523	KY 587	Gasoline	550	Removal Confirmed	None	N/A	N/A
68523	KY 587	Gasoline	550	Removal Confirmed	None	N/A	N/A
54043	309 Main St	Regular unleaded gasoline	4,000	Removal Confirmed	None	37.573673	-83.711185
54043	309 Main St	Regular unleaded gasoline	4,000	Removal Confirmed	None	37.573673	-83.711185
54043	309 Main St	Regular unleaded gasoline	6,000	Removal Confirmed	None	37.573673	-83.711185
59990	85 River St	Gasoline	2,000	Removal Confirmed	None	37.569095	-83.708641
59992	KY 11 N	Gasoline	1,000	Removal Confirmed	None	N/A	N/A
59992	KY 11 N	Gasoline	1,000	Removal Confirmed	None	N/A	N/A
60002	284 Main St	Gasoline	8,000	Removal Confirmed	None	37.573611	-83.710556
60002	284 Main St	Gasoline	8,000	Removal Confirmed	None	37.573611	-83.710556
60002	284 Main St	Gasoline	6,000	Removal Confirmed	None	37.573611	-83.710556
60002	284 Main St	DSL	2,000	Removal Confirmed	None	37.573611	-83.710556

UST ID	Address	Substance	Capacity in gallons	Status	Leak Detection	Lat.	Long.
60005	17 KY 11 S	Gasoline	5,000	Removal Confirmed	None	37.568889	-83.706944
60005	17 KY 11 S	Gasoline	8,000	Removal Confirmed	None	37.568889	-83.706944
64989	Main St	Gasoline	2000	Removal Confirmed	None	N/A	N/A
65365	KY 11	Gasoline	3,000	Removal Confirmed	None	N/A	N/A
65365	KY 11	Gasoline	2,000	Removal Confirmed	None	N/A	N/A
69745	KY 52 W	Gasoline	1,000	Removal Confirmed	None	N/A	N/A
69745	KY 52 W	Gasoline	500	Removal Confirmed	None	N/A	N/A
168207	28 Railroad St	Diesel	500	Removal Confirmed	Unknown	37.574085	-83.712031
54993	79 E Main St	Regular unleaded gasoline	9,000	Active	Yes	37.571283	-83.706774
54993	79 E Main St	Diesel	3,000	Active	Yes	37.571283	-83.706774
54993	79 E Main St	Premium gasoline	6,000	Active	Yes	37.571283	-83.706774
54993	79 E Main St	Kerosene	3,000	Active	Yes	37.571283	-83.706774
54993	79 E Main St	Diesel	3,000	Active	Yes	37.571283	-83.706774
60005	17 KY 11 S	Diesel	4,000	Active	Yes	37.568889	-83.706944
60005	17 KY 11 S	Premium gasoline	4,000	Active	Yes	37.568889	-83.706944
60005	17 KY 11 S	Regular unleaded gasoline	12,000	Active	Yes	37.568889	-83.706944
105647	285 Main St	Regular unleaded gasoline	12,000	Active	Yes	37.57327	-83.710654
105647	285 Main St	Premium gasoline	3,000	Active	Yes	37.57327	-83.710654
59989	185 Broadway St	Regular unleaded gasoline	10,000	Closed	Yes	37.571437	-83.706561

UST ID	Address	Substance	Capacity in gallons	Status	Leak Detection	Lat.	Long.
59989	185 Broadway St	PLS	8,000	Closed	Yes	37.571437	-83.706561
59989	185 Broadway St	Premium gasoline	8,000	Closed	Yes	37.571437	-83.706561
103802	76 E Main St	Gasoline	8,000	Removal Confirmed	Yes	37.5716151	-83.7079024
103802	76 E Main St	Gasoline	4,000	Removal Confirmed	Yes	37.5716151	-83.7079024
103802	76 E Main St	Gasoline	4,000	Removal Confirmed	Yes	37.5716151	-83.7079024

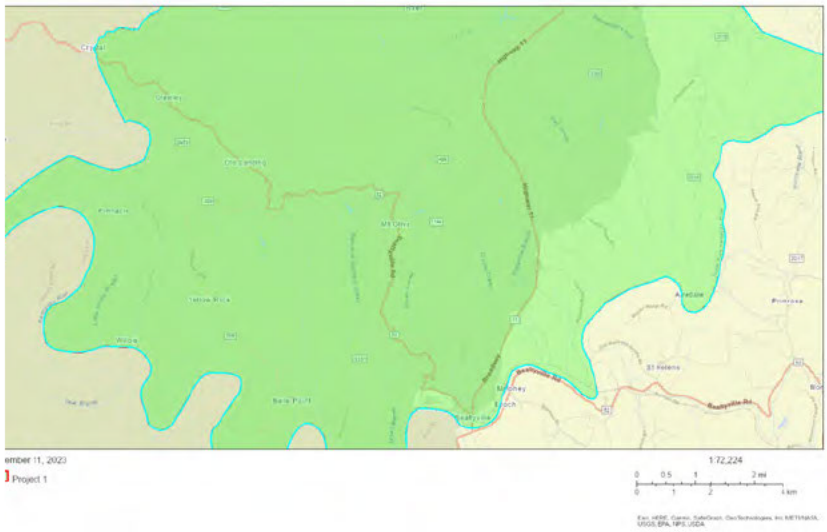
EPA

EJScreen Community Report

This report provides environmental and socioeconomic information for user-defined areas, and combines that data into environmental justice and supplemental indexes.

Lee County, KY

Tract: 21129950100
Population: 4,234
Area in square miles: 93.44



COMMUNITY INFORMATION

Low income: 52 percent	People of color: 9 percent	Less than high school education: 29 percent	Limited English households: 0 percent
Unemployment: 4 percent	Persons with disabilities: 24 percent	Male: 59 percent	Female: 41 percent
72 years Average life expectancy	$20,362 Per capita income	Number of households: 1,454	Owner occupied: 68 percent

BREAKDOWN BY RACE

White: 93%	Black: 2%	Asian: 0%	Hispanic: 2%
American Indian: 0%	Hawaiian/Pacific Islander: 0%	Other race: 0%	Two or more races: 5%

LANGUAGES SPOKEN AT HOME

LANGUAGE	PERCENT
English	99%
Spanish	1%
Total Non-English	1%

BREAKDOWN BY AGE

From Ages 1 to 4	5%
From Ages 1 to 18	20%
From Ages 18 and up	80%
From Ages 65 and up	16%

LIMITED ENGLISH SPEAKING BREAKDOWN

Speak Spanish	0%
Speak Other Indo-European Languages	0%
Speak Asian-Pacific Island Languages	0%
Speak Other Languages	0%

Notes: Numbers may not sum to totals due to rounding. Hispanic popultion can be of any race.
Source: U.S. Census Bureau, American Community Survey (ACS) 2017 -2021. Life expectancy data comes from the Centers for Disease Control.

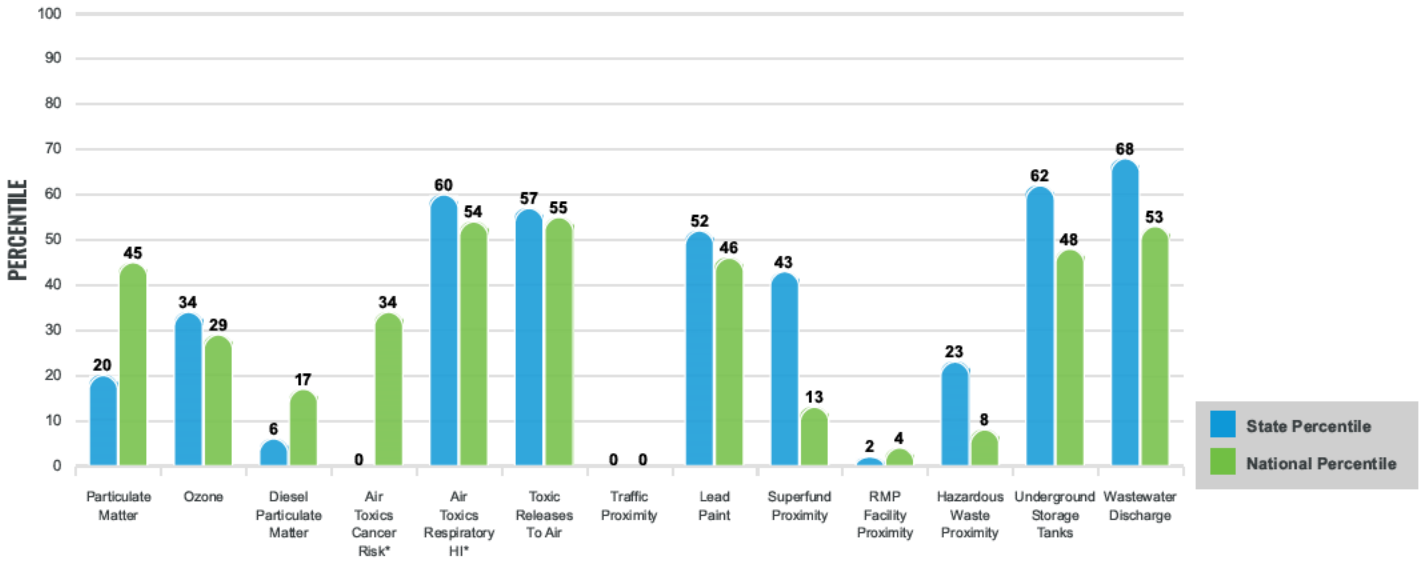
Environmental Justice & Supplemental Indexes

The environmental justice and supplemental indexes are a combination of environmental and socioeconomic information. There are thirteen EJ indexes and supplemental indexes in EJScreen reflecting the 13 environmental indicators. The indexes for a selected area are compared to those for all other locations in the state or nation. For more information and calculation details on the EJ and supplemental indexes, please visit the EJScreen website.

EJ INDEXES

The EJ indexes help users screen for potential EJ concerns. To do this, the EJ index combines data on low income and people of color populations with a single environmental indicator.

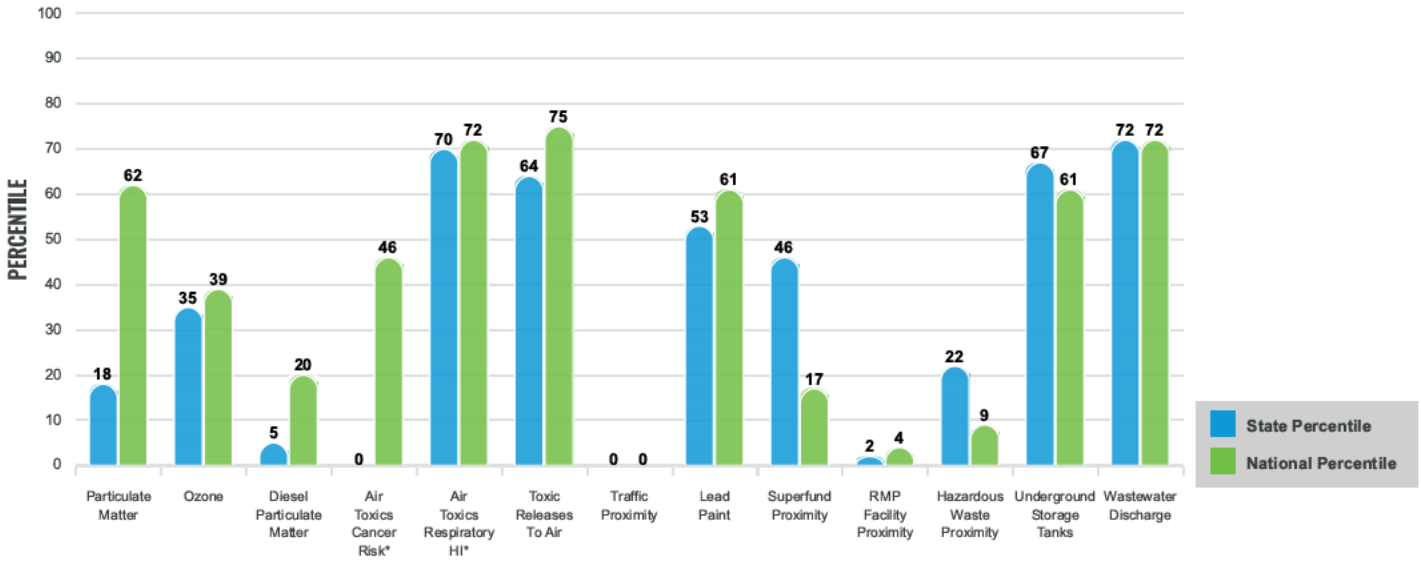
EJ INDEXES FOR THE SELECTED LOCATION



SUPPLEMENTAL INDEXES

The supplemental indexes offer a different perspective on community-level vulnerability. They combine data on percent low-income, percent linguistically isolated, percent less than high school education, percent unemployed, and low life expectancy with a single environmental indicator.

SUPPLEMENTAL INDEXES FOR THE SELECTED LOCATION



These percentiles provide perspective on how the selected block group or buffer area compares to the entire state or nation.

Report for Tract: 21129950100

EJScreen Environmental and Socioeconomic Indicators Data

SELECTED VARIABLES	VALUE	STATE AVERAGE	PERCENTILE IN STATE	USA AVERAGE	PERCENTILE IN USA
POLLUTION AND SOURCES					
Particulate Matter ($\mu g/m^3$)	7.56	8.54	12	8.08	33
Ozone (ppb)	56.9	59.3	20	61.6	18
Diesel Particulate Matter ($\mu g/m^3$)	0.0754	0.203	4	0.261	9
Air Toxics Cancer Risk* (lifetime risk per million)	20	26	0	25	5
Air Toxics Respiratory HI*	0.3	0.32	2	0.31	31
Toxic Releases to Air	480	7,500	35	4,600	46
Traffic Proximity (daily traffic count/distance to road)	0.068	78	0	210	0
Lead Paint (% Pre-1960 Housing)	0.13	0.24	39	0.3	39
Superfund Proximity (site count/km distance)	0.014	0.039	26	0.13	8
RMP Facility Proximity (facility count/km distance)	0.021	0.33	1	0.43	2
Hazardous Waste Proximity (facility count/km distance)	0.03	0.78	13	1.9	4
Underground Storage Tanks (count/km^2)	0.25	1.1	45	3.9	33
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.00067	0.48	52	22	45
SOCIOECONOMIC INDICATORS					
Demographic Index	31%	26%	69	35%	52
Supplemental Demographic Index	23%	16%	82	14%	84
People of Color	9%	16%	49	39%	20
Low Income	52%	37%	76	31%	83
Unemployment Rate	4%	6%	55	6%	54
Limited English Speaking Households	0%	1%	0	5%	0
Less Than High School Education	29%	13%	91	12%	91
Under Age 5	5%	6%	45	6%	47
Over Age 64	16%	17%	47	17%	50
Low Life Expectancy	26%	22%	88	20%	94

*Diesel particulate matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

Sites reporting to EPA within defined area:

Superfund	0
Hazardous Waste, Treatment, Storage, and Disposal Facilities	0
Water Dischargers	21
Air Pollution	0
Brownfields	1
Toxic Release Inventory	0

Other community features within defined area:

Schools	3
Hospitals	0
Places of Worship	6

Other environmental data:

Air Non-attainment	No
Impaired Waters	Yes

Selected location contains American Indian Reservation Lands*	No
Selected location contains a "Justice40 (CEJST)" disadvantaged community	Yes
Selected location contains an EPA IRA disadvantaged community	Yes

Report for Tract: 21129950100

EJScreen Environmental and Socioeconomic Indicators Data

HEALTH INDICATORS

INDICATOR	HEALTH VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Low Life Expectancy	26%	22%	88	20%	94
Heart Disease	9.7	7.4	90	6.1	96
Asthma	12.9	11.5	89	10	95
Cancer	5.8	6.5	21	6.1	41
Persons with Disabilities	25.9%	18.3%	84	13.4%	96

CLIMATE INDICATORS

INDICATOR	HEALTH VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Flood Risk	N/A	12%	N/A	12%	N/A
Wildfire Risk	N/A	3%	N/A	14%	N/A

CRITICAL SERVICE GAPS

INDICATOR	HEALTH VALUE	STATE AVERAGE	STATE PERCENTILE	US AVERAGE	US PERCENTILE
Broadband Internet	32%	17%	87	14%	90
Lack of Health Insurance	3%	6%	28	9%	21
Housing Burden	No	N/A	N/A	N/A	N/A
Transportation Access	Yes	N/A	N/A	N/A	N/A
Food Desert	No	N/A	N/A	N/A	N/A

Footnotes

Report for Tract: 21129950100

Greenhouse Gas Emissions for NAA

	HHV [1] MMBtu/gal)	Default CO_2 EF[2] (kg CO_2/MMBtu)	Default CH_4 EF [2] (kg CH_4/MMBtu)	Default N_2O EF[2] (kg N_2O/MMBtu)
Distillate Fuel Oil #2 (Diesel)	0.138	73.96	0.0030	6.00E-04
Motor Gasoline	0.125	70.22	0.0030	6.00E-04

GHG	Amount of Fuel[3] (Gal)	HHV	EF Coefficient	Total produced[4] (metric tons)	Total Produced (grams)	CO_2e[5]	CO_2e[5]
CO_2 (Motor Gasoline)	8,903	0.125	70.22	78.144	78143975.90	78.14 MT	78143975.9 g
CO_2 (Diesel)	4,961	0.138	73.96	50.639	50638736.07	50.64 MT	50638736.07 g
CH_4 (All Fuel)	13,864	0.138	0.0030	0.006	5739.77	0.14 MT	143494.263 g
N_2O (All Fuel)	13,864	0.138	6.00E-04	0.001	1147.95	0.34 MT	342090.323 g
					Project total	**129.27 MT**	**129,268,296.55 g**

[1]High Heat Values (HHV) from Title 40 CFR, Part 98, Subpart C, Table C-1
[2]Emission Factors (EF) from Title 40 CFR, Part 98, Subpart C, Tables C-1 and C-2
[3]Data calculated based on anticipated cleanup effort

[4]=

where:
CO_2 = Annual CO_2 mass emissions for the specific fuel type (metric tons).
Fuel = Mass or volume of fuel combusted per year, from company records as defined in § 98.6 (express mass in short tons for solid fuel, volume in standard cubic feet for gaseous fuel, and volume in gallons for liquid fuel).
HHV = Default high heat value of the fuel, from Table C–1 of this subpart (mmBtu per mass or mmBtu per volume, as applicable).
EF = Fuel-specific default CO_2 emission factor, from Table C–1 of this subpart (kg CO_2/mmBtu).
1×10^{-3} = Conversion factor from kilograms to metric tons.

CH4 Total	5,739.77
N20 total	1,147.95
C02 total	128,782,711.97

[5]=

$$CO_2eq = X*CO + X*CO_2 + Y*N_2O + Z*CH_4$$

Where X = 100 Year Global Warming Potential for Carbon Monoxide and Carbon Dioxide = 1
Where Y = 100 Year Global Warming Potential for Nitrous Oxide = 298
Where Z = 100 Year Global Warming Potential for Methane = 25

CFR Title 40 Chapter I Subchapter C Part 98: Table A-1 Global Warming Potentials

The GHG emissions calculated using Tier 1 methodology resulted in emissions reported as metric tons of GHG per year. To determine the sum of total GHG emissions, the emissions for each type of GHG were standardized to a common unit. This standard unit is the carbon dioxide equivalent (CO_2e), which is calculated by multiplying the GHG emissions for each gas by their Global Warming Potential (GWP).

The GWP is a relative measure of how much heat a GHG traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the GHG in question to the amount of heat trapped by a similar mass of CO_2. The GWP for CO_2 is 1; CH_4 is 25; and N_2O is 298. After converting the individual GHG emissions to CO_2e, these can be added to estimate the overall GHG emissions from the facility.

Greenhouse Gas Emissions for TSP

	HHV [1] MMBtu/gal)	Default CO_2 EF[2] (kg CO_2/MMBtu)	Default CH_4 EF [2] (kg CH_4/MMBtu)	Default N_2O EF[2] (kg N_2O/MMBtu)
Distillate Fuel Oil #2 (Diesel)	0.138	73.96	0.0030	6.00E-04
Motor Gasoline	0.125	70.22	0.0030	6.00E-04

GHG	Amount of Fuel[3] (Gal)	HHV	EF Coefficient	Total produced[4] (metric tons)	Total Produced (grams)	CO_2e[5]	CO_2e[5]
CO_2 (Motor Gasoline)	2,954	0.125	70.22	25.929	25928735.00	25.93 MT	25928735 g
CO_2 (Diesel)	53,115	0.138	73.96	542.117	542117185.20	542.12 MT	542117185.2 g
CH_4 (All Fuel)	56,070	0.138	0.0030	0.023	23212.98	0.58 MT	580324.5 g
N_2O (All Fuel)	56,070	0.138	6.00E-04	0.005	4642.60	1.38 MT	1383493.608 g
					Project total (6 yrs)	**570.01 MT**	**570,009,738.31 g**
					Annual	**95.00 MT**	**95,001,623.05 g**

[1]High Heat Values (HHV) from Title 40 CFR, Part 98, Subpart C, Table C-1
[2]Emission Factors (EF) from Title 40 CFR, Part 98, Subpart C, Tables C-1 and C-2
[3]Data provided by Cost Engineering.

[4]=

where:
CO_2 = Annual CO_2 mass emissions for the specific fuel type (metric tons).
Fuel = Mass or volume of fuel combusted per year, from company records as defined in § 98.6 (express mass in short tons for solid fuel, volume in standard cubic feet for gaseous fuel, and volume in gallons for liquid fuel).
HHV = Default high heat value of the fuel, from Table C–1 of this subpart (mmBtu per mass or mmBtu per volume, as applicable).
EF = Fuel-specific default CO_2 emission factor, from Table C–1 of this subpart (kg CO_2/mmBtu).
1×10^{-3} = Conversion factor from kilograms to metric tons.

CH4 Total (6yrs)		23,212.98
	Annual	3,868.83
N20 total (6 yrs)		4,642.60
	Annual	773.77
C02 (6 yrs)		568,045,920.20
	Annual	94,674,320.03

[5]=

$$CO_2eq = X*CO + X*CO_2 + Y*N_2O + Z*CH_4$$

Where X = 100 Year Global Warming Potential for Carbon Monoxide and Carbon Dioxide = 1
Where Y = 100 Year Global Warming Potential for Nitrous Oxide = 298
Where Z = 100 Year Global Warming Potential for Methane = 25

CFR Title 40 Chapter I Subchapter C Part 98: Table A-1 Global Warming Potentials

The GHG emissions calculated using Tier 1 methodology resulted in emissions reported as metric tons of GHG per year. To determine the sum of total GHG emissions, the emissions for each type of GHG were standardized to a common unit. This standard unit is the carbon dioxide equivalent (CO_2e), which is calculated by multiplying the GHG emissions for each gas by their Global Warming Potential (GWP).

The GWP is a relative measure of how much heat a GHG traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the GHG in question to the amount of heat trapped by a similar mass of CO_2. The GWP for CO_2 is 1; CH_4 is 25; and N_2O is 298. After converting the individual GHG emissions to CO_2e, these can be added to estimate the overall GHG emissions from the facility.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

July 18, 2023

Planning, Programs, and
Project Management Division

To All Interested Parties:

In accordance with regulations pertaining to the National Environmental Policy Act (NEPA); Title 40 of the Code of Federal Regulations, part 1501.8, and Section 1005 of the Water Resources Reform and Development Act (WRDA) of 2014 and Section 106 of the National Historic Preservation Act (NHPA), the U.S. Army Corps of Engineers, Louisville District (Corps) is inviting you and your agency and/or Tribe to participate in the scoping process to evaluate alternatives for the City of Beattyville, Lee County, Kentucky General Investigation Feasibility Study. This project is authorized under Section 203 of the Flood Control Act of 1962 and would research all available flood reduction methods, including but not limited to impoundments, floodwalls, levees, gated structures, pumping stations, and diversions, as well as a wide array of non-structural measures, including but not limited to flood proofing, relocation, elevating, and flood warning emergency evacuation planning. The study would seek to provide recommendations for optimal solutions to alleviate flooding from the Kentucky River.

The Corps will be holding an Interagency Meeting on Monday, August 7, 2023, from 2:00 to 3:00 p.m. to inform agencies and Tribes of the ongoing project scoping and measures that are being considered. We request that you attend the meeting and provide any information about the potential project area that would be relevant to the study. Subsequent consultation relating to NEPA and Section 106 of the NHPA will be forthcoming after the Interagency Meeting.

The meeting can be attended online:
https://usace1.webex.com/usace1/j.php?MTID=m4f7c3c6ffe47788791635a2d9a17840d

Or by phone: 1-844-800-2712 (Meeting number – 2764 794 3106)

If you have any questions regarding this interagency meeting or the overall study, please contact Jacob Sinkhorn at Jacob.C.Sinkhorn@usace.army.mil or (502) 315-6286.

Sincerely,

[redacted]
Chief, Environmental Resources Section

Beattyville Interagency Meeting

1. **Meeting Details**
   Date: August 7, 2023

2. **Attendees:**
   U.S. Army Corps of Engineers (USACE)
   a. Jacob Sinkhorn
   b. Steele McFadden
   c. Chris Wernick
   d. Lacey Gabbard
   e. Carrie Fry
   f. Brennan Gregory
   Larry Long – U.S. EPA
   Ntale Kajumba – U.S. EPA
   Shawn Hokanson – Kentucky Division of Water
   Caitlin Nichols – Osage Nation

3. **Meeting Purpose**
   The purpose of this meeting was to:
   - Provide a brief overview of the project
   - Deliver the proposed schedule and status update for the study
   - Deliver proposed measures and alternatives being considered during the planning process
   - Review already known environmental permitting requirements and concerns (Kentucky Arrow Darter)
   - Have stakeholders provide input on risks to the project
   - Have stakeholders provide input on requirements not mentioned

4. **Presentation**
   The USACE presented a PowerPoint presentation detailing an overview of the project and objectives, updated project schedule, details of alternatives being considered, known environmental concerns and permits, and known cultural resources and expected upcoming section 106 coordination. Feedback was requested on potential project risks and requirements not discussed in the presentation.

5. **Summary of Feedback**:

   Larry Long Question: Is this project funded through BIL funding or other sources?
   USACE Answer: No, this project was specifically authorized by congress (Congressionally Directed Spending).

   Larry Long Question: Are you reaching out to Tribes?
   USACE Answer: Yes, we are beginning coordination with Tribes and the SHPO with this interagency meeting, and once a Tentatively Selected Plan is chosen formal consultation with Tribes and the SHPO would be complete.

Larry Long Question: Will you be sending out scoping letters?

USACE Answer: Yes, once we have chosen a Tentatively Selected Plan the NEPA scoping process will begin and scoping letters will be sent out to agencies for comment.

Caitlin Nichols Comment: Tribes currently have a very high workload, and it is challenging to respond to all requests for input in a timely manner. Do not take this as a sign that Tribes do not care about the project. Please follow up with phone calls and emails and do not take no response as a "go-ahead" from the Tribes. Additionally, many Tribes have websites that list the proper way to notify for project review, please use this.

USACE Response: Absolutely understand. We can be sure to follow up two weeks after submitting the project for reviews to ensure that it has been received and see if additional time is needed for review.

Larry Long Comment: At this point in the project there is not enough detail to make any comments on the project. We look forward to hearing more about the project and receiving scoping letters, in which we will send out formal responses.

USACE Response: Thank you, we will be sending scoping letters sometime around March 2024.

Caitlin Nichols Question: Can you send the slides for review.

USACE Answer: Yes.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 12, 2024

Civil Works - Planning, Programs
and Project Management Branch
Environmental Resources Section

To All Interested Parties:

The U.S. Army Corps of Engineers, Louisville District (Corps) is preparing an Environmental Assessment (EA), under the National Environmental Policy Act (NEPA) of 1969, as amended, to evaluate alternatives for the City of Beattyville, Lee County, Kentucky General Investigation Feasibility Study. Alternatives are currently being considered for the project to address the ongoing flood risk that the community faces, and we are continuing scoping efforts after the interagency meeting that was held on August 7, 2023. Construction of a floodwall, as well as nonstructural measures, have been evaluated to address flooding. Nonstructural measures include the acquisition and removal, floodproofing, or raising of structures. There are two primary action alternatives currently being considered, including: 1) two separate floodwalls with nonstructural measures applied to the structures outside of the floodwalls, and 2) a complete nonstructural plan in which all at-risk structures would be considered for acquisition and removal, floodproofing, or raising in place. Maps of these proposed alternatives are enclosed for your review.

In accordance with NEPA and associated implementing regulations, the EA will be prepared to evaluate viable alternatives, including the “No Action” alternative, for the project. We request any information you may have about resources (such as biological and cultural) in or around the project area that should be considered in the assessment. This information will aid in further development and evaluation of alternatives. This EA will provide the basis for a decision whether to proceed with an Environmental Impact Statement or a Finding of No Significant Impact. You or your agency will be notified when the draft EA is available for public review.

We request that you send any comments or information you can provide by April 11, 2024. If you have any questions regarding this project, please contact [redacted] You may submit comments to the same email address or send by mail to:

U.S. Army Corps of Engineers, Louisville District
Attn: Steele McFadden, Room 708
PO Box 59
Louisville, KY 40201-0059

Sincerely,

[redacted]
Chief, Environmental Resources Section

Enclosure

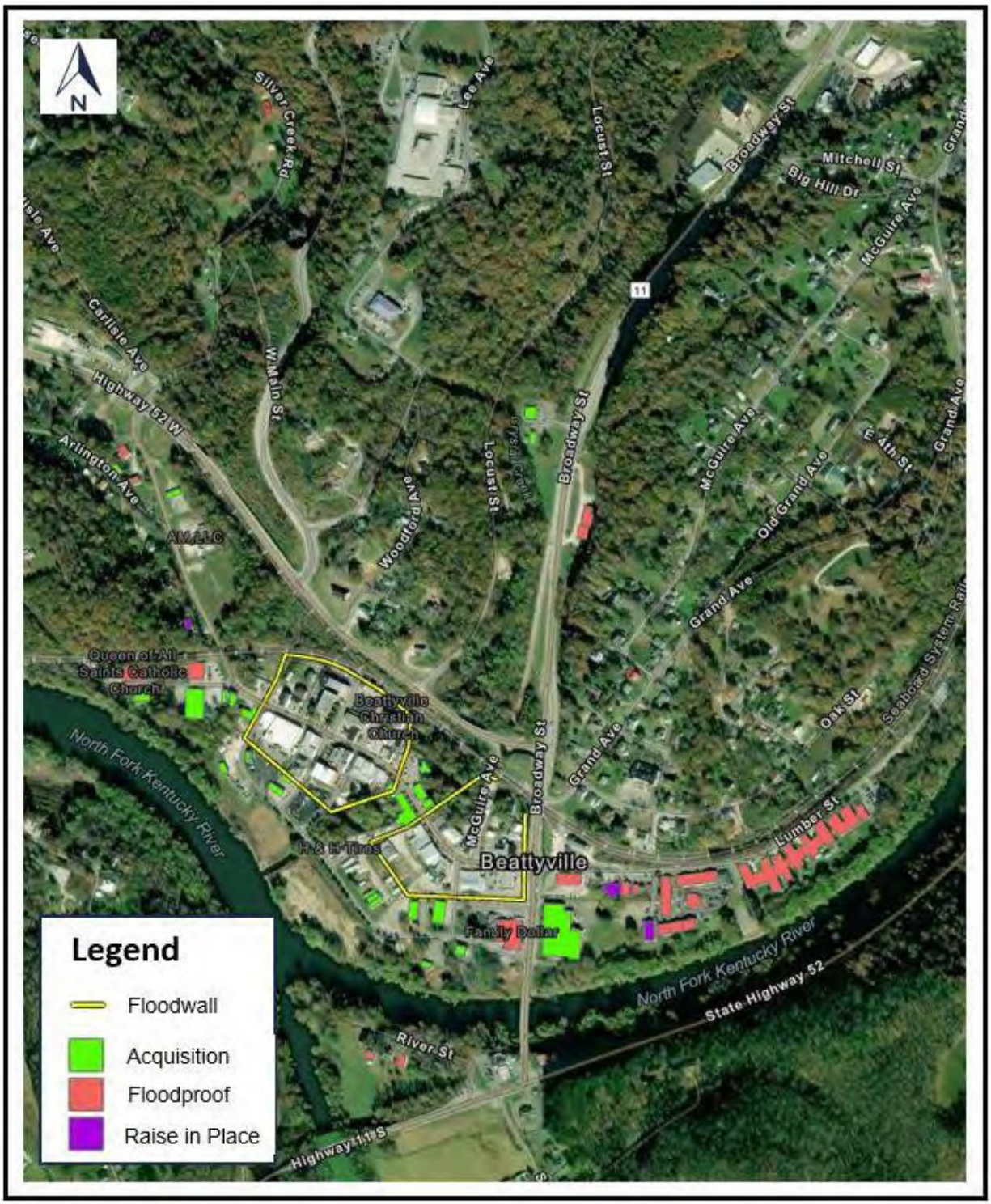


Figure 1. Floodwall construction combined with nonstructural measures.

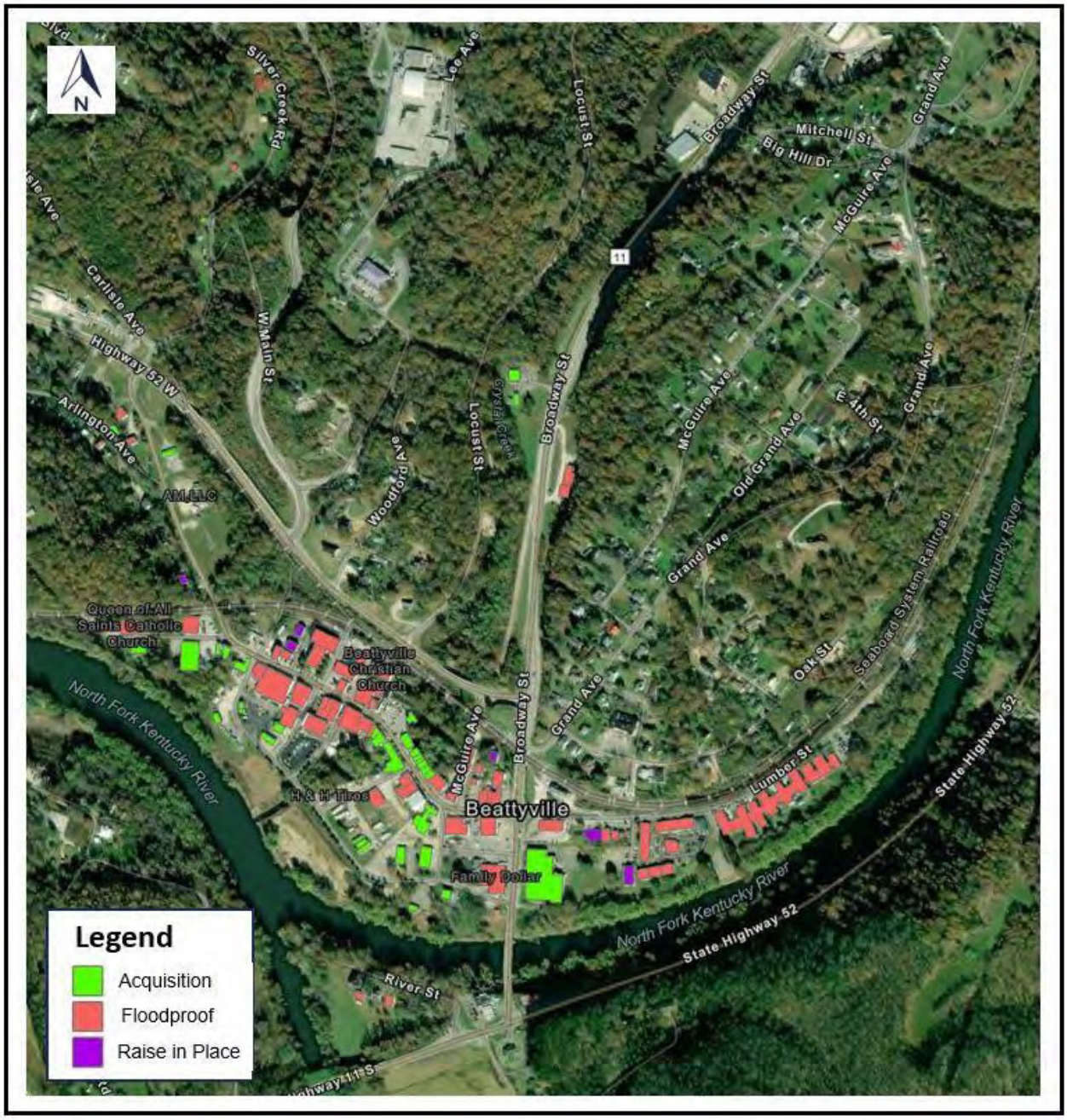


Figure 2. Total nonstructural plan.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs, and
Project Management Division

[redacted]
Executive Director and State Historic Preservation Officer
[redacted]

Dear [redacted]

The U.S. Army Corps of Engineers, Louisville District (USACE) is conducting a General Investigation Feasibility Study with the City of Beattyville, Lee County, Kentucky related to flood risk management authorized by Section 6 of the Flood Control Act of 1939, PL 76-396 and under Section 105(a) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 U.S.C. 2215(a). This study will evaluate and propose the structural modifications to properties throughout the City of Beattyville and the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). This project has the potential to effect historic properties, and therefore is considered an Undertaking necessitating consultation under Section 106 of the National Historic Preservation Act (NHPA).

This Undertaking is currently within the Feasibility Phase of planning and specific details related to the scope of work (SOW) are incomplete at this time. However, the Tentatively Selected Plan (TSP) has been defined as the Nonstructural Alternative and the FWEEP which is outlined in Attachment 1 (Enclosed). The TSP provides the basis for the area of potential effect (APE) and is defined by the structures located within the 500-year floodplain (see Figure 1 in Attachment 1). Currently, USACE proposes the following level of effort (LOE) to identify historic properties within the APE:

1. A background review of known historic structures and historic properties within the APE.
2. Develop and award a contract to evaluate the National Register of Historic Places (NRHP) significance for the identified structures eligible for nonstructural measures.
3. Provide the final Cultural Historic Report to KHC for review and comment.
4. Conduct a Phase I Archaeological Survey if potentially undisturbed areas are likely to be impacted by the Undertaking. The results of this survey will be provided to KHC for review and comment.

USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or recommendations, please contact [redacted]

Sincerely,

[redacted]
Chief, Environmental Resources Section

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

July 18, 2023

Planning, Programs, and
Project Management Division

To All Interested Parties:

In accordance with regulations pertaining to the National Environmental Policy Act (NEPA); Title 40 of the Code of Federal Regulations, part 1501.8, and Section 1005 of the Water Resources Reform and Development Act (WRDA) of 2014 and Section 106 of the National Historic Preservation Act (NHPA), the U.S. Army Corps of Engineers, Louisville District (Corps) is inviting you and your agency and/or Tribe to participate in the scoping process to evaluate alternatives for the City of Beattyville, Lee County, Kentucky General Investigation Feasibility Study. This project is authorized under Section 203 of the Flood Control Act of 1962 and would research all available flood reduction methods, including but not limited to impoundments, floodwalls, levees, gated structures, pumping stations, and diversions, as well as a wide array of non-structural measures, including but not limited to flood proofing, relocation, elevating, and flood warning emergency evacuation planning. The study would seek to provide recommendations for optimal solutions to alleviate flooding from the Kentucky River.

The Corps will be holding an Interagency Meeting on Monday, August 7, 2023, from 2:00 to 3:00 p.m. to inform agencies and Tribes of the ongoing project scoping and measures that are being considered. We request that you attend the meeting and provide any information about the potential project area that would be relevant to the study. Subsequent consultation relating to NEPA and Section 106 of the NHPA will be forthcoming after the Interagency Meeting.

The meeting can be attended online:
https://usace1.webex.com/usace1/j.php?MTID=m4f7c3c6ffe47788791635a2d9a17840d

Or by phone: 1-844-800-2712 (Meeting number – 2764 794 3106)

If you have any questions regarding this interagency meeting or the overall study, please contact Jacob Sinkhorn at Jacob.C.Sinkhorn@usace.army.mil or (502) 315-6286.

Sincerely,

[redacted] Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

Dear [redacted]

The U.S. Army Corps of Engineers, Louisville District (USACE) is conducting a General Investigation Feasibility Study with the City of Beattyville, Lee County, Kentucky related to flood risk management authorized by Section 6 of the Flood Control Act of 1939, PL 76-396 and under Section 105(a) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 U.S.C. 2215(a). This study will evaluate and propose the structural modifications to properties throughout the City of Beattyville and the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). This project has the potential to effect historic properties, and therefore is considered an Undertaking necessitating consultation under Section 106 of the National Historic Preservation Act (NHPA).

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1. A background review of known historic structures and historic properties within the APE.
2. Develop and award a contract to evaluate the National Register of Historic Places (NRHP) significance for the identified structures eligible for nonstructural measures.
3. Provide the final Cultural Historic Report to the Absentee-Shawnee Tribe of Oklahoma for review and comment.
4. Conduct a Phase I Archaeological Survey if potentially undisturbed areas are likely to be impacted by the Undertaking. The results of this survey will be provided to the Absentee-Shawnee Tribe of Oklahoma for review and comment.

USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or recommendations, please contact [redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

Dear [redacted]

The U.S. Army Corps of Engineers, Louisville District (USACE) is conducting a General Investigation Feasibility Study with the City of Beattyville, Lee County, Kentucky related to flood risk management authorized by Section 6 of the Flood Control Act of 1939, PL 76-396 and under Section 105(a) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 U.S.C. 2215(a). This study will evaluate and propose the structural modifications to properties throughout the City of Beattyville and the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). This project has the potential to effect historic properties, and therefore is considered an Undertaking necessitating consultation under Section 106 of the National Historic Preservation Act (NHPA).

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1. A background review of known historic structures and historic properties within the APE.
2. Develop and award a contract to evaluate the National Register of Historic Places (NRHP) significance for the identified structures eligible for nonstructural measures.
3. Provide the final Cultural Historic Report to the Cherokee Nation for review and comment.
4. Conduct a Phase I Archaeological Survey if potentially undisturbed areas are likely to be impacted by the Undertaking. The results of this survey will be provided to the Cherokee Nation for review and comment.

USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or

[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

Dear [redacted]

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2. Develop and award a contract to evaluate the National Register of Historic Places (NRHP) significance for the identified structures eligible for nonstructural measures.
3. Provide the final Cultural Historic Report to the Delaware Nation for review and comment.
4. Conduct a Phase I Archaeological Survey if potentially undisturbed areas are likely to be impacted by the Undertaking. The results of this survey will be provided to the Delaware Nation for review and comment.

USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or

[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

The U.S. Army Corps of Engineers, Louisville District (USACE) is conducting a General Investigation Feasibility Study with the City of Beattyville, Lee County, Kentucky related to flood risk management authorized by Section 6 of the Flood Control Act of 1939, PL 76-396 and under Section 105(a) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 U.S.C. 2215(a). This study will evaluate and propose the structural modifications to properties throughout the City of Beattyville and the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). This project has the potential to effect historic properties, and therefore is considered an Undertaking necessitating consultation under Section 106 of the National Historic Preservation Act (NHPA).

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[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

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3. Provide the final Cultural Historic Report to the Eastern Band of Cherokee Indians for review and comment.
4. Conduct a Phase I Archaeological Survey if potentially undisturbed areas are likely to be impacted by the Undertaking. The results of this survey will be provided to the Eastern Band of Cherokee Indians for review and comment.

USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or

[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]f Oklahoma

The U.S. Army Corps of Engineers, Louisville District (USACE) is conducting a General Investigation Feasibility Study with the City of Beattyville, Lee County, Kentucky related to flood risk management authorized by Section 6 of the Flood Control Act of 1939, PL 76-396 and under Section 105(a) of the Water Resources Development Act of 1986, PL 99-662, as amended (33 U.S.C. 2215(a). This study will evaluate and propose the structural modifications to properties throughout the City of Beattyville and the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). This project has the potential to effect historic properties, and therefore is considered an Undertaking necessitating consultation under Section 106 of the National Historic Preservation Act (NHPA).

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USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or

[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

April 29, 2024

Planning, Programs and
Project Management Division

[redacted]

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USACE would appreciate any information or feedback that the Absentee-Shawnee Tribe is willing to share within thirty (30) days of receiving this letter. If you have any questions, recommendations, or would like to discuss this request in further detail, please contact [redacted]

Sincerely,

[redacted]

Archaeologist and Tribal Liaison

Enclosure: Project Location Maps

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

April 29, 2024

Planning, Programs and
Project Management Division

[redacted]

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USACE would appreciate any information or feedback that the Cherokee Nation is willing to share within thirty (30) days of receiving this letter. If you have any questions, recommendations, or [redacted]

Sincerely,

[redacted]

Archaeologist and Tribal Liaison

Enclosure: Project Location Maps

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

March 15, 2024

Planning, Programs and
Project Management Division

[redacted]

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USACE is requesting your concurrence with the proposed preliminary APE and LOE described above within thirty (30) days of receiving this letter. If you have any questions or

[redacted]

Sincerely,

[redacted]

Chief, Environmental Resources Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

April 29, 2024

Planning, Programs and
Project Management Division

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Sincerely,

[redacted]

Archaeologist and Tribal Liaison

Enclosure: Project Location Maps

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

April 29, 2024

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Project Management Division

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Enclosure: Project Location Maps

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
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Archaeologist and Tribal Liaison

Enclosure: Project Location Maps

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, LOUISVILLE DISTRICT
600 DR. MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202

April 29, 2024

Planning, Programs and
Project Management Division

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Sincerely,

[redacted]

Archaeologist and Tribal Liaison

Enclosure: Project Location Maps

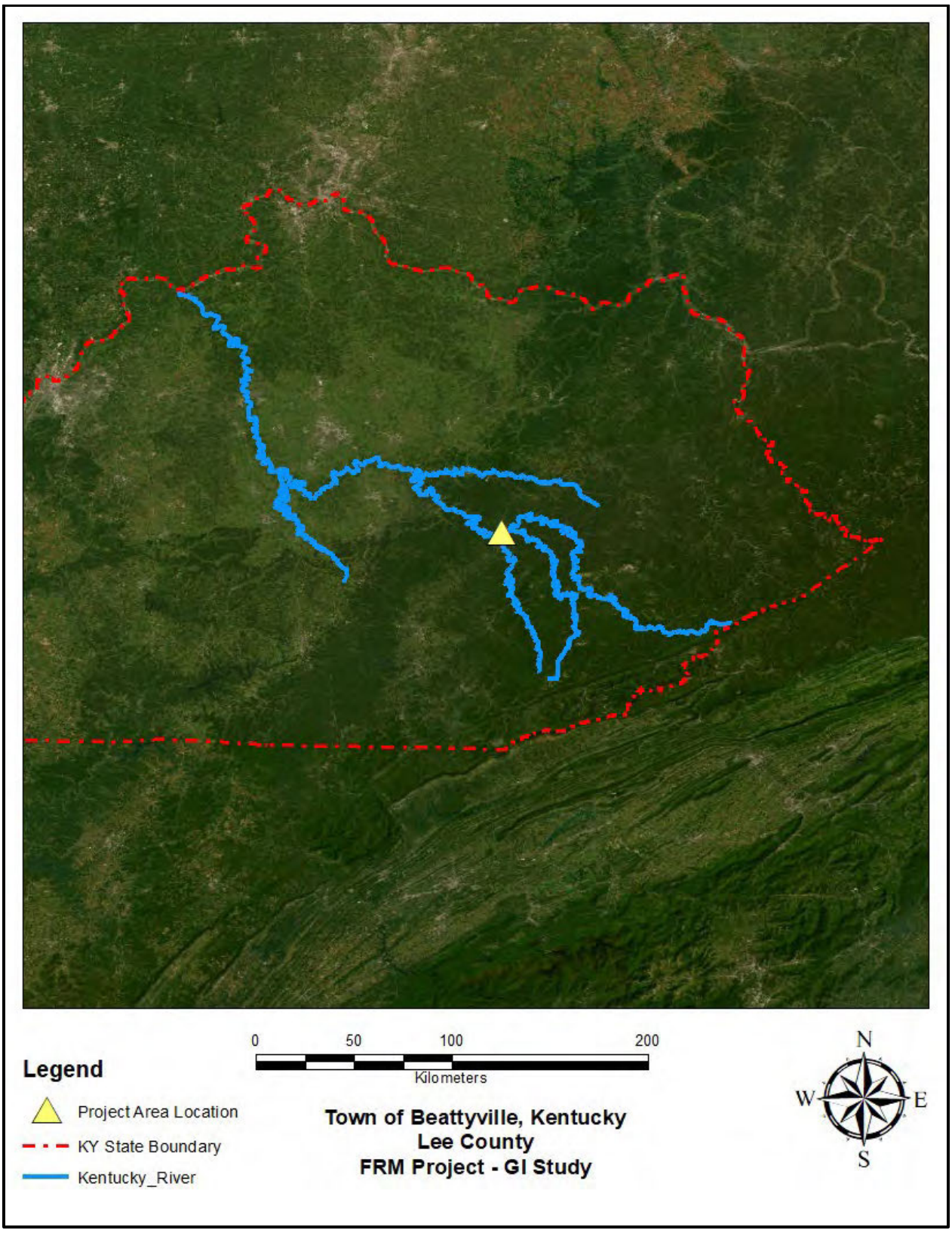


Figure 1: Location of the Beattyville Flood Risk Management Project (FRM) Project in relation to the Kentucky River.

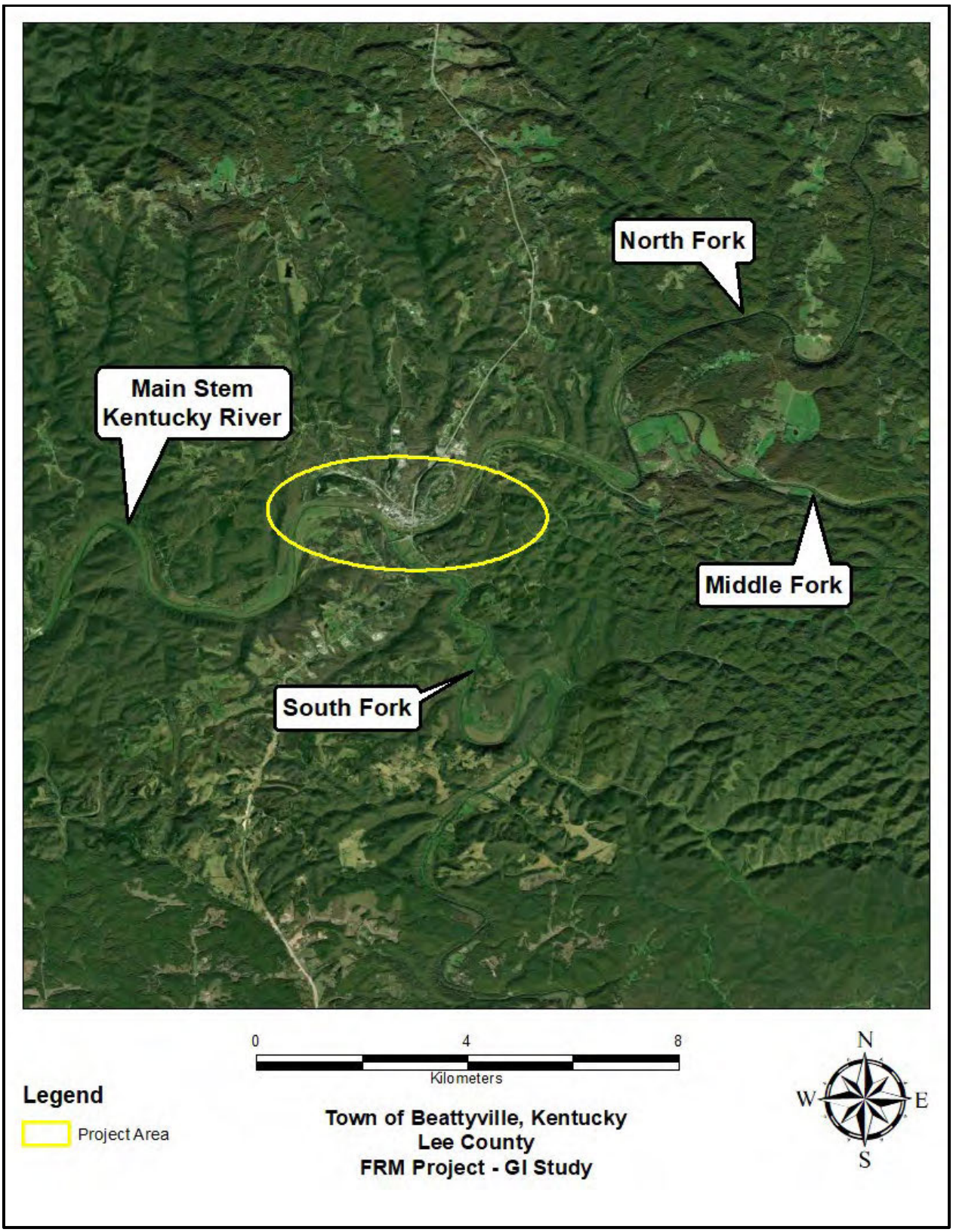


Figure 2: Project Area for the Beattyville FRM Project in relation to the Kentucky River. NOTE: Project area is NOT the same as the Area of Potential Effects.

ANDY BESHEAR
GOVERNOR

JACQUELINE COLEMAN
LT. GOVERNOR

TOURISM, ARTS AND HERITAGE CABINET
KENTUCKY HERITAGE COUNCIL
THE STATE HISTORIC PRESERVATION OFFICE
410 HIGH STREET
FRANKFORT, KENTUCKY 40601
(502) 564-7005
www.heritage.ky.gov

LINDY CASEBIER
SECRETARY

CRAIG A. POTTS
EXECUTIVE DIRECTOR &
STATE HISTORIC PRESERVATION OFFICER

April 15, 2024

[redacted]

RE: USACE-L, Beattyville General Investigation Feasibility Study, Lee County, KY

Dear [redacted]:

Thank you for your submittal of initiation materials for the above-referenced undertaking. We understand the Corps is proposing to evaluate and propose structural modifications throughout the City of Beattyville. This will also include the development of a Flood Warning & Emergency Evacuation Plan (FWEEP). The project is currently in the feasibility phase, but a tentative plan has been selected to include various non-structural alternatives and the FWEEP.

Based on the information provided, our office concurs with the above and below-ground identification measures and preliminary APE. Any above-ground properties within the APE should be evaluated in Cultural Historic, which should be completed by a Secretary of the Interior-qualified Historian or Architectural Historian. Previous disturbance should be evaluated by an SOI-qualified archaeologist to determine whether archaeological investigations are necessary. Any reports, as well as survey forms, should meet our office's report and survey form specifications.

Once completed, the Cultural Historic, any survey forms, and if necessary, the archaeology report should be submitted as separate PDF files to khc.section106@ky.gov. As part of the 106 process, we suggest the Corps reach out to Beattyville Main Street for potential consulting party involvement.

[redacted],

[redacted]
Executive Director and
State Historic Preservation Officer

CP: gf, peh
KHC # 240761

KENTUCKY TOURISM, ARTS & HERITAGE CABINET

An Equal Opportunity Employer M/F/D

Osage Nation Historic Preservation Office

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Date: April 22, 2024 **File No. 2324-6821KY-3**

Louisville District, USACE
[redacted]

RE: USACE, Louisville District, Beattyville General Investigation Study, Lee County, Kentucky

SENT VIA EMAIL

Dear [redacted],

The Osage Nation has received notification and accompanying information for the proposed project listed as USACE, Louisville District, Beattyville General Investigation Study, Lee County, Kentucky. **The Osage Nation Historic Preservation Office requests a copy of the cultural resource survey report for review and comment**.

In accordance with the National Historic Preservation Act, (NHPA) [54 U.S.C. § 300101 et seq.] 1966, undertakings subject to the review process are referred to in 54 U.S.C. § 302706 (a), which clarifies that historic properties may have religious and cultural significance to Indian tribes. Additionally, Section 106 of NHPA requires Federal agencies to consider the effects of their actions on historic properties (36 CFR Part 800) as does the National Environmental Policy Act (43 U.S.C. 4321 and 4331-35 and 40 CFR 1501.7(a) of 1969).

The Osage Nation has a vital interest in protecting its historic and ancestral cultural resources. **The Osage Nation anticipates reviewing and commenting on the survey report for the USACE, Louisville District, Beattyville General Investigation Study, Lee County, Kentucky.**

Should you have any questions or need any additional information please feel free to contact me at the number listed below. Thank you for consulting with the Osage Nation on this matter.

[redacted]

627 Grandview Ave. * Pawhuska, OK 74056 Telephone 918-287-5328 * Fax 918-287-5376
www.osagenation-nsn.gov/who-we-are/historic-preservation * HistoricPreservation@osagenation-nsn.gov

From: [redacted] Knowledge for Lee County, Kentucky
Date: Monday, May 6, 2024 1:14:25 PM

We do not claim Lee County as an area of interest therefore we will defer. Thank you.

Wanìshi,

[redacted]

From: [redacted]
Sent: Monday, May 6, 2024 8:04 AM
To: [redacted]
Subject: Beattyville FRM Project - Indigenous Knowledge for Lee County, Kentucky

Dear [redacted]

Please find the attached letter requesting any information regarding indigenous knowledge of the Beattyville, Lee County Kentucky area. We are intending to capture a more complete history of the area/region and would sincerely appreciate any historical/Indigenous Knowledge of the area that the Delaware Nation is willing to share.

Respectfully,
[redacted]

[redacted]

CONFIDENTIALITY NOTE:

This e-mail (including attachments) may be privileged and is confidential information covered by the Electronic Communications Privacy Act 18 U.S.C. 2510-2521 and any other applicable law, and is intended only for the use of the individual or entity named herein. If the reader of this message is not the intended recipient, or the employee or agent responsible to deliver it to the intended recipient, you are hereby notified that any retention, dissemination, distribution or copying of this communication is strictly prohibited. Although this e-mail and any attachments are believed to be free of any virus or other defect that might affect any computer system in to which it is received and opened, it is the responsibility of the recipient to ensure that it is virus free and no responsibility is accepted by Delaware Nation or the author hereof in any way from its use. If you have received this communication in error, please immediately notify us by return e-mail. Thank you.

Appendix C
Cost Estimate

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 INTRODUCTION

This Appendix presents the cost estimate that has been assembled for the Flood Risk Management (FRM) General Investigation (GI) Feasibility Study in Beattyville, KY. A discussion regarding cost, schedule and risk is included in this Appendix which contains all appropriate feature accounts. What follows is a discussion regarding the methodology used to develop the first cost for the Tentatively Selected Plan (TSP).

The costs provided have undergone District Quality Control (DQC) Review by Louisville District and pending Agency Technical Review (ATR) at the Walla Walla Cost Center of Expertise but is planned for in the coming weeks and months. These reviews will verify the reasonableness of total project costs, including the construction costs and calculated contingencies using the mandated Risk Analysis techniques.

2 REFRENCES

- ER 1110-1-1300, Cost Engineering Policy & General Requirements, 26 Mar 1993.
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016.
- ER 1110-2-1150, Engineering & Design for Civil Works Projects, 31 Aug 1999.
- ER 37-2-10 Change 89, Accounting And Reporting – Civil Works Activities, 31 Oct 2000.
- EC 11-2-187, Corps of Engineers Civil Works Direct Program: Program Development Guidance – Fiscal Year 2009, 30 Mar 2007.
- EP 1110-1-8 Volume 2, Construction Equipment Ownership and Operating Expense Schedule – Region II, July 2007.
- EC Bulletin No 2007-17, Application of Cost Risk Analysis Methods to develop Contingencies for Civil Works Total Project Costs, 10 Sep 2007.
- EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS), 30 Sept 2021.
- EC 1105-2-410, Review of Decision Documents, 22 Aug 2008
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 Sept 2008.

3 METHODOLOGY

3.1 GENERAL

The cost estimate was prepared using the Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII), version 4.4.3 for all feature accounts associated with construction. Applicable crews and equipment were applied in the estimate to correspond with the work being performed. Material prices were developed using the

2023 MII Cost Book and quotes were obtained from suppliers, when available. Cost which are not construction related (Lands & Damages, Cultural Resources, PED, CM, etc.) rely on PDT input or are calculated based on percentage(s) of the construction cost, based on other project experience.

3.2 COST METHODOLOGY

3.2.1 Historical Unit Pricing

In some instances, historical cost information was referenced and documented accordingly. These historical references include past contract bid prices for projects of similar design and magnitude and recent government studies and cost estimates.

3.2.2 Quote-in-Place

In some instances, a quote from a subcontractor may have been received that included overhead and profit. In that case, no additional markups were included for subcontractor's overhead.

3.2.3 Detailed MII Cost Estimate

The MII estimating software was used to develop a construction sequence for each item of work and applying detailed line items and crews to perform the work. Crews were developed in correspondence with the work being performed and estimated productivities. Wage rates were taken from the local Davis Bacon rates. The latest MII equipment database was also used and adjusted for current fuel and energy costs. Material prices were obtained through telephone solicitations with vendors, Internet suppliers, the MII Cost Book, and RS MEANS.

With much of the selected plan focused on cost which are considered Non-Structural, sources of information were difficult to come by and, when available, work previously completed by others was used to develop cost. For example, tools were provided by the Cost Engineer(s) assigned to the National Non-Structural Committee and were utilized to develop cost, specifically for structures identified to receive dry flood proofing or to be raised in place. These tools rely on a detailed structure inventory identifying building characteristics such as first floor elevation (FFE), structure square footage, structure perimeter, count/length of openings at grade, foundation type, etc. These characteristics feed into a Microsoft Excel spreadsheet which outputs all the relevant quantities which are then feed into pre-built folders/CSI task in the MCACES MII software.

Cost for structures identified to be acquired/demolished were developed by the Cost Engineer. A general assumption about these structures was made for use of developing Rough Order of Magnitude (ROM) cost so that alternatives could be compared to one another. This allows the PDT to get to a point in which an alternative could be chosen for the TSP.

Over the coming weeks and months, refinement of the TSP will occur and a closer, more detailed look at each structure will take place to ensure cost are being captured appropriately for each building type.

A summary level report of the MII cost estimate for the TSP, as it is currently assumed, can be found in Attachment A.

3.3 DIRECT COSTS

Direct costs are based on anticipated equipment, labor, and materials necessary to construct this project. Following formulation of the direct cost, a determination is made as to whether the work would be performed by the prime contractor or a subcontractor.

3.3.1 Labor - Wage Determination

Wage rates were taken from the latest Davis-Bacon wage determination KY20240043, Building updated on https://www.sam.gov as recent as 07/05/2024. Recognizing that Davis Bacon rates for specific trades sometimes lag an update, possibly for years, a labor adjustment tool was utilized which references the Employment Cost Index: Wages and Salaries: Private Construction Workers: Construction (ECICONWAG) index put out by the Federal Reserve Economic Data (FRED) https://www.stlouisfed.org. This index allows labor rates to be escalated to be representative of anticipated growth of labor cost, since the last Davis Bacon update.

3.3.2 Equipment Costs

The 2022 Equipment database, based on EP 1110-1-8, Construction Equipment Ownership and Operation Expense Schedule, Region II, was used and adjusted for current, local fuel and energy costs per https://www.eia.gov as recent at 07/22/2024.

3.3.3 Vendor Quotes

Vendor quotes will be or have been acquired and documented for the anticipated cost driving materials. At the time of the development of this initial cost, reliance on the provided tools and Cost book data was used. During the forthcoming refinement period, better coordination with contractors and vendors will help build more realistic and accurate cost. In some cases, given how little about non-structural cost are known across the USACE Enterprise, heavy reliance on input from Contractors may be the ideal path forward.

3.3.4 Crews

Project specific crews have been developed and applied to the detailed line items as appropriate. Crew members consist of selected complements of labor classifications and equipment pieces assembled to perform specific tasks. Productivity has been assigned to each crew reflective of the expected output per unit of measure for the specific activities listed in the cost estimate. In considering the crews and productivities, the engineer

typically referenced other, similar work found in national reference manuals such as RS MEANS construction data, the MII Cost book, and other projects developed by USACE.

3.3.5 Quantities

Quantities were developed by USACE for each feature of work. Quantities were checked/verified by the estimator and adjusted to account for construction methodology, shrink, swell, waste, etc. Other associated sub-quantities were also developed by the estimator, as needed. The primary method for quantification was through the use of the structure inventory developed by the PDT and the tools provided from the Cost Engineer(s) on the National Non-Structural Committee.

3.4 INDIRECT COSTS

3.4.1 Contract Acquisition Strategy

Through discussions with the Project Manager (PM) & PDT, it is very likely that the scope of this project, if funded, would be broken into multiple contracts which priorities structures. The acquisition method will likely be reflected in the estimate as Small Business as the plan would be to create a voluntary program which property owners will identify and hire a contractor to perform the design/work for their respective property, if they should choose to participate. The hired contractor would then be obligated to abide by criteria and inspection, set forth by USACE. Once these criteria are met and the work is completed, the property owners would be reimbursed.

3.4.2 Prime Contractors

3.4.2.1 Job Office Overhead (JOOH)

Job Office Overhead (JOOH) is currently estimated by a running percentage within the estimate for the Prime contractor. Because of the assumptions made in regard to a Small Business Contractor performing the majority of the work, the estimate uses 15% and is based on similar-sized projects and would account for such items as project supervision, contractor quality control, contractor field office supplies, personal protective equipment, field engineering, and other incidental field overhead costs.

3.4.2.2 Home Office Overhead (HOOH)

For Home Office Overhead (HOOH) expense, because of the assumptions made in regards to a Small Business Contractor performing the majority of the work, the estimate uses 10%. HOOH includes items such as office rental / ownership costs, utilities, office equipment ownership/maintenance, office staff (managers, accountants, clerical, etc.), insurance, and miscellaneous. The range of home office overhead can be quite broad and depends largely on the contractor’s annual volume of work and the type of work that is generally performed by the contractor.

3.4.2.3 Profit

Profit was included as a running percentage of 8% for Prime based on Estimator judgment.

3.4.2.4 Bonding

Bond was included as a running percentage of 1.0% (own work and subcontracted work).

3.4.3 Subcontractors

3.4.3.1 Overhead

All subcontractor overhead costs are set to 5% and 10% of direct cost to account their JOOH and HOOH costs, respectively. The exception is where a subcontractor has provided a quoted price including overhead. In that case, no additional markups have been included for subcontractor's overhead.

3.4.3.2 Profit

Sub Profit was included as a running percentage of 8% based on estimator judgement.

3.4.4 Escalation

The contract will be escalated to the mid-point of construction using EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS), to account for potential inflation during construction. This will be included in the TPCS file, not the cost estimate in MII. A rough schedule is included in Attachment D of this Appendix.

3.4.5 Construction Contingency

Contingency was applied based on the Cost Engineer's past experiences in performing Cost & Schedule Risk Analysis's. A formal risk analysis has not yet been performed to capture risk and assign appropriate contingencies more accurately. The estimated cost from MII will be broken out for the risk analysis so that each constructable element could be discussed as well as the other feature Civil Works Work Breakdown Structure (CWWBS) accounts. Based on the current estimate cost a formal CSRA is not required, and an Abbreviated Risk Analysis could be used. However, because of the complexity of the project a formal CSRA is planned. The results from the CSRA will be put into Attachment B of this Appendix once completed.

4 PROJECT FEATURE ACCOUNTS AND ASSOCIATED SCOPE

4.1 (01) LANDS & DAMAGES

- This feature includes all costs of acquiring for the project (by purchase or condemnation) real property or permanent interests therein, including Government costs, damages, and costs of disposal of real estate. Government costs include planning expenses for the real estate portion of the General Design Memo and for the detailed Real Estate Memo; and project real estate office administration, surveys, and marking for land acquisition purposes and appraisals.
- The cost estimate for this account was provided by the Real Estate PDT member and inserted into the MII estimate. More information can be found in the RE appendix/tab.

4.2 (06) FISH & WILDLIFE FACILITIES

- This account covers all cost to perform surveys for any potential listed species in the project's area such as mussels, turtles, salamanders, etc.
- Cost for this account were provided by the Biologist PDT member and account for Environmental ECP Assessment which would need to be performed on any demolish property. Additionally, costs were provided for general in-house expenses which might be needed during the D&I phase.
- Additionally, with the TSP, Environmental restoration measure have been included such as excavation and grading of streams and planting native trees, shrubs, and grasses.

4.3 (18) CULTURAL RESOURCES PRESERVATION

- This account includes all costs incurred by the government for actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties, and the mitigation of adverse effects, will be included in construction costs.
- These costs were provided by the Archeological PDT member. Provided cost account for coordination efforts, in house field work, contract management, and mitigation expected during the D&I phase.

4.4 (19) BUILDINGS, GROUNDS, AND UTILITIES

- These costs account for the non-structural plan which will be composed of flood proofing, raising in place, or acquiring/demolishing existing structures. In summary the structures breakdown as follows:
    - (9) structures to be dry flood proofed
    - (30) structures to be wet flood proofed

- (1) structure to be raised in place
- (13) structures to be acquired/demolished

4.5 (20) PERMENANT OPERATING EQUIPMENT

- This cost is meant to account for the Flood Warning and Emergency Evacuation Plan (FWEEP) which aims to create better flood preparedness and flood plain planning for the Beattyville Community. This would be measures such as inundation mapping, flood evacuation mapping, designing a flood sensor network, designing siren system, developing an emergency evacuation plan, and/or standing up a comprehensive flood plain management plan.
- Costs for these tasks are largely based on awarded contract for the Johnson County FRM project, Phase I. The level of effort in Beattyville is assumed to be significantly less as Johnson County was a county wide study.

4.6 (30) PLANNING, ENGINEERING, AND DESIGN

- The work covered under this account includes project management, project planning, preliminary design, final design, geotechnical and HTRW investigations, hydraulic modeling, preparation of plans & specifications, engineering during construction, adaptive management, coordination efforts, contract advertisement, opening of bids, and contract award.
- The cost for this account was estimated as percentage of the anticipated construction cost until a time in which the PDT can provide more accurate estimates for the D&I portion of the project.

4.7 (31) CONSTRUCTION MANAGEMENT (S&A)

- This feature includes such functions as inspection, supervision, project office administration, and distributive costs of area office and general overhead charged to the project. Costs for Office of the Chief of Engineers CE and Division Office Executive Direction and Management are not charged to Construction, General but to the General Expenses appropriation title.
- The cost for this account were estimated with input from the project manager and historical S&A rates from other similar-sized projects.

5 PROJECT SCHEDULE & DURATION

The current project schedule shows the Chief's Report being signed for this study on 12 DEC 2025. It is assumed that funding will be provided in parts based on previous projects and based on the Implementation Plan, Appendix G, the following work would be prioritized and broken into separate contracts or phases:

1. FWEEP (Contract #1)
2. Acquisitions in the floodway (Contract #2)
3. Recreation & Ecosystem (Contract #2)
4. Dry floodproof, wet floodproof Essential and community anchor structures (Contract #3)
5. Dry floodproof, wet floodproof, elevate (residential) Historic structures (Contract #4)

The actual overall schedule and durations are going to highly depend on property owner's participation, with the developed schedule assuming 100% participation. Should there be little interest or willingness from property owners to participate the overall project cost and duration could be dramatically less than depicted.

A rough order of magnitude schedule has been developed for each contract or phase and can be seen in Attachment D. The respective midpoints for construction and non-construction related activities were utilized in the Total Project Summary Sheet (TPCS).

6 TOTAL PROJECT COST SUMMARY (TPCS)

At the time of the economic analysis, conducted around June 14, 2024, the estimated construction cost was approximately $24,803,000, with the Total Project Cost estimated at $35,777,000. These figures represent the project cost presented during the Tentatively Selected Plan (TSP) selection meeting, as discussed with the vertical team at LRD and Non-Structural PCX. These estimates also form the basis for the financial data utilized throughout the draft report and would have been based off of this information.

Since the TSP meeting the cost have been refined and the up-to-date cost estimate for the Tentatively Selected Plan (TSP) at the Fiscal Year 2025 price level, referred to as the Project First Cost, is $30,068,000. This estimate excludes expenses incurred during the Feasibility Study and does not represent the Fully Funded Cost. The Fully Funded Cost, or Total Project Cost, which includes escalation to the anticipated midpoint(s) of construction, is estimated at $35,000,000. The detailed Total Project Cost Summary (TPCS) is provided in Attachment B of this Appendix.

ATTACHMENT A

MII SUMMARY REPORT

P2#: 498982

Location(s): Beattyville, KY

Lee County, KY

Solicitation Type: Full & Open (Assumed)

Solicitation #:

Procurement: Design-Bid-Build (Assumed)

Files located at <O:\ED\Public\MCACES\ED-M-C\0 Civil\FY24\498982 - Beattyville KY FRM (GI) Feasibility Study\02 - TSP>

EXISTING SITE CONDITIONS:

In March of 2021, the City of Beattyville (Beattyville) in Lee County, Kentucky suffered a severe flood event, estimated to be a 50-year or 2% annual exceedance probability (AEP) event (cresting at approximately 666.5 feet, impacting significant portions of the downtown area. Due to the configuration of Beattyville and its proximity to the Kentucky River, most of the businesses are in a high-risk flood area and many are located in the floodway. The recurrent flooding threatens life, causes loss of access to certain areas downtown, and has lasting adverse economic impacts for this already disadvantaged area. Additionally, frequent flooding creates a negative impact on the community structure and its identity, damages essential structures and infrastructure, and serves as a repetitive hazard to recreational facilities, activities, and tourism. Specific to the March of 2021 event, though there were no fatalities, most if not all businesses in downtown Beattyville suffered water damage and were closed for some time after the event. The flooding threat to human life, property damage, and economic loss for government, local businesses, and residents is substantial.

The compounded effects of Beattyville's location near the convergence of three forks of the Kentucky River (the North, Middle, and South Forks) and the increase in frequency and intensity of precipitation predicted for the area support the need for a flood risk management investigation in Beattyville. In response, the purpose of this study is to evaluate the flooding concerns in the area and identify potential alternatives which yield a positive impact on flood risk management.

SCOPE OF WORK for Tentativley Selected Plan (TSP):

Using the USACE Planning Processes, multiple alternatives (structural and non-structural) have been considered and eliminated with the tentatively selected plan (TSP) being a non-structural plan taking into consideration or prioritizing the structures within Beatyville deemed "essential" by the non-federal sponsor + historic structures + Flood Warning Emergency Evacuation Plan (FWEEP). Non-structural refering to actions taken to protect individual structures during future flood events (residential raising in-place, dry floodproofing, or wet floodproofing) or acquisition/demolition if a structure already existing within the flood plain.

Additionally on lands acquired within the flood plain, beneficial (recreational and environmental) re-use of those areas is planned through the installation of features such trails, picnic tables, historical markers, and planting native grasses, shrubs, and trees, as well as relocating an existing play ground.

Estimated by	Neal Ralston, PE, TCCE
Designed by	
Prepared by	Neal Ralston, PE, TCCE
Preparation Date	7/24/2024
Effective Date of Pricing	10/1/2023
Estimated Construction Time	Days

Reviewed by: Jacob Dehn, TCCC

This report is not copyrighted, but the information contained herein is For Official Use Only.

Date	Author	Note
11/9/2023 12:24:45 PM	Markups	**MARK-UPS:** Contractor Mark-Ups · Prime Contractor o PRIME JOOH: 15.0% o PRIME HOOH: 10.0% o PRIME PROFIT: 8.00% o BOND: 1.0% · Subcontractor Mark-Ups (General) o JOOH:10% o HOOH: 8% o Profit: 8% · Direct Mark-Ups o PRODUCTIVITY: 90% o Overtime: N/A o SALES TAX - 6% (Lee County, KY) o 2023 COST BOOK MARKUP (MAT): 6.39% - BASED UPON ENGINEERING NEWS RECORD (ENR) MATERIAL INDEX FACTORS FROM AUG 2022 TO MAY 2024 (6264 / 5888)
7/24/2024 1:21:38 PM	Implementation	Properties containing structures located in the floodplain (identified as acquisitions) will be mandatory acquisitions. Structures identified as dry floodproof, wet floodproof or raise in place will be voluntary. The Tentatively Selected Plan (TSP) will occur over a phased implementation period of approximately 5-10 years. However, the scale of the project is highly dependent upon the participation rate for implementation and the amount of funding allocated in any given year. If a structure owner does not want to participate in the project, USACE and the non-Federal Sponsor would defer any further action on that structure until such time as the structure owner elects to participate or until the period of eligibility ends. However, USACE reserves the right to determine whether a structure may be included in the nonstructural implementation after a structure owner has previously declined participation, and if allowed to participate, the timing and scheduling of such participation will not adversely impact the project. As funds are appropriated, scope would progress in the following order: 1.FWEEP (Contract #1) 2.Acquisitions in the floodway (Contract #2) 3.Recreation (Contract #2) 4.Dry floodproof, wet floodproof Essential and community anchor structures (Contract #3) 5.Dry floodproof, wet floodproof, elevate (residential) Historic structures (Contract #4)
7/24/2024 2:20:54 PM	Schedule & Escalation	New Project Note

Description	Quantity	UOM	DirectCost	ContractCost	Escalation	Contingency	SIOH	ProjectCost
Cost Summary Report			[redacted]	[redacted]	0	0	0	[redacted]
Alternative 5c - Essential / Historic Non-Structural Focus + FWEEP	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #1 - FWEEP	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Environmental Restoration	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study**
PROJECT NO: 498892
LOCATION: Beattyville, KY (Lee County)

DISTRICT: Louisville District, LRL **PREPARED: 7/15/2025**
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC

This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2026									
						Effective Price Level Date: 1 OCT 25									
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 1-Oct-23 ($K)	TOTAL FIRST COST ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES														
14	RECREATION FACILITIES														
18	CULTURAL RESOURCE PRESERVATION														
19	BUILDINGS, GROUNDS & UTILITIES														
20	PERMANENT OPERATING EQUIPMENT (FWEEP)														
	CONSTRUCTION ESTIMATE TOTALS:														
01	LANDS AND DAMAGES														
30	PLANNING, ENGINEERING & DESIGN														
31	CONSTRUCTION MANAGEMENT														
	PROJECT COST TOTALS:														

ESTIMATED TOTAL PROJECT COST:

CHIEF, COST ENGINEERING, Jim Vermillion, TCCC

PROJECT MANAGER, Jacob Sinkhorn, PE

CHIEF, REAL ESTATE, Ashley Klimaszewski

CHIEF, PLANNING, Nate Moulder

CHIEF, ENGINEERING, Ian Mitchel, PE

CHIEF, OPERATIONS, Waylon Humphrey

CHIEF, CONSTRUCTION, Kevin Jefferson

CHIEF, CONTRACTING, Misty Bock

CHIEF, PM-PB, Matt Schueler

CHIEF, DPM, John Bock, PE

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25								
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	RISK BASED CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Contract/Phase #1 - FWEEP													
06	FISH & WILDLIFE FACILITIES	[redacted]												
14	RECREATION FACILITIES	[redacted]												
18	CULTURAL RESOURCE PRESERVATION	[redacted]												
19	BUILDINGS, GROUNDS & UTILITIES	[redacted]												
20	PERMANENT OPERATING EQUIPMENT (FWEEP)	[redacted]												
	CONSTRUCTION ESTIMATE TOTALS:	[redacted]												
01	LANDS AND DAMAGES	[redacted]												
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	[redacted]												
0.5%	Planning & Environmental Compliance	[redacted]												
10.0%	Engineering & Design	[redacted]												
1.0%	Reviews, ATRs, IEPRs, VE	[redacted]												
1.0%	Life Cycle Updates (cost, schedule, risks)	[redacted]												
1.0%	Contracting & Reprographics	[redacted]												
1.0%	Engineering During Construction	[redacted]												
1.0%	Planning During Construction	[redacted]												
0.5%	Adaptive Management & Monitoring	[redacted]												
0.5%	Project Operations	[redacted]												
	Real Estate (All Federal Labor)	[redacted]												
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	[redacted]												
0.5%	Project Operation:	[redacted]												
1.0%	Project Management	[redacted]												
	CONTRACT COST TOTALS:	[redacted]												

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25								
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Enviornmental Restoration													
06	FISH & WILDLIFE FACILITIES													
14	RECREATION FACILITIES													
18	CULTURAL RESOURCE PRESERVATION													
19	BUILDINGS, GROUNDS & UTILITIES													
20	PERMANENT OPERATING EQUIPMENT (FWEEP)													
	CONSTRUCTION ESTIMATE TOTALS:													
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2029Q3	11.3%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2029Q3	11.3%			
10.0%	Engineering & Design			20.0%		6.6%				2029Q3	11.3%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2029Q3	11.3%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2029Q3	11.3%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2029Q3	11.3%			
1.0%	Engineering During Construction			20.0%		6.6%				2029Q3	11.3%			
1.0%	Planning During Construction			20.0%		6.6%				2029Q3	11.3%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2029Q3	11.3%			
0.5%	Project Operations			20.0%		6.6%				2029Q3	11.3%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2028Q4	8.8%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2029Q3	11.3%			
0.5%	Project Operation:			20.0%		6.6%				2029Q3	11.3%			
1.0%	Project Management			20.0%		6.6%				2029Q3	11.3%			
	CONTRACT COST TOTALS:													

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25								
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof													
06	FISH & WILDLIFE FACILITIES			40.0%		5.6%				2031Q4	15.9%			
14	RECREATION FACILITIES			40.0%		0.0%				0	0.0%			
18	CULTURAL RESOURCE PRESERVATION			40.0%		5.6%				2031Q4	15.9%			
19	BUILDINGS, GROUNDS & UTILITIES			40.0%		5.6%				2031Q4	15.9%			
20	PERMANENT OPERATING EQUIPMENT			0.0%		0.0%				0	0.0%			
	(FWEEP)			0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
	CONSTRUCTION ESTIMATE TOTALS:			40.0%										
01	LANDS AND DAMAGES			40.0%		5.4%				2029Q4	10.1%			
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2031Q4	19.1%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2031Q4	19.1%			
10.0%	Engineering & Design			20.0%		6.6%				2031Q4	19.1%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2031Q4	19.1%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2031Q4	19.1%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2031Q4	19.1%			
1.0%	Engineering During Construction			20.0%		6.6%				2031Q4	19.1%			
1.0%	Planning During Construction			20.0%		6.6%				2031Q4	19.1%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2031Q4	19.1%			
0.5%	Project Operations			20.0%		6.6%				2031Q4	19.1%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2029Q4	12.1%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2031Q4	19.1%			
0.5%	Project Operation:			20.0%		6.6%				2031Q4	19.1%			
1.0%	Project Management			20.0%		6.6%				2031Q4	19.1%			
	CONTRACT COST TOTALS:													

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place													
06	FISH & WILDLIFE FACILITIES			40.0%		5.6%				2032Q4	18.9%			
14	RECREATION FACILITIES			40.0%		0.0%				0	0.0%			
18	CULTURAL RESOURCE PRESERVATION			40.0%		5.6%				2032Q4	18.9%			
19	BUILDINGS, GROUNDS & UTILITIES			40.0%		5.6%				2034Q4	25.2%			
20	PERMANENT OPERATING EQUIPMENT			0.0%		0.0%				0	0.0%			
	(FWEEP)			0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
	CONSTRUCTION ESTIMATE TOTALS:			40.0%										
01	LANDS AND DAMAGES			40.0%		5.4%				2032Q4	18.9%			
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2034Q4	30.4%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2034Q4	30.4%			
10.0%	Engineering & Design			20.0%		6.6%				2034Q4	30.4%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2034Q4	30.4%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2034Q4	30.4%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2034Q4	30.4%			
1.0%	Engineering During Construction			20.0%		6.6%				2034Q4	30.4%			
1.0%	Planning During Construction			20.0%		6.6%				2034Q4	30.4%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2034Q4	30.4%			
0.5%	Project Operations			20.0%		6.6%				2034Q4	30.4%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2032Q4	22.8%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2034Q4	30.4%			
0.5%	Project Operation:			20.0%		6.6%				2034Q4	30.4%			
1.0%	Project Management			20.0%		6.6%				2034Q4	30.4%			
	CONTRACT COST TOTALS:													

ATTACHMENT B

COST & SCHEDULE RISK ANALYSIS (CSRA)

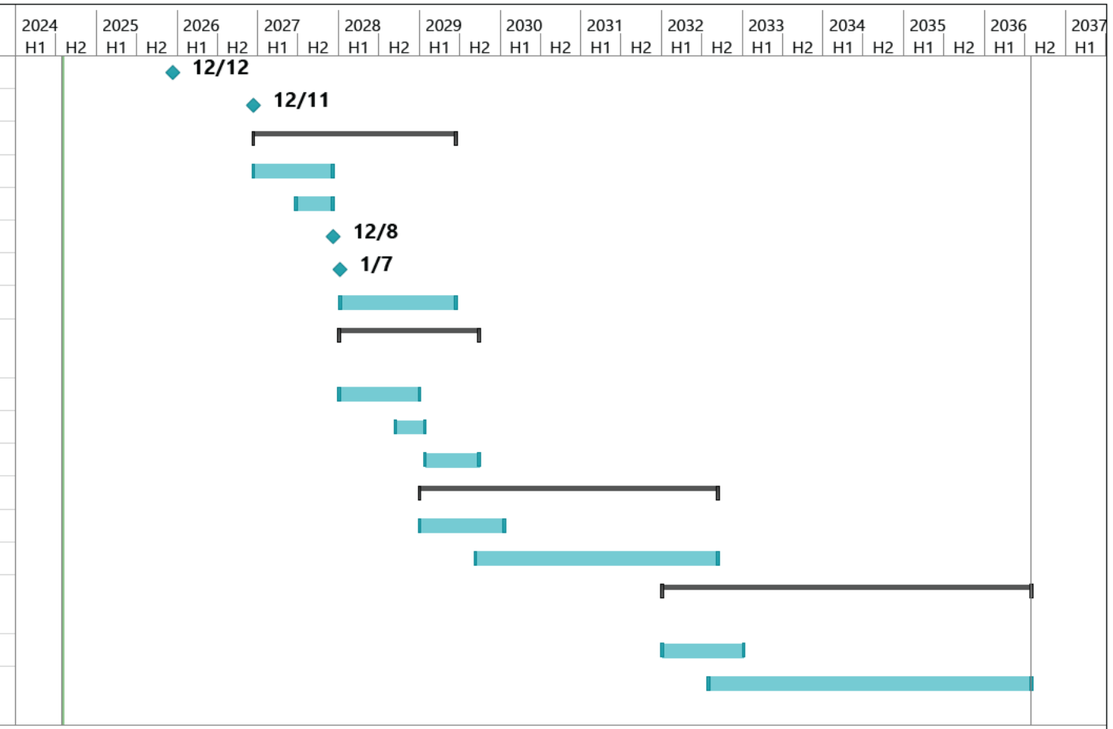
ATTACHMENT C

TOTAL PROJECT COST SUMMARY SHEET (TPCS)

ATTACHMENT D

CONSTRUCTION SCHEDULE

ID	Task Mode	Task Name	Duration	Start	Finish
1		Chief's Report Signature	0 days	Fri 12/12/25	Fri 12/12/25
2		Project Partnership Agreement (PPA) Signed & Executed	0 days	Fri 12/11/26	Fri 12/11/26
3		**Contract/Phase #1 - FWEEP**	**656 days**	**Fri 12/11/26**	**Fri 6/15/29**
4		Real Estate Acquisitions	258 days	Fri 12/11/26	Tue 12/7/27
5		D/B RFP Development	120 days	Wed 6/23/27	Tue 12/7/27
6		Contract Award to A/E Design Firm	0 days	Wed 12/8/27	Wed 12/8/27
7		Notice to Proceed (NTP) Issued	0 days	Fri 1/7/28	Fri 1/7/28
8		Design, Implementation, & Construction of required features	376 days	Fri 1/7/28	Fri 6/15/29
9		**Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Enviornmental Restoration**	**455 days**	**Mon 1/3/28**	**Fri 9/28/29**
10		Acquire Properties to be Demolished (Non-Federal Sponsor)	262 days	Mon 1/3/28	Tue 1/2/29
11		Demolish Acquired Structures Identified, 13 structures	95 days	Fri 9/15/28	Thu 1/25/29
12		Environmental Restoration / Recreational Work	176 days	Fri 1/26/29	Fri 9/28/29
13		**Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof**	**963 days**	**Wed 1/3/29**	**Sun 9/12/32**
14		Real Estate Acquisition/LEERDs	273 days	Wed 1/3/29	Fri 1/18/30
15		Design, Implementation, & Construction - (7) Wet, (8) Dry	784 days	Wed 9/12/29	Sun 9/12/32
16		**Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place**	**1194 days**	**Sat 1/3/32**	**Thu 7/31/36**
17		Real Estate Acquisition/LEERDs	265 days	Sat 1/3/32	Thu 1/6/33
18		Design, Implementation, & Construction - (23) Wet, (1) Dry, (1) Raise	1044 days	Mon 8/2/32	Thu 7/31/36



Project: Beattyville_KY - FRM Fe
Date: Mon 8/5/24

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

Appendix C
Cost Estimate

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 INTRODUCTION

This Appendix presents the cost estimate that has been assembled for the Flood Risk Management (FRM) General Investigation (GI) Feasibility Study in Beattyville, KY. A discussion regarding cost, schedule and risk is included in this Appendix which contains all appropriate feature accounts. What follows is a discussion regarding the methodology used to develop the first cost for the Tentatively Selected Plan (TSP).

The costs provided have undergone District Quality Control (DQC) Review by Louisville District and pending Agency Technical Review (ATR) at the Walla Walla Cost Center of Expertise but is planned for in the coming weeks and months. These reviews will verify the reasonableness of total project costs, including the construction costs and calculated contingencies using the mandated Risk Analysis techniques.

2 REFRENCES

- ER 1110-1-1300, Cost Engineering Policy & General Requirements, 26 Mar 1993.
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016.
- ER 1110-2-1150, Engineering & Design for Civil Works Projects, 31 Aug 1999.
- ER 37-2-10 Change 89, Accounting And Reporting – Civil Works Activities, 31 Oct 2000.
- EC 11-2-187, Corps of Engineers Civil Works Direct Program: Program Development Guidance – Fiscal Year 2009, 30 Mar 2007.
- EP 1110-1-8 Volume 2, Construction Equipment Ownership and Operating Expense Schedule – Region II, July 2007.
- EC Bulletin No 2007-17, Application of Cost Risk Analysis Methods to develop Contingencies for Civil Works Total Project Costs, 10 Sep 2007.
- EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS), 30 Sept 2021.
- EC 1105-2-410, Review of Decision Documents, 22 Aug 2008
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 Sept 2008.

3 METHODOLOGY

3.1 GENERAL

The cost estimate was prepared using the Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII), version 4.4.3 for all feature accounts associated with construction. Applicable crews and equipment were applied in the estimate to correspond with the work being performed. Material prices were developed using the

2023 MII Cost Book and quotes were obtained from suppliers, when available. Cost which are not construction related (Lands & Damages, Cultural Resources, PED, CM, etc.) rely on PDT input or are calculated based on percentage(s) of the construction cost, based on other project experience.

3.2 COST METHODOLOGY

3.2.1 Historical Unit Pricing

In some instances, historical cost information was referenced and documented accordingly. These historical references include past contract bid prices for projects of similar design and magnitude and recent government studies and cost estimates.

3.2.2 Quote-in-Place

In some instances, a quote from a subcontractor may have been received that included overhead and profit. In that case, no additional markups were included for subcontractor's overhead.

3.2.3 Detailed MII Cost Estimate

The MII estimating software was used to develop a construction sequence for each item of work and applying detailed line items and crews to perform the work. Crews were developed in correspondence with the work being performed and estimated productivities. Wage rates were taken from the local Davis Bacon rates. The latest MII equipment database was also used and adjusted for current fuel and energy costs. Material prices were obtained through telephone solicitations with vendors, Internet suppliers, the MII Cost Book, and RS MEANS.

With much of the selected plan focused on cost which are considered Non-Structural, sources of information were difficult to come by and, when available, work previously completed by others was used to develop cost. For example, tools were provided by the Cost Engineer(s) assigned to the National Non-Structural Committee and were utilized to develop cost, specifically for structures identified to receive dry flood proofing or to be raised in place. These tools rely on a detailed structure inventory identifying building characteristics such as first floor elevation (FFE), structure square footage, structure perimeter, count/length of openings at grade, foundation type, etc. These characteristics feed into a Microsoft Excel spreadsheet which outputs all the relevant quantities which are then feed into pre-built folders/CSI task in the MCACES MII software.

Cost for structures identified to be acquired/demolished were developed by the Cost Engineer. A general assumption about these structures was made for use of developing Rough Order of Magnitude (ROM) cost so that alternatives could be compared to one another. This allows the PDT to get to a point in which an alternative could be chosen for the TSP.

Over the coming weeks and months, refinement of the TSP will occur and a closer, more detailed look at each structure will take place to ensure cost are being captured appropriately for each building type.

A summary level report of the MII cost estimate for the TSP, as it is currently assumed, can be found in Attachment A.

3.3 DIRECT COSTS

Direct costs are based on anticipated equipment, labor, and materials necessary to construct this project. Following formulation of the direct cost, a determination is made as to whether the work would be performed by the prime contractor or a subcontractor.

3.3.1 Labor - Wage Determination

Wage rates were taken from the latest Davis-Bacon wage determination KY20240043, Building updated on https://www.sam.gov as recent as 07/05/2024. Recognizing that Davis Bacon rates for specific trades sometimes lag an update, possibly for years, a labor adjustment tool was utilized which references the Employment Cost Index: Wages and Salaries: Private Construction Workers: Construction (ECICONWAG) index put out by the Federal Reserve Economic Data (FRED) https://www.stlouisfed.org. This index allows labor rates to be escalated to be representative of anticipated growth of labor cost, since the last Davis Bacon update.

3.3.2 Equipment Costs

The 2022 Equipment database, based on EP 1110-1-8, Construction Equipment Ownership and Operation Expense Schedule, Region II, was used and adjusted for current, local fuel and energy costs per https://www.eia.gov as recent at 07/22/2024.

3.3.3 Vendor Quotes

Vendor quotes will be or have been acquired and documented for the anticipated cost driving materials. At the time of the development of this initial cost, reliance on the provided tools and Cost book data was used. During the forthcoming refinement period, better coordination with contractors and vendors will help build more realistic and accurate cost. In some cases, given how little about non-structural cost are known across the USACE Enterprise, heavy reliance on input from Contractors may be the ideal path forward.

3.3.4 Crews

Project specific crews have been developed and applied to the detailed line items as appropriate. Crew members consist of selected complements of labor classifications and equipment pieces assembled to perform specific tasks. Productivity has been assigned to each crew reflective of the expected output per unit of measure for the specific activities listed in the cost estimate. In considering the crews and productivities, the engineer

typically referenced other, similar work found in national reference manuals such as RS MEANS construction data, the MII Cost book, and other projects developed by USACE.

3.3.5 Quantities

Quantities were developed by USACE for each feature of work. Quantities were checked/verified by the estimator and adjusted to account for construction methodology, shrink, swell, waste, etc. Other associated sub-quantities were also developed by the estimator, as needed. The primary method for quantification was through the use of the structure inventory developed by the PDT and the tools provided from the Cost Engineer(s) on the National Non-Structural Committee.

3.4 INDIRECT COSTS

3.4.1 Contract Acquisition Strategy

Through discussions with the Project Manager (PM) & PDT, it is very likely that the scope of this project, if funded, would be broken into multiple contracts which priorities structures. The acquisition method will likely be reflected in the estimate as Small Business as the plan would be to create a voluntary program which property owners will identify and hire a contractor to perform the design/work for their respective property, if they should choose to participate. The hired contractor would then be obligated to abide by criteria and inspection, set forth by USACE. Once these criteria are met and the work is completed, the property owners would be reimbursed.

3.4.2 Prime Contractors

3.4.2.1 Job Office Overhead (JOOH)

Job Office Overhead (JOOH) is currently estimated by a running percentage within the estimate for the Prime contractor. Because of the assumptions made in regard to a Small Business Contractor performing the majority of the work, the estimate uses 15% and is based on similar-sized projects and would account for such items as project supervision, contractor quality control, contractor field office supplies, personal protective equipment, field engineering, and other incidental field overhead costs.

3.4.2.2 Home Office Overhead (HOOH)

For Home Office Overhead (HOOH) expense, because of the assumptions made in regards to a Small Business Contractor performing the majority of the work, the estimate uses 10%. HOOH includes items such as office rental / ownership costs, utilities, office equipment ownership/maintenance, office staff (managers, accountants, clerical, etc.), insurance, and miscellaneous. The range of home office overhead can be quite broad and depends largely on the contractor’s annual volume of work and the type of work that is generally performed by the contractor.

3.4.2.3 Profit

Profit was included as a running percentage of 8% for Prime based on Estimator judgment.

3.4.2.4 Bonding

Bond was included as a running percentage of 1.0% (own work and subcontracted work).

3.4.3 Subcontractors

3.4.3.1 Overhead

All subcontractor overhead costs are set to 5% and 10% of direct cost to account their JOOH and HOOH costs, respectively. The exception is where a subcontractor has provided a quoted price including overhead. In that case, no additional markups have been included for subcontractor's overhead.

3.4.3.2 Profit

Sub Profit was included as a running percentage of 8% based on estimator judgement.

3.4.4 Escalation

The contract will be escalated to the mid-point of construction using EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS), to account for potential inflation during construction. This will be included in the TPCS file, not the cost estimate in MII. A rough schedule is included in Attachment D of this Appendix.

3.4.5 Construction Contingency

Contingency was applied based on the Cost Engineer's past experiences in performing Cost & Schedule Risk Analysis's. A formal risk analysis has not yet been performed to capture risk and assign appropriate contingencies more accurately. The estimated cost from MII will be broken out for the risk analysis so that each constructable element could be discussed as well as the other feature Civil Works Work Breakdown Structure (CWWBS) accounts. Based on the current estimate cost a formal CSRA is not required, and an Abbreviated Risk Analysis could be used. However, because of the complexity of the project a formal CSRA is planned. The results from the CSRA will be put into Attachment B of this Appendix once completed.

4 PROJECT FEATURE ACCOUNTS AND ASSOCIATED SCOPE

4.1 (01) LANDS & DAMAGES

- This feature includes all costs of acquiring for the project (by purchase or condemnation) real property or permanent interests therein, including Government costs, damages, and costs of disposal of real estate. Government costs include planning expenses for the real estate portion of the General Design Memo and for the detailed Real Estate Memo; and project real estate office administration, surveys, and marking for land acquisition purposes and appraisals.
- The cost estimate for this account was provided by the Real Estate PDT member and inserted into the MII estimate. More information can be found in the RE appendix/tab.

4.2 (06) FISH & WILDLIFE FACILITIES

- This account covers all cost to perform surveys for any potential listed species in the project's area such as mussels, turtles, salamanders, etc.
- Cost for this account were provided by the Biologist PDT member and account for Environmental ECP Assessment which would need to be performed on any demolish property. Additionally, costs were provided for general in-house expenses which might be needed during the D&I phase.
- Additionally, with the TSP, Environmental restoration measure have been included such as excavation and grading of streams and planting native trees, shrubs, and grasses.

4.3 (18) CULTURAL RESOURCES PRESERVATION

- This account includes all costs incurred by the government for actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties, and the mitigation of adverse effects, will be included in construction costs.
- These costs were provided by the Archeological PDT member. Provided cost account for coordination efforts, in house field work, contract management, and mitigation expected during the D&I phase.

4.4 (19) BUILDINGS, GROUNDS, AND UTILITIES

- These costs account for the non-structural plan which will be composed of flood proofing, raising in place, or acquiring/demolishing existing structures. In summary the structures breakdown as follows:
    - (9) structures to be dry flood proofed
    - (30) structures to be wet flood proofed

- (1) structure to be raised in place
- (13) structures to be acquired/demolished

4.5 (20) PERMENANT OPERATING EQUIPMENT

- This cost is meant to account for the Flood Warning and Emergency Evacuation Plan (FWEEP) which aims to create better flood preparedness and flood plain planning for the Beattyville Community. This would be measures such as inundation mapping, flood evacuation mapping, designing a flood sensor network, designing siren system, developing an emergency evacuation plan, and/or standing up a comprehensive flood plain management plan.
- Costs for these tasks are largely based on awarded contract for the Johnson County FRM project, Phase I. The level of effort in Beattyville is assumed to be significantly less as Johnson County was a county wide study.

4.6 (30) PLANNING, ENGINEERING, AND DESIGN

- The work covered under this account includes project management, project planning, preliminary design, final design, geotechnical and HTRW investigations, hydraulic modeling, preparation of plans & specifications, engineering during construction, adaptive management, coordination efforts, contract advertisement, opening of bids, and contract award.
- The cost for this account was estimated as percentage of the anticipated construction cost until a time in which the PDT can provide more accurate estimates for the D&I portion of the project.

4.7 (31) CONSTRUCTION MANAGEMENT (S&A)

- This feature includes such functions as inspection, supervision, project office administration, and distributive costs of area office and general overhead charged to the project. Costs for Office of the Chief of Engineers CE and Division Office Executive Direction and Management are not charged to Construction, General but to the General Expenses appropriation title.
- The cost for this account were estimated with input from the project manager and historical S&A rates from other similar-sized projects.

5 PROJECT SCHEDULE & DURATION

The current project schedule shows the Chief's Report being signed for this study on 12 DEC 2025. It is assumed that funding will be provided in parts based on previous projects and based on the Implementation Plan, Appendix G, the following work would be prioritized and broken into separate contracts or phases:

1. FWEEP (Contract #1)
2. Acquisitions in the floodway (Contract #2)
3. Recreation & Ecosystem (Contract #2)
4. Dry floodproof, wet floodproof Essential and community anchor structures (Contract #3)
5. Dry floodproof, wet floodproof, elevate (residential) Historic structures (Contract #4)

The actual overall schedule and durations are going to highly depend on property owner's participation, with the developed schedule assuming 100% participation. Should there be little interest or willingness from property owners to participate the overall project cost and duration could be dramatically less than depicted.

A rough order of magnitude schedule has been developed for each contract or phase and can be seen in Attachment D. The respective midpoints for construction and non-construction related activities were utilized in the Total Project Summary Sheet (TPCS).

6 TOTAL PROJECT COST SUMMARY (TPCS)

The cost estimate for the Tentatively Selected Plan (TSP) at the FY25 price level (Project First Cost) is [redacted]. This excludes cost which have been spent to perform the Feasibility Study itself and does not represent Fully Funded Cost. The fully funded cost, or Total Project Cost, including escalation to the anticipated midpoint(s) of construction, is [redacted]. The Total Project Cost Summary (TPCS) can be found in Attachment B of this Appendix.

ATTACHMENT A

MII SUMMARY REPORT

P2#: 498982

Location(s): Beattyville, KY

Lee County, KY

Solicitation Type: Full & Open (Assumed)

Solicitation #:

Procurement: Design-Bid-Build (Assumed)

Files located at <O:\ED\Public\MCACES\ED-M-C\0 Civil\FY24\498982 - Beattyville KY FRM (GI) Feasibility Study\02 - TSP>

EXISTING SITE CONDITIONS:

In March of 2021, the City of Beattyville (Beattyville) in Lee County, Kentucky suffered a severe flood event, estimated to be a 50-year or 2% annual exceedance probability (AEP) event (cresting at approximately 666.5 feet, impacting significant portions of the downtown area. Due to the configuration of Beattyville and its proximity to the Kentucky River, most of the businesses are in a high-risk flood area and many are located in the floodway. The recurrent flooding threatens life, causes loss of access to certain areas downtown, and has lasting adverse economic impacts for this already disadvantaged area. Additionally, frequent flooding creates a negative impact on the community structure and its identity, damages essential structures and infrastructure, and serves as a repetitive hazard to recreational facilities, activities, and tourism. Specific to the March of 2021 event, though there were no fatalities, most if not all businesses in downtown Beattyville suffered water damage and were closed for some time after the event. The flooding threat to human life, property damage, and economic loss for government, local businesses, and residents is substantial.

The compounded effects of Beattyville's location near the convergence of three forks of the Kentucky River (the North, Middle, and South Forks) and the increase in frequency and intensity of precipitation predicted for the area support the need for a flood risk management investigation in Beattyville. In response, the purpose of this study is to evaluate the flooding concerns in the area and identify potential alternatives which yield a positive impact on flood risk management.

SCOPE OF WORK for Tentativley Selected Plan (TSP):

Using the USACE Planning Processes, multiple alternatives (structural and non-structural) have been considered and eliminated with the tentatively selected plan (TSP) being a non-structural plan taking into consideration or prioritizing the structures within Beatyville deemed "essential" by the non-federal sponsor + historic structures + Flood Warning Emergency Evacuation Plan (FWEEP). Non-structural refering to actions taken to protect individual structures during future flood events (residential raising in-place, dry floodproofing, or wet floodproofing) or acquisition/demolition if a structure already existing within the flood plain.

Additionally on lands acquired within the flood plain, beneficial (recreational and environmental) re-use of those areas is planned through the installation of features such trails, picnic tables, historical markers, and planting native grasses, shrubs, and trees, as well as relocating an existing play ground.

Estimated by	Neal Ralston, PE, TCCE
Designed by	
Prepared by	Neal Ralston, PE, TCCE
Preparation Date	7/24/2024
Effective Date of Pricing	10/1/2023
Estimated Construction Time	Days

Reviewed by: Jacob Dehn, TCCC

This report is not copyrighted, but the information contained herein is For Official Use Only.

Date	Author	Note
11/9/2023 12:24:45 PM	Markups	**MARK-UPS:** Contractor Mark-Ups · Prime Contractor o PRIME JOOH: 15.0% o PRIME HOOH: 10.0% o PRIME PROFIT: 8.00% o BOND: 1.0% · Subcontractor Mark-Ups (General) o JOOH:10% o HOOH: 8% o Profit: 8% · Direct Mark-Ups o PRODUCTIVITY: 90% o Overtime: N/A o SALES TAX - 6% (Lee County, KY) o 2023 COST BOOK MARKUP (MAT): 6.39% - BASED UPON ENGINEERING NEWS RECORD (ENR) MATERIAL INDEX FACTORS FROM AUG 2022 TO MAY 2024 (6264 / 5888)
7/24/2024 1:21:38 PM	Implementation	Properties containing structures located in the floodplain (identified as acquisitions) will be mandatory acquisitions. Structures identified as dry floodproof, wet floodproof or raise in place will be voluntary. The Tentatively Selected Plan (TSP) will occur over a phased implementation period of approximately 5-10 years. However, the scale of the project is highly dependent upon the participation rate for implementation and the amount of funding allocated in any given year. If a structure owner does not want to participate in the project, USACE and the non-Federal Sponsor would defer any further action on that structure until such time as the structure owner elects to participate or until the period of eligibility ends. However, USACE reserves the right to determine whether a structure may be included in the nonstructural implementation after a structure owner has previously declined participation, and if allowed to participate, the timing and scheduling of such participation will not adversely impact the project. As funds are appropriated, scope would progress in the following order: 1.FWEEP (Contract #1) 2.Acquisitions in the floodway (Contract #2) 3.Recreation (Contract #2) 4.Dry floodproof, wet floodproof Essential and community anchor structures (Contract #3) 5.Dry floodproof, wet floodproof, elevate (residential) Historic structures (Contract #4)
7/24/2024 2:20:54 PM	Schedule & Escalation	New Project Note

Description	Quantity	UOM	DirectCost	ContractCost	Escalation	Contingency	SIOH	ProjectCost
Cost Summary Report			[redacted]	[redacted]	0	0	0	[redacted]
Alternative 5c - Essential / Historic Non-Structural Focus + FWEEP	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #1 - FWEEP	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Environmental Restoration	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]
Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place	1.00	LS	[redacted]	[redacted]	0	0	0	[redacted]

ATTACHMENT B

COST & SCHEDULE RISK ANALYSIS (CSRA)

ATTACHMENT C

TOTAL PROJECT COST SUMMARY SHEET (TPCS)

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study**
PROJECT NO: 498892
LOCATION: Beattyville, KY (Lee County)

DISTRICT: Louisville District, LRL **PREPARED: 7/15/2025**
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC

This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2026									
						Effective Price Level Date: 1 OCT 25									
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 1-Oct-23 ($K)	TOTAL FIRST COST ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES														
14	RECREATION FACILITIES														
18	CULTURAL RESOURCE PRESERVATION														
19	BUILDINGS, GROUNDS & UTILITIES														
20	PERMANENT OPERATING EQUIPMENT (FWEEP)														
	CONSTRUCTION ESTIMATE TOTALS:														
01	LANDS AND DAMAGES														
30	PLANNING, ENGINEERING & DESIGN														
31	CONSTRUCTION MANAGEMENT														
	PROJECT COST TOTALS:														

ESTIMATED TOTAL PROJECT COST:

CHIEF, COST ENGINEERING, Jim Vermillion, TCCC

PROJECT MANAGER, Jacob Sinkhorn, PE

CHIEF, REAL ESTATE, Ashley Klimaszewski

CHIEF, PLANNING, Nate Moulder

CHIEF, ENGINEERING, Ian Mitchel, PE

CHIEF, OPERATIONS, Waylon Humphrey

CHIEF, CONSTRUCTION, Kevin Jefferson

CHIEF, CONTRACTING, Misty Bock

CHIEF, PM-PB, Matt Schueler

CHIEF, DPM, John Bock, PE

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25								
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	RISK BASED CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	TOTAL ($K) *J*	Mid-Point Date *P*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
	Contract/Phase #1 - FWEEP													
06	FISH & WILDLIFE FACILITIES	[redacted]												
14	RECREATION FACILITIES	[redacted]												
18	CULTURAL RESOURCE PRESERVATION	[redacted]												
19	BUILDINGS, GROUNDS & UTILITIES	[redacted]												
20	PERMANENT OPERATING EQUIPMENT (FWEEP)	[redacted]												
	CONSTRUCTION ESTIMATE TOTALS:	[redacted]												
01	LANDS AND DAMAGES	[redacted]												
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management	[redacted]												
0.5%	Planning & Environmental Compliance	[redacted]												
10.0%	Engineering & Design	[redacted]												
1.0%	Reviews, ATRs, IEPRs, VE	[redacted]												
1.0%	Life Cycle Updates (cost, schedule, risks)	[redacted]												
1.0%	Contracting & Reprographics	[redacted]												
1.0%	Engineering During Construction	[redacted]												
1.0%	Planning During Construction	[redacted]												
0.5%	Adaptive Management & Monitoring	[redacted]												
0.5%	Project Operations	[redacted]												
	Real Estate (All Federal Labor)	[redacted]												
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management	[redacted]												
0.5%	Project Operation:	[redacted]												
1.0%	Project Management	[redacted]												
	CONTRACT COST TOTALS:	[redacted]												

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
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PREPARED: 7/15/2025

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	Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Enviornmental Restoration													
06	FISH & WILDLIFE FACILITIES													
14	RECREATION FACILITIES													
18	CULTURAL RESOURCE PRESERVATION													
19	BUILDINGS, GROUNDS & UTILITIES													
20	PERMANENT OPERATING EQUIPMENT (FWEEP)													
	CONSTRUCTION ESTIMATE TOTALS:													
01	LANDS AND DAMAGES													
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2029Q3	11.3%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2029Q3	11.3%			
10.0%	Engineering & Design			20.0%		6.6%				2029Q3	11.3%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2029Q3	11.3%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2029Q3	11.3%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2029Q3	11.3%			
1.0%	Engineering During Construction			20.0%		6.6%				2029Q3	11.3%			
1.0%	Planning During Construction			20.0%		6.6%				2029Q3	11.3%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2029Q3	11.3%			
0.5%	Project Operations			20.0%		6.6%				2029Q3	11.3%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2028Q4	8.8%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2029Q3	11.3%			
0.5%	Project Operation:			20.0%		6.6%				2029Q3	11.3%			
1.0%	Project Management			20.0%		6.6%				2029Q3	11.3%			
	CONTRACT COST TOTALS:													

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25								
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof													
06	FISH & WILDLIFE FACILITIES			40.0%		5.6%				2031Q4	15.9%			
14	RECREATION FACILITIES			40.0%		0.0%				0	0.0%			
18	CULTURAL RESOURCE PRESERVATION			40.0%		5.6%				2031Q4	15.9%			
19	BUILDINGS, GROUNDS & UTILITIES			40.0%		5.6%				2031Q4	15.9%			
20	PERMANENT OPERATING EQUIPMENT			0.0%		0.0%				0	0.0%			
	(FWEEP)			0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
	CONSTRUCTION ESTIMATE TOTALS:			40.0%										
01	LANDS AND DAMAGES			40.0%		5.4%				2029Q4	10.1%			
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2031Q4	19.1%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2031Q4	19.1%			
10.0%	Engineering & Design			20.0%		6.6%				2031Q4	19.1%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2031Q4	19.1%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2031Q4	19.1%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2031Q4	19.1%			
1.0%	Engineering During Construction			20.0%		6.6%				2031Q4	19.1%			
1.0%	Planning During Construction			20.0%		6.6%				2031Q4	19.1%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2031Q4	19.1%			
0.5%	Project Operations			20.0%		6.6%				2031Q4	19.1%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2029Q4	12.1%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2031Q4	19.1%			
0.5%	Project Operation:			20.0%		6.6%				2031Q4	19.1%			
1.0%	Project Management			20.0%		6.6%				2031Q4	19.1%			
	CONTRACT COST TOTALS:													

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Beattyville_KY - Flood Risk Management (FRM) - Feasibility Study
LOCATION: Beattyville, KY (Lee County)
This Estimate reflects the scope and schedule in report; Beattyville Feasibility Report_FOR_DQC

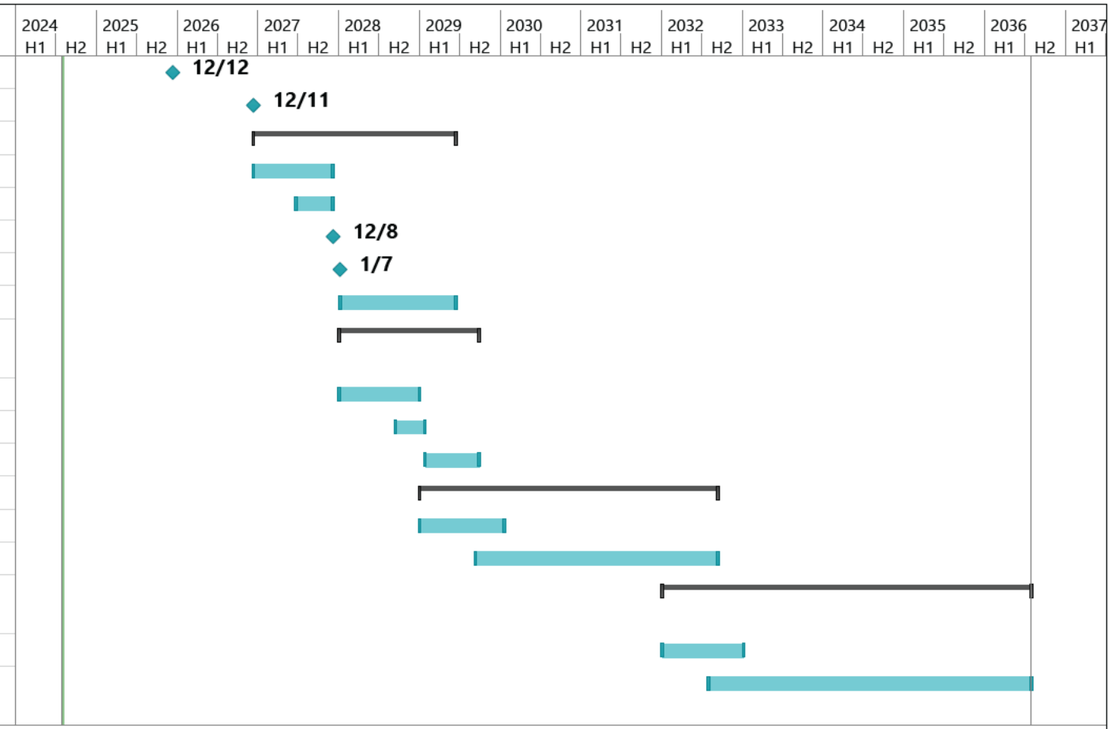
DISTRICT: Louisville District, LRL
POC: CHIEF, COST ENGINEERING, Jim Vermillion, TCCC
PREPARED: 7/15/2025

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 12-Jul-25 Effective Price Level: 1-Oct-23				Program Year (Budget EC): 2026 Effective Price Level Date: 1 OCT 25				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Mid-Point Date P	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
	Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place													
06	FISH & WILDLIFE FACILITIES			40.0%		5.6%				2032Q4	18.9%			
14	RECREATION FACILITIES			40.0%		0.0%				0	0.0%			
18	CULTURAL RESOURCE PRESERVATION			40.0%		5.6%				2032Q4	18.9%			
19	BUILDINGS, GROUNDS & UTILITIES			40.0%		5.6%				2034Q4	25.2%			
20	PERMANENT OPERATING EQUIPMENT			0.0%		0.0%				0	0.0%			
	(FWEEP)			0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
				0.0%		0.0%				0	0.0%			
	CONSTRUCTION ESTIMATE TOTALS:			40.0%										
01	LANDS AND DAMAGES			40.0%		5.4%				2032Q4	18.9%			
30	PLANNING, ENGINEERING & DESIGN													
1.0%	Project Management			20.0%		6.6%				2034Q4	30.4%			
0.5%	Planning & Environmental Compliance			20.0%		6.6%				2034Q4	30.4%			
10.0%	Engineering & Design			20.0%		6.6%				2034Q4	30.4%			
1.0%	Reviews, ATRs, IEPRs, VE			20.0%		6.6%				2034Q4	30.4%			
1.0%	Life Cycle Updates (cost, schedule, risks)			20.0%		6.6%				2034Q4	30.4%			
1.0%	Contracting & Reprographics			20.0%		6.6%				2034Q4	30.4%			
1.0%	Engineering During Construction			20.0%		6.6%				2034Q4	30.4%			
1.0%	Planning During Construction			20.0%		6.6%				2034Q4	30.4%			
0.5%	Adaptive Management & Monitoring			20.0%		6.6%				2034Q4	30.4%			
0.5%	Project Operations			20.0%		6.6%				2034Q4	30.4%			
	Real Estate (All Federal Labor)			20.0%		6.6%				2032Q4	22.8%			
31	CONSTRUCTION MANAGEMENT													
6.0%	Construction Management			20.0%		6.6%				2034Q4	30.4%			
0.5%	Project Operation:			20.0%		6.6%				2034Q4	30.4%			
1.0%	Project Management			20.0%		6.6%				2034Q4	30.4%			
	CONTRACT COST TOTALS:													

ATTACHMENT D

CONSTRUCTION SCHEDULE

ID	Task Mode	Task Name	Duration	Start	Finish
1		Chief's Report Signature	0 days	Fri 12/12/25	Fri 12/12/25
2		Project Partnership Agreement (PPA) Signed & Executed	0 days	Fri 12/11/26	Fri 12/11/26
3		**Contract/Phase #1 - FWEEP**	**656 days**	**Fri 12/11/26**	**Fri 6/15/29**
4		Real Estate Acquisitions	258 days	Fri 12/11/26	Tue 12/7/27
5		D/B RFP Development	120 days	Wed 6/23/27	Tue 12/7/27
6		Contract Award to A/E Design Firm	0 days	Wed 12/8/27	Wed 12/8/27
7		Notice to Proceed (NTP) Issued	0 days	Fri 1/7/28	Fri 1/7/28
8		Design, Implementation, & Construction of required features	376 days	Fri 1/7/28	Fri 6/15/29
9		**Contract/Phase #2 - Flood Plain Acquisition/Demolition with Recreation & Enviornmental Restoration**	**455 days**	**Mon 1/3/28**	**Fri 9/28/29**
10		Acquire Properties to be Demolished (Non-Federal Sponsor)	262 days	Mon 1/3/28	Tue 1/2/29
11		Demolish Acquired Structures Identified, 13 structures	95 days	Fri 9/15/28	Thu 1/25/29
12		Environmental Restoration / Recreational Work	176 days	Fri 1/26/29	Fri 9/28/29
13		**Contract/Phase #3 - Essential Structures - Dry/Wet Floodproof**	**963 days**	**Wed 1/3/29**	**Sun 9/12/32**
14		Real Estate Acquisition/LEERDs	273 days	Wed 1/3/29	Fri 1/18/30
15		Design, Implementation, & Construction - (7) Wet, (8) Dry	784 days	Wed 9/12/29	Sun 9/12/32
16		**Contract/Phase #4 - Historic Structures - Dry/Wet Floodproof, Raise In Place**	**1194 days**	**Sat 1/3/32**	**Thu 7/31/36**
17		Real Estate Acquisition/LEERDs	265 days	Sat 1/3/32	Thu 1/6/33
18		Design, Implementation, & Construction - (23) Wet, (1) Dry, (1) Raise	1044 days	Mon 8/2/32	Thu 7/31/36



Project: Beattyville_KY - FRM Fe
Date: Mon 8/5/24

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

Appendix D
Economics

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 INTRODUCTION

This appendix documents the economic analysis conducted for the Kentucky River, Beattyville, General Investigation Feasibility Study and the methodologies and assumptions made therein. The purpose of this analysis is to illustrate the effectiveness of the proposed structural and nonstructural alternatives in reducing flood risk to threatened homes and businesses as well as to life safety in the project area.

The final step of this study phase is to determine the National Economic Development (NED) plan. The economic analysis is a critical input in the development of the final recommendation, but not the sole determining factor. For further information regarding alternative development and plan selection, see the Main Report.

1.1 PROJECT AREA

The city of Beattyville is in Lee County, Kentucky, at the confluence of the north and south forks of the Kentucky River, shown in Figure 1.

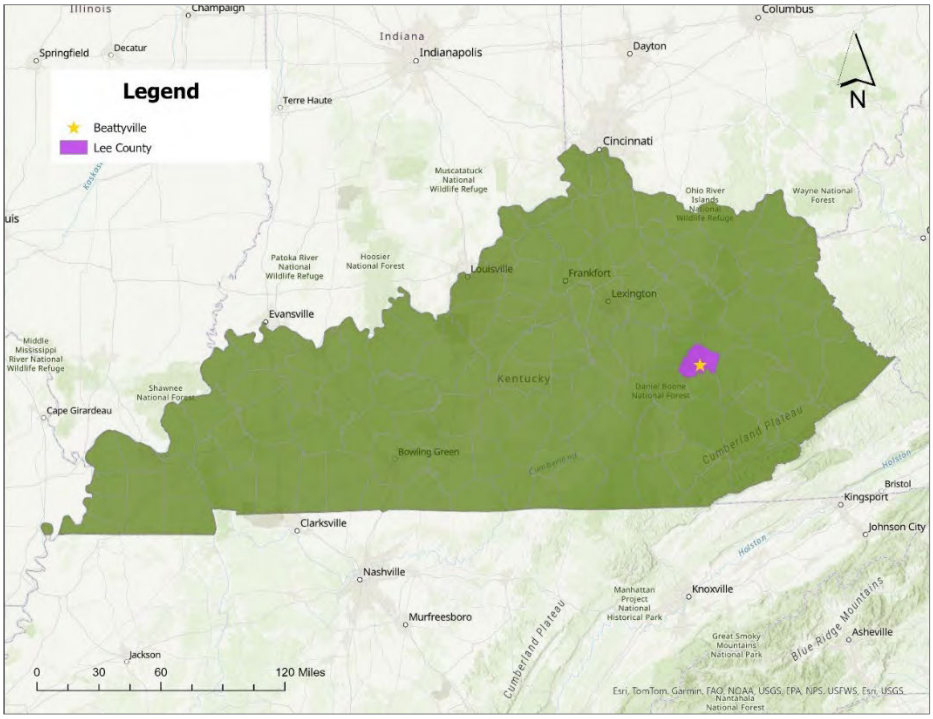


Figure 1: Beattyville is located in Lee County in Eastern Kentucky.

The extent of the project area is approximated by the expected inundation extent of a 0.2% annual exceedance probability (AEP) event, commonly referred to as a 500-year event, shown in Figure 2. An event of this magnitude would flood the entire downtown area of Beattyville on the right bank of the North Fork Kentucky River with significant backwater flooding along Crystal Creek and Silver Creek. The left bank extent of the project area extends only as far as the city limits of Beattyville.

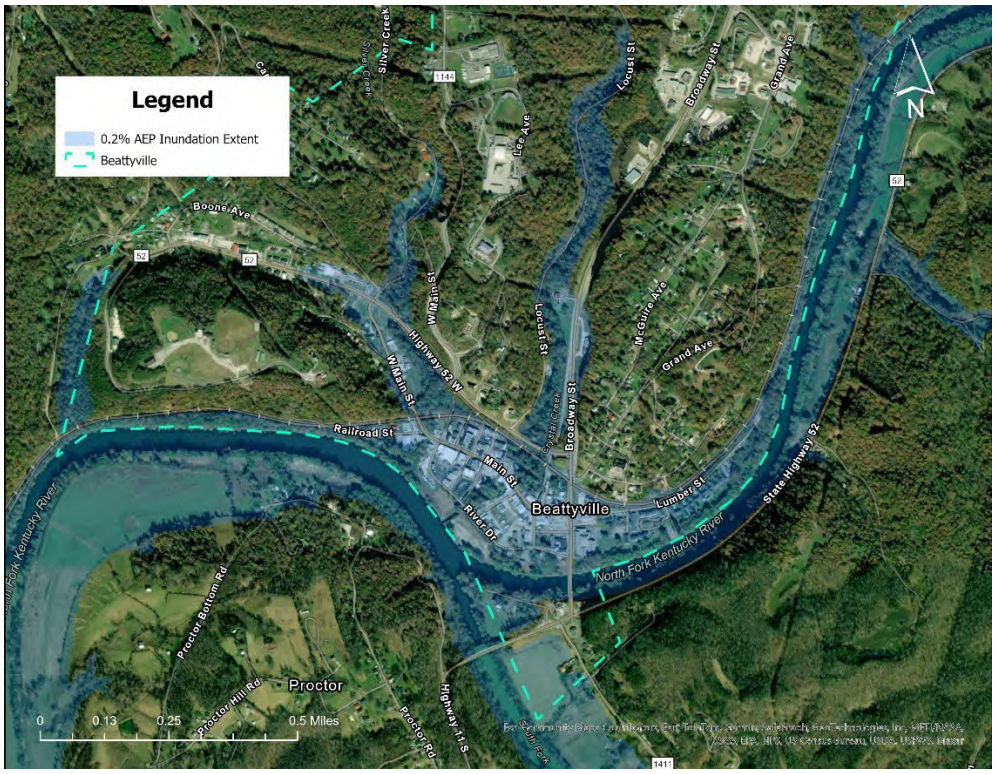


Figure 2: The approximate project area for this effort was delineated by the Kentucky River 0.2% AEP event at Beattyville

1.1.1 Population Characteristics

According to the Census Bureau's American Community Survey (2018-2022), the population of Beattyville is 1,956. Of this total, approximately 88% of the population is white, 4% is black or African American, 1% is American Indian, and 7% are two or more races. Of the total population, 5.6% are Hispanic or Latino ethnicity.

Among Beattyville's residents 25 years of age or older, approximately 66% are high school graduates, compared with 89% nationally, and 4.2% have a bachelor's degree or higher, compared with 34% nationally.

Only 24.5% of the population 16 years and older is in the civilian labor force, compared to 56.1% in Kentucky and 59.6 nationally. Median household income is significantly lower than both the state and national averages, and nearly half of the residents of Beattyville are in poverty – notably including 68% of children under the age of 5 years. The number of persons with a disability is more than twice the national rate.

The community also has a deficit of connectivity, with 68% of households having a broadband connection, compared to 88% nationally, and 2.2% of households have no telephone service, more than double the national proportion.

Table 1 displays population characteristics for Beattyville as compared to Kentucky and the United States.

Table 1: Beattyville Population Characteristics

	Beattyville	Kentucky	United States
Population	1,956	4,502,935	331,097,593
Population Characteristics			
Persons Under 18	21.0%	22.5%	22.1%
Persons 65 and over	10.4%	16.8%	16.5%
Female Persons	32.2%	50.3%	50.4%
Persons with a disability	26.9%	17.6%	12.9%
Race			
White	87.8%	84.8%	65.9%
Black or African American	3.9%	8.0%	12.5%
American Indian and Alaska Native	0.7%	0.2%	0.8%
Asian	0.0%	1.5%	5.8%
Native Hawaiian and Other Pacific Islander	0.0%	0.1%	0.2%
Two or more Races	7.6%	4.2%	8.8%
Ethnicity			
Hispanic or Latino	5.6%	4.0%	18.7%
Education and Employment			
High school graduate or Higher (age 25+)	65.8%	88.2%	89.1%
Bachelor's Degree or Higher (age 25+)	4.2%	26.5%	34.3%
Employment rate	24.5%	56.1%	59.6%
Unemployment rate	11.4%	5.1%	5.3%
Income			
Per capita income (dollars)	11,251	33,515	41,261
Median Household Income (dollars)	23,423	60,183	75,149
Persons in Poverty	49.2%	16.1%	12.5%
Under 5 years	68.4%	23.3%	18.1%
Under 18 years	55.8%	21.1%	16.7%
Connectivity			
Households with Broadband	67.8%	85.6%	88.3%
No telephone service available	2.2%	1.2%	1.0%
Source: U.S. Census Bureau, 2018-2022 American Community Survey 5-Year Estimates			

Table 2 displays the types of industries that employ residents of Beattyville as compared to Kentucky and the United States.

Table 2: Employment in Beattyville by Industry

Industry (civilian employed population, 16 years and over)	Beattyville	Kentucky	United States
Agriculture, forestry, fishing and hunting, and mining	2.3%	1.8%	1.6%
Construction	13.4%	6.2%	6.9%
Manufacturing	4.9%	14.2%	10.0%
Wholesale trade	5.9%	2.3%	2.4%
Retail trade	22.2%	11.8%	11.0%
Transportation and warehousing, and utilities	8.0%	6.8%	5.8%
Information	0.8%	1.4%	1.9%
Finance and insurance, and real estate and rental and leasing	0.8%	5.6%	6.7%

Professional, scientific, and management and administrative and waste management services	5.2%	9.0%	12.1%
Educational services, and health care and social assistance	19.8%	24.0%	23.3%
Arts, entertainment, and recreation, and accommodation and food services	0.0%	8.1%	9.0%
Other services, except public administration	1.3%	4.5%	4.7%
Public Administration	15.5%	4.3%	4.7%
Source: U.S. Census Bureau, 2018-2022 American Community Survey 5-Year Estimates			

1.2 ECONOMIC FRAMEWORK

The economic analysis described here follows the framework and methodology prescribed by the USACE Policy for Conducting Civil Works Planning Studies (ER 1105-2-103) dated 7 December 2023 and Principles and Requirements for Federal Investments in Water Resources, dated March 2013, as appropriate.

USACE follows a conceptual flood risk model which is a function of hazard, performance, and consequences. The hazard, or potential cause for harm, in the case of this study refers to a flood originating from the Kentucky River. Performance refers to how the proposed flood risk management measure is anticipated to handle the hazard. Finally, consequences refer to the harm—economic or otherwise—resulting from the hazard . Each of these terms are discussed more completely in ER 1105-2-101 “Risk Assessment for Flood Risk Management Studies” dated 15 July 2019 and depicted in Figure 3.

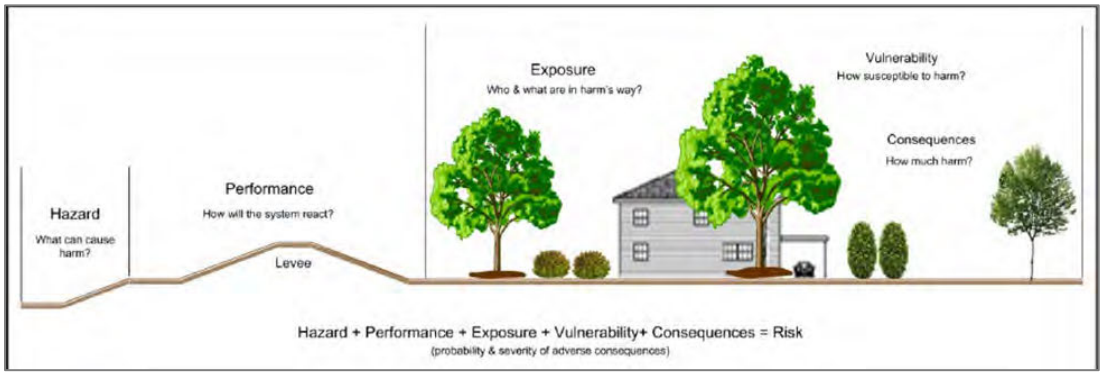


Figure 3: Flood Risk Conceptualized

The hazard inputs incorporated in the economic analyses are developed by hydrologic engineers. Brief descriptions are included within this appendix and additional information can be found in the H&H appendix.

This analysis incorporates risk and uncertainty as directed by ER 1105-2-101, Risk-Based Analysis for Evaluation of Hydrology/Hydraulics, Geotechnical Stability, and Economics in Flood Damage Reduction Studies (1 March 1996) and EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies (August 1996). Uncertainty is inherent in all economic related input variables used in a typical flood damage analysis whether they are ground elevations, first floor elevations, valuation of structures, generic depth-damage functions, content values based on content-structure value ratios, or assignment of occupancy type to structures for purposes of depth-damage calculations. Key hydrologic and hydraulic inputs such as frequency-discharge and stage-discharge relationships also possess their own elements of uncertainty.

The analyses of without-project and with-project damages include damages or costs incurred from a range of categories, such as damage to residential and nonresidential structures and their contents, as well as damage to vehicles associated with those structures. These categories are intended to capture a substantial portion of the financial burden incurred by a flood event; however, they are not comprehensive enough to capture every cost or damage that could result from flooding in the area.

To estimate without-project and with-project expected annual damages (EADs) from flooding, eight flooding events were modeled, representing a range of recurrence probabilities from a 99 percent-chance (1-year) flood event to a 0.2 percent-chance (500-year) flood event. These modeling efforts included uncertainty present in the input variables

The difference between with-project EAD and without-project EAD represents expected annual benefits. Whether an alternative can be considered economically justified is determined by comparing expected annual benefits to average annual costs. If expected annual benefits for an alternative exceed the average annual costs, then the alternative is considered economically justified. All plans with positive average annual benefits will yield a benefit-to-cost ratio (BCR) greater than or equal to 1.0.

The analyses described herein utilize risk-based estimates to objectively evaluate alternatives and the associated contributions to NED.

Further important assumptions employed in the evaluation of alternatives are:

(1) All inputs in this analysis are estimates, and therefore subject to varying degrees of uncertainty. As such, an attempt has been made to quantify this uncertainty and better inform interested parties, including decision-makers.

(2) The FY24 discount rate of 2.75% (Engineering Guidance Memorandum 24-01) is used for present value calculation. Costs and benefits are expressed in 2024 price levels.

(3) The project period of evaluation is estimated to be 50 years, including necessary costs for operation, maintenance, repair, replacement, and rehabilitation activities.

(4) All structural computations are based on industrial, commercial, and residential depreciated replacement values (DRVs) and do not include land values.

(5) Resources have potential alternative uses and, consequently, opportunity costs.

(6) Individuals are risk neutral and rational economic agents.

(7) All elevations are expressed in feet and are understood to represent “Ft. NAVD88” (Feet North American Vertical Datum 1988).

(8) The project area is developed and will remain so throughout the period of analysis.

(9) For consistency, all annualized benefits and costs were calculated using an end of year discounting method, including interest during construction.

1.2.1 Without Project Condition

According to ER 1105-2-103, potential project alternatives are to be compared to the future without project (FWOP) condition. For this analysis, the FWOP is assumed to closely mirror the existing condition. The project area is relatively small, but completely developed. Publicly

available historic imagery shows that the primary structural features (roads, ditches, and buildings) within the area have been in the same location for decades. While the future precipitation in Eastern Kentucky may change in intensity and frequency over time, such impacts were not quantified for this study.

1.2.2 Impact Areas

In the initial stages of formulation, the team aggregated the community's structures based upon structure and hydraulic characteristics. These groupings were maintained as impact areas for purposes of the economic modeling, delineated as shown in Figure 4.

The first group is bound generally by the Kentucky River, Silver Creek, and the railroad. Group two is bound by the Kentucky River, Silver Creek, Crystal Creek, and the railroad. Group three and four are both bound by the Kentucky River, Crystal Creek, and the railroad. The age of the buildings, the elevations of the first floors and the geographic locations were contributing factors to dividing these two groups. Group five includes all structures south of the Kentucky River. Group six includes the structures north of the railroad along Silver Creek, and group seven is north of the railroad along Crystal Creek.

It is important to note that only three larger groupings were deemed necessary to account for differences in hydraulic characteristics at the confluence of the forks of the Kentucky River. Those groups are Impact areas 1,2 and 6; Impact areas 3,5, and 7, and Impact Area 4.

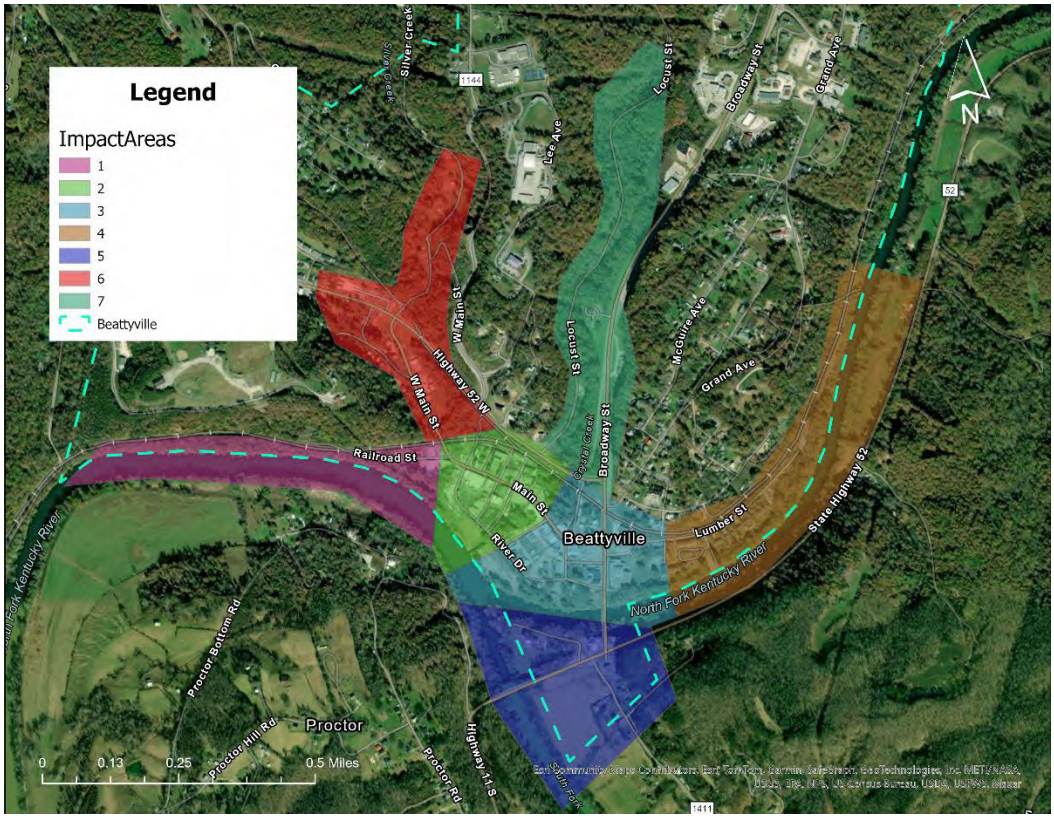


Figure 4: The project area was divided into seven impact areas.

1.2.3 Hazard

The Kentucky River water surface profiles (WSPs) for the economic analysis were provided by Louisville District Hydraulics and Hydrology (H&H) engineers. The values below represent mean WSPs for a given exceedance probability at stations that would be representative for each grouping of impact areas.

Table 3: Future Without Project Condition Water Surface Profiles

Impact Areas	Station	Stage by Annual Exceedance Probability							
		0.99	0.5	0.2	0.1	0.04	0.02	0.01	0.002
1,2,6	Kentucky River Reach 1 - 257.5189	640.15	649.32	653.55	655.73	664.88	669.86	672.38	678.8
3,5,7	North Fork Kentucky River Reach 3 – 0.101	640.15	649.32	653.55	655.73	664.88	669.86	672.38	678.8
4	North Fork Kentucky River Reach 3 – 0.574	640.17	649.48	653.84	656.11	665.21	670.09	672.6	678.95

[1] *Mean modeled river stages in feet NAVD88*

1.2.4 Consequences Analysis Inputs

The Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) 2.0 program was used to estimate damages to residential and non-residential structures and their contents for without-project and with-project alternatives. Performing flood damage reduction analysis using HEC-FDA requires a series of inputs, both geospatial and text-based. The following sections explain the sources and development of those inputs.

1.2.4.1 Terrain

The terrain grid is a digital elevation model that represents the topographic surface of the earth and defines the ground elevation at each structure. It is the same file that was used to produce the hydraulic data, which ensures that the ground elevation applied to the study's structures matches the resolution of the hydraulic inputs. First floor elevations of structures are also defined relative to the terrain.

1.2.4.2 Hydraulics

Hydraulics for existing conditions and four floodwall alternatives were modeled using HEC-RAS. For analysis within HEC-FDA, Hierarchical Data Format (HDF) files representing the eight flood frequency events were required for all five scenarios. HDF files contain depth and velocity for each time step in the simulation. Further information on the hydraulic modeling performed can be found in the H&H appendix, Section 4.9.

H&H also provided text-based stage-discharge data for all scenarios at each frequency event at the three stations presented in Table 3.

1.2.4.3 Structure Inventory

The structure inventory developed for this feasibility study relied heavily on detailed records from the Lee County assessor, GIS data, and in-person visual assessment and photography of structures to determine characteristics.

The distribution of structures across the project area is shown in Figure 5.

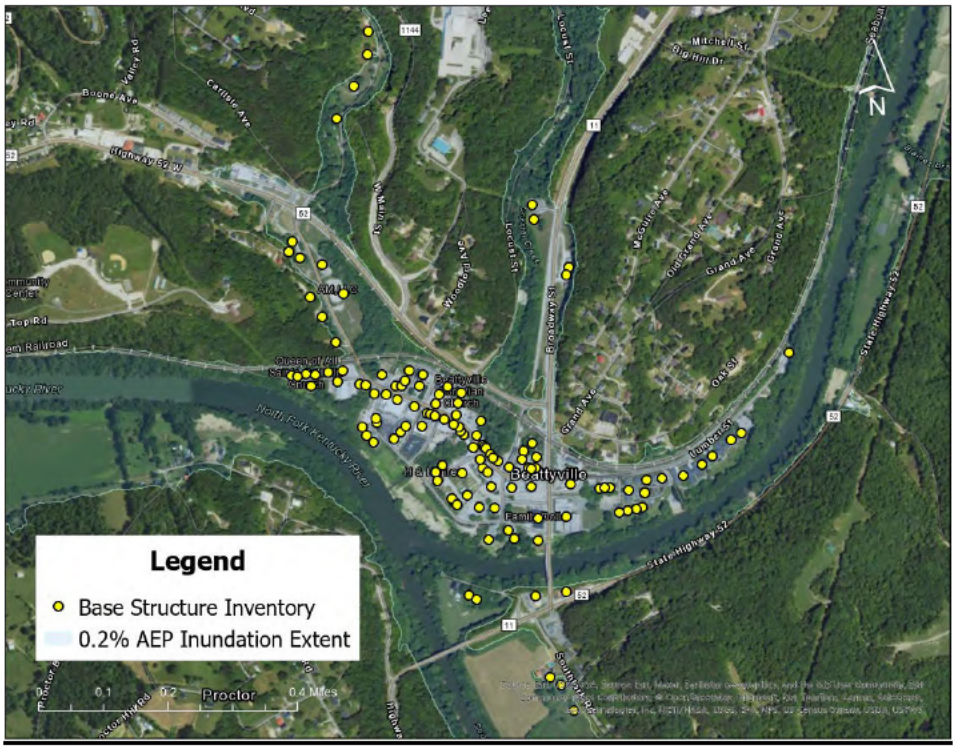


Figure 5: Beattyville Structure Inventory

1.2.4.3.1 Structure Values

Depreciated replacement values (based on structure type, features, quality, and effective age) were determined using Marshall and Swift valuation service, dated May 2020. Prices were inflated from 2020 to 2024 using the Civil Works Construction Cost Index System (CWCCIS) general construction cost index.

Structure count and total estimated values by damage category are presented in the following table. This represents the base inventory created for economic analysis and may differ marginally from structure counts in the main report or other appendices.

Table 4: Estimated Value of Structures in Project Area

Damage Category	Number of Structures	Estimated Total Structure Value (dollars)
Residential	43	9,475,000
Commercial	69	11,200,000
Industrial	1	3,000
Public	11	5,986,000
Total	**124**	**26,661,000**
Values are in 2024 price levels		

1.2.4.3.2 Content Values

Structure content values include all damages caused to a structure's contents. Structure contents are usually defined as everything within the structure that is not permanently installed and can range from furniture, rugs, appliances, and personal possessions for residences to industrial machinery, electronic equipment, and store or warehouse inventories for commercial properties. Content values are established by application of a specified content-to-structure value ratio

(CSVR) to the respective structure's value, and damages are estimated similarly to structure damages. More detailed information on this methodology can be found in sections 1.2.4.4.1 and 1.2.4.4.2.

1.2.4.3.3 Vehicle Values

Vehicles were assumed to have a value of approximately $30,000, based on data of average used car sales (iSeeCars, 2022, Average Used Car Prices by State). Approximately 65% of structures do not have associated vehicles.

All single-family homes and mobile homes were assumed to have one vehicle present (assuming that there are two vehicles per household, one evacuates, one is left behind). Using the same logic, multi-family homes are assumed to have one vehicle per unit, and senior living facilities are assumed to have one-half vehicle per unit.

Note that for structures where nonstructural measures are expected to elevate foundation height, new vehicle points were created within the inventory to prevent erroneous elevation of the vehicle within the model.

Commercial structures were assigned an estimated count of vehicles based on review of historic aerial imagery, and with each valued at $30,000, total estimated vehicle values were assigned as shown in Table 5

Table 5: Vehicles at Commercial Structures

Commercial entity	Estimated Vehicle Value (dollars)
IGA grocery Store	400,000
Don Begley Auto Sales	400,000
Nursing Home	400,000
Courthouse	240,000
City Hall	120,000
Health Department	120,000
Values are in 2024 price levels	

1.2.4.3.4 *Structure First Floor Elevation*

First floor elevations were calculated using the foundation height of each structure within the National Structure Inventory, version 2022, relative to that structure's location on the terrain grid.

The National Structure Inventory is a point-based dataset containing estimated information regarding the locations, building types, population, structure values, and other relevant information for all residential, commercial, industrial, agricultural, public, and private structures across the nation

Foundation height was established by surveys of each structure's first floor elevation and lowest adjacent ground elevation during site visit.

1.2.4.3.5 Population in Structures

Population distribution within structures, necessary for life safety analysis, was based on the NSI 2022 and manually adjusted for reasonableness.

1.2.4.4 Structure Depth Damage Functions

Each structure in the inventory was grouped into an appropriate damage category and then assigned a specific occupancy type. Upon determination of the appropriate occupancy type for each structure in the project area, an applicable depth damage function (DDF) was assigned. These DDFs estimate economic loss as a percentage of the value of the structure or contents based on the depth of flooding. Since these relationships are expressed as a percentage, DDFs can be applied to any number of structures within an inventory, so long as the structures are within the same occupancy type. A variety of depth-damage functions, based on damage category and occupancy type, were used for this analysis and are further explained in the following sections.

1.2.4.4.1 Residential

All structure and content DDFs assigned to residential structures were developed by the Institute of Water Resources (IWR) as referenced in Economic Guidance Memorandum (EGM) 04-01. These DDFs are considered generic and are appropriate for use throughout the United States. The DDFs are divided into multiple categories based on the type of structure (e.g., number of stories, foundation type). Separate DDFs represent damages to the structure and the contents, and uncertainty is expressed with a normal probability distribution. The IWR residential DDFs were developed to estimate content damages based on the structure value. The residential content-to-structure value ratio (CSVR) utilized in this analysis is 100 percent, per EGM 04-01 guidelines.

As the lone exception to the methodology explained above, mobile homes (while residential properties), are not included in EGM 04-01. As such, the DDF used for mobile homes in this analysis is a FEMA National Flood Insurance depth damage function. Uncertainty in mobile home DDFs is defined by a normal probability distribution from Table 6-4 of EM 1110-2-1619 and CSVR is 100 percent.

1.2.4.4.2 Nonresidential

Nonresidential structures in this study fall within one of three categories: commercial, industrial, or public structures. The nonresidential DDFs used in this analysis are a combination of functions from two different sources: 1) draft IWR report "Non-Residential Flood Depth Damage Functions Derived from Expert Elicitation" dated April 2009, revised 2013 and 2) the New Orleans District "Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVRs) in Support of the Jefferson and Orleans Flood Control Feasibility Studies" report, dated 1996.

Both the IWR and New Orleans nonresidential DDFs were developed by expert elicitation and have been employed continuously in USACE economic analyses since their development. The IWR functions were jointly developed by IWR and FEMA to be nationally relevant and are specific in their application. There are fewer New Orleans functions, and they are more general than the IWR functions. For this analysis, the IWR nonresidential DDFs will generally be applied with priority when applicable. The New Orleans functions will be used for categories of properties not addressed by the IWR functions or when a more general function is appropriate. Uncertainty in the IWR and New Orleans nonresidential depth-damage functions is defined by a triangular probability distribution for each occupancy type. In this analysis, content-to-structure value ratios for each occupancy type developed by New Orleans were applied to all nonresidential structures.

The damage category, occupancy type, description, and respective source of all depth-damage functions used in this model are shown in Table 6.

Table 6: Damage Category, HAZUS Occupancy Type Names, Descriptions, and DDF source

Damage Category	Occupancy Type	Description	DDF Source - Name
Residential -	RES1-1SNB	SF, 1 story, no basement	EGM 04-01
Single Family	RES1-1SWB	SF, 1 story, w/ basement	EGM 04-01
	RES1-2SNB	SF, 2 story, no basement	EGM 04-01
	RES1-2SWB	SF, 2 story, w/ basement	EGM 04-01
	RES1-3SNB	SF, 3 story, no basement	EGM 04-01
	RES1-3SWB	SF, 3 story, w/ basement	EGM 04-01
	RES1-SLNB	SF, split level, no basement	EGM 04-01
	RES1-SLWB	SF, split level, w/ basement	EGM 04-01
	RES2	Mobile Home	FEMA NFI DDF
Residential -	RES3AI	MF - duplex	IWR - APT-E
Multi-Family	RES3BI	MF - 3-4 units	IWR - APT-E
	RES3CI	MF - 5-9 units	IWR - APT-E
	RES3DI	MF - 10-19 units	IWR - APT-E
	RES3EI	MF - 20-49 units	IWR - APT-E
	RES3FI	MF - 50+ units	IWR - APT-E
	RES4	Hotel or Motel	IWR - HTL-E
	RES5	Institutional Dormitory/Jail	IWR - CF-E
	RES6	Nursing Home	IWR - HTL-P
Nonresidential -	COM1	Retail trade	NO - RET-A
Commercial	COM2	Wholesale trade/Warehouse	IWR - WH-P
	COM3	Personal/Repair Service	NO - REP-A
	COM4	Professional/Tech Service Office	IWR - OFF-E
	COM5	Bank	IWR - OFF-E
	COM6	Hospital	IWR - HOSP-E
	COM7	Medical Office/Clinic	IWR - MED-E
	COM8	Restaurant/Bar/Entertainment	IWR - REST-P
	COM9	Theater	NO - EAT
	COM10	Parking Garage	IWR - WH-P
	AGR1	Agriculture	IWR - WH-P
Nonresidential -	IND1	Heavy Industrial	IWR - LT-E
Industrial	IND2	Light Industrial	IWR - LT-E
	IND3	Food/Drug/Chemicals	IWR - LT-E
	IND4	Metal/Mineral Processing	IWR - LT-E
	IND5	High Technology	IWR - LT-E
	IND6	Construction Office	IWR - LT-E
Nonresidential -	GOV1	General Government Services/Office	IWR - OFF-E
Public	GOV2	Emergency Response	IWR - PS-E
	EDU1	Primary/Secondary School	IWR - SCH-E
	EDU2	College/University	IWR - SCH-E
	REL1	Church or Non-Profit	IWR - RF-P

1.2.4.5 Vehicle Depth Damage Functions

The depth damage function applied to all vehicles in the inventory is that for sedans, from Economic Guidance Memorandum 09-04, Generic Depth-Damage Relationships for Vehicles, dated 22 June 2009.

1.2.4.6 Other Categories

Transportation delays, traffic diversion costs, and emergency costs were not calculated for this analysis because it was not anticipated their inclusion would affect the decision.

1.2.5 FDA Analysis

For this study effort, data for residential and nonresidential structures were incorporated into HEC-FDA, version 2.0. HEC-FDA uses modeled flooding events to estimate damages to affected structures based on data associated with each structure. HEC-FDA was used to estimate the damages for structures and the contents therein. The HEC-FDA program compiles data generated during the H&H analyses, as well as the structure inventory and associated data described above.

Use of 2D data from HEC-RAS allows for the flood stage at each structure to be compared to that structure's foundation height, the difference applied the structure's individual depth-damage functions (content and structure), and percent damages computed using these functions. Dollar damages are computed by simply multiplying the percent damage by the total structure value. These total dollar damages are then aggregated to the impact area. HEC-FDA uses a Monte Carlo simulation to quantify uncertainty and calculate expected annual damages. This random sampling approach computes multiple thousands of successive iterations of each computation for which there is uncertainty, using the assigned standard deviations of error, and averages the results.

Typically, with-project and without-project damages are estimated for both the initial baseline conditions and future conditions, which account for any growth in development and runoff in the project area. As the hydrologic condition of the project area is not anticipated to increase over the period of analysis, the HEC-FDA model was run only for the initial baseline condition, with the resulting annual damages expected to prevail over the 50-year period of analysis.

1.2.5.1 Average Annual Damages

When evaluating flood damages, it is useful to relate the amount of damage to the water surface elevation in the river. In turn, each water surface elevation is related to certain amount of flow, and each flow is related to a frequency probability of exceedance. Therefore, each level of damage can be associated with a frequency, resulting in a damage-frequency curve. Average annual damage (AAD) is defined as the area under the damage-frequency curve.

Typically, AAD does not incorporate uncertainty in flows, water surface elevations, or damages. However, the term is often confused with expected annual damages. For the purposes of this report, AAD will represent the deterministic area under the damage-frequency curve (with no uncertainty).

AAD represents the average amount of damage that would occur in any given year, based on the frequency of recurrence for each flood event. No other probabilistic variables are factored into the calculation of AAD.

1.2.5.2 Expected Annual Damages

Expected annual damages (EAD) consider uncertainties in stage-damage, stage-flow, and flow-frequency relationships. EAD is the mean value of AAD, given the uncertainty associated with each damage, stage, and flow relationship. AAD and EAD are often confused due to the similarity in the terms "average" and "expected." For the purposes of this report, expected annual damages

refers to the probabilistic definition offered above. EAD are computed using HEC-, which utilizes Monte Carlo simulation for evaluating mean values.

Expected annual damage represents the mean amount of damage that would occur in any given year, if that year were repeated infinitely many times over. The mean value is based on the frequency of recurrence for each flood event, as well as the uncertainties in stage-damage, stage flow, and flow-frequency relationships.

AAD has no uncertainty calculated and EAD does calculate uncertainty around the damage-exceedance probability function (which is derived from the discharge-exceedance probability, stage-discharge probability, and damage-stage functions).

EAD can vary by year, depending on changes in hydraulic, hydrologic, and economic conditions.

Expected annual benefit (EAB) for any alternative is the difference between EAD without the alternative in place and EAD with the alternative in place.

1.2.5.3 HEC-FDA Uncertainty

USACE requires the use of risk-based analysis to evaluate flood damages and flood damage reduction measures, as described in ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies. HEC-FDA uses a Monte Carlo simulation to quantify uncertainty and derive EADs. This random sampling approach computes successive iterations of each computation for which there is uncertainty, using the assigned standard deviations of error and averages the results.

Various measures of uncertainty can be incorporated into the HEC-FDA models. For this study, uncertainty was incorporated into the results of the H&H analysis, the depth damage functions (DDF), first floor elevations (FFE), structure values, and content to structure value ratios (CSVR).

1.2.5.3.1 Uncertainty in H&H

Uncertainty associated with the H&H analysis was incorporated into the flow exceedance probability in the equivalent record lengths and the stage discharge functions. The H&H Appendix further discusses the uncertainty associated with the exceedance probability functions and the stage discharge functions.

1.2.5.3.2 Uncertainty in Depth-Damage Functions

The actual damage induced by specific flood depths is not known with certainty. The residential and non-residential depth-damage functions include uncertainty in the damage estimation to structure and contents. For all residential structures, the uncertainty was defined through a normal probability distribution for each unique depth-damage function as presented in EGM 04-01. Meanwhile, for both IWR and New Orleans nonresidential depth-damage functions, a triangular probability distribution was utilized for each occupancy type.

1.2.5.3.3 Uncertainty in First Floor Elevations

Elevations associated with each residential and nonresidential structure within the project area were calculated using surveyed foundation height of each structure relative to that structure's location on the terrain grid. Locations were assigned geospatially and verified against aerial imagery. Uncertainty for FFEs was defined through a normal probability distribution with a standard deviation of 0.3 feet.

1.2.5.3.4 Uncertainty in Structure Values

Residential and nonresidential values were estimated (as previously described) using Marshall and Swift valuation service methodology and were inflated to reflect 2024 prices using the USACE Civil Works Construction Cost Index System (CWCCIS). To account for the uncertainty associated with these values, a normal probability distribution with a standard deviation of 10% was applied to both residential and nonresidential structure values.

1.2.5.3.5 Uncertainty in Content-Structure Value Ratios

The uncertainty associated with residential content values is captured in each residential depth-damage function, in accordance with EGM 04-01. For nonresidential structures, a normal probability distribution with a standard deviation of 10% CSVR was applied.

1.3 Initial Alternative Formulation and Analysis

Alternative formulation was a collaborative effort by the entire Project Delivery Team (PDT). After without project conditions were developed, the PDT examined potential structural and nonstructural measures. Full descriptions of the structural and nonstructural measures considered can be found in the main report.

A preliminary array of alternatives was developed, which included a no-action alternative, a floodwall, nonstructural measures, and a Flood Warning and Emergency Evacuation Plan. That suite of structural and nonstructural alternatives was expanded, based on target elevations. That is, four floodwall alternatives (alternatives 2A-2D), each with a different elevation, and nonstructural alternatives (3A-3D) that aimed to apply nonstructural measures to structures aggregated based on those same four elevations.

Each alternative was evaluated for likelihood of success, efficiency, and potential for environmental impacts. The expanded array of alternatives is shown in Table 7.

Table 7: Expanded Array of Alternatives

Alternative	Description
1	Without Project
2A	Floodwall – Elevation 672.2
2B	Floodwall – Elevation 669.2
2C	Floodwall – Elevation 666.5
2D	Floodwall – Elevation 663.0
3A	Nonstructural – Elevation 672.2
3B	Nonstructural – Elevation 669.2
3C	Nonstructural – Elevation 666.5
3D	Nonstructural – Elevation 663.0
4	Flood Warning and Evacuation Emergency Plan

After an initial analysis, the PDT found the following flaws in the expanded array of alternatives. Floodwalls were inefficient and ineffective in the NED, EQ, and OSE accounts and were subsequently screened from further analysis. Nonstructural plans were poorly aggregated, that is, the selection of structures to which nonstructural measures were to be applied based solely on first floor elevation led to some plans having inflated inventory and some missing important

community assets. The FWEEP provided a positive impact on life safety, but alone did not represent a complete plan.

Based on these observations, a final series of alternatives built in increments, was established, beginning with the already mentioned FWEEP-only Alternative 4, shown in Table 8.

Table 8: Final Array of Alternatives

Alternative	Description
4	Flood Warning and Evacuation Emergency Plan
5A	FWEEP + Floodway Acquisition + Recreation Features
5B	5A + Nonstructural Measures for Essential Structures
5C	5B + Nonstructural Measures for Historic Structures

The analysis will be presented in the order in which it was completed. Discussion of the final array analysis begins in Section 1.4 of this appendix.

1.3.1 Preliminary Alternatives Defined

The alternatives are described in the following sections. It should be noted that Alternative 4, the Flood Warning and Evacuation Emergency Plan was not separately evaluated in HEC-FDA as the FWEEP by itself is not expected to have measurable impact on flood damages incurred. However, every other alternative does include a FWEEP, which will impact that alternative's cost as well as its impact to life safety risk.

1.3.1.1 Alternative 1: Without Project Condition, or No Action Plan

This alternative reflects the current, or baseline condition. The purpose of including the no action alternative is to provide a consistent baseline for comparison against other alternatives, and to describe the flood impacts associated with not developing a flood risk management project. Consideration of the No Action Plan is required by USACE guidance.

1.3.1.2 Alternative 2A: Floodwall – Elevation 672.2

This alternative includes a floodwall to elevation 672.2. The proposed alignment would consist of two segments in downtown Beattyville, one on either side of Crystal Creek is shown in Figure 6. For structures outside of the floodwall, nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures would be applied to those structures whose first-floor elevation is 672.2 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

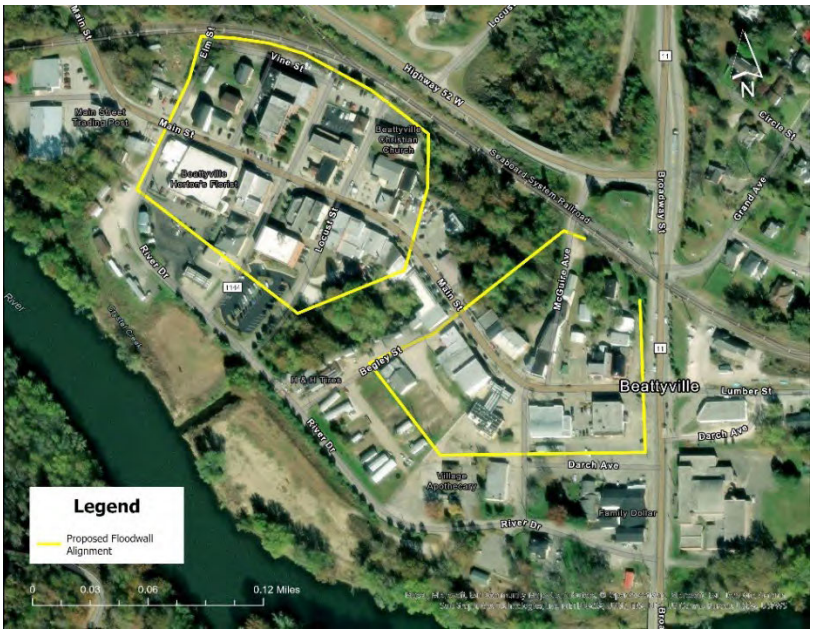


Figure 6: Proposed Floodwall Alignment at Beattyville

1.3.1.3 Alternative 2B: Floodwall – Elevation 669.2

This alternative includes a floodwall to elevation 669.2. The proposed alignment would consist of two segments in downtown Beattyville, one on either side of Crystal Creek is shown in Figure 6. For structures outside of the floodwall, nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures would be applied to those structures whose first-floor elevation is 669.2 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.4 Alternative 2C: Floodwall – Elevation 666.5

This alternative includes a floodwall to elevation 666.5. The proposed alignment would consist of two segments in downtown Beattyville, one on either side of Crystal Creek is shown in Figure 6. For structures outside of the floodwall, nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures would be applied to those structures whose first-floor elevation is 666.5 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.5 Alternative 2D: Floodwall – Elevation 663.0

This alternative includes a floodwall to elevation 663.0. The proposed alignment would consist of two segments in downtown Beattyville, one on either side of Crystal Creek is shown in Figure 6. For structures outside of the floodwall, nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures would be applied to those structures whose first-floor elevation is 663.0 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.6 Alternative 3A: Nonstructural – Elevation 672.2

This alternative would apply nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures to all structures in the project area whose first floor elevation is 672.2 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.7 Alternative 3B: Nonstructural – Elevation 669.2

This alternative would apply nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures to all structures in the project area whose first floor elevation is 669.2 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.8 Alternative 3C: Nonstructural – Elevation 666.5

This alternative would apply nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures to all structures in the project area whose first floor elevation is 666.5 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.9 Alternative 3D: Nonstructural – Elevation 663.0

This alternative would apply nonstructural flood risk management measures, including floodproofing, elevation, and acquisition of structures to all structures in the project area whose first floor elevation is 663.0 or below. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.3.1.10 Alternative 4: Flood Warning and Evacuation Emergency Plan (FWEEP)

Alternative 4 is the creation of a Flood Warning and Evacuation Emergency Plan (FWEEP) for the city of Beattyville. This would serve to shorten delays in warning issuance, warning diffusion, and mobilization of the population and would contribute to the reduction of life safety risk. Because this alternative would have no or little impact on damages to property, it is not included in the remainder of the FDA modeling discussion but is included in the life safety analysis, which begins in Section 1.5.

1.3.2 Model input modifications for Nonstructural Alternatives

The nonstructural alternatives were developed on a conceptual level, using modeled flood depths to identify which measures would be applicable to which structures. There are three basic nonstructural measures which were considered for the project area. The first measure, dry floodproofing, would result in the modification of the exterior of a structure so that it could withstand low levels of inundation (less than three feet above the first floor). The second measure would be to evacuate/ buyout the structures if the mean inundation was estimated to exceed three feet above the first floor. The third measure would elevate the structure to bring the first floor up to the target elevation in each nonstructural alternative.

Every Future with Project alternative modeled includes some nonstructural measures; therefore, all alternatives *except* Future Without Project, required modifications to the base structure inventory (for acquisition and elevation) and depth damage functions (for floodproofing).

1.3.2.1 Structure Inventory Modifications

In each alternative's new inventory, structures identified for acquisition were deleted, and structures identified for elevation were raised to elevation 672.2. Originally foundation heights were estimated by subtracting observed LAG from observed FFE. To obtain new foundation height, the observed LAG was subtracted from 672.2.

1.3.2.2 Depth Damage Function Modifications

Because floodproofing prevents damage up to the target depth, depth damage functions had to be modified to reflect this. For this analysis, floodproofing was assumed to provide three feet of

protection. Structures identified for floodproofing were given a new occupancy type indicating the measure, which corresponds with new DDFs wherein no damage occurs until depths are higher than three feet. At points above three feet, the DDFs are identical to those in the base inventory.

1.3.3 Preliminary Alternative Evaluation and Comparison (HEC-FDA 2.0)

The alternative evaluation and comparison planning steps require an examination of the potential risk across several categories (economic, engineering, and environmental). The following sections describe the alternative impacts based on monetary damages and damage reductions, while other impacts are discussed in the main report.

Expected annual damages associated with the ten modeled alternatives are presented in Table 9.

Table 9: Mean Expected Annual Damages by Damage Category

Alternative	Description	Commercial	Residential	Public	Industrial	Total Damage
1	Without Project	473,647	233,451	112	136,069	843,279
3D	Nonstructural – Elevation 663.0	347,985	225,494	112	89,137	662,727
3C	Nonstructural – Elevation 666.5	126,726	166,839	112	25,672	319,349
3B	Nonstructural – Elevation 669.2	62,600	116,058	112	7,447	186,216
3A	Nonstructural – Elevation 672.2	27,503	60,099	116	-	87,718
2D	Floodwall – Elevation 663.0	439,431	250,541	138	135,431	825,541
2C	Floodwall – Elevation 666.5	275,650	174,918	112	85,021	535,701
2B	Floodwall – Elevation 669.2	257,762	123,391	120	71,349	452,622
2A	Floodwall – Elevation 672.2	102,326	54,728	116	21,458	178,628

Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).

Table 10: Total Expected Annual Damage by Alternative (with Uncertainty)

Alternative	Description	Expected Annual Damage (Mean)	Expected Annual Damage (25th to 75th percentile)		
		Mean	Q1	Median	Q3
1	Without Project	842,705	498,313	740,168	1,060,804
3D	Nonstructural – Elevation 663.0	662,227	367,205	568,724	839,928
3C	Nonstructural – Elevation 666.5	319,093	168,018	263,283	397,658
3B	Nonstructural – Elevation 669.2	186,059	94,049	149,914	239,982
3A	Nonstructural – Elevation 672.2	87,648	36,879	64,409	117,003
2D	Floodwall – Elevation 663.0	824,936	439,075	688,511	1,062,554
2C	Floodwall – Elevation 666.5	535,309	295,981	465,525	672,619
2B	Floodwall – Elevation 669.2	452,311	258,047	396,266	567,629
2A	Floodwall – Elevation 672.2	178,448	78,714	134,463	225,026

Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).

Table 11: Estimated Damages by Damage Category and Event

		Frequency Event							
Alternative	**Damage Category**	**0.99**	**0.5**	**0.2**	**0.1**	**0.04**	**0.02**	**0.01**	**0.002**
1 – Without Project	Commercial	-	-	-	-	6,184,207	13,485,505	16,025,041	18,600,753
	Residential	-	-	-	-	799,275	4,183,101	6,766,464	10,680,948
	Industrial	-	-	-	-	-	2,660	4,532	8,001
	Public	-	-	-	-	1,083,996	2,936,230	4,440,819	6,039,783
	Total	-	-	-	-	8,067,477	20,607,496	27,236,856	35,329,486
3D Nonstructural – Elevation 663.0	Commercial	-	-	-	-	4,090,895	10,911,879	12,952,191	15,284,107
	Residential	-	-	-	-	681,600	4,087,010	6,840,179	10,806,820
	Industrial	-	-	-	-	-	2,660	4,532	8,001
	Public	-	-	-	-	390,911	1,881,073	3,297,869	4,888,101
	Total	-	-	-	-	5,163,407	16,882,621	23,094,771	30,987,029
3C Nonstructural – Elevation 666.5	Commercial	-	-	-	-	1,356,655	3,330,661	4,528,294	5,583,123
	Residential	-	-	-	-	287,971	3,175,485	5,839,978	9,848,664
	Industrial	-	-	-	-	-	2,660	4,532	8,001
	Public	-	-	-	-	-	231,022	1,029,046	2,213,425
	Total	-	-	-	-	1,644,627	6,739,829	11,401,849	17,653,213
3B Nonstructural – Elevation 669.2	Commercial	-	-	-	-	1,086,664	1,493,942	1,876,087	2,465,668
	Residential	-	-	-	-	188,826	1,577,792	3,436,779	6,100,514
	Industrial	-	-	-	-	-	2,660	4,532	8,001
	Public	-	-	-	-	-	207,150	309,954	443,174
	Total	-	-	-	-	1,275,490	3,281,544	5,627,351	9,017,358
3A Nonstructural – Elevation 672.2	Commercial	-	-	-	-	606,358	686,927	764,707	819,721
	Residential	-	-	-	-	188,826	657,070	1,100,367	2,286,444
	Industrial	-	-	-	-	-	2,660	4,532	8,001
	Public	-	-	-	-	-	-	-	-
	Total	-	-	-	-	795,184	1,346,656	1,869,606	3,114,166
2D Floodwall – Elevation 663.0	Commercial	-	-	-	-	5,426,993	12,714,128	15,165,737	17,776,910
	Residential	-	-	-	-	722,252	3,942,979	6,818,883	10,893,376
	Industrial	-	-	-	-	-	2,671	4,548	8,001
	Public	-	-	-	-	1,044,507	2,960,141	4,489,554	6,105,725
	Total	-	-	-	-	7,193,753	19,619,919	26,478,722	34,784,012
2C Floodwall – Elevation 666.5	Commercial	-	-	-	-	883,756	9,603,386	11,905,676	14,329,666
	Residential	-	-	-	-	283,134	3,227,779	6,068,558	10,062,268
	Industrial	-	-	-	-	-	2,665	4,542	8,001
	Public	-	-	-	-	-	2,184,190	3,524,429	4,934,583
	Total	-	-	-	-	1,166,890	15,018,020	21,503,205	29,334,519
2B Floodwall – Elevation 669.2	Commercial	-	-	-	-	605,982	8,937,242	10,523,976	12,742,261
	Residential	-	-	-	-	188,585	1,859,045	3,753,630	6,306,293
	Industrial	-	-	-	-	-	2,651	4,535	8,001
	Public	-	-	-	-	-	2,155,203	2,746,879	3,117,741
	Total	-	-	-	-	794,567	12,954,141	17,029,020	22,174,296
2A Floodwall – Elevation 672.2	Commercial	-	-	-	-	605,982	686,884	892,459	12,719,932
	Residential	-	-	-	-	188,584	653,741	1,034,117	2,437,086
	Industrial	-	-	-	-	-	2,674	4,545	8,001
	Public	-	-	-	-	-	-	-	3,117,741
	Total	-	-	-	-	794,566	1,343,298	1,931,121	18,282,761

Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).

The damages reduced, or expected annual benefits, are shown in Table 12.

Table 12: Damages and Benefits by Alternative

Alternative	**Description**	**Expected Annual Damage (Mean)**			**Expected Annual Damage (25th to 75th percentile)**		
		Total Without Project	Total With Project	Damage Reduced	Q1	Median	Q3
3D	Nonstructural – Elevation 663.0	842,964	662,484	180,480	367,350	568,974	840,175
3C	Nonstructural – Elevation 666.5	842,964	319,352	523,612	168,223	263,531	397,872
3B	Nonstructural – Elevation 669.2	842,964	186,513	656,451	94,412	150,334	240,471

3A	Nonstructural – Elevation 672.2	842,964	88,106	754,858	37,240	64,871	117,509
2D	Floodwall – Elevation 663.0	842,964	825,193	17,771	439,278	688,884	1,062,864
2C	Floodwall – Elevation 666.5	842,964	535,568	307,396	296,187	465,777	673,042
2B	Floodwall – Elevation 669.2	842,964	452,765	390,199	258,415	396,722	568,105
2A	Floodwall – Elevation 672.2	842,964	178,709	664,255	78,929	134,708	225,395
Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).							

1.3.4 Preliminary Array Cost Calculations

An overview of all project first costs is presented in the following table. All cost figures are presented in FY24 price levels. For further details, refer to the Cost Engineering Appendix.

Interest during construction for each alternative was based on an estimated time frame particular to that alternative, as shown in Table 13. The summation of total first costs and interest during construction provides the total investment cost for the plan. To annualize charges, each impact area's total investment cost was amortized over a 50-year period of analysis at the FY24 federal discount rate of 2.75%.

Table 13: Estimated Construction Duration

Alternative	Description	Estimated Construction Duration (months)
3D	Nonstructural – Elevation 663.0	25
3C	Nonstructural – Elevation 666.5	59
3B	Nonstructural – Elevation 669.2	74
3A	Nonstructural – Elevation 672.2	83
2D	Floodwall – Elevation 663.0	25
2C	Floodwall – Elevation 666.5	59
2B	Floodwall – Elevation 669.2	74
2A	Floodwall – Elevation 672.2	83
4	FWEEP	24

1.3.4.1 Total Project Costs

For the total project, project investment costs were also calculated via the sum of first costs and interest during construction. First costs consist of construction, real estate, environmental mitigation, preconstruction, engineering, and design (PED), and construction management. The addition of total first costs and interest during construction provides the total investment cost for the plan. To annualize charges, the project's total investment cost was amortized over a 50-year period of analysis at the FY24 federal discount rate of 2.75%.

Table 14: Total Project First Costs by Alternative

Alternative	Description	PED, Env Mitigation, Cultural Resources, Construction Management	Construction Cost	Real Estate Cost	FWEEP Cost	Total Cost
3D	Nonstructural – Elevation 663.0	4,081,922	12,997,140	3,995,400	2,500,000	23,574,462
3C	Nonstructural – Elevation 666.5	9,369,086	30,684,550	7,968,600	2,500,000	50,522,236
3B	Nonstructural – Elevation 669.2	13,203,427	44,519,800	9,075,600	2,500,000	69,298,827
3A	Nonstructural – Elevation 672.2	15,632,841	53,687,400	9,162,600	2,500,000	80,982,841
2D	Floodwall – Elevation 663.0	8,373,232	29,145,480	4,012,800	2,500,000	44,031,512
2C	Floodwall – Elevation 666.5	14,897,278	51,953,200	6,532,800	2,500,000	75,883,278
2B	Floodwall – Elevation 669.2	21,894,761	77,797,700	7,643,400	2,500,000	109,835,861
2A	Floodwall – Elevation 672.2	27,208,329	97,594,900	7,732,800	2,500,000	135,036,029
4	FWEEP	-	-	-	2,500,000	2,500,000

Values are presented in FY24 price levels.

1.3.5 Expanded Alternative Array Results

A summary of annual benefits and costs for each impact area is presented in Table 15.

Table 15: Summary of Annual Benefits and Costs by Alternative

Beattyville, KY
General Investigation
Summary of Annual Benefits and Costs
FY 2024 Price Levels
2.75% Interest Rate

Investment Cost	Alternative 03d - Full NS to ELEV 663 Plan 2	Alternative 03c - Full NS to ELEV 666.5 Plan 3	Alternative 03b - Full NS to ELEV 669.2 Plan 4	Alternative 03a - Full NS to ELEV 672.2 Plan 5	Alternative 02d - Floodwall w/ NS to Elev 663 Plan 6	Alternative 02c - Floodwall w/ NS to Elev 666.5 Plan 7	Alternative 02b - Floodwall w/ NS to Elev 669.2 Plan 8	Alternative 02a - Floodwall w/ NS to Elev 672.2 Plan 9
Construction First Cost	23,574,462	50,522,236	69,298,827	80,982,841	44,031,512	75,883,278	109,835,861	135,036,029
Interest During Construction	678,916	3,524,320	6,133,834	8,096,162	1,268,055	5,293,451	9,721,880	13,500,065
Total Investment Cost	24,253,378	54,046,556	75,432,661	89,079,003	45,299,567	81,176,729	119,557,741	148,536,094
Annual Charges								
Interest & Amortization	898,367	2,001,934	2,794,095	3,299,568	1,677,938	3,006,861	4,428,529	5,501,913
Operation & Maintenance	0	0	0	0	5,000	5,000	5,000	5,000
Total Annual Charges	898,367	2,001,934	2,794,095	3,299,568	1,682,938	3,011,861	4,433,529	5,506,913
Annual Benefits								
Flood Risk Management	81,479	218,496	265,741	291,909	61,579	224,659	260,250	467,817
Total Annual Benefits	81,479	218,496	265,741	291,909	61,579	224,659	260,250	467,817
Benefit vs. Cost Ratio	**0.09**	**0.11**	**0.10**	**0.09**	**0.04**	**0.07**	**0.06**	**0.08**
Net Benefits	-816,888	-1,783,439	-2,528,354	-3,007,659	-1,621,358	-2,787,202	-4,173,278	-5,039,097

Following this analysis, all floodwall alternatives were screened from further consideration.

1.3.6 Expanded Array Regional Economic Development Benefits

The Principles and Guidelines (1983) established the RED account to register changes in the distribution of regional economic activity that result from each alternative plan. In addition to the benefits accounted for within the NED account, the implementation of the Recommended Plan 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, state, and national economy. The following table provides an overview of the impact areas utilized for the RED analysis.

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.

The nonstructural alternatives were analyzed for impacts to the regional economy the results of which are presented in Table 16.

Table 16: Expanded Array RED Impact Summary

	Alternatives and Construction Costs							
	3D: Nonstructural – Elevation 663.0, $12,997,140		3C: Nonstructural – Elevation 666.5, $30,684,550		3B: Nonstructural – Elevation 669.2, $44,519,800		3A: Nonstructural – Elevation 672.2, $53,687,400	
Area	**Output**	**Jobs***	**Output**	**Jobs***	**Output**	**Jobs***	**Output**	**Jobs***
Local								
Direct Impact	$8,530,000	100	$17,990,000	210	$26,101,000	304	$31,476,000	367
Secondary Impact	$3,734,000	23	$7,566,000	47	$10,978,000	68	$13,238,000	82
Total Impact	$12,264,000	123	$25,556,000	257	$37,079,000	372	$44,714,000	449
State								
Direct Impact	$10,305,000	118	$23,024,000	254	$33,406,000	368	$40,285,000	444
Secondary Impact	$8,923,000	52	$19,916,000	116	$28,895,000	169	$34,845,000	203
Total Impact	$19,227,000	170	$42,940,000	370	$62,301,000	537	$75,130,000	648
US								
Direct Impact	$12,402,000	131	$29,281,000	310	$42,483,000	450	$51,231,000	542
Secondary Impact	$22,909,000	106	$54,085,000	249	$78,471,000	362	$94,630,000	436
Total Impact	$35,311,000	237	$83,365,000	559	$120,954,000	812	$145,860,000	979

* Jobs are presented in full-time equivalence (FTE)
Values are presented in FY 2024 price levels.

1.4 Final Array of Alternatives Formulation and Analysis

As described previously, flaws in the initial array of alternatives led the PDT to develop a new suite of alternatives. It is important to note that some minor changes to the base structure inventory occurred between the analysis of the preliminary array and the final array so the without project conditions between the two arrays can be expected to contain some discrepancies.

1.4.1 Final Array of Alternatives Defined

1.4.1.1 Alternative 4: Flood Warning and Evacuation Emergency Plan (FWEEP)

Alternative 4 was maintained from the initial array and is the creation of a Flood Warning and Evacuation Emergency Plan (FWEEP) for the city of Beattyville. This would serve to shorten delays in warning issuance, warning diffusion, and mobilization of the population and would contribute to the reduction of life safety risk. Because this alternative would have no or little impact on damages to property, it is not included in the remainder of the FDA modeling discussion but is included in the life safety analysis, which begins in Section 1.5.

1.4.1.2 Alternative 5A: Floodway Acquisition + Recreation Features

Alternative 5A is the acquisition of several structures with footprints lying in the FEMA regulatory floodway. This alternative also includes beneficial reuse of those acquired parcels to provide recreation features to the community. These recreation features are discussed in Section 1.4.4. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.4.1.3 Alternative 5B: 5A + Nonstructural Measures for Essential Structures

Alternative 5B builds on Alternative 5A by adding nonstructural FRM measures to essential, or anchor, structures in the community. These include grocery, health, and other community services. The nonstructural measures applied are dry- and wet-floodproofing. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.4.1.4 Alternative 5C: 5B + Nonstructural Measures for Historic Structures

Alternative 5C builds on Alternative 5B by adding nonstructural FRM measures to those structures that allow Beattyville to maintain its historic integrity. The nonstructural measures applied are dry- and wet-floodproofing, and in one case, elevation. A FWEEP (described in Section 1.4.1.1) is also included in this alternative.

1.4.2 Model input modifications for Nonstructural Alternatives

The nonstructural alternatives were developed on a conceptual level, using modeled flood depths to identify which measures would be applicable to which structures. There are a few basic nonstructural measures that were considered for the project area. The first measure, acquisition, includes the evacuation and buyout of certain structures within the FEMA regulatory floodway. Another measure, dry floodproofing, would result in the modification of the exterior of a structure so that it could withstand low levels of inundation (less than three feet above the first floor). The third measure is wet floodproofing, which makes a structure resilient to inundation up to a determined height. Because wet floodproofing allows water to flow into the interior of a structure, any contents stored below the target height would not be protected. The fourth measure would elevate the structure to bring the first floor up to the target elevation.

Every Future with Project alternative modeled includes some nonstructural measures; therefore, all alternatives *except* Future Without Project, required modifications to the base structure inventory (for acquisition and elevation) and depth damage functions (for floodproofing).

1.4.2.1 Structure Inventory Modifications

In each alternative's new inventory, structures identified for acquisition were deleted, and structures identified for elevation were raised to have a first-floor elevation of 672.2. Originally foundation heights were estimated by subtracting observed LAG from observed FFE. To obtain new foundation height, the observed LAG was subtracted from 672.2.

1.4.2.2 Depth Damage Function Modifications

Because floodproofing prevents damage up to the target depth, depth damage functions had to be modified to reflect this. For this analysis, all dry floodproofing was assumed to be to three feet. Structures identified for floodproofing were given a new occupancy type indicating the measure, which corresponds with new DDFs wherein no damage occurs until depths are higher than three feet. At points above three feet, the DDFs are identical to those in the base inventory.

For those structures targeted for wet-floodproofing, the target height of the floodproofing measure was eight feet. For these structures, the depth damage functions for the structure itself were shifted to make damages start at eight feet. The depth damage functions for contents and vehicles were unchanged because the PDT determined contents were unlikely to be elevated.

1.4.3 Final Array Evaluation and Comparison (HEC-FDA 2.0)

The alternative evaluation and comparison planning steps require an examination of the potential risk across several categories (economic, engineering, and environmental). The following sections describe the alternative impacts based on monetary damages and damage reductions, while other impacts are discussed in the main report.

Expected annual damages associated with the modeled alternatives are presented in Table 17.

Note that while in the following table Alternative 4, the FWEEP, is shown as having no measurable reduction in damages when compared to the without project condition, it can reasonably be expected that some FRM benefits would be realized with improved warning time.

Table 17: Mean Expected Annual Damages by Damage Category

Alternative	Description	Commercial	Residential	Public	Industrial	Total Damage
1	Without Project	469,922	200,880	124,766	106	795,674
4	Flood Warning and Evacuation Emergency Plan	469,922	200,880	124,766	106	795,674
5A	FWEEP + Floodway Acquisition + Recreation Features	442,681	167,639	125,821	106	736,247
5B	5A + Nonstructural Measures for Essential Structures	392,469	167,584	90,612	106	650,771
5C	5B + Nonstructural Measures for Historic Structures	367,980	161,113	78,236	106	607,435

Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).

Table 18: Total Expected Annual Damage by Alternative (with Uncertainty)

Alternative	Description	Expected Annual Damage (Mean)	Expected Annual Damage (25th to 75th percentile)		
		Mean	Q1	Median	Q3
1	Without Project	795,167	471,348	695,261	997,819
5A	FWEEP + Floodway Acquisition + Recreation Features	735,752	441,822	647,195	922,894
5B	5A + Nonstructural Measures for Essential Structures	650,316	375,514	566,974	818,137
5C	5B + Nonstructural Measures for Historic Structures	607,007	343,803	526,532	766,488
Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).					

Table 19: Estimated Damages by Damage Category and Event

		Frequency Event							
Alternative	Damage Category	0.99	0.5	0.2	0.1	0.04	0.02	0.01	0.002
1 – Without Project	Commercial	-	-	-	-	6,103,242	13,287,736	15,865,697	18,533,841
	Residential	-	-	-	-	649,107	2,926,394	4,922,183	8,504,420
	Industrial	-	-	-	-	0	2,660	4,532	8,001
	Public	-	-	-	-	843,996	2,588,380	4,083,940	5,679,783
	Total	-	-	-	-	7,596,345	18,805,169	24,876,352	32,726,046
5A – FWEEP + Floodway Acquisition + Recreation Features	Commercial	-	-	-	-	5,826,175	12,818,713	15,194,404	17,795,104
	Residential	-	-	-	-	482,062	2,535,383	4,497,352	8,065,964
	Industrial	-	-	-	-	0	2,660	4,532	8,001
	Public	-	-	-	-	843,996	2,588,380	4,083,940	5,679,783
	Total	-	-	-	-	7,152,233	17,945,135	23,780,227	31,548,852
5B – 5A + Nonstructural Measures for Essential Structures	Commercial	-	-	-	-	5,754,992	12,106,144	14,382,884	17,412,010
	Residential	-	-	-	-	482,062	2,535,383	4,497,352	8,065,964
	Industrial	-	-	-	-	0	2,660	4,532	8,001
	Public	-	-	-	-	554,822	1,701,500	2,917,601	5,044,054
	Total	-	-	-	-	6,791,876	16,345,686	21,802,368	30,530,029
5C – 5B + Nonstructural Measures for Historic Structures	Commercial	-	-	-	-	5,501,315	11,568,663	13,785,261	17,028,068
	Residential	-	-	-	-	421,795	2,403,704	4,389,002	8,025,332
	Industrial	-	-	-	-	0	2,660	4,532	8,001
	Public	-	-	-	-	462,145	1,354,776	2,547,567	4,877,289
	Total	-	-	-	-	6,385,254	15,329,803	20,726,361	29,938,689
Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).									

The damages reduced, or expected annual benefits, are shown in Table 20, below.

Table 20: Damages and Benefits by Alternative

Alternative	Description	Expected Annual Damage (Mean)			Expected Annual Damage (25th to 75th percentile)		
		Total Without Project	Total With Project	Damage Reduced	Q1	Median	Q3
5A	FWEEP + Floodway Acquisition + Recreation Features	795,167	735,752	59,439	27,248	47,040	77,729
5B	5A + Nonstructural Measures for Essential Structures	795,167	650,316	144,919	92,025	128,354	180,630
5C	5B + Nonstructural Measures for Historic Structures	795,167	607,007	188,253	125,279	169,826	232,779
Values are presented in FY24 price levels and were annualized over a period of 50 years using the FY24 discount rate (2.75%).							

1.4.4 Recreation

Because Alternative 5A includes the creation of recreation features, a benefits analysis was required for the proposed features. NED benefits from a project's recreation features are measured in terms of a visitor's 'willingness to pay' for the recreation opportunity.

Based on Engineer Regulation 1105-2-100, the Planning Guidance Notebook, when the expected costs of recreation features exceed 25 percent of expected total projects costs, as in this project, it is recommended to develop a regional model or conduct a site-specific study to determine willingness to pay. However, Economic Guidance Memorandum 24-02, Unit Day Method, specifies that if either of those methods is not feasible or justified, the Unit Day Value method may be used. For this study, it was determined that the time and cost required for proper development of a regional model or site-specific study were not feasible; thus, the UDV method was used.

1.4.4.1 Unit Day Value Assessment

The UDV method relies on informed opinion and judgment, considering both the quality of recreation experience and visitation rates and uses the 'unit day values for recreation' contained in EGM 24-02.

To score alternatives, point values are assigned based on measurement standards described for five criteria: recreational experience; availability of opportunity; carrying capacity; accessibility; and environmental quality.

For the proposed concept, the category of 'general recreation' was used, and the guidelines for assigning points and dollar values in the EGM were followed.

The PDT evaluated the future without project condition and the proposed recreation features. A subsequent elicitation was conducted with representatives from the City of Beattyville to validate the scoring.

The guidelines for assigning points for general recreation are shown in Table 21.

Table 21: Guidelines for Assigning Points for General Recreation

Criteria	Judgement Factors				
Recreation Experience	Two general activities	Several general activities	Several general activities: one high quality value activity	Several general activities; more than one high quality activity	Numerous high quality value activities; some general activities
Point Value	0-4	5-10	11-16	17-23	24-30
Availability of Opportunity	Several within 1-hour travel time; a few within 30 min. travel time	Several within 1-hour travel time; none within 30 min. travel time	One or two within 1 hour travel time; none within 45 min. travel time	None within 1 hour travel time	None within 2-hour travel time
Point Value	0-3	4-6	7-10	11-14	15-18
Carrying Capacity	Minimum facility for development for public health and safety	Basic facility to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Point Value	0-2	3-5	6-8	9-11	12-14
Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Point Value	0-3	4-6	7-10	11-14	15-18
Environmental Quality	Low aesthetic factors that significantly lower quality	Average aesthetic quality; factors exist that lower quality to a minor degree	Above average aesthetic quality; any limiting factors can be reasonably rectified	High aesthetic quality; no factors exist that lower quality	Outstanding aesthetic quality; no factors exist that lower quality
Point Value	0-2	3-6	7-10	11-15	16-20

Once scored, the total points for each alternative can be converted to a dollar value, known as the Unit Day Value, representing the value of the proposed features per visitor per day.

The FY 2024 values for general recreation, shown in Table 22, were applied for this study.

Table 22: Conversion of UDV Points to Dollar Values

Point Values	General Recreation Values (1)	General Fishing and Hunting Values (1)	Specialized Fishing and Hunting Values (2)	Specialized Recreation Values other than Fishing and Hunting (2)
0	$5.05	$7.26	$35.36	$20.52
10	$6.00	$8.21	$36.30	$21.78
20	$6.63	$8.84	$36.93	$23.36
30	$7.58	$9.79	$37.88	$25.25
40	$9.47	$10.73	$38.83	$26.83
50	$10.73	$11.68	$42.62	$30.31
60	$11.68	$12.94	$46.41	$33.46
70	$12.31	$13.57	$49.25	$40.41
80	$13.57	$14.52	$53.03	$47.04
90	$14.52	$14.84	$56.82	$53.67
100	$15.15	$15.15	$59.98	$59.98

The evaluation of each site's proposed recreation features is presented in the following sections.

1.4.4.1.1 Future Without Project

Currently the area of interest in Beattyville along the shoreline of the Kentucky River is underutilized, lacks recreational opportunities, and experiences frequent nuisance flooding.

While it is anticipated that a future without project would include measures by the non-federal sponsor to prevent further loss of shoreline to erosion, there is no aesthetic or functional improvement expected in a FWOP condition.

Scoring decisions were made based on the following factors.

Recreation Experience: The existing condition of the site is a barren stretch along the Kentucky River. There is a playground and picnic pavilion; however, due to the frequent flooding, the facilities are often impacted by buildup of mud and silt. The difficulty of maintaining these facilities leads to them being unusable for significant periods of time. The apparent kayak rental and RV park facilities are unmanned and therefore not considered available for this analysis. There is parking available. While there is a boat ramp, the river is inaccessible for activities such as fishing from the bank. Silver Creek and Crystal Creek are entirely inaccessible. Score: 3

Availability of Opportunity: There is ample opportunity for similar low-quality experiences along the riverbanks in Beattyville. Score: 1

Carrying Capacity: There are basic facilities (playground, parking, and picnic shelter), but they are often deteriorated by frequent flooding and unavailable for use. Other areas of the recreation site footprint have no development that would allow for safe use. Score: 3

Accessibility: The existing condition has fair access to playground, picnic shelter, and parking when mud/silt are not a problem, but there is limited to no access to Crystal Creek and Silver Creek. Score: 3

Environmental Quality: The site along the Kentucky River is of low aesthetic quality. The mud and silt that frequently impact the existing playground significantly lower quality of resource. Score: 1

The PDT scored the site as shown in Table 23.

Table 23: Unit Day Value estimate for Future Without Project condition

Future Without Project	Future With Project
Recreation Experience	3
Availability of Opportunity	1
Carrying Capacity	3
Accessibility	3
Environmental Quality	1
Total Recreation Points	11
Value	$6.06

1.4.4.1.2 Future With Project

The proposed concept for recreation features in alternatives 5A (and by extension, 5B and 5C), includes a walking trail made up of a mix of both elevated boardwalk and an asphalt path, relocation of the frequently flooded playground to higher elevation, picnic tables, and historical markers and educational signage.

Scoring decisions were made based on the following factors.

Recreation Experience: In the with-project condition, there will be a walking trail that extends along the Kentucky river between both creeks and connects with the historic downtown/Main Street area. Creeks will be accessible for fishing, crawdad catching, and experiencing greenspace. The playground will be relocated to sponsor-preferred, resilient site at higher elevation, so similar facilities will be more available due to reduced flooding. The areas along the creeks will include native riparian plants and trees to enhance the natural aesthetic and, in some places, elevated boardwalks will ensure access to trails. Score: 15

Availability of Opportunity: The nature of the high-quality walking trail incorporated with the historic downtown district of Beattyville is unique within at least an hour's travel time. Score: 12

Carrying Capacity: New facilities will be adequate to support activities without deterioration of the experience. Score: 8

Accessibility: The new walking trail will provide good access within site to creeks, the Kentucky River, and Main Street. Score: 12

Environmental Quality: New walking trails that incorporate creek access with historic downtown will have above average aesthetic quality, and relocated playground will not incur same frequency of flood inundation. Native riparian plants and trees will enhance environmental quality of the site. Score: 10

The PDT scored the site as shown in Table 24.

Table 24 Unit Day Value estimate for Future With Project

Concept 1 – Combined Concept	Future With Project
Recreation Experience	15
Availability of Opportunity	12
Carrying Capacity	8
Accessibility	12
Environmental Quality	10
Total Recreation Points	57
Value	$11.40

1.4.4.2 Visitation Estimate

To complete the recreation benefits estimate, annual visitation must be estimated for both the future with and without project scenarios. Because no direct estimation exist, similar day-use areas were examined for use as a potential proxy in lieu of better data.

The Confluence Recreation Area, a day-use recreation at USACE's Buckhorn Lake, upstream of Beattyville on the Kentucky River, experienced visitation over 70,000 in 2023, according to the Visitation Estimation and Reporting System.

Carr Creek Lake, also upstream of Beattyville, has day use areas ranging from 25,000 to 97,000 visitors annually, though these sites are less comparable to the site at Beattyville.

Because Beattyville's famous Wooly Worm Festival received 30,000 visitors over a three-day period annually, the PDT determined that with-project visitation of 55,000 was reasonable and still potentially conservative. Without project visitation was assumed to be 5,000 annually, to account for incidental use of the sub-adequate facilities.

1.4.4.3 Recreation Benefits

The estimated benefits provided by the addition of recreation features to the site at Beattyville are shown in below.

Table 25 Unit Day Value estimate for Future With Project

Concept 1 – Combined Concept	With Project	Without Project
Annual Visitors	55,000	5,000
Unit Day Value	$11.40	$6.06
Annual Recreation Benefits	$626,725	$30,315

Thus the benefits provided to the nation in the alternatives including the proposed recreation features total $596,410 annually.

1.4.5 Cost Calculations

An overview of all project first costs is presented in the following table. All cost figures are presented in FY24 price levels. For further details, refer to the Cost Engineering Appendix.

The summation of total first costs and interest during construction provides the total investment cost for the plan. To annualize charges, each impact area's total investment cost was amortized over a 50-year period of analysis at the FY24 federal discount rate of 2.75%. The assumed construction duration for each alternative was 24 months.

1.4.5.1 Total Project Costs

For the total project, project investment costs were also calculated via the sum of first costs and interest during construction. First costs consist of construction, real estate, environmental mitigation, preconstruction, engineering, and design (PED), and construction management. The addition of total first costs and interest during construction provides the total investment cost for the plan. To annualize charges, the project's total investment cost was amortized over a 50-year period of analysis at the FY24 federal discount rate of 2.75%.

Table 26: Final Array Total Project First Costs by Alternative

Alternative	Description	PED, Env Mitigation, Cultural Resources, Construction Management	Construction Cost	Real Estate Cost	Total Cost
4	Flood Warning and Evacuation Emergency Plan	516,750	1,950,000	-	2,466,750
5A	FWEEP + Floodway Acquisition + Recreation Features	2,452,359	8,391,747	2,474,400	13,318,506
5B	5A + Nonstructural Measures for Essential Structures	4,197,252	8,965,903	9,193,900	22,357,055
5C	5B + Nonstructural Measures for Historic Structures	6,688,747	18,657,403	10,430,544	35,776,694
Values are presented in FY24 price levels.					

1.4.6 Results

A summary of annual benefits and costs for each alternative is presented in Table 27.

Table 27: Final Array Summary of Annual Benefits and Costs by Alternative

Beattyville, KY
General Investigation
Summary of Annual Benefits and Costs
FY 2024 Price Levels
2.75% Interest Rate

	FWEEP Only	5A: FWEEP + Floodway Acquisition + Recreation Features	5B: 5A + Nonstructural Measures for Essential Structures	5C: 5B + Nonstructural Measures for Historic Structures
Investment Cost				
Construction First Cost	2,466,750	13,318,506	22,357,055	35,776,694
Interest During Construction	68,146	367,935	617,632	988,360
Total Investment Cost	2,534,896	13,686,441	22,974,687	36,765,054
Annual Charges				
Interest & Amortization	93,895	506,958	851,004	1,361,811
Operation & Maintenance	5,000	15,000	15,000	15,000
Total Annual Charges	98,895	521,958	866,004	1,376,811
Annual Benefits				
Flood Risk Management	0	59,428	144,903	188,239
Recreation	0	596,410	596,410	596,410
Total Annual Benefits	0	655,838	741,313	784,649
Benefit vs. Cost Ratio	**0.00**	**1.26**	**0.86**	**0.57**
Net Benefits	-98,895	133,879	-124,690	-592,162

Assumptions
$5K O&M for FWEEP and $10K for 2nd Increment
24 month construction period for all increments

Note that all calculations and benefit-cost ratios are based on cost estimates that were finalized for the Tentatively Selected Plan milestone in June 2024. Costs and benefit-cost ratios will be updated for the final report.

1.4.7 Regional Economic Development Benefits

The Principles and Guidelines (1983) established the RED account to register changes in the distribution of regional economic activity that result from each alternative plan. In addition to the benefits accounted for within the NED account, the implementation of the Recommended Plan 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, state, and national economy. The following table provides an overview of the impact areas utilized for the RED analysis.

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.

The nonstructural alternatives were analyzed for impacts to the regional economy the results of which are presented in Table 28.

Table 28: Final Array RED Impact Summary

	Alternatives and Construction Costs							
	4: FWEEP - $1,950,000		5A: FWEEP + Floodway Acquisition + Recreation Features - $8,391,747		5B: 5A + Nonstructural Measures for Essential Structures - $8,965,903		5C: 5B + Nonstructural Measures for Historic Structures - $18,657,403	
Area	**Output**	**Jobs***	**Output**	**Jobs***	**Output**	**Jobs***	**Output**	**Jobs***
Local								
Direct Impact	$1,143,000	13	$4,920,000	57	$5,257,000	61	$10,938,000	128
Secondary Impact	$481,000	3	$2,069,000	13	$2,211,000	14	$4,601,000	29
Total Impact	$1,624,000	16	$6,989,000	70	$7,467,000	75	$15,539,000	156
State								
Direct Impact	$1,463,000	16	$6,297,000	69	$6,728,000	74	$14,000,000	154
Secondary Impact	$1,266,000	7	$5,447,000	32	$5,819,000	34	$12,109,000	71
Total Impact	$2,729,000	24	$11,743,000	101	$12,547,000	108	$26,109,000	225
US								
Direct Impact	$1,861,000	20	$8,008,000	85	$8,556,000	91	$17,804,000	189
Secondary Impact	$3,437,000	16	$14,791,000	68	$15,803,000	73	$32,886,000	152
Total Impact	$5,298,000	36	$22,799,000	153	$24,359,000	163	$50,689,000	340

* Jobs are presented in full-time equivalence (FTE)
Values are presented in FY 2024 price levels.

1.5 LIFE SAFETY

The life safety consequence modeling for this study was performed using USACE's life loss and direct property damage estimation software LifeSim version 2.1.3. To determine the percentage of population at risk (PAR) within a structure that is warned and mobilized over time, several parameters are used within LifeSim to estimate the probable values of warning and mobilization percentages at each time step. These include when hazards are identified and warnings will be issued (hazard identification and delays), how long they will take to become effective (warning diffusion), and the rate at which PAR will mobilize in response (mobilization or Protective Action Inhiation (PAI). Figure 7 is an example breach warning and response timeline.

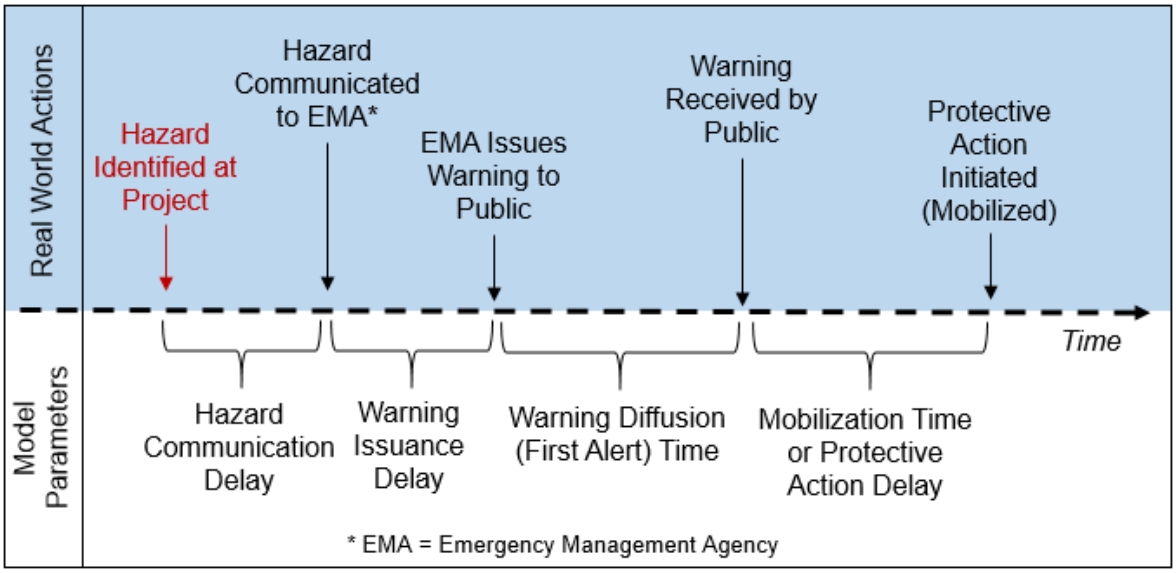


Figure 7: Warning and response timeline.

1.5.1 Life Loss Model Inputs and Parameters

1.5.1.1 Structure Inventory

The structure inventories used for life safety analysis are the same as those used for FDA analysis and are discussed in detail in Section 1.2.4.3.

1.5.1.2 Road Network and Destination Points

The road network was developed using data from OpenStreetMaps. The data contains information about road type, bridges, and directional attributes (one way). The road network was modified to account for overpasses and bridges so road segments will have the appropriate vertical offset relative to the ground elevation. The road network and destination points are shown in Figure 8.



Figure 8: Road network and destination points

1.5.1.3 Emergency Preparedness

Lee County has an all-hazards emergency operations plan that is currently under development; however, recent weather emergencies have shown little formal coordination as pertains to the issuance of first alerts and warnings.

The most recent major flood occurred in 2021 when Lee County officials stated water reached depths of six to seven feet downtown and affected 35 to 40 businesses. Multiple evacuations occurred, including one of approximately 20 people who were evacuated from a mobile home park downtown to an American Red Cross shelter (Chisenhall & Estep, 2021). There is evidence that many people had no advanced warning beyond law enforcement, or in some cases neighbors, knocking on the door and informing them they should evacuate immediately (Estep & Eads, 2021).

Since January 2009, Lee County has also experienced other significant weather emergencies including floods, ice storms, and a major windstorm. Each of these weather-related events initially paralyzed the county and required a well-coordinated recovery from the county's incident management team.

The Emergency Preparedness parameters within LifeSim are described in the sections below.

1.5.1.4 Relative Hazard Identification

The Hazard Identification time is the time at which a hazard is identified relative to when it occurs.

For Beattyville, the hazard was assumed to be when water begins to exceed the banks on Crystal Creek near McGuire Avenue between Main Street and the railroad.

It was assumed that for major floods—the 1% AEP event and the 0.2% AEP event—the hazard would be identified between six and 12 hours prior to Crystal Creek exceeding its banks. For the more frequent events—the 4% AEP event and the 2% AEP event—the hazard would be identified between zero and 12 hours prior to Crystal Creek exceeding its banks.

Table 29: Relative hazard identification times

AEP	Distribution Type	Minimum (hr)	Maximum (hr)
1%, 0.2%	Uniform	-12	-6
4%, 2%	Uniform	-12	-0

1.5.1.5 Hazard Communication Delay

The Hazard Communication Delay is the time that it would take from when the hazard is identified to when the emergency planning zone (EPZ) representatives would be notified. For example, if a breach occurs when no one is observing the project then the emergency managers could be notified after the hazard is identified. The hazard communication delay ranged between 0.01 and 0.5 hour and assumed a uniform distribution.

1.5.1.6 Warning Issuance Delay

The Warning Issuance Delay is the time it takes from when the emergency managers receive the notification of the imminent hazard to when they issue the first evacuation order to the public.

For the Future Without Project scenario, the LifeSim preset “Preparedness Unknown” warning issuance delay curves were used. Although the range of possible warning issuance delay is randomly sampled from 0 and 6 hours (300 minutes) after officials are notified of the flood hazard using a Lindell distribution, it is positively skewed so that results from 0 to 1.5 hours (90 minutes) are more likely.

For the with-project alternatives, all of which include a FWEEP, the LifeSim preset “Well Prepared” warning issuance delay curves were used. Like the FWOP condition, the range of possible warning issuance delay is randomly sampled from 0 and 6 hours (300 minutes) after officials are notified of the flood hazard, the Lindell distribution is positively skewed so that results from 0 to 0.5 hours (30 minutes) are more likely.

1.5.1.7 Warning Diffusion

For the Future Without Project scenario, the LifeSim preset “Preparedness Unknown” warning diffusion curves were used. The curves utilize a uniform distribution, and the warning diffusion curves are sampled during each Monte Carlo iteration in LifeSim. The upper bound of the curve reaches 100% diffusion just after 1.5 hours (100 minutes), and the lower bound reaches 100% diffusion after 6 hours (360 minutes).

For the with-project alternatives, the LifeSim preset “Fast” warning diffusion curves were used due to the assumption that the FWEEP will be in place. The curves utilize a triangular distribution and are sampled during each Monte Carlo iteration in LifeSim. The upper bound of the curve reaches 100% diffusion just after 1.5 hours (100 minutes), and the lower bound reaches 100% diffusion after 150 minutes.

1.5.1.8 Protective Action Initiation

Protective Action Initiation (PAI) is the rate at which PAR takes action after receiving an evacuation order (warning). Unlike the warning diffusion curves, the PAI "Preparedness Unknown" curve includes a perception element as well. The perception element describes a PAR as being aware of their flood risk (Perception = Likely to Impact) or generally unaware that they are at risk of being flooded (Perception = Unlikely to Impact). The "Preparedness Unknown, Perception Unknown" curve was used for all scenarios, because it is unclear what impact a FWEEP would have on the population's perception of their own risk and their likelihood to mobilize when warned, though it would be reasonable to assume there would be some improvement in both perception and preparedness.

Time	Initiated		
X	Min (a)	Most Likely (c)	Max (b)
0	0	0	0
15	1	29	75
30	4.0363	50	100
60	23	75	100
120	42	89	100
480	53	91	100
1,440	71	94	100
4,320	76.0323	97	100

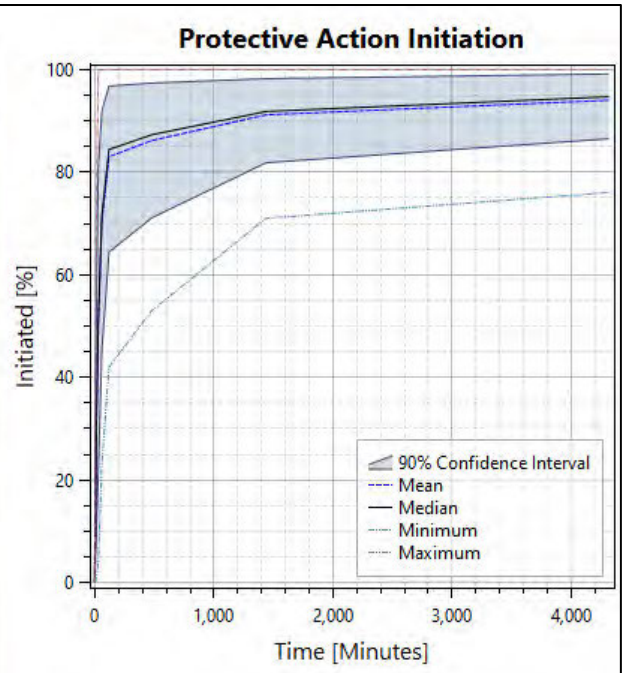


Figure 9. PAI curve for preparedness unknown, perception unknown.

1.5.2 Expanded Array of Alternatives Analysis

Life loss analysis was not completed on the expanded array of alternatives until after all floodwall alternatives had been screened from further consideration. Therefore, this section focuses on existing conditions, the FWEEP, and the four nonstructural alternatives that were aggregated by target elevations.

1.5.2.1 Population at Risk

Population at risk (PAR) is defined as the number of people within a project area that would be subject to inundation during a flood hazard event. Estimates of PAR were generated in LifeSim using the previously described inundation scenarios. The estimated number of inundated structures and PAR are summarized in Table 30 and Table 31, respectively.

Table 30: Expanded Array Estimated number of inundated structures

Alternative	Description	Structures Inundated			
		0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	129	129	123	84
3D	Nonstructural – Elevation 663.0	112	109	106	69
3C	Nonstructural – Elevation 666.5	97	91	91	57
3B	Nonstructural – Elevation 669.2	93	90	88	57
3A	Nonstructural – Elevation 672.2	94	91	89	57

Table 31: Expanded Array Estimated mean population at risk

Alternative	Description		Population at Risk			
			0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	Day	369	364	361	175
		Night	317	310	306	135
3D	Nonstructural – Elevation 663.0	Day	338	333	330	147
		Night	309	303	299	125
3C	Nonstructural – Elevation 666.5	Day	309	304	300	119
		Night	282	276	272	100
3B	Nonstructural – Elevation 669.2	Day	296	291	289	116
		Night	270	264	262	97
3A	Nonstructural – Elevation 672.2	Day	296	291	289	116
		Night	270	264	262	97

1.5.2.2 Direct Life Loss

Estimates of direct life loss were generated using LifeSim for the 4%, 2%, 1%, and 0.2% AEP inundation scenarios, for both with- and without-project. The more frequent scenarios were not modeled because structures in Beattyville are not expected to incur inundation in those cases.

LifeSim utilizes Monte Carlo uncertainty analysis, and 5,000 iterations were performed for each scenario. The estimated direct life loss by scenario is summarized in Table 32 through Table 37.

Table 32. Estimated direct life loss for Future Without Project

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	80	93	38	38	17	16	5	5
95th Percentile	27	22	10	9	5	4	2	1
75th Percentile	15	12	5	5	3	2	0	0
Mean	**11**	**9**	**4**	**3**	**2**	**1**	**0**	**0**
Median	**9**	**7**	**3**	**2**	**1**	**1**	**0**	**0**
25th Percentile	4	3	1	1	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 33. Estimated direct life loss for FWEEP Only

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	59	70	15	15	10	7	4	4
95th Percentile	19	16	7	6	4	3	1	1
75th Percentile	10	9	3	3	2	1	0	0
Mean	**7**	**6**	**2**	**2**	**1**	**1**	**0**	**0**
Median	**6**	**5**	**1**	**1**	**0**	**0**	**0**	**0**
25th Percentile	2	2	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 34. Estimated direct life loss for 663.0 + FWEEP

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	71	107	20	21	9	9	4	3
95th Percentile	20	18	9	8	4	3	1	1
75th Percentile	11	10	5	4	2	2	0	0
Mean	**8**	**7**	**3**	**3**	**1**	**1**	**0**	**0**
Median	**6**	**6**	**2**	**2**	**1**	**0**	**0**	**0**
25th Percentile	3	2	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 35. Estimated direct life loss for 666.5 + FWEEP

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	58	81	17	28	15	10	5	4
95th Percentile	18	16	7	7	4	3	1	1
75th Percentile	10	9	3	3	2	2	0	0
Mean	**7**	**6**	**2**	**2**	**1**	**1**	**0**	**0**
Median	**5**	**5**	**1**	**1**	**0**	**0**	**0**	**0**
25th Percentile	2	2	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 36. Estimated direct life loss for 669.2 + FWEEP

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	51	63	25	22	9	9	5	3
95th Percentile	17	14	7	6	4	3	1	0
75th Percentile	9	8	3	3	2	1	0	0
Mean	**6**	**5**	**2**	**2**	**1**	**1**	**0**	**0**
Median	**5**	**4**	**1**	**1**	**0**	**0**	**0**	**0**
25th Percentile	2	1	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 37. Estimated direct life loss for 672.2 + FWEEP

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	60	70	16	21	11	7	4	3
95th Percentile	16	14	7	6	4	3	1	1
75th Percentile	9	7	3	3	2	2	0	0
Mean	**6**	**5**	**2**	**2**	**1**	**1**	**0**	**0**
Median	**5**	**4**	**1**	**1**	**0**	**0**	**0**	**0**
25th Percentile	2	1	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

The above statistical summaries only reflect the uncertainty in the LifeSim input parameters and do not include uncertainties for breach parameters or other hydrologic and hydraulic factors.

1.5.2.3 Life Loss on Roads

A potentially important element of the life safety consequences occurs while the PAR is evacuating after receiving an evacuation order. In Beattyville's recent major floods, it was noted that many downtown roads were inundated, which introduces the potential for individuals to lose their lives by coming into contact with flood waters while evacuating. To account for this life loss while evacuating, LifeSim simulates evacuation in vehicles on a road network, making it possible to estimate how much life loss on roads contributes to the total life loss. The estimated mean life loss on roads is summarized in Table 38.

Table 38: Expanded Array Estimated mean breach life loss on roads.

Alternative	Description		Mean Life Loss on Roads			
			0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	Day	1	1	0	0
		Night	1	1	0	0
3D	Nonstructural – Elevation 663.0	Day	1	1	0	0
		Night	1	0	0	0
3C	Nonstructural – Elevation 666.5	Day	1	0	0	0
		Night	1	0	0	0
3B	Nonstructural – Elevation 669.2	Day	1	0	0	0
		Night	1	0	0	0
3A	Nonstructural – Elevation 672.2	Day	1	0	0	0
		Night	1	0	0	0
4	FWEEP Only	Day	1	0	0	0
		Night	1	0	0	0

1.5.2.4 Life Safety Risk

While LifeSim, described in the sections above, produces event-based life loss estimates, those alone are not adequate to describe the annual risk to life safety from riverine flooding, which is reliant on the probability of the modeled events occurring.

The USACE Risk Management Center has developed quantitative risk analysis software (RMC-TotalRisk) to perform risk analysis based on probability of hazard occurrence and the consequences that occur as a result of those user-defined hazards.

1.5.2.4.1 Hazard

To define the hazard and its uncertainty within RMC-TotalRisk, each modeled frequency event was assigned a minimum, most likely, and maximum stage (PERT distribution). In addition to the eight events modeled in HEC-FDA and LifeSim, the 0.001 and 0.0002 AEP events were included to inform the analysis.

Because all structural alternatives had been previously screened from further analysis, only one hydraulic event was needed for this analysis, which was applied to the future without project condition and all nonstructural alternatives.

Table 39: Stage-frequency data used in RMC-TotalRisk

Exceedance Probability	Stage (ft-NAVD88)		
X	Minimum	Most Likely	Maximum
0.99	638.77	640.62	642.59
0.5	647.94	649.47	650.96
0.2	651.26	653.28	656.31
0.1	653.38	656.7	663.29
0.04	656.46	663.47	669.7
0.02	660.91	667.77	675.52

0.01	664.34	671.43	681.31
0.002	669.98	680.17	696.66
0.001	672.24	684.09	704.22
0.0002	677.31	693.6	724.37

The uncertainty distribution for the flood hazard is shown in the following figure.

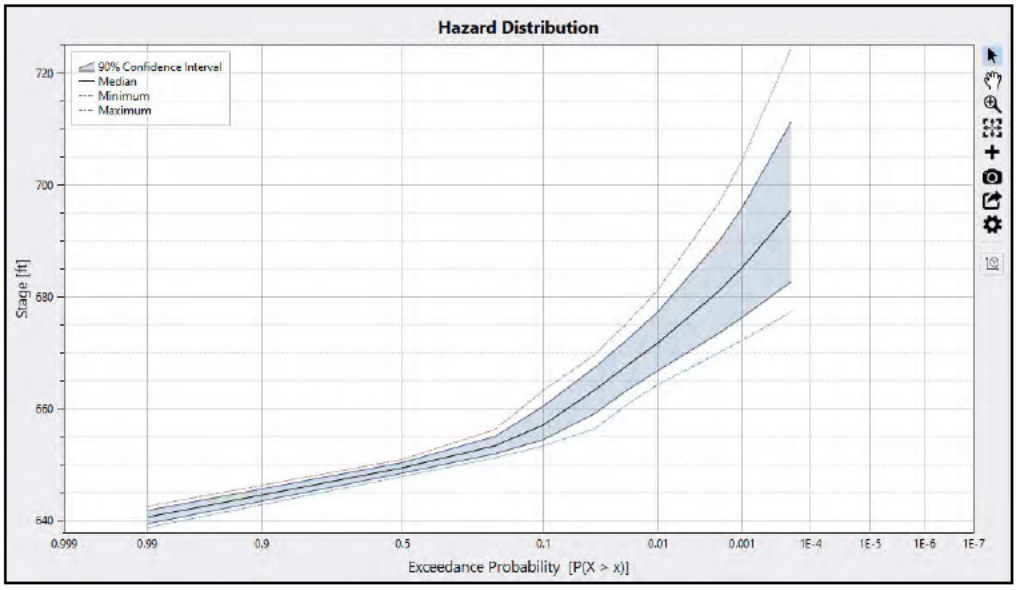


Figure 10: Stage-Frequency Uncertainty Distribution

1.5.2.5 Average Annual Life Loss

As described in Section 1.5.2.2, daytime and nighttime life loss estimates were developed for a range of flood frequency events for the following scenarios: Future Without Project, Nonstructural to elevation 672.2 + FWEEP, Nonstructural to elevation 669.2 + FWEEP, Nonstructural to elevation 666.5 + FWEEP, Nonstructural to elevation 663.0 + FWEEP, and FWEEP only.

In RMC-TotalRisk, three consequence functions are created for each scenario: Day, Night, and Composite. The daytime exposure scenario rate was assumed to be 45% while the nighttime exposure rate was assumed to be 55%, and the composite curves were created using the day and night scenarios weighted by their respective exposure rates.

Given the likelihood of each modeled event and the expected life loss associated with each event, the result of the RMC-TotalRisk analysis is the total average annual incremental life loss (AALL) for each scenario, shown in Table 40.

Table 40: Expanded Array Average Annual Life Loss

Alternative	Description	Average Annual Life Loss (Lives/Year)	Change in Average Annual Life Loss	
			Lives/Year	Percent
1	Without Project	0.1349	0	0
3D	Nonstructural – Elevation 663.0	0.1138	-0.0216	-16%
3C	Nonstructural – Elevation 666.5	0.0971	-0.0383	-28%
3B	Nonstructural – Elevation 669.2	0.0941	-0.0413	-31%
3A	Nonstructural – Elevation 672.2	0.0923	-0.0431	-32%
4	FWEEP Only	0.1252	-0.0093	-7%

In the without project condition, the expected life loss is 0.1354 lives per year – nearly 7 individuals whose lives are expected to be lost due to direct contact with flood waters over the 50-year period of analysis. It should be noted that these figures do not include indirect life loss; that is, life loss that occurs due to other effects of a flood, such as a power outage, exposure to extreme weather conditions, or lack of access to emergency services.

All proposed alternatives reduce the expected annual life loss, several of them by 25-30 percent. However, the cost of the proposed measures must be considered. While USACE does not place a monetary value on human life, the cost per statistical life saved can be a useful measurement to compare the cost-effectiveness of the proposed alternatives.

The procedure to calculate the cost-to-save-a-statistical-life, or CSSL, is described in Appendix P of Engineering Regulation 1110-2-1156. In short, the CSSL is the difference between the annualized cost of a safety remediation measure and the annualized economic benefit of risk reduction to property, divided by the incremental reduction in the annualized risk of life loss brought about by the safety remediation.

Table 41: Expanded Array Cost to Save a Statistical Life

Alternative	Description	Average Annual Life Loss (Lives/Year)	Cost to Save a Statistical Life
1	Without Project	0.1354	-
3D	Nonstructural – Elevation 663.0	0.1138	$33,160,000
3C	Nonstructural – Elevation 666.5	0.0971	$38,550,000
3B	Nonstructural – Elevation 669.2	0.0941	$51,770,000
3A	Nonstructural – Elevation 672.2	0.0923	$58,990,000
4	FWEEP Only	0.1261	$10,230,000

While Alternatives 3A and 3B, Nonstructural to elevation 672.2 and 669.2, respectively, contribute the largest reductions to life safety risk at Beattyville, they are the costliest per life saved. Among the proposed alternatives, Alternative 4, FWEEP Only, has the lowest cost to save a statistical life.

1.5.3 Final Array Alternatives Analysis

The life safety analysis of the final array of alternatives is described below. Note that, like the flood damage analysis, some minor changes to the base structure inventory occurred between the analysis of the expanded array and the final array so the without project conditions/no-action alternatives between the two arrays can be expected to contain some discrepancies.

Also note that the alternatives 5B and 5C were not modeled as the additional dry- and wet-floodproofing was not expected to provide significant enough changes to life safety risk to warrant further analysis. It can be assumed for purposes of this analysis that the life safety outcomes for 5B and 5C are equivalent to those for 5A shown below.

1.5.3.1 Population at Risk

As described in the life safety analysis of the expanded array, population at risk (PAR) is defined as the number of people within a project area that would be subject to inundation during a flood hazard event. The estimated number of inundated structures and PAR are summarized in Table 42 and Table 43 , respectively.

Table 42: Final Array Estimated number of inundated structures

Alternative	Description	Structures Inundated			
		0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	123	120	117	79
4	Flood Warning and Evacuation Emergency Plan	123	120	117	79
5A	FWEEP + Floodway Acquisition + Recreation Features	110	107	104	69

Table 43: Final Array Estimated mean population at risk

Alternative	Description		Population at Risk			
			0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	Day	333	327	358	170
		Night	361	356	309	134
4	Flood Warning and Evacuation Emergency Plan	Day	313	306	347	161
		Night	377	372	321	142
5A	FWEEP + Floodway Acquisition + Recreation Features	Day	288	281	321	141
		Night	351	346	296	123

1.5.3.2 Direct Life Loss

Estimates of direct life loss were generated using LifeSim for the 4%, 2%, 1%, and 0.2% AEP inundation scenarios, for both with- and without-project. The more frequent scenarios were not modeled because structures in Beattyville are not expected to incur inundation in those cases.

As in the analysis of the expanded array, 5,000 iterations were performed for each scenario. The estimated direct life loss by scenario is summarized in Table 44 through Table 46.

Table 44. Estimated direct life loss for Future Without Project

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	38	36	21	20	12	11	6	4
95th Percentile	19	20	8	9	5	4	1	1
75th Percentile	11	11	4	4	2	2	0	0
Mean	7	8	3	3	1	1	0	0
Median	6	6	2	2	1	1	0	0
25th Percentile	2	3	0	1	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 45. Estimated direct life loss for Alt. 4: FWEEP Only

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	34	47	23	21	15	10	4	4
95th Percentile	17	20	8	8	4	4	1	1
75th Percentile	10	11	4	4	2	2	0	0
Mean	6	8	2	3	1	1	0	0
Median	5	7	2	2	1	0	0	0
25th Percentile	2	3	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

Table 46. Estimated direct life loss for Alt. 5A: FWEEP + Floodway Acquisition

	0.2% AEP		1% AEP		2% AEP		4% AEP	
Statistic	Day	Night	Day	Night	Day	Night	Day	Night
Maximum	32	32	15	14	9	11	4	4
95th Percentile	14	16	6	6	4	3	1	1
75th Percentile	7	9	2	3	2	1	0	0
Mean	5	6	1	2	1	1	0	0
Median	4	5	1	1	0	0	0	0
25th Percentile	1	2	0	0	0	0	0	0
5th Percentile	0	0	0	0	0	0	0	0
Minimum	0	0	0	0	0	0	0	0

The above statistical summaries only reflect the uncertainty in the LifeSim input parameters and do not include uncertainties for breach parameters or other hydrologic and hydraulic factors.

1.5.3.3 Life Loss on Roads

A potentially important element of the life safety consequences occurs while the PAR is evacuating after receiving an evacuation order. In Beattyville's recent major floods, it was noted that many downtown roads were inundated, which introduces the potential for individuals to lose their lives by coming into contact with flood waters while evacuating. To account for this life loss while evacuating, LifeSim simulates evacuation in vehicles on a road network, making it possible to estimate how much life loss on roads contributes to the total life loss. The estimated mean life loss on roads is summarized in Table 47.

Table 47: Final Array Estimated mean breach life loss on roads.

Alternative	Description		Mean Life Loss on Roads			
			0.2 % AEP	1% AEP	2% AEP	4% AEP
1	Without Project	Day	1	0	0	0
		Night	1	0	0	0
4	Flood Warning and Evacuation Emergency Plan	Day	0	0	0	0
		Night	1	0	0	0
5A	FWEEP + Floodway Acquisition + Recreation Features	Day	0	0	0	0
		Night	0	0	0	0
		Night	1	0	0	0

1.5.3.4 Life Safety Risk

The hazard inputs for RMC-TotalRisk are the same described in Section 1.5.2.4.

1.5.3.5 Average Annual Life Loss

Given the likelihood of each modeled event and the expected life loss associated with each event, the result of the RMC-TotalRisk analysis is the total average annual incremental life loss (AALL) for each scenario, shown in Table 40.

Table 48: Final Array Average Annual Life Loss

Alternative	Description	Average Annual Life Loss (Lives/Year)	Change in Average Annual Life Loss	
			Lives/Year	Percent
1	Without Project	0.1349	0	0
4	Flood Warning and Evacuation Emergency Plan	0.1252	-0.01	-7%
5A	FWEEP + Floodway Acquisition + Recreation Features	0.0949	-0.04	-30%

In the without project condition, the expected life loss is 0.1349 lives per year – nearly 7 individuals whose lives are expected to be lost due to direct contact with flood waters over the 50-year period of analysis. It should be noted that these figures do not include indirect life loss; that is, life loss

that occurs due to other effects of a flood, such as a power outage, exposure to extreme weather conditions, or lack of access to emergency services.

Both proposed alternatives reduce the expected annual life loss; however, the cost of the proposed measures must be considered. While USACE does not place a monetary value on human life, the cost per statistical life saved can be a useful measurement to compare the cost-effectiveness of the proposed alternatives.

The procedure to calculate the cost-to-save-a-statistical-life, or CSSL, is described in Appendix P of Engineering Regulation 1110-2-1156. In short, the CSSL is the difference between the annualized cost of a safety remediation measure and the annualized economic benefit of risk reduction to property, divided by the incremental reduction in the annualized risk of life loss brought about by the safety remediation.

Table 49: Final Array Cost to Save a Statistical Life

Alternative	Description	Average Annual Life Loss (Lives/Year)	Cost to Save a Statistical Life
1	Without Project	0.1349	-
4	Flood Warning and Evacuation Emergency Plan	0.1252	$10,195,000
5A	FWEEP + Floodway Acquisition + Recreation Features	0.0949	$11,563,000

1.6 Estimating the non-Federal Cost Share – Ability to Pay

Section 103(m) of Public Law 99-662, 33 U.S.C. 2213m (Jan. 26, 1995) requires that all cost-sharing agreements for flood risk management covered by the terms of Section 103(a) or 103(b) be subject to the ability-to-pay test. As a result of the application of the test, some projects will be cost shared by the non-Federal sponsor at a lower level than the standard non-Federal share that would be required under the provisions of Section 103 of PL 99-662, 33 USC 2213.

All ability-to-pay calculations, procedures, and methodologies are presented in ER 1165-2-121, which can be found here:

https://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1165-2-121.pdf?ver=2013-09-08-233444-150

The non-Federal cost share is equivalent to the benefits-based floor for this study, which is 14.25%. The cost share is determined via the benefits and income tests and the process for calculating each is shown below.

1.6.1 Benefits Test

If the Benefit-Cost Ratio divided by 4 (BCR/4) when expressed as a percentage is greater than or equal to the standard non-federal cost share, the project is not eligible for a reduction and would be subject to the standard non-federal cost share required under the provisions of Section 103 within Public Law 99-662.

This figure (BCR/4 expressed as a percentage) is known as the "Benefits-based floor," shown in Table 50.

Table 50: Ability to Pay – Benefits Test

Plan	Average Annual Benefits	Average Annual Cost	BCR	BCR/4	Benefits-based floor
Recommended Plan	784,649	1,376,811	0.57	0.1425	14.25%

1.6.2 Income Test

Since the calculated BBF is less than the standard level of cost sharing, the amount of the non-federal share to be applied to the alternatives' costs must be determined by the income test. The income test as outlined in ER 1165-2-121 determines the fraction of reduction in cost sharing depending on the current economic resources of the state and county in which the project is located.

The first step is to calculate the Eligibility Factor (EF) for the project area according to the following formula (based on EGM 19-04):

EF (Eligibility Factor) = a – b1 (State income index) – b2 (County income index)

Where a = 18.22; b1 = 0.079; b2 = 0.158

It should be noted that a, b1, and b2 are fixed values supplied directly from EGM 19-04.

The state income index and county income index are factors created directly from the Bureau of Economic Analysis's Per Capita Personal Income data, using the three most recent years for which data are available. For the Recommended Plan, this was 2020-2022.

Table 51: Ability to Pay - Eligibility Factor

Plan	State Index	County Index	Eligibility Factor
Recommended Plan	79.61	53.79	3.43

If the EF > 1, the non-federal share is equal to the Benefits Based Floor, calculated in Section 1.6.1.

1.6.3 Non-Federal Cost Share

Thus, the non-Federal cost share is 14.25% of the estimated cost. When applied to the total construction cost of $35,777,000, the resulting non-Federal cost share is $5,098,000, as shown in Table 52.

Table 52: Non-Federal Cost Share

Plan	Total Cost	Benefits Based Floor (NFS Cost Share %)	NFS Cost Share Amount
Recommended Plan	$35,776,694	14.25%	$5,098,179

Appendix E

Draft Real Estate

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1. PURPOSE

This Real Estate Plan (REP) presents the real estate requirements for the Beattyville, KY Flood Risk Management Project (Project) in accordance with ER 405-1-12. This REP supports the Feasibility Study with integrated Environmental Assessment. 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. Anticipated requirements for lands, easements, rights-of-way, relocations, and disposal areas (LERRD) are based on information furnished by the project development team (PDT).

2. PROJECT AUTHORIZATION

Section 6 of the Flood Control Act of 1939, P.L. 76-396 authorizes the Secretary of the Army to perform examinations and studies for flood control on the Kentucky River and its tributaries. An explanatory statement in the Consolidated Appropriations Act of 2022 (P.L. 117-103), Division D, Title 1, authorized funds for a flood control study at Beattyville, Kentucky. Section 105(a) of the Water Resources Development Act of 1986, P.L. 99-662, as amended (33 U.S.C. 2215a), specifies the cost-sharing requirements.

3. PROJECT DESCRIPTION

The Project is located in Beattyville, Lee County, Kentucky. The non-Federal Sponsor (NFS) is the Lee County Fiscal Court. Beattyville is located in eastern Kentucky, approximately 60 miles southeast of Lexington, KY, at the confluence of the North and South Forks of the Kentucky River. The recommended plan is a fully non-structural plan that includes wet and dry floodproofing, raise in place, and acquisitions of eligible structures in Beattyville. See the Non-Structural Implementation Appendix for eligibility criteria. The plan also includes implementation of a flood warning and emergency evacuation plan (FWEEP). Ecosystem restoration and recreation features will be implemented on approximately 8 acres of land acquired in the regulatory floodway. A playground located in the floodway will also be relocated.

The nonstructural portion of the recommended plan will involve acquisition of 13 structures (6 acquisitions), wet floodproofing of 30 non-residential structures, dry floodproofing of 9 non-residential structures, and elevation of one residential structure. The structures identified as acquisitions will be mandatory acquisitions with the expectation that the NFS will exercise their power of eminent domain to ensure all acquisitions are complete. Floodproofing measures are voluntary. Owners of structures identified for floodproofing that choose to participate will be required to grant the NFS a permanent real estate interest in the property; whether that is a restrictive covenant or permanent easement is to be determined. The actual number of structures that receive a nonstructural treatment may change once each structure is evaluated on a case-by-case basis. It is anticipated that floodproofing may not be feasible for some structures in Beattyville given their condition and structural integrity.

Four structures proposed for wet floodproofing are owned by the NFS. The NFS will be required to abide by the implementation plan when floodproofing their own structures, including providing clear title and recording a similar real estate instrument on their property as the privately owned

structures. For NFS-owned structures, a deed restriction in the form of a restrictive covenant that runs with the land would be used in lieu of a permanent easement. A floodproofing agreement between the NFS and itself would not be feasible; however, the PDT in coordination with the NFS will determine the best means of ensuring that the NFS meets the requirements set forth in the implementation plan.

The FWEEP portion of the recommended plan may include several components, such as flood inundation mapping, evacuation planning, creation of a local floodplain management plan, installation of flood sensors and sirens, etc. The only FWEEP components that would require real estate acquisitions are flood sensors and sirens. The NFS would need to acquire a permanent real property interest anywhere such FWEEP infrastructure is constructed.

Utility and facility relocations are expected to be negligible. Most utility impacts will not rise to the level of a relocation as they will involve either the permanent disconnection of utilities from structures being demolished or temporary service interruption to individual structures during implementation of floodproofing measures.

4. ESTATES

The standard estate Fee will be required for all acquisitions. Fee title is also required anywhere recreation or ecosystem recreation features will be constructed.

> *FEE*
>
> *The fee simple title to (the land described in Schedule A) (Tracts Nos._____, _____ and ____), subject, however, to existing easements for public roads and highways, public utilities, railroads, and pipelines.*

Should the FWEEP include installation of sirens and/or sensors, the NFS will acquire permanent easements wherever such features are located. While there is no standard estate for the installation of flood warning and emergency evacuation infrastructure, ER 405-1-12 allows the District Chief of Real Estate to approve a non-standard estate if it serves the intended project purpose, substantially conforms with, and does not materially deviate from the corresponding standard estate and does not increase the costs nor potential liability of the Government. LRL proposes the following estate language be used for FWEEP infrastructure acquisitions. It is considered a minor deviation from the standard estate Flood Protection Levee Easement and has been approved by LRL Office of Counsel for the installation of flood warning and emergency evacuation sirens and sensors for another project within the district.

> *FLOOD PROTECTION LEVEE EASEMENT (modified for FWEEP infrastructure)*
>
> *A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection warning and emergency evacuation (sensor) (siren), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

CECW-ZA Memorandum dated 22 July 2024 entitled Guidance for Nonstructural Project Planning and Implementation sets forth the following standard estate to be acquired for projects with

nonstructural residential elevations and basement fill-in measures. See Exhibit E-3 for a sample Deed Restriction. This language will be used for the one proposed residential elevation. This easement would be applied to the footprint of the structure and will not encumber the entire parcel.

> *PERPETUAL RESTRICTIVE EASEMENT FOR RESIDENTIAL ELEVATION*
>
> *A perpetual and assignable easement for the establishment, maintenance, operation and use of a restricted area in, on, over and across only that portion of land occupied by a residential structure(s) as described (in Schedule C or Exhibit A), said residential structure(s) to be elevated in connection with the construction, operation, maintenance, repair, replacement, and rehabilitation of the (Project Name and Authorization), consisting of the right to (prohibit human habitation between the ground level and the first floor of the elevated structure, to prohibit construction or placement of any enclosure or permanent obstruction or impairment of the flow of water between the ground level and the first floor of the elevated structure, and to prohibit other uses of the elevated structure or the land that would impair, contravene, or interfere with the integrity of the elevated structure) (to prohibit the enclosure of flood vents to the infilled basement); (together with the right of ingress and egress, with advanced owner notification, over and across other portions of the property for the purpose of inspecting and monitoring the residential structure and project measures located on said land, and for the purpose of enforcing the rights, land use restrictions, and prohibitions set forth herein); reserving to the grantor(s), heirs, successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights, easement, and restrictions hereby acquired, including the right to (utilize the area between the ground level and the elevated structure for parking and storage;) to demolish and rebuild the structure with a first floor elevation that is three (3) feet above the community Base Flood Elevation requirement; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired.*

If utility relocations are necessary, the standard estate Utility and/or Pipeline Easement will be required for all relocated utilities.

> *UTILITY AND/OR PIPELINE EASEMENT*
>
> *A perpetual and assignable easement and right-of-way in, on, over and across (The land described in Schedule A) (Tracts Nos._____, _____ and _____) for the location, construction, operation, repair and patrol of (overhead) (underground) (specifically name type of utility or pipeline); together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.*

At this time, it is unknown whether temporary work areas or staging and storage areas will be needed to implement the Project. Should they be necessary once design is complete, the standard estate Temporary Work Area Easement will be required for all such areas.

TEMPORARY WORK AREA EASEMENT

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

5. NON-STANDARD ESTATES

A non-standard estate may be necessary for implementation of the recommended plan. The NFS will need the ability to protect the Project benefits as well as the Federal investment on floodproofed structures using some form of permanent real estate instrument. HQUSACE Real Estate (CEHQ-RE) is currently formulating guidance for implementation of nonstructural projects Corps-wide. Interim Guidance specific to residential floodproofing was issued by CECW-ZA in July 2024 setting forth a standard estate for residential elevations and basement in-fill. No standard estate has been approved for non-residential floodproofing measures. If a new standard estate for non-residential structures is not available during implementation of the Project, the PDT, in coordination with the NFS, will submit a request through the MSC to CEHQ-RE for approval. Whatever instrument is ultimately utilized for floodproofed structures, the easement or restriction will only apply to that portion of land occupied by the structure.

6. EXISTING FEDERAL PROJECTS/LANDS

No Federal projects or lands are located within or near the Project area.

7. NAVIGATION SERVITUDE

Navigation servitude does not apply.

8. PROJECT AREA MAPS

See Exhibit E-1 for preliminary Project area mapping.

9. POSSIBLE INDUCED FLOODING

No induced flooding is anticipated as a result of Project construction, operation, or maintenance.

10. BASELINE COST ESTIMATE FOR REAL ESTATE

A rough order of magnitude cost estimate was prepared for the proposed recommended plan. This estimate includes NFS incidental acquisition costs (survey, title, appraisal), estimated fair market value of acquisitions, P.L. 91-646 relocation assistance benefits, and Federal administrative expenses.

Owners of structures identified for floodproofing, both residential and non-residential, will be required to waive their right to just compensation in writing for the real estate interest to be acquired and release the NFS from any requirement or obligation to be informed of the market value of the easement. The owners will receive a direct benefit as a result of the Project measure being constructed at no cost to them, and as a result will not be further compensated. This estimate does not include the cost of any utility/facility relocations or any acquisitions that may be required to support them as no such acquisitions are anticipated. This estimate does include a nominal cost for the acquisition of small easements in downtown Beattyville for the installation of FWEEP sirens. The estimated cost of real estate acquisitions and P.L. 91-646 residential and nonresidential relocations, including NFS incidental costs and Federal administrative costs is approximately $3.9 million.

Action	Cost Estimate	Contingency	Total with Contingency
01 - Lands and Damages			
a. Flood Protection Measure Costs			
6 Acquisitions (13 structures)	$1,176,000		
10 Easement Acquisitions (FWEEP sirens)	$10,000		
b. P.L. 91-646 Relocation Costs			
Acquisitions (permanent)	$703,000		
Floodproofing (temporary)	$50,000		
c. Non-Federal Incidental Costs	$635,000		
Lands and Damages Total	***$2,574,000***	***40%***	***$3,604,000***
30 - Federal Administrative Costs			
Federal Administrative Cost Total	***$220,000***	***20%***	***$264,000***
Total Real Estate Project costs	**$2,794,000**		**$3,868,000**

NOTE: This real estate cost estimate differs slightly from the real estate costs used in the economic analysis in Appendix D due to new nonstructural guidance that was issued on 22 July 2024. The new guidance led to changes in the real estate costs which are reflected here but not in Appendix D. The economic analysis will be updated with revised real estate costs in the final report.

11. RELOCATION ASSISTANCE BENEFITS (P.L. 91-46)

The NFS shall comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 C.F.R. Part 24 (the "Uniform Act"), in acquiring lands, easements, and rights-of-way required for the construction, operation, and maintenance of the Project, including those necessary for relocations, and shall inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

The Uniform Act authorizes payment of relocation benefits to persons displaced from their homes, businesses, or farms by Federal and Federally assisted programs. Those benefits are separate from and in addition to the acquisition payments for real property. Estimated benefits for residential displacements include moving and replacement housing expenses. Owner-occupants and tenant-occupants of mobile homes will be afforded the same benefits as occupants of conventional dwellings with respect to P.L. 91-646. Relocation benefits for non-residential displacements are limited to moving and related expenses, including search expenses and, if applicable, reestablishment expenses. Relocation assistance benefits are not authorized for individuals or businesses temporarily displaced for the purposes of installing nonstructural measures unless the person temporarily displaced is a residential tenant.

12. MINERAL/TIMBER ACTIVITY

There is no mineral or timber activity in the area that would impact Project construction, operation, or maintenance.

13. SPONSOR CAPABILITY

The NFS has been deemed moderately capable of acquiring the necessary real estate for Project purposes pending confirmation of their financial capability to implement the recommended plan. The Sponsor Capability Assessment was completed on 17 July 2024 and is attached as Exhibit E-2.

14. ZONING ORDINANCES ENACTED

No application or enactment of zoning ordinances is proposed in lieu of, or to facilitate, acquisition in connection with the project.

15. ACQUISITION SCHEDULE WITH MILESTONES

While a timeline with specific dates is unavailable at this time, the NFS is expected to be able to adhere to the following general schedule. Given that this Project may be implemented in Phases depending on funding, this schedule is subject to change and will be updated as more information is received.

Activity (as needed)	Duration
Notice to proceed with real estate acquisitions issued	After PPA execution and finalized design
Real estate acquisitions	Duration is dependent on the number/type of acquisitions and sponsor capabilities. A minimum of two to three years is anticipated given the unique nature of the floodproofing acquisitions and the potential for condemnation of the mandatory acquisitions.
Certification of real estate interests	1 month
Process LERRD Credit requests	As requests are received

16. UTILITIES/FACILITY TO BE RELOCATED

As no large structural elements are included in the Project, no utility impacts that would rise to the level of a relocation are anticipated. Only temporary service interruptions to structures being floodproofed are expected as a result of the Project. However, if the need for a utility relocation is identified during the design phase, an Attorney's Opinion of Compensability will be prepared for each impacted utility to determine whether or not the utility owner possesses a real property interest. The NFS will be responsible for performing all utility/facility relocations.

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN, OR ELSEWHERE IN THIS PROJECT REPORT, THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES.

17. HTRW CONSIDERATIONS

Refer to main report Section 2.12 for a description of the status of the District's investigation into the presence of hazardous, toxic, and radioactive waste (HTRW). For property owners who elect to participate in the nonstructural portion of the Project, any HTRW, such as asbestos or lead paint, found in their structure must be abated prior to construction at the landowner's expense.

18. OWNER ATTITUDE/ISSUES

The Beattyville community is ambivalent to the Project currently. There appears to be a lack of belief among residents that any Federal flood risk management project will actually be implemented in Beattyville.

The PDT is also aware of the impact the lack of relocation assistance benefits may have on participation. Only residential tenants are authorized temporary relocation assistance benefits. Should implementation of floodproofing measures on non-residential structures require the owners and/or tenants to be temporarily displaced, the Project cannot offer them any financial assistance to relocate temporarily or provide compensation for lost business. This may negatively impact property owners' willingness or ability to participate in the Project.

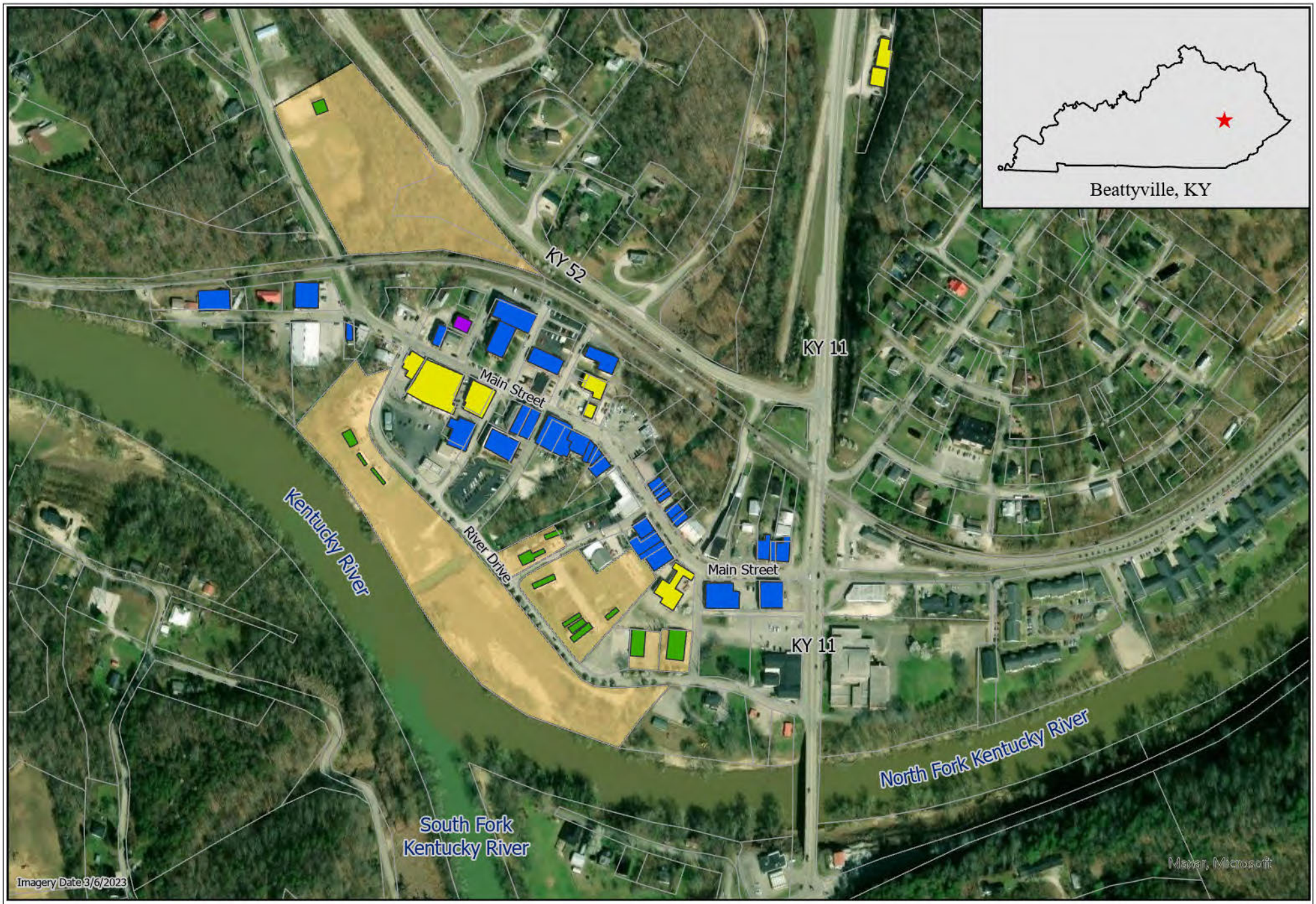
19. SPONSOR NOTIFIED OF RISKS OF ADVANCE ACQUISITION

The sponsor was not notified of the risk of advanced acquisition. Upon acceptance of the Recommended Plan, a notification will be issued.

20. ANY OTHER REAL ESTATE ISSUES

A survey of the available residential replacement housing and available commercial office space was beyond the scope of this REP. At this time, it is unknown whether the Beattyville community has the capacity to absorb the permanent residential and non-residential relocations that are being proposed. Additionally, it is not known whether or not housing of last resort benefits will be necessary to implement the Project.

One of the structures proposed for floodproofing is a United States Post Office located on privately-owned property. Any proposed floodproofing or relocation of this structure must be carefully planned in coordination with the US Postal Service so as not to disrupt mail services in Beattyville and the surrounding area.



Residential - Elevation
Non Residential - Wet Flood Proofing
Non Residential - Dry Flood Proofing
Structure Acquisition (demolition)
Land Acquisition
Parcel Lines

0 100 200 400 600 800 Feet

BEATTYVILLE
LEE COUNTY
KENTUCKY

US ARMY CORPS OF ENGINEERS
REAL ESTATE DIVISION
LOUISVILLE DISTRICT

DATE: JULY 2024

SHEET: EXHIBIT B-1

KENTUCKY RIVER, BEATTYVILLE, KY
GENERAL INVESTIGATION FEASIBILITY STUDY

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

Sponsor(s): Lee County Fiscal Court

Authority:
Section 6 of the Flood Control Act of 1939, PL 76-396 authorizes the Secretary of the Army to perform examinations and studies for flood control on the Kentucky River and its Tributaries, Kentucky, and the Consolidated Appropriations Act of 2022 (PL 117-103), Division D, Title 1, through an explanatory statement authorized funds for a flood control study at Beattyville Kentucky.

Non-Federal Sponsor Real Estate Contact:
Steve Mays, Judge Executive

I. Legal Authority

a. **Does the non-Federal Sponsor have legal authority to acquire and hold title to real property for project purposes?**

Yes X No____

Non-Federal Sponsor is authorized to acquire and own land by authority of KRS 67.080 & 67.083.

Note: If NO; who will acquire LERRD? Who will hold title?

b. **Does the non-Federal Sponsor have the power of eminent domain for this project?**

Yes X No____

The use of eminent domain is authorized by KRS 67.085 & KRS 58.140.

Note: If NO, who will acquire tracts if condemnation is required?

c. **Does the non-Federal Sponsor have "quick-take" authority for this project?**

Yes X No____

Non-Federal Sponsor's "quick-take" authority is authorized by Kentucky Eminent Domain Act of 1975, KRS 416.610.

Note: If NO; will lack of "quick take" authority impact the project schedule?

d. **The non-Federal Sponsor has reviewed the project maps and confirmed that all of the lands/ interests in land required for the project are located inside of their political boundary.**

Yes_X_No_____

Note: If NO; what is the plan for acquiring? Can the non-Federal Sponsor hold title to land outside of their political boundary?

e. **Are any of the lands/ interests in land required for the project owned by an entity whose property the non-Federal Sponsor cannot condemn?**

Yes_____No_X___

Note: If YES; what is the plan for acquiring?

Section I. _____ Date: 7 / 15 / 24
Realty Specialist

II. Financial Capability

a. **The non-Federal Sponsor has reviewed and concurs with the real estate cost estimates.**

Yes_X_No_____

Note: If NO; provide the anticipated resolution.

b. **It has been established by the responsible district element that the non-Federal Sponsor is financially capable of fulfilling all requirements identified in the Project Partnership Agreement (PPA).**

Yes_____No_X___ This is an investigation study. No plan has been selected and the funding requirements that the sponsor may be responsible for are unknown at this time.

Note: If NO; is another entity going to provide the non-Federal Sponsor with financial assistance?

Section II. _____ Date: 7 / 15 / 24
Realty Specialist

III. Willingness To Participate

a. **The non-Federal Sponsor has stated in writing its general willingness to participate in the project and its understanding of the general scope of the project and its part of the project.**

Yes_____ FCSA with the NFS was signed on 1/23/23, no LOI was received.

Letter of Intent from the NFS dated _____/_____/_____.

Note: If more than one sponsor is to be involved explain the Real Estate roles of each non-Federal Sponsor.

b. **The non-Federal Sponsor is agreeable to signing a project partnership agreement and supplying funding as stipulated in the agreement.**

Yes X

c. **The non-Federal Sponsor was provided the Local Sponsors Toolkit on** 8 / 9 / 2023 .
http://www.lrd.usace.army.mil/Portals/73/docs/RealEstate/Non-Federal_Sponsor_Package.pdf

Section III. _____ Date: 7 / 15 / 24
Realty Specialist

IV. Acquisition Experience and Capability

a. **Taking into consideration the project schedule and complexity, the non-Federal Sponsor has the capability with in-house staffing or contract capability, to provide the necessary services such as surveying, appraising, title, negotiating, condemnation, closings, and relocation assistance that will be required for the acquisition of properties for this project.**

Yes X No_____

Note: If work will be done in-house give brief summary, staff size, expertise, experience, etc.

b. **The non-Federal Sponsor's staff is familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended.**
Yes_____No X

Note: If NO; additional funding for USACE training/ oversight will be required.

c. **The non-Federal Sponsor can obtain contractor support and meet project schedules.**

Yes X No_____

Note: If NO; does the acquisition timeline account for this?

d. **The non-Federal Sponsor's staff is located within a reasonable proximity to the project site.**

Yes X No_____

Note: If NO; provide summary of plan to make contact; i.e., project office, travel, local contractors etc.

e. **Will USACE assistance likely be requested by the non-Federal Sponsor in acquiring real estate?**

Yes_____No X

Note: If YES; provide a summary of the level of support that will be requested. Will a Memorandum of Agreement be required in accordance with the Project Partnership Agreement?

Section IV. _____ Date: 7/15/24
Realty Specialist

V. Schedule Capability

The non-Federal Sponsor has approved the tentative project/ real estate schedule/ milestones and has indicated its willingness and ability to incorporate its financial, acquisition, and condemnation capability to provide the necessary project LERRDs in accordance with proposed project schedules so the Government can advertise and award the construction contract as required by overall project schedules and funding limitations.

Yes_____No X___ No project implementation schedule has been prepared.

Section V. _____ Date: 7 / 15 / 24
Realty Specialist

VI. LERRD Credits

The sponsor has indicated its understanding of LERRD credits and its capability and willingness to gather the necessary information to submit as LERRD credits in within six months after possession of all real estate and completion of relocations in order that the project can be financially closed and there can be a final financial accounting with a proper settlement with the non-Federal Sponsor.

Yes X

Note: If a multi-year phased project discuss plan for interim submittals.

Section VI. _____ Date: 7 / 15 / 24
Realty Specialist

VII. Capability

With regard to this project, the non-Federal Sponsor is anticipated to be:
moderately capable.

Note: Choices are: fully capable, moderately capable, marginally capable, and insufficiently capable.

a. Fully Capable: *Previous experience. Financially capable. Authority to hold title. Can perform, with in house staff, the necessary services (survey, appraisal, title, negotiation, closing, relocation assistance, condemnation & "quick-take" authority) required to provide LERRD.*

b. Moderately Capable: *Financially capable. Authority to hold title. Can provide, with contractor support, the necessary services (survey, appraisal, title, negotiation, closing, relocation assistance and condemnation authority) required to provide LERRD. Quick-take authority will be provided by*_____.

c. Marginally Capable: *Financially capable. Authority to hold title. Will rely on approved contractors to provide the necessary services (survey, appraisal, title, negotiation, closing, and relocation assistance). Quick-take authority and authority to condemn will be provided by*_____.

d. Insufficiently Capable: *Financially capable. Will rely on approved contractors to provide the necessary services (survey, appraisal, title, negotiation, closing, and relocation assistance). Quick-take authority and authority to condemn will be provided by*_____.
*Will rely on*_____*to hold title.*

Summarize what support will be provided to the non-Federal Sponsor to ensure project success.

NOTE: Sponsor will be considered moderately capable upon determination of their financial capability.

VIII. Coordination

This assessment has been coordinated with the non-Federal Sponsor and it concurs with the assessment.

Yes X

This assessment has been coordinated with:

Name: [redacted]
Title: Judge Executive

Prepared by:

[redacted]
Real Estate Division
Louisville District

Considering the capability of the non-Federal Sponsor and the ancillary support to be provided by n/a, and identified above, it is my opinion that the risks associated with LERRD acquisition and closeout have been properly identified and appropriately mitigated.

[redacted]
Louisville District

Non-Federal Sponsor Representative:

Signature [redacted]
Name: [redacted]
Title: Judge Executive
Date: 7/12/24

Appendix F
Climate Assessment

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 GENERAL

This qualitative assessment of climate change impacts is required by U.S. Army Corps of Engineers (USACE, "the Corps") Engineering and Construction Bulletin (ECB) 2018-14, "Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects." This is a screening-level climate assessment that documents the qualitative effects of climate change on hydrology in the region and informs the Beattyville, KY General Investigation of the potential impacts and risks drivers which can potentially be attributed to climate change.

USACE projects, programs, missions, and operations have generally proven to be robust enough to accommodate the range of natural climate variability over their operating life spans. However, recent scientific evidence shows that in some places and for some impacts relevant to USACE operations, climate change is shifting the climatological baseline about which that natural climate variability occurs and may be changing the range of that variability as well. This is relevant to USACE because the assumptions of stationary climatic baselines and a fixed range of natural variability as captured in the historic hydrologic record may no longer be appropriate for long-term projections of the climatologic parameters, which are important in hydrologic assessments for flood risk management in watersheds such as the Kentucky River Basin.

The Beattyville GI study is a flood risk mitigation study where flood risk in Beattyville is mainly driven by intense rainfall events. The flood-risk reduction business line will be considered in this climate assessment and the discussion will be focused on temperature, precipitation, and streamflow.

Beattyville, KY has had major flooding in the past couple years. Due to the flooding impacts, alternatives are being assessed to determine the best flood risk management projects. Some of the structural alternatives that are being considered are constructing levees or floodwalls that incorporate pump stations or pressure pipes to keep flooding out of the protected area. Non-structural alternatives are relocating structures, acquiring structures, wet/dry floodproofing, and raising structures. The final alternatives involve Flood Warning Emergency Evacuation Plans (FWEEP), determining the extent of inundation, evacuation planning, floodplain management plan, flood sensors/gages, and flood sirens. These are the alternatives being considered to help mitigate the flood risk in Beattyville, KY. This climate assessment will be used to verify and determine which alternatives will be most resilient to climate change or improve community resiliency.

The North Fork Kentucky River, Middle Fork Kentucky River, and South Fork Kentucky River join in Beattyville, KY to form the Kentucky River. The Kentucky River lies completely within the State of Kentucky and flows into the Ohio River. The Kentucky River Basin has a total watershed area of 7,000 square miles. The Kentucky River flows in the general Northwest direction for 255 river miles to its junction with the Ohio River at Carrollton, Kentucky. North Fork, Middle Fork, and South Fork join to form the Kentucky River draining 1,220, 1,130, and 1,262 square miles, respectively, of the total basin. The headwaters lie on the Appalachian Plateau and the lower portion of the basin consists of relatively wide valleys and gentle, rounded hills. The Kentucky River Basin falls within the U.S. Geologic Survey (USGS) region 05 and makes up approximately 73% of the area in the 4-digit Hydrologic Unit Code (HUC) 0510. The rest of the HUC-4 region consists of the Licking Basin, as seen in Figure 1.



Figure 1. Map of the Kentucky River Basin HUC-6 0510 region

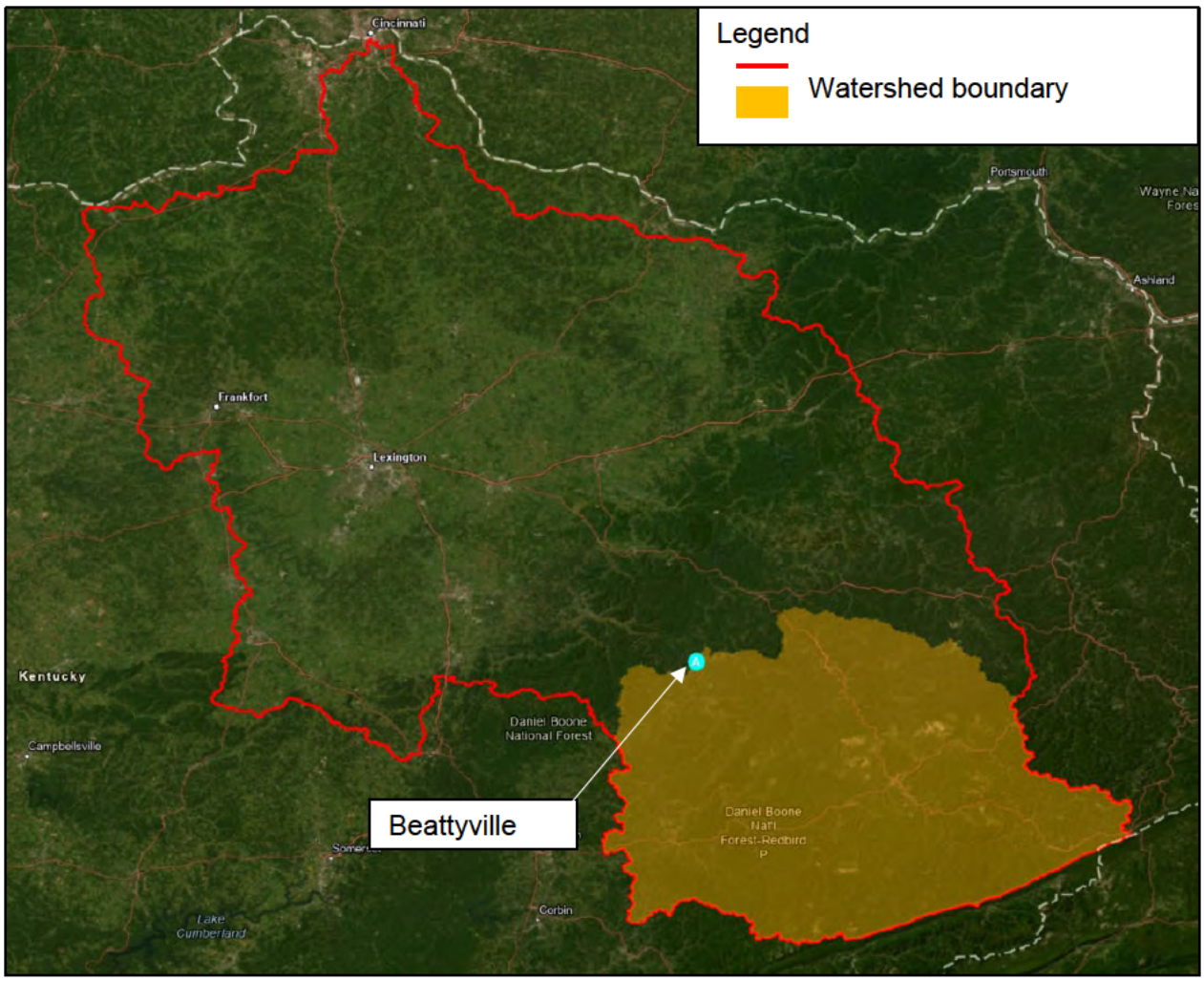


Figure 2. Map of the Kentucky River HUC-4 0510 region

Beattyville, KY is located in the Kentucky River Basin at the confluence of North Fork, Middle Fork, and South Fork; all headwaters of the Kentucky River. Approximately 2,164 square miles of the Kentucky River Basin Watershed are upstream of Beattyville, KY, as can be seen in Figure 2 shaded in orange.

The U.S. Army Corps of Engineers operates Flood Risk Management (FRM) projects within the Kentucky River Basin upstream of Beattyville, KY: Carr Creek Dam and Buckhorn Dam. These projects serve a primary function of flood risk management, as well as other congressionally authorized purposes such as: irrigation, water supply, water quality, fish and wildlife conservation, forest resources conservation, and recreation. Buckhorn Dam is on the headwaters of the Middle Fork Kentucky River. Construction on Buckhorn Dam began in October 1956 and was placed in operation in December 1961. Buckhorn Dam has a drainage area of 408 square miles. Carr Creek Dam is on the headwaters of the North Fork Kentucky River. Construction on Carr Creek Dam was completed in December 1975, with filling complete in January 1976. Carr Creek Dam has a drainage area of 58.2 square miles. The two FRM reservoirs constitute of 17.5% of the drainage area being regulated in the Kentucky River Basin Watershed upstream of Beattyville, orange

shaded area in Figure 2. In addition to the two USACE dam and reservoir projects within the Kentucky River Basin, there are 14 USACE lock and dam projects. The lock and dams were built prior to the reservoirs as a means of navigation to transport goods along the Kentucky River.

In total, there are 13 active stream gages distributed throughout the South Fork, Middle Fork, and North Fork of the Kentucky River Basin watershed: 2 gages on the South Fork, 6 on the Middle Fork, and 5 on the North Fork. The gage that is the main subject of this study is located in Heidelberg, KY on the Kentucky River about three air miles downstream of Beattyville (USGS 03282000). The gage has a drainage area of 2,657 square miles, as shown in Figure 3.

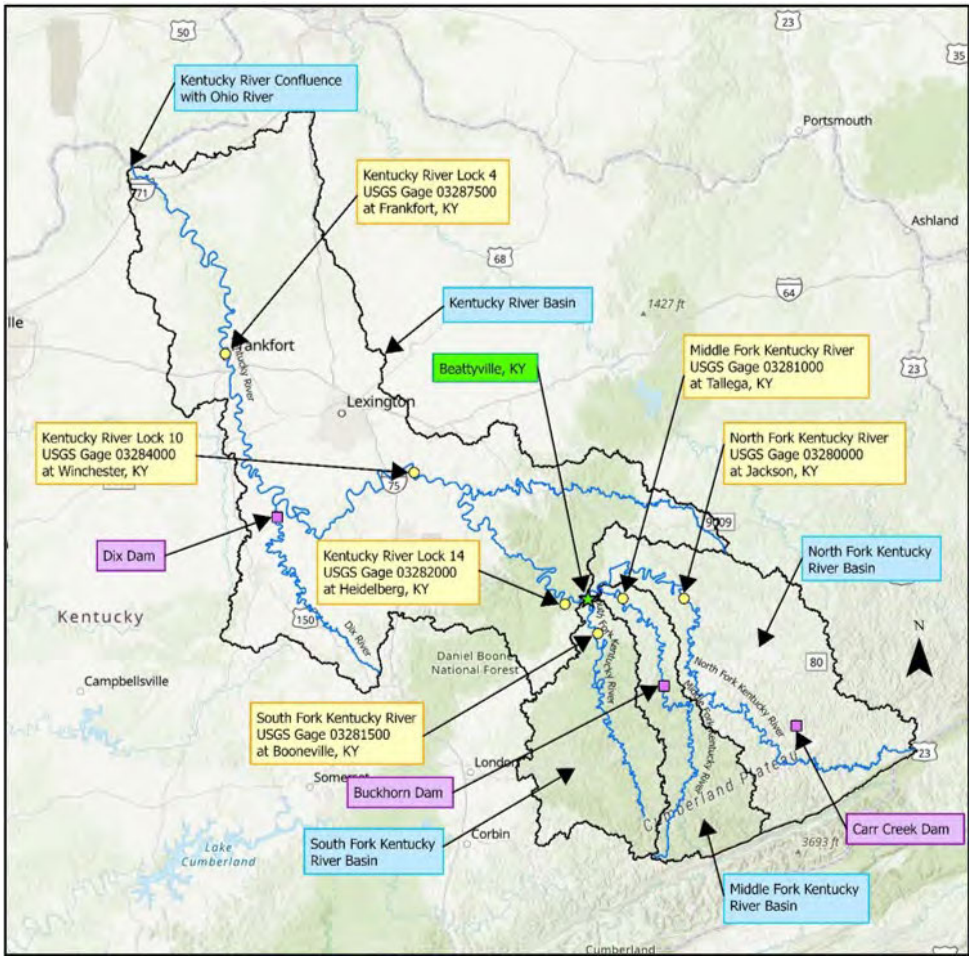


Figure 3. Kentucky River Basin Gages

The other gage considered is upstream of Beattyville. The majority of the closest gages to Beattyville are regulated by the two USACE reservoirs with the exception of the two gages on the South Fork. The South Fork gages are unregulated since there are no USACE reservoirs along this headwater nor are there any local levees. In order to separate out the hydrologic influence of observed climate change from other significant anthropogenic impacts, such as upstream regulation, an effort was made to identify a relatively “pristine” gage which was largely free of the

effects of watershed modification. The USGS gage on the South Fork Kentucky River at Booneville (USGS 03281500) is representative of natural run-of-the-river morphologic conditions, allowing for greater insight into the impacts which may have been caused by climate change. While the pristine gage chosen for analysis was selected primarily because of the lack of regulation within its upstream watershed, preference was also given to the site with lengthy annual peak streamflow period of record and to the site with relatively large drainage areas. Land-use change over time, such as urbanization and changing forestry practices, were not considered when selecting the pristine gage, which may have some impact on nonstationarity analysis.

Both analyzed gages and relevant parameters such as drainage area, peak streamflow, and period of record (POR) are in Table 1. It should be noted that reservoir operation was assumed to be consistent and uniform across the period of regulation. While there have been numerous deviations from the authorized water control plan, these changes were assumed to be relatively minor from a statistical and operational perspective.

Table 1. Relevant Gages used in Qualitative Analysis

USGS Gage #	USGS Site Name	Period of Record	Air Miles from Beattyville	# of Observations	Drainage Area (square miles)	Regulation
03282000	Kentucky River at Lock 14 at Heidelberg, Ky	1926 - 2023	3	97	2,657	Regulated Since 1960
03281500	South Fork Kentucky River at Booneville, Ky	1925 - 2022	7	98	722	Pristine

1.1 HISTORIC CLIMATE WITHIN THE KENTUCKY RIVER BASIN

Two FRM projects upstream of Beattyville discharge into the Kentucky River Basin: Buckhorn Reservoir and Carr Creek Reservoir. The climate of these reservoirs is continental in nature which is characterized by large annual and daily ranges of temperature. These reservoirs lie near the average path of moisture-bearing cyclones that move in a general easterly direction across the United States. Annual precipitation is well distributed with peaks in early spring and summer. Snowfall occurrence varies from year to year but is common from November through April (*Reservoir Regulation Plan - Carr Fork Lake*, 1980; *Water Control Plan - Buckhorn Lake*, 1995).

Temperature. Temperatures in the Kentucky River Basin area are generally highest during July and lowest during January. The expected mean annual temperature for the area is in the upper 50 degrees Fahrenheit. Extreme summer temperatures usually exceed 100 degrees Fahrenheit and minimum temperatures of zero or lower can be expected during the winter at the

forementioned reservoirs in the basin (*Reservoir Regulation Plan - Carr Fork Lake*, 1980; *Water Control Plan - Buckhorn Lake*, 1995).

Precipitation. Most of the precipitation over the Kentucky River Basin results from general storms which move easterly to northeasterly across the basin. These storms vary considerably in frequency and character, producing a wide variation in precipitation for individual months and years. These storms are well-distributed throughout the year with the most severe ones occurring from mid-winter to early spring. Winter and summer-type storms have separate and distinct characteristics (*Reservoir Regulation Plan - Carr Fork Lake*, 1980; *Water Control Plan - Buckhorn Lake*, 1995).

An assessment of observed trends in historic temperature and precipitation was conducted using local climate data in Beattyville and Heidelberg available from the National Oceanic and Atmospheric Administration's Climate Data Online (NOAA CDO). Since the Beattyville gage had data only from 2002-2023, data from the Heidelberg gage was used in conjunction with the data from Beattyville's gage to best portray the area's historical temperature and precipitation trends. The Heidelberg gage is 3 air miles from Beattyville and had a large range of data- 1934-2011. Therefore, dataset from the Heidelberg gage was used to observe historic trends prior to 2002. It was deemed important to include more recent large precipitation events that were captured by the Beattyville gage starting at the beginning of its data availability. Although the combined data and Heidelberg's individual data do not portray the exact same slope in their trendlines (see Figure 4 and Figure 5), both are increasing or decreasing at just a slightly different rate or have approximately no slope dependent on the data in question. In the figures below, data points and trendlines in red and yellow are from Heidelberg's data only. Meanwhile, data points in blue and green are from Beattyville's data only. Trendlines in purple and orange are based on the combined dataset for the Heidelburg and Beattyville gages (Heidelberg's data ranges from 1934 to 2002 and Beattyville's data ranges from 2002 to 2023).

Before combination, both data sets were plotted and analyzed separately to determine if statistically significant trends occurred in either dataset individually. Data analyzed includes monthly average temperature and monthly total precipitation. These monthly values were used to calculate annual average temperatures and annual total precipitation for 1934-2023. This dataset, associated trends, and statistical significance values are displayed in Figure 4 and Figure 5 for both gages as well as for Heidelberg individually. The annual average temperature as well as the highest monthly average temperature for each year are displayed in Figure 4. The total annual precipitation and maximum monthly precipitation for each year are displayed in Figure 5.

No statistically significant trends (p-value < 0.05) were identified in Beattyville's individual dataset when analyzed at a 95% confidence level. However, in Heidelberg's individual dataset, the following statistically significant decreasing trends were identified with the same evaluation criteria: annual average temperature and maximum monthly temperature. In the gages' combined dataset, the same datasets- annual average temperature and maximum monthly temperature- were identified as having statistically significant decreasing trends while total annual precipitation was identified as having a statistically significant increasing trend. Discussion of regional temperature and precipitation trends is discussed in more detail within the literature review below.

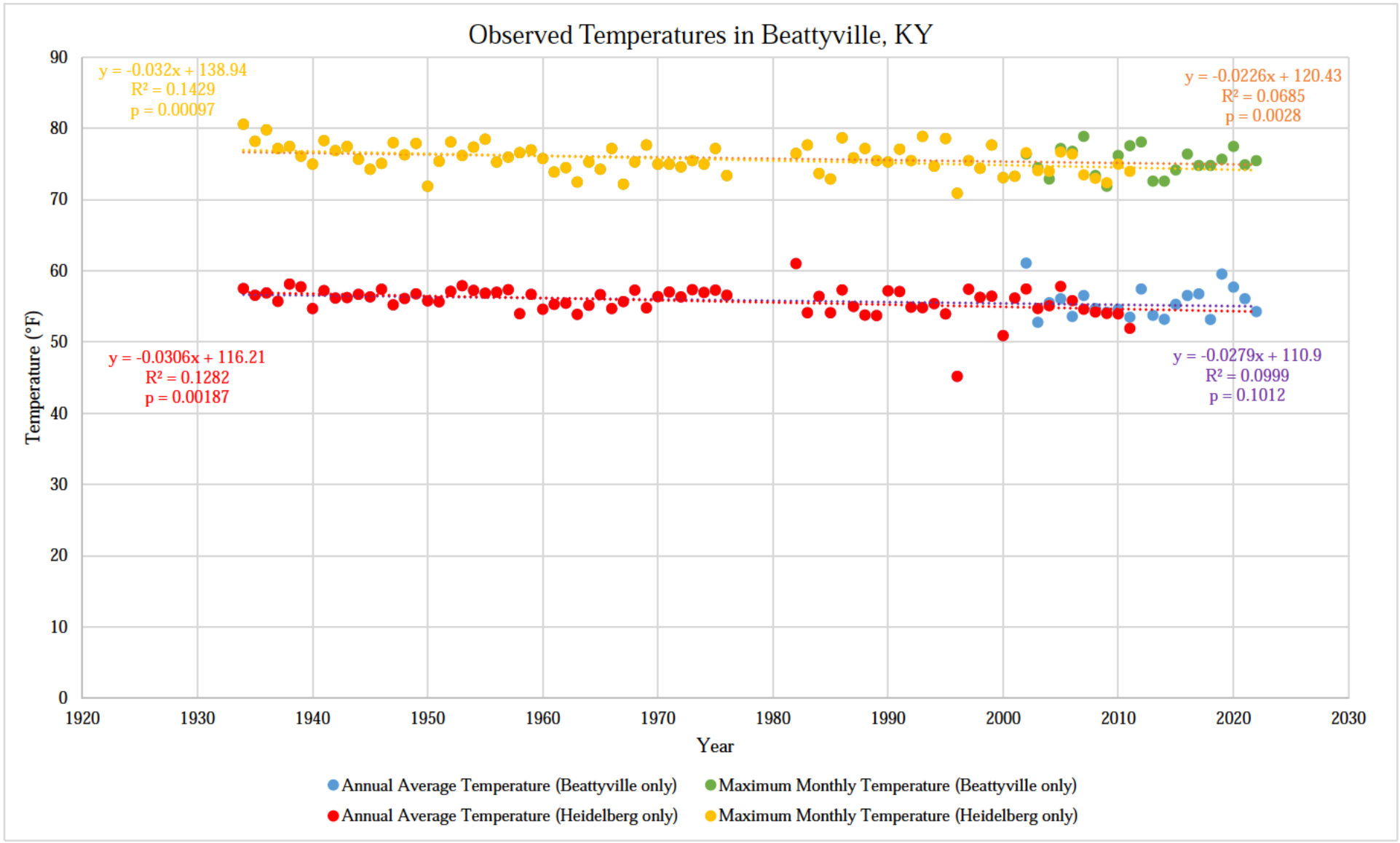


Figure 4. Trends in Annual and Maximum Monthly Temperature in Beattyville

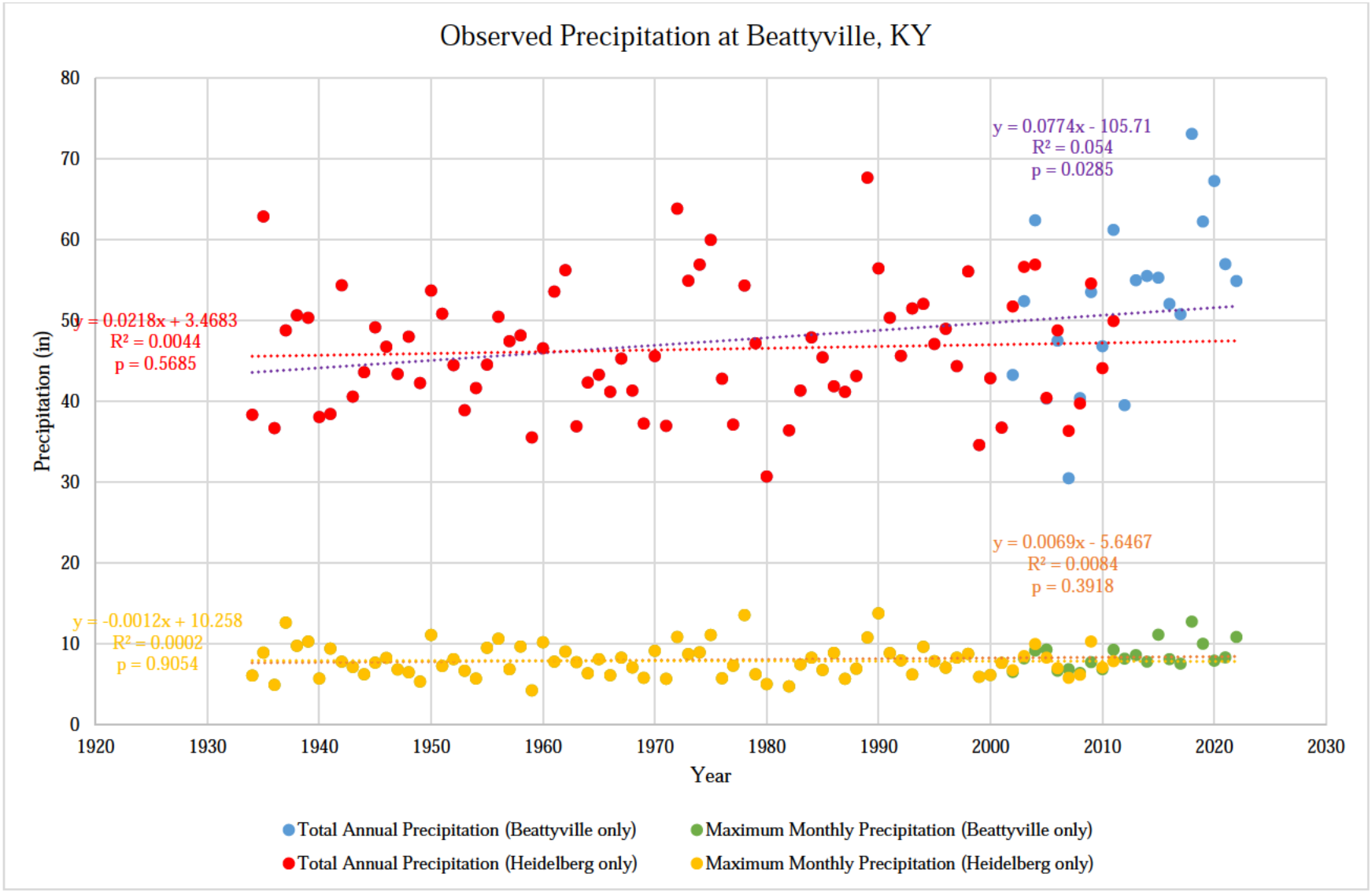


Figure 5. Trends in Annual and Maximum Monthly Precipitation in Beattyville

2 Observed Trends in Current Climate and Climate Change

2.1 Literature Review

2.1.1 Recent US Climate Change and Hydrology Literature Syntheses

A January 2015 report conducted by the USACE Institute of Water Resources summarizes the available peer reviewed literature related to trends in both observed and projected hydrometeorological variables for the Ohio Region (HUC-0205), which includes the Ohio River Valley. The Kentucky River Basin is located in the southeast portion of the region. Figure 7 shows a summary of observed and project climate trends and literary consensus from the syntheses. It should be noted that Figure 7 was created in 2015 and does not include any publications since that date. It should also be noted that the climate change characteristics of the Kentucky River Basin may not necessarily match the trends of the Ohio River Valley region as a whole.

Temperature. The 2015 USACE Literature Synthesis found a general consensus that the region spans a transition zone between a century-long warming trend toward the north and a cooling trend toward the south. However, the extent and seasonality of the warming and cooling zones vary between studies. In most studies, the Kentucky River Basin has less drastic, or sometimes opposite, changes in temperature than the rest of the Ohio Region.

Precipitation. According to the USACE Literature Synthesis: "A mild increasing trend in precipitation in the study region, in terms of both annual totals and occurrence of storm events, has been identified by multiple authors but a clear consensus is lacking. Results show increases in precipitation in some portions of the Ohio Region and show decreases in other portions. Recent reports indicate that rainfall may be concentrated more in larger events now than in the past." In most evaluated studies, the Kentucky River Basin is within areas of little-to-no increase or a decrease in precipitation.

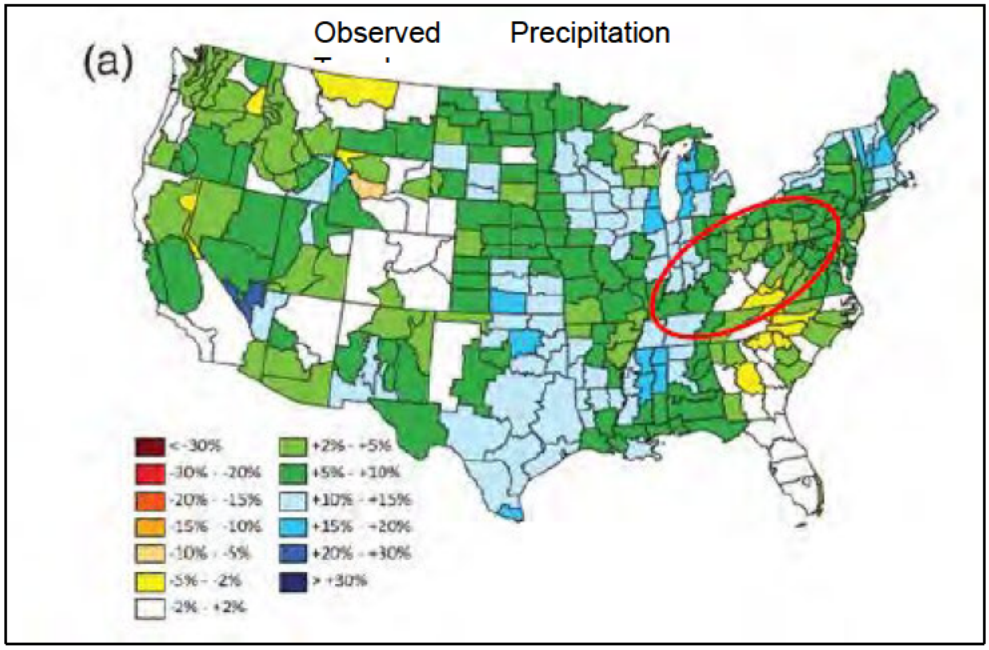


Figure 6. Linear trends in annual precipitation, 1895 - 2009, percent change per century.

Hydrology / Streamflow. The 2015 USACE Literature Synthesis found split conclusions about streamflow trends in the Ohio Region; however, more literature supported an upward trend in streamflow.

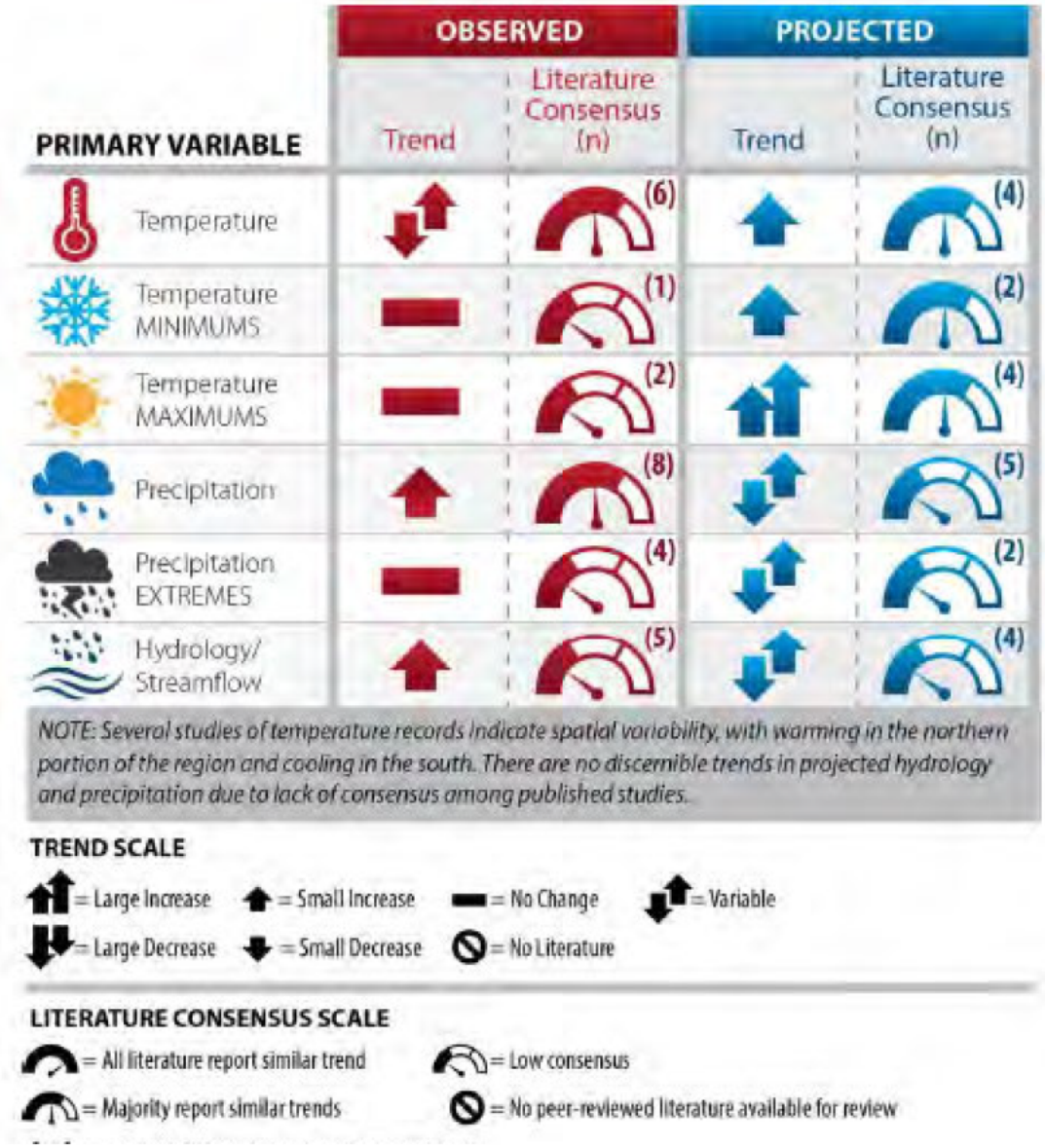


Figure 7. Summary of Findings from 2015 USACE Literature Synthesis, Ohio Region 05

2.1.2 Fifth National Climate Assessment (NCA5)

The NCA5, released in 2023, draws on science described in NCA4 Volume II and focuses on human welfare, societal, and environmental elements of climate change and variability for 10 regions and 18 national topics. Particular attention is paid to observed and projected risks, impacts, consideration of risk reduction, and implications under different mitigation pathways. Of specific interest to this qualitative analysis are the chapters regarding changing climate, water, and the Southeast region, which includes Virginia, Kentucky, Tennessee, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, and North Carolina. The Kentucky River Basin is entirely located in the Southeast region. Additionally, the entirety of the area that drains through Beattyville, KY is included in this region.

Temperature. Temperatures in the contiguous United States has risen by 2.5°F since 1970. While average temperatures have increased, warming trends are not consistent across seasons as can be seen in Figure 8. Winter is warming twice as fast than summer in many northern states. In Beattyville, KY winter temperatures have increased between 0 °F and 0.5 °F while summer temperatures have remained the same of decreased between 0 °F and 0.5 °F. The approximate study area is circled in the following figures.

While heatwaves are becoming for frequent globally, the number of very hot day (days over 95°F) for the central and eastern United States has decreased. Additionally, cold days has increased by 3 days (days below 32°F) and warm nights (number of nights bellow 70°F) have increased by 7.9 days, as seen in Figure 9.

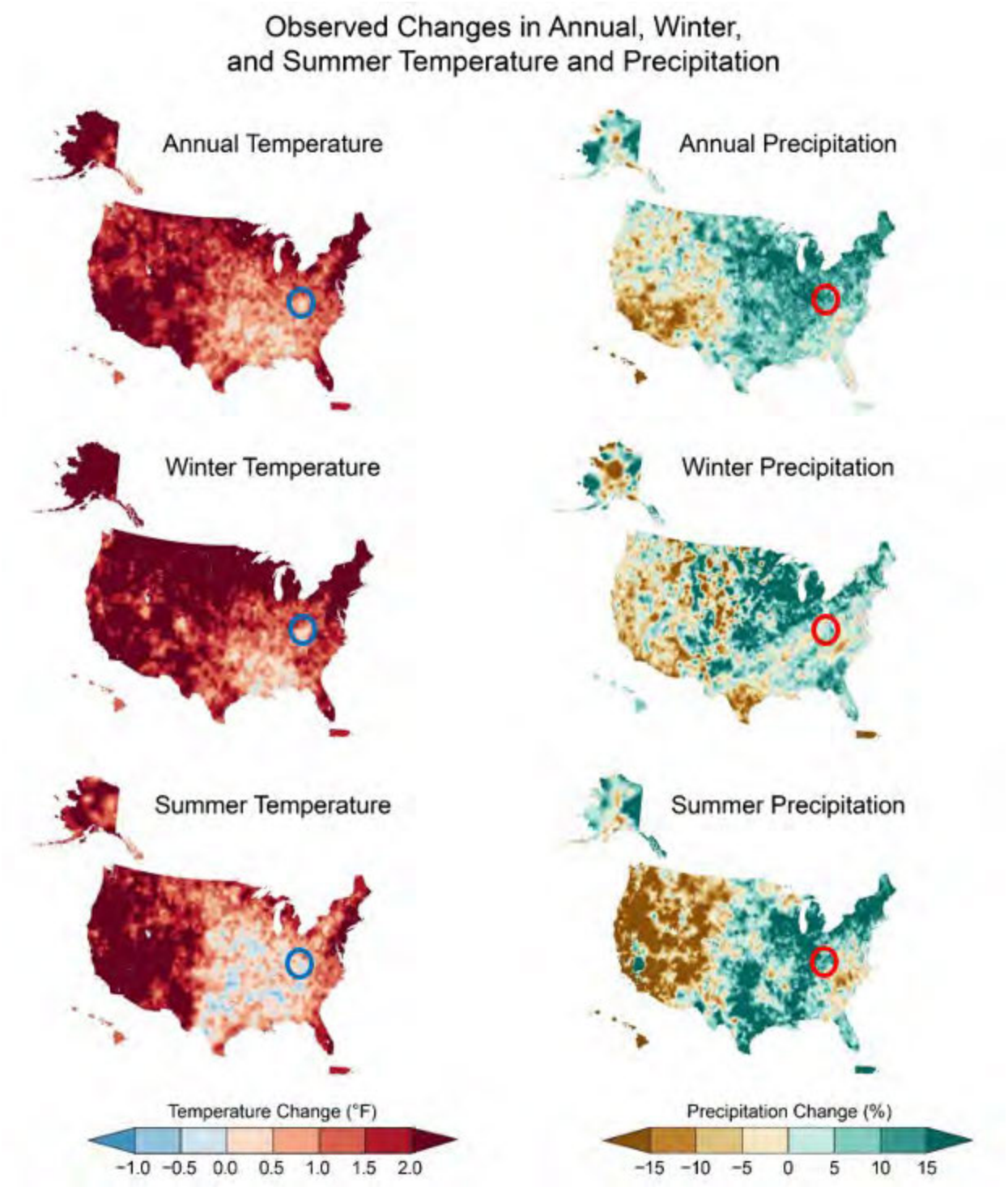


Figure 8. Observed Changes in Annual, Winter, and Summer Temperature and Precipitation

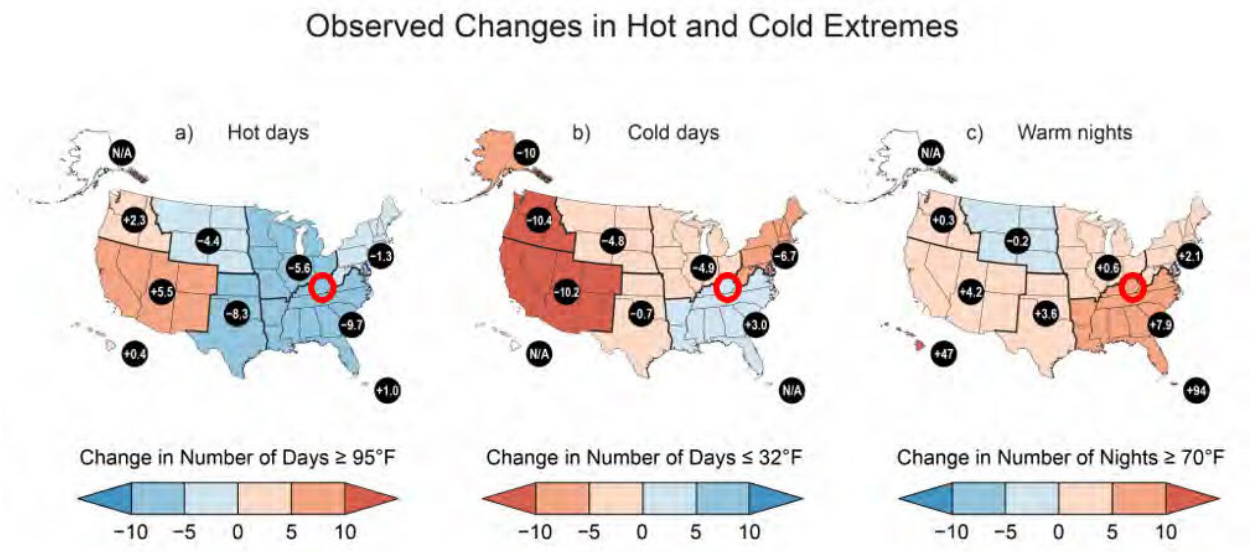


Figure 9. Observed Changes in Hot and Cold Extreme

Precipitation. The average annual precipitation from 2002-2021 is 5-15% higher than the 1901-1960 average for the central and eastern US, which the NCA5 attributes to climate change. The Southeast has experienced more precipitation in the fall and drier conditions in the spring and summer. Figure 8 shows the observed changes in annual precipitation, winter precipitation, and summer precipitation. Beattyville, KY, part of the Southeast region, has experienced a 0-5% increase in precipitation in winter and a 10-15% increase in precipitation in summer.

Since the 1950s an increase trend in heavy precipitation has been experienced across the US. The increasing trend is a result from more frequent precipitation extremes with smaller changes in the intensity of the extreme precipitation events. Figure 10 displays the percentage change in observed total precipitation on heaviest 1% of days, five-year maximum daily precipitation, and the annual maximum daily precipitation. For all three of the observed changes an increase was found for the Southeast with the total precipitation on heaviest 1% of days having the largest increase of 37%.

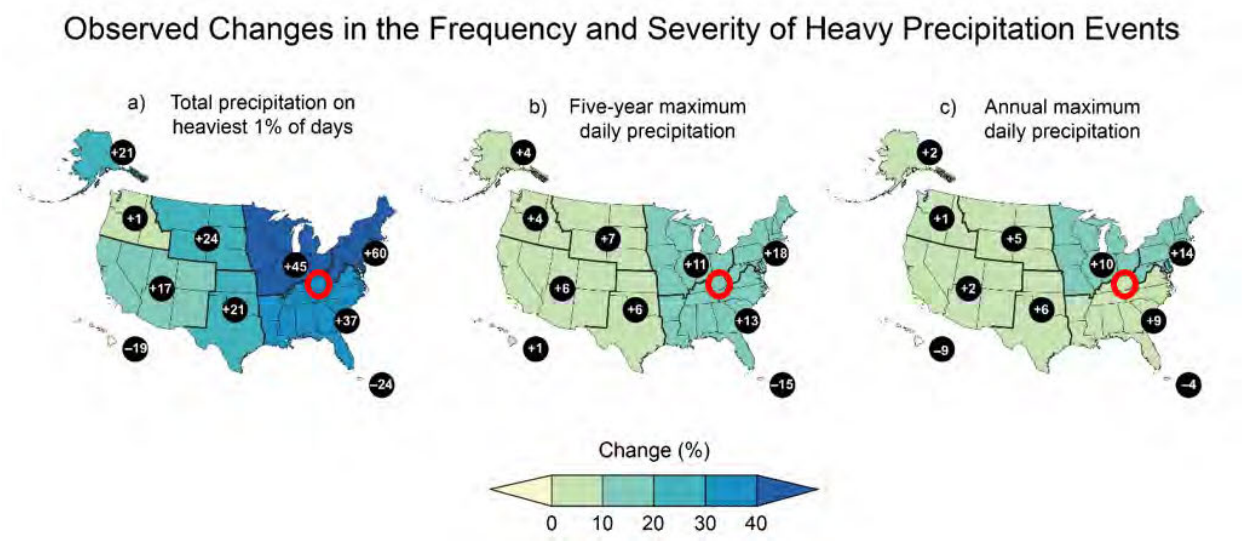


Figure 10. Observed Changes in the Frequency and Severity of Heavy Precipitation Events

2.1.3 NCEI Kentucky State Climate Summary

The National Centers for Environmental Information (NCEI) produces climate summaries for individual states. The Kentucky State Climate Summary, published in 2022, offers a review of observed and projected climate trends for the state of Kentucky as a whole. The entirety of the Kentucky River Basin lies within the state, but it should be noted that the portion of Kentucky within the Appalachian Mountains- the southeastern half of the Kentucky River Basin- experiences different climate change effects than the rest of the state.

Temperature. While the United States as a whole has warmed by about 1.5°F since 1900, the summary states: “Temperatures in Kentucky have risen by 0.6°F, less than half of the warming for the contiguous United States, since the beginning of the 20th century, but the warmest consecutive 5-year interval was 2016-2020.” The summary also notes that since 1955, the number of extremely hot days and number of extremely cold events has been below average.

Precipitation. “Total annual precipitation in Kentucky exhibits an overall upward trend and has averaged 7.4 inches above the long-term (1895-2020) average since 2011.” Also, the overall number of extreme precipitation events, while highly variable, has an upward trend.

2.1.4 Appalachian Region Climate Change Vulnerability Assessments

In December 2015, NatureServe- a non-profit organization that shares scientific studies to support environmental conservation- reported the results of vulnerability assessments upon the Appalachian Landscape Conservation Cooperative Region (Sneddon et. al). A portion of the Kentucky River Basin lies in the Appalachian Mountain region, as identified by this report. The report states the following regarding the Appalachian region’s historical climate: “The Appalachian LCC region saw temperatures ranging from no change in portions of eastern Kentucky to 1.5°F increase in the Central Appalachians between 1895 and 2011, and a 71% increase in extreme precipitation in the northeast (defined as the heaviest 1% of all daily events), and 27% increase between 1958 and 2010.”

2.2 NONSTATIONARITY DETECTION

The USACE Time Series Toolbox nonstationary detection tool (TST NSD) was used to assess whether the assumption of stationarity- which is the assumption that the statistical characteristics of a time-series dataset are constant over the period of record- is valid for a given hydrologic time-series dataset. Nonstationarities are detected through the use of 12 different statistical tests which examine how the statistical characteristics of the dataset change with time (Engineering Technical Letter (ETL) 1100-2-3, *Guidance for Detection of Nonstationarities in Annual Maximum Discharges*; *Nonstationarity Detection Tool User Manual*, version 1.2). The TST NSD Tool was applied to the same stream gage sites listed previously in Table 1, and the same observed period of record was analyzed. A nonstationarity can be considered "strong" when it exhibits consensus among multiple nonstationarity detection methods, robustness in detection of changes in statistical properties, and a relatively large change in the magnitude of a dataset's statistical properties. Many of the statistical tests used to detect nonstationarities rely on statistical change points. These are points within the time series data where there is a break in the statistical properties of the data such that data before and after the change point cannot be described by the same statistical characteristics. Similar to nonstationarities, change points must exhibit consensus, robustness, and a significant magnitude of change.

Figure 11 displays the nonstationary detection tool output for the complete period of record (minus historic flows with large data gaps) for the Kentucky River at Lock 14 at Heidelberg, KY gage. Note that there are multiple nonstationarities tests triggered in the period of record. Most notably is the strong nonstationarity detected around the end of the 1970s. This strong nonstationartiy can be attributed to a significant decrease in mean annual peak flow as Carr Fork Lake began regulating streamflow upstream of the gage in the 1970s (USGS, 2024). This nonstationarity shows both consensus and robustness as it was detected by multiple statistical tests targeting different statistical properties (mean, variance, and overall distribution) all around the same time. The timing of this strong nonstationarity aligns with the construction and impoundment of Carr Creek Reservoir, whose primary intent is to lower peak flows. Therefore, this nonstationarity can be attributed to the upstream regulation of Carr Creek and Buckhorn Reservoirs.

Figure 12 displays the nonstationary detection tool results for the gage on the South Fork Kentucky River in Booneville, KY. It was deemed to be "pristine" and largely free of influence from the type of upstream regulation affecting the Kentucky River at Lock 14 at Heidelberg gage. The South Fork gage was expected not to have strong nonstationaries, but multiple tests detected changes in stream flow in the 1980s. The change point detected around 1985 had consensus and change in magnitude of the statistics (mean, variance, and standard deviation) but it lacked the robustness of having multiple tests triggering for the same change in statistic.

Given that the South Fork Kentucky River at Boonville gage was one test short of having a strong nonstationarity, more data were analyzed. First, aerial imagery was analyzed to see if there were any reservoirs, logging efforts, or strip-mining scars that would have caused a nonstationarity; nothing of significance was noted. Second, active and inactive gages near and on the South Fork were explored. Many of the gages started recording in the 1990's, excluding the 1980's which is the time frame that needed to be analyzed. There was another gage upstream on the South Fork Kentucky River on Goose Creek, a headwater of the South Fork. Goose Creek at Manchester, KY gage had no strong nonstationarities detected because there was no consensus or robustness in the detection (Figure 13).

Since there was no consensus for the nonstationarity after looking at the aerial imagery and other gages, precipitation was analyzed with TST. Multiple sources were analyzed to find precipitation for the South Fork. The earliest precipitation record found for South Fork Kentucky River at Booneville, KY was in 2007, so a similar location with 1980's records was used to analyze the precipitation. Hourly precipitation data was pulled from nca

for Buckhorn Lake, on the Middle Fork. The dataset was used to calculate the Annual Max 1-Day and Annual Max 3-Day Precipitation. In the NSD Tool, no nonstationaries were detected for the precipitation. Overall, no similarities were found in the nonstationaries of the datasets analyzed for the South Fork Kentucky River at Booneville, KY gage. This indicates that the multiple tests triggered on the South Fork gage were in response to a localized change and likely not part of a larger regional trend.

Both stream gages had negative trends that were not statistically significant (p-value > 0.05). Considering these related lines of evidence, it can be assumed that climate change, long-term natural climate trends, and land use/land cover, and dam construction changes are significantly undermining the stationarity of the historically, observed, peak streamflow records on Kentucky River at Lock 14 at Heidelberg, KY and South Fork Kentucky River at Booneville, KY in the Kentucky River Basin.

Note that for all outputs generated from the TST, the following abbreviations apply for the statistical nonstationarity detection tests. CPM indicates a change point method.

Table 2. Nonstationary Detection Test Abbreviations

Method Abbreviations	Statistical Test Name
CVM	Cramer-Von-Mises (CPM)
KS	Kolmogorov-Smirnov (CPM)
LP	LePage (CPM)
END	Energy Divisive Method
LW	Lombard Wilcoxon
PT	Pettitt
MW	Mann-Whitney (CPM)
BAY	Bayesian
LM	Lombard Mood
MD	Mood (CPM)
SLM	Smooth Lombard Wilcoxon
SLW	Smooth Lombard Mood

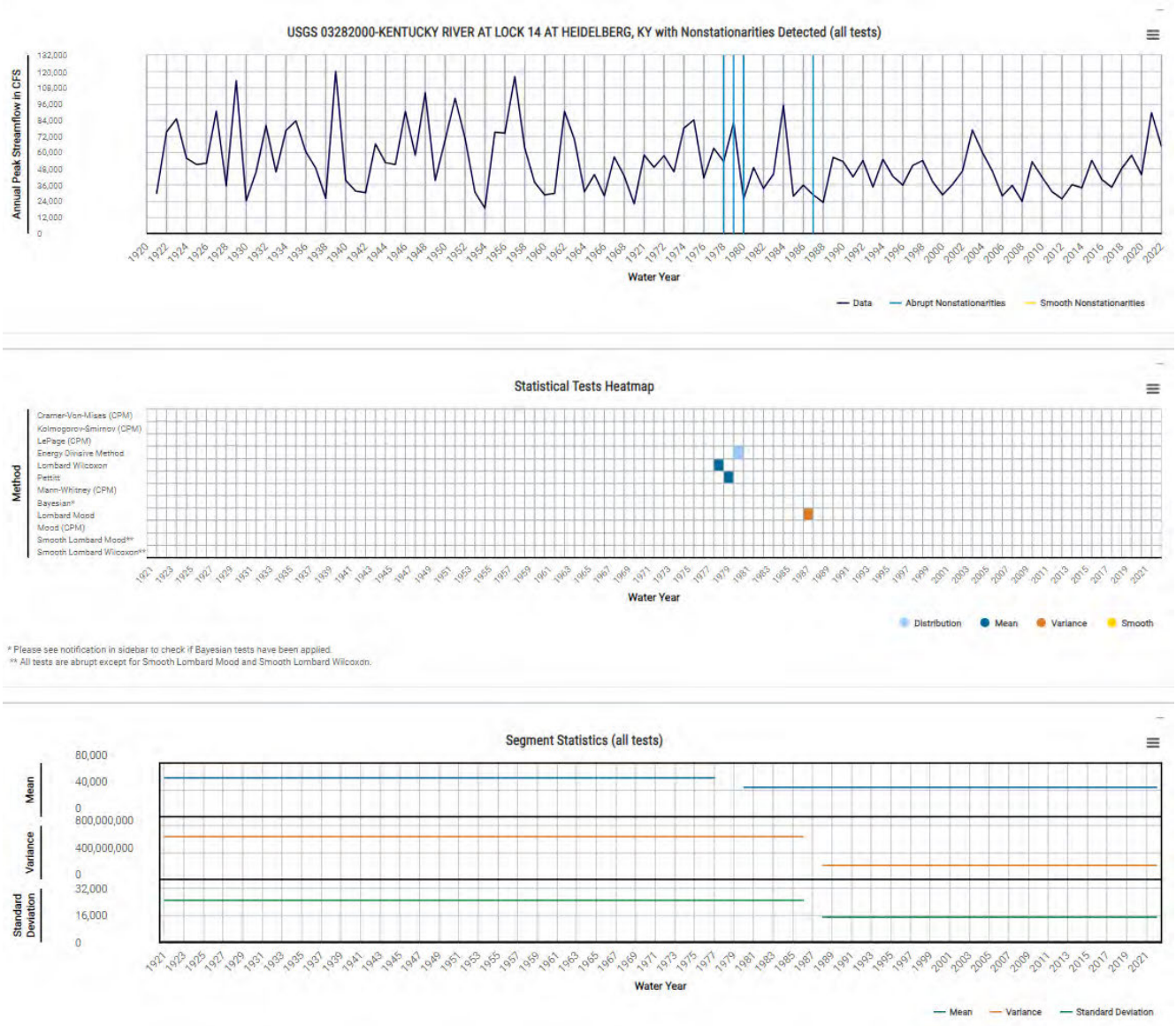


Figure 11. Nonstationarity Detection for Kentucky River at Lock 14 at Heidelberg, KY. Complete Period of Record. 1921-2022.

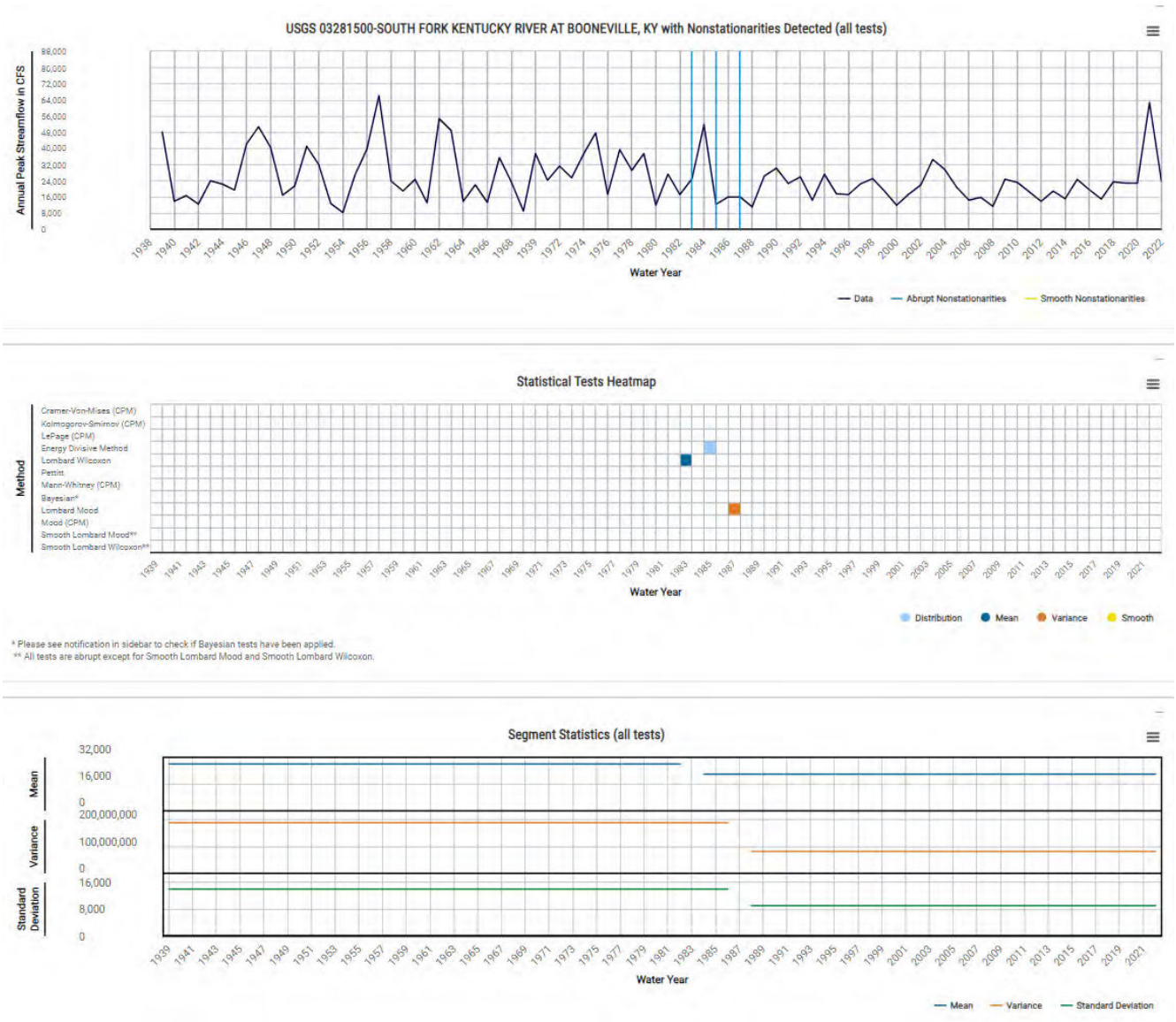


Figure 12. Nonstationarity Detection for South Fork Kentucky River at Booneville, KY. Period of Record. 1926-2012.

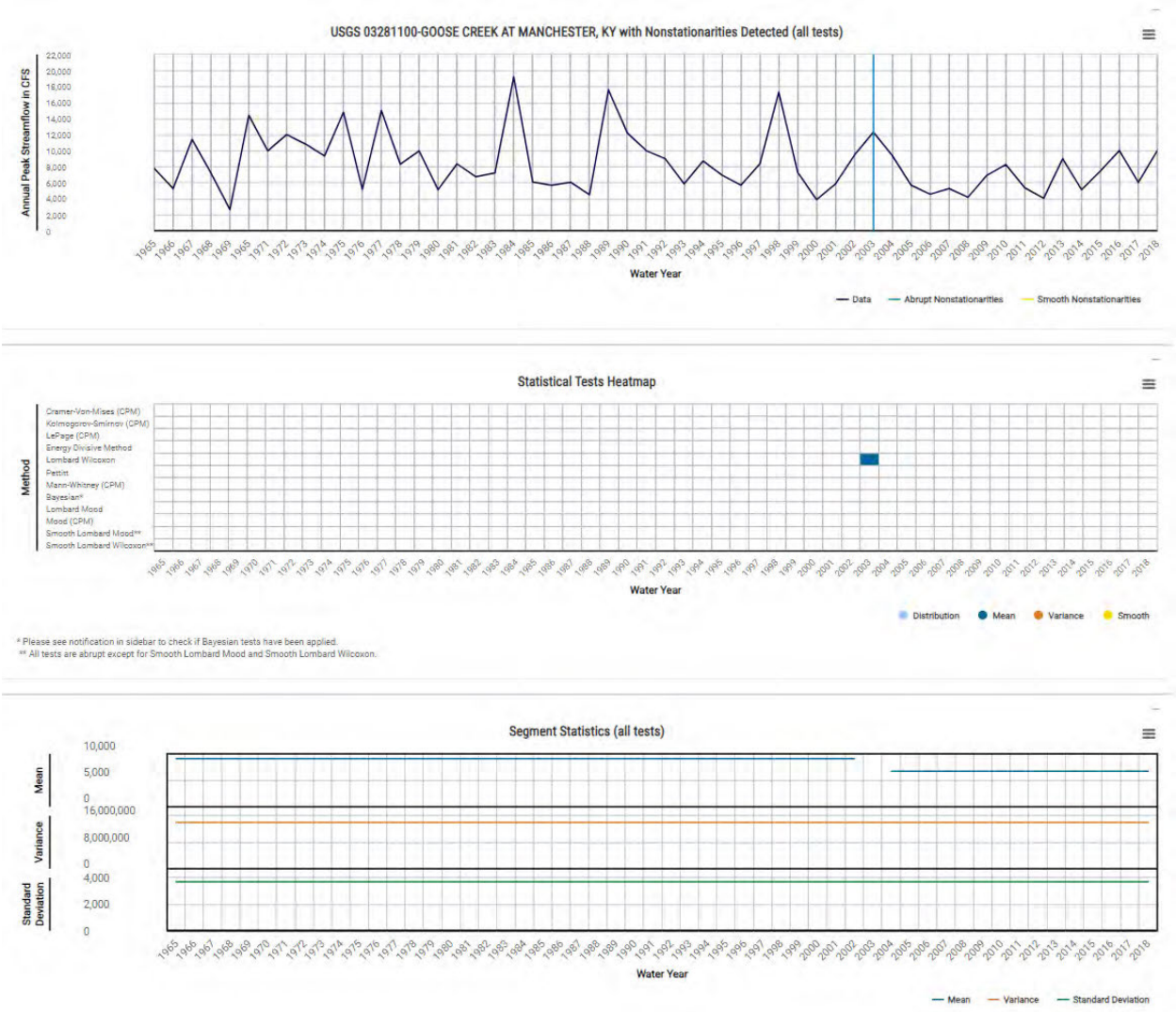


Figure 13. Nonstationarity Detection for Goose Creek at Manchester, KY. Complete Period of Record. 1965-2018.

2.2.1 Time Series Toolbox (TST)

The Time Series Toolbox (TST) developed by USACE was utilized to examine trends in observed annual peak streamflow for the various gage locations shown in Table 1. The TST tool is used to fit a linear regression to the peak streamflow data in addition to providing a p-value indicating the statistical significance of a given trend. Many of the gages selected for TST analysis have been heavily impacted by regulation over different periods of time. For gages where the observed period of record includes the effects of regulation, the annual peak streamflow dataset cannot be considered homogeneous, and it is difficult to draw conclusions based upon the trends identified within these datasets. In addition to assessing the entire period of record at regulated gage sites, subsets of data prior to and after reservoir construction were also analyzed.

The gage on Kentucky River at Lock 14 at Heidelberg, KY can be used to illustrate how periods of reservoir regulation influence trends in streamflow. Peak annual flow for this gage is available

on a continuous basis from 1921 until 2022 in the TST. The annual peak data from 1921-1978 represents a pre-regulation dataset. Buckhorn reservoir was impounded upstream in 1960, however, as shown through the data, the impoundment did not have a large impact on the annual peak data. Carr Creek was impounded in 1975, and coincidingly, there was a noticeable change in the annual peak data. The time period of 1978–1980 represents an era of dam building and reservoir filling upstream of Heidelberg, KY; this period disrupts the homogeneity and homoscedasticity of the streamflow dataset. After 1980, reservoir operations became established, and once again the period of record can roughly be considered homogeneous in terms of reservoir operation. For these reasons, the period of record for the Kentucky River at Lock 14 at Heidelberg, KY was analyzed over 3 time periods: (1) complete heterogeneous period of record, (2) pre-regulation period, and (3) post-regulation period. The complete heterogeneous period of record has a negative trend that is statistically significant, see Figure 14. When the data was divided into pre-regulation and post-regulation periods the trends were negative with no statistical significance (p-value > 0.05).

When dividing the period of record into different intervals of regulation for each gage, consideration was given to ensure that the shortened record length remained adequate for trend analysis. Of the gage whose record was divided based on regulation, the shortest record length was the post-regulation record length of 40 years. This shortened length may impact the linear regression analysis and the statistical significance of the data analyzed. Additionally, there is uncertainty regarding whether the post-regulation period of record reflects homogenous reservoir operation since reservoir regulation is not always consistent and operational deviations are common. However, for the purposes of this analysis, reservoir operations were assumed to be consistent, and the impacts of changes in regulation and deviations from typical operation were considered to be minor. Nonstationarity detection results offer further insight into the homogeneity of the peak streamflow dataset and are discussed below.

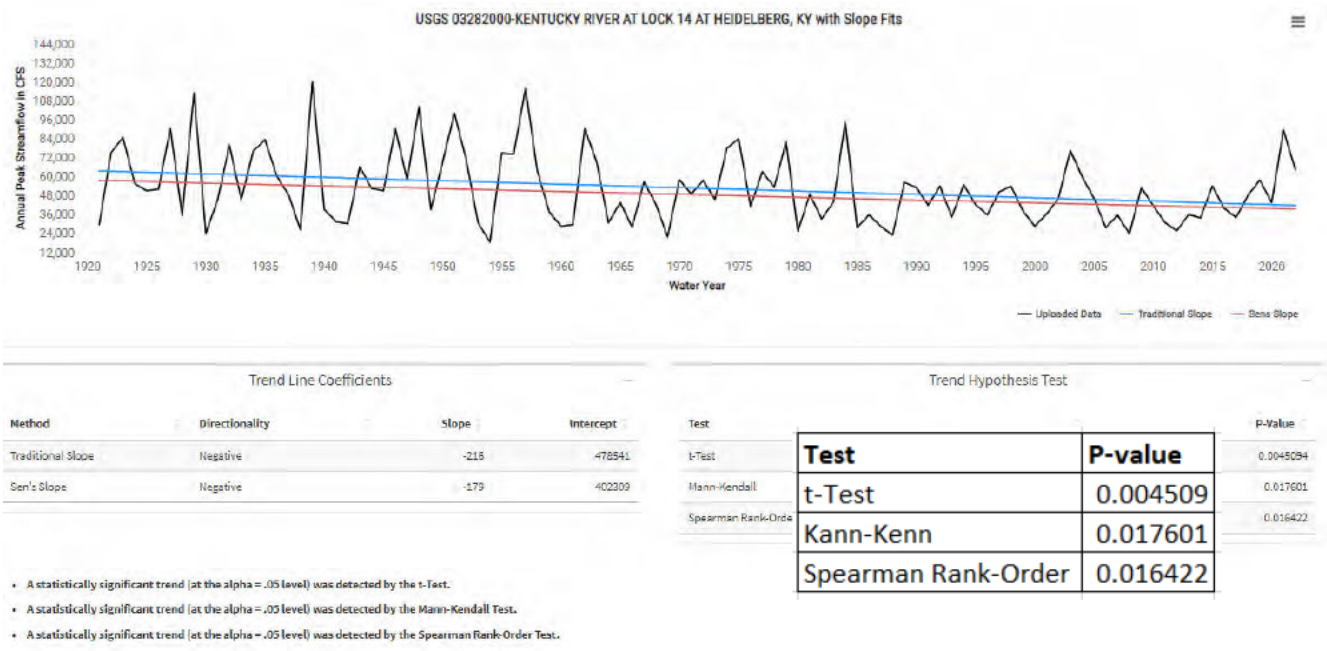
The South Fork Kentucky River Booneville, KY gage (USGS 03281500), with a period of record from 1926-2022, was also analyzed in the TST to represent unregulated conditions within the Kentucky River Basin. Although considered pristine the gage did trigger several nonstationarity tests around 1985 but not enough to be considered a strong nonstationarity in Section 2.2. The stream gage was analyzed over 3 time periods: (1) complete heterogeneous period of record, (2) pre-detection period, and (3) post-detection period. No statistical significance (p-value > 0.05) was detected over the 3 separate time periods in the streamflow data. The model analysis calculated three different trends over the analyzed time periods: (1) negative, (2) positive, and (3) positive.

Precipitation was also analyzed for trends in this basin due to the South Fork gage having several tests triggered around 1985. The earliest precipitation record found for South Fork Kentucky River Booneville, KY was 2007, given the short period of data, it wasn't used to analyze nonstationary of the precipitation in Booneville. A close area with a greater range of data, Buckhorn Lake on the Middle Fork, was used. The hourly precipitation dataset was compiled and analyzed from NOAA for Buckhorn Lake. The dataset was used to calculate the Annual Max 1-Day and Annual Max 3-Day precipitation. No statistical significance (p-value > 0.05) was detected in the precipitation data, but the analysis showed a negative trend.

Individual graphical output for each gage and period of record were analyzed. Note that only the complete period of record for streamflow at Beattyville, KY had a strong statistically significant trend (p-value << 0.05) detected. This trend was in the negative direction and was found when

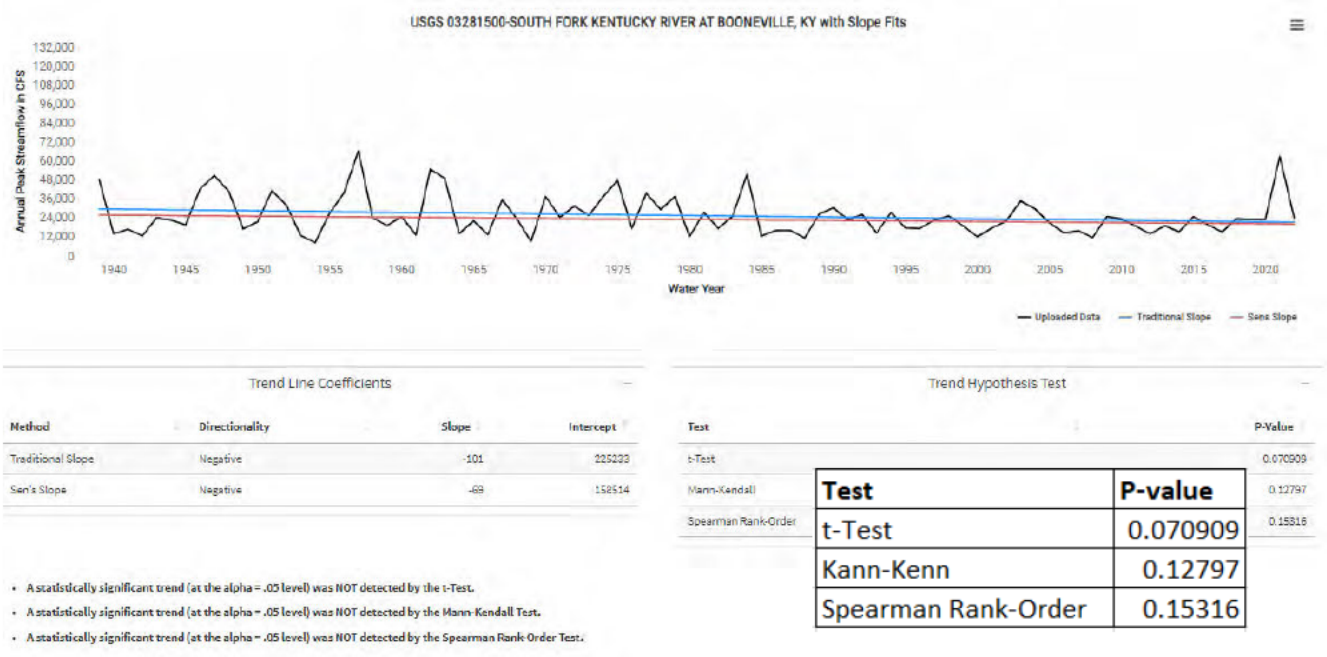
looking at the entire period of recorded flows at sites impacted by regulation. This is to be expected because the primary function of flood risk management regulation is to reduce peak flows. Thus, relative to the pre-regulation period, the post-regulation period consists of lower flood peaks resulting in the observed downward trend. When these same gages were examined either by limiting the period of record to pre-regulation or post-regulation, the trends became statistically insignificant.

The agreement across the watershed and through various time periods indicates that the only statistically significant trend is likely due to the influence of upstream regulation and likely not due to climatic shifts driving changes in hydrology. There were no statistically significant trends detected in any homogeneous period of record that would indicate changes in streamflow due to sources other than regulation.



Test	P-value
t-Test	0.004509
Kann-Kenn	0.017601
Spearman Rank-Order	0.016422

Figure 14. Kentucky River at Lock 14 at Heidelberg, KY. Complete POR 1921 – 2022. Regulated.



Test	P-value
t-Test	0.070909
Kann-Kenn	0.12797
Spearman Rank-Order	0.15316

Figure 15. South Fork Kentucky River at Booneville, KY. Complete POR 1926-2022. Pristine.

2.2.2 Climate Hydrology Assessment Tool (CHAT): Historical Trends

The USACE Climate Hydrology Assessment Tool (CHAT) was used to assess hindsight projected trends within the Upper Kentucky River Basin, HUC-05100204 stream segment ID 05000135. Since the focus of this tool is on the predicted trends, the figures of the results will be presented in the Projected Trends section. The tool displays the range of projected streamflow, precipitation, and temperature variables from 1951-2099, with the projections from 1951-2005 representing hindcast projections and 2006-2099 representing forecasted projections. The annual maximum of mean monthly streamflow and annual maximum 1-day precipitation were looked at for this review. The 2006-2099 forecasted streamflow and precipitation is discussed in a latter section.

Figure 21 through Figure 24 show the range in simulated results from the 32 combinations of CMIP5 general circulation models (GCMs) with representative concentration pathway (RCPs) 4.5 and 8.5 scenarios for streamflow and precipitation variables produced using Localized Constructed Analogs (LOCA) statistical downscaling. RCP 4.5 and 8.5 represent different emissions scenarios and are used for the simulated future projections discussed later.

The streamflows are simulated using an unregulated Variable Infiltration Capacity (VIC) hydrologic model for the stream segment (ID: 05000135) of the Upper Kentucky River (HUC 05100204) where the South Fork of the Kentucky River meets the North Fork of the Kentucky River directly downstream of Beattyville, Kentucky. It should be noted that the hindcast projections do not replicate historically observed precipitation or streamflow and should therefore not be compared directly with historical observations. This is in part because observed streamflows are impacted by regulation, while the VIC model used to produce the results displayed in Figure 21 through Figure 24 are representative of the unregulated condition.

Upon examination of Figure 21 through Figure 24, the historic simulated range in projections lower range of results are steady while the higher projections show more variability. A wide range of results are produced from the 32 combinations of CMIP5 GCM due to the sources of variation

and the significant uncertainty associated with these models including the boundary conditions applied to the GCMs, as well as variation between GCMs and selection of RCPs applied. Each GCM and RCP independently incorporate significant assumptions regarding future conditions, thus introducing more uncertainty into the climate changed projected hydrology. Climate model downscaling and a limited temporal resolution further contribute to the uncertainty associated with CHAT results. There is also uncertainty associated with the hydrologic models. The large spread of results shown in Figure 21 through Figure 24 highlights current climatic and hydrologic modeling limitations and associated uncertainty.

Figure 25 through Figure 28 show the mean of the range of model results. A linear regression was fitted to the mean of the results of the 32 GCM historical simulated projects for the annual maximum of mean monthly streamflow. The slope was found to be 5.3252 cfs/yr. While the slope suggests an increasing streamflow, the statistical test performed by CHAT shows the trend to not be statistically significant. The three statistically significant test performed by the CHAT resulted in a p-value greater than 0.05. A p-value less than 0.05 would indicate a statistically significate trend. The results of statistics test can be seen in Table 3.

The slope of the mean historical simulated projections for the annual maximum 1-day precipitation scenario was found to be 7e-04 in/yr. In addition to the insignificant increasing slope, the statistics test shows the trend to be statistically insignificant as can be seen in Table 3. The models show no historic simulated increase in precipitation.

Table 3. P-values for GCM historic simulated projections for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204.

Test	P-value	
	Streamflow	Precipitation
t-Test	0.343	0.24
Mann-Kendall	0.309	0.211
Spearman Rank-Order	0.285	0.192

The outputs of the simulated historic projections quantitatively suggest no increase in the annual maximum of mean monthly streamflow and the annual maximum 1-day precipitation from 1951 - 2005. The results from CHAT are simulated and do not measure historic streamflow or precipitation. Streamflow results cannot be compared to historic measurements as the CHAT results are unregulated. The results show no increases in flow or precipitation as compared to the simulated future projects discussed latter.

2.2.3 Summary of Observed Trends in Climate

Based on the literature review and the first order statistical analysis carried out in support of the study, there is little evidence or consensus regarding significant temperature or precipitation changes in the Kentucky River Basin Region. This is likely due to the region being a "transition zone" within the Appalachian Mountain region, where the northern and southern Appalachian regions are being impacted by climate change in different, almost opposite, ways. Additionally, no statistically significant trends were observed in precipitation or temperature in the historic record.

Based on the results of the linear regression analysis performed with the TST and the nonstationarity analysis, there is little observed evidence of statistically significant increasing or decreasing trends or nonstationarities within the basin that can be attributed to climate change. There are statistically significant decreasing trends and nonstationarities in observed, peak streamflow that can be directly attributed to the construction of flood risk management project.

The literature review and first order statistical analyses' results are compiled in the table below:

Table 4. Summary of Observed Climate Trends in Beattyville, KY with Used Methods/Tools

Analysis Method/Tool	Significant Temperature Changes	Significant Precipitation Changes	Significant Streamflow Changes
Literature Review	Inconclusive Trend	Slightly increasing trend in volume/frequency	Increasing Trend
Time Series Toolbox Nonstationary Detection tool (TST NSD)	Not Analyzed	Not Analyzed	Decreasing Trend but **not** statistically significant
Climate Hydrology Assessment Tool (CHAT)	Not Analyzed	Increasing trend but **not** statistically significant	Increasing trend but **not** statistically significant

3 PROJECTED TRENDS IN FUTURE CLIMATE AND CLIMATE CHANGE

3.1 LITERATURE REVIEW

3.1.1 Recent US Climate Change and Hydrology Literature Syntheses

In addition to the observed trends discussed previously, the 2015 USACE Literature Synthesis for the Ohio Region 5 also summarizes available literature for projected future trends in various hydrometeorological variables. These variables are projected using a variety of statistical methods in conjunction with global circulation models (GCMs). Figure 7 summarizes the findings of the literature synthesis regarding projected climatic trends. Additional discussion is provided in the following paragraphs.

Temperature. The 2015 USACE Literature Synthesis found strong consensus in the literature that average and extreme temperatures in the Ohio Region show an increasing trend over the next century. Temperatures are projected to change across all months, however there is no consensus on the predicted amount of change. The intensity, duration, and frequency of extreme heat waves are projected to increase in the vicinity of the Kentucky River Basin.

Precipitation. The USACE Literature Synthesis states: “Although precipitation is projected to increase in most studies surveyed, there are no clear trends in the literature indicating the magnitude or geographic distribution of future changes to average or extreme precipitation.” Compared to the rest of the Ohio Region, the Kentucky River Basin is projected to have lower increases in precipitation.

Hydrology / Streamflow. Low consensus exists amongst the literature with regards to projected changes in hydrology for the region. Large variability in the projected hydrologic parameters (e.g., runoff, streamflow, SWE) exist across the literature and varied with location, hydrologic modeling approach, GCM used, and adopted emission scenario.

3.1.2 Fifth National Climate Assessment (NCA5)

In addition to the observed trends discussed previously, the NCA5 offers some insight into future climatic projections, as well as the implications of these projections on risk, infrastructure, engineering, and human health.

Temperature. The NCA5 reported on temperature trends based on global warming level (GWL). GWL is the global average temperature change in degrees Celsius relative to preindustrial temperatures. Figure 16 shows the expected temperature changes for the US for GWL of 1.5°C, 2°C, 3°C, and 4°C. Expected increases in temperatures are not uniform across the globe. Most of the US is expected to have larger increases in temperature with respect to the global average with the northern and western portions of the country experiencing largest levels of warming. At a GWL of 2°C (3.6 °F) the US experiences an average increase between 4.4°F to 5.6°F degrees of warming. At a GWL of 2°C (3.6 °F) Beattyville, KY experiences 4°F to 5°F of warming. As can be seen in Figure 16, Beattyville, KY experiences middle levels of warming for each of the GWL.

Note that in general, increases in projected temperature are greater in higher latitudes and lessen farther south in the country. Coastal states are largely projected to experience less warming than interior regions. The Kentucky River Basin, circled in the figures below, is in a transition zone between the coastal and interior regions. Regardless of spatial variation, temperature increases are projected for the entire country under all GWLs.

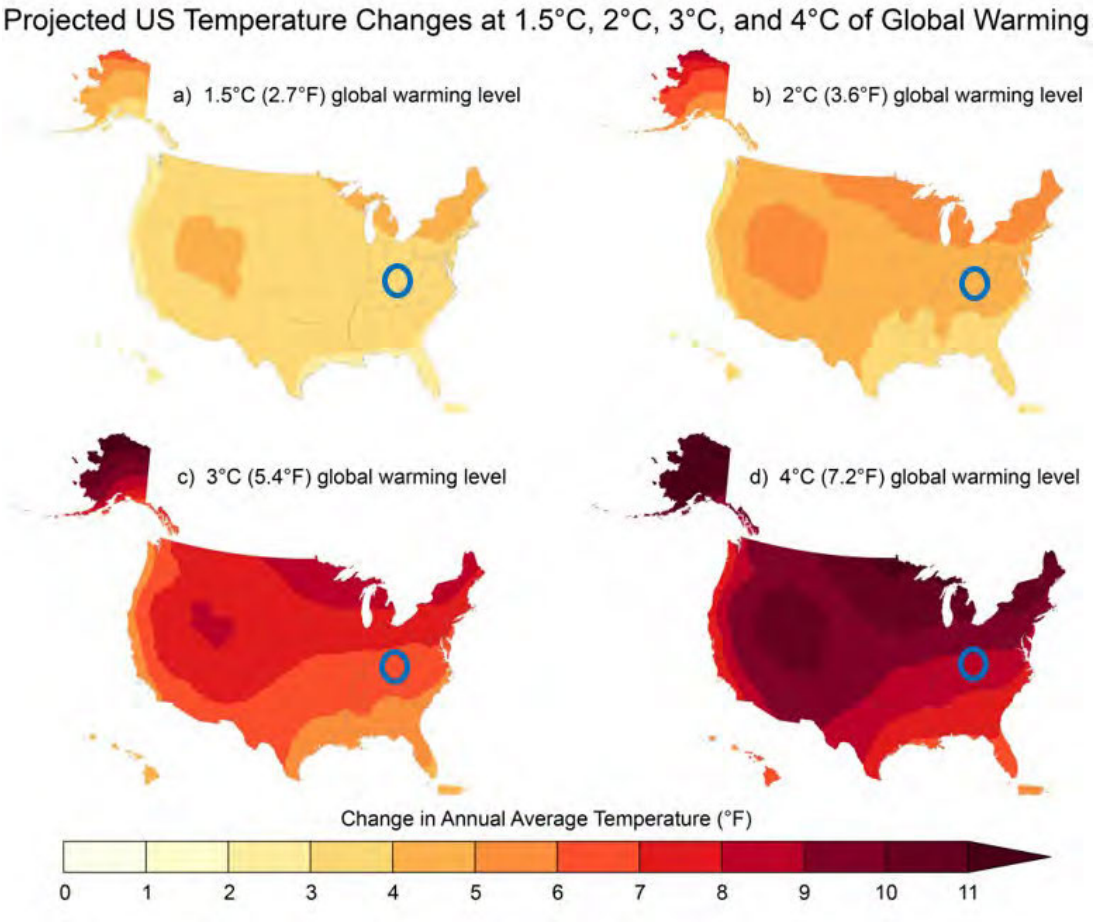


Figure 16. Projected US Temperature Changes at 1.5°C, 2°C, 3°C, and 4°C of Global Warming

As average temperatures increase the risk of extreme temperatures increase. Figure 17 shows the projected changes to hot and cold extremes for three metrics at 2°C of warming relative to the period 1991-2020: number of days ≥ 95°F (hot days), days ≤ 32°F (cold days), and day ≥ 70°F (warm nights). As shown in Figure 17, Beattyville, KY is expected to see in increase in around 10 to 15 hot days, a decrease of about 15 to 20 cold days, and increase in around 15 to 20 warm nights.

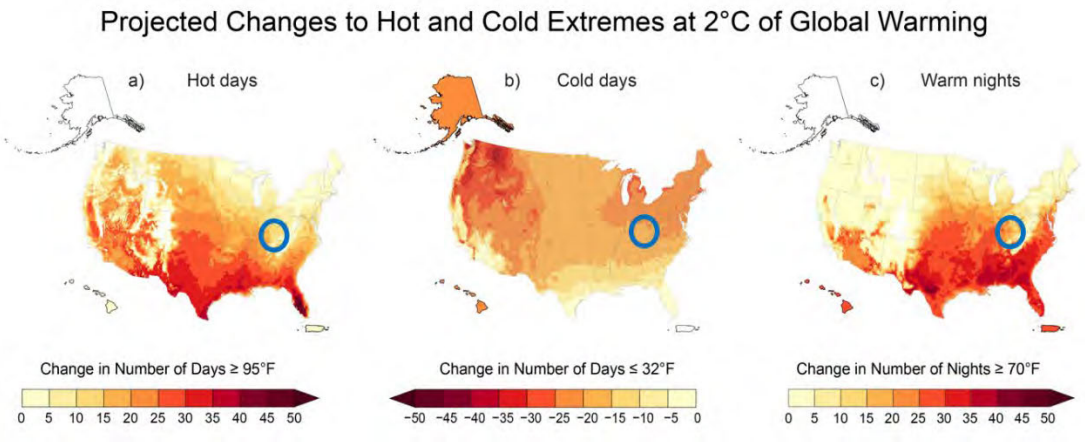


Figure 17. Projected Changes to Hot and Cold Extremes at 2°C of Global Warming

Precipitation. The NCA5 noted precipitation changes are less certain than temperature changes. For the eastern US annual average precipitation is very likely to increase as global temperatures increase. Figure 18 shows the projected changes in average annual precipitation for different GWL. Areas with hatching indicate where 80% or more of models agree on the sign of the change. As temperatures increase average annual precipitation increases for Beattyville, KY in all of the global warm levels. For the three higher GWL, Beattyville's average annual precipitation are located in areas with hatching. The precipitation for the 2°C (3.6°F) GWL in the Kentucky River Basin is projected to increase by 0-10%.

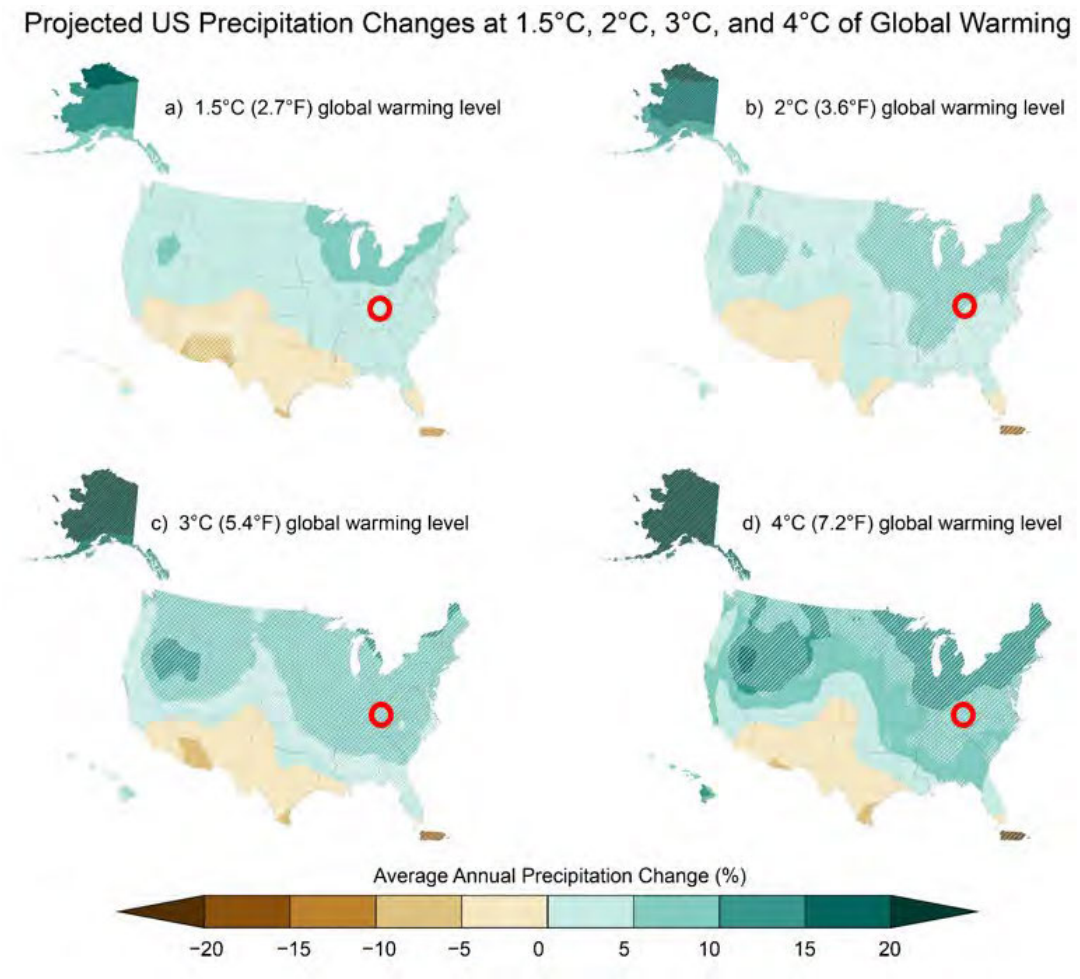


Figure 18. Projected US Precipitation Changes at 1.5°C, 2°C, 3°C, and 4°C of Global Warming

Recent trends in the frequency, severity, and amount of extreme precipitation are expected to continue across the US. Figure 19 displays projected changes in extreme precipitation for GWL of 2°C to the period 1991-2020. Figure 19 includes three metrics to portray projected percentage change in extreme precipitation: total precipitation on heaviest 1% of days, five-year maximum daily precipitation, and annual maximum daily precipitation. Additionally, the NCA5 noted changes in extreme precipitation events differ seasonally. Projected increases in extreme precipitation are larger for spring and winter months which are the typical flood season. Extreme precipitation is likely to increase by 20% to 40% for the Total precipitation on heaviest 1% of days in the Kentucky River Basin. Projected changes for the summer season are more uncertain.

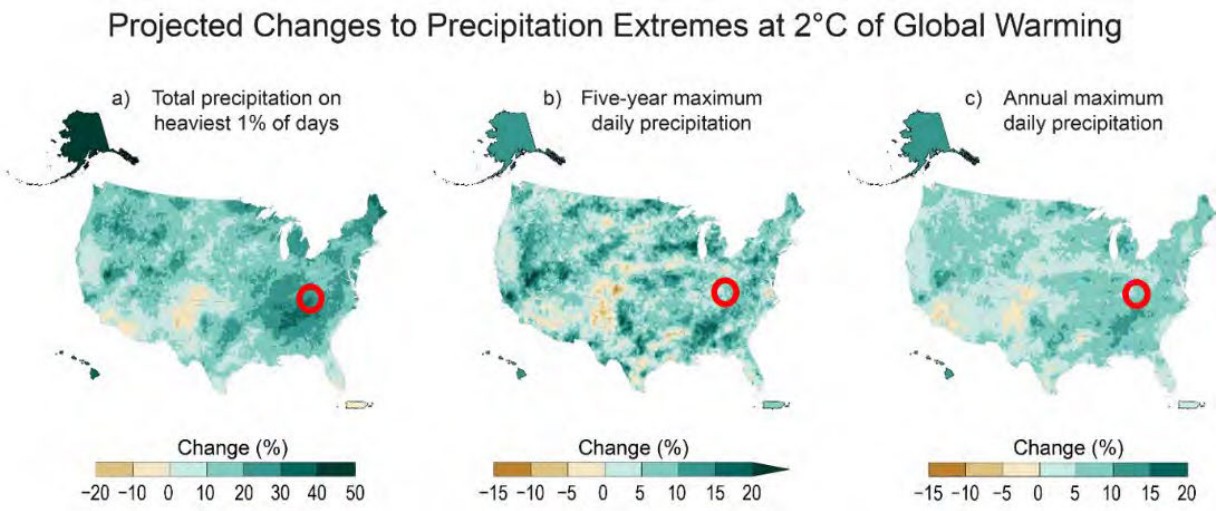


Figure 19. Projected Changes to Precipitation Extremes at 2°C of Global Warming

There is potential for climate change driven changes to hydrologic conditions to increase stress on infrastructure and water supply within the Kentucky River Basin. More frequent and intense extreme weather and climate-related events are expected to damage infrastructure, ecosystems, and social systems. Increasing temperatures and changes in precipitation are intensifying droughts, which can impact water supply. Heavy precipitation events are also expected to occur more frequently, making current infrastructure that is designed for historical climate conditions more vulnerable for future events.

The NCA5 goes on to qualitatively discuss some of the risks associated with projected, future climate conditions. The NCA5 report emphasizes that the likelihood of hydrometeorological phenomena like droughts, extreme storms and flood events may be misrepresented when defined using historic records that are limited in length (approximately 10-100 years). Selected points from this discussion relevant to the Kentucky River Basin include:

- Extreme precipitation events are projected to increase in a warming climate and may lead to more severe rainfall-driven floods and a greater risk of infrastructure failure.
- Long-lasting droughts and warm spells can compromise earthen dams and levees as a result of soil cracking due to drying, resulting in a reduction of soil strength, erosion, and land subsidence.
- The procedures used to design water resources infrastructure, estimations of probability of failure, and risk assessments for infrastructure typically rely on 10-100 years of observed data to define flood and rainfall intensity, frequency, and duration. This approach assumes that frequency and severity of extremes do not change significantly with time. However, numerous studies suggest that the severity and frequency of climatic extremes, such as precipitation and heat waves, have in fact been changing due to human-driven climate change. These changes represent a regionally variable risk of increased frequency and severity of floods and drought. Additionally, tree ring-based reconstructions of climate over the past 500 years for the U.S. illustrates a much wider range of climate variability than does the instrumental record (beginning around 1900). This historic variability includes wet and dry periods with statistics very different from those of the 20th century. Infrastructure design that uses recent historic

data may underrepresent the risk seen from the paleo record, even without considering future climate change.

- Statistical methods have been developed for defining climate risk and frequency analysis that incorporate observed and/or projected changes in extremes. However, these methods have not yet been widely incorporated into infrastructure design codes, risk assessments, or operational guidelines.
- Climate change is expected to increase the frequency and/or intensity of many extreme events that affect infrastructure. Available vulnerability assessments for infrastructure show the prominent role that future extremes play. Since much of the existing infrastructure was designed and is managed for an unchanging climate, changes in the frequency and intensity of flooding, drought, wildfire, and heat waves affect the reliability of water, transportation, and energy services.

Streamflow. Extreme flood events and runoff (surface water flow) are difficult to predict due to complex interactions of precipitation amount and timing, soil moisture, snowpack, and land cover. Increases in precipitation do not always translate directly into increases in runoff or river flooding due in part to the many processes at the land surface. Figure 20 shows projected changes in annual runoff by midcentury for 2036 – 2065 relative to 1992-2020. The average of all available projections found an increase of 0.1-inch to 0.5-inch in the Kentucky River Basin. Additionally, Figure 20 displays the average of wettest 20% and average of driest 20% of projections which displays an increase of 0.1-inch to 1-inch difference and a decrease of 0-inch to 0.1-inch difference, respectively.

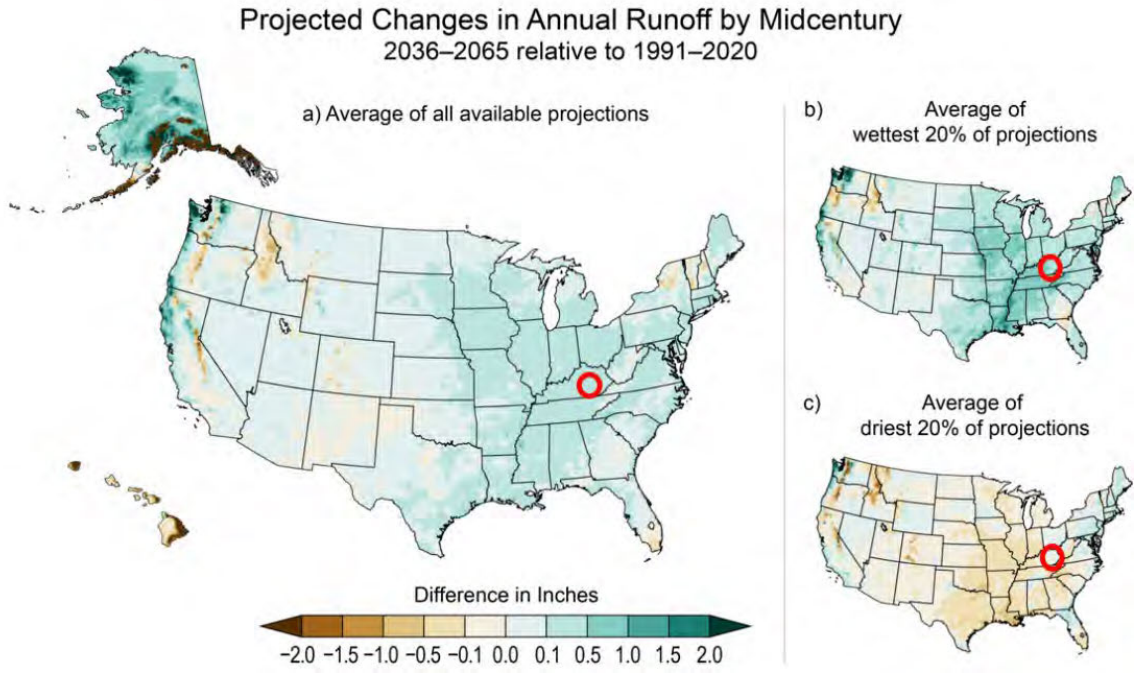


Figure 20. Projected Changes in Annual Runoff by Midcentury

3.1.3 NCEI Kentucky State Climate Summary

In addition to the observed trends previously discussed, the NCEI Kentucky State Climate Summary also analyzed projected trends in climate change. Trends were extrapolated under both higher and lower pathways of greenhouse gas concentrations.

Temperature. Temperatures in Kentucky are projected to exceed historical levels by the mid-21st century under both the higher and lower emissions pathways. Heat waves are projected to be more intense while cold waves are projects to be less intense.

Precipitation. Precipitation in Kentucky is projected to increase in the winter and spring under the higher emissions pathway. Changes in fall and summer precipitation are uncertain. The number and intensity of extreme precipitation events are also expected to increase in the future, following the recent observed trends.

The Climate Summary also projects that future droughts and floods may be more intense in the region due to temperature-caused increases in evaporation and increased extreme precipitation events.

3.2 CLIMATE HYDROLOGY ASSESSMENT TOOL (CHAT): PROJECTED TRENDS

The USACE CHAT was used to assess projected future trends within the Upper Kentucky River Basin, HUC-05100204 stream segment ID 05000135. Forecasted annual maximum of mean monthly streamflows and the annual maximum 1-day precipitation projections from 2006-2099 are analyzed in this review. The 1951-2005 hindsight projections were previously discussed.

Figure 21 through Figure 24 displays the range of forecasted projections for 32 combinations of CMIP5 GCMs with RCPs 4.5 and 8.5 scenarios for streamflow and precipitation variables produced using LOCA statistical downscaling. Upon examination of the range of model results, there is no clear increasing trend in the higher projections for the RCP 4.5 scenario for the annual maximum of mean monthly streamflow variable. There is an increase trend for the RCP 4.5 annual maximum 1-day precipitation scenario and both the RCP 8.5 scenario variables. The lower projections appear to be relatively stable and unchanging through time for all scenarios and variables. The spread of the model results for the RCP 4.5 precipitation scenario and both RCP 8.5 scenario variables also increases with time which is expected as uncertainty in future projections increase as time moves away from the model initiation point.

Figure 25 through Figure 28 display only the mean result of the range of the 32 projections of future, climate changed hydrology and precipitation which are shown in Figure 21 through Figure 24. A linear regression line was fit to this mean and displays an increasing trend with a slope of approximately 0.742 cfs/yr for the RCP 4.5 streamflow scenario and 6.1955 cfs/yr for the RCP 8.5 streamflow scenario. The CHAT tool uses three statistical significances test: the Student t-test, Mann-Kendall, and Spearman Rank Order. The results of the statistic test for all RCP scenarios and variables are shown in Table 5. A p-value of less than 0.05 indicates that the trend should be considered as statistically significant. The RCP 4.5 scenario has no significant p-values. As such, the linear regression trend for the RCP 4.5 scenario is not considered statistically significant. The RCP 8.5 scenario has a p-value less than 0.05 for both the Mann-Kendall and Spearman Rank Order while the student t-test was slightly larger than 0.05, making it statistically

significant. The majority suggests there is a statistically significant increasing trend for the RCP 8.5 scenario.

The linear regression line fit to the mean of the annual maximum 1-day precipitation for the RCP 4.5 scenario was found to have a slope of 0.0023in/yr and the RCP 8.5 scenario was found to have a slope of 0.0038in/yr. The statistical significance tests for both the precipitation RCP 4.5 and RCP 8.5 scenarios were found to be less than 0.05. This indicates a statistically significant increasing trend for both emission scenarios.

Table 5. P-values for GCM projections for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204.

Test	P-value			
	Annual-Maximum of Mean Monthly Streamflow		1-Day Precipitation	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
t-Test	0.825	0.0538	6.3e-10	2.07e-12
Mann-Kendall	0.774	0.0154	< 2.2e-16	< 2.2e-16
Spearman Rank-Order	0.735	0.0364	6.26e-10	4.14e-12

These outputs from the CHAT qualitatively suggest that the annual maximum of the mean monthly flows for the RCP 4.5 scenario are not expected to increase in the future. The CHAT outputs suggest that the annual maximum of the mean monthly flows for the RCP 8.5 scenario, the annual maximum 1-day precipitation for the RCP 4.5, and the annual maximum 1-day precipitation for the RCP 8.5 are expected to increase in the future relative to the current time. The CHAT indicates a slight increase in the RCP 8.5 scenario streamflow while the tool shows a larger increase for both precipitation scenarios. An important caveat is that the CHAT tool is simulating an unregulated watershed. Reservoir operations can be expected to decrease the variance of flows shown in the CHAT, as well as decrease the magnitude of their peaks. It is important to consider that the CHAT results do not assess peak stream flow which is more significant to flood infrastructure in the region. While the results indicated by the CHAT suggest an increase in streamflow for the RCP 8.5 scenario, there was no consensus in the literature review pertaining to the projected future streamflow. While the literature does not find consensus in magnitude and location of precipitation changes, the CHAT does reflect the trend of increasing precipitation found in the literature.

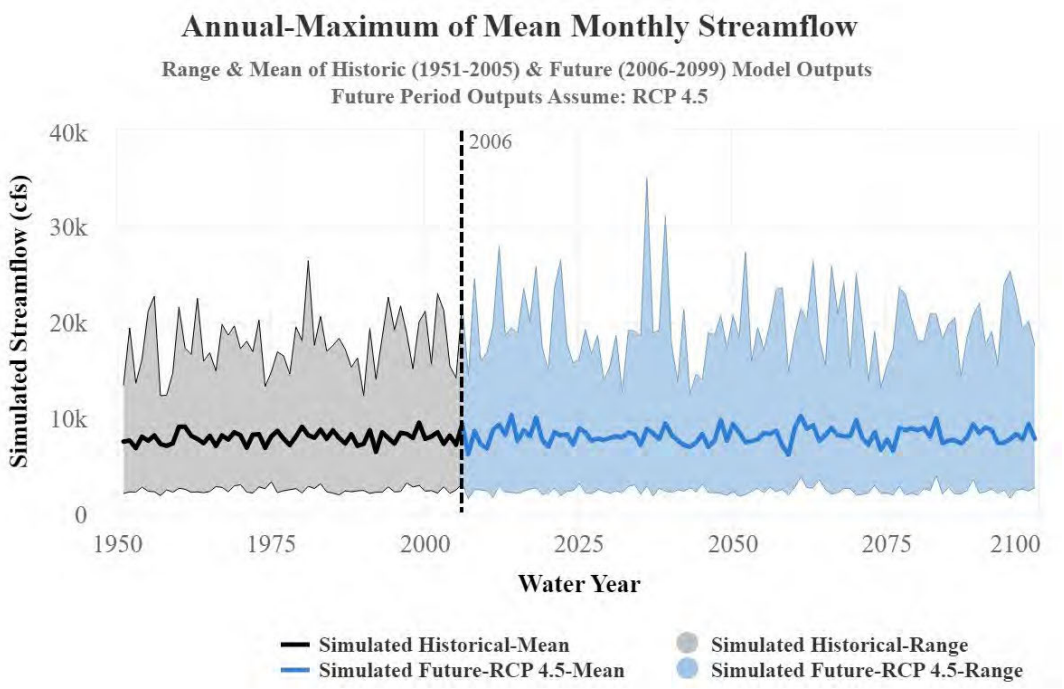


Figure 21. Range of GCM projections for a RCP 4.5 scenario for the Annual Maximum of Mean Monthly Streamflow for Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

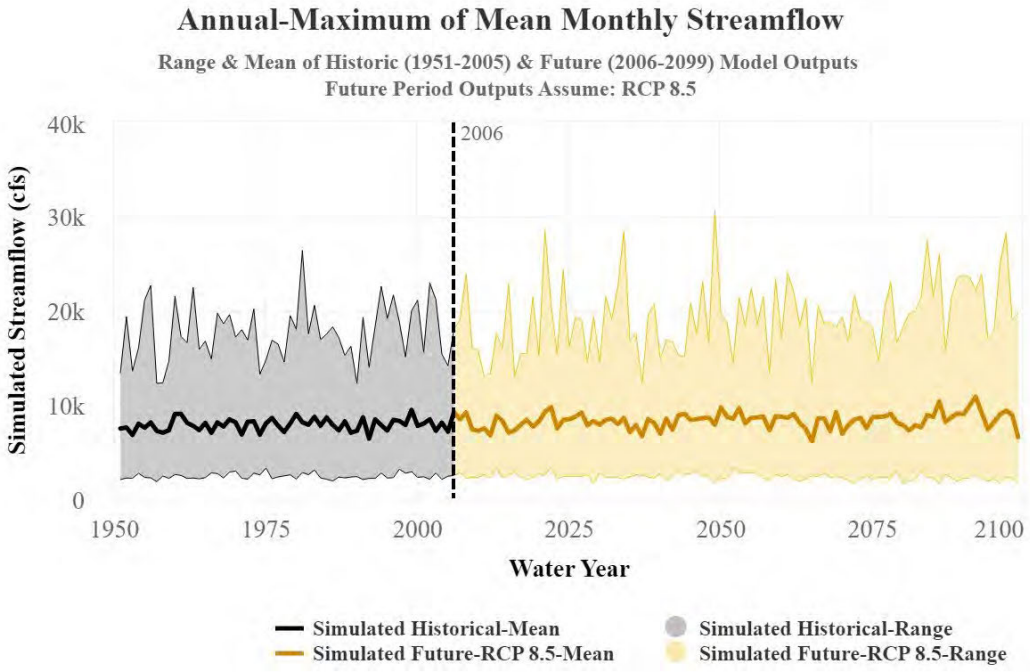


Figure 22. Range of GCM projections for a RCP 8.5 scenario for the Annual Maximum of Mean Monthly Streamflow for Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

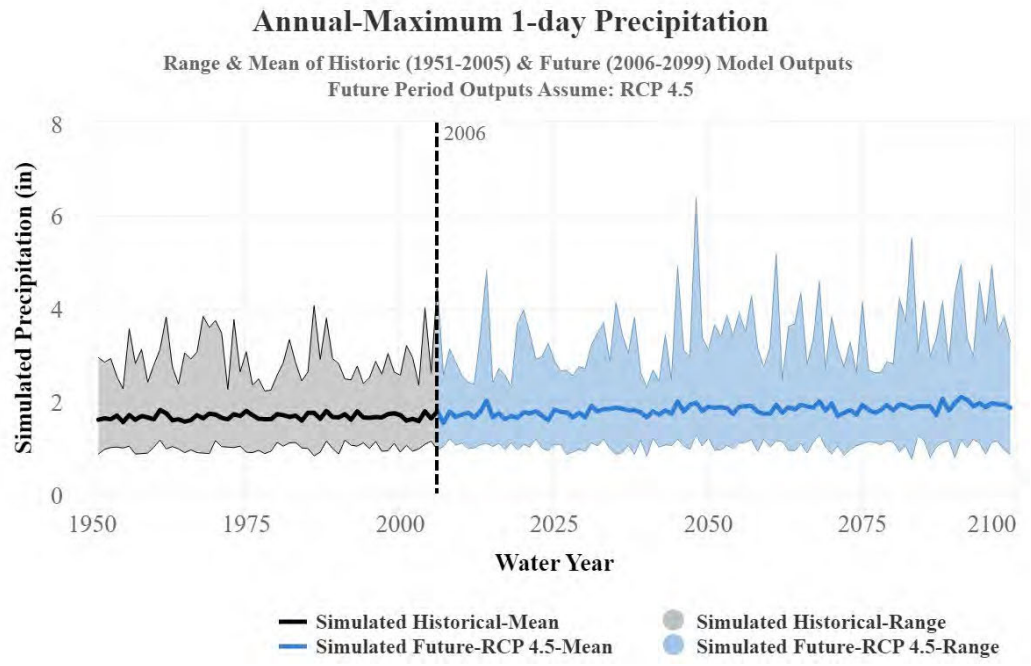


Figure 23. Range of GCM projections for the Annual Maximum 1-day Precipitation RCP 4.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

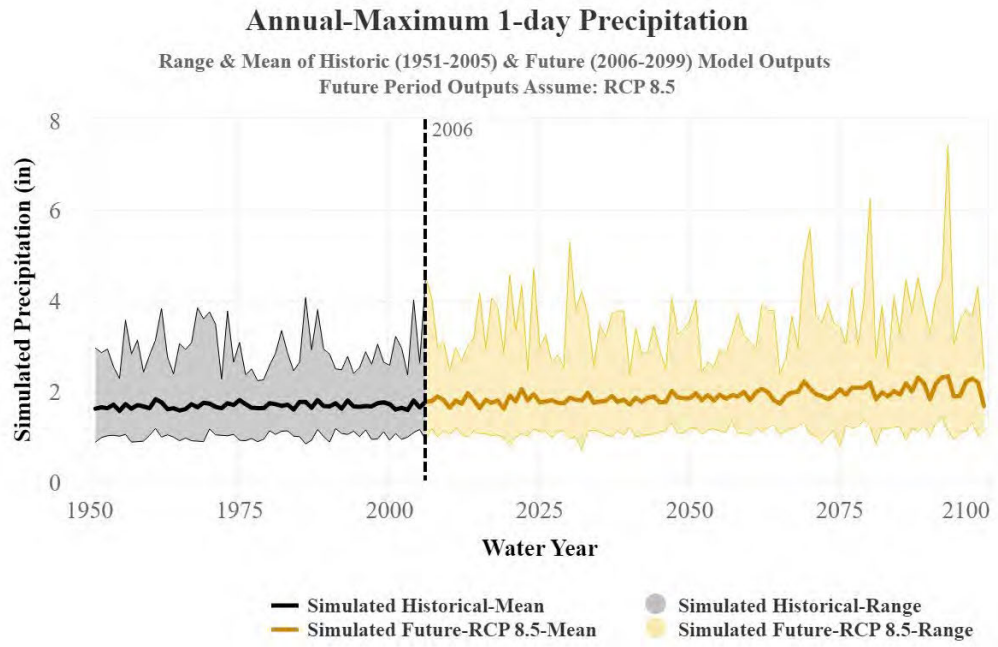


Figure 24. Range of GCM projections for the Annual Maximum 1-day Precipitation RCP 8.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

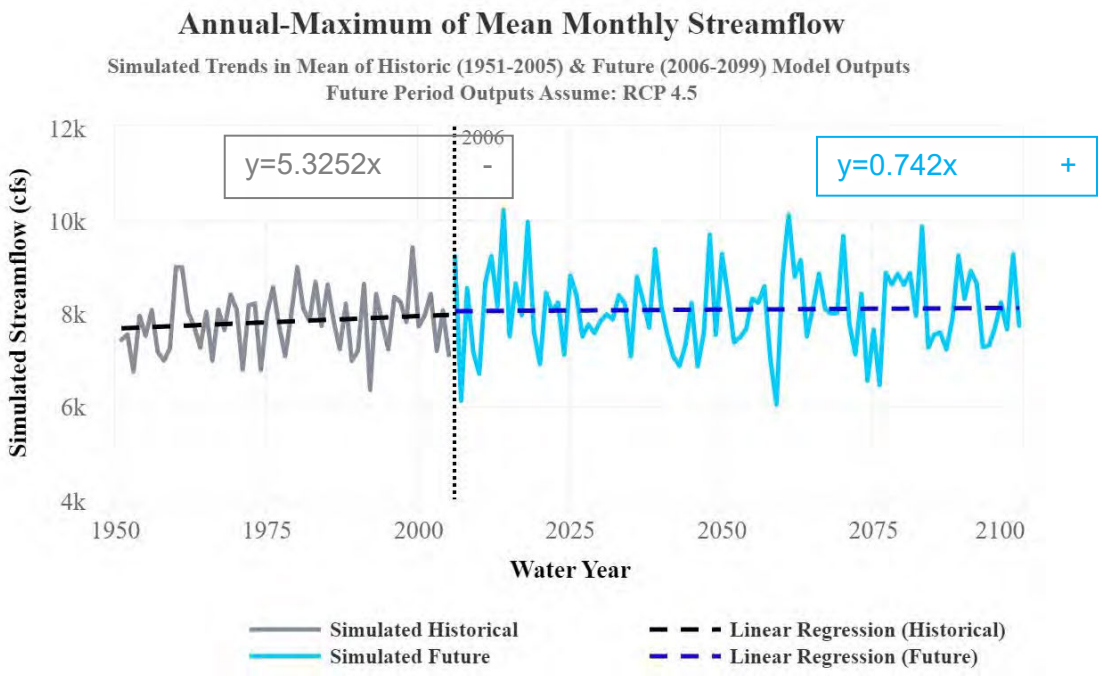


Figure 25. Mean of GCM projections for the Annual Maximum of Mean Monthly Streamflow RCP 4.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

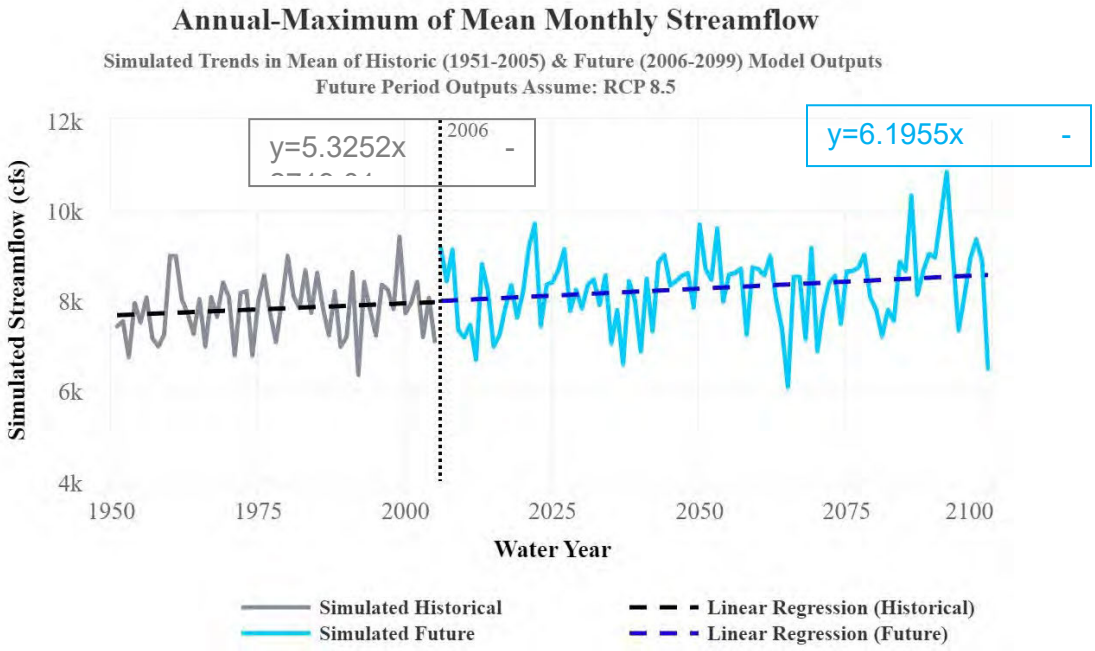


Figure 26. Mean of GCM projections for the Annual Maximum of Mean Monthly Streamflow RCP 8.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

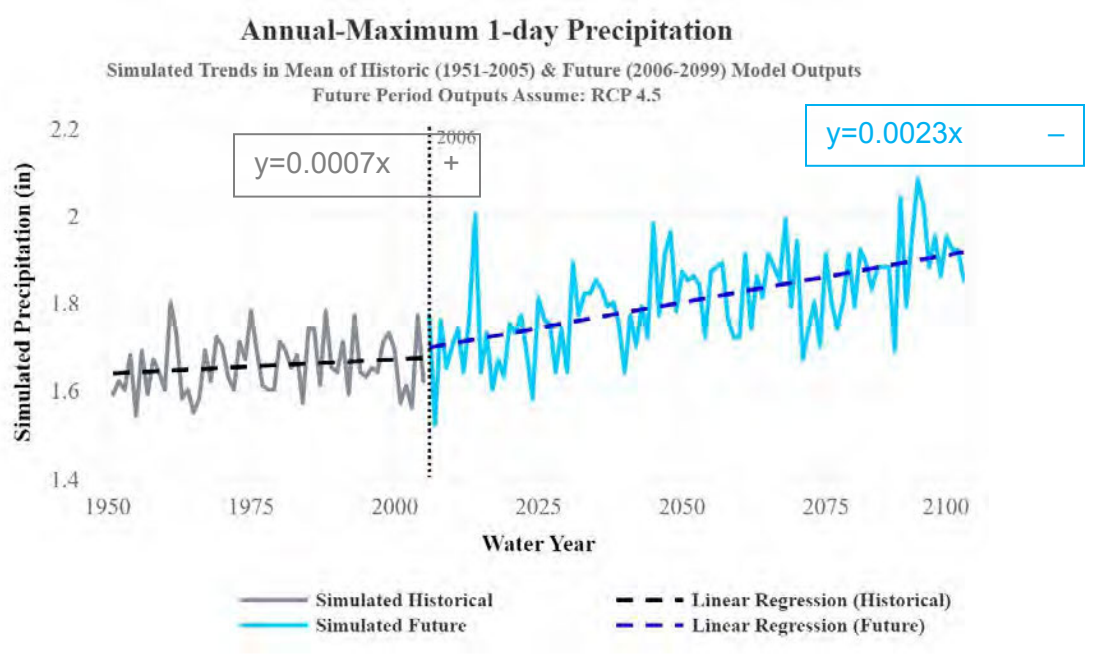


Figure 27. Mean of GCM projections for the Annual Maximum 1-day Precipitation RCP 4.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

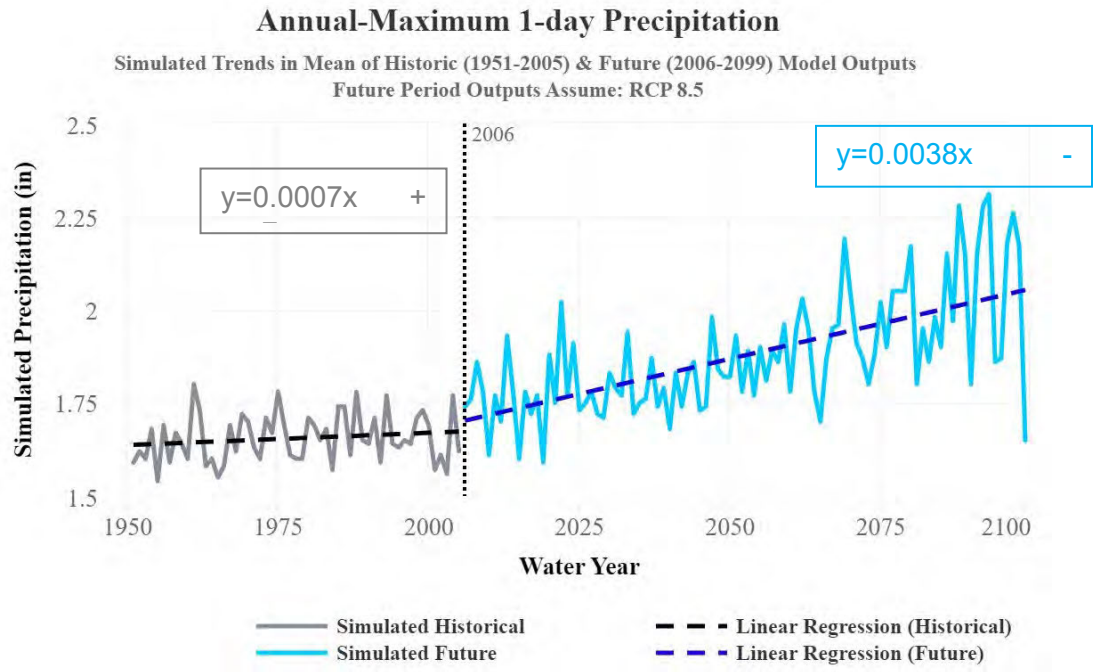


Figure 28. Mean of GCM projections for the Annual Maximum 1-day Precipitation RCP 8.5 scenario for the Stream Segment ID: 05000125 of the Upper Kentucky River, HUC-05100204

3.3 VULNERABILITY ASSESSMENT

The USACE Watershed Climate Vulnerability Assessment Tool (VA Tool) facilitates a screening level, comparative assessment of how vulnerable a given HUC-4 watershed is to the impacts of climate change relative to the other 202 HUC-4 watersheds within the continental United States (CONUS). The tool can be used to assess the vulnerability of a specific USACE business line such as “Flood Risk Reduction” or “Navigation” to projected climate change impacts. Assessments using this tool help to identify and characterize specific climate threats and particular sensitivities or vulnerabilities, at least in a relative sense, across regions and business lines. The tool uses the Weighted Ordered Weighted Average (WOWA) method to represent a composite index of how vulnerable a given HUC-4 watershed (Vulnerability Score) is to climate change specific to a given business line. The HUC-4 watersheds with the top 20% of WOWA scores are flagged as being vulnerable. It should be noted that although a watershed may not be deemed vulnerable, this does not mean that climate change will not impact the study area, but rather that climate change is anticipated to impact this region less than other regions in the United States for a particular business line.

When assessing future risk projected by climate change, the USACE Climate Vulnerability Assessment Tool makes an assessment for two 30-year epochs of analysis centered in 2050 and 2085. These two periods were selected to be consistent with many of the other national and international analyses. The Vulnerability tool assesses how vulnerable a given HUC-4 watershed is to the impacts of climate change for a given business line using climate hydrology based on a combination of projected climate outputs from the general circulation models (GCMs) and representative concentration pathway (RCPs) resulting in 100 traces per watershed per time period. The top 50% of the traces is called “wet” and the bottom 50% of the traces is called “dry.” Meteorological data projected by the GCMs is translated into runoff using the Variable Infiltration Capacity (VIC) macro-scale hydrologic model. For this assessment, the default National Standards Settings are used to carry out the vulnerability assessment.

Business lines included in the VA tool include ecosystem restoration, emergency management, flood risk reduction, hydropower, navigation, recreation, regulatory, and water supply. All business lines were evaluated for the Kentucky-Licking Basin. The basin was not considered vulnerable to climate change impacts for any of the forementioned business lines within a threshold of 20%, meaning that its business lines’ vulnerability did not score in the top 20% of the most vulnerable for any of its business lines. For this project, flood risk reduction is the most relevant business line and the output for this business line from the VA tool is discussed more in-depth below.

Table 6 displays the overall vulnerability scores for the flood risk reduction business line. The scores are shown for both wet and dry scenarios and for both epochs. The indicators driving the residual vulnerability for the flood risk reduction business line are shown in Figure 29. Table 7 displays the indicators contributing to vulnerability within the Kentucky-Licking Basin for the flood risk reduction business lines; the table is generally sorted from largest to smallest average indicator contribution to vulnerability. Additionally, the tables display the indicator code, name, and a brief description of the indicator’s meaning.

Regarding the Flood Risk Reduction business line, the primary indicators driving vulnerability within the watershed are flood magnification (indicator 568C) and the runoff-precipitation elasticity index (indicator 277). The flood magnification factor represents how the monthly flow exceeded 10% of the time is predicted to change in the future; a value greater than 1 indicates flood flow is predicted to increase. For all epochs and scenarios within HUC 0510, the flood magnification

factor is slightly greater than 1 and ranges between 1.04 and 1.37. This agrees with the literature reviews which indicate there will be increasing amounts of extreme rainfall events in the future. The runoff-precipitation elasticity index is defined as the percent change in runoff divided by the percent change in precipitation. The values for HUC 0510 are 2.07-2.20, meaning for every 1% increase in monthly precipitation, there is a 2.07-2.20% increase in monthly runoff. With the projected increases in precipitation, the region will produce even more runoff that could cause flooding and stress on flood-control infrastructure.

Note that some of the indicators contain a suffix of “L” (local) or “C” (cumulative). Indicators with an “L” suffix reflect flow generated within only one HUC-4 watershed, whereas indicators with a “C” suffix reflect flow generated within a HUC-4 watershed and any upstream watersheds. In the case of the Kentucky-Licking (HUC 0510), there is a substantial drainage area upstream of the 4-digit HUC- approximately 3,612 square miles of the Kentucky River Basin Watershed (U.S. Army Corps of Engineers, 2016).

It is important to note the variability displayed in the VA tool’s results highlights some of the uncertainty associated with the projected climate change data used as an input to the VA tool. Because the wet and dry scenarios each represent an average of 50% of the GCM outputs, the variability between the wet and dry scenarios underestimates the larger variability between all the underlying projected climate changed hydrology estimates. This variability can also be seen between the 2050 and 2085 epochs, as well as various other analysis within this report, such as output from the CHAT (Figure 21 and Figure 22).

Table 6. Overall Vulnerability Scores for all Epochs and Scenarios

	Flood Risk Reduction	
Epoch	2050	2085
Dry	47.09	45.44
Wet	50.54	54.09

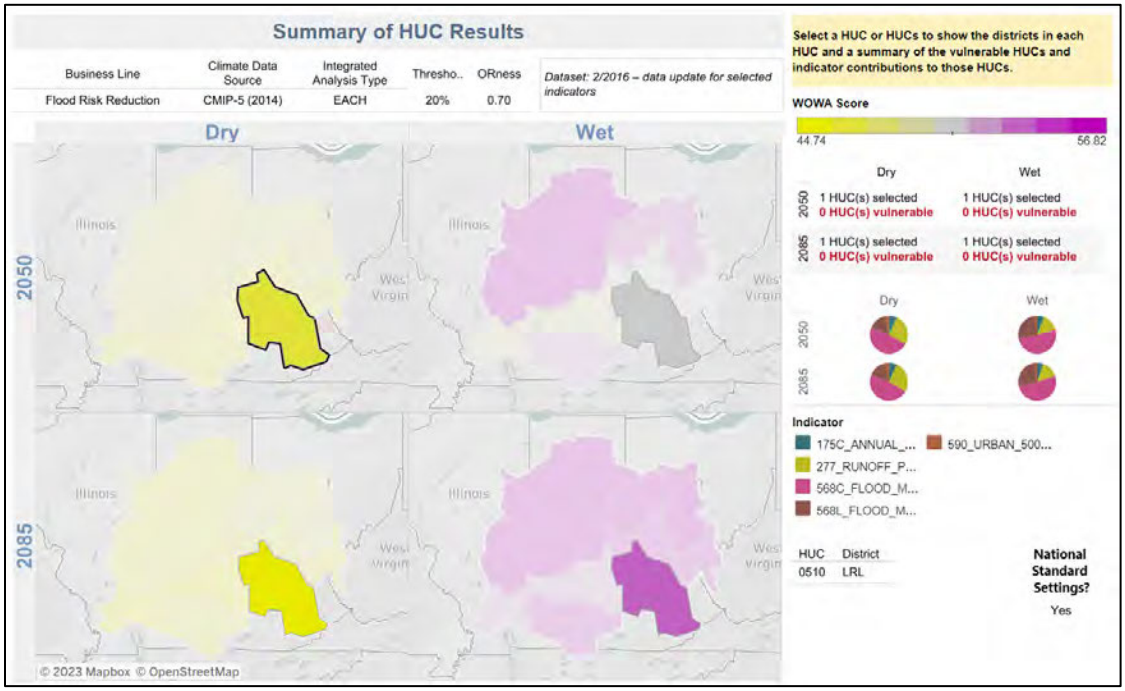


Figure 29. VA Tool Summary of HUC 0510 Results for Flood Risk Reduction Business Line

Table 7. Vulnerability Indicators for Flood Risk Reduction Business Line. Sorted by highest to lowest indicator contribution to vulnerability.

Flood Risk Reduction Business Line			2050	2050	2085	2085
Indicator Code	Indicator Name	Description	Dry	Wet	Dry	Wet
568C	Flood Magnification	Change in flood runoff: ratio of indicator 571C (monthly runoff exceeded 10% of the time, including upstream freshwater inputs) to 571C in base period.	47.81%	50.48%	47.73%	51.47%
277	Runoff-Precipitation Elasticity	Median of: deviation of runoff from monthly mean times average monthly runoff divided by deviation of precipitation from monthly mean times average monthly precipitation.	26.44%	15.22%	26.42%	14.35%
568L	Flood Magnification	Change in flood runoff: ratio of indicator 571L (monthly runoff exceeded 10% of the time, excluding upstream freshwater inputs) to 571L in base period.	15.69%	25.51%	15.67%	26.00%
175C	Annual Covariance of Runoff	Long-term variability in hydrology: ratio of the standard deviation of annual runoff to the annual runoff mean. Includes upstream freshwater inputs (cumulative).	6.86%	5.87%	6.79%	5.39%

590	Urban 500-year Floodplain	Acres of urban area within the 500-year floodplain.	3.20%	2.91%	3.40%	2.79%

3.4 SUMMARY OF PROJECTED TRENDS IN CLIMATE

Across the range of literature reviewed in this analysis, there is conflicting evidence regarding the hydrologic trends which can be expected in the future. In general, the following statements represent the probable hydrologic future that can be expected within the Kentucky River Basin:

- Winter and spring precipitation could potentially increase while trends summer and fall precipitation are uncertain. Projected increases to fall during the typical flood season, which is likely to further increase peak streamflow and reservoir levels. This projection emphasizes the continued need for flood risk management projects into the future. The associated increases in flows on the rivers in the Kentucky River Basin may lead to more frequent and higher loading of levees and other flood infrastructure in the region during the winter and spring flood season.
- The frequency and intensity of extreme precipitation events could potentially increase, making current infrastructure that is designed for historical climate conditions more vulnerable for future events.
- Projected future temperatures are anticipated to increase moderately over historic norms. This has various hydrologic implications including increased atmospheric moisture, evapotranspiration rates, frequency of droughts, and water supply demand.

Data analyzed in the CHAT for precipitation, displayed similar results to the literature review. While the CHAT found increasing stream flows for the higher emissions scenario, the literature review did not find a consensus for hydrologic trends. For the projected Annual-Maximum of Mean Monthly Streamflow with scenario RCP 4.5, the slope was trending slightly upward. With the p-values it was determined that it is not a statistically significant test, meaning the trend is due to natural variation. For the projected Annual-Maximum of Mean Monthly Streamflow with scenario RCP 8.5, the slope was trending upward. Out of the three statistically significant tests run, two noted the upward trend as significant, meaning it is a probable trend. For the projected annual maximum 1-day precipitation with scenario RCP 4.5 and RCP 8.5, the slope was trending upwards, and all statistically significant test were found to be significant. Overall, scenario RCP 4.5 will not have an increase in mean monthly streamflow while scenario RCP 8.5 will have a slight increase in mean monthly streamflow. While precipitation can be expected to increase for both scenarios, a large increase in precipitation can be expected for the RCP 8.5 scenario. It is also important to note that CHAT is simulating an unregulated watershed when considering the results.

For the Beattyville, KY General Investigation, flood risk reduction is the most relevant business line. The Kentucky-Licking Basin was not within the threshold of the top 20% of HUC's for this business lines in the VA tool. Despite not being within the top 20% of HUC's for the flood risk reduction business line, the VA tool results agree with the literature reviews which indicate there will be increasing amounts of extreme rainfall and runoff events. However, it should be noted that there is uncertainty associated with the projected climate change data due to the variability seen in the VA tool results.

The literature review and tool analyses' results are compiled in the table below:

Table 8. Summary of Projected Climate Trends in Beattyville, KY with Used Methods/Tools

Analysis Method/Tool	Significant Temperature Changes	Significant Precipitation Changes	Significant Streamflow Changes
Literature Review	Increasing Trend	Slightly increasing trend in volume/frequency	Inconclusive Trend
Climate Hydrology Assessment Tool (CHAT)	Not Analyzed	For both RCP 4.5 and 8.5, there **is** a statistically significant increasing trend	For RCP 4.5, there is **not** a statistically significant increasing trend For RCP 8.5, there **is** a statistically significant increasing trend
Vulnerability Assessment Tool (VAT)	Not Analyzed	Slightly increasing trend in volume/frequency	Increasing Trend

4 SUMMARY AND CONCLUSION

The Kentucky River Basin flood risk management reservoirs and this related Beattyville, KY General Investigation operate to reduce risks and associated damages of flooding for Beattyville, Kentucky. Based on the literature review and the first order statistical analysis carried out in support of the study, there is little evidence or consensus in regards to significant observed temperature or precipitation changes in the Kentucky River Basin Region. This is likely due to the region being a “transition zone” within the Appalachian Mountain region, where the northern and southern Appalachian regions are being impacted by climate change in different, almost opposite, ways. An assessment of observed peak annual streamflow by the CHAT and TST revealed little evidence of statistically significant increasing or decreasing trends or nonstationarities within the basin that can be attributed to climate change. There are statistically significant decreasing trends and nonstationarities in observed peak streamflow at the Heidelberg gage that can be directly attributed to the construction of flood risk management projects within the basin. The nonstationary found on the “pristine” gage on the South Fork Kentucky River Booneville, KY, determined that there are no statistically significant trends in precipitation or streamflow meaning the nonstationary is localized and not likely part of a larger regional trend.

Regarding projected trends, there is literature supporting increasing temperatures, precipitation, and streamflow. However, trends in projected streamflow are weaker and were not strongly supported in the analysis of the historic and observed data and the literature review of projected climate trends offered little consensus. While trends for typical streamflow were inconclusive, more consensuses exist for increases in extreme precipitation events. Therefore, project features impacted from extreme precipitation such as interior drainage structures may expect increase in the future. While project features impacted from increases in streamflow can be assumed to not be significantly impacted during its lifecycle. It should be noted that substantial uncertainty exists within future climate projections, this uncertainty is effectively illustrated by the range of GCM peak annual streamflow projections shown in Figure 21 though Figure 22. At this time, each of the 32 climate projections included in this figure’s range can be considered equally likely to occur.

All of these trends in observed and projected temperature, precipitation, and streamflow are driving vulnerability within the HUC-4 region and for Beattyville, KY. The HUC-4 region is not considered to be within the threshold of the top 20% of HUCs for the flood risk reduction business line compared to other HUC regions throughout the United States, however this does not mean that climate change will not impact the region. Beattyville’s flood risk is currently reduced by two USACE flood protection reservoirs located upstream within the Kentucky River Basin.

Table 9 displays the residual risk table required by ECB 2018-14. This table lists potential climatic triggers, hazards, harms, and approximate qualitative likelihood of occurrence. The table is primarily focused on the business line of interest, flood risk reduction, however that is not to say that other USACE business lines will not be impacted by climate change. Because this qualitative analysis is focused on the Beattyville, KY General Investigation as a whole, only generic project features of consideration have been identified within the table.

It is recommended that stage-frequency, flow-frequency, and precipitation-frequency for Kentucky River and South Fork Kentucky River be reevaluated periodically in the future to determine how projected trends manifest themselves in future observations. Depending on the results of these future analyses, additional flood risk reduction measures may be required.

Based on this assessment, it is recommended that the potential, future effects of climate change be treated as occurring within the uncertainty range calculated for the current hydrologic analysis. If this assumption proves to be inadequate when future observations or more refined projections become available, then a quantitative evaluation and revision of these results may be required.

Table 9. Residual Risk Table for the Beattyville, KY General Investigation

Feature of Measure	Trigger	Hazard	Harm	Qualitative Likelihood (Frequent, Occasional, Likely, Seldom, Unlikely)	Consequence (Catastrophic, Critical, Marginal, Negligible)	Adaptation
Levee/Floodwall (Structural)	Increased streamflow from precipitation	Levee/Floodwall have a greater probability of overtopping	Levee/floodwall is overtopped leading to loss of structure and protected side of the levee/floodwall gets inundated	Likely or Seldom (Depends on conservatism in crest design height)	Earthen Levee – Catastrophic Floodwall - Marginal	Increase crest design height for projected streamflow increase
Interior Drainage (Structural)	Increased precipitation	Pump and pipes are undersized	Low lying structures would be inundated from interior ponding	Likely or Seldom (Depends on conservatism in interior drainage design)	Pump Station - Marginal Gravity Drains - Negligible	Design for larger pump and pipe sizes
Relocation/ Acquisition (Non-Structural)	Increased streamflow from precipitation	Increased 100-year inundation extents and depths	Structures that are near but not in the current 100-year floodplain may be at a higher risk of flooding in the future but may not be relocated or acquired during this project	Likely or Seldom (Depends on sensitivity of structure inundation near the 100-year floodplain extents)	Critical to Negligible (Depends on sensitivity of structure inundation near the 100-year floodplain extents)	Buyout structures at an increased floodplain extent
Floodproofing Wet/Dry (Non-Structural)	Increased streamflow from precipitation	Increased 100-year inundation extents and depths	Floodproofing efforts are not done to a high enough elevation	Likely or Seldom (Depends on conservatism in floodproofing design height)	Marginal	Increase floodproofing elevation

FWEEP (Inundation Mapping, Evacuation Planning, Flood Plain Management Plan)	Increased precipitation intensity (rate of inundation depth rise)	Inundation rises at a quicker rate than existing conditions	Warning times are reduced leading to individuals not evacuating in time	Seldom	Critical or Marginal (Depends on sensitivity of warning times)	Earlier warning notification in FWEEP, triggered with lower elevations
Floodway Acquisition Ecosystem Restoration Features	Increase in extreme temperatures	Increase in droughts frequency and extreme heat waves	Increase in temperature and drought stresses ecosystem restoration features	Likely	Critical of Marginal (Depends on design of ecosystem restoration features)	Include vegetation which is more resilient to drought and extreme temperatures.
Floodway Acquisition Recreational Features	Increased magnitude and frequency of extreme precipitation	Increases in localized flooding	Drainage features in recreation features are not capable of resulting in minimal flooding	Likely (Depends on selected project features and location)	Marginal to Negligible (Depends on recreation features)	Add recreational features which are resilient to extreme events

Note: Likelihood and Consequence ratings are based on Risk Register Criteria

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Appendix G
Draft Nonstructural Implementation Plan

FY: 2024
Project Title: Beattyville, KY FRM Project
Project No.: 498982
Location: Lee County, Kentucky

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1 INTRODUCTION

This Nonstructural Implementation Plan describes the general process for the implementation of the tentatively selected plan (TSP) nonstructural measures, as described in the accompanying main report with integrated EA and the Engineering and Real Estate Appendices. The primary goal of the tentatively selected plan is to reduce the flood risk for structures in Beattyville, KY, reduce risk to life safety, and to maintain community cohesion. This study will support the community in developing local floodplain management regulations and is developed with consideration of the National Flood Insurance Program (NFIP) compliance standards. Since the City does not currently maintain a local floodplain ordinance, the base flood elevation (BFE) established by FEMA Flood insurance study will be used as the Design Flood Elevation (DFE). The DFE is the nonstructural mitigation elevation that will be targeted for building elevation and wet flood proofing modifications. Dry floodproofing elevations will be dependent on the maximum height dry floodproofing can be supported up to the DFE.

The Tentatively Selected Plan (TSP) is Alternative 5C Incremental Nonstructural Plan consisting of acquisition, dry or wet floodproofing and raising in place paired with a flood warning emergency evacuation plan (FWEEP). Structures identified as acquisitions will be mandatory. Structures identified as dry floodproof, wet floodproof or raise in place will be voluntary.

- FWEEP - individual components to be further developed and provided in detail at the Agency Decision Milestone (ADM)
- Acquisition – properties consisting of structures in the floodway (13 structures)
- Playground relocation, construction of a walking trail, and tree, shrub, and grass planting.
- Dry floodproofing – commercial structures (10 structures)
- Wet floodproofing – commercial structures (30 structures)
- Raising in place – residential structures (1 structures)

Interested property owners will be informed of the details of implementation of the nonstructural features of the project, including inspections and related USACE engineering and management requirements by written notice. It is anticipated that implementation of the Tentatively Selected Plan will occur over a phased implementation period of approximately 5-10 years. However, the scale of the project is highly dependent upon the participation rate for implementation and the amount of funding allocated in any given year. If an owner of a structure eligible for a voluntary nonstructural measure does not want to participate in the project, USACE and the non-Federal Sponsor would defer any further action on that structure until such time as the structure owner elects to participate or until the period of eligibility ends. However, USACE reserves the right to determine whether a structure may be included in the nonstructural implementation after a structure owner has previously declined participation.

2 DETERMINING PROPERTY-OWNER HTRW ABATEMENT REQUIREMENT

Structures identified by the USACE Beattyville FRM Feasibility study recommended plan will be investigated for the presence of HTRW through the completion of an ASTM Phase I environmental site assessment (ESA) and asbestos investigation report. This report will be completed by USACE after the completion of the feasibility study but prior to the owner application period. If the Phase I ESA indicates the potential presence of HTRW on the property, the property owner will be notified in writing by USACE that the property has been identified as potentially being contaminated with HTRW. The notice will request the property owner execute a right-of-entry for further HTRW investigations and the performance of a Phase II ESA. This investigation will determine the property-owner's HTRW abatement requirements or if there will be no abatement requirement. Upon completion of the Phase II assessment findings will be provided to the property-owner. If contamination is identified, the property owner will be required to remove the contamination from the property prior to moving forward in the application. The Phase II assessment may be completed at the same time as the structural inspection discussed in section 3.

3 DETERMINING PROPERTY-OWNER STRUCTURAL REPAIR REQUIREMENT

Structures identified by the USACE Beattyville FRM Feasibility study recommended plan will be eligible to apply for voluntary flood risk management benefits. Applicants will be required to complete a structure inspection that will determine the condition of structure and need for repair or rehabilitation, which is sole responsibility of the property owner. Applications will be accepted in phases. The first phase is different from the second and third phase, as it only includes structures in the floodway identified for mandatory acquisition. The second phase includes the structures identified in the feasibility study as essential or as an anchor asset or service. The participation of these property owners is voluntary. The third phase includes structures identified in the feasibility study as historic structures. The participation of these property owners is voluntary.

These structures will require additional structure-specific analysis during the design phase to determine if the property-owner will be responsible for any structural repair or rehabilitation to support the construction of the flood risk management measure.

3.1 ELIGIBLE PROPERTY STRUCTURE INSPECTION

Individual structure inspections will occur on each eligible structure for which the owner has made application to participate. The inspection team will be comprised of USACE specialists and the non-Federal Sponsor. The property owner will be required to grant a temporary right-of-entry, as part of the application, to USACE and the non-Federal Sponsor to enter the property to conduct investigations necessary to determine owner repairs and rehabilitation costs necessary to support the flood risk reduction measure. The inspection may include activities such as structural wall and foundation integrity assessments, mechanical equipment assessment, surveys, limited environmental testing for hazardous and toxic materials or wastes, utility inspections, and a site

investigation verifying existing elevations, and conducting such other activities deemed necessary by USACE and the Non-Federal Sponsor to make a final determination on what the property-owner's repair and rehabilitation responsibility would be if they proceed. A property owner may elect not to participate at any time prior to execution of an agreement for the implementation of the nonstructural measure upon the property. Refusal to grant temporary right-of-entry as part of the application will constitute the property owner's election to not participate.

4 NFS REQUIREMENTS

The Non-Federal Sponsor (NFS) shall submit satisfactory documentation as deemed necessary by USACE (to be detailed during design) which may include, but will not be limited to:

- Proof of ownership/title, including but not limited to a legal description of the property, deed, or a tax assessor's receipt.
- The names of all the owners of the property and provide information regarding the names and addresses of all third-party interest holders and any holders of a lien or encumbrance against the property.
- In instances involving the representation of a person, or persons, whose signature is required for any document, subordination, or release which may be required to be executed for the project, either through a trust, agency, succession, partnership, business, corporation, or any other form of representation under law or contract, documentation will be provided along with the title evidence that documents the identity, powers, and authorities of the person or persons authorized to act on behalf of the required signatory.
- The non-Federal Sponsor shall conduct title research to confirm the property has clear title and update property and structure appraisals.

5 OTHER PROPERTY-OWNER REQUIREMENTS

Once the environmental and other structure integrity assessments have been completed, the NFS will conduct property title research, based upon state requirements, to confirm fee ownership and identify encumbrances on title. The property must have a clear chain of title (with the exception of mortgages and utility or access easements). Otherwise, the property owner will be responsible for clearing title defects prior to gaining approval to initiate the flood risk management design and construction process. The property must not have previously received any disaster assistance for flood damage reduction from any federal sources.

5.1 ELIGIBLE AND INELIGIBLE PROJECT COSTS

Implementation of nonstructural measures will require local permits prior to onsite construction. Only the costs of acquisition, elevation, basement fill, and appropriate utility room additions, foundation retrofitting, dry floodproofing are eligible costs. No Federal funds will be used to restore, replace, repair, or to bring the structure up to current local and state codes and ordinances. A 50 square foot addition to first floor area of the structure to relocate any utilities out of the basement and/or crawlspace is incorporated as project cost, if the lot size allows.

5.2 ELIGIBLE PROJECT COSTS

Elements of nonstructural measure implementation work determined to be eligible project costs include the following:

- Administrative cost of the Non-Federal Interest to discuss project with owner and obtain signed real estate agreements.
- Structures attached to the main building:
- Raising of mechanical equipment.
- Utility connections that meet existing code.
- Vent construction for flood water entry and exit.
- Special access requirements and improvements.
- Tree removal and site restoration.
- Measures necessary to meet Federal statutes such as the Endangered Species Act and the National Historic Preservation Act.
- Temporary site protection measures during site work.
- Allowable relocation assistance funds for displaced residential tenants in accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970, Public Law (PL) 91-646, 84 Stat. 1894 (42 USC 4601) (URA), as amended by the Surface Transportation and Uniform Relocation Assistance Act of 1987, Title IV of PL 100-17, 101 Stat. 246-256.
- Design costs, including plans and specifications for permits application.
- Costs of obtaining all required permits (i.e., zoning or land use approvals, environmental permits or required certifications, historic preservation approvals, and building permits), except as identified to be an ineligible item of project cost.
- Real estate acquisition and other associated incidental real estate costs, including but not limited to title costs, appraisal costs, survey costs, closing and attorney's fees, mapping costs, and actual amounts expended for payment of any qualified relocation assistance benefits.
- In instances where special access improvements (i.e., elevators, lifts, ramps, etc.) may be required, special handicapped access can be considered an eligible improvement cost when documented by the medical certificate of a licensed physician. Multiple special access points may also be eligible for funding where necessary to meet state or local building code compliance.
- Site grading and site restoration including restoring landscaping to its preconstruction condition.

Costs specific to dry floodproofing include but are not limited to:

- Water resistant sealant and masonry veneer.
- Water resistant materials.
- Certified closure panels.
- Concrete masonry unit (CMU) wall if needed, including footing and foundation.
- Sewer backflow values and skimmer pumps.
- Raising electrical and relocating utilities.

Costs specific to wet floodproofing include but are not limited to:

- Installation of flood vents.

- Replacement of insulation, wall board, and trim with level 4 or 5 flood resilient materials.
- Replacement of level 1-3 flooring, doors, and windows with level 4 or 5 resilient materials.
- Raising air conditioners, furnaces, electrical panels, and water heaters up to the DFE.

Rating levels (1-5) for flood resilient materials are based on the FEMA technical bulletin titled "Flood Damage – Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program Technical Bulletin 2 Aug 2008".

Historic Structures that are in the floodway and identified for acquisition may be excluded if the Historic structure cannot be properly mitigated by relocating the structure or other mitigation means.

5.3 INELIGIBLE PROJECT COSTS

Costs that exceed those activities necessary to safely implement the nonstructural measure for an eligible structure are ineligible costs, and any such costs remain the sole responsibility of the property owner. These costs may include, among others:

- Costs to elevate above the identified DFE.
- The proper remediation, removal, and disposal of environmental contaminants including but not limited to HTRW, asbestos, and asbestos-containing materials in damaged or friable form; and
- Costs associated with bringing a non-conforming structure into compliance with current building codes, housing codes, and/or other applicable codes.

6 NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

The nonstructural flood risk management measures considered for residential structures are elevation (with or without basement filling), and acquisitions. The nonstructural mitigation measures considered for non-residential structures are dry floodproofing (with or without basement filling), wet floodproofing, and acquisitions. While each eligible structure has been evaluated for the most cost-effective nonstructural measure based on structure type, the non-Federal sponsor and USACE study team reserves the right to make the final determination as to which measure shall be implemented. Community cohesion is one of the primary study objectives; and because an NED waiver is being pursued, in some cases the measure that keeps a business in-place when an acquisition is the less expensive option may still be permitted and pursued.

6.1 RESIDENTIAL STRUCTURES

The appropriate nonstructural measures for residential structures based upon the flood risk are elevation (with or without basement filling), wet floodproofing, or acquisitions. Owners of eligible residential structures may participate in having their structure evaluated to the DFE and/or the structure's basement filled.

6.1.1 Elevation consists of raising the existing structure from its original foundation, CMU block or slab-on-grade, to the DFE on extended foundation walls. If the elevated foundation below the first floor is an enclosed masonry perimeter, then appropriately sized flood vents will be installed in the foundation walls, located no more than 1 foot above lowest adjacent grade to allow

hydrostatic forces to equalize. Elevation greater than 12 feet above the adjacent ground elevation is not permitted due to potential cost increases because of wind factors, and the associated risk with occupancy evacuation. There are no elevations foreseen at this time to be greater than 12 feet in the study area.

6.1.2 Basement fill and utility addition consists of filling in the existing basement with sand or gravel, and if practical placing a vapor barrier on the top of the fill. Filling in the basement is required when elevating residential structures which have basements. This measure could occur without elevating the structure if the first floor is located above the eligibility limit, but the basement is below the eligibility limit. To compensate for a portion of the lost basement area and provide a location for relocation of the utilities located in the basement (electrical panel, furnace, water heater, water softener, washer, and dryer), an above ground addition of 50 square feet is to be constructed onto the structure at the DFE if the lot size allows.

6.1.3 Acquisitions of a residential structure consists of buying the structure and the associated land and demolishing the structure. Land acquisition is in the form of fee title. After acquisition, the land must be maintained as open space through deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is consistent with open space restrictions, such as trails, parks, golf courses, shoreline access, and interpretive markers. Existing infrastructure, including utilities, streets, and sidewalks, can be removed as part of the project when previously developed land is converted to open space.

Acquisitions are a dependable way to reduce flood risk to people and property however is the least favorable measure as it relates to community cohesion.

6.2 NON-RESIDENTIAL STRUCTURES

The appropriate nonstructural measures for non-residential structures are dry floodproofing, wet floodproofing, basement fill, and acquisitions. Owners of eligible non-residential structures may participate in having their structure dry floodproofed to the maximum floodproofing height of 3 feet. If there is a basement located in the non-residential structure, it would be required that the basement is filled as well.

6.2.1 Dry floodproofing non-residential structures consists of sealing the entire structure from the ground level up to the maximum 3 feet in height, to reduce the risk of damage from flooding by making walls, doors, windows, and other openings resistant to penetration by flood waters. Dry floodproofing involves applying a water-resistant sealant around the structure to prevent flood water from entering. The sealant layer is then protected with a brick veneer or similar material. Certified closure panels are used at pedestrian and vehicular openings, backflow prevention devices are installed on sanitary sewer lines, and skimmer pumps with discharge tubes are placed at the openings to control potential seepage.

6.2.2 Basement fill and utility addition consists filling in the existing basement with sand or gravel, and if practical placing a vapor barrier on the top of the fill. Filling in the basement is required when flood-proofing non-residential structures which have basements. This measure could occur without floodproofing the structure if the first floor is located above the eligibility limit, but the basement is below the eligibility limit. To compensate for a portion of the lost basement area and provide a location for relocation of the utilities located in the basement (electrical panel,

furnace, water heater, water softener, washer, and dryer), an above ground addition of 50 square feet is to be constructed onto the structure at the DFE if the lot size allows.

6.2.3 Wet floodproof of non-residential structures allows floodwater to enter the structure, vulnerable items such as utilities appliances and furnaces are relocated or waterproofed to higher locations. By allowing floodwater to enter the structure hydrostatic forces on the inside and outside of the structure can be equalized reducing the risk of structural damage.

6.2.4 Acquisition of a nonresidential structure consists of buying the structure and the associated land and demolishing the structure. Land acquisition is in the form of fee title. After acquisition, the land must be maintained as open space through deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is consistent with open space restrictions, such as trails, parks, golf courses, shoreline access, and interpretive markers. Existing infrastructure, including utilities, streets, and sidewalks, can be removed as part of the project when previously developed land is converted to open space. Acquisition is a dependable way to reduce flood risk to people and property however is the least favorable measure as it relates to community cohesion.

6.3 STRUCTURES IN THE FLOODWAY

Structures that are completely located in the floodway are not eligible for elevation, dry floodproofing, or basement filling. Residential and Non-Residential structures that have at least 50% of their first-floor square footage out of the floodway will be eligible for elevation and dry flood proofing, respectively, along with basement filling as needed. Structures with more than 50% of their first-floor elevation in the floodway will only be eligible for acquisition. Structures identified for acquisition are mandatory.

6.3.1 Acquisition of a nonresidential structure consists of buying the structure and the associated land and demolishing the structure. Land acquisition is in the form of fee title. After acquisition, the land must be maintained as open space through deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is consistent with open space restrictions, such as trails, parks, golf courses, shoreline access, and interpretive markers. Existing infrastructure, including utilities, streets, and sidewalks, can be removed as part of the project when previously developed land is converted to open space.

7 PRIORITIZING THE NONSTRUCTURAL IMPLEMENTATION

Scheduling nonstructural mitigation activities will be subject to the availability of project funds. The locations for scheduling or prioritizing the implementation of nonstructural work will be determined during design but will be fully assessed for implementing the nonstructural plan in an efficient and cost-effective manner. As funds are appropriated, scope would progress in the following order:

1. FWEEP
2. Acquisitions in the floodway
3. Recreation
4. Dry floodproof, wet floodproof essential and community anchor structures

5. Dry floodproof, wet floodproof, elevate (elevation only for residential) historic structures

8 NONSTRUCTURAL MITIGATION AGREEMENTS

All individual structure implementation activities will be executed through a nonstructural mitigation agreement for structures having their FFE raised to the DFE, for structures implementing dry floodproofing to reduce their flood risk, or for structures implementing wet floodproofing to reduce their flood risk. If the structure contains a basement, the mitigation agreement will include specific language for filling this area and incorporating a utility addition onto the modified structure.

A voluntary nonstructural mitigation agreement will be executed between the non-Federal Sponsor and the property owner(s) regarding the eligible structure before design and implementation can begin. The mitigation agreement and supporting curative instruments, subordinations, and releases will be filed in the records of the Clerk of the City/County where the property is located, and will be binding upon the owners, their heirs, assignees, transferees, and any other successors in interest. The agreement will be accompanied by the requisite curative documents, including, but not limited to, any subordinations or releases of interest from third party interest owners, and holders of any liens or encumbrances against the property. The provisions of the nonstructural mitigation agreement will be developed during the design phase. The agreement will obligate the property owner to expend any costs that may be necessary in connection with the nonstructural measure implementation of the structure in order to meet eligibility requirements. The agreement holds USACE and the non-Federal Sponsor harmless for all loss, cost, damage, or expense arising out of any claims, including third party claims that arise directly or indirectly from any project-related activity.

Additionally, the agreement will include provisions that would prohibit the conversion or modification of any part of the structure in a manner that would damage or impair the elevation or floodproofing work performed on the structure by the project, and prohibit the construction of any new structure on the property or modification to the existing structure that is not elevated or floodproofed in accordance with the project flood risk reduction objectives and requirements. The agreement will include either restrictive covenants or a permanent easement estate, both of which will run with the land in perpetuity. Among other rights, the agreement will include the right for the non-Federal Sponsor and USACE to inspect the property during implementation.

For elevated structures, the agreement will include provisions that would prohibit both the conversion of any part of the structure located below the lowest habitable finished floor for purposes of human habitation, the alteration of the structure in any way that would impede the movement of flood waters under the structure and would prohibit the construction of any new habitable structures on the property that do not meet the DFE requirements of the project and local floodplain regulations.

9 COMMENCEMENT AND IMPLEMENTATION PROCUREMENT

Following the completion of preliminary requirements for individual structures including receipt of proof of recordation of the required documentation, the signed mitigation agreement, HTRW assessment and mitigation, and structural assessment, the implementation of the nonstructural mitigation measure on the structure will commence. Structure owners, having completed the

application process and meeting eligibility requirements, would work with individual contractors to perform the mitigation activities as defined in the mitigation agreement. The structure owner's contractor will be responsible for all work associated with implementation of the agreed upon nonstructural measure, from approval of the plans and specifications for each structure to final inspection. USACE makes no warranties or guarantees in connection with the contractors or with the contractors' ability to satisfactorily perform the required mitigation activities; and that the structure owner is responsible to arrange for their contractors' satisfactory completion of all assigned activities.

10 NFS LED CONTRACTING

The authority in Section 204 of WRDA 1986, as amended ("Section 204") allows the NFS to carry out water resource projects and be reimbursed by the USACE for the Federal share of the Project costs, when Federal funds are made available.

Section 204 allows for reimbursement upon completion of a project, separable element, or identified discrete segments of a project defined as a physical portion of a project that the NFS can operate and maintain, independently and without creating a hazard, in advance of final completion of the project or separable element.

Prior to initiating construction of project, separable element, or discrete segment thereof, the NFS will provide the design work plans for such construction, which shall include identification of any discrete segment(s), and proposed real property interests for acquisition, designs and specifications, and arrangements for carrying out that work under a contract, for review and approval by the USACE Louisville District Commander to determine that the design work plans are technically feasible, environmentally acceptable and in compliance with applicable laws and regulations, including Section 204. Any proposed changes to the approved design work must also be reviewed and approved by the Louisville District Commander in advance of construction of the changed plans. Upon approval by the Louisville District Commander, only discrete segments directly affected by the proposed changes shall be subject to being placed on design or construction hold pending the design change approval by the Government. The Government shall strive to complete reviews in a timely manner, recognizing that time is of the essence in executing the Project.

The NFS will submit invoices and supporting documentation to the Louisville District Commander, requesting reimbursement for the Federal share of each completed discrete segment, as identified, and approved in the design work plans. The Louisville District Commander will review the requests to determine whether the costs incurred are reasonable, allowable, and allocable to the Project and that the discrete segment was completed in compliance with all applicable laws and regulations. Upon favorable review, the Louisville District Commander will certify that the discrete segment was constructed in accordance with all applicable permits and approvals and Section 204.

Subject to available funding appropriated for this project, upon certification of reimbursement, payments will be released to the NFS. In the event Federal funding has not been appropriated in sufficient quantity, the certified reimbursements will be reserved for such a time that appropriations are made available.

The FWEEP, recreation features, and floodway acquisitions would be one separable element. The essential structures would be one separable element, and the historic structures would be one separable element. A discrete segment would be an individual structure. Separable elements two and three will be considered complete when all eligible structures are completed, or the owners have opted to not participate in the program.

Upon execution of the mitigation agreement, the property-owner would select the design and construction contractor, the NFS would pay for eligible costs and upon availability of Federal funds the Louisville District Commander would reimburse funds for completed discrete segments once proper documentation is provided. Five percent of each discrete segment will be retained until the separable element is complete.

The Section 204 agreement approval level is the Assistant Secretary of the Army (Civil Works) (ASA(CW)). The ASA approves all implementation plans along with any conditions the Secretary deems appropriate pursuant to Subsection (b)(1)(B), provides necessary delegations consistent with a plan for the Louisville District Commander to make the necessary approvals, determinations, and certification provided in Subsection 204(d).

11 NOTICE OF CONSTRUCTION COMPLETE

After the nonstructural mitigation agreement and associated curative documents are recorded in the public records of the Clerk of the City/County in which the property is located, the nonstructural mitigation work will commence. Upon completion of the nonstructural measure implementation, an inspection will be performed by USACE to ensure all mitigation activities meet the requirements of the design and specifications, utilities and mechanical equipment were appropriately permitted. Upon final approval by the USACE Louisville District Engineer, or a designee, a notice of construction completion will be issued to the non-Federal Sponsor, and the individual nonstructural implementation project will be closed out as complete. It is the property owner's responsibility to submit the Elevation Certificate or Floodproofing Certificate to their representative insurance agent for any adjustments in flood insurance ratings.

12 OPERATION, MAINTENANCE, REPAIR, REHABILITATION, AND REPLACEMENT (OMRR&R)

Residential and non-residential operation and maintenance costs are the responsibility of the owner/occupant and are expected to be conducted on an annual basis to ensure the project is compliant with all floodplain management regulations. The owner of the structure will be responsible for the minimal costs of maintaining, repairing, rehabilitating, and replacing of all nonstructural mitigation measures that were utilized for the subject property.

An OMRR&R Manual will be developed and provided to the non-Federal Sponsor after project implementation. At the time of the issuance of a Notice of Construction Complete memo, the non-Federal Sponsor's obligations for operation and maintenance for the subject structure or lands commences. The non-Federal Sponsor will be responsible for maintaining all properties (mowing, trimming, debris removal, etc.) for all locations where acquisition or relocation occurred.

The non-Federal Sponsor is responsible for the enforcement of the requirements of the OMRR&R Manual, and the provisions of all nonstructural mitigation agreements. The non-Federal Sponsor shall conduct periodic inspections at the intervals specified in the OMRR&R Manual to ensure that the owners, their heirs, and assignees, are in compliance with the terms and conditions of the executed agreements and shall provide written certification to USACE that the structures and lands have been inspected and that no violations have been found. With regards to elevated residential structures, the periodic inspections will determine that no part of the structure located below the DFE has been converted to habitable living area, or otherwise altered in any manner which would prevent the inundation by flood waters beneath the structure.

These include:

- The area below the DFE is being used solely for access to the structure and not for human habitation.
- Mechanical, electrical, or plumbing devices are not installed below the DFE.
- The property is in compliance with all applicable floodplain ordinances and regulations.