Three Forks of Beargrass Creek Ecosystem Restoration
Appendix I
Preliminary Monitoring and Adaptive Management Plan

US Army Corps
of Engineers
Louisville District

Three Forks of Beargrass Creek Ecosystem Restoration

Preliminary Monitoring & Adaptive Management Plan

June 2021

Page left blank intentionally

Contents

Contents

1.0 Introduction 6
1.1 Purpose 6
1.2 Statutory Basis for Monitoring and Adaptive Management 7

2.0 Decision Making Process 7
2.1 Decision Criteria 8
2.2 Sources of Uncertainty 9
2.3 Use of Monitoring Results and Analysis 9

3.0 Monitoring **9**
3.1 Monitoring Plan 10
3.2 Monitoring Period 10
3.3 Reference Site 11
3.4 Performance Standards 11
3.4.1 Hydrologic Regime 12
3.4.2 Vegetation Monitoring 12
3.4.3 Aquatic Habitat 13
3.4.4 Vegetative Monitoring 14
3.4.5 Cover of Native Plants 14
3.4.6 Planting Survival 14
3.4.7 Fish ..... **Error! Bookmark not defined.**
3.5 Use of Monitoring Results and Analysis 14
3.7 Photo-Documentation 16
3.8 Assessment Phase 16
3.9 Database Management 16
3.10 Annual Reports 17

4.0 Objectives and Performance Measures 17
4.1 Monitoring Design and Rationale 17

5.0 Vegetative Cover and Structure Triggers 18

6.0 Potential Adaptive Management Measures 18

7.0 Conclusion of Monitoring 19

8.0 Costs for Monitoring and Adaptive Management Programs 20
8.1 Total Costs for Implementation of Monitoring and Adaptive Management Program 20

9.0 References 20

List of Tables

Table 1. Preliminary Success Criteria, Standards for Success, and general monitoring schedule. 15

1.0 Introduction

1.1 Purpose

This document outlines the feasibility level Monitoring and Adaptive Management Plan (MAMP) for the Three Forks of Beargrass Creek Ecosystem Restoration Feasibility Study, Jefferson County, Kentucky. The U.S. Army Corps of Engineers (USACE) in partnership with the Louisville and Jefferson County Metropolitan Sewer District (MSD) has developed feasibility level plans to restore riparian and aquatic habitat and connectivity at 12 locations within the Beargrass Creek watershed.

This MAMP reflects a level of detail consistent with the feasibility study phase. The expected timelines for achieving successful establishment of self-sustaining restored habitat were used to develop an estimation of the monitoring and adaptive management program costs and duration for the Study. This plan identifies and describes the monitoring and adaptive management activities proposed and estimates their cost and duration.

The general purpose of the MAMP is to provide a systematic approach for improving resource management outcomes and a structured process for recommending decisions, with an emphasis on uncertainty about resources response to management actions and the value of reducing that uncertainty to improve management.

More specifically, the MAMP will identify:

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

This plan will be reviewed and revised by the USACE and Non-Federal Sponsor(s) as needed during the Preconstruction, Engineering, and Design (PED) phase as specific design details are made available.

1.2 Statutory Basis for Monitoring and Adaptive Management

Section 2039 of Water Resources Development Act (WRDA) 2007 directs the Secretary of the Army to ensure that, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. Section 2039 of WRDA 2007 requires that the monitoring plan include a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring, and specifies that monitoring will be performed until restoration success is achieved. The USACE' implementation guidance for Section 2039, in the form of a memo dated 31 August 2009, also requires that an adaptive management plan (i.e., contingency plan) be developed for all ecosystem restoration projects. Section 1161 of WRDA 2016 amends Section 2039 of WRDA 2007, to specify information required to be included in monitoring plans for ecosystem restoration projects, and to direct when nonfederal operation and maintenance responsibilities of these projects may cease. The USACE' implementation guidance for Section 1161, in the form of a memo dated 19 October 2017, also requires specific information to be included in the monitoring plan and extends the cost-shared monitoring to a period of ten years.

This MAMP includes elements required by the WRDA 2016 implementation guidance, including:

a. Types and number of restoration activities to be carried out;
b. Physical actions to be undertaken to achieve project objectives;
c. Functions and values that will result from the restoration plan;
d. Monitoring activities to be carried out;
e. Criteria for ecosystem restoration success;
f. Estimated cost and duration of the monitoring; and
g. A contingency plan for taking corrective actions in cases in which the monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.

This plan will be reviewed and revised as needed during the PED phase as specific design details are identified. A full description of the proposed restoration activities, including the physical activities that would be carried out and the resulting functions and values are detailed in the IFR to which this plan is
appended.

2.0 Decision Making Process

This MAMP describes a monitoring plan and identifies triggers upon which an adaptive management action may be implemented. The USACE would be responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision-making process. If the USACE determines that adaptive management actions are needed, it will consult with the Adaptive Management Team (AMT) on those actions. The AMT will be made up of technical experts from the USACE and the Non-Federal Sponsor(s). The AMT shall review the monitoring results and advise on and recommend actions that are consistent with the Project goals and reflect the current and future needs of the habitat within the Study area. The USACE shall have final determination

on all adaptive management actions recommended. The USACE will also be responsible for Project documentation, reporting, and external communication.

This MAMP provides the framework and guidance for the AMT to review and assess monitoring results and consider and recommend adaptive management actions when habitat success criteria are not met. The AMT would be comprised of the USACE and the Non-Federal sponsor(s). The AMT will be officially established after the Project has been authorized and appropriations have been received to begin the PED phase.

The AMT will meet at a minimum of once per year, as scheduled by the USACE during the monitoring period, to review the results of monitoring and assess whether Project objectives are being met. If objectives are not being met, the AMT may recommend that adaptive management actions be taken in response to monitoring results as compared to decision-making triggers. The AMT may also consider other related projects in the Beargrass Creek watershed in determining the appropriate adaptive management actions. Recommendations for adaptive management would be based on:

- Monitoring data from previous years;
- Consideration of current habitat conditions; and
- Consideration of current and potential threats to habitat success.

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. The information generated by the monitoring plan would be used by the USACE and the Non-Federal Sponsor(s) to guide decisions on adaptive management that may be needed to ensure that the ecosystem restoration Project meets the success criteria. Final decisions on implementation of adaptive management actions are made by the USACE. However, any decision criteria or actions outside of those proposed in this MAMP would require HQUSACE approval (WRDA 2007 Section 2039 guidance).

2.1 Decision Criteria

Decision criteria, also referred to as adaptive management triggers, are used to determine if and when adaptive management opportunities should be implemented. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions. Initial decision criteria are identified below, based on Project objectives and performance measures. More specific decision criteria, based on other parameters such as hydrology, geomorphology, and vegetation dynamics will be developed during PED phase of the project. If assessments show that any or all of these triggers are not met, investigations may be required to determine the cause of failure and adaptive management actions may be recommended.

2.2 Sources of Uncertainty

Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent with any large-scale ecosystem restoration project. Uncertainties associated with restoration of the habitats within the Project include:

- Project engineering and design fully address project objectives;
- Future operation and maintenance regime maintain project objectives;
- Ability of hydrologic models to predict project impacts/benefits;
- Future availability of water for restored habitat due to extreme drought or other climate change issues; and
- Other factors which are not completely within the USACE' or the Non-Federal Sponsor(s) control or ability to predict, such as high flow events that may occur before the restored habitat has fully established, vandalism, or upstream watershed changes that may affect the project area.

Uncertainties may remain concerning specific Project features, monitoring elements, and adaptive management opportunities.

2.3 Use of Monitoring Results and Analysis

Results of the monitoring will be assessed in comparison to project objectives and decision-making triggers to evaluate whether the Project is functioning as planned and whether adaptive management actions are needed to achieve Project objectives. The results of the monitoring will be provided to the AMT members who will evaluate and compare data to Project objectives and decision-making triggers. The AMT will use the monitoring results to assess habitat responses to management actions, evaluate overall Project performance, and make recommendations for adaptive management actions as appropriate. If monitoring results, as compared to desired outcomes and decision-making triggers show that Project objectives are not being met, the AMT will evaluate causes of failure and recommend adaptive management actions to remedy the underlying problems.

As data is gathered through monitoring, more information will also be available to address uncertainties and fill information gaps. Uncertainties such as effective operational regimes, benefits generated by restored features, and accuracy of hydrologic models can be evaluated to inform adaptive management actions and future restoration needs.

3.0 Monitoring

An effective monitoring program is required to determine if the Project outcomes are consistent with original Project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued Project monitoring and corresponding Project management. A well-conceived monitoring program is the

central component of the Project adaptive management program as it identifies the information to assess whether the Project is functioning as planned.

Monitoring must be closely integrated with the adaptive management components as monitoring data feeds directly into the evaluation of adaptive management needs. Objectives must be considered to determine appropriate indicators to monitor. In order to be effective, monitoring must be able to distinguish between ecosystem responses that result from project implementation (i.e., management actions) and natural ecosystem variability, including the impacts of climate change. Achieving Project objectives requires monitoring that focuses on target habitats and the hydrologic and geomorphic processes that support them.

A qualified USACE restoration biologist will coordinate the restoration monitoring. This monitoring program is intended to provide continued oversight of the restoration areas after installation is completed. The restoration areas will be monitored through a combination of vegetative, hydrologic/hydraulic, and geomorphological means. Vegetative monitoring provides proactive information related to vegetation development occurring within restored riparian and wetland areas. Hydrologic/hydraulic and geomorphological monitoring provides proactive information related to the streams response to the restoration. This monitoring will accomplish two objectives: (1) provide feedback for the maintenance contractor and (2) provide information to evaluate progress so that recommendations can be made to help meet performance standards.

3.1 Monitoring Plan

According to the CECW-PB Memo dated 19 October 2017: “Monitoring includes the systematic collection and analysis of data that provides information necessary to determine if the project is meeting its performance standards, and to determine when ecological success has been achieved or whether adaptive management measures are necessary to ensure that the project will attain project benefits.

Development of a monitoring plan was be initiated during the plan formulation process for an ecosystem restoration project, or component of a project, and should focus on key indicators of project performance.” The following discussion outlines the key components of the monitoring plan that will support the project MAMP.

The plan identifies performance measures along with desired outcomes (i.e. targets) in relation to specific project goals and objectives. A performance measure includes specific feature(s) to be monitored to determine project performance.

Overall, monitoring results will be used to evaluate the progress of habitat restoration toward meeting project objectives and to inform the need for adaptive management actions to ensure success is achieved.

3.2 Monitoring Period

This monitoring plan includes the minimum monitoring actions to evaluate success and to determine adaptive management needs. Assuming that multiple construction contracts may be required to implement all of the restoration elements associated with the recommended plan,

monitoring and adaptive management would be initiated at the completion of each phase of construction if determined to be practicable, dependent on implementation of additional phases.

Upon completion of construction of the Project, cost-shared monitoring for ecological success and adaptive management would be initiated and continue for a minimum of five (5) years or until ecological success is achieved as defined by the Project's established success criteria, but for no longer than ten years. Concurrent monitoring of one or more nearby reference sites with similar conditions to the desired restored habitat is recommended to differentiate changes at the restoration site that are attributable to the restoration activity versus normal environmental variability affecting the region, including climate change. Reference sites will be identified prior to implementation of the Project and detailed in this Plan.

Although WRDA 2007 allows for up to ten years of cost-shared monitoring when necessary, this plan anticipates that only five (5) years of monitoring and adaptive management would be required for habitat to mature sufficiently to be self-sustaining and to meet ecological success criteria for Project objectives. Once the USACE determines that ecological success has been fully achieved, even if this occurs in less than five (5) years, no further monitoring would be performed. For each phase, if ecological success criteria for project objectives have not been met within the first five (5) years, then cost-shared monitoring and adaptive management would continue within those areas until ecological success criteria are met or for a maximum of five (5) additional years, whichever is less. If success cannot be determined within the ten-year period of cost-shared monitoring allowed by law, any additional monitoring and management will be a non-Federal responsibility. Cost-shared monitoring shall not continue beyond ten years.

Monitoring will be accomplished by evaluating the performance criteria determined for vegetation and geomorphic conditions by an experienced biologist and stream restoration practitioner over a five-year period. This will include a qualitative and quantitative evaluation of success in relation to the performance criteria. Reports documenting the progress will be submitted on an annual basis.

3.3 Reference Site

Riverine vegetation cover types within undisturbed portions of the project area surrounding restoration areas will provide the reference vegetation community data for the adjacent areas being restored. Reference sites will be free of invasive exotic perennial weeds and possess the habitat qualities and vegetation alliances. These areas will be dominated by a variety of tree, shrub, and herbaceous species that are included in the restoration planting palette. The reference sites will be identified based on proximity to the restoration areas, similar hydrologic regime, and similar topographic position within the similar creek. Each reference site will be mapped with a Global Positioning System (GPS) to ensure accurate measurements are taken each monitoring visit.

Riverine and riparian reference sites for the restoration areas will be chosen once implementation of the restoration program phase has begun.

3.4 Performance Standards

Performance standards will be used to monitor site development and to decide when to implement remedial measures to correct any deficiencies in progress. These standards are based on previous experience and agency recommendations. Performance criteria will be assessed by the Project restoration biologist based on comparing the reference site to the restoration area. Performance standards are characteristic of expected growth within the Beargrass Creek Watershed and will be utilized for the on-site restoration areas.

Restoration will be considered successful, when the restoration areas are well established, and invasive plant species have been eradicated or controlled. The restoration areas will be monitored both qualitatively and quantitatively for at least five years following implementation. Quantitative monitoring methods will be chosen once implementation of the restoration program phase has begun and detailed in this Plan. The monitoring data will evaluate the functions and values of restored habitat, vegetative cover, species diversity, and density relative to reference areas within the surrounding native habitat.

By satisfying the performance criteria, the restoration areas indicate that they are establishing themselves as self-sustaining habitat that is equivalent in form, function, and value to the natural, undisturbed reference sites. Moreover, restoration sites are expected to sustain themselves for a minimum of two years in the absence of significant maintenance measures (i.e., irrigation) prior to completion of the five-year monitoring period. It is expected that once the restoration areas are considered successful, they will exhibit the riverine ecosystem functions and values. The restored channel would provide unimpeded passage to upstream habitats, restore in-stream habitat within the area, restore natural fluvial geomorphic processes, and restore riparian vegetation to be made up of a diverse suite of native species with little coverage of invasive plants. Monitoring procedures that would provide information necessary to evaluate the Project objectives include:

3.4.1 Hydrologic Regime

The target hydrologic regime for the Project area will be supported by groundwater and the seasonal flooding within the restored floodplain of the creek. The surface topography would reflect the restored invert of the restored floodplain with terraced benches delineating the levels of estimated storm event flooding out of the low flow channel of the creek. Riffles and pools would be established to stabilize creek slope as well as provide habitat for aquatic species. Refugia and other off-line pond features would be created for lateral movement of amphibians and megafauna. The restored vegetative alliances would rely on existing seasonal fluctuations of the water table, surface flows, and supplemental water for plantings during the establishment period.

3.4.2 Vegetation Monitoring

Vegetation sampling by USACE would occur annually for the duration of the monitoring period. Sampling would occur during spring months at the peak of growing season and would consist of permanent field monitoring plots along one or more transects either perpendicular to the stream centerline or parallel to the floodplain slope and hydraulic gradient. Plots would be located randomly within each reach/feature, and the distance between plots and along transects would be dependent on the project site area and variability. Monitoring would also measure percent cover of native and non-native plant species, structural diversity, and percent cover over water.

Photograph stations are also important for documenting vegetation conditions. All plots and photograph stations would be documented via GPS coordinates to be duplicated in each year of surveying for consistency.

Vegetation monitoring includes quantitative measurements of the growth and establishment of plants, and assessment of the invasion non-native species. Vegetation monitoring will be performed to measure development of vegetation at the restoration sites, and to document that the area achieves the success criteria as defined by the performance standards (Table 1). Vegetation monitoring will begin the second spring following implementation of restoration activities in order to allow time for the new vegetation within the restoration areas to become established. Annual monitoring will be conducted in late spring in Years two (2) through five (5).

Some plant species take significantly longer than five years to mature, therefore, full maturation plants within the restoration areas will not be achieved by the end of the monitoring period. However, the monitoring data will be analyzed for trends and changes in cover of the most common tree, shrub, and herbaceous species. Year-to-year changes in vegetative cover will be compared to determine whether the restoration areas are approaching characteristics of mature vegetation. The performance standards described below for achieving percent cover will be based on a relative percentage of reference site values (Table 1). For example, if a reference community had 60 percent total native cover, after five years of monitoring the restoration area must reach 75 percent of that, or 45 percent total native cover. Survivorship of plantings and cover for non-native invasive species will be assessed as absolute values.

3.4.3 Aquatic Habitat

To assess the overall creek health, habitat quality would be assessed annually by USACE at permanent monitoring stations using the Qualitative Habitat Evaluation Index (QHEILS) methodology (McKay, In Review). This assessment is meant to assess the stream based on the physical characteristics of the site. Some of the physical factors that are assessed include the stream gradient, substrate composition, organic material in the stream, and vegetative cover above the stream.

Creek characteristics would also be recorded annually by surveying creek cross-sections at permanent monitoring stations. Methods involve placing a transect line perpendicular to flow at up to four representative locations of a site at least 300 feet apart. Substrate composition (silt, sand, gravel, cobble, boulder, sandbars, and emergent vegetation), channel width, channel depth, and mid-column current velocity will be measured at three (3) foot intervals along each transect line.

Representative streambed profile surveys would occur at Year 1 and Year 5 and may be generated using LiDAR or a ground survey crew. Hydrology changes would be assessed seasonally each monitoring year and following storm events. Mid-column current velocities would be measured at three (3) foot intervals along each in-stream cross-section transect line. Hydroperiod metrics (depth, duration, and frequency of flooding) would be obtained from documented elevations and recorded water levels.

3.4.4 Vegetative Monitoring

Evaluation of plant health and identifying and correcting problem areas is necessary for ensuring successful restoration establishment. In Year 1, qualitative monitoring will be conducted monthly, then quarterly for Years 2 through 5 and possibly year 10. The monitor will review the project areas to assess germination, survival, and growth of seeded and planted material, levels of weed competition, erosion, and other detrimental actions. The monitor will record and report findings and make recommendations for remedial actions, if needed, to the restoration contractor after each monitoring event. If site conditions are such that additional remedial actions are required beyond those envisioned in this plan, the monitor will communicate recommendations for remediation. A major component of vegetative monitoring will be to determine the efficacy of weed management/treatment methods. Monitoring for invasive non-native species will consist of site visits to determine the presence and location of invasive species as well as the percent cover and life stage. Monitoring will dictate whether remedial measures are required. Results will objectively determine if the treatment areas approach the goals specified at the beginning of treatment activities.

3.4.5 Cover of Native Plants

Monitoring data will be analyzed separately for cover of the herbaceous understory, shrub midstory, and tree overstory; this will allow specific deficiencies to be corrected. An absolute cover value will be determined based on cumulative vegetative coverage. The values presented for Years 2 through 4 in Table 1 are recommended interim goals to be used as a guide for attaining the success criteria for cover identified for Year 5, all determinations are a relative percentage of the cover measured at the reference site. A determination will be made after year five (5) for further monitoring to year ten (10).

3.4.6 Planting Survival

Quantitative sampling will be carried out during the late spring or early summer to ensure the best representation of species diversity. Sampling locations will be established according to a stratified random sampling design and a map will be provided in the monitoring reports. General observations, such as fitness and health of native plant species recruitment, and signs of drought stress would be noted during the surveys. Potential soil erosion, flood damage, vandalism and intrusion, trampling, and pest problems would be qualitatively identified.

3.5 Use of Monitoring Results and Analysis

Results of the monitoring will be assessed in comparison to project objectives and decision-making triggers to evaluate whether the project is functioning as planned and whether adaptive management actions are needed to achieve project objectives. The results of the monitoring will be provided to the AMT who will evaluate and compare data to project objectives and decision-making triggers. The AMT will use the monitoring results to assess habitat responses to management, evaluate overall project performance, and make recommendations for adaptive management actions as appropriate. If monitoring results, as compared to desired outcomes and decision-making triggers, show that project objectives are not being met, the AMT will evaluate causes of failure and recommend adaptive management actions to remedy the underlying problems.

As data is gathered through monitoring, more information will also be available to address uncertainties and fill information gaps. Uncertainties such as effective operational regimes, urban restoration design needs, benefits generated by restored features, and accuracy of hydrologic models can be evaluated to inform adaptive management actions and future restoration needs.

Table 1. Preliminary Success Criteria, Standards for Success, and general monitoring schedule.

Type/Category	Criteria	Year 1	Year 2	Year 3	Year 4	Year 5
Hydrological	Bankfull Flow Events	Minimum of at least one bankfull event by end of year 2, two cumulative bankfull events by end of year 4, and three by year 5.				
	Flow Regime, OHWM, Bed and Bank	Meet or exceed Flow Regime, OHWM, Bed and Bank	Meet or exceed Flow Regime, OHWM, Bed and Bank	Meet or exceed Flow Regime, OHWM, Bed and Bank	Meet or exceed Flow Regime, OHWM, Bed and Bank	Meet or exceed Flow Regime, OHWM, Bed and Bank
Geomorphological	Vertical Stability – (Degrading) WBHR	WBHR between 0.9 and 1.2 at the surveyed cross-sections	WBHR between 0.9 and 1.2 at the surveyed cross-sections	WBHR between 0.9 and 1.2 at the surveyed cross-sections	WBHR between 0.9 and 1.2 at the surveyed cross-sections	WBHR between 0.9 and 1.2 at the surveyed cross-sections
	Lateral Stability – (Aggrading) W/D		< 20% change from As-Built value	< 15% change from Year 2		< 15% change from year 3
	Vertical Stability – (Aggrading) W/D		< 45% change from As-Built value	< 45% change from As-Built value		< 45% change from As-Built value
	Bank Erosion Hazard Index (BEHI)	Dominant BEHI Moderate	Dominant BEHI Moderate	Dominant BEHI Low	Dominant BEHI Low	Dominant BEHI Low
	Large Woody Debris Index (LWDI)	LWDI ≥ 250	LWDI ≥ 250	LWDI ≥ 250	LWDI ≥ 250	LWDI ≥ 250
	Stable Banks and Channel	No headcuts. Provide pictures from photo stations; plus, document all additional sites of erosion with picture and location info and visually assess site for unstable areas. Unstable areas shall be reported immediately such that possible remediation measures can be considered and initiated. (Supplemented by annual quantitative metrics of BEHI/NBS, LWDI, WBHR)				
	Floodplain Erosion	No connected chute cut off channel with a cross-sectional area greater than 25% of design channel				
In-stream Habitat	QHEIL Scores	TBD	TBD	TBD	TBD	TBD
Vegetation	Species Richness	At least 75% of all species planted/seeded should be alive at the site by year 2 and remain that way through year 5				
	Max Invasive Species Cover	20%	15%	10%	10%	10%
	Total Ground Cover	90%	90%	90%	90%	90%
	Minimum Woody Stems Per Acre (Reforested sites only)	200	200	200	200	200
	Special Status Species	At least 75% of planted Running Buffalo Clover and Giant Cane should be alive at the site by year 2 and remain that way through year 5				

3.6 Monitoring Schedule

The monitoring period will begin during PED to gather baseline biotic and physical data. Monitoring will resume with completion of the restoration work and will last for a minimum of five (5) years or until the restored vegetation has met performance standards. If ecological success criteria for project objectives have not been met within the first five (5) years, then cost-shared monitoring and adaptive management would continue within those areas until ecological success criteria are met or for a maximum of five (5) additional years. A general monitoring schedule is presented in Table 1. All quantitative monitoring assessments will be performed annually, unless otherwise indicated in Table 1. The monitoring program will be coordinated by the Project restoration biologist as outlined below for the first five years. As built (*i.e*., year 0) conditions will be assessed for appropriate criteria as determined by the USACE and the Non-Federal Sponsors.

3.7 Photo-Documentation

The restoration effort will be qualitatively documented using photographic monitoring and general observations. Several permanent viewpoints for photo-documentation will be established in each of the different restoration areas. Photos shall be taken each monitoring period from the same vantage point and in the same direction and shall reflect information discussed in the monitoring report. These photos will be included in each annual report.

3.8 Assessment Phase

The assessment phase of the adaptive management framework describes the process by which the results of the monitoring efforts will be compared to the Project performance measures or objectives of the restoration action. This assessment process will measure the progress of the Project in relation to the stated Project objectives. The results of the Project monitoring program will be assessed annually through the AMT. The AMT will compare monitoring results to decision- making triggers to evaluate Project effectiveness and consider if adaptive management actions are needed. The assessments will indicate if the habitat responses to management actions are undesirable (e.g., are moving away from restoration goals) or if the responses have met the success criteria for the Project. Assessments will also inform the AMT if other factors are influencing the response that may warrant further research.

3.9 Database Management

Individuals with responsibility for data management activities (data managers) will be identified from the USACE who will develop the data management plan in collaboration with the AMT. The data management plan will describe how and where data will be archived, data standards, data upload process and format, quality assurance and quality control procedures, metadata standards, and public data release. The USACE will be responsible for storage of all data, however, a web-based location may be used for outside agency use if deemed appropriate. Data analysis and reporting will be the responsibility of the USACE that will provide reports for the AMT to facilitate evaluation of adaptive management needs.

3.10 Annual Reports

The USACE will be responsible for submittal of the Annual Report. The USACE will produce annual reports that measure progress towards meeting Project objectives as characterized by the performance measures. Reports filed at the end of each year will include a summary and analysis of monitoring data, an evaluation of restoration progress relative to performance standards, assessments, and the results of the AMT deliberations. Annual reports will be prepared and distributed to the members of the AMT for a period of five years or less if success criteria are met sooner than 5 years, beginning approximately one year after installation.

These reports will include:

- A list of names, titles, and companies of all persons who prepared the content of the annual report and participated in monitoring activities for that year;
- An analysis of all qualitative and quantitative monitoring data;
- A report of number of acres of invasive non-native vegetation removed, treated, and retreated;
- Copies of monitoring photographs;
- Maps identifying monitoring areas, planting zones, etc., as appropriate; and
- Beginning in Year 3, if the site has not met its performance standards at the end of the annual maintenance and monitoring period, the Project restoration biologist will meet with the AMT to recommend remedial measures. Each annual report will contain a section that addresses remedial actions that should be taken in order to meet the Project goals. If followed, these recommended contingency measures will ensure that the restoration project is successful.

4.0 Objectives and Performance Measures

The specific restoration objectives of the Three Forks of Beargrass Creek Ecosystem Restoration Project include:

Objective 1: Reestablish quality and connectivity of riverine habitats

Objective 2: Reestablish quality and connectivity of riparian and wetland habitats

4.1 Monitoring Design and Rationale

Permanent monitoring stations would be established for monitoring of geomorphology and in-channel habitat elements including:

- large woody debris;
- stream gradient;
- channel form;
- dimensions and dynamics;
- gravel bars or riffle-pool-run complexes and distributions; and
- substrate composition and distribution.

Monitoring would be performed twice annually (wet season and dry season) post-construction for five (5) years or less if success criteria are met sooner than five years.

representative profile surveys and Wolman pebble counts would be utilized to evaluate widespread geomorphic changes, such as sedimentation and degradation would be performed at the end of Year 1 after construction and at the end of Year 5 after construction. Scour and erosion would also be assessed as part of Geotechnical O&M procedures. Water quality, flow, and hydroperiod will be assessed seasonally for five years post construction.

Monitoring of these features would determine the successful establishment of gravel and cobble substrates, structural diversity and refugia, in-channel geomorphic diversity, and perennial flowing water. Changes to geomorphology would affect the vegetation component of target habitats. If vegetative cover and structure criteria are not being met, data from monitoring of geomorphology and hydrology may provide additional information on the underlying causes of failure.

Permanent vegetation monitoring stations would be established for assessing Project area habitat. These stations would be sampled annually for five (5) years post-construction or less if success criteria are met sooner than 5 years.

Monitoring of vegetation, including structural diversity, shade over water that supports cooler water temperatures, and habitat function would indicate if target habitats and the hydrology that supports them have been successfully restored.

5.0 Vegetative Cover and Structure Triggers

Trigger: Suitable structural diversity is not achieved within 5 years whereby cover vegetation does not reach minimum of 90%.

Trigger: Monitoring of geomorphology and in-channel habitat elements are providing habitat or if uniform channel form (i.e., lack of sinuosity and riffle-pool-run complexes, uniform depth) has established, as compared to the channel form of reference sites.

Desirable geomorphic conditions could be evaluated using reference sites to determine quantitative thresholds for channel form and substrates.

In-channel habitat may not achieve the target composition due to improper geomorphic conditions caused by natural events or design. Flood events may wash gravel and cobble substrates out of the study area. Adaptive management actions may be implemented to address problematic conditions and achieve project objectives.

Riverine habitats may not achieve the target percent cover or structural conditions due to unfavorable geomorphic conditions. Such conditions may include increased distance to groundwater, sedimentation, new channel incision, or sediment scour. These conditions may be created naturally, such as during storm events, or may be the consequence of design. Lack of water due to drought may affect the establishment and persistence of vegetation, and subsequently the percent cover. Plantings may fail due to predation or trampling.

Invasive infestation may occur due to upstream inputs of seed/source material. It is expected that invasive species will be adequately controlled through O&M procedures. However, if invasive infestation control is found to be ineffective, the USACE may recommend adjustments to invasive control methods utilized under O&M. Adaptive management actions may be implemented to address problematic conditions in order to achieve Project objectives.

6.0 Potential Adaptive Management Measures

The results of monitoring would be used by the AMT to evaluate project status and adaptive management needs. Some potential adaptive management actions for this Project are described below. Prior to implementing adaptive management measures, the USACE and the Non-Federal Sponsor(s) shall assess whether supplemental environmental analysis is required.

Irrigation/Supplemental Water: Irrigation and/or supplemental water may be needed if triggers for vegetative cover are met. Assessment of monitoring results may show that drought condition are causing poor establishment or die off of planted vegetation. Adaptive management actions would include supplemental water to support achievement of percent cover criteria and successful restoration of riverine habitats. This is expected to only be necessary during the initial establishment of plant communities and would only be implemented if a trigger is met during year 1 or if significant replanting actions are required.

Replanting: Additional planting of habitat may be required if triggers for vegetative cover are met. Monitoring results would be reviewed to identify source of underlying cause of inadequate cover, which may require that additional adaptive management actions be implemented. Monitoring results may indicate that drought conditions are causing poor establishment or die off of planted vegetation. Trampling or other factors may also trigger action.

Plant Protection: Plant protection may be needed if triggers for vegetative cover are met. Monitoring results may show that plantings are failing due to predation or trampling from recreational use, homeless encampments, or nuisance species. Adaptive management actions would include measures such as plant cages or protective fencing that could be installed to protect plantings.

Invasive Species Control: It is expected that invasive species will be adequately controlled through O&M procedures. However, if monitoring results show that triggers for invasive species are met, the USACE may recommend adjustments to invasive control methods under O&M.

Erosion Control: Erosion control may be needed if triggers for vegetative cover are met. Monitoring results may show that vegetative cover is inadequate due to stream bank or terraced slope erosion. Adaptive management actions would include erosion control measures such as installation of straw wattles or erosion mats. Additional information may be required to determine the cause of erosion and additional adaptive management measures may be required to be implemented, such as re-contouring or additional stream bank protection.

Re-grading: Re-grading of the creek invert may be needed if triggers for vegetative cover habitat are met. Monitoring results may determine that sedimentation, creek scour, or new channel incision or erosion have impacted the successful establishment of target riverine habitats or has prevented establishment of in-channel diversity. Adaptive management actions would include re-grading to support the appropriate geomorphic conditions for successful establishment of habitat.

In-stream Structure or Habitat Feature: Adjustments to installed structures or features may be needed if triggers for geomorphology are met. Monitoring results may show that geomorphic ratios associated with stable reaches are not within the desired tolerance. Adaptive management actions may include structure adjustments, additional structures, etc. to support successful criteria.

7.0 Conclusion of Monitoring

Ecological success of a project feature will be confirmed when desired outcomes have been achieved, measured by meeting or exceeding the 5-year achievement thresholds identified in the triggers in Section 6.1 (e.g., for vegetative cover, 90 percent cover is achieved; for non-native cover, less than 10 percent is achieved; for aquatic habitat, channel and substrate diversity is

achieved). Once ecological success has been documented by the District Engineer in consultation with the Federal and State resources agencies, and a determination has been made by the Division Commander that ecological success has been achieved, no further monitoring will be required. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results.

8.0 Costs for Monitoring and Adaptive Management Programs

The costs associated with implementing the MAMP were estimated based on current available data, methods proposed, and comparable projects. The potential adaptive management actions as described and potential expected frequency of need were used as a basis for estimating the MAMP cost. Because uncertainties remain as to detailed designs and adaptive management needs and opportunities, the estimated costs will be refined in PED during the development of the detailed monitoring and adaptive management plans for each project phase/feature.

8.1 Total Costs for Implementation of Monitoring and Adaptive Management Program

Cost calculations for monitoring are displayed as a five-year total. If ecological success is determined earlier, the monitoring program will cease, and costs will decrease accordingly.

Costs for the adaptive management program were based on estimated level of effort and potential frequency of need and include participation in the AMT and reporting. These costs do not include costs incurred by any of the other agencies for its participation in the AMT. The monitoring and adaptive management costs are shown in the certified total project cost summary in Appendix C.

The feasibility-level cost estimate for Adaptive Management and Monitoring at the FY22 price level (Project First Cost) is $1,389,000. The feasibility-level cost estimate for the Recommended Plan (Plan 10240) at the FY22 price level (Project First Cost) is $121,135,000 as discussed in Section 7.4 of the IFR.

9.0 References

McKay S.K., Athanasakes G., Taylor S., Miller W., Wagoner E., and Mattingly L. In review. *Qualitative Habitat Evaluation Index for Louisville Streams (QHEILS)*. ERDC TN-EMRRP. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.