Draft Appendix C4 – Monitoring and Adaptive Management Plan

River Road Aquatic Ecosystem Restoration
Feasibility Study

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US Army Corps
of Engineers®
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1 Introduction

This Draft Monitoring and Adaptive Management Plan (MAMP) outlines feasibility level monitoring and adaptive management strategy for the River Road Aquatic Ecosystem Restoration (ER) Feasibility Study (River Road). This plan identifies and describes monitoring and adaptive management activities proposed for the project and estimates costs and duration. As more design detail is provided during the Preconstruction, Engineering, and Design (PED) phase of the project, a more detailed MAMP will be developed. Any changes to the approved MAMP will be coordinated with U.S. Army Corps of Engineers Headquarters as required by policy guidance (Section 1161, Water Resources Development Act [WRDA] 2016).

The River Road MAMP will describe and justify whether adaptive management is needed in relation to alternatives identified in the Feasibility Study. The plan will outline when the monitored environmental conditions (triggers) would require adaptive management measures to ensure the successful establishment of project restoration features.

The primary intent of the MAMP is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. Management actions described in this document permit estimation of the adaptive management program costs and duration for the River Road Aquatic Ecosystem Restoration Project. This plan is based on currently available data and information developed during plan formulation as part of the Feasibility Study.

1.1 Authority and Purpose

Ecosystem restoration feasibility studies are required to include plans for monitoring the success of the restoration (Section 2039, WRDA 2007). "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits."

Section 2039 of WRDA 2007, as amended, directs the Secretary 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. The MAMP shall include a description of:

- Types and number of restoration activities to be implemented with the Recommended Plan;
- Physical actions to be undertaken to achieve project objectives;
- Desired outcome resulting from the Recommended Plan;
- Monitoring design and rationale;
- Decision criteria for ecosystem restoration success, including adaptive management triggers;
- Estimated cost and duration of the monitoring; and
- Adaptive management measures 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.

In accordance with WRDA of 2007 Section 2036, Section 2039 and subsequent implementation guidance (CECW-PB Memorandum dated August 31, 2009), MAMP are required for both National Ecosystem Restoration (NER) project components and for any Mitigation Plan required for the National Economic Development (NED) component.

This MAMP includes all elements required by the WRDA 2007 implementation guidance for Section 2039.

1.2 Project Goals and Objectives

During the initial stages of project development, the Project Delivery Team (PDT) developed restoration goals and objectives to be achieved by the restoration measures. The goal of the River Road project is to restore structure and function of the River Road segment of the San Antonio River's aquatic and riparian habitat within the study area. The resulting objectives focus on the importance of riverine and riparian habitat in the study area for migratory birds and aquatic wildlife. Additional information regarding the Tentatively Selected Plan (TSP) for the River Road Aquatic Ecosystem Restoration Feasibility Study can be found in the Integrated Feasibility Report and Environmental Assessment (IFR/EA).

The PDT performed thorough plan formulation to identify potential management measures and restoration actions that address the project objective. The PDT subsequently identified a TSP. The TSP included the following nonstructural ecosystem restoration measures:

- Restore and improve 3.1 acres of riverine habitat in the San Antonio River through non-native invasive species management, native aquatic species plantings, and natural establishment of native and other acceptable (non-native but non-problematic) species.
- Restore and improve 13 acres of non-native grassland habitat and 9 acres of existing riparian habitat within the study area through non-native invasive species management, native riparian species plantings, and natural establishment of native and other acceptable species.

A list of potential native species for the restoration of riverine and riparian habitat are included in Attachment A.

1.3 Introduction to Monitoring and Adaptive Management

Monitoring and adaptive management provide directed iterative approaches to achieve restoration project goals and objectives by focusing on strategies promoting flexible decision making that can be adjusted in the face of uncertainties as outcomes from restoration management actions and other events become better understood. Initiating a formal MAMP early in the study process enables the study team to prepare for uncertainties and other potential issues that can positively or negatively influence project outcomes during every stage of the planning and project implementation process. Hence, early implementation of monitoring and adaptive management will result in a project that can better succeed under a wide range of uncertain conditions and can be adjusted as necessary. Furthermore, careful monitoring of project outcomes both advances scientific understanding and helps adjust policies and/or operations as part of an iterative learning process.

Adaptive management acknowledges the uncertainty about how ecological systems function and how they may respond to management actions. Nevertheless, adaptive management is not a random trial-and-error process; it is not ad-hoc or simply reactionary. An essential element of adaptive management is the development and execution of a monitoring and assessment program to analyze and understand responses of the system to implementation as restoration progresses. The MAMP was developed and will be used to:

- Allow scientists and managers to collaboratively design plans for managing complex, dynamic, and incompletely understood ecological systems.
- Reduce the ecological and financial impact of inevitable uncertainty over time.
- Implement systematic monitoring of outcomes and impacts.
- Incorporate an iterative approach to decision-making.

- Provide a basis for identifying options for improvements in the design, construction and operation of restoration through adaptive management.
- Ensure interagency collaboration and productive stakeholder participation as they are key elements to success.

1.3.1 Monitoring and Adaptive Management Process

The monitoring and adaptive management program and process is complimentary to the USACE Project Life Cycle (planning, design, construction, and operation and maintenance). The process is not elaborate or duplicative and enhances activities that already take place. The basic process was adapted from a technical note published by the Engineering Research and Development Center (ERDC 2019). Elements of the program include an iterative process involving: planning a program or project; designing the project; building the project; operating and maintaining the project; monitoring and assessing project performance; and continuing, adjusting, or terminating a project if the goals and objectives are not being achieved (Figure 1).

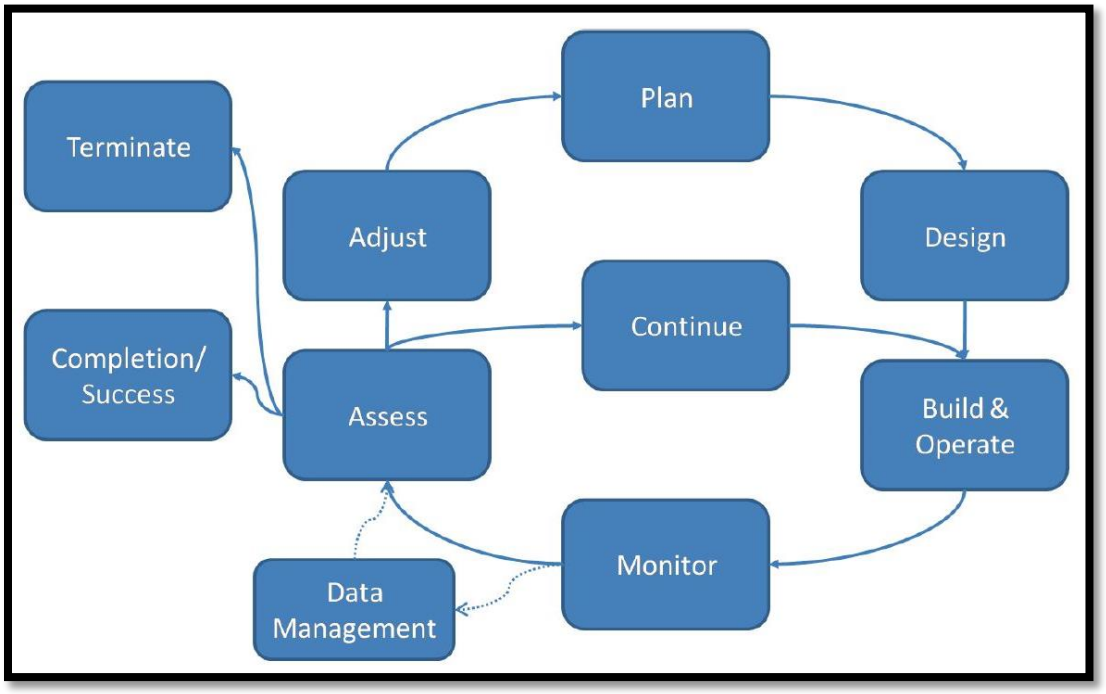

Figure 1. Monitoring and Adaptive Management Process for USACE Civil Works

1.3.2 Adaptive Management Team

As part of the MAMP, an interagency team is set up to implement the process. The MAMP provides the framework and guidance for the Monitoring and Adaptive Management Team (MAMT) to review and assess monitoring results and consider and recommend adaptive management actions when ecological success falls behind expectations and decision criteria are triggered. The MAMT members shall work together to make recommendations relevant to implementing the MAMP. The MAMT is composed of USACE staff, the non-Federal sponsor (NFS), contracted personnel (if needed) and interested resource agencies and/or other stakeholders. Although the USACE has coordinated with the entities that will most likely

comprise the MAMT in development of the IFR/EA, the MAMT will be officially established during Pre-Construction Engineering and Design.

The MAMT will focus on ecological function through related management actions to maintain and provide functional wetland and riparian habitat within the project area. The MAMT shall review the monitoring results and advise on recommend actions that are consistent with the project goals and reflect the current and future needs of the habitat and the species they support within the project area. The USACE shall have final determination on all adaptive management actions recommended.

The USACE is 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 coordinate with the MAMT on implementation of those actions. The USACE is also responsible for project documentation, reporting, and external communication.

The MAMT shall 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 MAMT may recommend that adaptive management actions be taken in response to monitoring results as compared to decision-making triggers.

The MAMT may also consider other related projects in the hydrologic basin in determining appropriate adaptive management actions, and may consult with other recognized experts or stakeholders as appropriate, to achieve project goals.

Recommendations for adaptive management should be based on:

- Monitoring data from previous years,
- Consideration of current habitat conditions,
- Consideration of current and potential threats to habitat establishment success, and
- Past and predicted response by target species and habitats.
- Economic dynamics
- Shifting municipal and government priorities
- Human population behavior
- Unknown unknowns

1.3.2.1 Team Structure

The MAMT shall include representatives from USACE and the NFS responsible for cost-sharing construction and future operations and maintenance.

The USACE may be represented by the Project Biologist(s), as well as the Project Hydrology and Hydraulics (H&H) representative and the Project Geotechnical representative as needed. Other USACE attendees may include the Project Manager, Project Real Estate Specialists, and/or Operations and Maintenance designees, as needed.

For the feasibility study, the NFS is the San Antonio River Authority (SARA). The NFS would ultimately be responsible for all Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities once USACE notifies the NFS of project completion. Prior to final project completion, USACE would transfer responsibility of functional elements of the

project to the NFS as they are completed. The NFS may be represented by its designees which may include Project Managers, Planners, Design Engineers, Environmental Specialists, or other designees.

The MAMT should also include representatives from resource agencies who would serve in an advisory capacity, to assist in evaluation of monitoring data and assessment of adaptive management needs. The agencies may include, but are not limited to, and upon their acceptance:

- U.S. Fish and Wildlife Service (USFWS), Austin Ecological Services Office
- Texas Parks and Wildlife Department (TPWD)
- Texas Commission on Environmental Quality (TCEQ)

1.4 Sources of Uncertainty and Associated Risks

A fundamental tenet underlying the adaptive management process is achieving desired project outcomes in the face of uncertainties. Scientific uncertainties and technological challenges are inherent with any large-scale restoration project with the principal source of uncertainty typically including:

- Incomplete description and understanding of relevant ecosystem structure and function,
- Imprecise relationships between project management actions and corresponding outcomes,
- Engineering challenges in implementing project alternatives, and
- Ambiguous management and decision-making processes.

It is important to determine the type of risk each uncertainty comprises and to discern what constitutes sufficient knowledge to proceed considering those risks. There is significant institutional knowledge regarding the construction of the restoration measures; therefore, there is minimal uncertainty from a construction standpoint. Uncertainties relating to measure design and performance are mainly centered on site specific, design-level details (e.g. exact water quantities, invasive species removal needs, construction staging area locations, timing and duration of construction, engineering challenges, etc.), which would be addressed during PED. Identified uncertainties with the River Road TSP are included below (note - in addition to “identified uncertainties” or rare events, true uncertainty cannot be identified or it would not be uncertainty. The central idea is to plan and prepare for rare and unpredictable events as best as possible in order to minimize ecological and financial impacts during project delivery):

- Natural variability in ecological and physical processes;
- Soil dynamics;
- Riverine and riparian restoration requirements such as water and nutrient requirements including magnitude and duration of inundation, and type and quantity of nutrients to achieve desired productivity;
- Native seed and/or plant provenance (species selection);
- Invasive and nuisance species; and
- Project feature implementation timing, including schedule and timeline, and availability of construction funds.

2 Monitoring

An effective monitoring program will be 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 carefully designed monitoring program is the central component of the project adaptive management program as it supplies the information to assess whether the project is functioning as planned.

Monitoring must be closely integrated with the adaptive management components because it is the key to 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.

2.1 Monitoring Plan

According to the USACE, the implementation guidance memo for WRDA Section 2039, "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success have been achieved, or whether adaptive management may be needed to attain project benefits."

The following discussion outlines a monitoring plan that will support the River Road Aquatic Ecosystem Restoration Adaptive Management Program. The plan identifies performance measures along with desired outcomes and monitoring design in relation to specific objectives. A performance measure includes specific feature(s) to be monitored to determine project performance. Additional monitoring is identified as supporting information needs that will help further understand interrelationships of restoration features and external environmental variability and to corroborate project effects.

Such criteria, or decision-making triggers, are related to each performance measure and desired outcome and identify the need to discuss potential implementation of adaptive management actions with the MAMT. These criteria/triggers are identified in Section 3.3.

Baseline vegetation metrics were compiled during the initial site assessments throughout the study area. Vegetation metrics included but are not limited to: species composition, percent canopy cover of trees, mean diameter at breast height of overstory trees, and number of hard mast tree species. These measurements allow the MAMT to assess the performance standards.

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 successful restoration is achieve.

2.2 Monitoring Period

Pre-construction/baseline data, during construction, and post-construction monitoring will be utilized to determine restoration success. Baseline monitoring will begin during PED, prior to project construction and continue during construction when possible. Monitoring will continue until the trajectory of ecological change and/or other measures of project success are determined as defined by project-specific objectives. Section 2039 of WRDA 2007 allows ecological success monitoring to be cost-shared for up to ten years post-construction. Once

ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring would be performed. If ecological success cannot be determined within the ten-year post construction period of monitoring, any additional required monitoring would be the responsibility of the NFS.

2.3 Monitoring Elements

Defining and assessing progress towards project objectives are crucial components of the MAMP. The following section outlines the proposed performance measure metrics, desired outcomes and monitoring design needed to measure restoration progress, determine ecological success and support the adaptive management program should changes need to be made to improve project performance. The elements described in this section are based on the available project information and will be updated and refined during PED.

Performance Measure 1: Restore and improve aquatic (riverine) habitat.

Success Criteria Success will be measured by an increase of 3 acres of native and other acceptable riverine species by year 3.

Monitoring Design and Rationale: To determine the increase in acreage, a polygon of the aerial extent of target habitat that has been successfully established based on performance measures would be measured using a GPS.

Performance Measure 2: Restore and improve 13 acres of non-native grassland and 9 acres of riparian habitat.

Success Criteria One year following completion of final construction activities achieve 85% survival of planted woody species. The 85% survival criteria would continue to three years after construction.

Monitoring Design and Rationale: Planted woody species will be assessed each year during site surveys to determine what percentage of each species the plants have survived. Sites will be sampled during PED to establish baseline conditions and annually post construction until success is determined.

Performance Measure 3: Obtain average cover of 85% of desired herbaceous riparian vegetation on restoration sites at year 3.

Success Criteria One year following completion of final construction activities achieve a minimum average cover of 50%, comprised of native and other acceptable herbaceous species. Three years following construction, achieve a minimum cover of 85% native riparian herbaceous species for the restorations areas (no non-native woody species are acceptable).

Monitoring Design and Rationale: Vegetation will be sampled annually, at the seven restoration sites. Permanent vegetation monitoring stations will be established for assessing the vegetation community at each site. Sites will be sampled during PED to assess pre-project conditions and sampled annually post-construction until success is determined.

Performance Measure 4: Establish overall site biodiversity through increasing plant species taxa richness.

Success Criteria: One year following completion of final construction activities achieve a minimum of a 25% increase in plant species taxa richness depending on initial site conditions, comprised of native species. Three years following construction, maintain or increase level of taxa richness achieved during vegetation establishment efforts during construction phase, comprised of native species.

Monitoring Design and Rationale: The species composition of each site will be sampled annually at the permanent vegetation monitoring sites. Sites will be sampled during PED to establish baseline conditions and annually post construction until success is determined. Diversity metrics may consist of species richness, species evenness, and/or other species diversity metrics such as the Shannon Weiner or Simpson Index.

Performance Measure 5: Manage non-native invasive vegetation within restoration sites.

Success Criteria One year following completion of final construction activities achieve less than 25% average cover of non-native invasive species. Three years following completion of final construction activities achieve average cover of less than 5% non-native invasive species with no area greater than 0.25 acres in size with greater than 10% non-native invasive species

Monitoring Design and Rationale: Vegetation will be sampled annually, at the seven restoration sites. Permanent vegetation monitoring stations will be established for assessing the vegetation community at each site. Sites will be sampled for a one- to two-year period pre-construction to assess pre-project conditions and sampled annually post-construction until success is determined. Initial control/removal of unwanted plants will be evaluated and determinations made on an annual or semi-annual basis on whether additional action will be needed.

Area Change: To determine changes of areas vegetated with aquatic and/or riparian species within the project area, near-vertical color-infrared digital aerial imagery will be acquired during pre-construction and used as a pre-construction standard for future changes in riparian vegetation and size. Three additional satellite and aerial photographic acquisitions will be conducted at year 1, 2, and 3. These data will be collected in conjunction with LiDAR missions and under separate acquisition in non-LiDAR years, if needed. The photography will be geo-referenced, classified, and analyzed using standard operating procedures developed during PED.

Vegetation: Vegetation sampling will occur annually within all restoration units and at reference sites for the duration of the monitoring period. Sampling will occur during spring months, at the peak of the growing season. Permanent 1/10th-acre, field monitoring plots will be located randomly within each riparian restoration plot. The distance between plots will be dependent on the project site area and variability. Monitoring will measure percent cover of native and non-native plant species and structural diversity. Photograph stations are also important for documenting vegetation conditions. All plots and photograph stations staked and will be documented via Global Positioning System (GPS) coordinates to reoccupy in each year of sampling.

General observations, such as fitness and health of plantings, survival, growth, soil moisture, precipitation, phenology, native plant species recruitment, and signs of drought stress should be noted during the surveys. Additionally, potential soil erosion, flood damage, vandalism and

intrusion, trampling, and pest problems would be qualitatively identified. Efficacy of invasive plant management will also be monitored.

A general inventory of all wildlife species observed and detected using the project area would be documented. Nesting sites, roosting sites, animal burrows, and other signs of wildlife use of the newly created habitat and habitat structures would be recorded. The notes would be important for early identification of species colonization patterns.

Transplant survival, growth and condition will be monitored monthly during active growing seasons following Year 1 plantings for a period of 3 years. Information acquired during monitoring will be used to ascertain whether field management implementation (e.g., irrigation, protection, pest management) will be necessary or not for each species planted. Survival information from initial plantings will also be used to formulate later planting strategies as the project progresses.

2.4 Use of Monitoring Results and Analysis

Results of 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 MAMT who will evaluate and compare data to project objectives and decision making triggers. The MAMT 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 MAMT 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 gap. Effective operational regimes, restoration design needs, benefits generated by restored features, and accuracy of models can be evaluated to inform adaptive management actions and future restoration needs.

2.5 Costs of Monitoring

Section 2039 of the WRDA 2007 allows monitoring to be cost-shared for up to ten years post-construction. For the purpose of the preliminary MAMP, cost estimating for up to 3 years was assumed for all features (Table 1). The total costs of monitoring for River Road are $110,000.

Table 1. Cost Estimates for Monitoring phases provided by USACE's ERDC. All costs assumed to impact a minimum of 25 acres.

	Restoration Site	Year 1	Year 2	Year 3	Total
Monitoring (Monitoring workgroup, drafting	Aquatic plantings	0	$20,000	$20,000	$40,000
	Grassland/shrub/scrub	0	$10,000	$10,000	$20,000

detailed monitoring plan, working with PDT on performance measures, vegetation and perimeter assessments)	Riparian woodland/BLH	0	$25,000	$25,000	$50,000

3 Adaptive Management

Scientific, technological, socio-economic, engineering, and institutional uncertainties are challenges inherent with any large-scale ecosystem restoration project. A structured monitoring plan will be implemented to provide the feedback necessary to inform decisions about future project adjustments.

Adaptive management is distinguished from more traditional monitoring in part through implementation of an organized, coherent, and documented decision process. For the River Road ER adaptive management program, the decision process includes:

- Anticipation of the kinds of management decisions that are possible within the original project design;
- Specification of values of performance measures that will be used as decision-criteria;
- Establishment of a consensus approach to decision making; and
- A mechanism to document, report, and archive decisions made during the timeframe of the adaptive management program.

3.1 Rationale for Adaptive Management

The primary incentive for implementing an adaptive management program is to increase the likelihood of achieving desired project outcomes given project uncertainties. All ecosystem restoration projects face uncertainty due to the complexity of dynamic abiotic and biotic processes resulting in imprecise relationships between project actions and corresponding outcomes. Given these uncertainties, adaptive management provides an organized and coherent process that suggests management actions in relation to measured project performance compared to desired project outcomes. Adaptive management establishes the critical feedback among project monitoring, and informed project management, and learning through reduced uncertainty.

Many factors such as ecosystem dynamics, engineering applications, institutional requirements, and many other key uncertainties can change and/or evolve over a project's life. The MAMP will be regularly updated to reflect monitoring-acquired and other new information as well as resolution and progress on resolving existing key uncertainties or identification of any new uncertainties that may emerge. Specifically, the MAMP will be developed during the feasibility level of design phase and refined further in PED phase as more detailed project designs are developed. The MAMP would then be used during and after project construction to adjust the project, as necessary to better achieve goals, objectives, and restoration/management outputs/results.

3.2 Assessment

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, which reflect the objectives of the restoration actions.

The results of the monitoring program will be assessed annually by the MAMT. Monitoring results will be assessed to ensure the ecosystem response is on track to meet the restoration performance measures and goals. This assessment process will measure the progress of the project and determine if adaptive management actions are needed. Assessments will also inform the MAMT if other factors are influencing the response that may warrant further research.

USACE will document and report the monitoring results, assessments, and the results of the MAMT deliberations to the managers and decision-makers designated for the River Road project. USACE, with assistance from the MAMT, will also produce annual reports that show progress towards meeting project objectives as characterized by the performance measures. Results of the assessments will be used to evaluate adaptive management needs and inform decision-making.

3.2.1 Database Management

Database management is an important component of the monitoring plan and the overall adaptive management program. Data collected as part of the monitoring and adaptive management plans will be archived as prescribed in the refined monitoring and adaptive management plan developed during PED. The database manager will be responsible for storing final monitoring reports and other study documentation (decisions, agendas, reports) and making them available when requested. Monitoring reports will be searchable by topic and principle author.

Data standards, quality assurance and quality control procedures and metadata standards will also be prescribed in the refined monitoring and adaptive management plan. The database will be designed to store and archive the monitoring and adaptive management data. The format of each data set will vary as appropriate to the type of monitoring. Therefore, data are expected to be archived separately, rather than collated in one master database. Each dataset will include: data and metadata transfer and input policies and standards; data validation procedures; and mechanisms to ensure data security and integrity.

3.3 Decision-Making

Decisions on the implementation of adaptive management actions are informed by the assessment of monitoring results. The information generated by the monitoring plan will be used by USACE and the NFS in consultation with other MAMT members to guide decisions on adaptive management that may be needed to ensure that the ecosystem restoration project achieves success. Final decisions on implementation of adaptive management actions are made by USACE.

If monitoring determines that a management trigger has been “activated” the MAMT may determine that more data is required and continue or modify monitoring methods; or identify and implement a remedial action.

3.3.1 Decision Criteria

Decision criteria, also referred to as adaptive management triggers, are used to determine if and when adaptive management 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. Several potential decision criteria are identified below, based on the project objectives and performance measures. More specific decision criteria, possibly based on other parameters such as hydrology, geomorphology, and vegetation dynamics, may be developed during PED.

If assessments show that any of these triggers are met, USACE would consult with the MAMT to discuss whether an adaptive management action is warranted, and if so, what that action will entail. Investigations may be required to determine the cause of need for action in order to inform the type of adaptive management response that should be implemented, if needed. Additionally, prior to enacting any adaptive management measures, USACE would assess whether supplemental environmental analyses are required. Efforts will be made to make lessons learned available to the USACE community for incorporation into future projects.

Performance Measure 1: Restore and improve aquatic (riverine) habitat.

Success Criteria Success will be measured by an increase of approximately 3 acres of native and other acceptable riverine species by year 3.

Monitoring Design and Rationale: To determine the increase in acreage, a polygon of the aerial extent of target habitat that has been successfully established based on performance measures would be measured using a GPS.

Trigger: By year 1, the ratio of non-native invasive species is greater than native and other acceptable riverine/aquatic species within the restoration site.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms for the successful establishment of aquatic habitats include drought or extreme storm events, predation, incompatible species selection, natural stream design errors/flaws resulting in excessive erosion or sedimentation, or reinfestation of non-native invasive or native noxious species.

Potential Adaptive Management Measures: Adaptive management measure would include predator control (i.e., exclosures) to ensure the vitality and survival of the plantings; changing the target plant species to those be more tolerant of site specific abiotic conditions; and modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), redesign of the natural channel design or erosion protection measures, and/or the refinement of the integrated pest management strategy to manage invasive and noxious plant species in the restoration areas.

Performance Measure 2: Restore and improve 13 acres of non-native grassland and 9 acres of riparian habitat.

Success Criteria One year following completion of final construction activities achieve 85% survival of planted woody species. The 85% survival criteria would continue to three years after construction.

Monitoring Design and Rationale: Planted woody species will be assessed each year during site surveys to determine what percentage of each species the plants have survived. Sites will be sampled during PED to establish baseline conditions and annually post construction until success is determined.

Trigger: By year 1, the number of surviving woody plant species is below 85%. Volunteer plant species may replace unsuccessful planting, but only if the species is consistent with the species diversity goals and is not a dominant component of the restoration target composition.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms for the successful establishment of riparian habitats may include drought or extreme storm events, predators (invertebrates and vertebrates), incompatible plant species selection, natural stream design errors/flaws resulting in excessive erosion or sedimentation, and/or reinfestation of non-native invasive and native noxious species.

Potential Adaptive Management Measures: Adaptive management measure would include irrigation or soil amendments during drought conditions; predator control (i.e., exclosures) to ensure the vitality and survival of the plantings; changing the target plant species to those be more tolerant of site specific abiotic conditions; and modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), redesign of the natural channel design or erosion protection measures, and/or the refinement of the integrated pest management strategy to manage invasive and noxious plant species in the restoration areas.

Performance Measure 3: Obtain average cover of 85% of desired herbaceous riparian vegetation on restoration sites at year 3.

Success Criteria One year following completion of final construction activities achieve a minimum average cover of 50%, comprised of native and other acceptable herbaceous species. Three years following construction, achieve a minimum cover of 85% native riparian herbaceous species for the restorations areas (no non-native woody species are acceptable).

Monitoring Design and Rationale: Vegetation will be sampled annually, at the seven restoration sites. Permanent vegetation monitoring stations will be established for assessing the vegetation community at each site. Sites will be sampled during PED to assess pre-project conditions and sampled annually post-construction until success is determined.

Trigger: The percent canopy cover of native herbaceous species is less than 50% after one year, 75% after two years, or 85% after three years.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms for the successful establishment of riparian habitats may include drought, predators (invertebrates and vertebrates), incompatible plant species selection, natural stream design errors/flaws resulting in excessive erosion or sedimentation, and/or reinfestation of non-native invasive and native noxious species.

Potential Adaptive Management Measures: Adaptive management measure would include irrigation or soil amendments during drought conditions; predator control (i.e., exclosures) to ensure the vitality and survival of the plantings; changing the target plant species to those be more tolerant of site specific abiotic conditions; modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), and/or modify the integrated pest management strategy to manage invasive and noxious plant species; and/or the redesign the natural channel design or erosion protection measures to address excessive erosion and sedimentation of the aquatic and riparian habitats.

Performance Measure 4: Establish overall site biodiversity through increasing plant species taxa richness.

Success Criteria: One year following completion of final construction activities achieve a minimum of a 25% increase in plant species taxa richness depending on initial site conditions, comprised of native species. Three years following construction, maintain or increase level of taxa richness achieved during vegetation establishment efforts during construction phase, comprised of native species.

Monitoring Design and Rationale: The species composition of each site will be sampled annually at the permanent vegetation monitoring sites. Sites will be sampled during PED to establish baseline conditions and annually post construction until success is determined. Diversity metrics may consist of species richness, species evenness, and/or other species diversity metrics such as the Shannon Weiner or Simpson Index.

Trigger: The target increase in species diversity is not achieved within one year of construction.

Possible Causes for Not Meeting Success Criteria Potential failure mechanisms associated with meeting the species diversity performance measure include those listed above for performance measures 1-3.

Potential Adaptive Management Measures: Potential adaptive management measures include those listed above for performance measures 1-3; however, modifying the plant species used to replace unsuccessful plantings would be the most likely adaptive management measures. This is especially the case when survival of a species is significantly lower than other species planted in the restoration area.

Performance Measure 5: Manage non-native invasive vegetation within restoration sites.

Success Criteria One year following completion of final construction activities achieve less than 25% average cover of non-native invasive species. Three years following completion of final construction activities achieve average cover of less than 5% non-native invasive species with no area greater than 0.25 acres in size with greater than 10% non-native invasive species

Monitoring Design and Rationale: Vegetation will be sampled annually, at the seven restoration sites. Permanent vegetation monitoring stations will be established for assessing the vegetation community at each site. Sites will be sampled for a one- to two-year period pre-construction to assess pre-project conditions and sampled annually post-construction until success is determined. Initial control/removal of unwanted plants

will be evaluated and determinations made on an annual or semi-annual basis on whether additional action will be needed.

Trigger: Non-native invasive species percent cover exceeds 25% after one year, 15% after two years, and/or 10% after 3 years.

Possible Causes for Not Meeting Success Criteria Possible failure modes for invasive species management include ineffective treatment of the invasive species, root sprouting of the invasive plant, reestablishment of invasive species from the seed bank in the restoration areas, or immigration of invasive species seeds from animals or floodwaters.

Potential Adaptive Management Measures: Adaptive management measures to address failures in invasive species control include modifying the active ingredient/surfactant or application rates of herbicides, changing the treatment methodology (chemical, mechanical, or biocontrol), or modifying the integrated pest management strategy.

This restoration plan involves active manipulation (as needed) to sustain project goals and objectives, primarily by applying an iterative process of assessing and learning from the results of management actions. The application of adaptive management principals in this project will therefore provide decision support tools to address site changes that may occur as the project progresses, as well as integrate additional project resources or technologies as needed. In some cases additional resources may be needed to address issues that occur (such as management of new infestations of invasive species), but in most cases reallocation of resources (e.g., modifying planting lists/species selection based upon successes and failure of earlier plantings) can be used to meet or exceed project goals as defined by tree, shrub, vine, and herbaceous plant establishment combined with nuisance plant control.

3.4 Reporting

Evaluation of the success of the River Road project will be assessed annually at a minimum until all performance standards are met. Site assessments will be conducted annually by the MAMT to determine success of performance standards and an annual report will be submitted to the USFWS, TPWD, and other interested parties by January 30 following each monitoring year.

Permanent locations for photographic documentation will be established to provide a visual record of habitat development over time. The locations of photo points will be identified in the pre-construction monitoring report. Photographs taken at each photo point will be included in monitoring reports.

3.5 Adaptive Management Costs

The MAMP establishes a feedback mechanism whereby monitored conditions will be used to adjust or refine construction or maintenance actions to better achieve project goals and objectives. Monitoring and adaptive management are not to be used as a substitute for OMRR&R. Per WRDA 1986, as amended by Section 210 of WRDA 1996, the NFS would be responsible for all OMRR&R. This includes operations and maintenance (O&M) that provides day-to-day activities necessary to properly operate a component of a system and routine maintenance activities to keep the system operating as designed. This also includes non-routine or beyond the scope of typical O&M activities of repair or fixing damage caused by an event;

rehabilitation or repair related to long-term wear and tear; and replacement of components when the useful life is exceeded.

In contrast, periodic monitoring of performance criteria which contain trigger values informs the iterative process of implementing specified adaptive management measures to help achieve ecological success. However, the project area is susceptible to several uncertainties that could significantly impact the ecological success of constructed restoration features as described in Section 3.3.1.

Costs for the adaptive management program were based on estimated level of effort and potential frequency of need, and include participation in the MAMT and reporting. Only those actions which are most likely to be needed have associated costs. Measures included in the TSP have been successfully implemented with very similar designs within Bexar County; therefore, the desired outcomes are expected and reasonable based on experience. The likelihood that extreme measures, such as complete replacement of all native vegetation, is very low.

The current total estimate for implementing the adaptive management program is $164,000 (Table 2).

Table 2. Cost Estimates for PED, Construction, Monitoring, Adaptive Management, and Reporting phases provided by the U.S. Army Corps of Engineers Engineering, Research, and Design Center. All costs assumed to impact a minimum of 25 acres.

	Restoration Site	Year 1	Year 2	Year 3	Total
Adaptive Management (Vegetation, Detailed Adaptive Management Plan and Program Implementation, and Management. Contingency plans for irrigation & replanting, additional field work, etc)	Aquatic plantings	0	$20,000	$20,000	$40,000
	Grassland/shrub/scrub	0	$10,000	$10,000	$20,000
	Riparian woodland/BLH	0	$25,000	$25,000	$50,000
Reporting	All Sites	9,000	20,000	25,000	54,000

4 Project Close-Out

Once ecological success has been documented by the District Engineer in consultation with the Federal and State resource agencies, and a determination has been made by the Division

Commander that ecological success has been achieved, no further monitoring or adaptive management will be required and the project can be closed-out. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results. Success would be considered to have been achieved when all performance measures have been met or when it is clear they will be met based upon the trend of site conditions and processes.

The project could also be closed out when the maximum 10-year monitoring period has been reached. If the monitoring plan requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-Federal responsibility.

5 References

U.S. Army Engineering, Research, and Development Center. 2019. A Systems Approach to Ecosystem Adaptive Management: a USACE Technical Guide.

Attachment A

Potential Native Species List for the River Road Project Area

Scientific name	Common name	Growth form
Acer negundo	Box elder	Woody
Acmella oppositifolia	Oppositeleaf spotflower	Herb/wildflower
Aesculus pavia	Red buckeye	Woody
Ampelopsis cordata	Heartleaf peppervine	Vine
Andropogon gerardii	Big bluestem	Graminoid
Andropogon glomeratus	Bushy bluestem	Graminoid
Asclepias sp.	Milkweeds	Herb/wildflower
Bacopa monnieri	Water hyssop	Emergent
Bouteloua curtipendula	Side-oats grama	Graminoid
Bouteloua dactyloides	Buffalo grass	Graminoid
Callicarpa americana	American beautyberry	Woody
Campsis radicans	Trumpet creeper	Vine
Carex sp.	Sedges	Emergent
Carya illinoinensis	Pecan	Woody
Carya texana	Black hickory	Woody
Celtis laevigata	Sugarberry	Woody
Cephalanthus occidentalis	Buttonbush	Woody
Cercis canadensis	Eastern redbud	Woody
Chasmanthium latifolium	Inland sea oats	Graminoid
Cocculus carolinus	Carolina snailseed	Vine
Condalia hookeri	Brazilian bluewood	Woody

Cordia boissieri	Anacahuita	Woody
Cornus drummondii	Roughleaf dogwood	Woody
Crataegus spathulata	Hawthorn	Woody
Dermatophyllum secundiflorum	Texas mountain laurel	Woody
Diospyros texana	Texas persimmon	Woody
Echinodorus berteroi	Tall burhead	Emergent
Echinodorus subcordatum	Creeping burhead	Emergent
Ehretia anacua	Knockaway	Woody
Eleocharis acicularis	Slender spikerush	Emergent
Eleocharis macrostachya	Flatstem spikerush	Emergent
Eleocharis quadrangulata	Squarestem spikerush	Emergent
Equisetum	Horsetail	Emergent
Forestiera pubescens	Stretchberry	Woody
Glandularia bipinnatifida	Dakota mock vervain	Herb/wildflower
Heteranthera dubia	Water stargrass	Submerged
Ilex decidua	Deciduous holly	Woody
Juglans microcarpa	Little walnut	Woody
Juglans nigra	Black walnut	Woody
Justicia americana	Water willow	Emergent
Lantana urticoides	Texas lantana	Herb/wildflower
Lonicera sempervirens	Coral honeysuckle	Vine
Malvaviscus arboreus	Turk’s cap	Herb/wildflower
Morus rubra	Red Mulberry	Woody

Nuphar lutea	Yellow pond-lily	Floating-leaved
Nymphaea mexicana	Mexican water lily	Floating-leaved
Nymphaea odorata	American water lily	Floating-leaved
Panicum virgatum	Switchgrass	Graminoid
Passiflora incarnata	Passion flower	Vine
Phyla lanceolata	Lanceleaf frogfruit	Herb/wildflower
Phyla nodiflora	Texas frogfruit	Herb/wildflower
Platanus occidentalis	American sycamore	Woody
Polygonum hydropiperoides	Swamp smartweed	Emergent
Pontederia cordata	Pickerelweed	Emergent
Potamogeton illinoensis	Illinois pondweed	Submerged
Potamogeton nodosus	American pondweed	Submerged
Prunus mexicana	Mexican plum	Woody
Ptelea trifoliata	Common hoptree	Woody
Quercus buckleyi	Texas red oak	Woody
Quercus fusiformis	Texas live oak	Woody
Quercus macrocarpa	Bur oak	Woody
Quercus muehlenbergii	Chinkapin oak	Woody
Quercus shumardii	Shumard oak	Woody
Sagittaria latifolia	Arrowhead	Emergent
Sagittaria platyphylla	Delta arrowhead	Emergent
Sambucus nigra	Elderberry	Woody
Sapindus saponaria	Western soapberry	Woody

Schizachyrium scoparium	Little bluestem	Graminoid
Schoenoplectus pungens	American bulrush	Emergent
Schoenoplectus tabernaemontani	Softstem bulrush	Emergent
Sideroxylon lanuginosum	Gum bumelia	Woody
Sophora affinis	Eve's necklace	Woody
Sorghastrum nutans	Indiangrass	Graminoid
Symphoricarpos orbiculatus	Coral berry	Woody
Taxodium distichum	Bald cypress	Woody
Tridens albescens	White tridens	Graminoid
Tridens flavus	Purpletop tridens	Graminoid
Tripsacum dactyloides	Eastern gamagrass	Graminoid
Ulmus americana	American elm	Woody
Ulmus crassifolia	Cedar elm	Woody
Ungnadia speciosa	Mexican buckeye	Woody
Vallisneria americana	Wild celery	Submerged
Verbesina virginica	Frostweed	Herb/wildflower
Vitis mustangensis	Mustang grape	Vine
Wedelia texana	Orange zexmenia	Herb/wildflower
Ziziphus obtusifolia	Lotebush	Woody