APPENDIX H

Contents:

BBA Swamp Planting Guidelines

PLANTING GUIDELINES FOR SWAMP HABITATS

Canopy species will be planted on 8 X 10 grid (average) to achieve a minimum initial stand density of 545 seedlings (trees) per acre. Midstory species will be planted on 16 X 20 grid (average) to achieve a minimum initial stand density of 136 seedlings per acre. Stock used for canopy species will be at least 1 year old, at least 3 feet tall (including roots), and have a root collar diameter that exceeds 0.5 inch. Stock used for midstory specieswill be at least 1 year old and will be at least 3 feet tall (including roots). All stock must be obtained from a registered licensed regional nursery/grower and of a regional eco-type species properly stored and handled to ensure viability.

The plants will typically be installed during the period from December through March 15 (planting season/dormant season); however, unanticipated events may delay plantings until late spring or early summer. The seedlings will be installed in a manner that that avoids monotypic rows of canopy and midstory species (i.e. goal is to have spatial diversity and mixture of planted species). If herbivory may threaten seedling survival, then seedling protection devices such as wire-mesh fencing or plastic seedling protectors will be installed around each planted seedling.

The canopy species installed will be in general accordance with the species lists provided in Table 3A. The species composition of the plantings should mimic the percent composition guidelines indicated in this table. However, site conditions (factors such as hydrologic regime, soils, composition of existing native canopy species, etc.) and planting stock availability may necessitate deviations from the species lists and/or the percent composition guidelines indicated. In general, a minimum of 3 canopy species should be utilized, the plantings must include baldcypress and tupelogum (water tupelo), and baldcypress should typically comprise at least 50% of the total number of seedlings installed.

The midstory species installed will be selected from the species list provided in Table 3B. Plantings will consist of at least 2 different species. The species used and the proportion of the total midstory plantings represented by each species (percent composition) will be dependent on various factors including site conditions (composition and frequency of existing native midstory species, hydrologic regime, soils, etc.) and planting stock availability.

Table 3A: Preliminary Planting List for Swamp Habitat, Canopy Species

Common Name	Scientific name	Percent Composition
Bald cypress	*Taxodium distichum*	60% - 75%
Tupelogum	*Nyssa aquatic*	20% - 25%
Green ash	*Fraxinus pennsylvanica*	10% - 15%
Drummond red maple	*Acer rubrum* var. *drummondii*	5%
Bitter pecan	*Carya x lecontei*	5% - 10%

Table 3B: Preliminary Planting List for Swamp Habitat, Midstory Species

Common Name	Scientific name	Percent Composition
Buttonbush	*Cephalanthus occidentalis*	TBD
Roughleaf dogwood	*Cornus drummondii*	TBD
Swamp privet	*Forestiera acuminata*	TBD
Possumhaw	*Ilex decidua*	TBD
Virginia willow	*Itea virginica*	TBD
Wax myrtle	*Myrica cerifera*	TBD
Swamp rose	*Rosa palustris*	TBD
American snowbell	*Styrax americanus*	TBD

TBD = To Be Determined

Deviations from Typical Planting Guidelines

Proposed mitigation features that involve restoration will commonly require planting the entire feature using the prescribed planting guidance addressed in the preceding sections. In contrast, mitigation features that involve enhancement will often require adjustments to the typical plant spacing/density guidelines and may further require adjustments to the guidelines pertaining to species composition.

For swamp enhancement projects that include the eradication of invasive and nuisance plant species, significant numbers of native canopy and/or midstory species may remain, but in a spatial distribution that leaves relatively large “gaps” in the canopy stratum and/or the midstory stratum. In such cases, areas measuring approximately 25 feet by 25 feet that are devoid of native canopy species should be planted and areas measuring approximately 45 feet by 45 feet that are devoid of native midstory species should be planted.

The initial enhancement actions involved within a particular swamp enhancement mitigation site could include a variety of measures such as the eradication of invasive and nuisance plant species, topographic alterations (excavation, filling, grading, etc.), and hydrologic enhancement actions (alterations to drainage patterns/features, installation of water control structures, etc.). These actions may result in areas of variable size that require planting of both canopy and midstory species using the typical densities/spacing described above. There may also be areas where several native canopy and/or midstory species remain, thus potentially altering the general guidelines described as regards the spacing of plantings, and/or the species to be planted, and/or the percent composition of planted species. Similarly, areas that must be re-planted due to failure in achieving applicable mitigation success criteria may involve cases where the general guidelines discussed above will not necessarily be applicable.

Given these uncertainties, initial planting plans specific to a mitigation site will be required and must be specified in the Mitigation Work Plan for the site. The initial planting plans will be developed by the USACE in cooperation with the Interagency Team. Initial plantings will be the responsibility of the USACE. If re-planting of an area is necessary following initial plantings, a specific re-planting plan must also be prepared and must be approved by the USACE in cooperation with the Interagency Team prior to re-planting. With the exception of any re-planting actions necessary to attain the initial survivorship success criteria (i.e. survival required 1 year following completion of initial plantings), the NFS will be responsible for preparing re-planting plans and conducting re-planting activities, subject to the provisions contained in the Introduction section. Re-planting necessary to achieve the initial survivorship criteria will be the responsibility of the USACE, subject to the aforementioned provisions.

BBA Swamp Mitigation Monitoring Plan

MITIGATION SUCCESS CRITERIA AND MITIGATION MONITORING:
SWAMP MITIGATION FEATURES

The Interagency Environmental Team (IET) is currently revising these general swamp guidelines. Once revisions are complete, they will be reflected in the final General Mitigation Guidelines document which will include marsh, bottomland hardwood, and swamp habitats.

MITIGATION SUCCESS CRITERIA

The success criteria specified herein apply to both swamp restoration projects and swamp enhancement projects unless otherwise indicated.

1. General Construction

A. For construction from existing land: complete all necessary earthwork and related construction activities in accordance with the mitigation work plan and the project plans and specifications. The necessary activities will vary with the mitigation site and may include, but not be limited to clearing, grubbing, and grading activities; construction of new water management features (weirs, flap-gates, diversion ditches, etc.); modifications/alterations to existing water control structures and surface water management systems; plantings; and eradication of invasive and nuisance plant species.

B. For mitigation projects that are constructed from open water: construction activities will occur during both an initial and final construction phase to allow for settlement of fill. All construction activities will be completed in accordance with the mitigation work plan and the project plans and specifications. Initial construction activities may include some of the activities listed under 1.A. (with the noted exception of plantings) as well as the construction of perimeter containment dikes where necessary and the installation of fill (dredged sediments or other soil). Final construction activities will typically occur approximately 1 year after completion of the initial construction activities and may vary with the mitigation site. Activities may include, but not be limited to degrading or “gapping” of perimeter retention dikes; plantings, construction of water management structures (weirs, etc.); and continued eradication of invasive and nuisance plant species.

2. Topography

A. Initial Success Criteria

1. For mitigation features requiring earthwork (grading) to attain desired elevations (excluding areas restored from existing open water features) – Following completion of general construction criteria 1.A but prior to plantings, demonstrate that at least 80% of the total graded area within each feature is within approximately +0.25 feet of the proposed target soil surface elevation (e.g. the desired soil surface elevation).

2. For mitigation features restored from existing open water areas:
   - One year after placement of fill material is complete, demonstrate that at least 80% of the total fill area within each feature is within approximately +0.5 feet of the projected settlement curve elevation and;
   - Two years after placement of fill material is complete, demonstrate that at least 80% of the total fill area within each feature is within approximately +0.5 feet of the projected settlement curve elevation.

3. Native Vegetation

A. Initial Success Criteria (at end of first growing season following the year planting meets construction requirements)

- Achieve a minimum average survival of 50% of planted canopy species excluding recruited seedlings (i.e. achieve a minimum average canopy species density of 269 seedlings/ac.).
- The surviving plants must approximate the species composition and the species percentages specified in the initial plantings component of the Mitigation Work Plan.
- These criteria will apply to the initial plantings as well as any subsequent re-plantings necessary to achieve this initial success requirement.

B. Intermediate Success Criteria

1. (3 growing seasons Following Completion of 3.A)

    - Achieve a minimum average density of 250 living native canopy species per acre (planted trees and/or naturally recruited native canopy species).
    - Achieve a minimum average density of 125 living bald cypress trees (planted trees and/or naturally recruited native canopy species). The species composition of the additional native canopy species present must be generally consistent with the planted ratios for such species.
    - Demonstrate that vegetation satisfies USACE hydrophytic vegetation criteria. This criterion will thereafter remain in effect for the duration of the remaining 50-year monitoring period.

2. (Within 12 Years Following Completion of 3.A)

    - Achieve one of the two following vegetative cover requirements:

    a. The average percent cover by native species in the canopy stratum is at least 75%.
    OR
    b. The average percent cover by native species in the canopy stratum is at least 50%, and; the average percent cover by native species in the midstory stratum exceeds 33%, or; the average percent cover by native species in the ground cover stratum (herbaceous cover) exceeds 33%.

B. Long-Term Success Criteria (Within 30 Years Following Completion of 3.B.2)

- Demonstrate that the average percent cover by native species in the canopy stratum is at least 80%.
- Demonstrate that the average diameter at breast height (DBH) of living bald cypress trees exceeds 10 inches. This criterion will thereafter remain in effect for the duration of the overall monitoring period.
- Demonstrate that the average DBH of the other living native trees in the canopy stratum (trees other than bald cypress) exceeds 12 inches. This criterion will thereafter remain in effect for the duration of the overall monitoring period.
- Demonstrate that the average total basal area accounted for by all living native trees in the canopy stratum combined exceeds approximately 161 square feet per acre. This criterion will thereafter remain in effect for the duration of the overall monitoring period.

Note: There are no success criteria for understory species, but data will be collected every monitoring event.

4. Invasive and Nuisance Vegetation

A. Initial, Intermediate, and Long-term Success Criterion

- Maintain all areas of the project area such that the total average vegetative cover accounted for by invasive and nuisance species constitute less than 5% of the total average plant cover throughout the 50-year project life. The list of invasive and nuisance species is found in Appendix A and will be tailored to reflect specific site needs.

Note: Yearly inspections to determine the need for invasive/nuisance control would be conducted until the intermediate success criteria for vegetation is achieved. After it is achieved, the frequency of inspections to determine the need for invasive/nuisance control would be adjusted based on site conditions but at least at every monitoring event.

5. Thinning of Native Vegetation (Timber Management)

The USACE, in cooperation with the IET, may determine that thinning of the canopy and/or midstory strata is warranted to maintain or enhance the ecological value of the site. This determination will likely be made after it is demonstrated that the average total basal area accounted for by living native canopy species exceeds 161 square feet per acre. If it is decided that timber management efforts are necessary, the NFS will develop a Timber Stand Improvement/Timber Management Plan, and associated long-term success criteria, in coordination with the USACE and IET. Following approval of the plan, the NFS will perform the necessary thinning operations and will demonstrate the successful completion of these operations. Timber management activities will only be allowed for the purposes of ecological enhancement of the mitigation site.

6. Hydrology

A. Intermediate and Long-term Success Criteria

- 4 years after successful completion of plantings, site hydrology will be assessed to determine that the property meets the wetland criterion as described in the 1987 manual and applicable regional supplement. The NFS will provide the CEVMN with a wetland delineation to accompany the monitoring report.

MITIGATION MONITORING GUIDELINES

Baseline Monitoring Report

Within 90 days of completion of all final construction activities (e.g. eradication of invasive and nuisance plants, planting of native species, completion of earthwork, grading, surface water management system alterations/construction, etc.), the mitigation site will be monitored and a “baseline” monitoring report prepared. Information provided will typically include the following items:

- A detailed discussion of all mitigation activities completed.
- A description of the various features and habitats within the mitigation site. Various qualitative observations will be made in the mitigation site to document existing conditions to include potential problem zones, general condition of native vegetation, wildlife utilization as observed during monitoring, and other pertinent factors.

- A plan view drawing, and shape files of the mitigation site showing the approximate boundaries of different mitigation features including planted areas, planted rows, areas only involving eradication of invasive and nuisance plant species; surface water management features, access rows, proposed monitoring transect locations, sampling plot locations, photo station locations, and, if applicable, piezometer and staff gage locations.

- Initial and final construction surveys for areas having had topographic alterations, including elevations of all constructed surface water drainage features, drainage culverts, and/or water control structures. The initial and final construction surveys should also include cross-sectional surveys of topographic alterations involving the removal of existing linear features such as berms/spoil banks, or the filling of existing linear ditches or canals. The number of cross-sections must be sufficient to represent elevations of these features. The initial and final construction surveys must include areas where existing berms, spoil banks, or dikes have been breached.

- A detailed inventory of all canopy and midstory species planted, including the number of each species planted and the stock size planted. In addition, provide a breakdown itemization indicating the number of each species planted in a particular portion of the mitigation site and correlate this itemization to the various areas depicted on the plan view drawing of the mitigation site.

- Photographs documenting conditions in the project area will be taken at the time of monitoring and at permanent photo stations within the mitigation site. At least two photos will be taken at each station with the view of each photo always oriented in the same general direction from one monitoring event to the next. The number of photo stations required and the locations of these stations will vary depending on the mitigation site. The USACE will make this determination in coordination with the IET and will specify the requirements in the project-specific Mitigation Monitoring Plan. At a minimum, there will be 4 photo stations established. For mitigation sites involving habitat enhancement/earthwork only, permanent photo stations will primarily be established in areas slated for planting of canopy and mid-story species, but some may also be located in areas where plantings are not needed. Multiple baseline reports may need to be submitted if additional plantings are required by the contractor to meet planting survival acceptance criteria. Each revision will be updated to incorporate information regarding the re-planting.

Additional Monitoring Reports

All monitoring reports generated after the Baseline Monitoring Report will be called Initial, Intermediate or Long-Term Success Criteria Monitoring Reports and shall be numbered sequentially based on the year in which the monitoring occurred (i.e. Initial Success Criteria Monitoring Report 2019). All Monitoring Reports shall provide the following information unless otherwise noted:

- All items listed for the Baseline Monitoring Report with the exception of: (a) the topographic/as-built survey, although additional topographic/as-built surveys are required for specific monitoring reports (see below); (b) the inventory of species and location map for all planted species.

- A brief description of maintenance and/or management and/or mitigation work performed since the previous monitoring report along with a discussion of any other significant occurrences.

- Quantitative plant data collected from (1) permanent monitoring plots measuring approximately 90 feet X 90 feet in size or from circular plots having a radius of approximately 53 feet, (2) permanent transects sampled using the point-centered quarter method with a minimum of 20 sampling points established along the course of each transect, or; (3) permanent belt transects approximately 50 feet wide and perpendicular to planted rows. The number of permanent monitoring plots and transects, as well as the length of each transect will vary depending on the mitigation site. The USACE will make this determination prior to the first monitoring event in coordination with the IET and will specify the requirements in the Mitigation Monitoring Plan. Data recorded in each plot or transect will include:

First monitoring report after a planting event

- number of living planted canopy species (excluding recruited) present and the species composition;
- number of living planted midstory species present and the species composition
- average density of living planted canopy species and the species composition (transect methods)
- average density of all native species in the midstory stratum, the total number of each species present, and the wetland indicator status of each species;
- average percent cover by native species in the midstory stratum;

- average percent cover accounted for by invasive plant species (all vegetative strata combined); average percent cover accounted for by nuisance plant species (all vegetative strata combined).

Subsequent monitoring reports

- number of living native canopy trees by species ;
- average density of all native species in the canopy stratum (i.e., the total number of each species present per acre), and the wetland indicator status of each species;
- average percent cover by native species in the canopy stratum;
- average diameter at breast height (DBH) for trees (measured 10 years after successful completion of plantings) in the midstory and upper strata;
- number of living native midstory species present and the species composition
- average density of all native species in the midstory stratum, the total number of each species present, and the wetland indicator status of each species;
- average percent cover by native species in the midstory stratum;
- average percent cover accounted for by invasive plant species (all vegetative strata combined); average percent cover accounted for by nuisance plant species (all vegetative strata combined).

Note: The DBH of planted canopy species will not need to be documented until the average DBH of these trees reaches approximately 2 inches. Total basal area data will also not need to be documented until such time that the average total basal area is estimated to exceed approximately 100 square feet per acre.
Note: Once 3.B.2.a (75% canopy cover) is achieved, only qualitative data will be collected for midstory species.

The permanent monitoring plots will typically be located within mitigation areas where initial planting of canopy and midstory species is necessary. The number of plots required as well as the locations of these plots will vary depending on the mitigation site. The USACE will make this determination in coordination with the IET and will specify the requirements in the Mitigation Monitoring Plan. Typically there will be at least one monitoring plot for every 20 acres planted.

- Quantitative data concerning plants in the understory (ground cover) stratum and concerning invasive and nuisance plant species will be gathered from sampling quadrats. These sampling quadrats will be established either along the axis of the belt transects discussed above, or at sampling points established along point-centered quarter transects discussed above, depending on which sampling method is used. Each sampling quadrat will be approximately 1 meter X 1 meter in size. The total number of sampling quadrats needed along each sampling transect will be determined by the USACE with the IET and will be specified in the Mitigation Monitoring Plan. Data recorded from the sampling quadrats will include: average percent cover by native understory species; composition of native understory species and the wetland indicator status of each species; average percent cover by invasive plant species; and average percent cover by nuisance plant species.

- A summary of rainfall data will be collected during the year preceding the monitoring report based on rainfall data recorded at a station located on or in close proximity to the mitigation site. Once all hydrology success criteria have been achieved, collection and reporting of rainfall data will no longer be required.

- In addition, various qualitative observations will be made in the mitigation site to help assess the status and success of mitigation and maintenance activities. These observations will include: general estimates of the average percent cover by native plant species in the canopy, midstory, and understory strata; general estimate of the average percent cover by invasive and nuisance plant species;

    - general estimates concerning the growth of planted canopy and mid-story species;

- general observations concerning the colonization by volunteer native plant species;
- general observations made during the course of monitoring will also address potential problem zones, general condition of native vegetation, trends in the composition of the plant communities, wildlife utilization as observed during monitoring, and other pertinent factors.

- For mitigation features restored from existing open water areas: Provide a topographic survey of all such mitigation features one year immediately following final construction activities (General Construction 1.B.). No additional topographic surveys will typically be required following this survey. However, if this survey indicates topographic success criteria have not been achieved and that supplemental topographic alterations are necessary, then another topographic survey may be required following completion of the supplemental alterations. This determination will be made by USACE in coordination with the IET.

- A summary assessment of all data and observations along with recommendations as to actions necessary to help meet mitigation and management/maintenance goals and mitigation success criteria.

- A brief description of anticipated maintenance/management work to be conducted during the period from the current monitoring report to the next monitoring report.

Monitoring Reports Involving Timber Management Activities

In cases where timber management activities (thinning of trees and/or shrubs in the canopy and/or midstory strata) have been approved by the USACE in coordination with the IET, monitoring will be required in the year immediately preceding and in the year following completion of the timber management activities (i.e. pre-timber management and post-timber management reports). These reports must include data and information that are in addition to the typical monitoring requirements. The NFS's proposed Timber Stand Improvement/Timber Management Plan must include the proposed monitoring data and information that will be included in the pre-timber management and post-timber management monitoring reports. The proposed monitoring plan must be approved by the USACE in coordination with the IET prior to the monitoring events and implementation of the timber management activities.

Monitoring Reports Following Re-Planting Activities

Re-planting of certain areas within the mitigation site may be necessary to ensure attainment of applicable native vegetation success criteria. Any monitoring report submitted following completion of a re-planting event must include:

- an inventory of the number of each species planted and the stock size used;
- a depiction of the areas re-planted, cross-referenced to a listing of the species and number of each species planted in each area;
- documented GPS coordinates for the perimeter of the re-planted area. If single rows are replanted, then GPS coordinates should be taken at the end of the transect; and
- all requirements listed under "Additional Monitoring Reports" of the Mitigation Monitoring Guidelines.

MITIGATION MONITORING SCHEDULE AND RESPONSIBILITIES

Monitoring will be dependent upon site conditions, but may be delayed until later in the growing season due to site conditions or other unforeseen circumstances. Monitoring reports will be submitted as soon as possible but no later than December 31 of each year of monitoring. Monitoring reports will be provided to the USACE, the NFS, and the agencies comprising the IET. The various monitoring and reporting responsibilities addressed in this section are all subject to the provisions set forth in the Introduction section.

The USACE will be responsible for conducting the monitoring events and preparing the associated monitoring reports until such time that the following mitigation success criteria are achieved (criteria follow numbering system used in success criteria section):

1. General Construction – 1.A or 1.B, as applicable.
2. Native Vegetation – 3.A.
3. Invasive & Nuisance Vegetation –until such time as monitoring responsibilities are transferred to the NFS.
4. Topography – 2, as applicable.

Monitoring events associated with the above will include the baseline monitoring event plus annual monitoring events thereafter until the mitigation monitoring responsibility is transferred to the NFS.

The NFS will be responsible for conducting the required monitoring events and preparing the associated monitoring reports for all other required years after the USACE has demonstrated the initial success criteria listed above have been achieved. The responsibility for management, maintenance, and monitoring of the non-structural components of mitigation project (vegetative) will typically be transferred The NFS will be responsible for conducting the required monitoring events and preparing the associated monitoring reports for all other required years after the USACE has demonstrated the initial success criteria listed above have been achieved. The responsibility for management, maintenance, and monitoring of the non-structural components of mitigation project (vegetative) will typically be transferred to the NFS during the first quarter of the year immediately following submittal of the monitoring report that demonstrates attainment of the initial success criteria. Once monitoring responsibilities have been transferred to the NFS, the next monitoring event (intermediate) should take place 2 growing seasons after initial success has been met. After intermediate success has been met, monitoring will be conducted every 5 years throughout the remaining 50-year period of analysis.

In certain cases it is possible that the Swamp mitigation features may be established along with other mitigation features, like BLH or marsh habitats, at the same mitigation site. This scenario could require some adjustments to the typical monitoring schedule described above in order to develop a reasonable and efficient monitoring schedule that covers all the mitigation features. Such adjustments, if necessary, would be made at the time final mitigation plans are generated. This schedule must be in general accordance with the guidance provided above and will be prepared by the USACE and the IET.

If the initial survival criteria for planted canopy species are not achieved (i.e. the initial success criteria specified in native vegetation success criteria 2.A), the IET will convene to decide by consensus between two remedial actions. 1) Complete replant or supplemental replant or 2) Wait one growing season, monitor for initial success again, and reconvene with the IET to discuss results and determine path forward. If a replant is selected, a monitoring report will be required for each consecutive year until two annual sequential monitoring reports indicate that all survival criteria have been satisfied (i.e. that corrective actions were successful). If the IET decides not to replant, then after one growing season another initial monitoring report will be prepared and the IET will reconvene to determine path forward. The USACE will be responsible for conducting this additional monitoring and preparing the monitoring reports. The USACE will also be responsible for the purchase and installation of supplemental plants needed to attain the initial success criterion, subject to the provisions mentioned in the Introduction section.

If the native vegetation success criteria specified in in Section 3 are not achieved, a monitoring report will be required for each consecutive year until two annual sequential reports indicate that these criteria have been satisfied. The NFS will be responsible for conducting this additional monitoring and preparing the monitoring reports. The NFS will also be responsible for the purchase and installation of supplemental plants needed to attain these success criteria.

If timber management activities are conducted by the NFS, the NFS will be responsible for conducting the additional monitoring and preparing the associated monitoring reports necessary for such activities (e.g. one monitoring event and report in the year immediately preceding timber management activities and one monitoring event and report in the year that timber management activities are completed). Management activities conducted should be documented in the monitoring report.

Once monitoring responsibilities have transferred to the NFS, the NFS will retain the ability to modify the monitoring plan and the monitoring schedule should this become necessary due to unforeseen events or to improve the information provided through monitoring. Twenty years following completion of initial plantings, the number of monitoring plots and/or monitoring transects that must be sampled during monitoring events may be reduced substantially if it is clear that mitigation success is proceeding as anticipated. Any significant modifications to the monitoring plan or the monitoring schedule must first be approved by the USACE in coordination with the IET.

Note:
The 50-year period of monitoring begins once final construction of the project is complete.

- For projects that are not planted, the 50-year monitoring period begins at the end of the first growing season after all final construction activities are completed, including degradation of temporary containment dikes, completion of armoring of permanent dikes, installation of fish dips, and construction of water management features.

- For projects that are planted, the 50-year monitoring period begins at the end of the first growing season after all final construction activities are completed (including planting) and when planting has been conducted to the satisfaction of CEMVN Environmental Branch.

BBA Adaptive Management Plan

ADAPTIVE MANAGEMENT

SWAMP

1.0. Introduction

This Adaptive Management (AM) Plan is for BBA mitigation projects which are designed to mitigate for swamp impacts. The mitigation features are fully described in Supplemental Environmental Impact Statement West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Study Draft Mitigation Plan. The Water Resources Development Act (WRDA) of 2007, Section 2036(a) and U.S Army Corps of Engineers (USACE) implementation guidance forSection 2036(a) (CECW-PC Memorandum dated August 31, 2009: "Implementation Guidance for Section *2036 (a) of the Water Resources Development* Act of 2007 (WRDA 2007) – Mitigation for Fish and Wildlife and Wetland Losses") require adaptive management be includedin all mitigation plans for fish and wildlife habitat and wetland losses.

It should be noted that even though the proposed mitigation actions include the potential purchase of credits from a mitigation bank this appendix only details the Adaptive Management planning for the Corps constructed projects. In the event that mitigation bank credits are purchased the mitigation management and maintenance activities for the mitigation bank credits will be set forth in the Mitigation Banking Instrument (MBI) for each particular bank. The bank sponsor (bank permittee) will be responsible for these activities rather than the USACE and/or the local Sponsor. USACE Regulatory staff reviews mitigation bank monitoringreports and conducts periodic inspections of mitigation banks to ensure compliance with mitigation success criteria stated in the MBI.

2.0. Adaptive Management Planning

Adaptive management planning elements included: 1) development of a Conceptual Ecological Model (CEM), 2) identification of key project uncertainties and associated risks, 3) evaluation of the mitigation projects as a candidate for adaptive management and 4) the identification of potential adaptive management actions (contingency plan) to better ensure the mitigation project meets identified success criteria. The adaptive management plan is a living document and will be refined as necessary as new mitigation project information becomes available.

2.1. Conceptual Ecological Model

A CEM was developed to identify the major stressors and drivers affecting the proposed BBA mitigation projects (see Table 1). The CEM does not attempt to explain all possible relationships of potential factors influencing the mitigation sites; rather, the CEM presents only those relationships and factors deemed most relevant to obtaining the requiredacres/average annual habitat units (AAHUs). Furthermore, this CEM represents the current understanding of these factors and will be updated and modified, as necessary, as new information becomes available.

Table 1. Conceptual Ecological Model

Alternatives/Issues/Drivers	Swamp	Mitigation Banks
Freshwater Input	+/-	*
Salinity Impacts	-	*
Subsidence	-	*
Sea Level Rise	-	*
Runoff	-	*
Vegetative Invasive Species	-	*
Herbivory	-	*
Hydrology	+/-	*
Topography (elevation)	+/-	*

Key to Cell Codes:
- = Negative Impact/Decrease
+ = Positive Impact/Increase
+/- = Duration Dependent
*Issues and drivers assumed to be addressed by Mitigation Bank sponsors

2.2. Sources of Uncertainty and Associated Risks

A fundamental tenet underlying adaptive management is decision making and achieving desired project outcomes in the face of uncertainties. There are many uncertainties associated with restoration of the coastal systems. The project delivery team identified the following uncertainties during the planning process.

A. Climate change, such as relative sea level rise, drought conditions, and variability of tropical storm frequency, intensity, and timing
B. Subsidence and water level trends at the mitigation sites
C. Uncertainty Relative to Achieving Ecological Success:
    i. Water, sediment, and nutrient requirements for Swamp
    ii. Magnitude and duration of wet/dry cycles for Swamp
    iii. Nutrients required for desired productivity for Swamp
    iv. Growth curves based on hydroperiod and nutrient application for Swamp
    v. Tree litter production based on nutrient and water levels for Swamp
    vi. Tree propagation in relation to management/regulation of hydroperiod Swamp
D. Loss rate of vegetative plantings due to herbivory
E. Long-Term Sustainability of Project Benefits

2.3. Adaptive Management Evaluation

The project sites were evaluated and planned to develop a project with minimal risk and uncertainty. The items listed below were incorporated into the mitigation project implementation plan and Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) plans to minimize project risks.

- Specified success criteria (i.e., mitigation targets)

- Detailed planting guidelines for Swamp
- Invasive species control
- Supplementary plantings as necessary (contingency)
- Corrective actions to meet topographic and hydrologic success as required (contingency)

Subsequently, as part of the adaptive management planning effort the mitigation project features were re-evaluated against the CEM and sources of uncertainty and risk were identified to determine if there was any need for additional actions and costs under the adaptive management plan to ensure that the project meets the required success criteria. Based on the uncertainties and risks associated with the project implementation the following contingency actions have been identified to be implemented if needed to ensure the required AAHUs are met.

Potential Action #1. Additional vegetative plantings as needed to meet identified success criteria.

Uncertainties addressed: A,B,C,D, E

Potential Action #2. Additional earthwork at mitigation sites (by adding sediment or degrading) to obtain elevations necessary for Swamp vegetative establishment and maintenance.

Uncertainties addressed: A,B,C,E

Potential Action #3. Invasive species control to ensure survival of native species and meet required success criteria.

Uncertainties addressed: E

Actions 1 & 3 are not recommended as separate adaptive management actions since they are already built into the mitigation plan and success criteria identified. In the event that monitoring reveals the project does not meet the identified vegetation, or hydrologic success criteria, additional plantings or construction activities are already accounted for and would be conducted under the mitigation project. Specific measures to implement Action 2, if determined necessary to achieve project benefits, would be coordinated with the NFS and other agencies to determine the appropriate course of action. If it is determined that the project benefits are significantly compromised because of improper elevation, additional fill material may need to be pumped into or removed from the project area. Due to the impact the addition of fill to the mitigation projects once they have been planted would incur, lifts to the projects are not currently considered as a viable remedial action. Instead, increasing the size of the existing mitigation project or mitigating the outstanding balance of the mitigation requirement elsewhere or through the purchase of mitigation bank credits would be options that could be considered through additional coordination with the NFS and the IET. However, such options would have to undergo further analysis in a supplemental NEPA document.

Action 2 is potentially very costly actions. Before implementing such an action, the Corps would coordinate with the NFS and other agencies to determine if other actions, such as purchasing of credits in a mitigation bank or building additional mitigation elsewhere, would be more cost-effective options to fulfill any shortfalls in the overall project success. The USACE would be responsible for performing any necessary corrective actions, but the overall cost would be shared with the NFS according to the project cost-share agreement.

The USACE would be responsible for the proposed mitigation construction and monitoring until the initial success criteria are met. Initial construction and monitoring would be funded in accordance with all applicable cost-share agreements with the NFS. The USACE would monitor (on a cost-shared basis) the completed mitigation to determine whether additional construction, invasive/nuisance plant species control, and/or plantings are necessary to achieve initial mitigation success criteria. Once the USACE determines that the mitigation has met the initial success criteria, monitoring would be performed by the NFS as part of its OMRR&R obligations. If after meeting initial success criteria, the mitigation fails to meet its intermediate and/or long-term ecological success criteria, the USACE would consult with other agencies and the NFS to determine the appropriate management or remedial actions required to achieve ecological success. The USACE would retain the final decision on whether or not the project's required mitigation benefits are being achieved and whether or not remedial actions are required. If structural changes are deemed necessary to achieve ecological success, the USACE would implement appropriate adaptive management measures in accordance with the contingency plan and subject to cost-sharing requirements, availability of funding, and current budgetary and other guidance.

MSA-2 Monitoring Plan

Maurepas Swamp Alternative-2 50 Year Mitigation Monitoring Plan

I. Introduction

The following monitoring plan evaluates the benefits of the Maurepas Swamp Alternative-2 (Public Lands only, MSA-2) mitigation plan for impacts to swamp habitats resulting from the construction and implementation of the West Shore Lake Pontchartrain (WSLP) project. The reintroduction of 2,000 square feet/second (ft^2/s) of Mississippi River flow to the Maurepas Swamp is anticipated to improve swamp health and productivity by increasing dissolved oxygen and nitrate availability, enhancing sedimentation, and maintaining low salinity levels. To evaluate the performance of the MSA-2 in the nearly 9,000-acre (3642 hectare (ha)) mitigation benefit area, monitoring would be conducted to determine if the MSA-2 is meeting the following set of success criteria: 1) enhance forest integrity, 2) improve water quality, 3) increase sediment accumulation and soil surface elevation, and 4) maintain salinity (Appendix A). The success criteria and each element of the following monitoring plan were developed through a collaborative effort between the U.S. Army Corps of Engineers (USACE), New Orleans District (MVN), the U.S. Army's Engineer Research and Development Center (ERDC), the Coastal Protection and Restoration Authority (CPRA) and their multi-agency Maurepas Technical Advisory Group (TAG), as well as the U.S. Fish and Wildlife Service (USFWS).

The following sections describe the monitoring plan design by providing information on 1) the selection of monitoring sites in the mitigation benefit area); 2) monitoring strategy within the mitigation benefit area; and 3) monitoring strategy within control and supportive sites. Subsequent sections outline the monitoring plan in relation to the four established success criteria. Each success criterion monitoring section discusses: A) An overview of monitoring design, purpose, and methods; B) detailed success criteria for the 50-year period (expected 2027-2077) of anticipated benefits; C) monitoring considerations; D) baseline monitoring and sampling frequency; E) mitigation monitoring and sampling frequency; and F) monitoring methodology.

II. Monitoring Design

The proposed alternative represents a novel approach to improve forest health and productivity, and limited data are available to predict the impacts of river reintroduction into a coastal Louisiana swamp. As a result, a robust monitoring design has been developed to address the novelty and uncertainty associated with implementation of the MSA-2. The monitoring plan is intended to mitigate potential risk through frequent monitoring and appropriate spatial coverage to inform potential adaptive management actions. Additional monitoring efforts are expended in the early years to rapidly inform potential adaptive management, if necessary (Stockton, 2008). The parameters included in the monitoring plan focus on determining whether each success criterion has been achieved. Advisory variables that support objectives of the MSA-2 would also be evaluated to understand the ecological trajectory of the mitigation benefit area and associated drivers of forest health.

1) Monitoring Site Selection

Given the difficulties of selecting monitoring sites that both reflect the variability observed within the mitigation benefit area while ensuring the monitoring plan is practical and executable, a randomized or probabilistic sample design was not applied. Instead, the selection of targeted monitoring locations to capture environmental conditions was chosen to evaluate the achievement of success criteria. Monitoring sites were selected to capture the range of current swamp conditions in addition to the range of expected diversion impacts in the mitigation benefit area. Thus, sites were selected to proportionately represent: 1) forest canopy cover (closed and transitional) and 2) freshwater reintroduction benefit areas (primary, secondary, and tertiary) (Edwards et al., 2019; FTN Associates, 2018; Keim et al., 2010; LaCour-Conant, Ramsey, and Bollfrass, 2019; USFWS, 2020). Canopy cover was used to represent current swamp conditions and were determined using Landsat 7 Thematic Mapper data from Keim et al. (2010). Primary, secondary, and tertiary freshwater reintroduction benefit areas established in the MSA-2 were used to represent the anticipated range of benefits. The primary benefit area assumes the greatest possible reintroduction benefits, while the secondary and tertiary areas assume 75% and 45% of primary area benefits, respectively (USFWS, 2020; Appendix B). Benefit area establishment was informed by the expected magnitude of hydrologic influence from freshwater reintroduction based on modeled nutrient and water surface elevation gradients (FTN Associates, 2018).

Monitoring site selection additionally considered the spatial distribution of data collection locations and feasibility of accessing monitoring sites, which would need to be revisited on a re-occurring basis. Final monitoring location placement determinations were made following an aerial flyover of the proposed MSA-2 location, on-site reconnaissance and field data collection trips, and consultation with the TAG and other experienced practitioners that have conducted research in the swamp.

A total of 46 monitoring sites are included in the monitoring plan (Appendix B). Sites within the mitigation benefit area were distributed proportionally to reflect the relative presence of swamp canopy cover type (transitional and closed) in the three freshwater reintroduction benefit areas (primary, secondary, and tertiary). Thus, the 46 stations in the mitigation benefit area were divided into six categories: primary closed canopy (21%; 10 stations); primary transitional canopy (20%%, 10 stations); secondary closed canopy (9%, 4 stations); secondary transitional canopy (23%, 10 stations); tertiary closed canopy (9%; 4 stations); and tertiary transitional canopy (18%; 8 stations). Four of the monitoring sites in the mitigation benefit area are currently established and monitored by the Coastwide Reference Monitoring System (CRMS), which are managed by the CPRA and have collected data since 2007 (Appendix C, Fig. 1). Monitoring at these four CRMS sites (which are included in the 46 sites listed above) for the MSA-2 would occur in addition to CRMS-specific monitoring.

2) Mitigation Site Monitoring

Data collected at monitoring sites established in the mitigation benefit area would be evaluated to determine if success criteria are being met. Baseline monitoring would occur in the three consecutive years preceding the operation of the MSA-2 to establish an accurate baseline record that is resistant to episodic events or non-representative data years. Initial, intermediate, and long-term targets were developed for each success criterion and monitoring would assess site conditions for each of these target phases (Appendix A). A significant amount of uncertainty surrounds the time required to achieve each stage of success; therefore, the timelines presented in this monitoring plan are estimates that would be iteratively re-evaluated using a data-driven approach. Initial success must be demonstrated within 10 years after diversion operations begin, with the earliest possible achievement at target year (TY) six (Stockton, 2008; 33 CFR 332.6(b)). Afterwards, the assessment of intermediate success would occur no sooner than 12 years (and four monitoring events) after the attainment of initial success. Long-term success monitoring assessments and reporting would then occur every 6 years until TY50. Table 1 outlines several potential monitoring timelines based on when initial success is achieved and assuming the earliest attainment of intermediate success.

The USACE MVN would deliver a report of baseline mitigation monitoring in TY1, the year following the completion of baseline monitoring. Similarly, the USACE MVN would deliver a report evaluating initial success in TY6 with subsequent reports delivered in TY8 and TY10 if previous evaluations fail to meet success criteria. If the MSA-2 fails to meet the success criteria, adaptive management or remediation may be required as outlined by the MSA-2 Adaptive Management Plan. Once initial success criteria are met, subsequent mitigation monitoring responsibility (intermediate and long-term) and associated reporting would transfer to the CPRA. The CPRA would provide a monitoring report in each year following the completion of data collection for intermediate (every three years) and long-term (every six years) success criteria assessment.

During the initial success phase, annual meetings between the MSA-2 partners would be held in the fall to share data and review performance resulting from the MSA-2 operation. During the intermediate and long-term success monitoring phases, meetings between partners would be held in the fall of years when forest integrity monitoring occurs (tentatively every 3 and 6 years for intermediate and long-term monitoring, respectively). Annual monitoring data would be shared among the MSA-2 partners for the 50 year benefit period regardless of the monitoring phase. Data review and the MSA-2 performance meetings during non-reporting years would help document whether the MSA-2 is on a trajectory to meet its success criteria or if adaptive management actions may be required.

Monitoring timeline if initial success is met at:			
Timeline	**TY6**	**TY8**	**TY10**
	Target Year (TY)		
Baseline	-4 to -1	-4 to -1	-4 to -1
Initial Success	1-6*	1-8*	0-10*
Intermediate	7-18*	9-20*	11-22*

Long-Term Success	19-50	21-50	23-50

Table 1: Monitoring timeline if initial success is met at TY6, TY8, and TY10. Negative (-) indicates baseline years/monitoring prior to the MSA-2 operation (i.e., -4 to -1 indicates baseline monitoring during the four years preceding MSA-2 operation). * Indicates a reporting year. Timeline assumes the earliest attainment of intermediate success. Long-term success criteria monitoring reports would be delivered every 6 years until TY50 to demonstrate the maintenance of success criteria.

3) Control and Supportive Monitoring

Control and supportive monitoring sites outside the benefit areas would be used to demonstrate future with project (FWP) benefits relative to a future without project (FWOP) scenario. Control sites are those located in swamp habitat outside of the mitigation benefit areas that are unlikely to be impacted by the operation of the MSA-2 but have similar site conditions to those in the mitigation benefit areas. Alternatively, supportive sites are those located in swamp habitat outside the mitigation benefit area that may receive some impacts to an unknown (if any) extent. If conditions at supportive monitoring sites are influenced by the MSA-2 operation, they'll be used to further inform the spatial extent and magnitude of benefits outside of the mitigation benefit area. If any of the supportive monitoring sites are determined to receive no benefits, these areas would be reclassified as control sites. All control or supportive sites are located at currently established CRMS sites and would not require additional monitoring for the MSA-2. Six CRMS sites in the Maurepas Swamp are proposed for utilization as control (3) and supportive (3) monitoring sites due to the long-term data record available and active monitoring status (Appendix C; (Fig. 1). Monitoring specific to the MSA-2 would not occur at the control and supportive monitoring stations but would rely on continued data collection from CRMS site monitoring. Station descriptions, available data, and monitoring techniques and frequency of CRMS sites can be found at http://cims.coastal.louisiana.gov.

Monitoring methodology described in this report closely follow standard operating procedures for CRMS sites as detailed in Folse et al. (2020) but includes some deviations from the CRMS protocols to ensure the data collected can determine whether success criteria have been achieved. Data collection that deviates from the CRMS protocol would still maintain compatibility with CRMS data. The proposed monitoring plan is presented as a living document to be iteratively reviewed and adjusted using a data driven and adaptive management approach as more knowledge about site conditions and outcomes become available. Monitoring sites may be added, moved (e.g., if sites or measurements become inaccessible), or eliminated; sampling frequency may be adjusted to better understand the response of the system to the MSA-2 implementation; or measurements may be added or eliminated if supported by the available data. Any significant modifications to the monitoring plan or the monitoring schedule must first be approved by the USACE in coordination with the Interagency Environmental Team (IET) and supported by monitoring data.

III. Success Criteria Monitoring

1) Enhance Forest Integrity

A. Overview

Forest integrity monitoring would document the basal areas and growth rates of bald cypress (*Taxodium distichum)* and water tupelo (*Nyssa aquatica)* trees using diameter at breast height (DBH) measurements on trees >5 cm within 1/8 ha (1200 m^2, 20 m radius) plots. Plot size was determined to complement and be comparable to the total plot sizes at each CRMS station (Folse et al., 2020). Each plot would contain four 1m^2 subplots for herbaceous vegetation (% cover) and canopy cover (%) measurements, located 10 m from the plot center in each cardinal direction. Dendrometer bands would be applied to a subset of trees (at least three each of bald cypress and water tupelo) in each plot to measure basal area increment (BAI) (m^2/ha/yr). Dendrochronology would also be used via tree core collection in TY5 (and TY10 if necessary) to support BAI growth rate measurements and provide additional insight on changes to forest health due to the MSA-2 operation. Duplicate tree cores would be collected from at least ten each of bald cypress and water tupelo trees for tree ring analysis within each habitat category (primary closed canopy, primary transitional canopy, etc.).

B. Success Criteria

Success Criterion	Initial Success	Intermediate and Long-Term Success
Basal Area (BA)	Maintain a stable or increasing mean BA (m^2/ha) relative to baseline (pre-MSA-2) BA for bald cypress and water tupelo trees in the mitigation benefit area.	N/A
Basal Area Increment (BAI)	Maintain stable or increasing BAI (m^2/ha/yr) growth rates relative to baseline (pre-MSA-2) growth rates for bald cypress and water tupelo trees in the mitigation benefit area.	Primary and Secondary Benefit areas: Demonstrate a 1.9-2.55x increase in mean BAI (m^2/ha/yr) growth rates relative to mean baseline (pre-MSA-2) growth rates at ≥ 75% of monitoring sites in the mitigation benefit area. Tertiary Benefit area: Demonstrate a 1.2-1.9x increase in mean BAI (m^2/ha/yr) growth rates relative to mean baseline (pre-MSA-2) growth rates at ≥ 75% of monitoring sites in the mitigation benefit area.

Table 2: Initial, Intermediate, and Long-term success criteria for Forest Integrity Enhancement

C. Considerations

- Initial success evaluates mean bald cypress and water tupelo growth rates in the entire site rather than by individual stations. Initial success accounts for possible BA/BAI declines at the onset of diversion operation, while ensuring any losses are offset by increased growth elsewhere during the first 10 years of implementation.

- Long-term success criteria must be maintained for the full 50 years of implementation. However, success criteria may be adjusted at the onset of long-term success monitoring based on available data describing site conditions. Any changes in the monitoring frequency or the success criteria must first be approved by the USACE in coordination with the MSA-2 partners and supported by monitoring data.

- Only the basal area and growth rates of bald cypress and water tupelo species are required for success achievement, but the health and presence of all woody species would be evaluated to document overall site changes. The presence of invasive species in the overstory, understory, and in ground vegetation would be noted and documented to inform possible adaptive management.

- Although not related to a success criterion, canopy cover measurements would be collected during forest integrity monitoring to help assess changes in forest productivity. Wetland Value Assessments for the MSA-2 anticipate a reduction in canopy cover decline relative to FWOP conditions. Comparing canopy cover changes in the MSA-2 area to those in control sites (FWOP sites) would help document the expected reduction in canopy cover decline.

- Remote sensing of forest habitat using satellite imagery would be conducted in TY-1 and approximately TY10, TY22, TY34, and TY50. Multi-temporal images from Landsat 7 Thematic Mapper data have been previously used in the Maurepas Swamp to categorize habitat and assess forest health and could be used for the MSA-2 as well (Keim et al., 2010; Keim et al., 2013).

D. Baseline Monitoring and Sampling Frequency (Table 3):

- Baseline monitoring for forest integrity would occur annually in the three years prior to diversion operation (TY-3 to TY-1) to establish baseline basal area, growth rates, and forest conditions. To maintain consistency and data compatibility between monitoring years, monitoring would occur at the same time every year to the extent possible.

E. Mitigation Monitoring and Sampling Frequency (Table 3):

- Monitoring for initial success would occur annually for the first five years (TY1-TY5) after implementation, then biennially until the forest integrity success criteria is achieved. The first possible evaluation for initial success would occur in TY6 with the last possible evaluation for initial success occurring in TY10. Once short-term success criteria are achieved, monitoring would transition into an assessment of the intermediate success criteria.

- Intermediate success monitoring would occur every three years until the success criteria are met. Sampling would coincide with CRMS monitoring, which also occurs at 3-year intervals, as closely as possible. Four consecutive successful monitoring events (i.e., at least a 12-year period) are required to document that intermediate success criteria have been met. Once intermediate success criteria are met, monitoring would transition into an assessment of the long-term success criteria.

- Long-term success monitoring would occur at six-year intervals for the remainder of the 50-year period of implementation. Long-term monitoring must demonstrate that the site continues to meet the success criteria for up to TY50.

- The number of forest integrity monitoring stations and frequency of monitoring could be decreased in later years of operation. The decision to decrease the sample intensity would be based on the 1) number of monitoring stations that meet the success criteria, and 2) distribution of those stations meeting the success criteria within the different forest cover types and benefit areas. The spatial distribution and similarity of monitoring stations would also be considered if decreasing the sampling intensity. Any changes in the number of monitoring stations must first be approved by the USACE in coordination with the IET and supported by monitoring data.

<table>
<tr><th>Timeline</th><th>Target Year (TY)</th><th>Monitoring Frequency</th><th># of Stations</th></tr>
<tr><td>Baseline</td><td>-3 to -1</td><td>Annually</td><td rowspan="5">46</td></tr>
<tr><td rowspan="2">Initial Success</td><td>1-5</td><td>Annually</td></tr>
<tr><td>6-10</td><td>Biennially</td></tr>
<tr><td>Intermediate</td><td>11-22</td><td>Every 3 years</td></tr>
<tr><td>Long-Term Success</td><td>23-50</td><td>Every 6 years</td></tr>
</table>

Table 3: Tentative timeline and frequency for forest integrity monitoring. Initial success is assumed to last 10 years for monitoring frequency description purposes but could be achieved as early as TY6. The conditional timeline presented considers the earliest period when success criteria can be met for intermediate monitoring if initial success is met at TY10.

F. Monitoring Methodology

- ***Basal Area and Basal Area Increment***
    - Diameter at breast height (DBH) measurements would be collected on all trees with a DBH >5cm within circular 1/8 ha (1,250 m^2, 20 m radius) plots for BA calculations. Although all trees in the plot would be measured, only bald cypress and water tupelo BA would be used for success evaluations. Diameter at breast height is measured at 4.5 ft (1.37 m) aboveground and trees would be tagged at DBH to ensure accurate measurements over time. Following CRMS SOP guidance, DBH on trees with a buttress greater than 3 ft (0.91 m) would be measured at 1.5 ft (0.46 m) above where the buttress stops tapering (Folse et al., 2020).

- Dendrometer bands would be applied at DBH to a subset of trees (at least three each of bald cypress and water tupelo) to calculate BAI growth rates. Species specific growth rates would be determined for bald cypress and water tupelo. To improve data accuracy for BAI measurements, dendrochronology measurements would be utilized in TY5 (and TY10 if necessary) to calculate changes in growth rates. Dendrochronology would analyze growth rates by measuring tree ring widths from duplicate tree cores collected from at least 10 bald cypress and 10 water tupelo trees in each of the six habitat categories, for a total of approximately 240 tree cores. Tree ring analysis can provide information on the influence of MSA-2 operation on forest health by comparing pre- and post-diversion tree ring widths. Additional ring analysis of tree cores in subsequent target years would provide continued insight on changes in forest health and BAI measurements.

- ***Canopy Cover***
  - Canopy cover (%) would be measured using a densitometer via ocular estimation within each of the four $1m^2$ subplots within each forest integrity monitoring plot.

- ***Herbaceous Vegetation***
  - Monitoring for herbaceous vegetation would occur within each of the four $1m^2$ subplots within each forest integrity monitoring plot. Herbaceous vegetation would be measured using percent cover (%) by ocular estimation and plants would be described to at least the genus level and the species level when possible.

2) Water Quality Improvement

A. Overview

Thirty-sites are selected for water quality (WQ) monitoring, including four CRMS sites and twenty-six mitigation specific stations co-located with forestry integrity monitoring stations (Appendix B). The 30 WQ stations are comprised of discrete only (12), continuous + discrete (14), and real-time + discrete (4) monitoring measurements. Discrete sampling stations would measure nitrate, DO, and additional WQ nutrients monthly. Continuous + discrete WQ stations would contain data loggers to measure water level and DO hourly (following CRMS guidance) with nitrate and additional WQ nutrients measured monthly. Real-time + discrete WQ stations provide water level, DO, and temperature data in present time, with nitrate and additional WQ nutrients measured monthly.

Fourteen sites are in the primary benefit area, nine in the secondary, and seven in the tertiary. Water quality measurements would be evaluated for success criteria monitoring when the MSA-2 is operating, but measurements would occur year-round. Water quality stations would be located near waterways adjacent to forest monitoring plots when possible to minimize possible channelization impacts from frequent site visits. Annual flight surveys during the MSA-2 operation would occur for the first six years of monitoring to assess operation and visually document freshwater flow and delivery to the mitigation benefit area in real time.

B. Success Criteria

Success Criterion	Initial Success	Intermediate and Long-Term Success
Nitrate	Demonstrate a 2x increase in surface water nitrate concentrations relative to baseline concentrations at ≥ 75% of monitoring sites during the MSA-2 operation. If baseline concentrations are ≤ 0.1 mg/L nitrate, then ≥ 0.2 mg/L nitrate must be attained for success.	All Benefit areas: Attain ≥ 0.45 mg/L nitrate concentrations at ≥ 75% of monitoring sites during the MSA-2 operation.
Dissolved Oxygen	Attain ≥ 2 mg/L dissolved oxygen concentrations at ≥ 75% of monitoring sites during the MSA-2 operation.	All Benefit areas: Attain ≥ 4 mg/L dissolved oxygen concentrations at ≥ 75% of monitoring sites during the MSA-2 operation

Table 4: Initial, Intermediate, and Long-term success criteria for Water Quality Improvement

C. Considerations

- Water quality stations adjacent to forest monitoring plots would be located, when possible, closer to adjacent waterways to minimize the potential of frequent boat visits to negatively impact forest conditions.

- Four real-time hydrographic stations would be located in the mitigation benefit area to document rapid changes to site conditions, such as extreme high or low water events, allowing an immediate response via adaptive management to operation if necessary.

- The four CRMS stations in the mitigation benefit area are currently equipped with hourly water level and salinity loggers and three are proposed for an upgrade to include hourly DO probes. A System-Wide Assessment and Monitoring Program (SWAMP) station is located at CRMS0063 and has monthly DO and nitrate data available since 2017.

- In addition to the metrics related to success criteria, additional WQ nutrients (C, N, and P) would be measured at the 30 discrete monitoring stations. These additional WQ measurements would help assess total nutrient introduction to the mitigation benefit areas to better understand diversion impacts and provide additional insight into nutrient dynamics that may impact conditions directly related to success criteria.

- During the initial success phase, water quality data and flight surveys would be used to assess hydrologic connectivity of the site and confirm diverted water is reaching the targeted mitigation benefit area. If data collection is insufficient to determine connectivity, isotopic measurements or remote sensing of hydrology may be alternatively utilized to better understand pathways, distribution, and extent of diversion flows throughout the mitigation benefit area.

- Discharge rates and water velocities would be measured to assess water flow within the mitigation benefit area and would be summarized in the mitigation monitoring reports.

D. Baseline Monitoring and Frequency (Table 5):

- Baseline monitoring would occur monthly during the three years prior to the MSA-2 operation (TY-3 to TY-1) to establish baseline WQ conditions. Three years of baseline data for WQ are scheduled to 1) account for any stochastic events (such as drought, saltwater intrusion, or high water events) that could occur during years of baseline data collection, and 2) improve accuracy of data representation of the site.

E. Mitigation Monitoring and Frequency (Table 5):

- Monitoring for initial success would occur monthly year-round (12 events per year).

- Monitoring for intermediate and long-term success would only occur during the MSA-2 operation.

- The number of WQ monitoring stations and frequency of monitoring could be decreased in later years of implementation. The decision to decrease the sample intensity would be based on the 1) number of monitoring stations that meet the success criteria, and 2) distribution of those stations meeting the success criteria within the forest cover and mitigation benefit area framework. The spatial distribution and similarity of monitoring stations would also be considered if decreasing the sampling intensity. Any changes in the number of monitoring stations must first be approved by the USACE in coordination with the IET and supported by monitoring data.

<table>
<tr><th>Timeline</th><th>Target Year (TY)</th><th>Monitoring Frequency</th><th># of Stations</th></tr>
<tr><td>Baseline</td><td>-3 to -1</td><td rowspan="2">Monthly</td><td rowspan="4">30

*12 discrete only
* 14 continuous and discrete (10 mitigation specific, 4 CRMS)
*4 real-time and discrete</td></tr>
<tr><td>Initial Success</td><td>1-10</td></tr>
<tr><td>Intermediate Success</td><td>11-22</td><td rowspan="2">Monthly during the MSA-2 operation</td></tr>
<tr><td>Long-Term Success</td><td>23-50</td></tr>
</table>

Table 5: Tentative timeline and frequency for Water Quality Improvement monitoring. Initial success is assumed to last 10 years for monitoring frequency description purposes but could be achieved as early as TY6. The conditional timeline presented considers the earliest period when success criteria can be met for intermediate monitoring if initial success is met at TY10. "During the MSA-2 operation" is defined as when the diversion is open and diverted water has spread throughout the mitigation benefit area, which is expected to occur after 20-30 days of continuous flow (FTN Associates, 2018).

F. Monitoring Methodology

- ***Nitrate***
  - Nitrate + nitrite (mg/L) would be measured by water sample collection at all 30 discrete monitoring stations. Water samples would be collected in HDPE bottles and analyzed using EPA method 353.4.

- ***Dissolved Oxygen***
  - Dissolved oxygen (mg/L and % saturation) would be measured using continuous (14) and real-time (4) monitoring loggers at 18 WQ stations. Continuous loggers would collect data hourly, be positioned at least 10 cm above the swamp floor, and placed in the water column where it would be submerged at mean low water level (Folse et al., 2020). Dissolved oxygen loggers would be checked and maintained periodically during the monthly water quality sampling. Dissolved oxygen would also be measured monthly in all 30 discrete WQ stations using a handheld sonde. If water depth is greater than 2 feet, DO would be measured at each one-foot depth increment (Folse et al., 2020). During discrete DO collection, water temperature (°C), pH, specific conductivity (µS/cm), salinity (ppt), and turbidity (FNU) would also be collected via the handheld sonde.

- ***Water Temperature and Level***
  - Water levels loggers that measure both water depth and temperature would be deployed at the 18 continuous and real-time WQ stations. Continuous loggers would collect data hourly, be positioned at least 10 cm above the swamp floor, and placed in the water column where it would be submerged at mean low water level (Folse et al., 2020).

- ***Water Quality Nutrients***
  - Water quality nutrients would be collected simultaneously with discrete nitrate measurements at all 30 discrete WQ stations. Ammonium (NH_4^+), Phosphorus (PO_4^{-3}), Total N (TN), and Total P (TP) would be measured using EPA methods 350.1, 365.5, and Standard Method 4500 P-J (TN and TP), respectively, following protocols outlined by CRMS SOP (Folse et al., 2020). Nutrient analysis is designed to capture all nutrient forms and delivery to the benefit area, providing a greater context for assessing nutrients related to success criteria.

- *Porewater Salinity and Temperature*
  - Porewater salinity and temperature would be collected using sipper samplers and measured using a handheld sonde in each herbaceous plot during forest integrity monitoring and bimonthly (every two months) at each continuous WQ station. Samples would be collected at 10 and 30 cm below the swamp surface, following CRMS protocol (Folse et al., 2020).

3) <u>Increase Sediment Accumulation and Soil Surface Elevation</u>

A. Overview

Sediment accumulation and soil surface elevation monitoring is designed to demonstrate increased sediment delivery, retention, and accretion in the mitigation benefit area. To evaluate sediment delivery, initial success monitoring would evaluate total suspended solid (TSS) measurements at varying distances from the diversion outfall. A decrease in TSS concentrations with distance from the outfall would provide evidence demonstrating sediment delivery is occurring. Sediment retention would be measured through bulk density and inorganic sediment content analyses in surface sediment. Bulk density and inorganic sediment content would provide evidence of increased sediment retention in the mitigation benefit area.

Total suspended solid measurements would occur at the 30 WQ stations, which are adjacent to/within waterways near forest integrity stations (Appendix B). Volatile suspended solids (VSS) would also be measured to better ensure TSS measurements are capturing new sediment delivery rather than the resuspension of existing site sediment. Inorganic sediment retention sampling would occur at the 18 forest integrity sites containing continuous/real-time water WQ stations. In addition to the specific metrics related to success criteria, soil nutrients and salinity would be measured from soil samples during initial success to quantify the impact of river reintroduction on soil nutrients.

Rod-Surface Elevation Tables (RSETs) would be utilized to demonstrate soil surface elevation changes for intermediate success monitoring. Accretion measurements, using feldspar marker horizons, would occur in conjunction with each RSET. Given the low bulk densities exhibited in the mitigation benefit area and associated difficulty with reliable surface elevation data, monitoring stations containing RSETs are located where reliable data can be collected while still representing a range of site conditions. There are eight RSET locations planned in the mitigation benefit area: three associated with CRMS stations and five MSA-2-specific stations (Appendix B).

B. Success Criteria

<table>
<tr><th>Success Criterion</th><th>Initial Success</th><th>Intermediate and Long-Term Success</th></tr>
<tr><td rowspan="2">Inorganic Sediment Retention</td><td>A) Increased sediment retention within the mitigation benefit area based on increased TSS concentrations delivered to the mitigation area compared to baseline (pre MSA-2) conditions.</td><td rowspan="2">N/A</td></tr>
<tr><td>B) Increased inorganic sediment concentrations in surface sediments relative to baseline (pre MSA-2) conditions and those observed in sites outside of the mitigation benefit area.</td></tr>
</table>

Soil Surface Elevation Change	N/A	Primary and Secondary Benefit areas: Attain an additional 5.0 ± 1 mm/yr increase in wetland soil surface elevation rates at ≥ 75% of monitoring sites. Tertiary Benefit area: N/A

Table 6: Initial, Intermediate, and Long-term success criteria for Sediment Accumulation and Soil Surface Elevation

C. Considerations

- Two active RSETs are located at CRMS stations 0097 and 5414. Six additional RSETs are proposed for installation, five at the MSA-2 specific stations and one at CRMS0063.

- Although not a success criterion, surface accretion measurements at each RSET plot would be collected in conjunction with RSET measurements using a feldspar marker horizon. Utilizing both RSET and the marker horizon technique allows for a better distinction between surface elevation changes from subsurface processes and surface accretion.

- After initial success is met, TSS, VSS, and inorganic sediment retention measurements would cease, and criteria monitoring would transition to surface elevation changes from RSETs. However, if concerns arise related to sediment delivery and retention in the tertiary benefit area after the initial success period ends, TSS, VSS, and inorganic sediment retention monitoring may continue into the intermediate and long-term success phases. Any changes in the monitoring frequency or the success criteria must first be approved by the USACE in coordination with the IET and supported by monitoring data.

D. Baseline Monitoring and Frequency (Table 7):

- Baseline TSS monitoring would occur monthly in conjunction with other WQ measurements in the two years (TY-2 to TY-1) prior to diversion operation to establish pre-construction sediment conditions.

- Baseline sediment content monitoring would occur once in the year preceding diversion operation (TY-1).

- The five MSA-2-specific Rod-SETS would be installed in TY-4 and monitored annually to measure baseline soil surface elevation measurements.

E. Mitigation Monitoring and Frequency (Table 7):

- **TSS and VSS:** Monitoring for TSS + VSS would occur in the 30 forest integrity sites containing WQ stations, with samples collected monthly throughout the year. Only measurements collected during diversion operation would relate to success determinations.

- **Inorganic Sediment Retention:** Sediment cores would be collected annually in the 18 forest integrity sites containing real-time/continuous WQ stations for the first five years (TY1-TY5) post construction. Afterwards, samples would be collected biennially until success criteria are met.

- **Soil Surface Elevation Change**: Rod-SETS/accretion stations would be monitored annually throughout the MSA-2 implementation but would not be used for success evaluations until the intermediate and long-term success monitoring phases.

- The number of monitoring stations and frequency of monitoring could be decreased in later years. The decision to decrease the sample intensity would be based on the 1) number of monitoring stations that meet the success criteria, and 2) distribution of those stations meeting the success criteria within the forest cover and benefit area framework. The spatial distribution and similarity of monitoring stations would also be considered if decreasing the sampling intensity. Any changes in the number of monitoring stations must first be approved by the USACE in coordination with the MSA-2 partners and supported by monitoring data.

Timeline	Target Year (TY)	Monitoring Frequency	# of Stations	Monitoring Method
Baseline	-2 to -1	Monthly	30	TSS and VSS
	-1	Annually	18	Sediment Retention
	-4 to 10	Annually	8	R-SETS
Initial Success	1-10	Monthly	30	TSS and VSS
	1-5	Annually	18	Sediment Retention
	6-10	Biennially		
Intermediate Success	11-22	Annually	8	R-SETS
Long-Term Success	23-50	Annually	8	R-SETS

Table 7: Tentative timeline and frequency for Sediment Accumulation and Soil Surface Elevation monitoring. Initial success is assumed to last 10 years for monitoring frequency description purposes but could be achieved as early as TY6. The conditional timeline presented considers the earliest period when success criteria can be met for intermediate monitoring if initial success is met at TY10.

F. Monitoring Methodology

- ***TSS and VSS***
  - Grab water samples would be collected using HDPE bottles and analyzed for TSS and VSS using methods SM 2540 D and SM 2540 E, respectively (Folse et al., 2020).

- ***Inorganic Sediment Retention***
  - Sediment cores (2 duplicates per site) for bulk density (g/cm^3) and inorganic sediment content (%) measurements would be collected using the push core (4 cm diameter) method to a depth of 20 cm. Cores would be divided in to 4 cm sections for a total of 5 samples per core and 15 samples per site. Samples would be analyzed for inorganic sediment content by sample drying and combustion of organic material to determine mineral content. If bulk density and organic matter measurements are insufficient to determine sediment retention, short-lived radioisotope tracers, such as Berrilyium-7 (^{7}Be), may be used annually to quantify recent sediment deposition.

- ***Soil Properties***
  - Soil properties would be measured from the sediment samples collected for inorganic sediment retention measurements. Soil TN/TC/TP (mg/kg), extractable NO_3^- (mg/kg), NH_4^+ (mg/kg), PO_4^{-3} (mg/kg), and salinity (ppt) would be measured according to their respective USEPA standard methods. Soil properties would only be assessed during initial success monitoring and would inform nutrient input into the site, providing additional context for nutrient assessments related to success.

- ***Soil Surface Elevation Change***
  - Protocols for installing, maintaining, and monitoring RSETs are detailed in Folse et al. (2020) and follow methods previously described by Cahoon et al. (2002a and 2002b). If RSET measurements are ineffective to demonstrate surface elevation changes, radioisotope dating, such as lead-210 (^{210}Pb), radium-226 (^{226}Ra), and cesium-137 (^{137}Cs), of sediment cores may be used to measure long-term sediment accretion.

4) <u>Salinity Maintenance</u>

A. Overview

Salinity monitoring would document the impact of river reintroduction on maintaining or decreasing current salinities in the Maurepas Swamp. Salinity monitoring would coincide with the WQ monitoring, containing discrete-only (12), continuous + discrete (14), and real-time + discrete (4) stations (Appendix B). Discrete station sampling would measure salinity monthly using a handheld sonde. Continuous + discrete stations would contain data loggers to measure salinity hourly (following CRMS guidance). Real-time stations would provide current salinity and specific conductance measurements in present time.

B. Success Criteria

Success Criterion	Initial Success	Intermediate and Long-Term Success
Salinity Maintenance	All Benefit areas: Maintain a salinity of ≤0.8 ppt at ≥ 75% of monitoring sites	

Table 8: Initial, Intermediate, and Long-term success criteria for Salinity Maintenance

C. Considerations

- Four real-time hydrographic stations would be located in the mitigation benefit area to document rapid changes to site conditions, such as extreme high or low water events, allowing an immediate response via adaptive management to operation if necessary.

- Four CRMS stations in the mitigation benefit area (CRMS0063, 5414, 0097, and 0089) contain active, continuous salinity loggers and are included in the 14 continuous salinity monitoring stations.

- The success criterion related to salinity would only be evaluated during diversion operation; however, monitoring would occur year-round to capture salinity changes due to storm surges, drought, saltwater intrusion events, etc., to inform potential adaptive management operations.

D. Baseline Monitoring and Frequency (Table 9):

- Baseline monitoring would occur monthly during the three years prior to diversion operation (TY-3 to TY-1).

E. Mitigation Monitoring and Frequency (Table 9):

- Monitoring for initial success would occur monthly year-round (12 events per year) in the 30 WQ stations. Only salinity measurements recorded during diversion operation would be used to determine if success criteria are being met, but monitoring would occur year-round to document salinity changes from episodic events.

- The number of monitoring stations and frequency of monitoring could be decreased in later years. The decision to decrease the sample intensity would be based on the 1) number of monitoring stations that meet the success criteria, and 2) distribution of those stations meeting the success criteria within the forest cover and benefit area framework. The spatial distribution and similarity of monitoring stations would also be considered if decreasing the sampling intensity. Any changes in the number of monitoring stations must first be approved by the USACE in coordination with the IET and supported by monitoring data.

Timeline	Target Year (TY)	Monitoring Frequency	# of Stations
Baseline	-3 to -1	Monthly	30 *12 discrete only * 15 continuous and discrete (11 MSA-2 specific, 3 CRMS) *4 real-time
Initial Success	1-10		
Intermediate Success	11-22	Monthly during the MSA-2 operation	
Long-Term Success	23-50		

Table 9: Tentative timeline and frequency for Salinity Maintenance. Initial success is assumed to last 10 years for monitoring frequency description purposes but could be achieved as early as TY6. The conditional timeline presented considers the earliest period when success criteria can be met for intermediate monitoring if initial success is met at TY10. "During the MSA-2 operation" is defined as when the structure is open and diverted water has spread throughout the mitigation benefit area, which is expected to occur after 20-30 days of continuous flow (FTN Associates, 2018).

F. Monitoring Methodology

- ***Salinity Maintenance***
  - Salinity would be measured using continuous (14 stations) or real-time (4 stations) monitoring loggers in 18 WQ stations. Continuous loggers would collect data hourly. Salinity loggers would be checked and maintained periodically during the monthly water quality sampling. In all 30 discrete WQ stations, salinity would also be measured manually using a handheld sonde during the monthly water quality sampling. If water depth is greater than 2 feet, salinity would be measured at each one-foot depth increment. During discrete salinity collection, water temperature (°C), pH, specific conductivity (µS/cm), DO (mg/L and % saturation), and turbidity (FNU) would also be collected via the handheld sonde.

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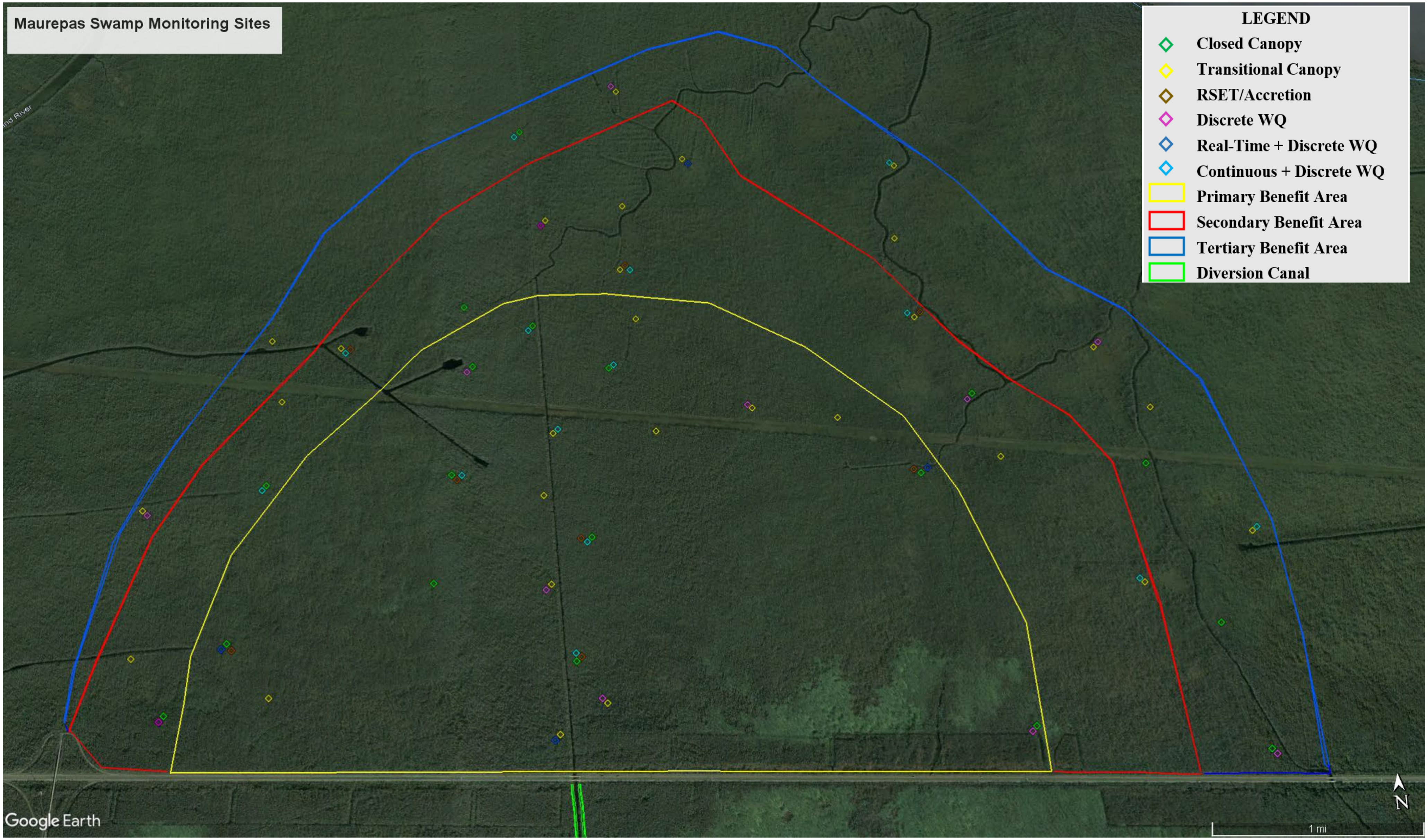
Appendix A: Summary of Initial, Intermediate, and Long-Term Success Criteria

Success Criteria	Initial Success Target	Intermediate and Long-Term Success Target
Increase Forest Integrity	Stable or increasing BA (m^2/ha) and BAI (m^2/ha/yr) growth rates relative to baseline conditions (pre MSA-2) for bald cypress and water tupelo in the mitigation benefit areas.	Primary and Secondary Benefit areas: 1.9-2.55x increase in BAI relative to baseline growth rates at ≥ 75% of monitoring sites in the mitigation benefit area. Tertiary Benefit area: Demonstrate a 1.2-1.9x increase in mean BAI (m^2/ha/yr) growth rates relative to mean baseline (pre-MSA-2) growth rates at ≥ 75% of monitoring sites in the mitigation benefit area.
Water Quality Improvement	**Nitrate (mg/L)**: 2x increase relative to baseline conditions at ≥ 75% of monitoring sites during the MSA-2 operation. *If baseline concentrations are ≤ 0.1 mg/L nitrate, then target is ≥ 0.2 mg/L nitrate.	All benefit areas: Attain ≥ 0.45 mg/L at ≥ 75% of monitoring sites during the MSA-2 operation.
	Dissolved Oxygen (mg/L): ≥ 2 mg/L at ≥ 75% of monitoring sites during the MSA-2 operation.	All benefit areas: Attain ≥ 4 mg/L at ≥ 75% of monitoring sites during the MSA-2 operation.
Increase Sediment Accumulation and Soil Surface Elevation	**Sediment Delivery and Retention**: **1)** Increased sediment retention within the mitigation benefit area. **2)** Increased inorganic sediment content relative to baseline conditions and those observed in sites outside of the mitigation benefit area.	None for intermediate or long-term success.
	Wetland Soil Surface Elevation Change: None for initial success.	Primary and Secondary Benefit areas: An additional 5.0 ± 1 mm/yr increase at ≥ 75% of monitoring sites in the mitigation benefit area. Tertiary Benefit area: None for intermediate or long-term success.
Salinity Maintenance	All benefit areas: ≤0.8 ppt at ≥ 75% of monitoring sites in the mitigation benefit area.	

Appendix B: Map of proposed monitoring locations in the Maurepas Swamp Mitigation Benefit Area



Appendix C: CRMS locations and their associated monitoring in the Maurepas Swamp

Success Criteria	Data Collected	In Mitigation Benefit Area				Proposed Control Sites			Proposed Supportive Monitoring Sites		
		0063	5414	0097	0089	5167	0065	0047	0061	5255	0090
Enhance Forest Integrity	Basal Area/Basal Area Increment	x	x	x	x	x	x	x	x	x	x
	Herbaceous Vegetation	x	x	x	x	x	x	x	x	x	x
	Canopy Cover	x	x	x	x	x	x	x	x	x	x
Improve Water Quality	Water Level/Water Temp	x	x	x	x	x	x	x	x	x	x
	Dissolved NO_3^-	x*								x*	
	Dissolved Oxygen	x*								x*	
	Water Nutrients	x*								x*	
Increase Sediment Accumulation and Soil Surface Elevation	RSET/Accretion	x (last in 2013	x	x		x	x	x	x	x	
	Soil Properties (% Organic Matter and Bulk Density)	x	x	x	x	x	x	x	x	x	x
	TSS/VSS	x*								x*	
Maintain Salinity	Salinity (ppt)	x	x	x	x	x	x	x	x	x	

**** Data collected monthly in SWAMP0205***

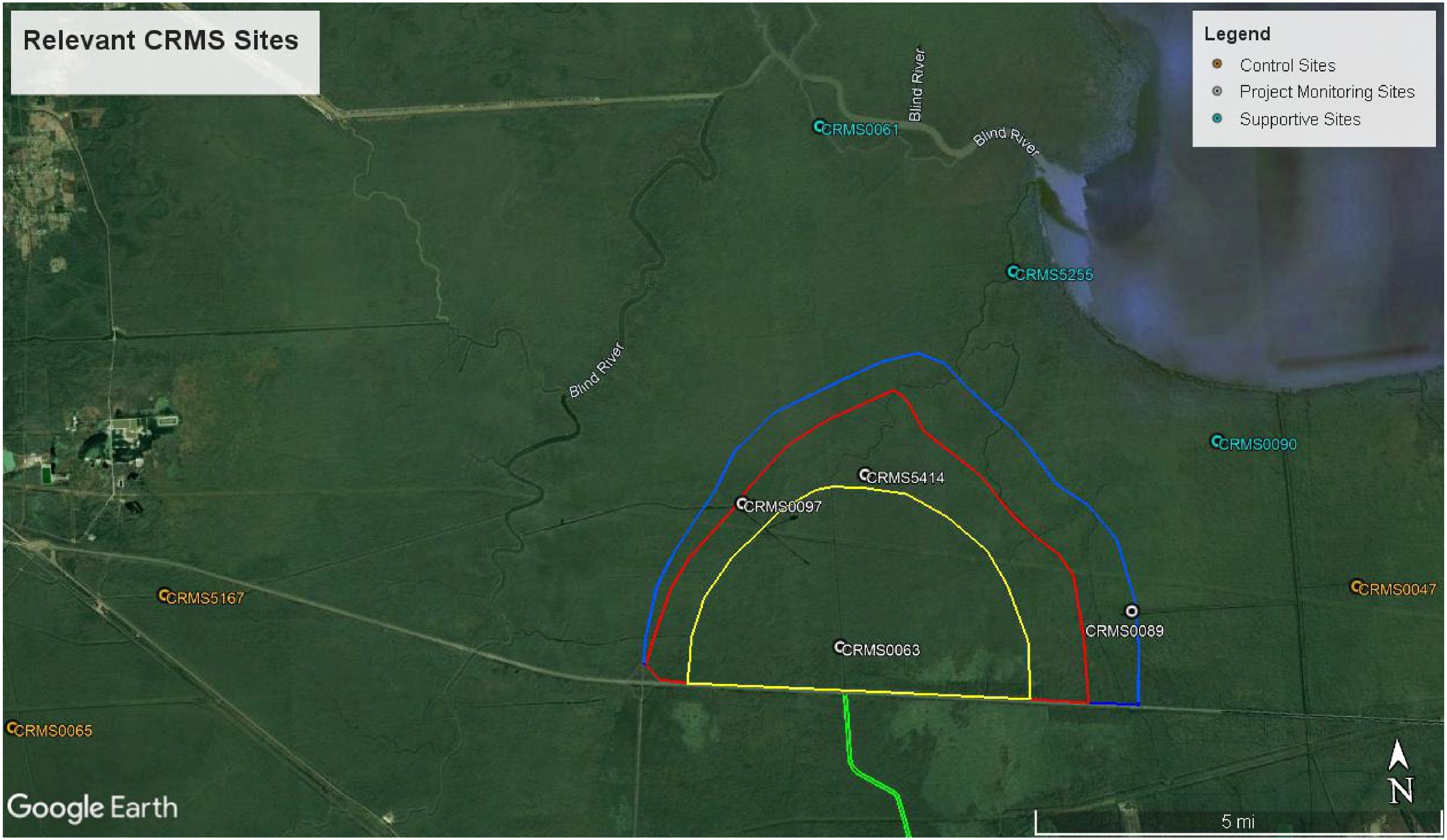


Figure 1: Locations of relevant CRMS Stations in and near the MSA-2 area. CRMS sites labeled in white are within the mitigation benefit area and would be used for mitigation monitoring. Light blue sites are potential control sites and orange sites are potential supportive monitoring sites. (Google Earth, 2022)

Appendix D: Summary of Monitoring Measurements

Criteria	Measurement	Method	Monitoring Locations
Enhance Forest Integrity	**Basal Area (m^2/ha) and Basal Area Increment (m^2/ha/yr)**	DBH measurements using at 4.5 ft (1.37 m) above grade within 1/8 ha plots. A subset of trees in each site would be equipped with dendrometer bands for BAI measurements. Dendrochronology measurements would be additionally utilized in TY5 for BAI measurements.	Primary Closed canopy: 10 Primary Transitional Canopy: 10 Secondary Closed Canopy: 4 Secondary Transitional Canopy: 10 Tertiary Closed Canopy: 4 Tertiary Transitional Canopy: 8
	Canopy cover (%)	Densitometer	
	Herbaceous Vegetation	Subplots (0.004 ha) within forestry sites; % cover by ocular estimation	
Improve Water Quality	**Nitrate (mg/L)**	Discrete sample collection and subsequent laboratory analysis	30 Co-located with a subset of forest plots (Combination of discrete, continuous, and real-time)
	Dissolved Oxygen (mg/L)	Continuous DO loggers and measured manually via handheld sondes at discrete locations	
	Water temperature and water level	Continuous loggers	
	NH_4^{+}, PO_4^{-3}, TN, TP	Discrete sample collection and subsequent laboratory analysis	
	pH, specific conductivity, and turbidity	Measured manually via handheld sondes at discrete locations	
Increase Sediment Accumulation and Soil Surface Elevation	**Total Suspended Solids (TSS)**	TSS + VSS measurements	Within all 30 WQ plots
	Inorganic Sediment Retention	Sediment core collection and subsequent sample drying and combustion of organic material to determine mineral content	At the 18 continuous and real-time WQ monitoring sites
	Soil Properties. Soil TN/TC/TP; NO_3^{-}; NH_4^{+}; PO_4^{-3}; % organic matter; soil salinity; bulk density	Sediment core collection and subsequent laboratory analysis	
	Soil surface elevation change	Rod-SETs	Within 8 R-SET locations: 3 CRMS + 5 new locations. (Would reinstate surface elevation measurements at CRMS0063 if possible.)
Salinity Maintenance	**Salinity (ppt)**	Continuous loggers + measured manually at discrete monitoring locations	Within all 30 WQ plots

Table 1: Summary of Monitoring measurements, methods, and locations. Bold measurements are those directly related to success criteria.

MSA-2 Adaptive Management Plan

Draft Adaptive Management Plan
Maurepas Swamp Alternative for WSLP Mitigation

3/08/2022

Table of Contents

1. Overview

This Adaptive Management Plan (AMP) for the Maurepas Swamp Alternative 2 (MSA-2) has been developed in coordination with the Louisiana Coastal Protection and Restoration Authority (CPRA), U.S. Army Corps of Engineers (USACE), Mississippi Valley Division, New Orleans District (CEMVN) and the interagency Habitat Evaluation Team (HET) members, including U.S. Fish and Wildlife Service (USFWS), Louisiana Department of Wildlife and Fisheries (LDWF), and the Louisiana Department of Natural Resources (LDNR). This plan presents the decision-making framework that would be used to assess and determine success of the MSA-2 as compensatory mitigation and identifies potential thresholds for implementing adaptive management actions to ensure mitigation success criteria are achieved.

The AMP for the No-Action alternative is contained within EA#576. The AMPs for the MSA-2's known impacts to BLH and marsh habitat are identified in Section 5 of the SEIS and included in Appendix G and are not discussed within this AM plan.

This plan is a living document that would be updated as needed to reflect current site conditions and/or other environmental changes; revisions to the monitoring plan: Maurepas Swamp Alternative-2 50 Year Mitigation Monitoring Plan (SEIS Appendix H; Hurst and Berkowitz, 2022), hereafter referred to as the Monitoring Plan; adaptive management actions; and updates to the decision-making framework. This plan would be executed and maintained by the CEMVN Environmental Planning Branch of Regional Planning & Environment Division, South until the initial success criteria targets are met, which must occur within ten years after the start of diversion operations. Once initial success is achieved, the non-federal sponsor (CPRA) would assume responsibility for executing and maintaining the AMP as necessary to ensure full satisfaction of the mitigation requirement is achieved.

2. Background and History

2.1 Alternative Description

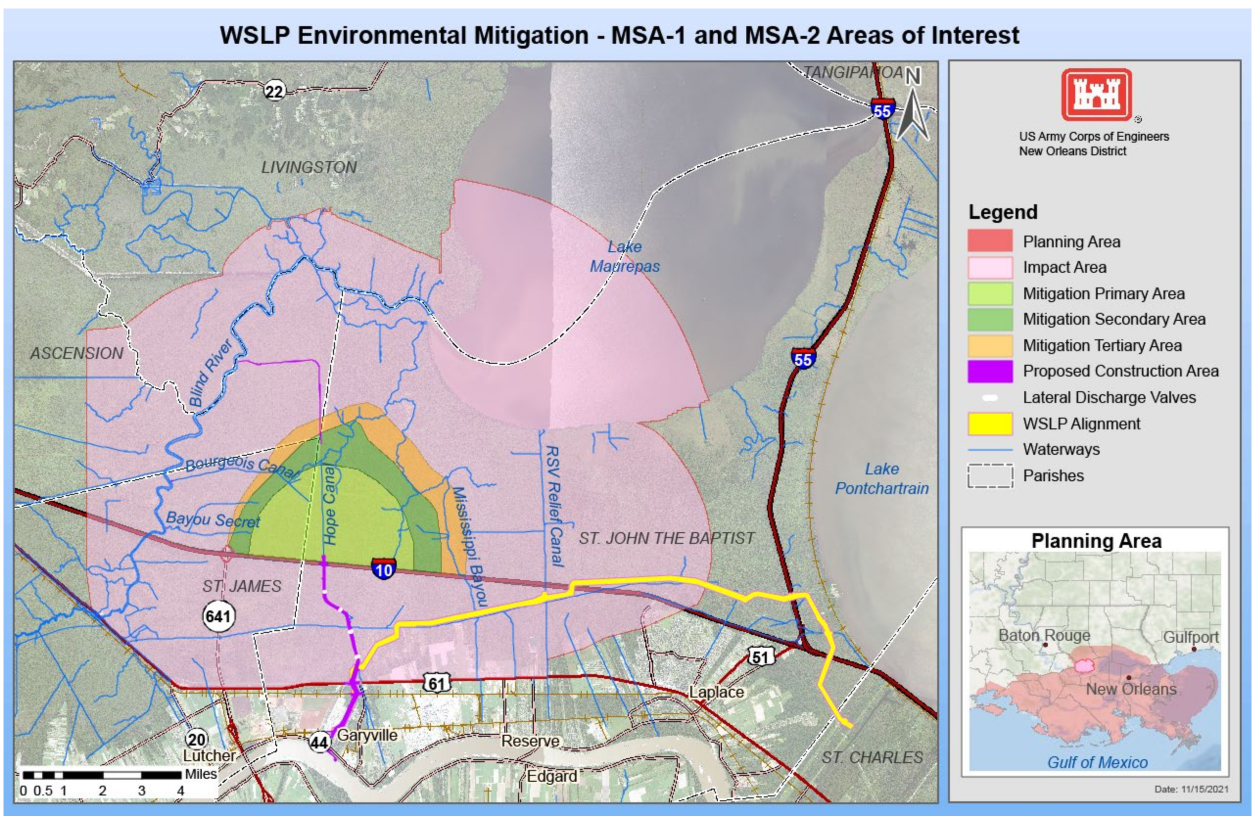
The Maurepas Swamp Project, (MSP), was considered by the CEMVN as compensatory mitigation for coastal zone (CZ) swamp impacts incurred by the WSLP project. The MSP was converted into several viable compensatory mitigation alternatives including MSA-1 (public and private lands) and MSA-2 (public lands only). The alternatives were evaluated, determined to provide sufficient benefits through enhancement of existing swamp habitat and compared to the no action plan (BBA alternative). This analysis determined that the no action plan remained the federally selected plan. However, since the Non-Federal Sponsor (CPRA) supported and agreed to pay costs above the federally selected plan, , the MSA-2 was selected as the Tentatively Selected Alternative. The reintroduction of 2,000 ft^2/s of Mississippi River flow to the Maurepas Swamp is anticipated to improve swamp health and productivity by increasing dissolved oxygen and nitrate availability, enhancing sedimentation, and maintaining low salinity levels. The primary diversion features include the following:

- an intake channel in the batture of the Mississippi River;
- an automated gate structure in the Mississippi River levee;
- a sedimentation basin;
- a 5.5-mile-long open conveyance channel;

- box culverts under River Road, Canadian National Railroad (CN), and Airline Highway;
- a bridge over the channel at Kansas City Southern Railroad (KCS);
- up to approximately 32 lateral discharge valves between Airline Highway and I-10 to carry flow from the conveyance channel to areas east and west of the channel;
- check valves on culverts underneath I-10 to reduce or eliminate southward backflow;
- reshaping of the geometry of the existing Hope Canal channel under I-10;
- embankment cuts in the existing ridge of an old railroad embankment located in St. John the Baptist and Ascension Parishes;
- submerged rock rip-rap weirs in Bayou Secret and Bourgeois Canal located in St. James Parish;

2.2 Location

The MSA-2 is located in the Maurepas Swamp north of Interstate 10, east of Blind River, south of Lake Maurepas, and west of Reserve Relief Canal. Establishment of the mitigation area boundaries for MSA-2 was completed by the Interagency Environmental Team (IET), including the CPRA and CEMVN, using hydrologic modeling results produced by the CPRA and benefits determined by the wetland value assessment (WVA). The geographic boundaries of the mitigation area, including Primary, Secondary and Tertiary Benefit Areas, are depicted below in Figure 1.



The intake structure of the diversion would be located on the east bank of the Mississippi River in St. John the Baptist Parish, immediately west of Garyville, Louisiana, at River Mile 144 above Head of Passes. The conveyance channel traverses between the Marathon Petroleum Terminal upriver and the Ernest Amann residential subdivision downriver and extends northward for 5.5 miles, terminating approximately 1,000 feet north of Interstate 10 (I-10). The majority of the MSA-2 features are located in St. John the Baptist Parish, with the exceptions being the Bayou Secret and Bourgeois Canal weirs that are located in St. James Parish, and the railroad embankment gaps, which are located in St. John the Baptist and Ascension Parishes.

2.3. MSA-2 Objectives

The objective of the MSA-2 is to enhance important Maurepas Swamp habitat to provide compensatory mitigation for adverse impacts to swamp habitat from the construction and implementation of the WSLP project. The MSA-2 would convey Mississippi River water into the Maurepas Swamp to improve the structure, function, and resilience of the coastal forest habitat through reintroduction of fresh oxygenated water, nutrients, and sediment. The MSA-2 can generate approximately 1,033 net AAUHs in all three of the benefit areas (primary, secondary, and tertiary) combined.

3. Data Collection, Management, Analysis and Reporting

3.1 Data Collection and Management

Independent of adaptive management, an effective monitoring program would be required to determine if the MSA-2 outcomes are consistent with mitigation objectives and requirements stated in 33 USC 2283 (d)(3)(B) for mitigation. Appendix H of the SEIS includes the plan for monitoring the implementation and ecological success of the MSA-2, including the duration of any monitoring, as well as the criteria for ecological success by which the mitigation project would be evaluated.

Monitoring associated with the MSA-2 would include two types of monitoring: monitoring to ensure mitigation benefits are achieved and monitoring to ensure no additional impacts are incurred from the implementation of the MSA-2 that would require additional mitigation. The monitoring specified in the Mitigation Monitoring Plan (Appendix H of the SEIS Monitoring Plan) is associated with ensuring the MSA-2 produces sufficient benefits to mitigate impacts incurred by the WSLP project and the implementation of the MSA-2. The monitoring included in this Adaptive Management Plan is associated with ensuring additional impacts beyond what has already been assessed for the MSA-2 are not experienced. If additional impacts from the implementation of the MSA-2 are identified, adaptive management actions may be employed to either rectify or mitigate such impacts and the potential for additional NEPA documentation may be necessary to identify what additional mitigation would be necessary. Monitoring data from all sources can be used to inform the Operation Plan (Appendix N of the SEIS).

The currently known impacts from implementation of the MSA-2 and plans to mitigate those impacts are identified in Section 5 of the SEIS. These mitigation plans would require their own monitoring and adaptive management plans which would be included in Appendix G of the SEIS.

Data collection and management, associated methods, station locations, and monitoring frequency required to ensure mitigation requirements are met are detailed in the Monitoring Plan (Appendix H of the SEIS Monitoring Plan). The CEMVN is responsible for data collection and management until Initial Success is attained, after which time, attainment of Intermediate and Long-Term Success becomes the responsibility of CPRA.

3.2 Data Delivery and Management

Data management is an important component of the overall adaptive management program. A data management plan would be developed between the CEMVN and the CPRA to inform adaptive management actions as well as guide data collection activities that may be conducted by multiple agencies. This plan would include descriptions of data standards, quality assurance/quality control requirements, and metadata standards.

The CPRA would, when possible, utilize their public Coastal Information Management System (CIMS) database (https://cims.coastal.louisiana.gov) to store, display, and facilitate download of data that would be collected for mitigation and adaptive management monitoring; however, differences in CEMVN data collection protocols and quality assurance/quality control (QA/QC) may require some additional processing of the data before being posting to CIMS could occur, especially prior to the MSA-2 turnover. Information about the CPRA's well-established system for data collection, processing, and QA/QC is outlined in the Coastwide Referencing Monitoring System (CRMS)/System-Wide Assessment and Monitoring Program (SWAMP) standard operation procedures manual (Folse et al., 2020). Data collection that deviates from the CRMS protocol would still maintain compatibility with CRMS data.

The timeline for delivery of data between the CEMVN, CPRA, and the IET would be specific to the type of data being collected and would be outlined in the Monitoring Plan prior to the initiation of baseline data collection efforts.

3.3 Data Analysis and Assessment

Data Analysis and assessment is a critical step in determining if AM actions need to be implemented for the MSA-2. The results of the monitoring program would be regularly assessed in relation to the required MSA-2 projected outcomes. This assessment process would continually measure the progress of the MSA-2 in relation to the stated goals and objectives in Section 2.3. This assessment process would continue through the life of MSA-2 and would be used to inform reporting and support AM decision making.

The specifics regarding data analysis have yet to be finalized and may require further IET discussion. Once these details have been determined, the MSA-2 Monitoring and Adaptive Management plans would be updated with clear guidance regarding data analysis required for AM.

3.4 Reporting

3.4.1 Mitigation Monitoring Reports

The IET would be responsible for reviewing monitoring data, analyses, procedures, and reports; providing their assessment on whether success criteria have been met; and proposing appropriate actions when one or more success criteria have not been attained. The IET would be primarily comprised of federal and state agency practitioners and scientists. Team members would be involved in specific scientific details of the MSA-2 and may make scientifically-based operational and adaptive management recommendations. Assembling the IET and outlining member roles and responsibilities would be the responsibility of the USACE and CPRA.

3.4.2 Operations, Maintenance and Adaptive Management Reports

An Operations, Maintenance and Adaptive Monitoring Report would be written every three years at a minimum after the start of diversion operations. The report would summarize and assess diversion operations during the previous three-year period and would describe anticipated operations for the next three years in accordance with the operations plan (Appendix N). Any unanticipated changes that were needed would also be described and evaluated for potential inclusion in the AMP. All completed maintenance during the previous three years would be documented in the report and upcoming potential maintenance needs would be addressed. Any new adaptive management monitoring data (water elevation, forested and herbaceous vegetation, bioaccumulation/ contaminants) collected during the previous three-year period would also be presented in the report, and these data would be analyzed with any previously collected data, as applicable (see sections 5.6 and 5.7). All adaptive management measures that were enacted as a result of mitigation monitoring, adaptive management monitoring, inspections, or any events or conflicts would be documented and discussed.

4. AMP Development and Purpose

4.1 AMP Development

The initial version of the AMP was developed and reviewed by the CEMVN, CPRA and the HET members, including USFWS, LDWF, and LDNR. The plan has been heavily influenced and assisted by PDT discussion, HET meetings, and input both from USACE Engineer Research and Development Center (ERDC) and the Maurepas Technical Advisory Group (TAG) that consists of Dr. Ken Krauss, Dr. Richard Keim, Dr. Gary Shaffer, and Dr. Jim Chambers. The plan was revised after the selection of the MSA-2 as the Tentatively Selected alternative by the USACE.

4.2 AMP Purpose

The purpose of this AMP is to assess the risks associated with achieving (or not achieving) the projected benefits of the MSA-2 and to address what actions may be necessary to ensure the mitigation requirements are achieved if these risks become reality. This AMP would guide decisions for revising operations and maintenance plans and implementing measures to address both foreseeable and unforeseeable circumstances that may adversely affect the MSA-2 success. The AMP is heavily reliant on the results of mitigation monitoring, as detailed in the Monitoring Plan, and AM actions are anticipated to be largely associated with the operation and maintenance (O&M) of the MSA-2, as described in the Operations and Maintenance plans (Appendix N). If O&M actions do not result in attainment of the required average annual habitat units (AAHUs) for the MSA-2, alternate options to attain the MSA-2 success are also provided. Additionally, adaptive management would include the management of targeted invasive species that threaten the functionality and integrity of the MSA-2.

5. Adaptive Management

Adaptive management is a process that allows for decisions to be made in the face of uncertainty to increase the likelihood that the MSA-2 goals and objectives are met. The MSA-2 would be adaptively managed to achieve the desired outcomes and mitigation objectives, while reducing undesirable impacts. The expected outcome is to provide at least 1,239 AAHUs of swamp habitat through enhancement as compensatory mitigation for the WSLP project impacts and impacts incurred by implementation of the MSA-2.

The MSP has been in development for decades and, at the programmatic level, knowledge gained through various studies and designs and from lessons learned from other constructed freshwater diversions (e.g., Davis Pond, Caernarvon, etc.) in Louisiana have been applied to the development of the MSA-2. The use of adaptive management approaches during the MSA-2 planning informed the selection of design and operation elements to meet the MSA-2 objectives and mitigation requirements. This AMP defines and justifies where adaptive management is needed during construction and/or the operations phase in relation to mitigation success criteria. A primary component of adaptive management for the MSA-2 is the mitigation Monitoring Plan, which contains multiple success criteria that were developed to gauge whether the MSA-2 is meeting mitigation requirements. Additional monitoring would be conducted as part of adaptive management to address potential indirect impacts from the MSA-2 construction and inform the operation of lateral release valves. Adaptive management monitoring would also investigate contaminants in fish and wildlife prior to and after the start of diversion operations.

5.1 Success Criteria

The success criteria that were drafted by ERDC and CPRA, reviewed and modified by the PDT, HET, and the TAG, and ultimately agreed upon by the PDT on February 18, 2021, are listed in Attachment A (See Appendix H Monitoring Plan for additional details). Not all criteria have to be met to claim success. Success criteria may need to be modified in the adaptive management process based on monitoring data or site conditions.

Success would be determined by collecting and analyzing monitoring data in accordance with established protocols appropriate for each parameter. Monitoring assessments before and after the start of the diversion operation would determine how the ecosystem is responding to the diversion through a comparison to baseline data and success criteria targets. Because of the current variation in forest health in the diversion influence area, the MSA-2 would not have consistent effects in all locations. In addition, the MSA-2 effects would vary with respect to space and time; therefore, monitored parameters would be collected at locations and time intervals reflective of the ability to detect changes of each parameter, especially in their influence on the target habitat. The MSA-2 has initial, intermediate and long-term success criteria to capture this spatial and temporal variability. If the MSA-2 outcomes do not meet the desired expectations, adaptive management actions would be considered and selected remedies implemented.

5.2 Decision-Making Framework

Failure to meet any mitigation success criterion would be discussed by the IET, and the need and options for adaptive management and additional monitoring and reporting would be assessed,

taking into account the reason(s) for, and the spatial and temporal extent of noncompliance. If changes to the operational regime of the diversion or structural changes, either to the functional portions of the MSA-2 or to topography/bathymetry within the mitigation area are proposed such recommendations to the USACE for consideration in their decision on the path forward.
As described in the Operations Plan (Appendix N), USACE and CPRA would establish, assemble, and utilize the Maurepas Interagency Team (MIT), comprised of federal, state, and local agencies, to manage the operation of the MSA-2 (CPRA, 2021b). The MIT would provide recommendations on the operational management plan for the structure, procedures for test operations of the structure, emergency shutdown procedures, and other operational concerns deemed appropriate. The MIT would consider the recommendations of the Maurepas Technical Advisory Group, comments by state and federal agencies, stakeholders, and the public, and rely on MSA-2 monitoring data and other relevant information, as appropriate. The MIT would consist of members with varied backgrounds and interests with respect to the diversion structure operations. The MIT would be led by USACE and CPRA, who would determine membership.

Varying levels of approval may be required to implement any adaptive management actions. The decision making structure with respect to adaptive management of this MSA-2 would be determined by agencies/organizations who provide funding for MSA-2 construction, operations, monitoring, and adaptive management. The CPRA and the USACE would implement adaptive management actions in consideration of MIT recommendations.

5.3 Potential Triggers for Adaptive Management Action

The need for adaptive management actions would be identified largely through the analysis of ecological monitoring data, inspections, and associated assessments. Potential options for adaptive management would be identified and discussed by the IET and MIT, and if action is determined to be necessary, the decision for action would be documented in the appropriate plans and reports. Many circumstances may trigger the need for adaptive management action(s), especially in relation to not attaining one or more success criteria. While attaining all success criteria is the goal of the MSA-2, the benefit of meeting one success criterion would always be assessed in relation to meeting other success criteria. Improving the health of swamp habitat in the Maurepas Swamp, meeting required mitigation success criteria, and maintaining the health of the surrounding environment, would all guide diversion operations. Some of the potential triggers for adaptive management may include, but not be limited to the items listed in Table 1. Several identified potential triggers are maintenance issues and are included in the table due to their potential effect on preventing the attainment of success criteria. Specific timelines or measurements that would trigger AM would be developed by the IET prior to operations of the diversion and would be revised as necessary during the project's life based on the response of the swamp habitat.

Table 1. Potential adaptive management triggers and responses for the MSA-2.

Potential Adaptive Management (AM) Trigger	Potential AM actions that could be taken to address Trigger Event	Potential Associated and/or Impacted Monitoring Success Criteria
One or more monitoring success criteria metrics are not attained	• Adjust diversion operations • Alter the original mitigation area footprint • Purchase swamp mitigation credits • Reassess need to attain success criteria metric in relation to attainment of other success criteria and overall response of the swamp • Reassess ability to attain success criteria targets in relation to current environmental conditions and revise targets as needed	• All success criteria
Hydrologic connectivity between the river and swamp is not adequately achieved	• Adjust diversion operations • Add embankment cuts to improve hydrologic connectivity • Install weirs or other outfall management structures	• All success criteria
Conveyance channel is eroding or clogging	• Adjust diversion operations • Clear channel of sediment/debris • Remove/treat aquatic vegetation • Fortify channel banks	• All success criteria
Hydrology is negatively impacted in the mitigation area due to siltation, erosion, or aquatic invasive species	• Adjust diversion operations • Invasive species management • Add embankment cuts to improve hydrologic connectivity • Install weirs or other outfall management structures	• All success criteria
Mitigation area is, or is anticipated to be impacted by a severe weather event	• Adjust diversion operations • CRASH monitoring	• All success criteria
Diversion operations result in water level exceeding expectations	• Adjust diversion operations • Add embankment cuts to improve hydrologic connectivity • Install weirs or other outfall management structures	• All success criteria
Adjustments to Nitrate levels in the swamp are needed	• Adjust diversion operations • Add embankment cuts to improve hydrologic connectivity • Install weirs or other outfall management structures	• All success criteria

Mortality increases and/or growth is reduced for non-target woody species	• TBD-based on species and extent of impact • Consider adjustments of diversion operations or outfall management	• All success criteria
Data collection methods do not sufficiently measure parameters specified in the success criteria	• Revise the Monitoring Plan as necessary to determine success	• All success criteria
Prevalence of invasive species increases or new invasive species are introduced in the diversion area	• Attempt to identify source, determine if there is a negative impact on the mitigation area, incorporate invasive species management if feasible	• All success criteria
River conditions change	• Adjust diversion operations	• All success criteria
Existing or future projects cause unexpected interactions with MSA-2	• TBD-based on assessments	• All success criteria
Landowner exhibits concerns	• TBD-based on concerns	• All success criteria
Negative change in habitat conditions south of 1-10	• Adjust operations of lateral relief valves	• Success criteria do not apply south of I-10 • Monitoring would be conducted to ensure there are no negative impacts associated with construction and operations
Negative impact on wildlife	• TBD-based on species and impacts	• All success criteria

5.4 Potential Adaptive Management Actions

If the MSA-2 is not meeting some of the mitigation success criteria targets, specific adaptive management actions may be identified, recommended, and implemented to ensure the USACE attains their required AAHUs for compensatory mitigation for the WSLP project and the MSA-2 implementation. These recommendations could be made by state and federal agencies or stakeholders. Several potential adaptive management actions were noted in Table 1. A further discussion of some of the principal actions are explained in greater detail below the table.

The primary means of adaptively managing this diversion would involve adjustments to the operation of the diversion structure, as outlined in the Operations Plan (Appendix N; CPRA, 2021b). These adjustments could include changes in the timing, flow rate, duration, and frequency of operations. Operational adjustments may be needed due to a variety of factors, including Mississippi River conditions, seasonal environmental trends, tropical storms, and weather patterns. Operations may also be adjusted if monitoring data indicate that operational changes could improve the response of the swamp. The lateral release valves (LRV) would also be adaptively managed based on water elevation data and vegetative response in the impacted areas, as outlined in Section 5.6.

If changes to the operational regime do not result in the outputs required to meet mitigation success criteria targets, MSA-2 features may need to be added or altered. These features could include the addition of gaps in spoil banks and/or the abandoned railroad embankment to foster hydrologic connectivity where monitoring indicates a lack of flow-through. If diversion water is being lost from the mitigation area too rapidly and at too great of a volume through channels, water control structures (i.e., weirs) could be installed to increase retention time in the swamp. If hydrologic impediment is suspected to be a result of siltation or blockage from debris, bathymetric surveys may be required to identify the extent of blockage and clearing may be required in mitigation area channels or in the conveyance channel itself. Should any proposed adaptive management action require ground disturbance or clearance, it would be evaluated for its potential to affect historic properties, following the provisions of the executed No Action alternative (BBA 18) Mitigation Programmatic Agreement (see Section 5.8 for more discussion).

In addition to changing operational regimes, the most inexpensive, expeditious, and least complicated adaptive management action to attain the required AAHUs could be expansion of how the benefits for mitigation are calculated to include private lands. The mitigation area is currently limited to the size required to provide the required AAHUs needed for mitigation of WSLP project and the MSA-2 only, excluding the measurement of benefit on private lands within that area. The mitigation area for the MSA-2 could be revised to incorporate the benefits from private lands in the primary and secondary areas. If the footprint is expanded, additional monitoring and associated costs would need to be incorporated into the Monitoring Plan.

It should be noted that even though hydrologic modeling conducted by FTN and Associates shows a larger area than the mitigation area being projected to receive river water (Figure 2) expansion beyond the tertiary is not supported by the HET. This option is not currently a proposed adaptive management option since it would be difficult to measure and define success in these areas to meet mitigation requirements.

Altering the MSA-2 benefit area to incorporate private lands could be a component of a larger adaptive management response should a portion of the original mitigation benefit footprint not meet defined success criteria.

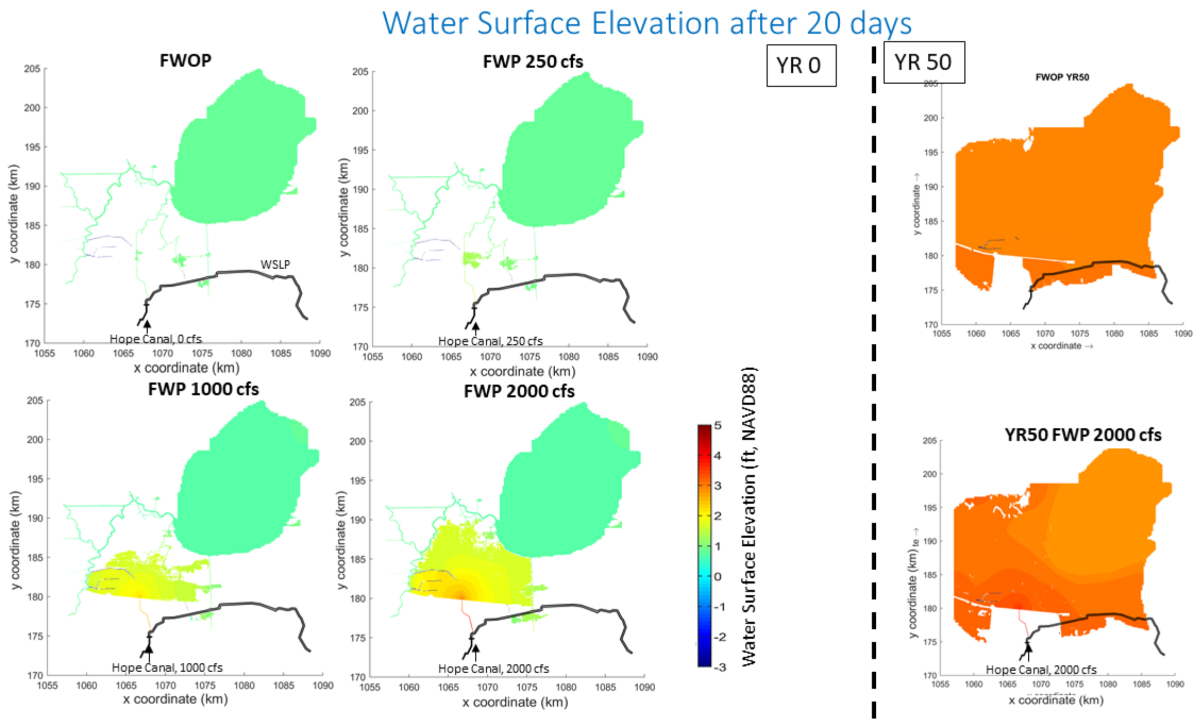


Figure 2. Predicted water surface elevation contours after 20 days under operational regimes ranging from 250–2,000 cfs *(taken from FTN and Associates, LTD Hydraulic and Water Quality Modeling of Proposed River Reintroduction into Maurepas Swamp (PO-0029) report, Figure C-5, 2021.*)

If CEMVN determines initial, intermediate, and/or long-term success criteria cannot be met, adaptive management actions should be implemented to ensure full satisfaction of the mitigation requirements. CEMVN will consult with other agencies and the Non-Federal Sponsor to determine whether operational changes would be sufficient to achieve ecological success criteria. If, instead, structural changes (e.g., plantings or channel modification) are deemed necessary to achieve ecological success, CEMVN will implement appropriate adaptive management measures in accordance with this AMP and subject to cost sharing requirements, availability of funding, and current budgetary and other guidance.

While the preferred adaptive management actions include modifying operations, or expanding the project area, location-targeted plantings of bald cypress and water tupelo are also an option. However, plantings are not preferred. Site hydrologic conditions would need to be monitored post-operations to assess the best location for plantings to maximize survivability, and the number, density, and size of trees planted would be highly dependent onsite conditions. Due to all of these uncertainties, plantings are included as a potential adaptive management action, but no costs are estimated. Another potential adaptive management action to attain mitigation success is the implementation of the approved mitigation plan for swamp in EA# 576, which includes the purchase of mitigation bank credits.

Throughout the project life, extreme weather events such as storms and droughts, external environmental contamination, and acute biologic hazards (*e.g.,* fish kills, algal blooms, invasive species, etc.) may require additional monitoring. Additional monitoring would also be needed if increasing the mitigation benefit area is implemented as an adaptive management action. For these reasons, CRASH (Contingent, Rapid Assessment of Status of Habitat) monitoring is budgeted throughout the project life.

A reassessment of the suitability of the success criteria and targets to measure benefits may occasionally be warranted, especially in response to the potential effects on the swamp from climate change. Additionally, as data are collected and analyzed, the IET may determine that changes to the plan, including station number, station location, and analyses, are necessary to more effectively assess the impact of the diversion on the swamp. Any changes agreed to by the USACE would be documented in an updated Monitoring Plan.

5.5 Invasive Species

There are no success criteria tied to invasive species management; however, if a species begins to negatively impact operations of the diversion, monitoring, or attainment of success criteria, implementation of adaptive management actions may be considered. Invasive species of greatest concern to the mitigation benefit area were determined through an initial review and evaluation of the many studies on the status of invasive species in the Maurepas Swamp and throughout coastal Louisiana, which was followed by project-specific evaluations and discussions among stakeholders, including CPRA, USFWS, LDWF, and USACE. The species discussed in this section are some of the primary species of concern to the MSA-2, but are not an exhaustive list of the invasive species currently documented in the Maurepas swamp.

The invasive species of greatest concern to the MSA-2 are floating aquatic plants, including water hyacinth (*Eichhornia crassipes*), common Salvinia (*Salvinia minima*), giant Salvinia (*Salvinia molesta*), alligator weed (*Alternanthera philoxeroides*), and crested floating heart (*Nymphoides cristata*). These species are currently present in the Maurepas swamp and may negatively impact the MSA-2's success by affecting water quality parameters (such as dissolved oxygen) or functionality by impeding the flow of river water. Access to monitoring stations may also be restricted by invasive aquatic species such as water hyacinth clogging waterways, a situation that has already been experienced multiple times by CPRA staff in the Maurepas Swamp.

Potential adaptive management actions that may be considered to manage invasive aquatic vegetation include biological control (such as Salvinia weevils), chemical control (spraying with herbicides), mechanical control (physical removal), or operation of the diversion to flush the channels. Herbicide spraying would likely be contracted to the LDWF, since they are the primary landowner and currently spray in the area. While it is possible that the introduction of nutrient-rich river water may increase the growth rate of floating aquatic plants, the swamp forest is expected to rapidly uptake a substantial percentage of available nutrients.

Woody invasive plant species, in particular Chinese tallow (*Triadica sebifera*), could colonize higher-elevation project features; however, routine maintenance would likely prevent their establishment. The spoil banks and abandoned railroad embankments in the area are already dominated by Chinese tallow and potentially other terrestrial invasive or nuisance vegetative species, which are not expected to establish in the swamp or impact the forest's integrity. Woody and herbaceous invasive species would be documented during swamp vegetation surveys, which would occur throughout the 50-year period of analysis. The need for treatment of woody or herbaceous invasive vegetation in the swamp is not anticipated, as their presence is not likely to

impede the attainment of forest integrity success criteria. However, if a tree planting is conducted as an adaptive management action and invasive species control is required, treatment with herbicide by a licensed applicator may be conducted in the planting area using foliar application, hack and squirt treatment, or felling with basal herbicide application (as applicable to the species and growth stage).
Nutria (*Myocastor coypus*) could damage the guide levees or other structure embankments by burrowing into them, potentially causing erosion. Nutria, through herbivory, could also damage bald cypress or water tupelo plantings and naturally regenerating seedlings. If nutria are causing excessive damage to the area, USACE and CPRA could work with LDWF and their Coast-wide Nutria Control Program to potentially increase bounties or implement other options.

It is generally acknowledged that the eradication of invasive species already widely distributed within the area is not realistic. Additionally, apart from the diversion, numerous pathways currently exist for the introduction of new invasive species into the Maurepas Swamp. If the USACE, in coordination with CPRA and the LDWF, determine that an invasive species is hindering the attainment of mitigation success, especially as a potential result of the diversion, then appropriate measures to control the species would be considered if advised by the IET.

5.6 Monitoring to Address Potential Indirect Impacts South of Interstate 10

Adaptive management monitoring would be conducted of the swamp and BLH habitats that are immediately south of the MSA-2 and are bounded by Interstate 10 (I-10) to the north, Reserve Relief Canal to the east, Airline Highway to the south, and Blind River to the west (Figure 3). There are two primary reasons to conduct monitoring in this area. The rationale for monitoring are to monitor for 1) Anticipated indirect impacts and 2) impacts in excess of anticipated indirect impacts to the neighboring forested communities from construction of the conveyance channel and the resulting localized alteration of hydrology.

Sixteen 24″ Lateral Relief Valves (LRVs), or features with equivalent capacity for discharge and drainage to achieve what was assumed in the WVA, would be constructed on each side of Hope Canal. The LRVs are assumed to discharge 140 cfs on each side of the conveyance channel (280 cfs total) for at least seven days at the end of each pulse. Operating LRVs to coincide with the end of each pulse would deliver flowing water, nutrients, and potentially some sediments into the neighboring forested habitats, while ensuring the introduced water can adequately drain post-pulse. The LRVs would be actively operated and can function bi-directionally to facilitate drainage of discharged water and precipitation to minimize potential impacts from increased inundation. Monitoring may indicate that the LRVs should be operated differently than currently planned to prevent negative impacts, or to further enhance positive impacts that are seen in the area. If monitoring data indicate that a change is needed, the use of the LRVs would be modified as approved by the PDT.

Three subareas were delineated south of I-10 to assess potential indirect impacts from construction of the conveyance channel and operation of the LRVs (Figure 3). Each of these areas would be monitored for water elevation and forest vegetation impacts, with monitoring station locations taking into account when feasible the bottomland hardwood, lower elevation swamp, and higher elevation swamp habitats that were differentiated in the wetland value assessment. Specifics regarding monitoring station location and the number of stations would be determined after site visits; however, station numbers are expected to range between four to nine stations. Two CRMS sites (CRMS0039 and CRMS5373) are currently located within the indirect impact monitoring areas (Figure 3). Both sites would be valuable for baseline hydrologic and vegetative data; however, CRMS5373 would be impacted by construction of the conveyance channel. It is undetermined at this time if the hydrographic station would be relocated and if it was, whether the preconstruction data obtained from this station would still be usable as existing conditions.

Water elevation would be measured through the use of continuous recorders to determine if and how water elevation depth and variability have changed since construction and assess whether impacts are in-line with model predictions. Forest vegetation would be assessed through the measurement of diameter at breast height (DBH) to calculate tree growth rates pre- and post-diversion operations. Canopy cover would also be measured at forested sites using a densiometer. Herbaceous monitoring would be conducted within forested sites to assess changes in species and vegetative cover. The methodologies utilized would follow those included in the Monitoring Plan (SEIS Appendix H; Hurst and Berkowitz, 2022), which incorporates protocols outlined in the CRMS standard operating procedures manual (Folse et al., 2020). A broader assessment of forest health would be attained through the use of multitemporal satellite imagery, such as Landsat 7 Thematic Mapper data, following procedures similar to those previously used in the Maurepas Swamp to categorize habitat and assess forest health (Keim et al., 2010; Keim et al., 2013). If measurements of DBH are inadequate to assess growth rates of targeted tree species, dendrochronology may be utilized to measure growth rates on a subset of trees within the areas of concern.

The start of adaptive management baseline monitoring would coincide with the start of baseline mitigation monitoring and would continue at the frequency noted in Table 2. Termination of monitoring is planned to occur prior to year 50, with the assessment of the need for continued monitoring of some parameters beginning at 10 years after the start of diversion operations. The IET would provide recommendations on whether continued monitoring is needed and if the number of stations or frequency of monitoring events can be reduced later in the project life. Data would be analyzed on a yearly basis and would be made publicly-available through CIMS if feasible. Alternate methods of providing data to the public would be identified if necessary.

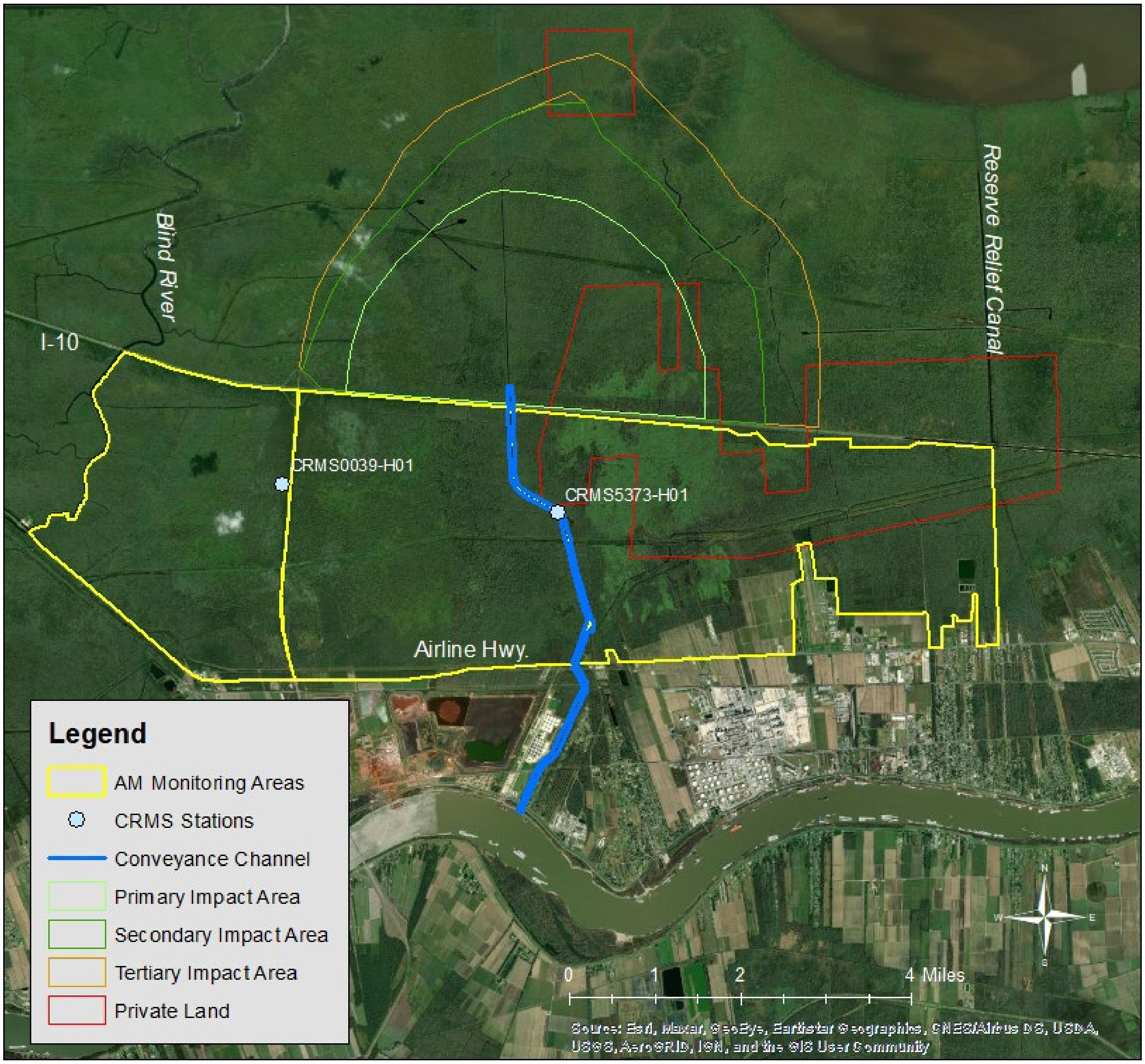


Figure 3. Areas of potential indirect impacts (AM Monitoring Areas) where adaptive management monitoring would occur.

Table 2. Proposed monitoring parameters, methods and timelines for adaptive management monitoring south of I-10.

Monitoring Parameter	Method	Project Year	Frequency	Monitoring Timeline
Water Level	Continuous recorders	-3 to 10	Continuous	Decision to continue monitoring would be made at year 10. If monitoring is continued, the number of stations may be reduced.
Forested Vegetation	Permanent plots (1250 m^2/station)	-3 to -1	Annually	Decision to continue monitoring would be made at year 20. If monitoring is continued, the number of stations may be reduced.
		1–10	Biennially	
		10–19	Every 3 years	
Forested Vegetation	Remote sensing of forest habitat	-1, 10, 22, 34, 50	Annually during noted project years	Analysis would be conducted in conjunction with MSP analyses.
Forested Vegetation	Dendrochronology	No earlier than year 10	Single event	This monitoring technique would only be utilized if DBH data inadequately assess impacts.
Herbaceous Vegetation	Permanent plots ($1m^2$)	-3 to 5	Annually	Decision to continue monitoring would be made at year 10. If monitoring is continued, the number of stations may be reduced.
		6–10	Biennially	

5.7 Pollution, Contaminant and Water Quality Monitoring

Measuring and monitoring various water quality (WQ) parameters would inform whether inputs from the Mississippi River are impacting water quality in the area. For pre-/post-construction water quality monitoring the same constituents included in Bonnet Carre monitoring, mainly nutrients, chlorophyll/phycocyanin, phytoplankton community, the algal toxin microcystin, total suspended solids, and oxygen isotopes is proposed. These parameters would help understand the impacts of nutrient loading from the diversion and other sources (e.g., the Amite River) on phytoplankton community, nutrient removal by wetlands, and the distribution of Mississippi River water vs. water from other sources in the receiving area. WQ parameters are being collected by CPRA and other agencies in the area, as part of the Operations Plan (Appendix N) and as part of the monitoring plan (Appendix H), the WQ parameters that would be included as part of this AM plan would be in addition to those and fill in the gaps for the needed additional WQ parameters to access impacts.

Monitoring to assess bioaccumulation of pollutants and contaminants on fish and wildlife was requested by the USFWS in their January 22, 2022 Draft Coordination Act Recommendations (See Section 8.7 of the SEIS). The USFWS recommends that sampling of fish and shellfish occurs pre- and post-diversion operations from the outfall area and the Mississippi River. The USFWS recommends that USACE, in coordination with the USFWS, develop a list of contaminants to be analyzed. This list could be taken from the most recent EPA Priority Pollutants and Contaminants of Concern (COC) list (https://www.epa.gov/eg/toxic-and-priority-

pollutants-under-clean-water-act), but not necessarily all pollutants on the list would be measured, and other elements, such as trace metals could be added.
The pollutant and contaminant monitoring could be modeled after the contaminant sampling plan conducted for the Davis Pond Diversion (Jenkins et al. 2008, Jenkins et al. 2011). In this plan, fish were collected via electroshocking in the Mississippi River and at three sites in the basin that increased in distance from the diversion. Fish species that were collected for analysis were striped mullet (*Mugil cephalus*), largemouth bass (*Micropterus salmoides*), and blue catfish (*Ictalurus furcatus*). Shellfish, including rangia clams (*Rangia cuneata*) and zebra mussels (*Dreissena polymorpha*) tissue was also collected and analyzed. Rangia clams were collected in the basin and zebra mussels were collected in the Mississippi River. Eaglet blood was collected prior to diversion operations but not after operation. The major contaminant categories that were assessed were metals, aliphatic hydrocarbons (AHs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine (OC) pesticides. The Davis Pond study assessed contaminants six years after operation began. Specific species that are collected and tested for the MSA-2 would be determined after discussions and agreement within the IET.

Specific data collection protocols, including a list of pollutants and chemicals to be assessed, methods, sample locations, sample species, and sample frequency would be decided by the IET before operations begin. Pre-diversion sampling is essential for these parameters as river water, which has potentially reached the area for decades from the Bonnet Carré Spillway, and other industrial activities that occur in the basin could have already introduced pollutants and chemicals of concern to the area. Once a more specific data collection protocol is decided, the estimated budget would be revised.

There are some potential sources of existing data that could help in this effort. The Louisiana Department of Environmental Quality collects mercury level data in fish tissue, vegetation, sediment, and water as part of their Mercury Initiative, Project: WQ1994001 – Mercury Contaminant Levels in Louisiana Biota (https://waterdata.deq.louisiana.gov/s/WQ1994001). There are approximately six sample sites under this program, in and around the MSA-2 diversion influence area. There are also some sites where LDEQ samples a variety of parameters under their Ecoregions Project. These data include sampling alkalinity, iron, magnesium, manganese and perhaps other parameters. It is hard to determine sampling frequency for these LDEQ projects but they should be investigated as a potential source of useful data. USGS also collects contaminant data 18 times a year at two locations in the Mississippi River (St. Francisville and Belle Chasse) and in Lake Pontchartrain near the Causeway as part of the National Water Quality Network (NWQN; https://nrtwq.usgs.gov/nwqn/#/). Numerous parameters are analyzed at these sites, including basic water quality, metals, pesticides, etc. These collections have been occurring for at least two decades and would provide useful long-term trends that would help to develop a proper sampling plan. If it is determined that these sources of data would not provide the data at the required frequency or time period mercury would be sampled to include in the water quality and tissue analysis.

It is important to note that, as of 2020, many of the rivers that feed into Lake Maurepas, including the Blind River, Amite River, Tickfaw River, and Natalbany River, are impaired for fish and wildlife propagation due to elevated mercury levels from atmospheric deposition

(LDEQ 2020). It is also important to note that the Mississippi River has no listed impairments under the Clean Water Act Sections 305(b)/303(d) (LDEQ, 2020).

5.8 Cultural Resources

Cultural Resources of greatest concern to the MSA-2 were determined through an initial evaluation of the many studies conducted in the MSA-2 and diversion influence areas. These studies document the location and National Register of Historic Places status of recorded cultural resources including archaeological sites, cemeteries, and historic standing structures, and are discussed in the SEIS. These data were shared with consulting parties, including the Alabama Coushatta Tribe of Texas, Chitimacha Tribe of Louisiana, Choctaw Nation of Oklahoma, Coushatta Tribe of Louisiana, Jena Band of Choctaw Indians, Mississippi Band of Choctaw Indians, Muscogee (Creek) Nation, Seminole Nation of Oklahoma, Tunica-Biloxi Tribe of Louisiana, Louisiana State Historic Preservation Office (SHPO), and the Advisory Council of Historic Places (ACHP). Additional identification strategies are planned to document unrecorded properties within the MSA-2 and the diversion influence areas, which would also be coordinated and consulted upon with the same parties. Currently, cultural resources of concern within the MSA-2 diversion influence area are: four (4) prehistoric shell middens (16AN8, 16LV73, 16LV24, 16SJB4), 2 possible watercrafts/shipwrecks (16LV74, 16SJ72), one (1) railroad bridge (16SJ72), and the Amite River Diversion Canal (16LV103); two (2) cemeteries, 16SJ58 and 16SJ61, both dating back to the Civil War.

While most of the proposed AM actions would not have the potential to affect historic properties, a few, such as spoil bank gapping, water control structures (i.e., weirs), or cuts in railroad embankments to assist with establishing the desired hydrology, and targeted vegetative plantings, which may require access routes and groundwork, have the potential to affect archeological deposits in the action areas.

To address these potential impacts, the provisions of the *Programmatic Agreement Among the U.S. Army Corps of Engineers, New Orleans District; Amite River Basin Commission; East Baton Rouge Parish; Louisiana Coastal Protection and Restoration Authority; Louisiana Department of Transportation and Development; Pontchartrain Levee District; Louisiana State Historic Preservation Officer of the Department of Culture, Recreation & Tourism; and Choctaw Nation of Oklahoma; Regarding the Bipartisan Budget Act of 2018 Compensatory Habitat Mitigation Program for the Comite River Diversion, East Baton Rouge Parish Watershed Flood Risk Management, and West Shore Lake Pontchartrain Hurricane and Storm Damage Risk Reduction Projects In Louisiana* (BBA 18 Habitat Mitigation PA) shall be implemented. The most relevant provision would be, Stipulation III A. Changes to an Approved Scope of Work, which outlines project review steps to be taken when project actions change following survey and determinations of effect.

6. Responsibilities

Division of the roles and responsibilities between the USACE and CPRA regarding monitoring and adaptive management actions, including who funds these actions, would be included in the final version of the AM plan. Monitoring, data collection, analysis, assessment, data management and decision making responsibilities would be clearly defined documenting which agency is conducting what activities and when. In general, it is expected that USACE would have a larger role in elements prior to final determination that success criteria have been met. Long-term management of the MSA-2 would be the responsibility of CPRA through the 50-year post-construction life once initial success criteria have been met.

The roles, membership and relationships of the HET, IET, TAG and the MIT would also be defined.

Costs for adaptive management have been estimated and budgeted through 50 years for MSA-2.

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8. Conceptual Ecological Model

A Conceptual Ecological Model (CEM) for the Maurepas Swamp was developed and included in the feasibility level monitoring and adaptive management plan for the Louisiana Coastal Area Program: Small Diversion at Convent/Blind River Project (USACE, CPRA 2010). The model serves as an appropriate surrogate for representation for the Maurepas Swamp system and was used as a tool to support the development of the AM plan (Figure 5). This CEM would be modified as new monitoring information updates the understanding of the Maurepas Swamp. The CEM documentation is included in Attachment B.

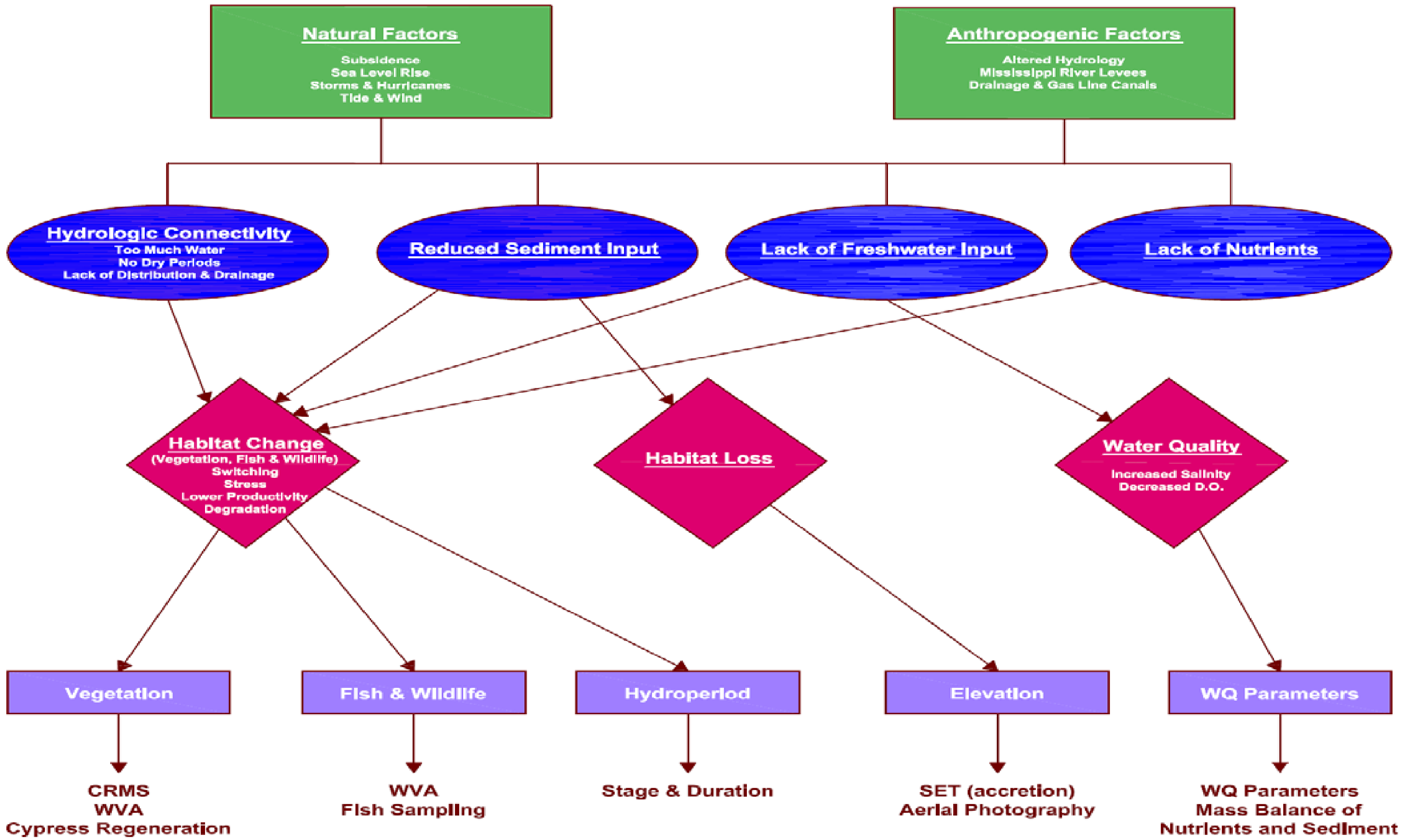


Figure 5. Maurepas Swamp CEM (*taken from USACE, NOD and OCPR. 2010. Louisiana Coastal Area Program (LCA) Program: Small Diversion at Convent/Blind River Project Feasibility-Level Monitoring and Adaptive Management Plan. 19 pp., Figure 3).*

Attachment A

Summary Table of Mitigation Monitoring Success Criteria (from Hurst and Berkowitz, 2022).

Success Criteria	Initial Success Target	Intermediate and Long-Term Success Target
Increase Forest Integrity	Stable or increasing BA (m^2/ha) and BAI (m^2/ha/yr) growth rates relative to baseline conditions for baldcypress and water tupelo in the mitigation area.	Primary and Secondary Benefit areas: 1.9-2.55x increase in BAI relative to baseline growth rates at ≥ 75% of monitoring sites Tertiary Benefit area: Demonstrate a 1.2-1.9x increase in mean BAI (m^2/ha/yr) growth rates relative to mean baseline (pre-MSA-2) growth rates at ≥ 75% of monitoring sites in the mitigation area.
Water Quality Improvement	**Nitrate (mg/L)**: 2x increase relative to baseline conditions at ≥ 75% of monitoring sites during MSA-2 operation. *If baseline concentrations are ≤ 0.1 mg/L nitrate, then target is ≥ 0.2 mg/L nitrate	All benefit areas: Attain ≥ 0.45 mg/L at ≥ 75% of monitoring sites during MSA-2 operation
	Dissolved Oxygen (mg/L): ≥ 2 mg/L at ≥ 75% of monitoring sites during MSA-2 operation	All benefit areas: Attain ≥ 4 mg/L at ≥ 75% of monitoring sites during MSA-2 operation
Increase Sediment Accumulation and Soil Surface Elevation	**Sediment Delivery and Retention**: **1)** Increased sediment retention within the mitigation area. **2)** Increased inorganic sediment content relative to baseline conditions and those observed in sites outside of the mitigation area area.	None for intermediate or long-term success
	Wetland Soil Surface Elevation Change: None for initial success	Primary and Secondary Benefit areas: An additional 5.0 ± 1 mm/yr increase at ≥ 75% of monitoring sites. Tertiary Benefit area: None for intermediate or long-term success
Salinity Maintenance	All benefit areas: ≤0.8 ppt at ≥ 75% of monitoring sites	

Attachment B

LCA Small Diversion at Convent/Blind River Project Conceptual Ecological Model

ANNEX 1. LCA Small Diversion at Convent/Blind River Project
Conceptual Ecological Model

1.0 INTRODUCTION

1.1 Conceptual Ecological Model Definition

Although the term "conceptual ecological model" (CEM) may be applied to numerous disciplines, CEMs are generally simple, qualitative models, represented by a diagram, that describe general functional relationships among the essential components of an ecosystem. CEMs typically document and summarize current understanding of, and assumptions about, ecosystem function. When applied specifically to ecosystem restoration projects, CEMs also describe how restoration actions propose to alter ecosystem processes or components to improve system health (Fischenich 2008). To describe ecosystem function, a CEM usually diagrams relationships between major anthropogenic and natural drivers, biological indicators, and target ecosystem conditions.

1.2 Purpose and Functions of Conceptual Ecological Models

CEMs can be particularly helpful in providing assistance with four important tasks: ecosystem description, communication, ecosystem restoration plan formulation, and monitoring and adaptive management.

1.2.1 Ecosystem Simplification

Because natural systems are inherently complex, resource managers must utilize tools that simplify ecosystem relationships and functions within the target ecosystem. An understanding of the target ecosystem is paramount to planning and constructing achievable ecosystem restoration projects. During CEM development, known and unknown connections and causalities in the systems are identified and delineated (Fischenich 2008).

CEMs can promote ecosystem description and simplification through the following processes:

- Organization of existing scientific information;
- Clear depiction of system components and interactions;
- Promotion of understanding of the ecosystem;
- Diagnosis of underlying ecosystem problems;
- Isolation of cause and effect relationships; and
- Identification of elements most likely to demonstrate ecosystem responses.

1.2.2 Communication

CEMs are an effective tool for the communication of complex ecosystem processes to a large diverse audience (Fischenich 2008). It is vitally important that project teams understand ecosystem function in order to realistically predict accomplishments to be achieved by restoration projects. CEMs can facilitate effective communication between project team members about ecosystem function, processes, and problems, and can assist in reaching consensus within the project team on project goals and objectives.

Because CEMs summarize relationships among the important attributes of complex ecosystems, they can serve as the basis for sound scientific debate. Stakeholder groups, agency functions (e.g., planning and operations), and technical disciplines typically relate to systems resource use and management independently, but CEMs can be used to link these perspectives.

The process of model development is at least as valuable as the model itself and affords an opportunity to draw fresh insight as well as address unique concerns or characteristics for a given project. Workshops to construct CEMs facilitate brainstorming sessions that explore alternative ways to compress a complex system into a small set of variables and functions. This interactive process of system model construction facilitates communication between project team members and almost always identifies inadequately understood or controversial model components.

CEMs can promote communication by facilitating the following:

- Integrating input from multiple sources and informing groups of the ideas, interactions, and involvement of other groups (Fischenich 2008);
- Assembling project/study managers with the project team and stakeholders to discuss ecosystem condition, problems, and potential solutions;
- Synthesizing current understanding of ecosystem function;
- Developing consensus on a working set of hypotheses that explain habitat changes;
- Developing consensus on indicators that can reflect project-specific ecological conditions; and
- Establishing a shared vocabulary among project participants.

1.2.3 Plan Formulation

Formulating a plan for an effective ecosystem restoration project requires an understanding of the following elements:

- The underlying cause(s) of habitat degradation;
- The manner in which causal mechanisms influence ecosystem components and dynamics; and
- The manner in which intervening with a restoration project may reduce the effects of degradation.

These three elements should form the basis of any CEM applied to project formulation (Fischenich 2008).

CEMs can provide valuable assistance to the plan formulation process through the following:

- Supporting decision-making by assembling existing applicable science;
- Assisting with formulation of project goals and objectives, indicators, management strategies, and results;
- Providing a common framework among team members from which to develop alternatives;
- Supplementing numerical models to assess project benefits and impacts; and
- Identifying biological attributes or indicators that should be monitored to best interpret ecosystem conditions, changes, and trends.

1.2.4 Science, Monitoring, and Adaptive Management

Through the recognition of important physical, chemical, or biological processes in an ecosystem, CEMs identify aspects of the ecosystem that should be measured. Hypotheses about uncertain relationships or interactions between components may be tested and the model may be revised through research and/or an adaptive management process. Indicators for this process may occur at any level of organization, including the landscape, community, population, or genetic levels; and may be compositional (i.e., referring to the variety of elements in a system), structural (i.e., referring to the organization or pattern of the system), or functional (i.e., referring to ecological processes) in nature.

CEMs can be helpful in restoration science, monitoring, and adaptive management through the following:

- Making qualitative predictions of ecosystem response;
- Identifying possible system thresholds that can warn when ecological responses may diverge from the desired effect;
- Outlining further restoration and/or research and development needs;
- Identifying appropriate monitoring indicators and metrics;
- Providing a basis for implementing adaptive management strategies;
- Interpreting and tracking changes in project targets;
- Summarizing the most important ecosystem descriptors, spatial and temporal scales, and current and potential threats to the system;
- Facilitating open discussion and debate about the nature of the system and important management issues;
- Determining indicators for monitoring;
- Helping interpret monitoring results and explore alternative courses of management;
- Establishing an institutional record of the ideas that inspired the management and monitoring plan;
- Forecasting and evaluating effects on system integrity, stress, risks, and other changes;
- Identifying knowledge gaps and the prioritization of research;
- Interpreting and monitoring changes in target indicators; and
- Assisting in qualitative predictions and providing a key foundation for the development of benefits metrics, monitoring plans, and performance measures.

1.2.5 Limitations of Conceptual Ecological Models

CEMs cannot identify the most significant natural resources within the target ecosystem or prioritize project objectives. They do not directly contribute to the negotiations and trade-offs common to ecosystem restoration projects. CEMs are not *The truth*, but are simplified depictions of reality. They are not *Final*, but rather provide a flexible framework that evolves as understanding of the ecosystem increases. CEMs are not *Comprehensive* because they focus only upon those components of an ecosystem deemed relevant while ignoring other important (but not immediately germane) elements. CEMs do not, in and of themselves, quantify restoration outcomes, but identify indicators that can be monitored to determine responses within the target ecosystem to restoration outputs.

Good conceptual models effectively communicate which aspects of the ecosystem are essential to the problem, and distinguish those outside the control of the implementing agency. The best conceptual models focus on key ecosystem attributes, are relevant, reliable, and practical for the problem considered, and communicate the message to a wide audience.

1.3 Types of Conceptual Ecological Models

CEMs can be classified according to both their composition and their presentation format. They can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. The most common types of CEMs are narrative, tabular, matrix, and various forms of schematic representations. A comprehensive discussion of these types of CEMs is provided in Fischenich (2008). Despite the variety in types of CEMs, "no single form will be useful in all circumstances" (Fischenich 2008). Therefore, it is of vital importance to establish the specific plan formulation needs to be addressed by the CEM, and develop the CEM accordingly because "[c]onceptual models . . . are most useful when they are adapted to solve specific problems" (Fischenich 2008).

1.3.1 Application of Conceptual Ecological Models to LCA Projects

CEMs have been widely used in other regions of North America when planning large-scale restoration projects (Barnes and Mazzotti 2005). The LCA team has decided to utilize the Ogden model (Ogden and Davis 1999). The LCA team recognizes that CEM development, like plan formulation, is likely to be an iterative process, and that CEMs developed for LCA projects during early plan formulation may be dramatically changed before project construction.

1.3.2 Model Components

The schematic organization of the CEM is depicted in Figure 1 and includes the following components:

- *Drivers*- This component includes major external driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g., eustatic sea level rise) or anthropogenic (e.g., hydrologic alteration) in nature.
- *Ecological Stressors*- This component includes physical or chemical changes that occur within natural systems, which are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.
- *Ecological Effects*- This component includes biological, physical, or chemical responses within the natural system that are produced or affected by stressors. CEMs propose linkages between one or more ecological stressors and ecological effects and attributes to explain changes that have occurred in ecosystems.
- *Attributes*- This component (also known as indicators or end points) is a frugal subset of all potential elements or components of natural systems representative of overall

ecological conditions. Attributes may include populations, species, communities, or chemical processes. Performance measures and restoration objectives are established for each attribute. Post-project status and trends among attributes are measured by a system-wide monitoring and assessment program as a means of determining success of a program in reducing or eliminating adverse effects of stressors.

- *Performance measures*- This component includes specific features of each attribute to be monitored to determine the degree to which attribute is responding to projects designed to correct adverse effects of stressors (i.e., to determine success of the project).

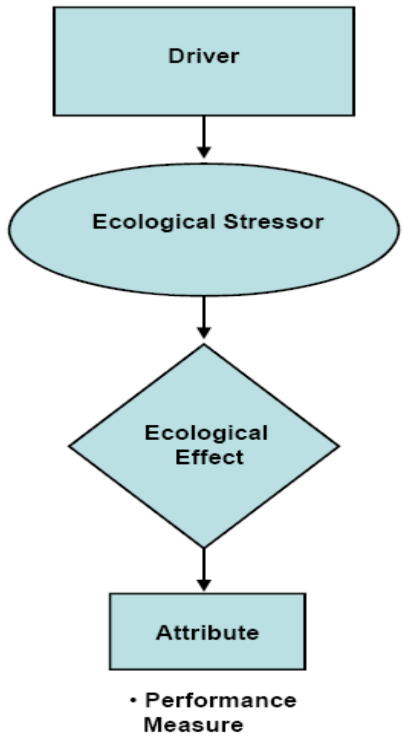


Figure 1. Conceptual Ecological Model Schematic Diagram.

This CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather, the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem monitoring goals.

2.0 CONCEPTUAL ECOLOGICAL MODEL DEVELOPMENT

2.1 Methodology

A CEM was developed for the Small Diversion at Convent/Blind River project by members of the project team and the interagency Project Delivery Team. The creation of this CEM was an interactive and iterative process. Prior to model development, the project team reviewed existing information on the project study area. The project team identified drivers, ecological stressors, ecological effects, attributes and performance measures for the project and a preliminary CEM was developed in two formats. The CEM in each of these formats was provided to the interagency Project Delivery Team and the then members from both teams met to clarify and improve the CEM, which is presented in this report. Additional information about the components of the CEM for this project is presented below.

2.2 Project Background

The Small Diversion at Convent/Blind River project was identified in the Louisiana Coastal Area (LCA), Louisiana - Ecosystem Restoration Study (2004 LCA Plan [USACE 2004]). The 2004 LCA Plan was recommended to the Congress by a Chief of Engineers report dated January 31, 2005. The 2004 LCA Plan recommended a coordinated, feasible solution to the identified critical water resource problems and opportunities in Coastal Louisiana.

The project was included in that plan along with other critical near-term restoration features throughout coastal Louisiana. This project, as well as ten additional projects, was recommended for further studies in anticipation that such features would be subsequently recommended for future Congressional authorization. The 2004 LCA Plan was developed by the State of Louisiana and the United States Army Corps of Engineers in order to implement some of the restoration strategies outlined in the 1998 Coast 2050 report.

The project was proposed to reverse the current decline of a portion of the Maurepas Swamp area and to prevent the transition of the swamp into marsh and open water. This project will work together with the Small Diversion at Hope Canal diversion and the LCA Amite River Diversion Canal Modification projects to bring Mississippi River water, sediment, and nutrients to the current swamp area. Reversing this decline will help to develop more sustainable wetland ecosystem which can serve to protect the local environment, economy, and culture. In light of Louisiana's extreme vulnerability to intense storms, this project may also provide some measure of flood damage protection.

The Maurepas Swamp is an area of considerable ecological, socio-economic, and cultural importance. Since the construction of the Mississippi River flood control levees, large portions of the Maurepas Swamp have largely been cut off from fresh water, sediments, and nutrients historically provided by the Mississippi River. Due to this disruption in natural processes, soil building in the swamp has been insufficient to keep up with subsidence and sea level rise. Consequently, much of the swamp is persistently flooded, the existing trees may be somewhat stressed, and there is little to no natural regeneration of baldcypress and tupelo trees, which are the dominant species in this swamp ecosystem. These factors, combined with increasing occurrences of high salinities, if not addressed, will result in a highly degraded swamp system which is at risk of conversion to open water.

This diversion project would reintroduce up to 3,000 cubic feet per second (cfs) of Mississippi River water into the southwest portion of the Maurepas Swamp, thereby increasing the flow of fresh water, nutrients, and fine-grained sediment into an area in the swamp that is somewhat stressed and in need of restoration. The diversion project is fully consistent with both the strategies used to develop the LCA restoration plan and the critical needs criteria for identifying near-term restoration opportunities.

2.2.1 Project Goals and Objectives

The purpose of the Small Diversion at Convent/Blind River project is to restore and protect the health and productivity of the swamps southwest of Lake Maurepas through reintroduction of Mississippi River water. The specific objectives of the project concept are to:

- Promote water distribution in the southeastern portion of the Maurepas Swamp to move stagnant water out of the system.
- Facilitate swamp building, at a rate greater than swamp loss due to subsidence and sea level rise, by increasing sediment input and swamp production to maintain or increase elevation in the swamp.
- Increase the durations of dry periods in the swamp to improve baldcypress and tupelo productivity and to increase seed germination and survival of these key species.

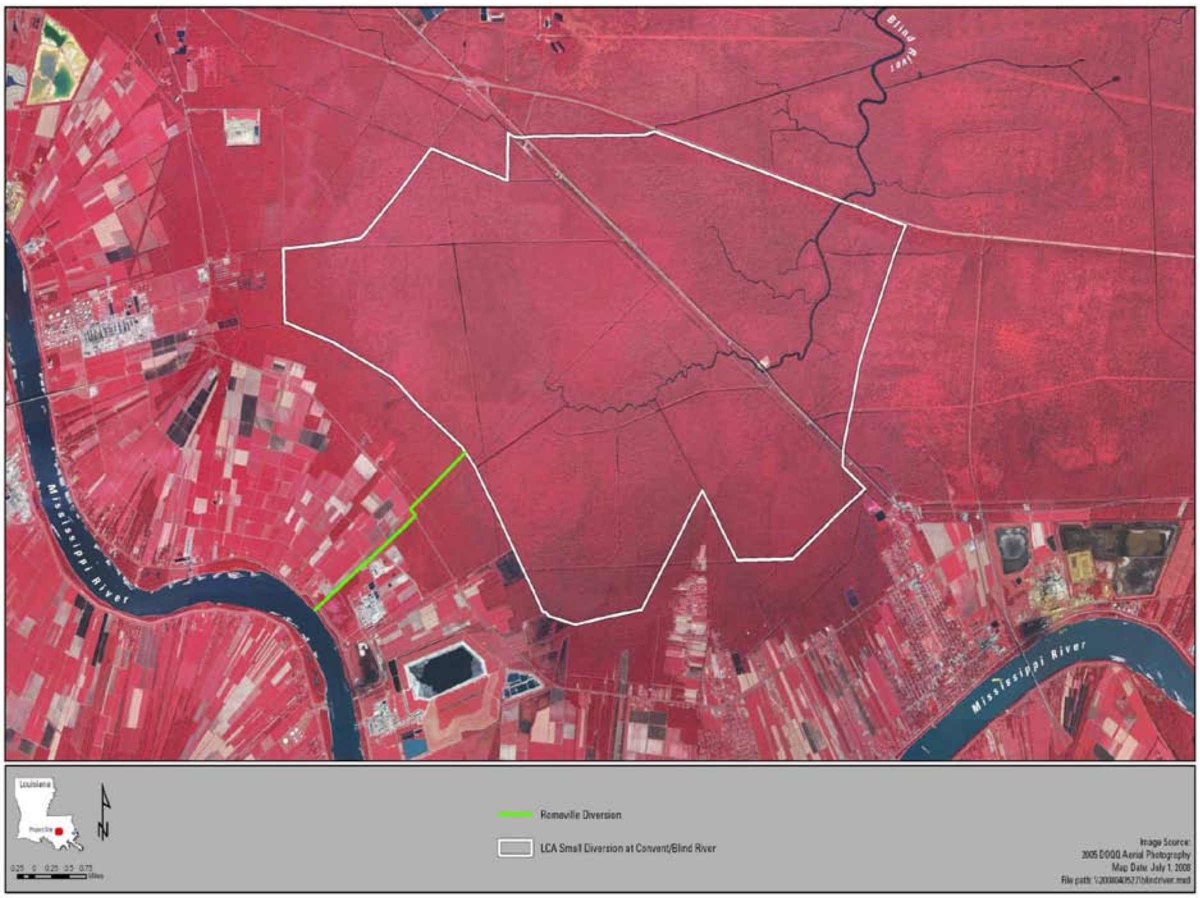
Improve fish and wildlife habitat in the swamp and in Blind River. This diversion project is located immediately west of the Hope Canal Diversion project and the influence areas are adjacent to each other. Both projects are planned to restore large areas of the Maurepas Swamp. As the diversion concepts and the swamp service areas are similar, many of the findings from the Hope Canal project will be applicable to this diversion project.

2.2.2 Project Description

The Maurepas Swamp is located in LCA Subprovince 1, west of Lake Pontchartrain and north of the I-10 corridor. The Maurepas Swamp is one of the largest remaining tracts of coastal freshwater swamp in Louisiana. Including Lake Maurepas, the Maurepas Swamp area comprises a total of approximately 232,928 acres, most of which is swamp, with some isolated areas of bottomland hardwood forest and fresh marsh. The diversion project involves evaluating a small hydraulic diversion (less than 5,000 cfs) from the Mississippi River into the Maurepas Swamp. Alternative locations for the proposed control structure in the vicinity of Romeville, located at Mississippi River Mile 161.5 above Head of Passes (AHP) were investigated. Reasonable alternatives were evaluated, and Alternative 2, diversion location at Romeville was selected.

The Blind River headwaters are located in St. James Parish approximately 23 miles north of Mississippi River at Mile 158.5 AHP. The Blind River flows north then east through Ascension and St. John the Baptist parishes before it empties into Lake Maurepas. The objective of this project is to introduce fresh water, sediment, and nutrients into the southwest portion of the Maurepas Swamp to help prevent the transition of the swamp into marsh and open water

Figure 2. Small Diversion at Convent/Blind River Project Study Area



3.0 CONCEPTUAL ECOLOGICAL MODEL DISCUSSION

The CEM developed for the Small Diversion at Convent/Blind River project is presented in Figure 3. Model components are identified and discussed in the following subsections.

3.1 Drivers

3.1.1 Natural Factors

Subsidence and Sea Level Rise

Increased subsidence is a physical response to lack of riverine input and the resulting loss of nutrients and sediments and decreased productivity in vegetation communities. The soil characteristics within the western Maurepas Swamp are indicative of a lack of riverine influence as evidenced by high soil organic matter content and low bulk density values (DeLaune et al. 1979, Hatton 1981, Messina and Conner 1998). Soil building within the Maurepas Swamp occurs almost exclusively as a result of organic productivity. Subsidence in this area is classified as intermediate, at about 1.1-2.0 feet per century (USACE 2004). With minimal soil building and moderately high subsidence, there has been a net lowering of ground surface elevation, leading to a doubling in flood frequency over the last four decades (Thomson 2000), so that the swamps are now persistently flooded. Thomson (2000) also indicated that there has been a rise in mean sea level of 1.6 mm per annum from 1957 to 2000 near the study area.

Shaffer et al. (2003) conducted a subsidence investigation in the Maurepas Swamp immediately east of the project study area in support of CWPPRA project PO-29 *Mississippi River Reintroduction into Maurepas Swamp*. Subsidence rates for the PO-29 project area were measured by the installation of two surface elevation tables at 13 representative study sites. The tables could be set in four compass directions and utilized the mean value of nine pin readings of soil elevation. Readings were collected from October-November 2001 and compared against readings collected in October-November 2002 to provide an accurate estimate of the net subsidence rates within the Maurepas Swamp. The results of this subsidence investigation indicate an average net elevation decrease of slightly less than one centimeter for the study area during the interval between sampling, although actual rates varied considerably by habitat type.

The combination of increased flood duration due to subsidence and sea level rise and increased salinity are likely to convert freshwater swamps to marsh and open water. The altered hydrology prevents the regeneration of swamps (Penfound 1952, Shaffer et al. 2003).

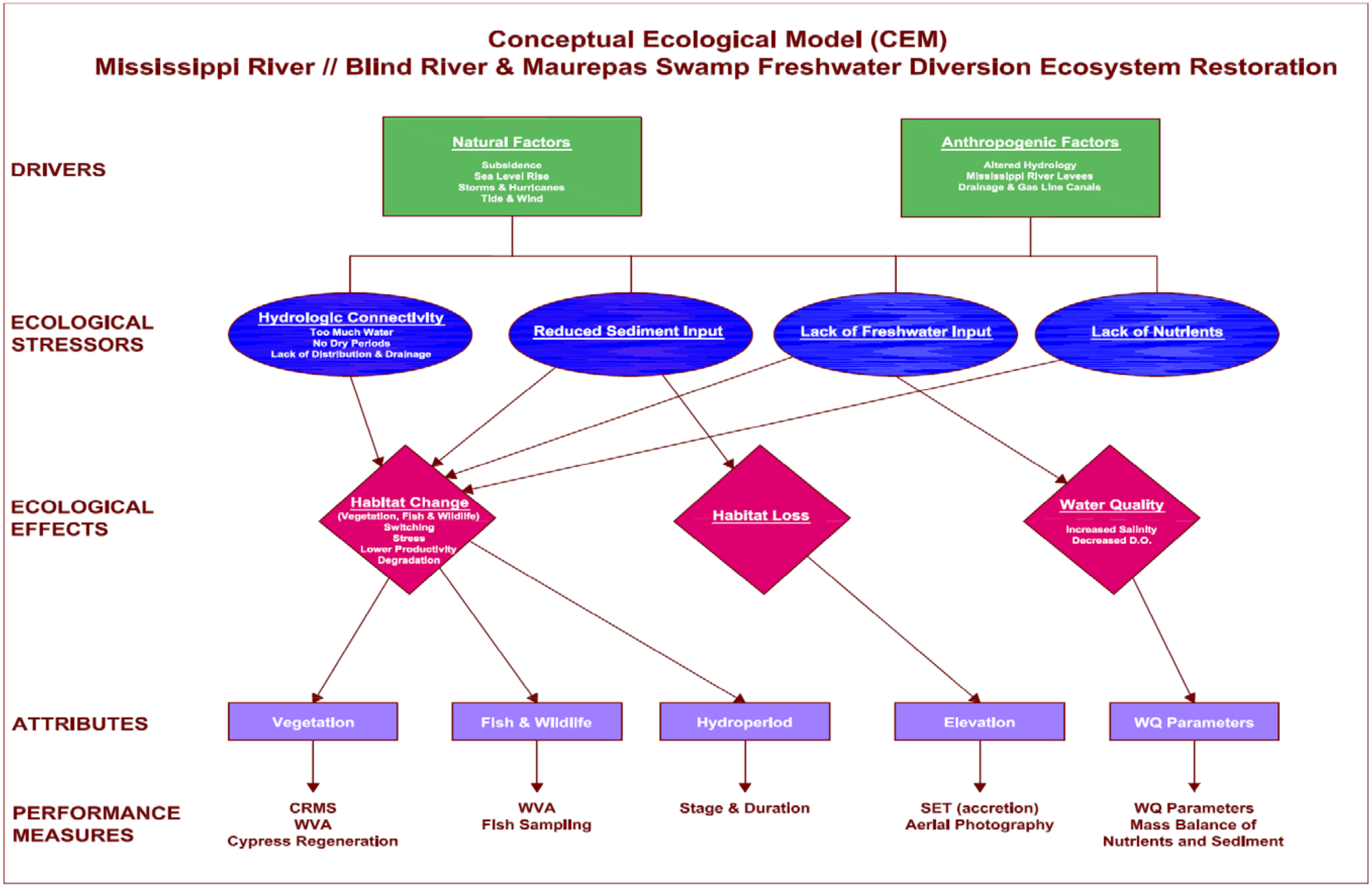


Figure 3. Conceptual Ecological Model, LCA Small Diversion at Convent/Blind River Project .

Storms and Hurricanes

Coastal storms, particularly tropical cyclone events, also exert a stochastic but severe influence on the study area. Storm surge frequency encourages continued degradation of the coastal forest habitat in and surrounding the study area, further reducing the ability of these habitats to attenuate storm surge. Consequently, an increase in storm surge and risk of flooding is imminent. Data obtained from the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center indicate that the storm centers of at least 14 tropical cyclones with a Saffir-Simpson Hurricane Scale of Category 2 or higher have passed within 50 miles of the study area during the interval 1851-2007, and at least 52 such tropical cyclones have passed within 100 miles of the study area during the same interval. The most recent tropical cyclones to affect the study area were hurricanes Katrina and Rita, which occurred in August 2005 and September 2005, respectively, and hurricanes Gustav and Ike, which occurred in September 2008.

Tides and Wind

The Blind River/Maurepas Swamp system is tidally affected although it is a freshwater system. The tides and wind affect the flow of water in the Blind River, and therefore the swamp, and are important natural driving factors. These factors were considered in addressing the hydrology and flow patterns in the system and in determining the appropriate measures for ecosystem restoration.

3.1.2 Anthropogenic Factors

Mississippi River Levees

With construction of the Mississippi River flood control levees, the Maurepas Swamp has been virtually cut off from any freshwater, sediment, and nutrient input from the Mississippi River floods. Thus, the only soil building has come from organic production within the wetlands, and vegetative productivity may be substantially depressed compared to pre-levee conditions. Subsidence in this area is classified as intermediate, at about 1.1 to 2.0 feet/century. With minimal soil building, moderately high subsidence rates, modified drainage in and around the swamp, there has been a net lowering of ground surface elevation, and the swamps are persistently inundated.

Altered Hydrology

Although the Blind River and Maurepas Swamp have been cut off from the Mississippi River, significant drainage flows to the river and the swamp from the northeast during large storms and hurricanes (that frequently occur in the study area, as indicated above). The flows are so large that the river and swamp drain slowly or not at all, resulting in high water levels, impoundment, and damping of the natural hydroperiod. With minimal ability to drain and persistent flooding, the typical seasonal drying of the swamp does not usually occur. Existing baldcypress and tupelo trees are able to grow in flooded conditions. However, neither baldcypress nor tupelo seeds can germinate when flooded. Seeds of both species remain viable when submerged in water and can germinate readily when floodwaters recede. The potential for re-establishment seems to also be hindered by the relatively low numbers of viable seeds observed in swamp seed banks and by herbivory.

Drainage Canals and Pipe Line Canals

Major drainage canals have been constructed in the project study area. These major drainage canals are associated with and essentially extend flows in Blind River throughout the project site. Canal construction has altered physical defining characteristics, including water storage, sheet flow, and nutrient and sediment input levels within swamp habitat in the study area. The canals are routinely dredged by St. James Parish and dredged material generated in the construction and maintenance of the canals is placed in spoil banks on both sides of the canal. These spoil banks form topographic high points within the study area that affect the distribution of water into the swamp.

Several gas transmission and hazardous liquid pipelines exist in the study area (refer to Table 4-33 in the main report). Dredged material banks that are higher than the natural land surface, and along with the many smaller canals dredged during exploration and pipeline installation, they alter the natural hydrology much the same way as drainage canals discussed previously. The banks constructed from dredged material create partially impounded areas that reduce water exchange resulting in water-logged areas and plant death.

3.2 Ecological Stressors

3.2.1 Hydrologic Connectivity

Hydrologic connectivity addresses the importance of the connection between the Blind River and Maurepas Swamp. The normal flow in the river and flow from large storm events and hurricanes are the ecological stressors that most affect the biological components and patterns that exist in the river and the swamp. These flows affect the drainage patterns in the system since high flows lead to impoundment and alteration of the hydroperiod. During the prolonged period of inundation, drainage is limited, resulting in too much water in the swamp for too long a period (high depth and duration). The overall effect is that there appear to be no dry periods in the swamp, which reduces or eliminates baldcypress and tupelo regeneration. Natural biological life cycle patterns can also be disturbed without dry periods. Impoundment within the study area has also resulted in decreased water quality.

3.2.2 Lack of Freshwater , Sediment, and Nutrient Input

Historically, hydrologic conditions within the study area were dominated by overbank flow from the Mississippi River, and by tidal influence from Lake Maurepas. Periodic flooding of the Mississippi River and/or the Blind River resulted in the inundation of baldcypress-tupelo habitat within the study area. Flooding occurred within the study area and vicinity on a cyclical basis, with peak water elevations in the late spring or fall. As floodwaters receded, surface waters in the study area were conveyed to the Blind River, and then to Lake Maurepas.

The implementation of flood control projects from the late 19th century to mid-20th century, including construction of flood protection levees on the Mississippi River and construction of major drainage canals, disrupted the natural hydrologic regime within the study area. Mississippi River channelization and levee construction greatly reduced overbank flooding in the study area, causing a loss of freshwater (as well as nutrients and sediments) in the ecosystem, decreased water quality, and increased subsidence. Input of freshwater, nutrients, and sediment are important to the biological make-up, productivity, and maintenance of the swamp relative to subsidence and sea level rise. The lack of periodic freshwater input has led to modifications in the swamp's ecology.

Loss of nutrients and sediments is a physical response to the lack of riverine input. Effler et al. (2006) examined the importance of nutrient influxes that accompany freshwater diversions or other hydrologic connectivity projects to swamp productivity. Nutrient augmentation of baldcypress and tupelo trees in the Maurepas Swamp (similar to nitrate loading rates expected from a small freshwater diversion) increased radial growth of both species (especially baldcypress) in degraded forest stands. Nutrient augmentation also increased nitrogen in foliage for both tree species. These findings support hypotheses that swamps in southeastern Louisiana are nutrient-limited, and existing trees can utilize, benefit from, and act as nutrient sinks for nutrient-laden river water accompanying diversions or other freshwater reintroductions.

Further evidence of nutrient starvation was identified in Shaffer et al. (2001). This study determined that nutrient augmentation significantly enhanced (by approximately 33 percent) biomass production of herbaceous vegetation at monitoring stations within the western Maurepas Swamp during 2000. Furthermore, several studies conducted over the last two decades have demonstrated that nutrient augmentation to baldcypress seedlings doubles growth rates in the western Maurepas Swamp (Boshart 1997, Forder 1995, Greene 1994, Myers et al. 1995), further indicating that the baldcypress-tupelo swamp in the study area and vicinity is nutrient-limited.

Shaffer et al. (2008) presented data at the Society of Wetland Scientists meeting on tree growth in the Maurepas Swamp. For the period 2000-2007, diameter growth was measured for over 1,800 trees. Diameter growth in the measured trees was significantly less than established growth levels for trees in healthy freshwater swamp systems. The study determined that in interior swamp locations such as the study area, the primary factor inhibiting diameter growth was nutrient-poor stagnant standing water and the lack of nutrient-rich freshwater throughput caused by the loss of hydrologic connectivity with riverine systems.

3.3 Ecological Effects

3.3.1 Habitat Change and Habitat Loss

Increased habitat conversion is a physical and biological response to both impoundment and the resulting lack of regeneration, increased seedling mortality as well as lack of riverine input and the resulting loss of nutrients and sediments resulting in decreased plant productivity. Hoeppner et al. (2007) concluded that the majority of the Maurepas Swamp is stressed and seems to be on a trajectory of slow degradation leading to a gradual conversion to marsh and open water. Stagnant flooding and nutrient deprivation appear to be the largest stressors in the swamp interior.

Natural regeneration throughout the Maurepas Swamp is very low and even absent at most sites (Hamilton and Shaffer 2001). Land conversion observations on the Manchac land-bridge and Jones Island demonstrate what is expected in the Maurepas Swamp in the coming decades, if no restoration action is taken. In 1956, most of the area of the Manchac land-bridge was dominated by second-growth swamp. By 1978, much of this swamp had converted to marsh and shrub-scrub, and by 1990 the marsh had begun to break up and convert to open water (Barras et al. 1994).

Under the continued influence of these conditions, tree mortality will continue to increase and tree density will continue to decline. Monitoring studies conducted for the CWPPRA PPL 12 proposal indicated that conversion of baldcypress-tupelo swamp to fresh marsh is already occurring in the Maurepas Swamp. The results of these monitoring studies indicate that many areas of interior swamp in the study area and vicinity that exhibit significantly stressed or dying overstory vegetation also contain bulltongue (*Sagittaria lancifolia*) or arrow arum (*Peltandra virginica*) as understory vegetation.

Factors contributing to this conversion include the much greater tolerance of baldcypress and water tupelo with respect to herbaceous understory vegetation for long-term deep inundation, and the increasingly unconsolidated nature of swamp substrate caused by the reduction of below-ground productivity. Consequently, it is expected that the swamp habitat adjacent to the Blind River Canal would convert to open water or marsh habitat without implementation of the proposed project.

Souther and Shaffer (2000) reported that in the early 20th century, baldcypress swamps were harvested *en masse* in coastal Louisiana, and that in many harvested areas, natural regeneration did not occur; instead, these areas converted to marsh or open water. The study concluded that prolonged flooding or complete submergence within the swamps may have suppressed germination or growth rates of young seedlings and even caused mortality. Neither baldcypress nor tupelo seeds can germinate when flooded (Hamilton and Shaffer 2001). Seeds of both species remain viable when submerged in water and can germinate readily when floodwaters recede. However, the seedlings require seasonal drying periods, and the substrate compaction associated with these drying periods, for their root systems to become properly established in the swamp substrate. With minimal ability to drain and persistent flooding, the typical seasonal drying of the swamp does not usually occur, leading to failure of seedlings to establish themselves and replace older trees that have been lost to other processes (CWPPRA Task Force 2002).

Decreased productivity in vegetative communities in the study area is a biological response to the lack of riverine input. Comparison of productivity in swamps that are either managed, have more favorable hydrology, and/or are receiving nutrient enrichment suggest that the existing levels of productivity in the western Maurepas Swamp are as low as 50 percent or even 25 percent of average values (Hamilton and Shaffer 2001).

As part of the CWPPRAPPL 11 effort to launch a project diverting Mississippi River water into the Maurepas Swamp, Shaffer et al. (2001) examined woody and herbaceous vegetation at 20 study sites in the Maurepas Swamp. The study examined cover values, annual production, herbaceous (understory) primary production, tree health and primary productivity, annual tree diameter growth, and litterfall production at these sites to develop a comprehensive picture of vegetation productivity in the region. The study concluded that salinity is currently an important stressor in the Maurepas Swamp, but that degradation of tupelo trees within the swamp has been occurring for decades and is almost certainly primarily due to altered hydrology and lack of throughput. The study determined that the low soil bulk densities and high soil organic matter content throughout much of this swamp are indicative of a lack of riverine influence.

The results of the Shaffer et al. (2001) and other studies indicate that the western Maurepas Swamp is highly degraded and would benefit from a substantial infusion of nutrients and freshwater from a river diversion or other freshwater reintroduction. Results of studies in wetlands receiving secondary treated sewage suggest that introduction of nutrients as well as sediments from river water could stimulate production by 300 to 500 percent (Rybczyk et al. 2002, Hamilton and Shaffer 2001).

3.3.2 Decreased Water Quality

Decreased water quality is a chemical response to the impoundment produced in the study area and the introduction of saline storm surge waters associated with tropical cyclone events. The Maurepas Swamp is characterized by nutrient-poor surface waters. Day et al. (2001) conducted a water quality analysis in support of CWPPRA Project PO-29 *Mississippi River Reintroduction into the Maurepas Swamps*. The observed concentrations of nitrate, ammonium, and nitrogen at surface water sampling stations within the western Maurepas Swamp were all reduced with respect to observed concentrations in the Mississippi River. The results of sampling of water quality parameters demonstrate that, for some nutrient forms, the Maurepas Basin has relatively low nutrient concentrations compared to the Mississippi River and other systems studied. The results of this study indicate that the baldcypress-tupelo swamp within the study area and vicinity is severely nutrient-limited.

Additionally, storm surges originating from Lake Maurepas associated with tropical cyclone events may exert a stochastic but severe stress upon the swamp habitat through salinity spikes in surface waters within the swamp. Recent tropical cyclone events, occurring at a rate of one to two per years, have produced measurable spikes in salinity within the western Maurepas Swamp (USACE 2004).

3.4 Attributes and Performance Measures

3.4.1 Vegetation Productivity

Swamp vegetation productivity has been identified as a key indicator of project success. Comparison of pre-project and post-project vegetation monitoring data would serve to determine if biomass production in plant communities within the study area increases in response to project features. A post-project increase in biomass production would also indicate the introduction of nutrients and sediment into the swamps as a result of the project. Three assessment performance measures have been identified for this attribute, including percent cover, diameter at breast height (dbh), and litterfall.

- *Percent cover* is the estimated percentage of the ground surface covered by vegetation. Canopy percent cover is the estimated percentage of the ground surface covered by tree canopies when the crowns are projected vertically. A high percent cover is indicative of significant productivity within the respective vegetation communities, and a high canopy percent cover is indicative of significant productivity within woody species.
- *Diameter at breast height (dbh)* is the measurement of tree diameter at a height of 4.5 feet above the forest floor on the uphill side of the tree. Ongoing monitoring studies of baldcypress and tupelo trees within the western Maurepas Swamp by Dr. Gary Shaffer indicate that average annual dbh increase for trees within the eastern study area is approximately one millimeter per year, a growth level that is significantly lower than expected levels of 1-2 centimeters per year for healthy baldcypress or tupelo trees (Shaffer, personal communication 2009).
- *Litterfall* is the measurement of the movement of leaves, twigs, and other forms of organic matter from the biosphere to the litter layer found in soil via interception in collection traps. Large volumes of litterfall are indicative of significant biomass production within the constituent forest community.

A post-project relative increase in productivity within the study area, as evidenced by these three measures, would be an indication of significant project success, while a post-project stabilization of these measures would be an indication of moderate project success. Conversely, a post-project decline in these measures within the study area would indicate that the project did not succeed in increasing swamp vegetation productivity.

3.4.2 Fish and Wildlife Habitat

The Maurepas Swamp is an important habitat for a variety of fish and wildlife species, including crawfish, alligators, snapping turtles, blue crab, and channel catfish. The Maurepas Swamp also provides valuable habitat to a number of avian species, including neo-tropical migratory songbirds and waterfowl. Two threatened species (the bald eagle and Gulf sturgeon) are found in this area. Bald eagles typically nest in baldcypress trees near low salinity to intermediate marshes or open water. The Gulf sturgeon is a threatened species found in Lake Maurepas. Although extremely rare, the West Indian manatee has been sighted in the area a few times over the last 25 years. The Maurepas Swamp is used for fishing, hunting, and other recreational activities, and as a large contiguous tract of baldcypress/tupelo swamp near the New Orleans metropolitan area, has considerable cultural significance. Wildlife habitat will be evaluated with the Wetland Value Assessment (WVA) procedure..

3.4.3 Hydroperiod

For any single year the hydroperiod of the swamp is bimodal. The water level generally rises in the spring, then falls to its lowest level during summer, rises to its highest level in the fall, and again falls to low levels in the winter. High water levels in the fall are attributed to tropical storms and hurricanes. Increases in flood duration are exacerbated by sea level rise and subsidence. Flood duration is one of the main drivers that control species diversity and productivity in the swamp.

Hydroperiod measurement is a key monitoring component for determining the hydrology and status of the project area. Flow in the Blind River will be measured and evaluated and piezometers will be established in Maurepas Swamp in each project area hydrologic unit.

3.4.4 Elevation

Ground surface elevation has been identified as a key indicator of project success with respect to reducing or reversing subsidence within the study area. Comparison of pre-project elevation levels with post-project elevation levels would serve to determine if sediment input and soil accretion is occurring within the study area in response to project features. A post-project increase in elevation would implicitly indicate the introduction of nutrients and sediment into the swamps as a result of the project, and would also indicate an increase in vegetation productivity and the resulting litterfall that is a principal factor in soil accretion within the Maurepas Swamp. Two assessment performance measures have been identified for this attribute, including surface elevation table (SET) measurements and feldspar marker horizon measurements.

- *Surface Elevation Table (SET) measurements* provide a constant reference plane in space from which the distance to the sediment surface can be measured by means of pins lowered to the sediment surface. Repeated measurements of elevation can be made with high precision because the orientation of the table in space remains fixed for each sampling. Elevation change measured by the SET is influenced by both surface and subsurface processes occurring within the soil profile.

- *Feldspar marker horizon measurements* involve the placement of a cohesive layer of feldspar clay on the ground surface. Soil borings are periodically extracted at the marker horizon location to measure the amount of soil deposition and/or accretion that has occurred above the horizon since placement. Significant quantities of soil atop marker horizons are indicative of soil building within the area, which in turn indicates an increase in relative elevation.

Post-project increases in elevation as evidenced by SET measurements or documented soil accretion atop a marker horizon within the study area would be an indication of significant project success, while a post-project stabilization of elevation as evidenced by these measures would be an indication of moderate project success. Conversely, a post-project decline in elevation within the study area would indicate that the project did not succeed in offsetting subsidence and, by extension, habitat conversion, and future land loss.

3.4.5 Water Quality

Surface water quality in interior locations in the study area has been identified as a key indicator of project success with respect to establishing hydrologic connectivity between the Blind River and associated major canals, and the adjacent swamp habitat. Comparison of pre-project and post-project water quality would serve to determine if freshwater throughput is introducing nutrients and flushing out saline waters within the study area in response to project features. A post-project improvement in water quality would implicitly indicate the introduction of freshwater and the associated nutrients and sediment into the swamps as a result of the project. Four assessment performance measures have been identified for this attribute, including total suspended solids (TSS), dissolved oxygen (DO), nutrients, and salinity.

- *Total suspended solids* (TSS) is a measurement of the total volume of sediment and other solids suspended in a given volume of water.
- *Dissolved oxygen* (DO) is a relative measure of the amount of oxygen that is dissolved in a given volume of water. Surface waters within the swamps in the study area are expected to exhibit lower DO concentrations than those of nearby waterbodies, because water movement (which exposes surface water to a greater volume of air through lateral movement and results in greater dissolution of oxygen) is virtually nonexistent in the swamps.
- *Nutrients* are chemical compounds or minerals contained in surface waters that are extracted by organisms for nourishment. Common nutrients in surface waters include nitrates, phosphates, and ammonia. Surface waters within the swamps adjacent to the Blind River and associated major canals have been demonstrated to be nutrient-poor with respect to other waterbodies in the area because the hydrology prevents the accumulation of nutrients from surface runoff.
- *Salinity* is a measure of the concentration of dissolved salt in a given volume of water. Surface waters within the study area often exhibit elevated salinity levels with respect to other area waterbodies because saline storm surges introduced into the swamps during tropical cyclone events become trapped in the impounded swamps and are not allowed to drain out of the study area.

Post-project improvements in water quality within the study area as evidenced by analyses of these measures would be an indication of significant project success, while a post-project stabilization or decline in water quality within the study area would indicate that the project did not succeed in reestablishing riverine input to the study area and the resulting reintroduction of nutrients and sediments associated with freshwater throughput.

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