

**APPENDIX I**  
**MONITORING AND ADAPTIVE MANAGEMENT PLAN**





**Monitoring and Adaptive Management Plan  
San Marcos River  
Section 206 Aquatic Ecosystem Restoration Project**

A National Ecosystem Restoration (NER) Plan has been selected for the San Marcos River Section 206 Aquatic Ecosystem Restoration Project. This Adaptive Management Plan provides a schedule and description of monitoring and maintenance activities, as well as success criteria and potential adaptive management strategies.

Monitoring is included for each measure included in the NER Plan (Table 1), and reporting would occur by December 31 of each Target Year (TY) during which monitoring occurs. All monitoring reports would be submitted to U.S. Army Corps of Engineers, Fort Worth District (CESWF). It is assumed that all restoration measures would be sustainable with minimal maintenance following the 3-year establishment period. Monitoring would occur during each year of the establishment period to quantify and report the status of success criteria. The control of exotic emergent vegetation (EXOE), restoration of wetland (WET), restoration of discharge locations (DISC), and removal of accumulated sediment (SED) would all be monitored at 5-year intervals following successful establishment. The restoration of the riparian zone (RIP2) and control of exotic shrubs and trees (EXOT) would be monitored at TY15 (when the canopy is anticipated to begin forming) and at TY25 (when the canopy is anticipated to become closed).

**Table 1. Monitoring Schedule for Restoration Measures Included in the NER Plan**

Measure	Monitoring Year*										
	TY1 to TY3	TY5	TY10	TY15	TY20	TY25	TY30	TY35	TY40	TY45	TY50
EXOE	Annual	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
RIP2	Annual			yes		yes					
EXOT	Annual			yes		yes					
WET	Annual	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
DISC	Annual	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
SED	Annual	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

\*Additional monitoring years may be required where success criteria are not met.

The findings of the monitoring reports would be used to determine the sustainability of restoration measures. Annual monitoring would continue until all success criteria are met or coordination with resource agencies determines that the measures are self-sustaining. If

success criteria are not met, adaptive management measures would be implemented as described below.

## **EXOE**

EXOE would be implemented such that one-third of the existing area of elephant ear (*Colacasia esculenta*) at TY0 is removed during each year of the 3-year establishment period, and maintenance would include control of any reestablishment at 5-year intervals. Control would be implemented at discrete locations no larger than 500 square feet to be delineated and identified as a restoration site. A restoration site can include more than one patch of elephant ear, but the total area cannot exceed 500 square feet. Any patch of elephant ear larger than 500 square feet would be identified and reported as two independent restoration sites. The following information would be reported for each restoration site in any TY during which control of elephant ear occurs:

- qualitative description of restoration site with photographs
- location, area, and number of patches removed, as recorded using a GPS
- area, number, list and qualitative description of native species impacted (trampling, incidental removal, etc.)
- number and list of native species planted
- qualitative and quantitative description of any temporary best management practices (BMPs) installed

Monitoring of sites where elephant ear was removed in TY1 would occur prior to the initiation of removal at sites scheduled for TY2. Elephant ear removed at sites initiated in TY1 and TY2 would be monitored prior to initiation of the removal at sites scheduled for TY3. If success criteria are met at a site at the beginning of TY3, no further monitoring of that site would be required until TY5. The following information would be reported for each restoration site during the TY following initial control efforts:

- qualitative description of restoration site with photographs
- percent cover of plants by species, as quantified using three randomly located 1-square-meter quadrats

- qualitative description of any damage to site including damage to BMPs resulting from wildlife, recreation, or weather events
- quantitative and qualitative description of any evidence of erosion

Monitoring and reporting would occur at each restoration site where removal was implemented during the previous TY or where success criteria were not met in the previous TY. The following success criteria are required for EXOE:

- no elephant ear present
- at least 50 percent relative cover of native plants
- no evidence of uncontrolled erosion occurring within or downstream of the restoration site

Any elephant ear remaining would be removed. If elephant ear are observed at the same restoration site over 2 subsequent years, additional efforts would be implemented to remove rhizomes to a greater depth. Any exotic plants present would be removed by hand. If the relative cover of native plants is less than 50 percent, additional plantings would be installed. Plantings would be selected from those native species with the greatest percent cover at the site. Any uncontrolled erosion would be addressed by implementing additional temporary BMPs. If uncontrolled erosion continues for more than 1 year, additional long-term measures would be considered, such as contouring and bank stabilization through placement of aggregate, wattles, or other native plants, or implementing other measures appropriate for the situation.

It is assumed that all elephant ear would be removed from the study area by the end of the TY3 and that control of upstream sources (i.e., Spring Lake) would prevent future establishment in the study area. However, monitoring of the study area for newly established patches of elephant ear would continue at 5-year intervals throughout the life of the project. The same monitoring, reporting, and management measures implemented during the establishment period would be implemented during subsequent monitoring and maintenance.

## **RIP2**

RIP2 would be implemented such that all initial soil preparation, planting, and BMPs would be completed during TY1. Restoration would be conducted at discrete sites supported by an

independent irrigation system. The following information would be reported for each restoration site at the end of TY1:

- qualitative description of restoration site with photographs
- location and area of planting zones, as recorded using a GPS
- location, total length, and estimated use of installed irrigation, as recorded using a GPS
- area, number, and list of native species planted by zone, as recorded using a GPS
- qualitative and quantitative description of any temporary BMPs installed

Monitoring would occur at each restoration site during the late spring of TY2 and TY3, and the following information would be reported:

- percent cover of woody plants by species, as quantified using one line-intercept transect situated perpendicular to the river and passing through the widest part of the restoration site; at least one transect would be surveyed for every 100 yards (or part thereof) of restoration site (as measured parallel to the river)
- percent mortality of planted trees and shrubs, as quantified by enumerating live and dead specimens following a wandering transect within the restoration site
- percent cover of herbaceous plants by species within Zone 3, as quantified using three randomly located 1-square-meter quadrats within every 0.5 acre of restoration site or any part thereof
- qualitative and quantitative description of any evidence of erosion occurring within or downstream of the restoration site

The success of RIP2 would be evaluated at the end of TY3 and again at the end of TY5. The following success criteria are required for RIP2 at TY3:

- percent cover of native woody plants greater than 20 percent
- percent cover of exotic woody plants less than 5 percent
- percent mortality of planted shrubs and trees less than 20 percent
- percent cover of native herbaceous plants in Zone 3 greater than 70 percent
- percent cover of exotic herbaceous plants in Zone 3 less than 5 percent
- no evidence of uncontrolled erosion occurring within or downstream of the restoration site

If percent cover of native woody plants is less than 20 percent at TY3, irrigation would be left in place for 2 more years. Additional plantings would be made to replace dead shrubs and trees and to fill gaps in Zone 3. Plantings would be selected from those species with the greatest percent cover at the site. All exotic plants would be removed by hand where feasible, and an herbicide would be applied to exotic plants where establishment is pervasive. Any uncontrolled erosion would be addressed by implementing additional temporary BMPs. If uncontrolled erosion continues for more than 1 year, additional long-term measures would be considered, such as contouring and bank stabilization through placement of aggregate, wattles, or other native plants, or other measures appropriate for the situation.

If RIP2 success criteria are not met at the end of TY3, the following success criteria are required for RIP2 at TY5:

- percent cover of native woody plants exceeds 60 percent
- percent cover of exotic woody plants is less than 1 percent
- percent mortality of planted shrubs and trees is less than 20 percent
- percent cover of native herbaceous plants in Zone 3 exceeds 90 percent
- percent cover of exotic herbaceous plants in Zone 3 is less than 5 percent
- no evidence of uncontrolled erosion occurring within or downstream of the restoration site

If RIP2 success criteria are not met at the end of TY5, irrigation would remain in place, additional plantings would be made, invasive species would be controlled, and any evidence of erosion would be remediated using long-term measures. These measures would be repeated each year until TY5 success criteria are met.

Following successful establishment, restoration sites would be monitored at TY15 and TY25, and the following information would be reported:

- percent cover of plants by species as quantified using one line-intercept transect situated perpendicular to the river and passing through the widest part of the restoration site; at least one transect would be surveyed for every 100 yards (or part thereof) of restoration site (as measured parallel to the river)
- qualitative and quantitative description of any evidence of erosion occurring within or downstream of the restoration site

There are no success criteria for TY15 and TY25. The restoration site would be established at this time, and only maintenance of exotic plants or erosion would be required.

## **EXOT**

EXOT would be implemented such that the application of herbicide would be completed at the end of TY1. EXOT would be conducted at discrete sites defined by contiguous patches of forest not separated by trails, roads, or surface waters. The following information would be reported at the end of TY1 for each restoration site:

- qualitative description of restoration site with photographs
- approximate location and area of herbicide application, as recorded using a GPS
- list and estimated relative abundance of species controlled
- type, concentration (rate), and volume of herbicide applied and number of herbicide spikes used

It is assumed that some resprouts and germination of exotic plant seeds in the seed bank would continue through TY3. Thus, control of exotic plants and monitoring of each restoration site would be repeated in TY2 and TY3. The following success criterion is required for EXOT at TY3:

- less than 5 percent cover of exotic shrubs or trees, as quantified using a GPS; each individual or patch of exotic trees would be quantified or delineated, respectively, and total area of exotics would be divided by total area of the restoration site to determine percent cover

If greater than 5 percent cover of exotic shrubs or trees is reported, an additional year of exotic control, monitoring, and reporting would be required. Herbicide application would continue until the success criterion is met.

It is assumed that all exotic shrubs and trees, including any shrubs or trees below the 5 percent success threshold, would be controlled at the end of TY3; however, each restoration site would be monitored at TY15 and TY25 to ensure that any new establishment of exotic species is controlled. The same monitoring, reporting, and management measures implemented during

the establishment period would be implemented during subsequent monitoring and maintenance.

## **WET**

WET would be implemented such that construction activities and planting of native vegetation is completed by the end of TY1. The following information would be reported at the end of TY1 for each wetland restoration site (Sessoms Creek and Cheatham Street):

- qualitative description of restoration site with photographs
- number and list of native species planted
- qualitative and quantitative description of any temporary BMPs installed

Each wetland restoration site would be monitored at the end of TY2 and TY3, and the following information would be reported:

- qualitative description of restoration site with photographs
- percent cover of aquatic plants by species, as quantified using five 1-square-meter quadrats located randomly along the edge of each separate wetland area (i.e., one area at Cheatham Street site and three separate areas/wetponds on Sessoms Creek site)
- water depth, as measured at the deepest point using a graduated rod
- qualitative and quantitative description of any evidence of erosion occurring within or downstream of the restoration site

It is assumed that the wetlands would be established at the end of TY3, and the following success criteria are required:

- at least 55 percent cover of aquatic plants
- water present at a depth of at least 1 foot
- percent cover of exotic plants is less than 5 percent
- percent cover of native invasive plants (e.g., cattails) is less than 5 percent
- no evidence of uncontrolled erosion occurring within or downstream of the restoration site

If these criteria are not met at TY3, an assessment of the wetlands functionality would be conducted. If beneficial, additional plantings would be made selecting those species that are successful at the site. It may be determined either that climatic conditions have prevented success criteria from being met, or that some aspect of the wetland design is not functioning as intended. If climatic conditions are determined to be the issue, then the wetlands will continue to be monitored until conditions are observed during a normal climate year. If wetland design is determined to be the issue, potential solutions would be developed to remediate suspected design deficiencies. Coordination with resource agencies would be required prior to any modification of wetlands.

## **DISC**

DISC would be implemented such that all improvements to topography, addition of natural, flow dampening materials, and plantings are completed by the end of TY1. The following information would be reported at the end of TY1 for each discharge restoration site:

- qualitative description of discharge restoration site with photographs
- location and total area of soil disturbance, as recorded using a GPS
- number and list of native species planted
- qualitative and quantitative description of any temporary BMPs implemented

Each discharge restoration site would be monitored at the end of TY2 and TY3, and the following information would be reported:

- qualitative description of restoration site with photographs
- percent cover of plants by species, as quantified using one randomly located line-intercept transect situated along one side of the drainage; each transect would cover the entire length of the discharge restoration site
- percent mortality of planted trees and shrubs, as quantified by enumerating live and dead specimens following a wandering transect within the restoration site
- no unintended accumulation of sediments or obstruction to flow
- qualitative and quantitative description of any evidence of erosion occurring within or downstream of the restoration site

It is assumed that all discharge locations would be established and self-sustaining at the end of TY3; however, the following success criteria are required:

- percent cover of plants greater than 80 percent
- percent mortality of planted shrubs and trees less than 20 percent
- percent cover of exotic woody plants is less than 1 percent
- percent cover of exotic herbaceous plants is less than 5 percent
- no evidence of unintended obstructions or uncontrolled erosion occurring within or downstream of the restoration site

If these success criteria are not met, an assessment of the drainage's functionality would be assessed. If beneficial, additional plantings or seeding would be implemented. If mortality of planted shrubs and trees is less than 20 percent, the plants would be replaced with species selected from those providing the greatest cover at the site. If there is evidence of unintended obstructions or uncontrolled erosion, the design of the drainage would be reviewed and any steps necessary to remediate the problems would be implemented. Potential remediation could include installation of additional temporary BMPs or more permanent measures such as the re-contouring or installing of additional plantings or natural materials to reduce flow velocity. Coordination with resource agencies would be required prior to any modification of discharges.

## **SED**

SED would be implemented such that no more than 10 percent of the river channel would be affected in any year. At TY0, a survey of the river channel would be conducted to identify areas of accumulation. Areas of accumulation would be identified as patches of fine sediment greater than 50 square feet in area and greater than 2 inches in depth. Accumulated sediments would be removed from discrete locations to be identified as substrate restoration sites. The results of the initial survey would be reported to CESWF and resource agencies, and the list of restoration sites would be prioritized. This survey for accumulation and the consultation with resource agencies would be repeated for each monitoring year. The following information would be reported for each substrate restoration site for any TY during which sediment removal occurs:

- qualitative description of each restoration site with photographs
- location, area, depth, and volume of sediments removed, as quantified using a GPS

- area, number, list, and qualitative description of native species impacted (trampling, incidental removal, etc.)
- qualitative and quantitative description of any BMPs implemented

It is assumed that measures to control the input of sediments (RIP2, DISC, and WET) would reduce sediment accumulation after TY3. There are no success criteria for SED. Monitoring, reporting, and sediment removal would occur at 5-year intervals. If there is not sufficient accumulation of sediments to warrant removal, no removal would occur.