State of Louisiana

Coastal Protection and Restoration Authority of Louisiana

Monitoring Plan

for

Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2)

State Project Number BA34-2
Priority Project List 10

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St. James Parish

Prepared by:
Glen P. Curole
Coastal Protection and Restoration Authority of Louisiana
Thibodaux Field Office
1440 Tiger Drive, Suite B
Thibodaux, LA 70301

The Coastal Protection and Restoration Authority (CPRA) and the United States Environmental Protection Agency (EPA) agree to carry out the terms of this Monitoring Plan (hereinafter referred to as the "Plan") of the accepted, completed project features in accordance with the Cost Sharing Agreement PR-00F62401 dated November 22, 2013. The EPA will be included as part of the Plan as a reviewing federal sponsor.

The project features covered by this plan are inclusive of and are identified as the Hydrologic Restoration and Vegetative Planting in the des Allemands Swamp (BA-34-2). The intention of the provisions of this plan is to monitor the project using standardized data collection techniques and to analyze those data to determine whether the project is achieving the anticipated benefits. Reports will be generated and recommendations made to adaptively manage the project. There are no requirements that this project function to any standard beyond the economic life, except that it is not left as a hazard to navigation or a detriment to the environment.

Construction of the Hydrologic Restoration and Vegetative Planting in the des Allemands Swamp was authorized by Section 303(a) of Title III Public Law 101-646, the Coastal Wetlands Planning and Protection Restoration Act (CWPPRA) enacted on November 29, 1990 as amended. This project was approved on the tenth (10^{th}) Priority Project List.

1. PROJECT DESCRIPTION, PURPOSE, GOALS, and FEATURES

Description

The Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project will attempt to restore the hydrology of a semi-impounded 969 ha (2,395 acres) bald cypress-water tupelo (*Taxodium distichum-Nyssa aquatica*) swamp. This will be achieved by breaching the almost continuous Bayou Chevreuil spoil bank in six (6) positions to reduce the duration of rain driven flooding events. The project is located within the western St. James Parish town of Vacherie, LA, which lies in the northern reaches of the Barataria Basin between the Bayou Lafourche and Mississippi River ridges (Figure 1). The BA-34-2 project is bounded by LA Hwy 20 on its western margin, by Board Road and the Vacherie Canal on its northern margin, and by Bayou Chevreuil on its southern margin (Figure 2). Additionally, Lac des Allemands is situated approximately 8.0 km (5.0 mi) to the east of the project area (Figure 1).

Cypress-tupelo swamps first appeared in the Lower Mississippi Valley around 12,000 years B. P. coinciding with the end of the last ice age. Since that time, the Mississippi River has created a series of meander belts through sedimentation and river forcing (Saucier 1994). Over the past 6,000 years, the River has formed a sequence of delta complexes, which have deposited sediments over the River's delta plain creating hardwood forests, cypress-tupelo swamps, and marshes via overbank flooding and crevasse splays (Frazier 1967; Saucier 1994; Reed 1995; Day et al. 2000). The Northern Barataria Basin is believed to have been an active alluvial floodplain of the River during the St. Bernard, Lafourche, and Plaquemines delta complexes (Frazier 1967;

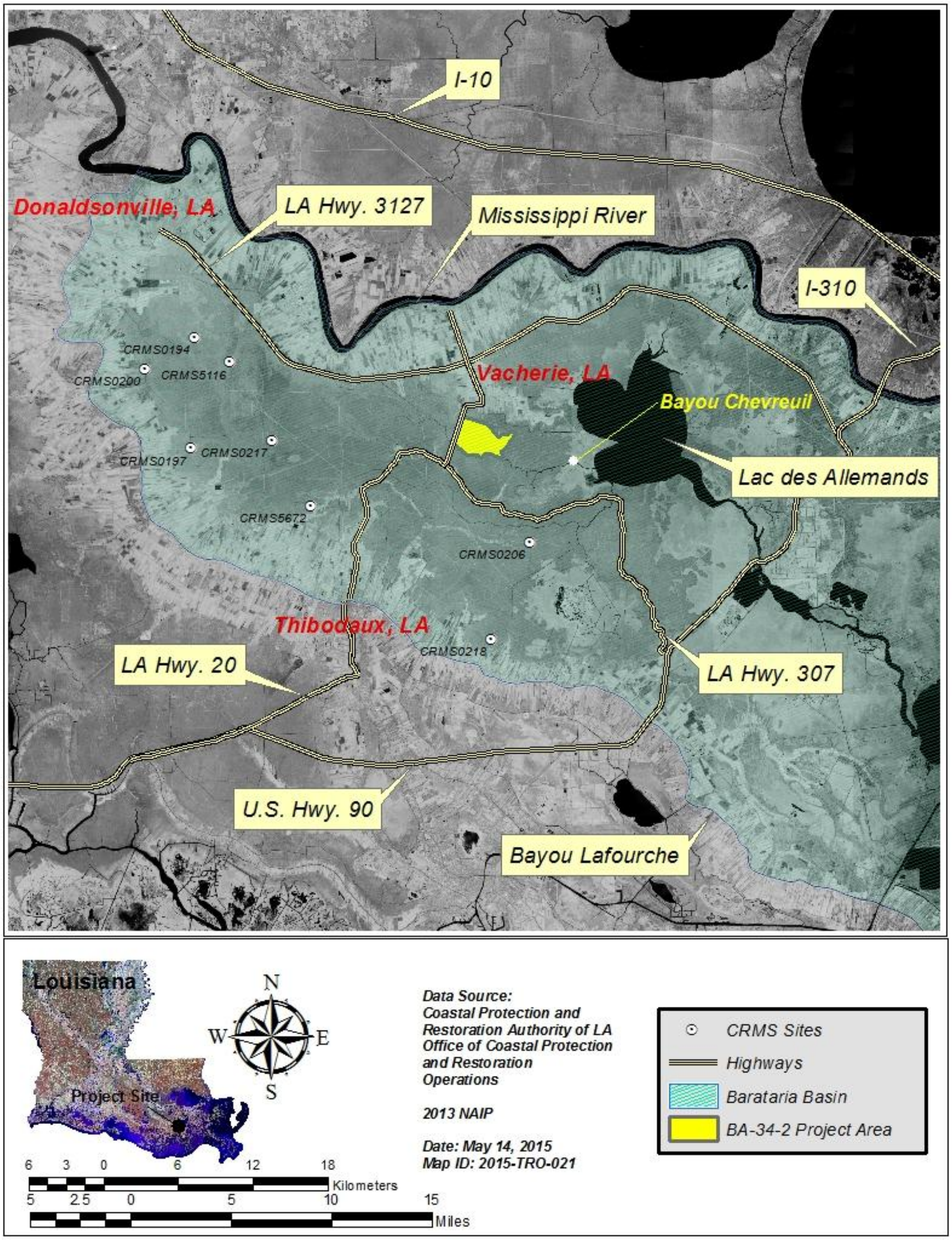

Figure 1. **Location and vicinity of the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project.**

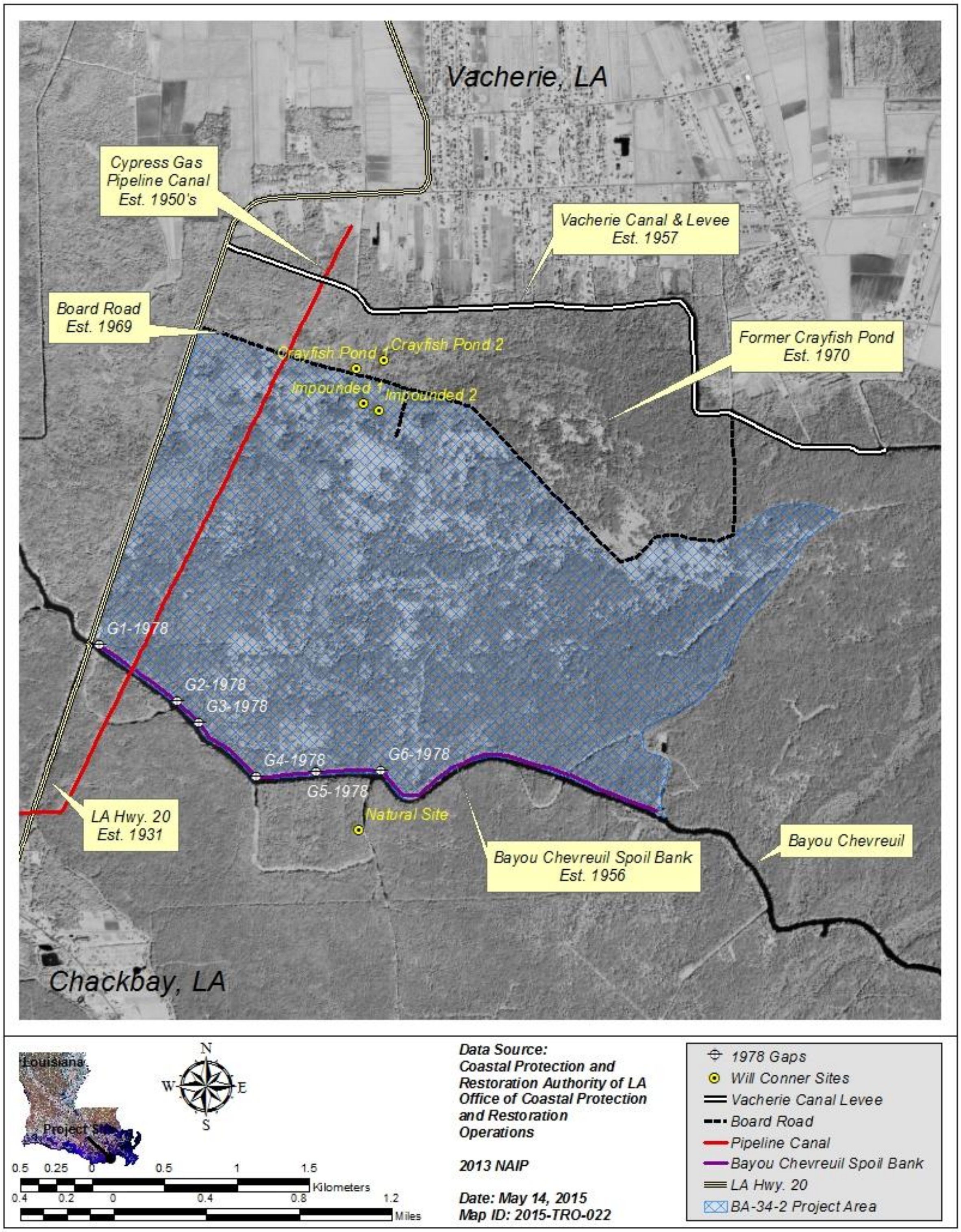

Figure 2. Location of the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project area.

Saucier 1994). The deposition of sediment in the northern basin for this extended geologic period and multiple delta complexes led to the creation of extensive bottomland hardwood and cypress-tupelo forests. The cypress-tupelo forest in the BA-34-2 project area is classified as an inland swamp, interior wetland forest with low relief, poor drainage, and low rates of mineral accretion (Saucier 1994).

The soils on BA-34-2 project area are composed of Barbary association, Sharkey association, frequently flooded, and Commerce silt loam sediments. The Barbary association soil is a muck that is continuously saturated and frequently flooded soil that extends over 95% of the project area. This soil is located in areas that are very flat with little relief and poor drainage (USDA 1973). The Sharkey association, frequently flooded soil is a clayey soil dispersed in bands between natural ridges and the swamp while the Commerce silt loam is a silty clay loam to silty loam soil that is somewhat poorly drained and occupies elongated areas on natural levees. Both of the latter soils are only distributed in narrow bands between LA Hwy. 20 and the Cypress Gas Pipeline (USDA 1973).

The BA-34-2 project area habitats generally consist of cypress-tupelo wetland forest. The dominant soil Barbary association is classified as cypress-tupelo habitat. *Quercus texana* Buckley (Nuttall oak), *Quercus nigra* L. (water oak), *Ulmus americana* L. (American elm), *Fraxinus pennsylvanica* Marshall (green ash), and *Liquidambar styraciflua* L. (sweetgum) species dominate the Sharkey association, frequently flooded, and Commerce silt loam soils (USDA 1973). Reed (2005) cataloged the alluvial river swamps of the upper Barataria Basin as being dominated by *Taxodium distichum* (L.) Rich. (baldcypress) and *Nyssa aquatica* L. (water tupelo) with *Fraxinus profunda* (Bush) Bush (pumpkin ash) and *Acer rubrum* var. *drummundii* L. (swamp red maple) as sub-dominants. Sasser et al. (2014) classified the project area as swamp habitat.

The virgin cypress forests of the upper Barataria Basin were harvested in the late 19th and early 20th centuries. The current wetland forests of the northern basin are second growth. These forests regenerated naturally and are approximately 100 years in age (Conner and Day 1976; Conner 1988; Faulkner et al. 2007). In 1904, a dam was placed at the headwaters of Bayou Lafourche and later in the mid-20th century the Mississippi River was channelized by the construction of artificial levees along its banks for flood control, eliminating the sediment source and substantially impacting the freshwater supply to the northern Barataria forests (Reed 1995). Currently, the only freshwater source in the upper basin is precipitation [150 cm/yr (59 in/yr)] because no rivers or bayous discharge into these northern forests and marshes (Saucier 1994; Reed 1995; Park et al. 2004). The reduced sediment supply has resulted in an increase in subsidence causing water levels in the northern basin to elevate. As a result, the northern Barataria wetland forests have been found to be flooded for longer durations (Conner and Day 1988; Conner and Brody 1989; Keim et al. 2006).

The hydrology of the cypress-tupelo forest within the BA-34-2 project area has been further altered by the installation of artificial embankments on three sides. In 1931, an elevated roadbed was built on the western border of the project area during the construction of LA Hwy. 20. In 1956, spoil banks were built along the Bayou Chevreuil shoreline (southern edge of the project area) with material excavated to deepen the channel (Figure 2) (Conner and Day 1992a). In 1957 a drainage canal, the Vacherie Canal, was constructed immediately north of the project area and an elevated berm was created with the excavated soil material. In 1969, Board Road was built on the northern perimeter of the project area by excavating local material to build an oil field access road (Figure 2) (Conner and Day 1992a). Since 1957, the duration of flooding events has increased to the point of almost constant impoundment of the project area due to these elevated earthen embankments (Conner et al. 1981). Moreover, LA Hwy 20, Board Road, and the Vacherie Canal berm formed the guide levees for a crayfish pond that has since ceased to operate (Figure 2) (Conner and Day 1992a). In addition, the Cypress Gas Pipeline Company installed a 35.6 cm (14.0 in) gas pipeline and canal within the project area sometime in the 1950's. This pipeline canal bisects the project area and is situated approximately 0.3-0.7 km (0.2-0.4 mi) from LA Hwy. 20 (Figure 2). No spoil banks were built along the edges of the canal with the excavated material. Therefore, the pipeline canal is not thought to intensify the drainage restrictions in the project area.

The scientific record shows that altering hydrological patterns and increasing inundation affects cypress-tupelo habitats. Mature cypress-tupelo wetland forests have been found to be less productive and incur slower vegetative growth in deep-flooded stagnant waters (Harms 1973; Conner and Day 1976; Donovan et al. 1988; Conner 1994; Keim et al. 2006; Shaffer et al. 2009; Keim et al. 2012; Keim et al. 2013). Swamp structure and function also have been reported to be inversely impacted in impounded habitats (Conner et al. 1981; Conner and Day 1992a; Faulkner et al. 2007; Shaffer et al. 2009). Moreover, tree mortality in cypress-tupelo forest increases under impounded conditions (Conner and Day 1992b; Conner et al. 2002; Shaffer et al. 2009). Vegetative growth in these swamps is greater in flowing water (Harms 1973; Conner and Day 1976; Donovan et al. 1988; Shaffer et al. 2009). Regeneration of cypress-tupelo forest is also negatively affected by deep-flooded stagnant waters. Seedlings require drainage to elongate their roots (Pezeshki 1991) and survive (Conner 1988; Pezeshki et al. 1993; Keim et al. 2006; Faulkner et al. 2007; Faulkner et al. 2009). Moreover, natural or artificial (planting seedlings) regeneration is not possible in severely impounded swamps without drainage enhancements (Faulkner et al. 2009).

The BA-34-2 project area has been the subject of a long-term scientific study. Dr. William Conner has chronicled the effects of inundation on the project area and its surroundings over an approximate three (3) decade period (Conner and Day 1976; Conner et al. 1981; Conner and Day 1988; Conner and Brody 1989; Conner and Day 1992a; Conner and Day 1992b; Conner et al. 2002). He studied three (3) distinct cypress-tupelo habitats - the impounded area (BA34-2 project area), the crayfish pond (location described above), and the natural site (located off the south bank of Bayou Chevreuil). Some of his study sites are shown in Figure 2. His studies have revealed that the BA34-2 project area has been negatively influenced by severe inundation. One of Dr. Conner's studies examined the effects of breaching the Bayou Chevreuil spoil bank (gap creation). This earthen embankment was breached in six (6) locations in 1978 (Figure 2). The results of this five (5) year investigation provided evidence showing that the productivity of cypress-tupelo habitats can be enhanced in the immediate vicinity of gapped locations by improving water exchange. However, productivity in areas progressively further from the gaps did not increase because drainage did not improve (Conner and Day 1992b). Micro-topographical variation in the swamp surface has been suggested as a cause of this inhibited drainage (Conner and Day 1992a). Also, earthen gaps tend to silt in periodically and require maintenance. Currently, these gaps are partially functioning due to siltation. Therefore, gaps alone will not improve drainage throughout most large, impounded swamps. Identification of relief, drainage enhancements, and maintenance are also required to improve cypress-tupelo productivity, survivorship, and regeneration.

Two (2) recent studies completed for the BA-34-2 project indicate that restoration of the cypress-tupelo habitats can be attained by improving drainage within the project area. Shaffer (2011) performed an ecological review of the project area through field investigation and literature review. He concluded that it is highly likely that cypress-tupelo habitats of the project area will become sustainable if the impairments to hydrology are removed. Jadhav (2015) conducted a 2D hydrodynamic model for the BA-34-2 project using hydrological, topographic, and meteorological data. He surmised that water levels in the swamp will emulate that of Bayou Chevreuil if the spoil bank is breached in six (6) positions to a depth of -0.3 m (-1.0 ft) NAVD88. Currently, the water levels in the swamp do not follow that of the bayou due to swamp inundation (Jadhav 2015).

Three (3) different culvert projects have been initiated to improve the drainage along the perimeter of the BA-34-2 project. In 2001, three (3) 91 cm (36 in) culverts were installed under LA Hwy. 20 as part of a highway resurfacing project by the LA Department of Transportation and Development (LA DOTD) (Figure 3). In 2002, the St. James Parish Public Works Department placed nine (9) 46 cm (18 in) gated culverts beneath the Vacherie Canal Levee allowing the former crayfish pond to drain into the Vacherie Canal (Figure 3). In 2013, eight (8) 61 cm (24 in) culverts were embedded under Board Road as part of a Parish Coastal Impact Assistance Project (CIAP) allowing water to flow from the impounded area into the former crayfish pond (Figure 3). These eight culverts were installed adjacent to two (2) pre-existing 41 cm (16 in) culverts (construction date unknown). Therefore, ten (10) culverts currently bisect Board Road. The influence of the twenty-two (22) constructed culverts on the hydrology of the BA-34-2 project area has not been studied extensively to date although Shaffer (2011) noted regeneration of cypress-tupelo habitats in the immediate outfall of existing culverts and gaps. However, the project area is still inundated (Jadhav 2015) and the impounded cypress-tupelo habitats are repressed (Shaffer 2011).

Purpose:

The purpose of the BA-34-2 project is to alleviate flooding stress and enhance cypress-tupelo forest growth, productivity, function, and regenerative success in a well-studied, impounded swamp habitat. This will be achieved by breaching the almost continuous

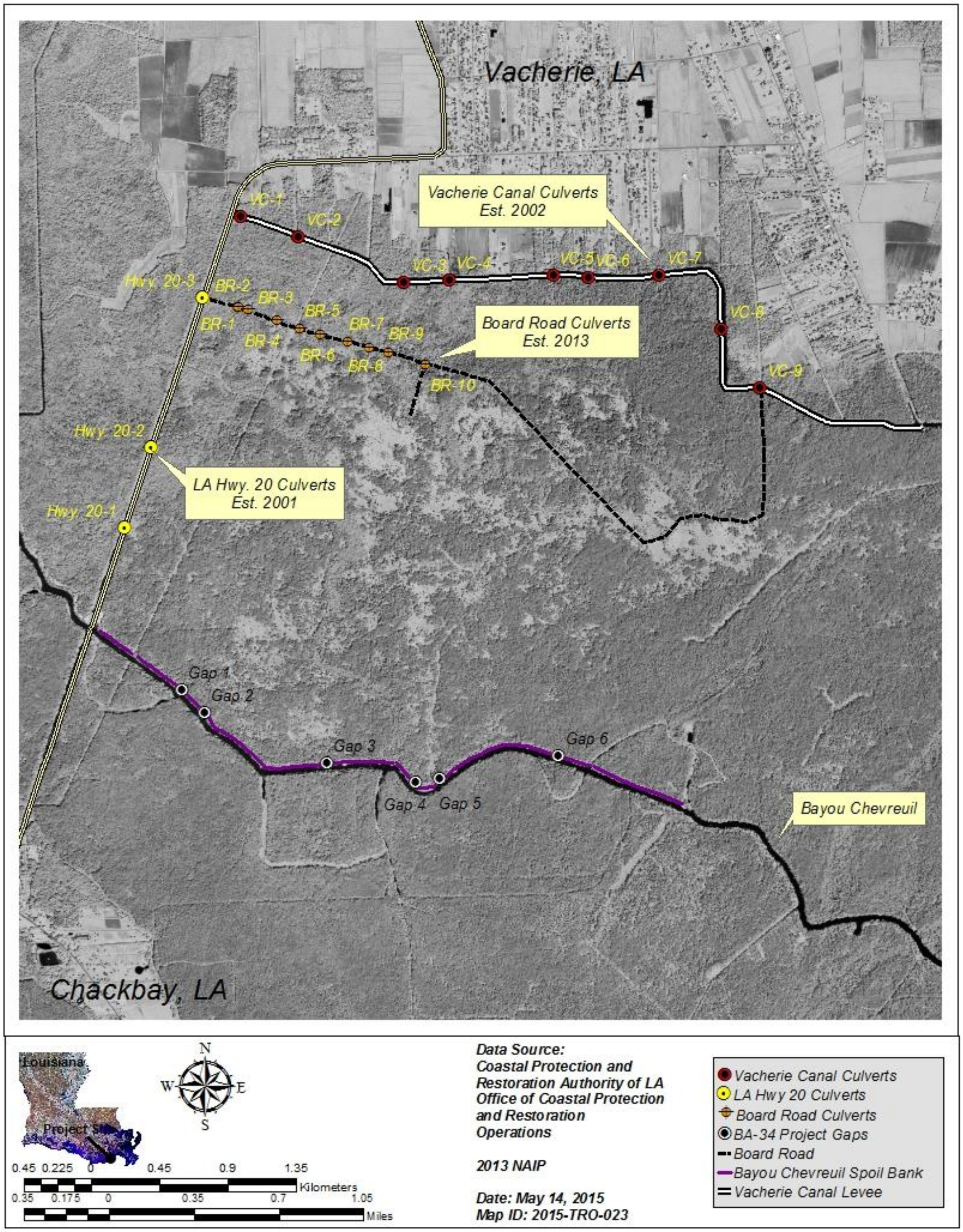

Figure 3. Location of the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project features.

Bayou Chevreuil spoil bank in six (6) positions to improve swamp drainage and reduce the duration of rain derived flooding events.

Goals:
The specific project goals are:

1. Restore the hydrology of the cypress-tupelo forest to mimic the water levels in Bayou Chevreuil.
2. Increase the productivity, survivorship, and function of the cypress-tupelo forest.
3. Increase the canopy cover of the cypress-tupelo forest by the end of the twenty year project life.
4. Increase regenerative success of both canopy and midstory species.
5. Increase the rate of mineral accretion within the southern segments of the project area adjacent to the Bayou Chevreuil shoreline.
6. Enhance the survival rate of artificially planted seedlings.

Features:
The project features for the first construction phase of this project involves gapping of the Bayou Chevreuil spoil bank. This spoil bank will be breached in six (6) locations over a 2.9 km (1.8 mi) mile segment of the project area shoreline to improve swamp drainage and water exchange with the bayou (Figure 3). The first three (3) gaps (Gaps 1, 2 and 3) are remnants of the 1978 gapping event (Figure 2) detailed in the Conner and Day (1992b) study while Gaps 4, 5, and 6 are new breaches. The first gap is positioned 0.8 km (0.5 mi) from LA Hwy. 20 and the final gap will be positioned 1.0 km (0.6 mi) from the eastern terminus of the BA-34-2 project area (Figure 3). The gaps will be excavated to a depth of -0.3 m (-1.0 ft) NAVD88 (Geoid12A) and will have a bottom width of 15.2 m (50.0 ft) and a surface width of 30.5 m (100.0 ft) (Figure 4). The length of these gaps will extend from the edge of the bayou to end of the spoil bank (edge of natural swamp surface) and will depend on the cross sectional width of the spoil bank at each location. The gaps will be constructed by clearing and grubbing and excavation of the earthen spoil. In addition, the BA-34-2 project has Operations and Maintenance (O&M) funding to maintain the constructed dimensions of the gaps. These maintenance events will occur when the performance of the constructed gaps negatively restricts swamp drainage.

2. ITEMS REQUIRING MONITORING

The Coast-wide Reference Monitoring System (CRMS)-*Wetlands* is a network of 392 monitoring sites distributed throughout the coastal zone of Louisiana. A total of 56 of these sites are classified as consisting of swamp habitats. Eight (8) of these swamp sites were established in the northern Barataria Basin. Hydrographic, accretion, surface elevation, forested swamp vegetation, herbaceous vegetation, soils, and aerial photography data are collected at each CRMS swamp site. There are no CRMS

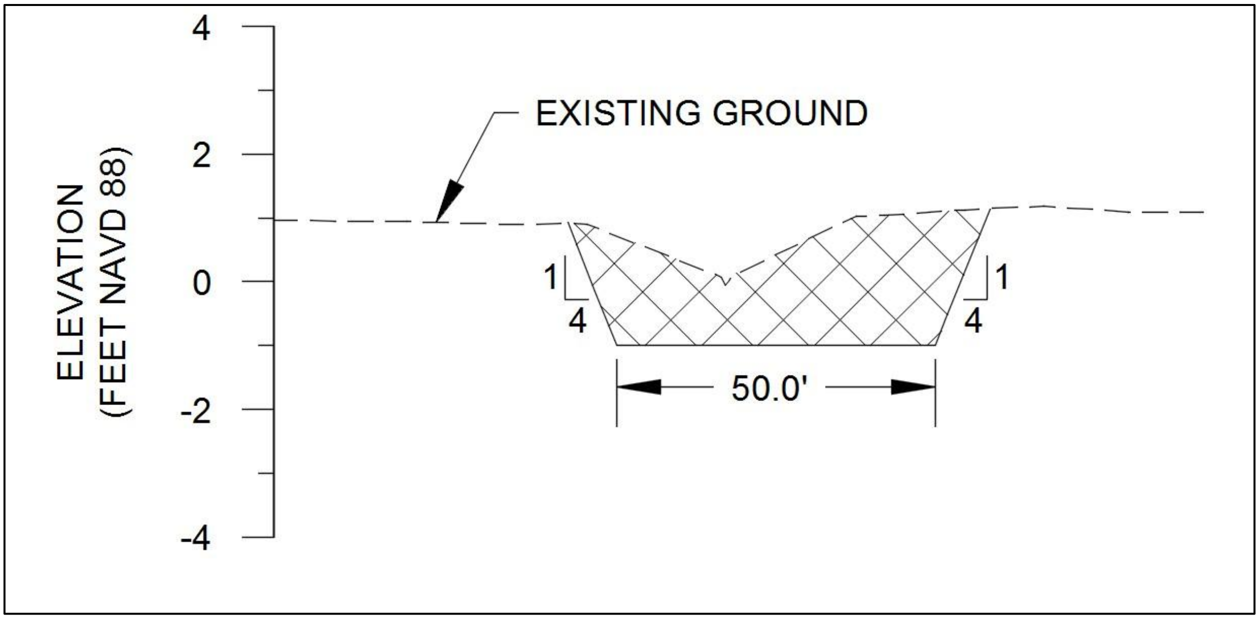

Figure 4. **Cross sectional view showing a typical Bayou Chevreuil spoil bank gap for the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project.**

monitoring stations located within the BA-34-2 project area. However, CRMS0194, CRMS0197, CRMS0200, CRMS0206, CRMS0217, CRMS0218, CRMS5116, and CRMS5672 are domiciled in forested habitats in the upper basin (Figure 1). Data from these sites may be used to characterize conditions within the northern basin and compare forested wetland growth and reproductive success.

Project-specific monitoring for BA-34-2 includes twelve (12) continuous recorder water level stations, (1) rain gauge station, ten (10) forested swamp vegetation stations, fifty (50) litterfall stations, six (6) sediment elevation stations, eighteen (18) surface accretion stations, and (10) soil property stations (Figure 5). These stations will allow for comparison to the aforementioned CRMS stations outside the project area. CRMS methods are described in detail in Folse et al. (2008, revised 2014).

The following monitoring strategies will provide the information necessary to evaluate the specific project goals**.**

A. Forested Swamp Vegetation – Ten (10) project specific 625 m^2 (25 m x 25 m) forested swamp plots will be established in the BA-34-2 project and reference areas (Figure 5). These plots will identify species, estimate canopy cover, measure diameter at breast height (DBH) for mature trees (≥ 5 cm) and mid-story trees and shrubs (≤ 5 cm) when ≥ 137 cm tall, count stems of mid-story trees and shrubs, and estimate herbaceous cover. Forested swamps plots will be sampled annually in the fall. Forested swamp vegetation data will also be collected at each CRMS site (Figure 1) to measure the composition and growth of cypress-tupelo

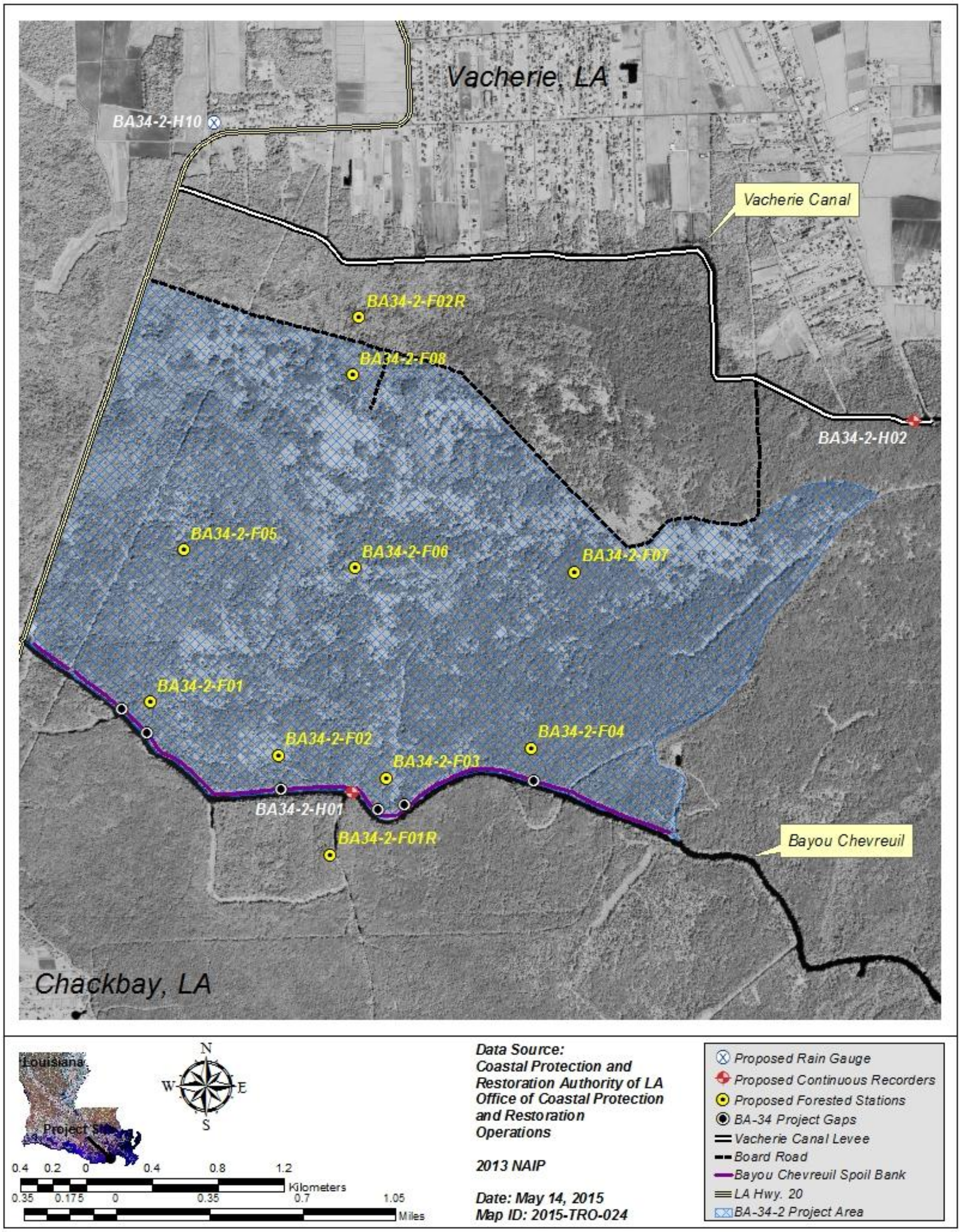

Figure 5. **Location of the proposed monitoring stations for the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project.**

habitats. CRMS forested swamp vegetation data will be collected every three (3) years in the fall.

B. Litterfall - Five (5) 1 m^2 litterfall traps will be placed in each 625 m^2 forested swamp plot. These traps will be emptied as often as montly during periods of high litterfall (i.e., late fall (Figure 5). The contents of the traps will be subsequently dried, weighed and sorted into cypress, tupelo, and "other" categories.

C. Herbaceous Vegetation - Each of the ten 625m^2 stations will contain two 2m x 2m herbaceous plots located 4m from a station diagonal for annual estimation of vegetation cover by species and will follow the Braun-Blanquet methodology (Mueller-Dombois and Ellenberg 1974). Additionally, vegetation sampling at CRMS sites will also utilize the Braun-Blanquet methodology and will consist nine replicate 2m x 2m stations are located within a 200m x 200m square of each CRMS site. CRMS vegetation data will be collected annually in late summer.

D. Water Level - Project specific water level recorders will be deployed in all ten (10) 625 m^2 of the forested swamp plots and in Bayou Chevreuil and the Vacherie Canal (Figure 5). These continuous recorders will measure water levels hourly. Water level readings will also be recorded hourly at each CRMS site (Figure 1) to determine frequency, depth, and duration of flooding.

E. Precipitation – Rainfall will be continuously monitored throughout the life of the project at one (1) reference station (Figure 5). This monitoring will begin at project inception and culminate at year nineteen (19) of the project.

F. Soil Properties – Project specific soil cores will be extracted from all ten (10) of the forested swamp vegetation stations (Figure 5) at 3-year intervals beginning at site establishment and terminating at year nineteen (19) of the project. Soil cores also will be collected at a six (6) year intervals at each CRMS site (Figure 1). The first cores were extracted upon site establishment. Analysis of soil properties will include soil pH, salinity (EC), bulk density, moisture, percent organic matter, wet/dry volume and texture (Particle Size Distribution) analysis.

G. Sediment Elevation – Project specific Rod Surface Elevation Tables (RSET) will be installed in six (6) of the ten 625 m^2 forested swamp plots (BA34-2-F01, BA34-2-F01R, BA34-2-F02, BA34-2-F03, BA34-2-F04, and BA34-2-F08) (Figure 5). Sediment elevation will be measured annually in the fall. RSET data also will be collected at each CRMS site (Figure 1) to measure changes in sediment elevation over time relative to a fixed datum. CRMS data will be collected biannually in the spring and fall.

H. Surface Accretion - Project specific accretion plots will be deployed in in six (6) of the ten 625 m^2 forested swamp plots (BA34-2-F01, BA34-2-F01R, BA34-2-F02, BA34-2-F03, BA34-2-F04, and BA34-2-F08) (Figure 5) in triplicate.

Surface accretion data will be measured annually in the fall. Vertical accretion also will be collected at each CRMS site (Figure 1) and is to be used in conjunction with the RSET to provide information on belowground processes that influence surface elevation change. CRMS data will be collected semi-annually in spring and fall.

I. Salinity - Salinity readings will be recorded hourly using continuous recorders located at each CRMS site (Figure 1). Discrete porewater salinity will be collected when sondes are serviced and during vegetation monitoring.

3. MONITORING BUDGET

The cost associated with project-specific monitoring variables outlined in Section 2 of this plan for the twenty (20) year project life is included and summarized in Attachment 1. Funding for monitoring was approved by the CWPPRA task force on January 22, 2016.

4. RESPONSIBILITIES

A. CPRA will:

1. Coordinate and oversee all scientific data collection.

2. Ensure that all data goes through quality control procedures and is entered into the public database.

3. Analyze the data and report on the status of the project after data collection events. Should the data indicate that the project is not meeting the goals and objectives, adaptive management recommendations will be made to improve the response.

4. Review the monitoring plan and budget annually with the EPA to determine that the data being collected adequately evaluates the project.

B. EPA will:

1. Review the monitoring plan and budget annually with the CPRA to determine that the data being collected adequately evaluates the project.

References

Conner, W. H. 1988. Cypress Regeneration in Coastal Louisiana and the Impact of Nutria Upon Seedling Survival. P. 130-136 in: Wetlands: Proceedings 13th Annual Conference of the Society of Wetland Scientists, New Orleans, LA 990 p.

Conner, W. H. 1994. Effect of Forest Management Practices on Southern Forested Wetland Productivity. Wetlands 14: 27-40.

Conner, W. H. and M. Brody. 1989. Rising Water Levels and the Future of the Southeastern Louisiana Swamp Forest. Estuaries 12: 318-323.

Conner, W. H. and J. W. Day, Jr. 1976 . Productivity and Composition of a Baldcypress-Water Tupelo Site and a Bottomland Hardwood Forest Site in a Louisiana Swamp. American Journal of Botany. 63: 1354-1364.

Conner, W. H. and J. W. Day, Jr. 1988. Rising Water Levels in Coastal Louisiana: Implications for Two Coastal Forested Wetland Areas in Louisiana. Journal of Coastal Research 4: 589-596.

Conner, W. H. and J. W. Day, Jr. 1992a. Diameter growth of *Taxodium distichum* (L.) Rich. and *Nyssa aquatica* L. from 1979-1985 in Four Louisiana Swamp Stands. American Midland Naturalist 127: 290-299.

Conner, W. H. and J. W. Day, Jr. 1992b. Water Level Variability and Litterfall Productivity of Forested Freshwater Wetlands in Louisiana. American Midland Naturalist 128: 237-245.

Conner, W. H., J. G. Gosselink, and R. T. Parrando. 1981. Comparison of the Vegetation of Three Louisiana Swamp Sites with Different Flooding Regimes. American Journal of Botany 68(3): 320-331.

Conner, W. H., I. Mihalia, and J. Wolfe. 2002. Tree Community Structure and Changes from 1987-1999 in Three Louisiana and Three South Carolina Forested Wetlands. Wetlands 22(1): 58-70.

Day, J.W., G.P. Shaffer, L.D. Britsch, S. Hawes, D.J. Reed, and D. Cahoon. 2000. Pattern and Process of Land Loss in the Mississippi Delta: A Spatial and Temporal Analysis of Wetland Habitat Change. Estuaries 23: 425-438.

Donavan, L. A., K. W. McLeod, K. C. Sherrod, Jr., and N. J, Stumpff. 1988. Response of Woody Swamp Seedlings to Flooding and Increased Water Temperatures. I. Growth, Biomass, and Survivorship. American Journal of Botany 75 (8): 1181-1190.

Faulkner, S. P., P. Bhattarai, Y. Allen, J. Barras, and G. Constant. 2009. Identifying Baldcypress-Tupelo Regrneration Classes in Forested Wetlands of the Atachafalaya Basin, Louisiana. Wetlands 29 (3): 809-817.

Faulkner, S. P., J. L. Chambers, W. H. Conner, R. F. Keim, J. W. Day, E. S. Gardiner, M. S. Hughes, S. L. King, K. W. McLeod, C. A. Miller, J. A. Nyman, and G. P. Shaffer. 2007. Conservation and Use of Coastal Wetland Forests in Louisiana. P. 447-460 in: The Ecology of Tidal Freshwater Swamps of the Southeastern United States, W. H. Conner, T. W. Doyle, and K. W. Krauss, Ed. Springer Science.

Frazier, D. E. 1967. Recent Deltaic Deposits of the Mississippi River: Their Development and Chronology. Transactions of the Gulf Coast Association of Geological Societies 17: 287-315.

T. M. Folse, L. A. Sharp, J. L. West, M. K. Hymel, J. P. Troutman, T. E. McGinnis, D. Weifenbach, L. B. Rodrigue, W. M. Boshart, D. C. Richardi, W. B. Wood, and C. M. Miller. 2008, revised 2014. A Standard Operating Procedures Manual for the Coastwide Reference Monitoring System-Wetlands: Methods for Site Establishment, Data Collection, and Quality Assurance/Quality Control. Louisiana Coastal Protection and Restoration Authority. Baton Rouge, LA. 228 pp.

Harms, W. R. 1973. Some Effects of Soil Type and Water Regime on Growth of Tupelo Seedlings. Ecology 54: 188-193.

Jadhav, R. 2015. Hydrodymamic Modeling for Hydrologic Restoration of the Lac Des Allemands Swamp (BA-34-2). FTN Associates, Ltd., Baton Rouge, LA (FTN No. 11623-0310-001) 70 pp.

Keim, R. F., J. L. Chambers, M. S. Hughes, J. A. Nyman, C. A. Miller, J. B. Amos, W. H. Conner, J. W. Day Jr., S. P. Faulkner, E. S. Gardiner, S. L. King, K. W. McLeod, and G. P. Shaffer. 2006. Ecological Consequences of Changing Hydrological Conditions in Wetland Forests of Coastal Louisiana. P. 383-395 in: Coastal Environment and Water Quality, Y.J. Xu and V.P. Singh, eds. Challenges in Coastal Hydrology and Water Quality, Water Resource Publications, Highlands Ranch, Colo. 534 p.

Keim, R. F., T. J. Dean, and J. L. Chambers. 2013. Flooding Effects on Stand Development in Cypress-Tupelo. P. 431-437 in: Proceedings, 15th Biennial Southern Silvicultural Research Conference, Hot Springs, AK. USDA Forest Service Technical Report SRS-175.

Keim, R. F., C. W. Izdepski, and J. W. Day, Jr. 2012. Growth Responses of Baldcypress to Wastewater Nutrient Additions and Changing Hydrologic Regime. Wetlands 32: 95-103.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. J. Wiley and Sons, New York, NY. 547 pp.

Park, D., M. Inoue, W. J. Wiseman, Jr., D. Justic, and G. Stone. 2004. High-Resolution Integrated Hydrology-Hydrodynamic Model: Development and Application to Barataria Basin, Louisiana. U. S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS2004 - 063. 74 pp.

Pezeshki, S. R. 1991. Root Responses of Flood-tolerant and Flood-sensitive Tree Species to Soil Redox Conditions. Trees 5: 180-186.

Pezeshki, S. R., R. D. DeLaune, and W. H. Patrick, Jr. 1993. Responses of Forested Wetland Species to Alteration in Soil Hydrology/Chemistry. P. 878-885 in: Wetlands: Proceedings 13th Annual Conference of the Society of Wetland Scientists, New Orleans, LA 990 p.

Reed, D., ed. 1995. Status and Trends of Hydrologic Modification, Reduction in Sediment Availability, and Habitat Loss/Modification in the Barataria-Terrebonne Estuarine System. Barataria-Terrebonne National Estuary Program, Thibodaux, LA, 20: 388 pp.

Sasser, C. E., J. M. Visser, E. Mouton, J. Linscombe, and S. B. Hartley. 2014. Vegetation Types in Coastal Louisiana in 2013. U.S. Geological Survey Scientific Investigations Map 3290, 1 sheet, scale 1:550,000.

Saucier, R. T. 1994. Geomorphology and Quaternary Geologic History of the Lower Mississippi Valley. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 364 pp.

Shaffer, G.P., W.B. Wood, S.S. Hoeppner, T.E. Perkins, J. Zoller and D. Kandalepas. 2009. Degradation of Baldcypress-Water Tupelo Swamp to Marsh and Open Water in Southeastern Louisiana, USA: An Irreversible Trajectory? Journal of Coastal Research 54: 152-165.

Shaffer, G. P. 2011. Review of Ecological Benefits of the Proposed Mississippi River Reintroduction into Northwest Barataria Basin (BA-34) Project. Contract Report Prepared for the Coastal Protection and Restoration Authority of Louisiana (CPRA), Baton Rouge, LA. 6 pp.

United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). 1973. Soil Survey of St. James and St. John the Baptist Parish, Louisiana. 46 pp.

Attachment 1

Project Monitoring Budget

Table 1. – Listed below are the post-construction budgets for the Hydrologic Restoration and Vegetative Planting in the Lac des Allemands Swamp (BA-34-2) project. The monitoring budget is highlighted in gray.

Year	FY	State Monitoring	State O&M	Fed Monitoring	Fed O&M & Insp	Corps Admin
0	2018	$134,834	$12,282	$0	$8,903	$1,265
-1	2019	$38,656	$12,515	$0	$9,072	$1,289
-2	2020	$39,751	$12,765	$0	$9,254	$1,314
-3	2021	$52,311	$13,021	$0	$9,439	$1,341
-4	2022	$68,419	$306,463	$0	$14,958	$1,367
-5	2023	$41,843	$13,547	$0	$9,820	$1,395
-6	2024	$55,861	$13,818	$0	$10,017	$1,423
-7	2025	$72,252	$14,094	$0	$10,217	$1,451
-8	2026	$44,766	$14,376	$0	$10,421	$1,480
-9	2027	$84,959	$338,360	$0	$16,515	$1,510
-10	2028	$77,051	$14,957	$0	$10,842	$1,540
-11	2029	$47,122	$15,256	$0	$11,059	$1,571
-12	2030	$62,908	$15,561	$0	$11,280	$1,602
-13	2031	$81,367	$15,872	$0	$11,506	$1,634
-14	2032	$50,414	$373,577	$0	$18,233	$1,667
-15	2033	$66,343	$16,513	$0	$11,971	$1,700
-16	2034	$86,772	$16,844	$0	$12,210	$1,734
-17	2035	$53,067	$17,181	$0	$12,454	$1,769
-18	2036	$135,542	$17,524	$0	$12,703	$1,804
-19	2037	$70,387	$17,875	$0	$58,027	$3,373
	Total	**$1,364,626**	**$1,272,400**	**$0**	**$278,902**	**$32,228**