State of Louisiana
Coastal Protection and Restoration Authority of Louisiana (CPRA)

2019 Operations, Maintenance, and Monitoring Report

for

Highway 384 Hydrologic Restoration (CS-21)

State Project Number CS-21
Priority Project List 2

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Cameron Parish

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2019 Operations, Maintenance, and Monitoring Report
For
La. Hwy 384 Hydrologic Restoration (CS-21)

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Preface

This report includes monitoring data collected through December 2018, and the annual maintenance inspection from May 2015. The La. Highway 384 Hydrologic Restoration project (CS-21) is a 20-year Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA, Public Law 101-646, Title III, Priority List 2) project administered by the Natural Resources Conservation Service (NRCS) and the Coastal Protection and Restoration Authority of Louisiana (CPRA).

The 2019 report is the 6th and final report in a series of reports. For additional information on lessons learned, recommendations and project effectiveness, please refer to the previous four OM&M Reports (2004, 2005, 2007, and 2010) and 2015 Summary Report online at http://coastal.Louisiana.gov. These reports will be made available for download at the following website: http://cims.coastal.la.gov.

I. Introduction

The La. Highway 384 Hydrologic Restoration project area contains 935 ac (378 ha) of deteriorated wetlands located along the northeast shoreline of Calcasieu Lake in Cameron Parish. The project area is bounded by Calcasieu Lake to the west, the Gulf Intracoastal Waterway (GIWW) to the east, and higher elevation prairie formations to the north and south.

The project area (figure 1) is divided into three Conservation Treatment Units (CTUs). CTU 1 extends from Calcasieu Lake easterly to the La. Highway 384 embankment and includes 250 ac (101 ha) of open water and brackish marsh. A shell oilfield access road forms its northern boundary and prairie formations form its southern boundary. CTU 2 includes 226 ac (91 ha) of open water and intermediate marsh. This unit extends easterly from the La. Highway 384 embankment. The northern boundary of CTU 2 is the prairie formation on which the community of Grand Lake is located. A continuous oil field road embankment joins the prairie formations north and south of the project area and forms the remainder of the southern and eastern boundaries of CTU 2. CTU 3 lies between CTU 2 and the GIWW and includes 459 ac (186 ha) of intermediate marsh. Increased tidal volumes, enlargement of tidal exchange routes, and salt water intrusion resulting from human-induced changes to the area's hydrology are the primary causes of wetland loss in the project area.

Two small reference areas have been selected for monitoring this project. Reference Area 1 (R1) is comprised of 424 ac (172 ha) of deteriorated brackish marsh and open water located 2 mi (3.2 km) south of the community of Grand Lake along the east bank of Calcasieu Lake (figure 1). Reference Area 2 (R2) consists of approximately 106 ac (43 ha) of open water and deteriorated brackish marsh located along the north side of the shell road that forms the northern boundary of CTU 1.

Hurricane Rita struck the coast of southwestern Louisiana on September 24, 2005 with maximum storm surge of approximately 7 ft (2.1 m) in the CS-21 project area. USGS calculated the amount of land that changed to water resulting from the storm to be 98 square miles in southwestern

Louisiana, 22 square miles of land lost in the Calcasieu/Sabine basin (Barras, 2006). This land loss can be attributed to several patterns. Shearing, which is ripping and removal of marsh vegetation in historically healthy marshes was observed north of Johnson's Bayou and south of the Sabine National Wildlife Refuge. The removal of remnant marsh from areas with historical land loss from the surge was observed in the marsh just north of Johnson's Bayou and north of Mud Lake.

The objective of the project is to protect and maintain approximately 935 ac (378 ha) of intermediate to brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation. This will be achieved through structural modification of hydrologic conditions. Construction for the La. Highway 384 Hydrologic Restoration Project began on October 20, 1999 and was completed on January 4, 2000.

The principal project features include:

1. Set of 3 culverts (ES-1), each with a manual sluice gate on the exterior and a flap gate on the interior to provide controlled freshwater introduction from the GIWW (CTU 2/CTU 3 perimeter levee).

2. Approximately 95 ft (28 m) of armored plug (ES-8) to reduce hydrologic exchange with Calcasieu Lake and to decrease tidal scour and salinity in the project area (existing exchange point in CTU 1).

3. Set of 2 culverts (ES-12), each with a variable-crested weir inlet and flap gated outlet to reduce and stabilize tidal ranges and salinity in project area south of the central shell road in CTU 1 (existing shell road along north side of CTU 1).

4. Maintenance of approximately 10,000 ft (3 km) of existing road embankment to maintain the hydrologic barrier between CTU 2 and CTU 3 (existing southern and eastern perimeter embankment of CTU 2).

5. Maintenance of 1 flow-through culvert (ES-11) to maintain an existing storm water drainage point for the adjacent prairie formation (existing southern perimeter embankment of CTU 2).

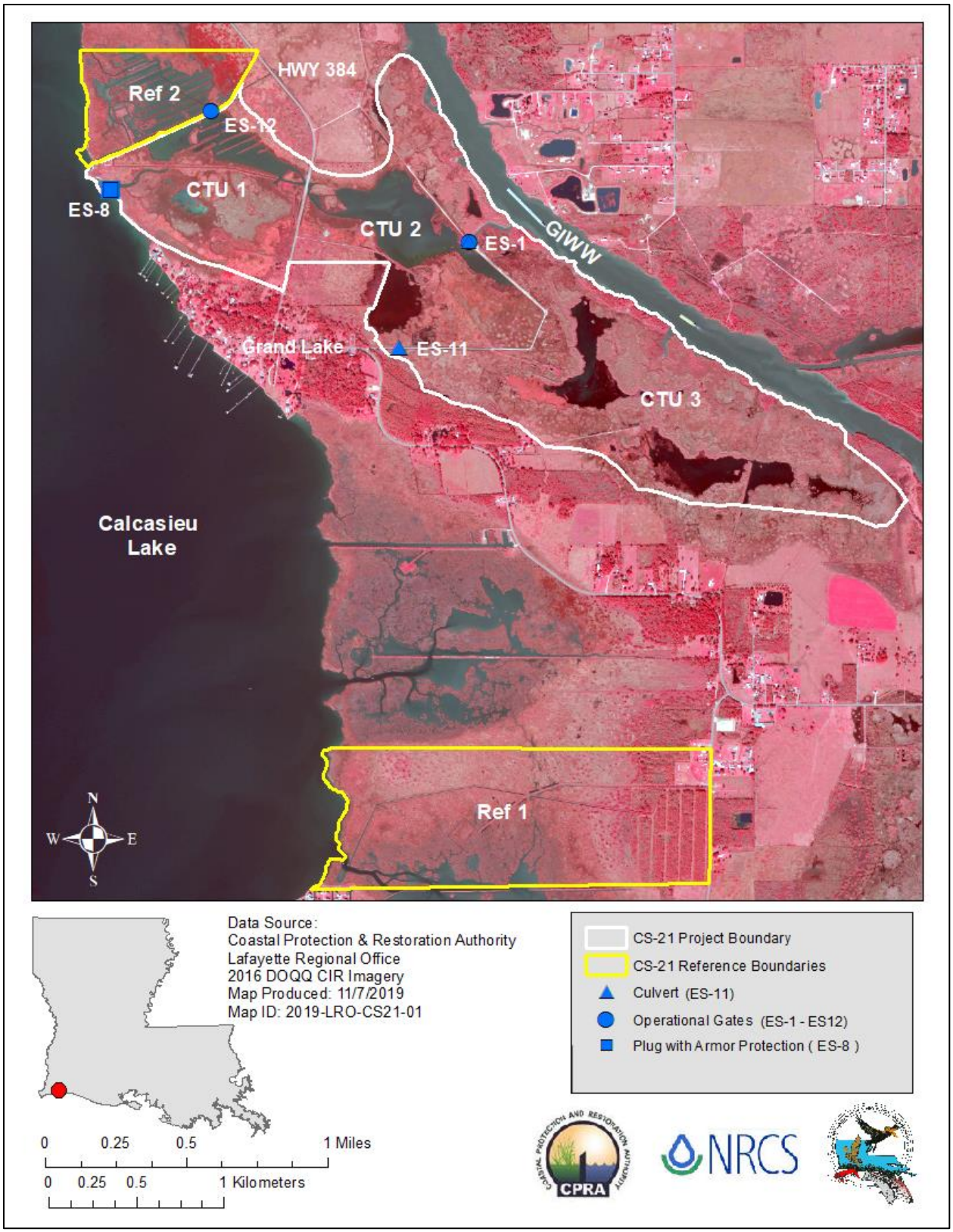


Figure 1. La. Highway 384 Hydrologic Restoration (CS-21) project and reference area boundaries and features.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Hwy. 384 Hydrologic Restoration Project (CS-21) is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing the condition of project features and recommended corrective actions needed. Should it be determined that corrective actions are needed, CPRA shall provide, in the report, a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs (O&M Plan, 2003). The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of the constructed project features and an estimated projected budget for the upcoming three (3) years for operation, maintenance and rehabilitation. The three (3) year projected operation and maintenance budget is shown in Appendix B.

An inspection of the Hwy. 384 Hydrologic Restoration Project (CS-21) was held on March 23, 2017 under sunny and mild conditions. The water level was very low due to a north wind and front moving through the area. In attendance were Jody Roger-White and Stanley Aucoin of CPRA, Dale Garber of NRCS, and Operations Contractor, Chris Simon with Simon and Delany. The annual inspection began at approximately 10:20 a.m. at Structure No. 1.

The field inspection included a complete visual inspection of all features. Staff gauge readings where available were used to determine approximate elevations of water, rock plugs, earthen embankments, and other project features. Photographs were taken at each project feature (see Appendix A) and Field Inspection notes were completed in the field to record measurements and deficiencies (see Appendix C).

b. Inspection Results

Structure No.1 (Freshwater Introduction Structure)

The structure and inlet channel are in good condition. The inlet channel which was dredged in 2015 is still supplying freshwater to the structure; however, sediment has deposited around the hyacinth fence, the culvert inlets and on the project interior adjacent to the structure. The collection of sediment has restricted the flow through the culverts and prevents the flaps from opening properly. Currently limited flow is passing through two of the three culverts. Flow can be restored by cleaning out adjacent to the structure to allow the flaps to operate as intended.

The levee north of the structure which was repaired in 2015 is intact with no signs of erosion. The water level on the inside of the project at Structure No. 1 was at -0.4ft elevation. The water level on the outside was not measurable due to the sediment around the staff gauge.

The board walkways are in good conditions since being replaced. An ever increasing amount of vegetation has established itself on the inside of the project area near Structure No. 1. There is evident submerged vegetation in the cove north of the structure. (See Appendix B, Photos 1-4)

The levee (previously noted as Existing Access Road No.2) leading up to the structure is in good condition since it was repaired in June 2006.

Structure No. 12 (Salinity Control Structure)

The structure is in good condition. The water level was very low. The staff gauge read -0.6ft on the inside and -0.7ft on the inside. The vegetation on the terraces was plentiful and expanding. The board walkways were in good condition. (Appendix B, Photos 5&6)

Site No. 8

The rock plug was in excellent condition. Vegetation has expanded along the rock plug on the lake side and on the interior. Open water in the marsh interior can no longer be seen from the rock plug. (Appendix B, Photos 7&8)

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

ii. Programmatic/ Routine Repairs

Clearing of sediment and debris around Structure No. 1 would restore freshwater into the project interior. This work would be necessary ever two to three years to ensure continued flow into the project.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since January 2000, the construction completion date of the La. Highway 384 Hydrologic restoration Project (CS-21).

Nov. 2000- Glenn Lege Construction

- Placed 40.32 cy. of #610 limestone on the road near Structure #12 due to some overtopping of the road during high tidal events
- Placed 12 cy. of man size rip-rap on the inlet side of Structure #12 due to some scouring of the bankline around the structure.

TOTAL CONSTRUCTION COST- $3,461.14

June 2002- Glenn Lege Construction

- Provided labor and materials to construct a "hyacinth fence" on the inlet side of Structure No. 1. The fence is constructed of galvanized woven wire and CCA treated timber piles and whalers.
- Provided labor and materials to reinforce the existing levee around Structure No. 1 with graded crushed stone.

- Provided labor and materials to repair the rock plug at Site No. 8 that had been leaking and also had been vandalized. The plug was repaired by hauling in earth fill from an off-site location and pushing it over the existing rock plug with a bulldozer. The earthen plug was then planted under separate contract by DNR plantings group.

TOTAL CONSTRUCTION COST- $14,386.87

February 2004 – Lonnie G. Harper and Associates
Provided a survey of the existing shoreline to determine lake rim elevations within the project area along the eastern side of Calcasieu Lake.

TOTAL COST- $3,345.00

May 2005- Bertucci Construction
Provided labor, material and equipment to repair thirteen linear feet of the rock plug at Site No. 8. The rock was removed by vandals. 39.9 tons of 1200# rip rap stone was used to repair the thirteen foot gap. A four foot thick layer of 150# stone was applied to the marsh side slope of the plug to prevent water flow through the plug. This required 343.4 tons of rock. Completion and final acceptance was on May 15, 2005.

TOTAL CONSTRUCTION COST- $45,090.00

May 2006- F. Miller & Sons
Provided labor, material and equipment to repair the existing access roads to permit elevations (+3.0 on Existing Access Road No.1 West side of Hwy 384, +2.5 on Existing Access Road No. 2, East side of Hwy 384). Approximately 3,225 tons of recycled concrete were used to elevate the roadways. Two Portable Multi-Parameter Water Quality Troll 9500 units were provided through this contract and installed by Simon & DeLany for operation of Structures No. 1 and No. 12. Completion and final acceptance was on June 28, 2006.

Engineering, Design ,Surveying,	
Construction Oversight & As-Builts	$ 26,705.00
Construction Cost	$150,000.00

TOTAL CONSTRUCTION COST $176,705.00

June 2006 – F. Miller & Sons
Provide labor, material and equipment to refurbish and install flap gate on west culvert of Structure No. 12. This flap gate was vandalized during spring of 2006. Completion and final acceptance was on June 28, 2006.

TOTAL CONSTRUCTION COST $1,600.00

March 2007 – Simon & Delany
Provide labor necessary to remove and dispose of trash and debris which has accumulated within the hyacinth fence and adjacent to the sluice gates at Structure No.1

TOTAL CONSTRUCTION COST $900.00

May 2010 – Simon & Delany
Provide labor necessary to remove and dispose of trash and debris which has accumulated within the hyacinth fence and adjacent to the sluice gates at Structure No.1

TOTAL CONSTRUCTION COST $2,000.00

October 2011 – Simon & Delany
Provide labor necessary to install bird excluder devices on the solar panels and install plastic pile caps on Structures No. 1 and No. 12.

TOTAL COST $1,300.00

November 2013 – Simon & Delany
Provide labor and equipment necessary to remove vegetation and debris adjacent to the hyacinth fence, inlet sluice gates, and outlet flap gates at Structure No. 1.

TOTAL CONSTRUCTION COST $2,800.00

March 2015 – CC Lynch
Provide labor and equipment to replace the Aqua Troll 200 Base Unit Level Sensor at Station 29r on Structure No. 1

TOTAL COST $2,529.50

May 2015- Patriot Construction
Royal Engineers was tasked with design engineering, bidding, surveying, and construction oversight and administration. The Engineering Contract included evaluation surveys of the existing staff gauges and installation of new staff gauges. Patriot Construction provided labor, material and equipment to repair and existing earthen levee north of Structure No. 1, dredge the inlet channel to Structure No. 1, repair the board walkways, and clean debris from around the culverts and flaps. Fill material was brought in to raise and reshape 1174 linear feet of the existing earthen levee to the original elevation of +3.5 NAVD88.

Approximately 1128ft of the inlet channel from the GIWW to Structure No. 1 was dredged to an elevation of -2.11ft.
The Contract Completion date was October 16, 2015 and final acceptance was issued January 15, 2016.

Engineering Design, Surveying, Construction Oversight & As-Builts	$ 67,762.25
Construction Cost	$ 99,154.49
TOTAL CONSTRUCTION COST	**$166,916.74**

February 2016 - CC Lynch
Provide labor and equipment to replace the Troll Link 101 telemetry system with a Tube 300R Telemetry System (3G modem) at Stations 29r and 15r for structures No. 1 and No. 12 respectively. In addition to equipment and labor, the data service cost is included for a 12 month period.

TOTAL COST	**$3,285.50**

October 2016 – Simon and Delany
Provide labor and materials to replace the one missing PVC pile cap on the piles at Structure No. 1's hyacinth fence and replace the staff gauge on the Structure No. 12 outlet side.

TOTAL COST	**$585**

III. Operation Activity

a. Operation Plan

HIGHWAY 384 HYDROLOGIC RESTORATION
CS-21

"WATER MANAGEMENT PLAN"

Revised 05-03 -06

ES #1 Structure - 3-24" Aluminum culverts with Interior 24" Flapgates and Exterior 24" Sluice Gate

	Culvert # 1		Culvert #2		Culvert #3	
Salinity	Sluice	Flap	Sluice	Flap	Sluice	Flap
≥ 7 ppt	down	down	down	down	down	down
< 7 ppt	open	down	open	down	open	down

Average Marsh Level CTU 2 = 1.253 ft NAVD88

NOTE: When exterior salinities at ES #1 structure meet or exceed 7 ppt, the structure will be set according to the above chart. When exterior salinities fall below 7 ppt, the structure will be reset according to the above chart.

ES #12 Structure - 2-48" Aluminum Culverts, each with an Interior 10' Variable-Crested Weir Inlet with a 4" vertical slot and an Exterior 48" Flapgate.

	Culvert #1			Culvert #2		
Salinity	Flap	Stoplog	Slot	Flap	Stoplog	Slot
< 7 ppt	open	.88 ft	open	open	None	open
7-10 ppt	down	.88 ft	open	open	None	open
>10 ppt	down	.88 ft	open	down	.38 ft	open

Average Marsh Level CTU 1 = 1.38 ft NAVD88
"None" refers to removal of all stop logs.
Salinity will be monitored on the northern side of the shell road at ES #12

b. Actual Operations

In accordance with the operation schedule outlined in the Operation and Maintenance Plan and USACE Permit, structures were manipulated as required by Simon & Delany, Resource Management personnel who were under contract with CPRA. Copies of the quarterly reports that are provided as well as a copy of the operations contract between DNR and Simon & DeLany are attached in the "Structure Operations" section of the CS-21 Hwy. 384 Operation & Maintenance Plan.

The original operating procedures for Structure #1 was based on water level only, there was no provision for salinity control. Records for the structure showed salinities of 9+ ppt. The procedure was modified to close the Structure #1 sluice gates at 7 ppt. Operations for Structure #12 were not changed. The real time conditions at Structures No.1 and No. 12, are uploaded to the website, www.hydrovu.com. Access can be obtained by CPRA personnel with the appropriate email and password. Note when reviewing the data that Monitoring Station 15r is located near Structure No.12, and Station 29r is located at structure No.1.

IV. Monitoring Activity

The original monitoring plan was approved in December 1996 and was modified in 1998 when it was determined that water level and salinity would be monitored continuously from 1997 through 2002, and then evaluated to determine if the project goals were achieved. It was determined that the goals had been met and monitoring was discontinued in 2004.

Pursuant to a decision made on November 9, 1999 by the Natural Resources Conservation Service and the Louisiana Department of Natural Resources, the project area boundary was revised to exclude the northernmost third of CTU 1 and all associated structural measures due to landright constraints. The monitoring plan was modified to reflect changes in reference areas and elimination of shoreline change monitoring.

Pursuant to a CWPPRA Task Force decision on August 14, 2003 to adopt the Coastwide Reference Monitoring System-*Wetlands* (CRMS-*Wetlands*) for CWPPRA, updates were made to the CS-21 Monitoring Plan to merge it with CRMS-*Wetlands* and provide more useful information for modeling efforts and future project planning while maintaining the monitoring mandates of the Breaux Act. There are no CRMS-*Wetlands* sites in the CS-21 project area.

a. Monitoring Goals

The objective of the La. Highway 384 Hydrologic Restoration Project is to protect and maintain 935 ac (378 ha) of intermediate and brackish wetlands by reducing water level variability, thereby increasing the abundance of emergent vegetation.

The following goals will contribute to the evaluation of the above objective:

1. Decrease the rate of marsh loss in the project area.
2. Reduce water level variability within the project area.
3. Maintain salinity levels within CTU 1 at ≤ 10 ppt for brackish marsh vegetation.
4. Maintain salinity levels in CTU 2 and CTU 3 within the 0-5 ppt target range (1997 – 2004) using project-specific sondes and 0-7 ppt (2005 – 2010) using telemetry sondes, for intermediate marsh vegetation
5. Increase the coverage of emergent wetland vegetation and submersed aquatic vegetation (SAV) in shallow open water areas within the project area.

b. Monitoring Elements

Habitat Mapping:

Near-vertical, color-infrared aerial photography (1:12,000 scale, with ground controls) was used to measure vegetated and non-vegetated areas for the project and reference areas. The photography was obtained preconstruction for the project area and reference area 2 in December 1996 and again in January 1997 due to overexposed frames. In March 1997, R1 was flown. Post-construction photography was obtained in 2002 and 2015. The original photography was checked for flight accuracy, color correctness, and clarity and was subsequently archived. Aerial photography was scanned, mosaicked, and georectified by USGS/ NWRC personnel according to the standard operating procedures (Steyer et al. 1995, revised 2000). No additional photography is scheduled.

Salinity:

Water salinity was monitored monthly at twenty-nine discrete sampling stations and hourly at four continuous recorder stations within the project and reference areas (figure 2). The recorders were operated from May 1997 until July 2004 to determine project goals. It was determined that the goals had been met and project specific monitoring was discontinued in 2004.

In accordance with the operation schedule outlined in the Operation and Maintenance Plan and USACE Permit, continuous and discrete monitoring stations where established to allow for structure operations. In July 2006, two continuous recorder (15R-29R) and eight discrete (12R-15R-16-18-18R-19-26-29R) sampling stations were established and monitored. In December 2009 the eight discrete stations were decreased to five discrete stations (15R-16-19-26-29R) due to project improvements. Stations 15R and 29R collected hourly salinity data to aid in structure operations. Station 15R is operated under a 10 ppt threshold and station 29R was operated under a 5 ppt threshold from 1997 – 2004 and modified to operate under a 7 ppt threshold to better achieve project goals.

Water Level:

Water level was monitored monthly at twenty-nine discrete sampling stations, four staff gauges installed in/out near the project structures and hourly at four continuous recorder stations within the project and reference areas (figure 2). The recorders were operated from May 1997 until July 2004 to determine project goals. It was determined that the goals had been met and project specific monitoring was discontinued in 2004.

In accordance with the operation schedule outlined in the Operation and Maintenance Plan and USACE Permit, continuous monitoring stations were established to allow for structure operations. In July 2006, two continuous recorder sampling stations (15R -29R) were installed. Stations 15R and 29R collect hourly water level data (NAVD 88 ft) to aid in structure operations. While water level is not the main trigger for operations, the structures are closed under extreme high tides and hurricane events.

Emergent Vegetation:

Vegetation was monitored at a maximum of 30 sampling stations established uniformly along transects in the project and reference areas (CTU 1, CTU 2, CTU 3, R1, and R2) (figure 3). At each sampling station, percent cover, species composition, and dominant plant height were documented in a 2m x 2m sampling plot marked with a pole in the southeast corner of the plot to allow for revisiting each site over time. Vegetation was evaluated at the sampling sites pre-construction in 1997, and post-construction in 2002, 2015 and 2018. A subset of twenty three of the established CS-21 vegetation stations was monitored in 2005, 2006, 2007 & 2008 to determine the impacts of Hurricane Rita within the project and reference areas.

Floristic Quality Indices (FQIs) have been developed for several regions to determine the quality of a wetland based on its species composition (Cretini et al., 2012). A Floristic Quality Index (FQI) was developed by Jenneke Visser and an expert panel for Louisiana as part of CRMS. A list of plants occurring in Louisiana's coastal wetlands (~500 species) was provided to all known Louisiana coastal vegetation experts and their input on scoring was requested. The panel then provided an agreed upon group score (Coefficient of Conservatism or CC Score) for each species. CC scores are weighed based on cover in the FQI for Louisiana coastal wetlands. All species known to occur in the coastal zone were given a floristic quality score on a scale of 0 to 10. Species that scored lowest were considered by the panel to indicate disturbance or unstable marsh environments.

Submerged Aquatic Vegetation (SAV):

SAV was monitored using the modified rake method (Chabreck & Hoffpauir 1962, Nyman and Chabreck 1996). Within each study area (CTU 1, CTU 2, CTU 3, and R2), 2 ponds were sampled for presence or absence of SAV at 25 random points within each pond. Species composition and frequency of occurrence [freq = (n occurrences SAV species / n total sampling points)*100] were determined (figure 3). SAV was monitored pre-construction in 1996 and 1997 and post-construction in 2002, 2015 and 2018. No additional SAV sampling is scheduled.

Soil Characteristics:

Soil samples were collected from the emergent vegetation sampling plots established in the project and reference areas and analyzed for bulk density, percent organic matter, and soil salinity. Soil samples collected pre-construction in 1997 were not collected post construction.

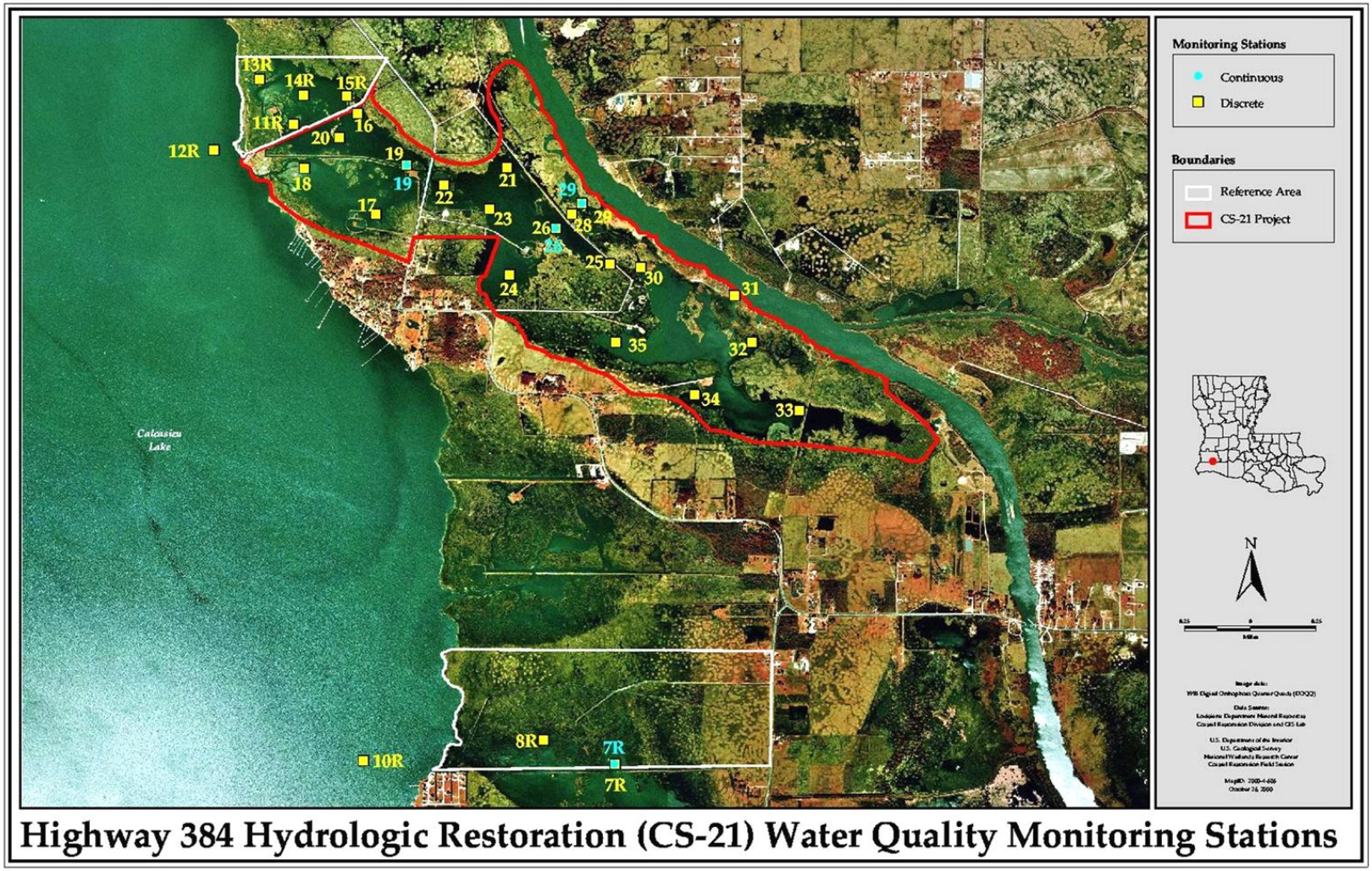


Figure 2. Location of continuous recorders and discrete water quality stations for La.Highway 384 Hydrologic Restoration (CS-21).

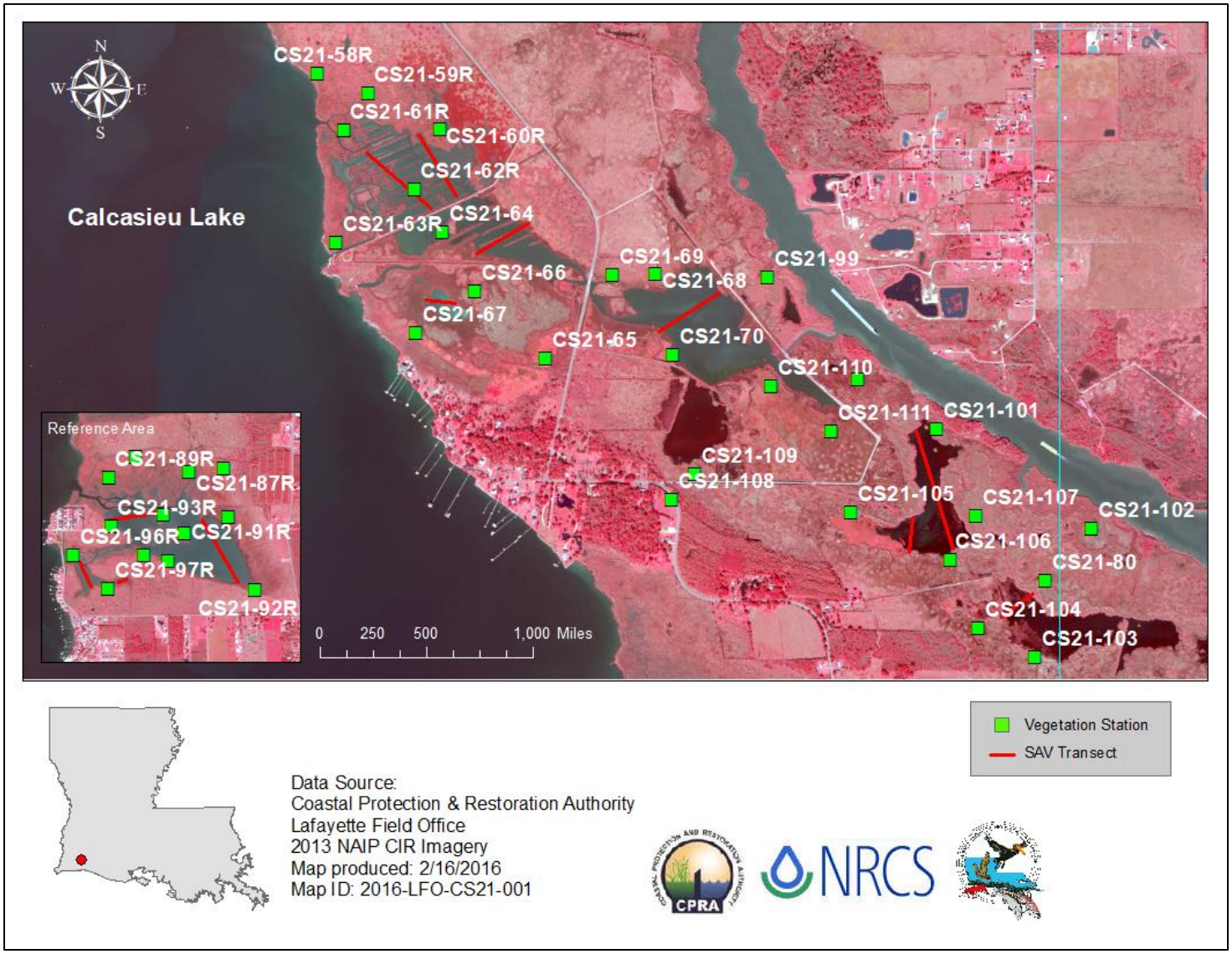


Figure 3. Location of herbaceous vegetation stations and SAV transects within the La.Highway 384 Hydrologic Restoration (CS-21) project.

IV. Monitoring Activity (continued)

c. Preliminary Monitoring Results and Discussion

Habitat Mapping

Photography of the project area was obtained by USGS in 1997, 2002 and 2015 (figures 4, 5 and 6). All three flights showed an increase in the percentage of each area that can be considered land (figure 7). The greatest increase in land was in CTU1 in 2015 (44.6%). The total increase for the project areas combined was 20.5% from 1997-2015 while the reference areas collectively increased by 6.5% (table 1). The reference area averaged a small gain through time on average, however, R1 showed a slight loss in 2015.

Table 1. Ratios of land and water for the La. Highway 384 Hydrologic Restoration (CS-21) project from aerial photography obtained pre-construction in 1997 and post-construction in 2002 and 2015. The 1997 photography was classified by habitat (figure 4) while the 2002 and 2015 photography was classified by land and water so acreages of land were summed (figure 5). Mudflats were considered land and upland habitats were included. Total acreages from the two years are not exactly the same, therefore percentages and differences in percentages should be used for comparison.

	Total Project		CTU 1		CTU 2		CTU 3		Total Reference		R 1		R 2	
	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha	ac	ha
1997 Land	547	221	69	28	91	37	387	157	436	176	387	157	49	20
1997 Water	429	173	130	52	119	48	180	73	90	36	32	13	58	23
2002 Land	580.0	234.7	72.0	29.1	97.0	39.3	411.0	166.3	440.0	178.0	390.0	157.8	50.0	20.2
2002 Water	396.0	160.3	127.0	51.4	113.0	45.7	156.0	63.1	87.0	35.2	30.0	12.1	57.0	23.1
2015 Land	746.0	301.9	160.0	64.7	130.0	52.6	456.0	184.5	444.0	179.7	381.0	154.2	63.0	25.5
2015 Water	229.0	92.7	38.0	15.4	80.0	32.4	111.0	44.9	83.0	33.6	39.0	15.8	44.0	17.8
1997 Land %	56.0		34.7		43.3		68.3		77.8		92.3		45.6	
1997 Water %	44.0		65.3		56.7		31.7		22.2		7.7		54.4	
2002 Land %	59.4		36.2		46.2		72.5		80.3		92.9		46.7	
2002 Water %	40.6		63.8		53.8		27.5		19.7		7.1		53.3	
2015 Land %	76.5		80.8		61.9		80.4		84.3		90.7		58.9	
2015 Water %	23.5		19.2		38.1		19.6		15.7		9.3		41.1	
1997 TOTAL	975.1	394.6	198.4	80.3	209.9	84.9	567.1	229.5	526.0	212.9	419.6	169.8	106.4	43.1
2002 TOTAL	976.0	395.0	199.0	80.5	210.0	85.0	567.0	229.5	527.0	213.3	420.0	170.0	107.0	43.3
2015 TOTAL	975.0	394.5	198.0	80.1	210.0	85.0	567.0	229.5	527.0	213.3	420.0	170.0	107.0	43.3
2015-1997 Land Change	20.5		46.1		18.3		12.1		6.5		-1.6		13.3	

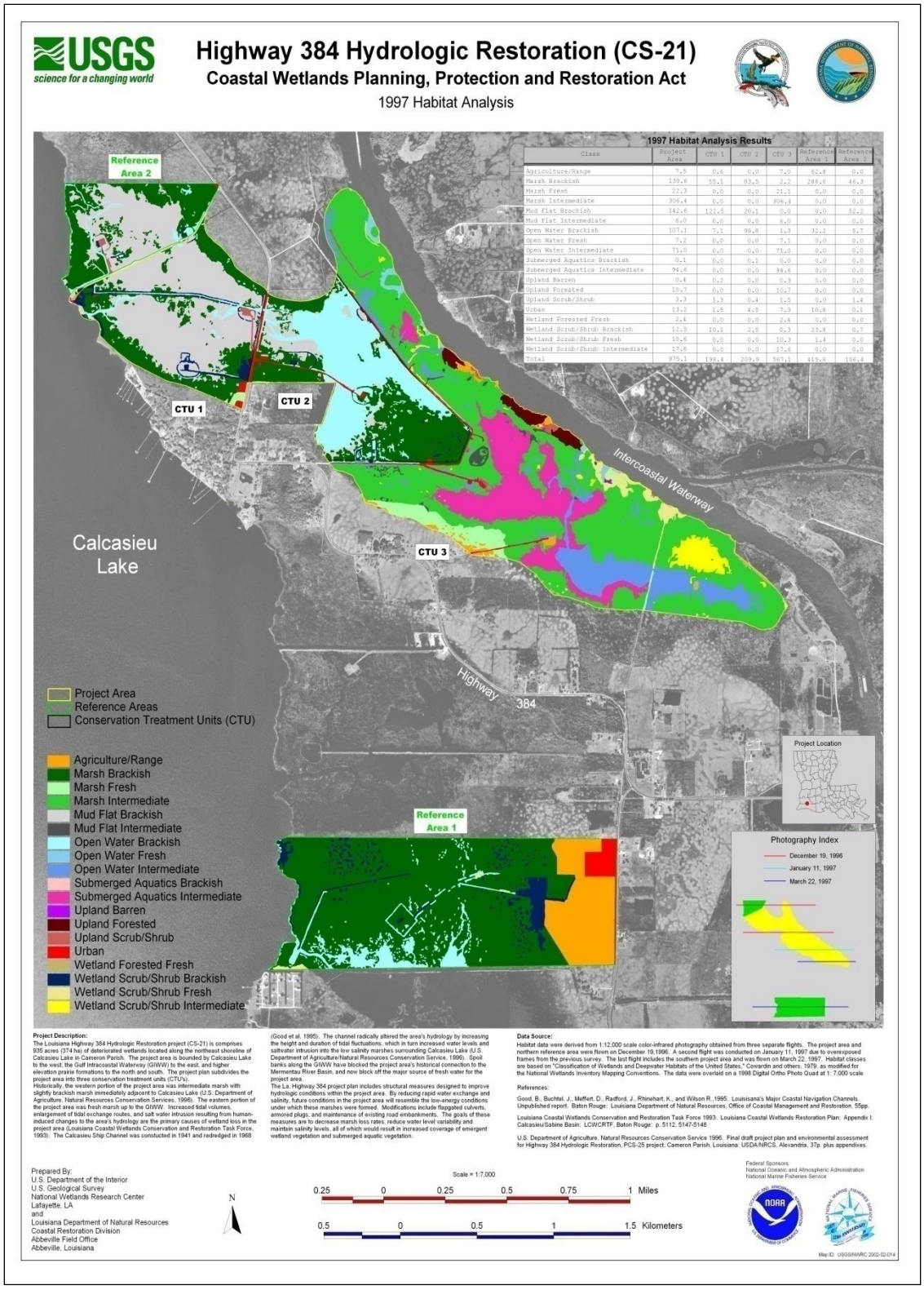


Figure 4. Habitat analysis from aerial photography flown January 11 and March 22, 1997.

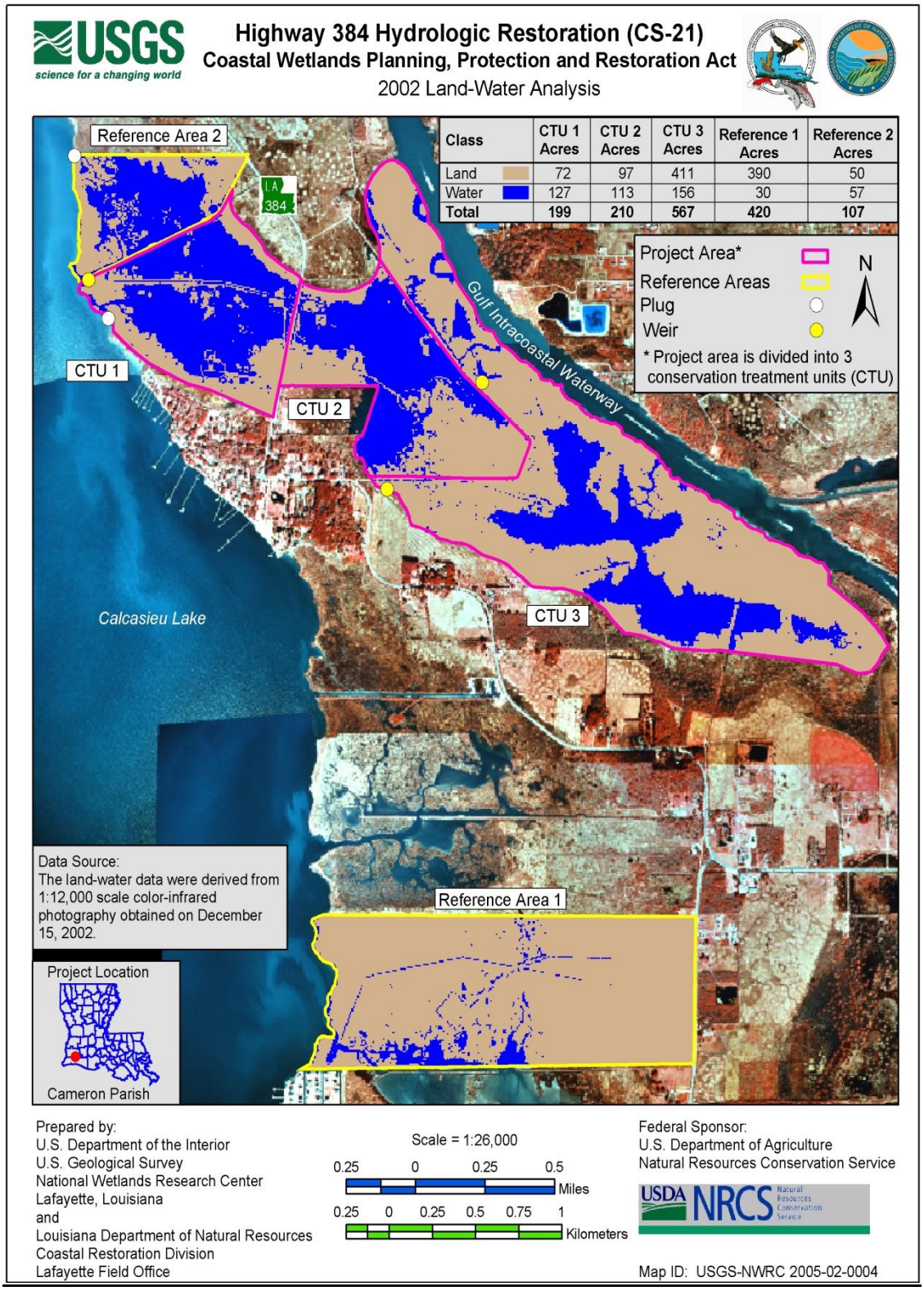
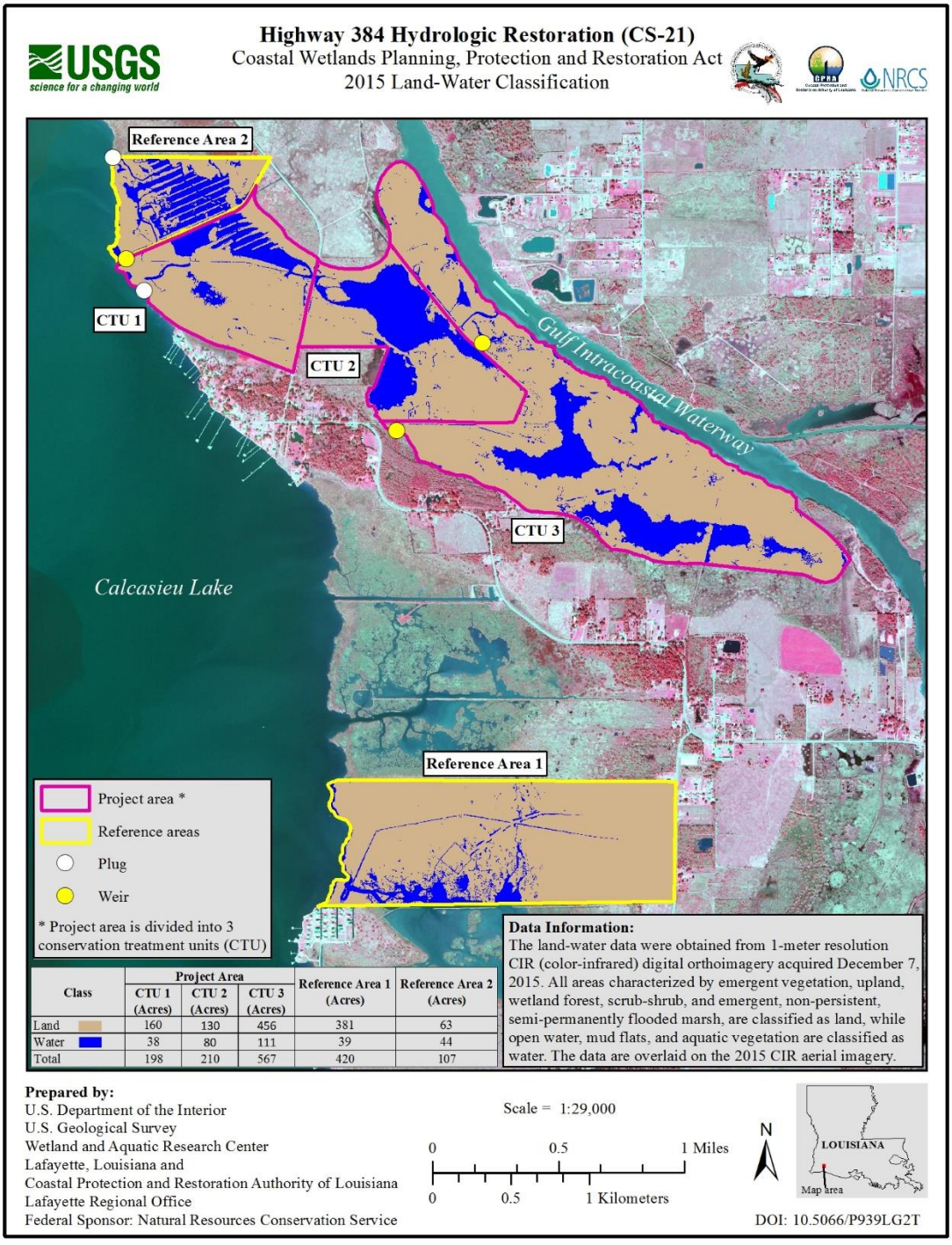


Figure 5. Land to water analysis from aerial photography flown December 15, 2002.



Class	Project Area			Reference Area 1 (Acres)	Reference Area 2 (Acres)
	CTU 1 (Acres)	CTU 2 (Acres)	CTU 3 (Acres)		
Land	160	130	456	381	63
Water	38	80	111	39	44
Total	198	210	567	420	107

Figure 6. Land to water analysis from aerial photography flown December 7, 2015.

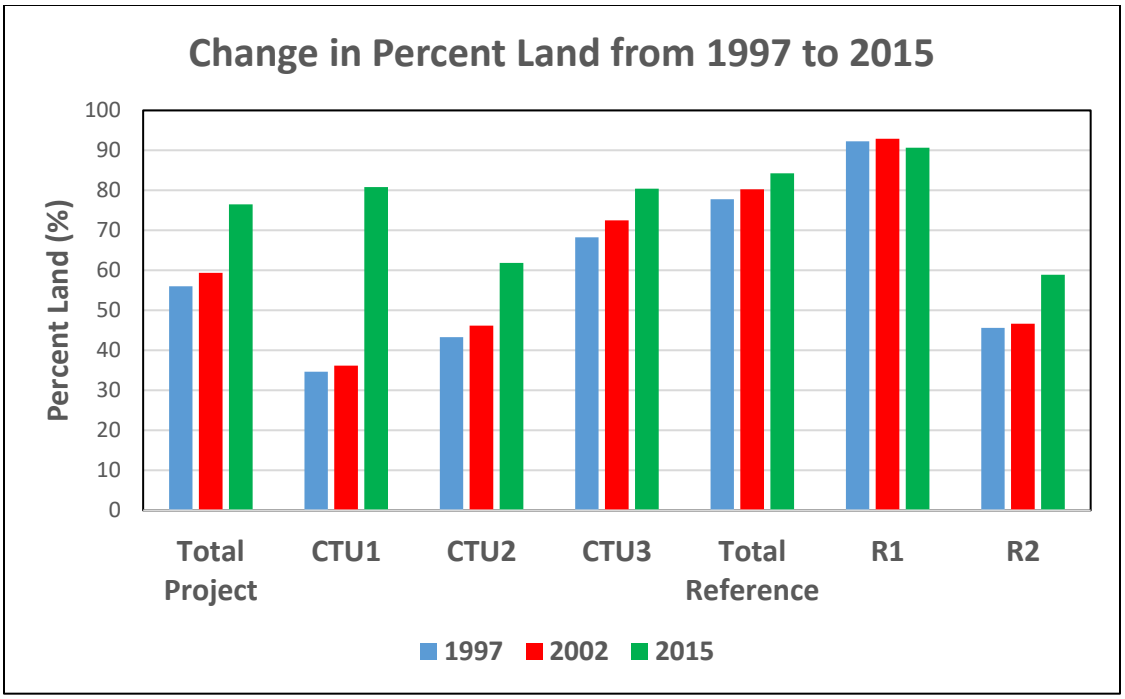


Figure 7. Percent of land area in 1997, 2002 and 2015 from aerial photography of each project CTU and the reference areas.

Salinity and Water Level

Hourly salinity and water level data have been collected at the following continuous recorder and discrete stations:

Station	Period of data collection
CS21-19 (CTU 1)	January 1997 – July 2004
CS21-26 (CTU 2)	January 1997 – January 2002
CS21-98 (CTU 2)	January 2002 – July 2004
CS21-29 (CTU 3)	January 1997 – July 2004
CS21-07R (R1)	January 1997 – July 2004
CS21-15R (CTU 1)	July 2006 – December 2010
CS21-29R (CTU 2)	July 2006 – December 2010

Due to low water levels, the recorder at CS21-26 was no longer able to function properly and was replaced by CS21-98 and moved approximately 100 yards north.

The original project goals for salinity were to maintain salinities in a target range of 0-10 ppt in CTU 1 and 0-5 ppt in CTU 2 and CTU 3. Comparison of the percentages of time salinities were within the target range before and after construction (by years) in CTU 1 and R1 showed that the reference area has been above 10 ppt at least 10% of the year (1999) and up to 80% of the year

(2000) from 1997 to 2004 (figure 8). Before construction (which was completed in early January 2000), salinities in R1 and CTU 1 followed the same trend relative to the 10 ppt target level most of the time. In 2000 both units were inundated with salinities above the target range for CTU 1 over 80% of the time due to drought conditions. Following 2000, the project seems to have had an effect on salinities in CTU 1 as the amount of time salinity was above the target range has decreased and the two units have ceased to follow the same trends.

The project goals for salinity in CTU 2 were to maintain salinities in a target range of 0-5 ppt from 1997 to 2004. In 2004 the target range was revised to 0-7 ppt to allow for better management of an intermediate marsh. Comparisons of the percentage of time salinities were within the target range in those units showed a similar trend to CTU 1. Salinities in the reference area were above 5 ppt 40% (1998) to above 90% (2003) of the year from 1997 to 2004 (figure 9). Before project construction, salinities in CTU 2 and CTU 3 were rarely as high as in the reference area, but were consistently above the target range. During the drought of 2000, salinities in CTU 2 exceeded those in the reference area. Following project construction, salinities in CTU 2 and CTU 3 dramatically decreased and were within the target range more often, especially compared to the reference area, R1. CTU 3 has an open breach that connects it to the GIWW, so structure management does not directly affect this unit, although salinities have decreased in CTU 3 since construction. Structure operation when salinities are above 7 ppt will increase the effect of the project on salinities in CTU 2 .

Bi-weekly means of discrete salinities used for operations were analyzed from 2006 to 2010 to review operational oppurtunities within the CTU 1, R1 and CTU 2, R2 units. The CTU 1, R1 unit had less operational opportunities than the CTU 2, R2 unit over time, mainly due to its close proximity to Calcasieu Lake (figures 10-11). Comparison of the percentages of time salinities were within the target range (by years) within R1 ranged from 20% in 2006 to 51% in 2007 with years 2008 to 2010 avereging over 40% (figure 12). Comparison of the percentages of time salinities were within the target range (by years) within R2 ranged from 43% in 2010 to 89% in 2008 with the remaining years averaging over 70% (figure 12).

The project goal was to reduce water level variability in the project areas. This effect was tested using mean daily water level range (ft NAVD 88) by areas and years. The analysis indicates that the project has greatly reduced water level variability (or range) in the three project areas (figure 13). The mean daily range of water levels has increased each year from 1997 to 2004 in the reference area, R1. Following project construction completion in early 2000, water level range significantly decreased in CTU 1 and CTU 2 from between 0.6 and 0.8 ft NAVD 88 pre-construction to below 0.2 ft NAVD 88 post-construction (figure 13). Similarly, water level range in CTU 3 decreased from between 0.3 and 0.6 ft NAVD 88 pre-construction to below 0.4 ft NAVD 88 post-construction. Therefore the project has reached the goal of decreasing water variability. Note that although water level range decreased in the project areas, overall mean water level does not appear to have been affected by the project (figure 14).

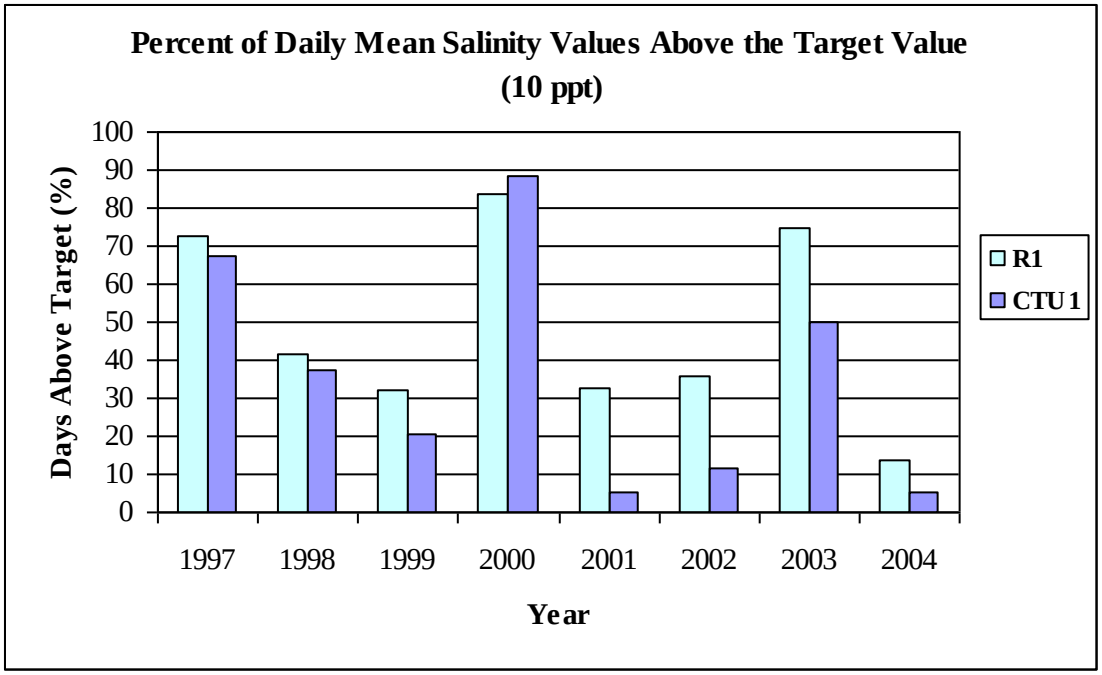


Figure 8. Percent of daily mean salinity values above the target value of 10 ppt in CTU 1 and R1 by years.

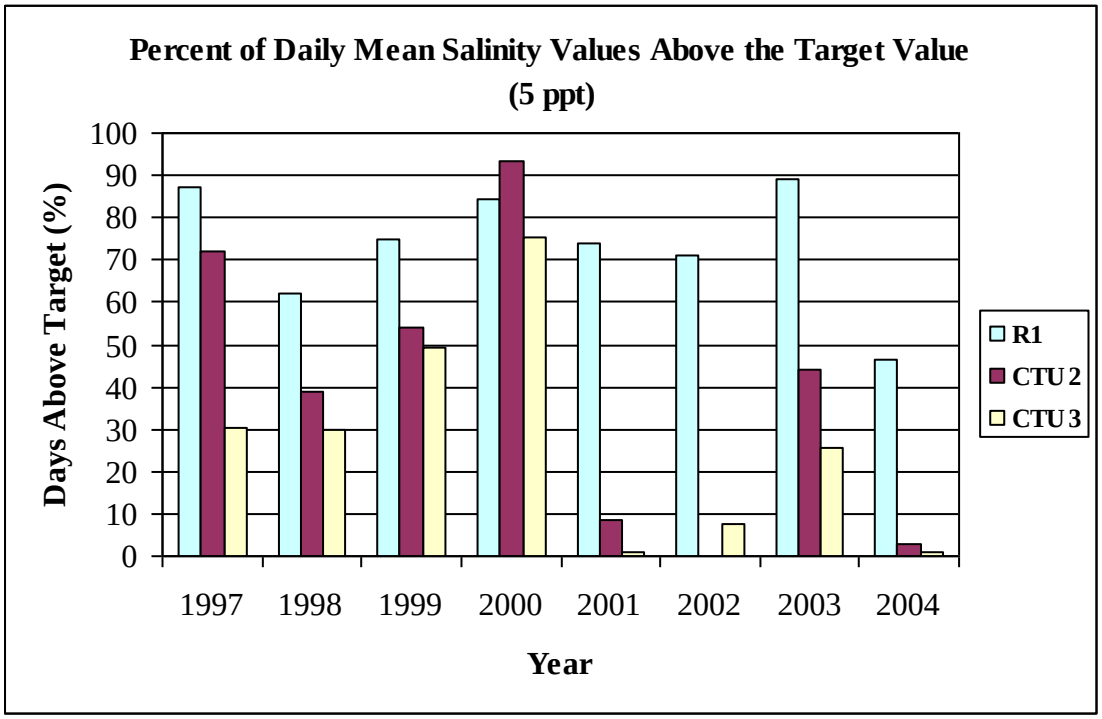


Figure 9. Percent of daily mean salinity values above the target value of 5 ppt in CTU 2, CTU 3, and R1 by years.

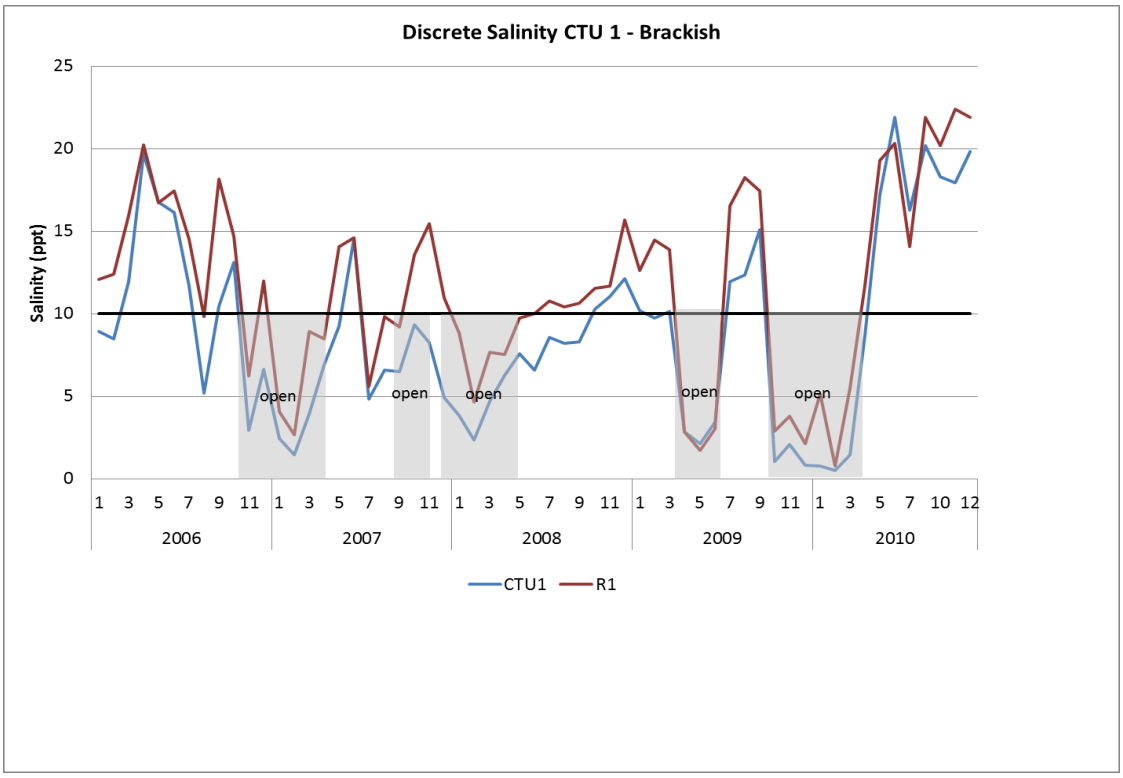


Figure 10. Bi-weekly means of discrete salinities within CTU 1 showing operations performed for the 10 ppt target range.

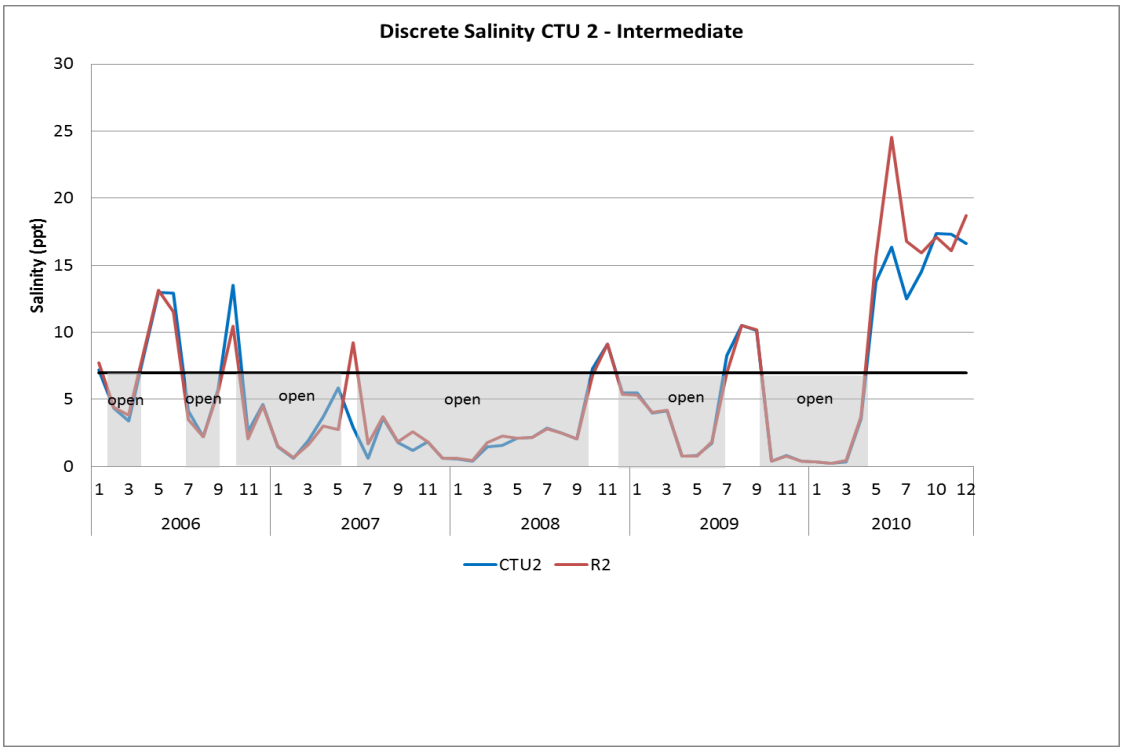


Figure 11. Bi-weekly means of discrete salinities within CTU 2 showing operations performed for the 7 ppt target range.

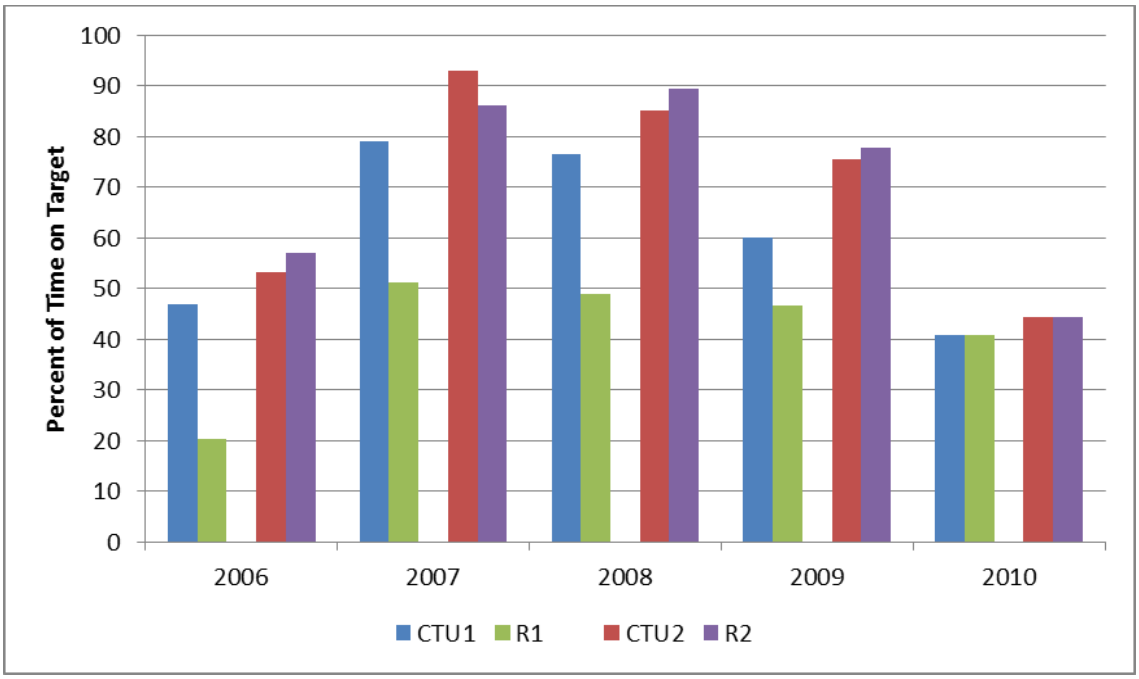


Figure 12. Percent of time salinities where within target range (0-7 ppt) within CTU 1 and CTU 2 from years 2006 to 2010.

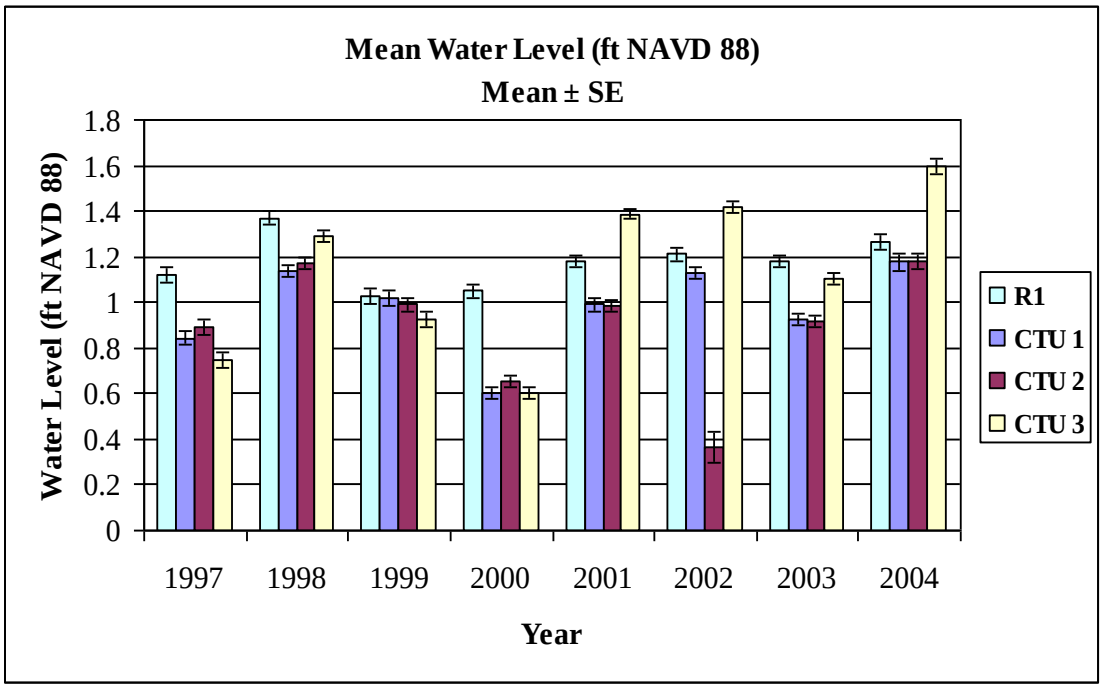


Figure 13. Water level range (ft NAVD 88) in the CS-21 Hwy 384 Project Area from 1997 to 2004.

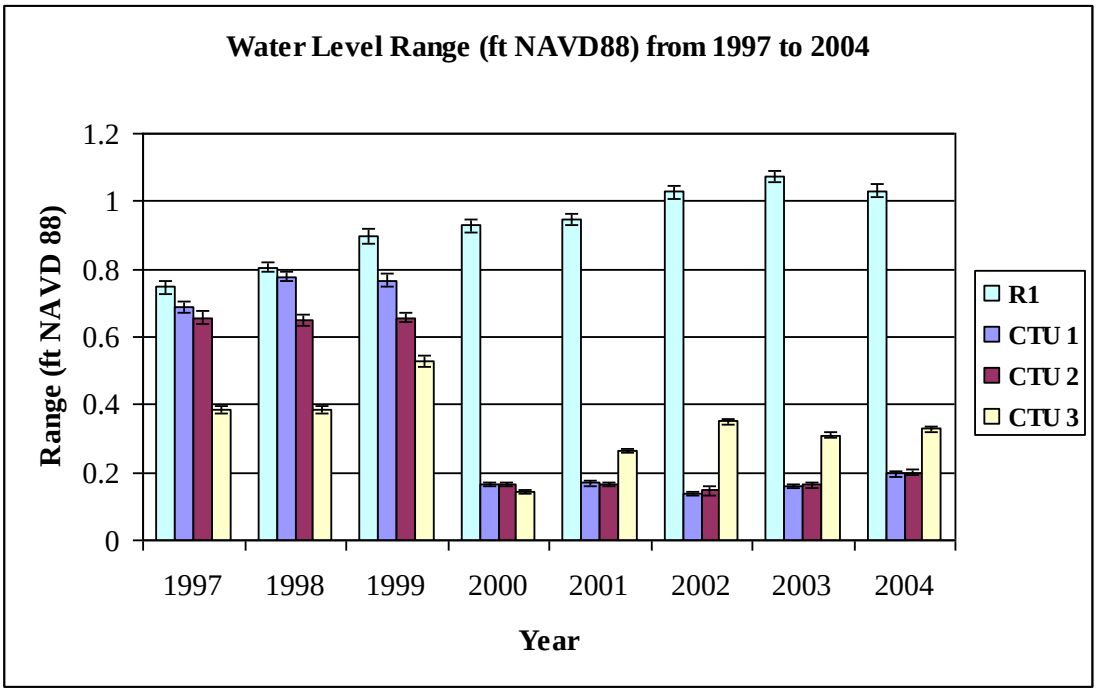


Figure 14. Yearly means of water level (ft NAVD 88) in the CS-21 Hwy 384 Project Area from 1997 to 2004.

Submerged Aquatic Vegetation

The project goal for SAV was to increase cover or frequency of occurrence. SAV was measured pre-construction in 1996 and 1997 and post-construction in 2002, 2015 and 2018. SAV cover increased every year measured in the project area through 2015 (Figure 15). In 2018, percent cover decreased, but was still greater than pre-construction conditions and much greater than the reference area. Also, two of the transects in CTU 3 had cracked pond bottoms indicating the ponds had been recently dry. Excluding these transects, total cover increases to near 80% for 2018 in the project area. SAV presence in the reference area was minimal in all years, except 2002, when 35% cover was noted.

In 1996, 1997, and 2002 the project area was dominated by *Ruppia maritima* with some *Najas guadalupensis, Myriophyllum spicatum*, and a few other SAV species (Figure 16). In 2015, the project area samples were dominated by fresher species like *M. spicatum* and *Najas minor.* However, CTU's 1 and 2 were not sampled due to the ponds being dry. In 2018, *R. maritima* was the only species found in CTU's 1 and 2. *Hydrilla verticillata* dominated the samples in CTU 3 reflecting very fresh conditions in this unit. In the reference area, a very small amount of *R. maritima* was found in 1996, 1997, 2002 and 2018. No SAV was found in 2015. Salinities during sampling in 2018 were around 2 ppt in CTU3, around 10 ppt in CTU 2 and over 20 ppt in CTU 1 and the reference areas.

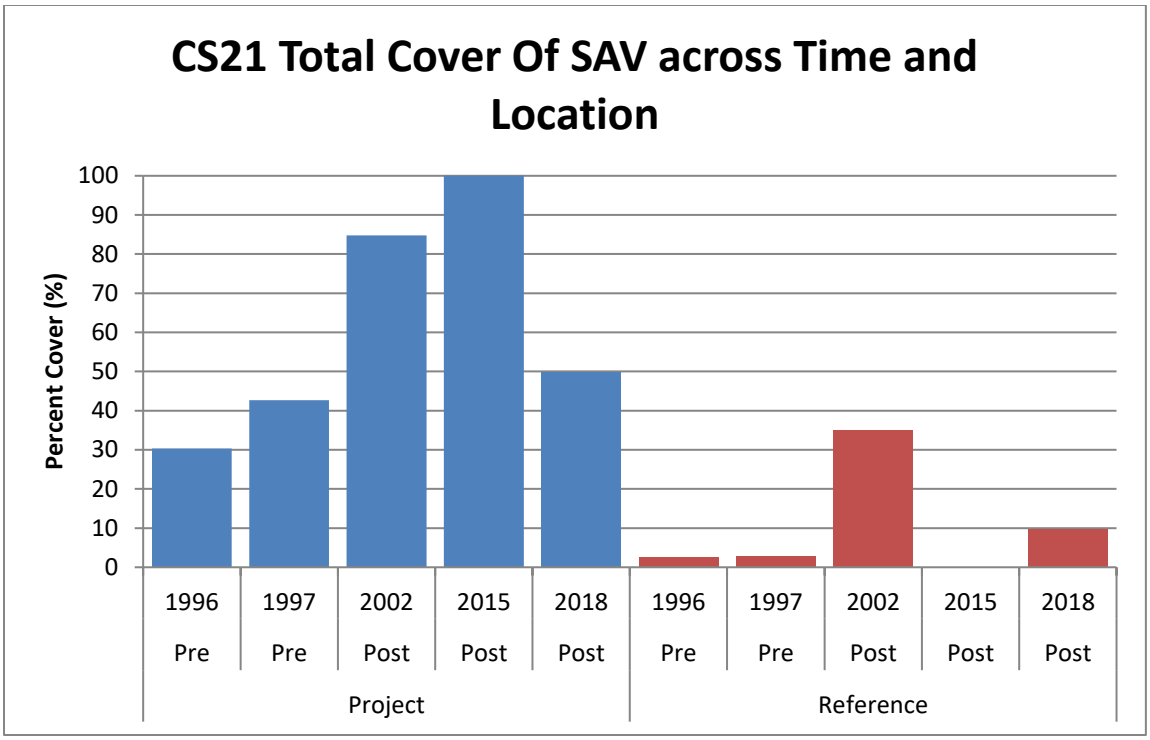


Figure 15. Total percent cover of SAV within the project and reference area for pre-construction in 1996 and 1997 and post-construction in 2002, 2015 and 2018.

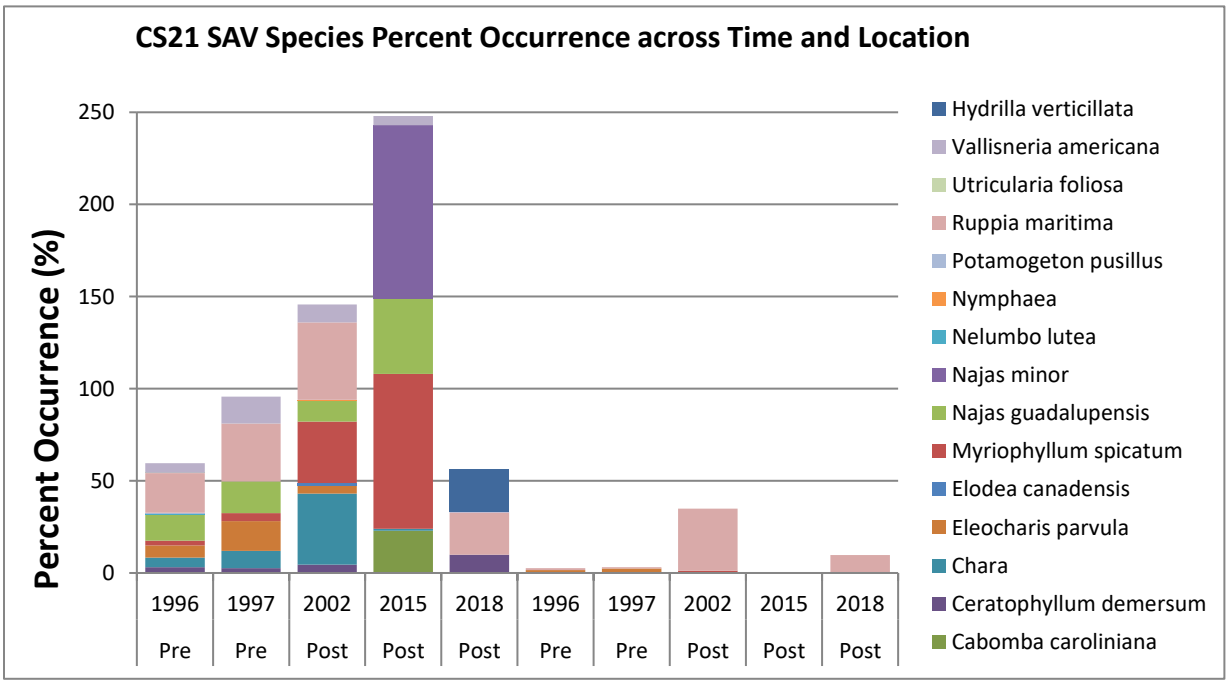


Figure 16. Percent occurrence of SAV species within the project and reference area pre-and post-construction.

Emergent Vegetation

The project goal for emergent vegetation was to increase cover in the project area. Vegetation recovered from Hurricane Rita from 2006 to 2008 but had decreased overall by 2015, most likely due to very dry conditions (Figure 17). By 2018, though, cover rebounded to its highest levels since monitoring started. The FQI score was also very high in 2018 due to the presence of species that are indicative of a stable marsh environment. Vegetation in the project area has shifted from Saline species to Intermediate species over time and is now dominated by *Spartina patens* along with several other species including *Paspalum vaginatum*, *Phragmites australis*, and *Juncus roemerianus*. Cover and FQI score of saline vegetation in the reference area has remained high throughout the project.

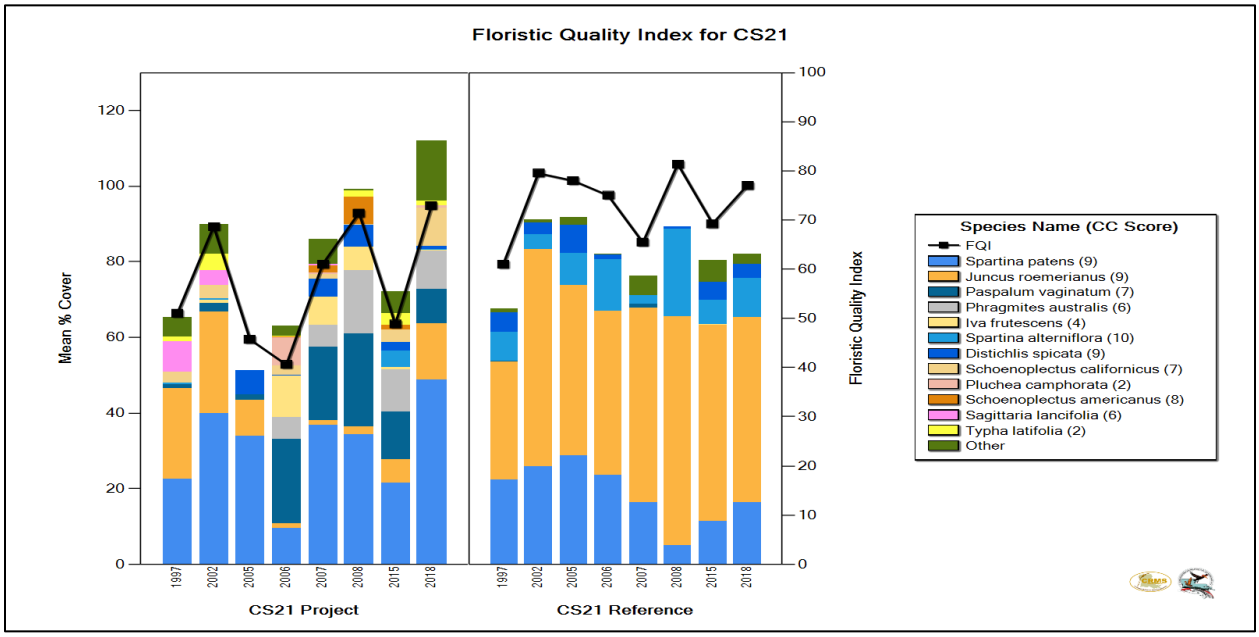


Figure 17. Floristic Quality Index (FQI) and mean % cover of plant species within CTUs 1-3 and the reference area from 1997 to 2018.

Soil Characteristics

Soil characteristics were originally collected in 1997. Soil characteristics are consistent with brackish type marshes (table 2) (Palmisano 1972). Post-construction samples which were to be collected in conjunction with the vegetative sampling were not collected in 2005.

Table 2. Pre-construction (1997) soil characteristic data for La. Highway 384 Hydrologic Restoration (CS-21) project and reference areas.

Unit	Percent (%) Organic Matter (%)	Bulk Density (oven) (g/cm3)	Percent (%) Water (Moisture) (%)	Pore Water Salinity (ppt)	Organic Matter Density (oven) (g/cm3)	Mineral Matter Density (oven) (g/cm3)
CTU 1	0.20	0.68	0.72	17.65	0.13	0.54
CTU 2	0.21	0.70	0.71	18.32	0.12	0.58
CTU 3	0.12	0.85	0.49	12.63	0.09	0.75
Reference 1	0.26	0.49	0.75	18.53	0.12	0.37
Reference 2	0.11	0.81	0.63	17.10	0.39	0.72

V. Conclusions

a. Project Effectiveness

The CS-21 project has met the objective to protect and maintain the wetlands of the project area. The rate of marsh loss was not only decreased, but land area has expanded. This was accomplished by effectively introducing sediments from the GIWW, reducing water level variability and maintaining salinities within a range suitable for brackish and intermediate marsh vegetation. This has resulting in an increase in the coverage of emergent wetland vegetation as well as submersed aquatic vegetation since project construction.

b. Recommended Improvements

The structures have proven effective in achieving the goals of the project except during extreme weather conditions such as the drought in 2000. A revision to the permitted structure operations was recommended by LADNR in late 2005, to provide increased control, restricting high salinity water from entering the project area from the GIWW, particularly in CTU 1 and 2. This revision is also designed to increase the flow of freshwater into CTU 1 and 2 when freshwater is available. A permit modification of the original operating procedures mandating closure of the sluice gates at Structure #1 when salinities exceed 7 ppt, was approved and enacted in early 2006, reflecting these recommendations. Ongoing structure operations on salinities and high water thresholds are necessary in maintaining the project area to a healthy and sustainable ecosystem. Routine cleaning of the freshwater introduction channel from the GIWW to the ES-1 structure is needed to allow for optimum sediment input into the system along with routine cleaning of debris and vegetation along the hyacinth fence.

c. Lessons Learned

The following improvements have performed well in this project and should be considered in future projects of this type:

- A hyacinth fence installed at the inlet structure
- The rock reinforcement of the bankline at the structures
- The use of recycled concrete material to repair access roads
- The two InSitu Aqua Troll 200 Sonde units used for operation of the structures

No salinity data was available for the GIWW during the design phase of this project. It was assumed that the Calcasieu Locks prevented high salinity water from entering the GIWW from Calcasieu Lake. Data gathered after construction of the project proved this assumption to be erroneous. The intermediate marsh within CTU-3, adjacent to the GIWW, is particularly vulnerable to elevated salinity flow from the GIWW, as no provisions were made to restrict this flow through this portion of the project area. Future designs should be based on actual information gathered at specific locations.

Sediment deposition occurs naturally within the freshwater introduction channel and requires routine channel cleaning. The freshwater inlet should be cleaned on a regular as-needed basis. Debris and vegetation buildup occurs naturally over time at the hyacinth fence especially at the CTU-1 structure. Routine maintenance of debris and vegetation removal from the structures is critical in maintaining flows in and out of the project area. As accretion occurs in the interior project area, trenasses would be beneficial to continue to carry flow into the interior open water areas. The trenasses could be dug during the freshwater channel cleaning events.

d. End of Project Life

The construction, operation, and maintenance of the Highway 384 structures has been highly successful in creating marsh, managing water level variability and eliminating salinity spikes in the project area for the past 18 years. However, landowners were not interested in the maintenance and operation of the project features. The projects rocks, water control structures, and culverts were left in place but the stop logs and flap gates were removed from each structure. With this being a project closeout the long term stability of the project area marshes is unlikely. Therefore, continued maintenance and operation of the project features is critical to the long term stability of the project area marshes.

VI. Literature Cited

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APPENDICES

APPENDIX A
(Inspection Photographs)

Photo No. 1, Structure No.1, Project Interior

Photo No. 2, Structure No.1, Inlet Channel, Hyacinth Fence and Operations Equipment

Photo No.3, Structure No.1, Culverts - Sediment

Photo No. 4, Inlet Channel to Structure No.1, Last Dredged in 2015

Photo No. 5, Structure No. 12, Inlet Side

Photo No. 6, Structure No. 12, Outlet Side

Photo No. 7, Structure No. 8, Rock Plug Looking South towards lake

Photo No. 8, Structure No. 8, Rock Plug - Vegetation on Project Interior

Photo No. 9, Vegetation Changes Over Time (2014- 2016): Project Interior –Structure No.1

Photo No. 10, Vegetation Changes Over Time (2017): Project Interior –Structure No. 1

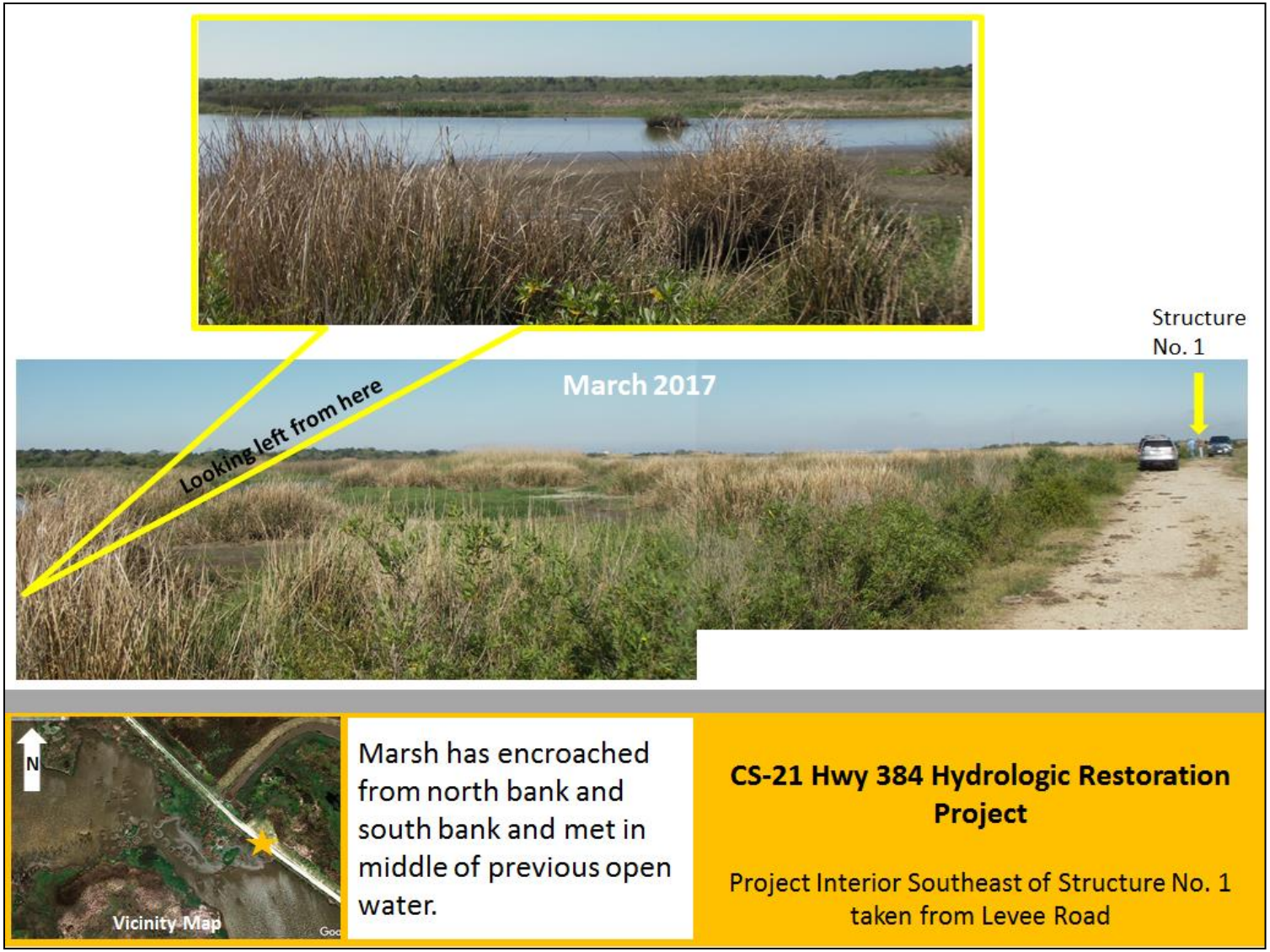

Photo No. 11, Vegetation Changes Over Time (2017): Project Interior – Southeast of Structure No. 1

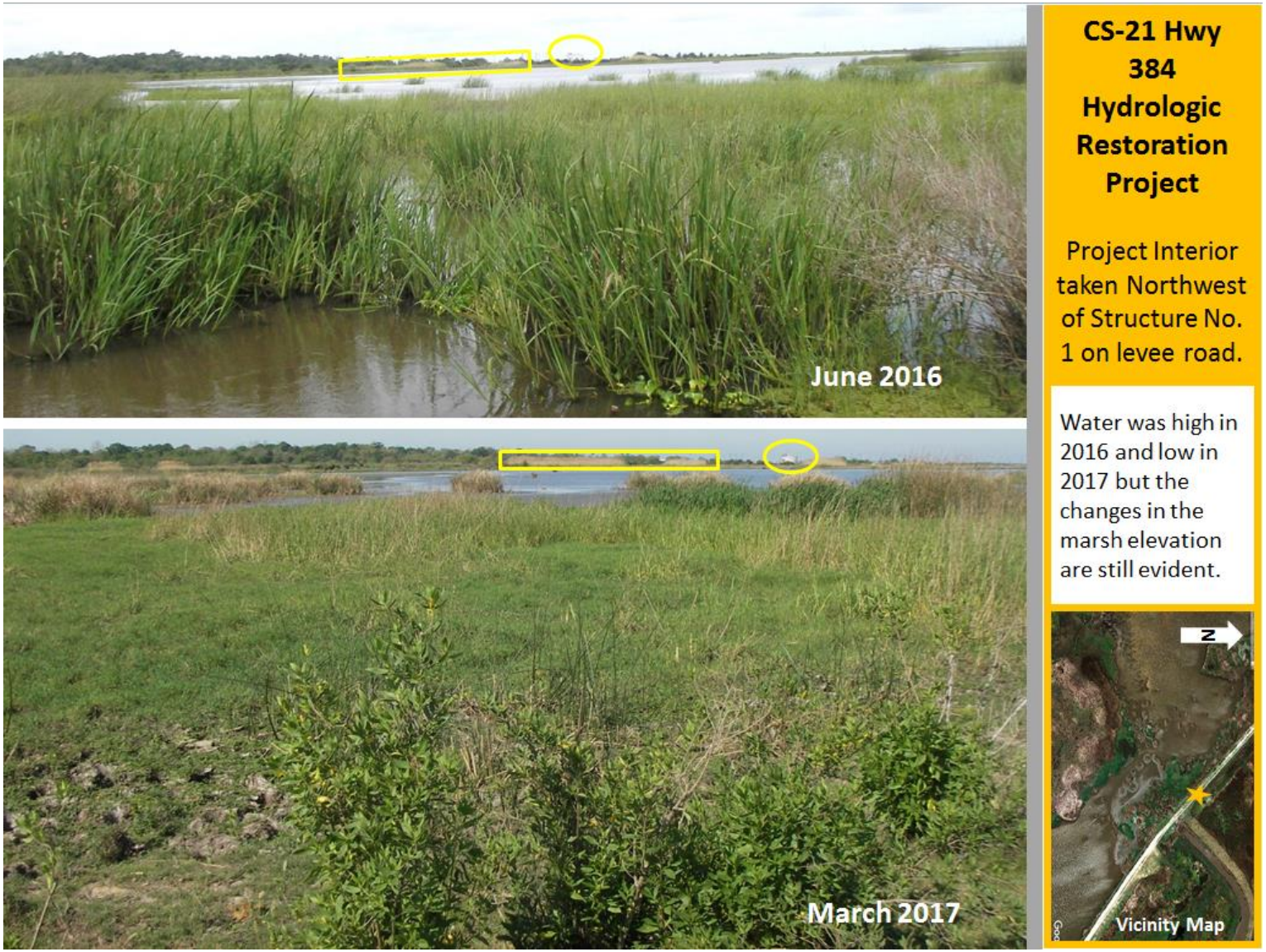

Photo No. 12, Vegetation Changes Over Time (2017): Project Interior – Northwest of Structure No. 1

September 16, 2003


4/7/2010
384
Miguez St
Catherine Ln
Old Bump Rd
Image © 2017 DigitalGlobe
Google Ea

April 7, 2010

March 4, 2012

March 13, 2017

APPENDIX B
(Three Year Budget Projection)

HWY 384/ CS-21 / PPL 2

Three-Year Operations & Maintenance Budgets 07/01/2017 - 06/30/2020

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Pat Landry	*Jody White*	*NRCS*	*Jody White*

	2017/2018 (-18)	2018/2019 (-19)	2019/2020 (-20)
Maintenance Inspection	$ 7,269.00		
Structure Operation	$ 10,600.00		
State Administration	$ 3,000.00		$ -
Federal Administration	$ -		$ -
Maintenance/Rehabilitation			

17/18 Description: Equipment Removal

E&D	
Construction	$ 3,000.00
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ 3,000.00

18/19 Description:

E&D	$ -
Construction	
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

19/20 Description:

E&D	$ -
Construction	$ -
Construction Oversight	$ -
Sub Total - Maint. And Rehab.	$ -

	2017/2018 (-18)	2018/2019 (-19)	2019/2020 (-20)
Total O&M Budgets	**$ 23,869.00**	**$ -**	**$ -**

O &M Budget (3 yr Total)	**$ 23,869.00**
Unexpended O & M Budget	**$ 27,800.00**
Remaining O & M Budget (Projected)	**$ 3,931.00**

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-21 Hwy. 384

Date of Inspection: 03-23-17 Time: 10:20am

Structure No. 1

Inspector(s): Jody White and Stan Aucoin (CPRA), Dale Garber (NRCS), Chris Simon (Simon & Delany)

Structure Description: 3-24" Culverts

Water Level: Inside -0.4ft Outside

Type of Inspection: Annual

Weather Conditions: sunny and mild, low water due to front/north wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Flapgates/Outlet Pipe	Fair			1	Sediment has restricted the flapgates from opening all the way.
Inlet Channel	Good			2&4	Inlet channel is in good condition after the 2015 dredging project; however, sediment has collected adjacent to the hyacinth fence, and culverts
Hardware/Sluicegates	Good			2	All gates are open but only two are partially flowing water due to sediment against the structure
Hyacinth Fence	Good			2-4	Sediment, debris and vegetation is accumulating since the 2015 maintenance event.
Timber Piles	Good			2-4	
Timber Wales	N/A				
Plastic Pile Caps	Good			2 & 4	pile caps are in place
Cables	N/A				
Signage /Supports Staff Gauges	Good			1 & 2	Staff Gauges were replaced on the inlet and outlet side in 2014 with reference to NAVD88 Geoid12A
Rip Rap embankment	Good				
InSitu AquaTroll 200 - 29r	Good			2	Telemetry has been replaced with a 300R tube unit and ATT 3G services. Sonde was not operational due to sedimient around it.
Levee/ Access Roadway	Good				Roadway is in good condition due to the 2015 maintenance to the area north of structure no 1.

What are the conditions of the existing levees? good

Are there any noticeable breaches?

Settlement of rock plugs and rock weirs?

Position of stoplogs at the time of the inspection?

Are there any signs of vandalism?

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-21 Hwy. 384

Date of Inspection: 03-23-17 Time: 11:20 am

Structure No. 8

Inspector(s): Jody White and Stan Aucoin (CPRA)
Dale Garber(NRCS), Chris Simon - Simon and Delany

Structure Description: Rock plug

Water Level: Inside -0.4ft Outside -0.6ft

Type of Inspection: Annual

Weather Conditions: Sunny and mild, low water levels

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	N/A				
Stop Logs	N/A				
Hardware	N/A				
Timber Piles	N/A				
Timber Wales	N/A				
Galv. Pile Caps	N/A				
Cables	N/A				
Signage /Supports Staff Gages	N/A				no longer necessary
Rip Rap (plug)	Good			7 & 8	The rock plug is in tact and vegetation has expanded along the plug on the lake side. Besides the small channel there is no longer any open water visible from the plug in the project interior.
Earthen Embankment					

What are the conditions of the existing levees?
Are there any noticeable breaches? no
Settlement of rock plugs and rock weirs? no
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism? no

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-21 Hwy. 384

Date of Inspection: 03-23-17 Time: 11:40 am

Structure No. 12

Inspector(s): Jody White and Stan Aucoin (CPRA)
Dale Garber (NRCS) and Chris Simon (Simon & Delany)

Structure Description: 2-48" Culverts

Water Level: Inside Outside

Type of Inspection: Annual

Weather Conditions: Sunny and mild, low water level due to north wind

Item	Condition	Physical Damage	Corrosion	Photo #	Observations and Remarks
Steel Bulkhead / Caps	N/A				
Steel Grating	Good			5	
Stop Logs	Good			5	
Hardware/Flapgates	Good			6	
Timber Piles	Good			5	
Timber Wales	N/A				
Plastic Pile Caps	Good			5 & 6	Plastic pile caps were in place.
Cables	N/A				
Staff Gages	Fair			5 & 6	Staff gauges on the inlet and outlet side were replaced in 2014 to the GEOID 12A datum.
Rip Rap embankment	Good			5 & 6	Embankment was in good condition.
InSitu AquaTroll 200 - 15r	Good				The telemery equipment has been upgraded to a 300R tube unit with ATT 3G service.
Access Roadway	Good				The access road was in good condition. New limestone was placed in sections on the road by others, possibly due to monitoring well work in the project area and use of the road for access.

What are the conditions of the existing levees? good
Are there any noticeable breaches?
Settlement of rock plugs and rock weirs?
Position of stoplogs at the time of the inspection?
Are there any signs of vandalism? no