State of Louisiana

Coastal Protection and Restoration Authority of Louisiana (CPRA)

2023 Operations, Maintenance, and Monitoring Report

for

Black Bayou Culverts Hydrologic Restoration

State Project Number CS-29
Priority Project List 9

December 2023
Calcasieu and Cameron Parishes

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2023 Operations, Maintenance, and Monitoring Report
For
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Preface

The Black Bayou Culverts Hydrologic Restoration (CS-29) project was funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) on the 9th Priority Project List with the Natural Resources Conservation Service (NRCS) as the federal sponsor and the Coastal Protection and Restoration Authority (CPRA). The 2023 OM&M Report format combines the Operations and Maintenance annual project inspection information with the Monitoring data and analyses for the project. This report includes monitoring data collected through December 2022, and annual Maintenance Inspections through December 2022.

The 2023 report is the 2nd report in a series of OM&M reports. For additional information on lessons learned, recommendations, and project effectiveness please refer to the additional materials available from the CPRA web site at:

(http://lacoast.gov/new/Projects/Info.aspx?num=CS-29).

I. Introduction

The Black Bayou Culverts Hydrologic Restoration Project (CS-29) is located in north-central Cameron Parish and southern portions of Calcasieu Parish. The project area is bordered by the Gulf Intracoastal Waterway (GIWW) for a significant distance either to the north or south, from the Mermentau River in the east, and ending near the large project water control structure in the northern reaches of Calcasieu Lake (Figures 1 and 2). The project area encompasses the Sweet Lake/Willow Lake area north of the GIWW (Area 2A, 5,725 ac), large areas of the Mermentau Lakes sub-basin to the south of the GIWW and west of the Mermentau River ending at Highway 27 (Area 2B, 23,558 ac and Area 3, 39,173 ac). There are also some smaller areas including tidal creeks north of the Town of Grand Lake (Area 1, 5,200 ac) and east and west of Deatonville (Area 4, 1441 ac) (Figure 3 and 4). The total project area is approximately 72,378 acres (29,290 ha) and is comprised of a vast majority of fresh to intermediate marsh in the Mermentau Lakes sub-basin and of brackish to saline marsh in the much smaller Area 4 west of the Black Bayou culverts water control structure and the U.S Army Corps of Engineers (USACE) Calcasieu locks. The marshes in the project area are dominated in large part by fresh flood tolerant species such as *Typha latifolia* (broadleaf cattail), *Sagittaria lancifolia* (bulltongue arrowhead), *Zizaniopsis miliacea* (giant cutgrass), and *Cladium jamaicense* (sawgrass) with more intermediate species mixed in at higher elevations with less flooding such as *Spartina patens* (saltmeadow cordgrass) and *Phragmites australis* (Roseau cane). Some locations within the project area are exposed to extreme long term flooding conditions with a cohort of species adapted to floating marshes consisting of, *Panicum hemitomon* (maidencane), *Ludwigia grandiflora* (large-flower primrose-willow), and *Eleocharis sp.* (spikerush) (Mouledous et al. 2016).

Historically, a majority of the Black Bayou culverts project area was in the southern watershed of the approximately 3,000,000-acre Mermentau River basin, receiving overland sheet flow from the surrounding uplands during periods of high rainfall and river discharge.

Drainage was predominantly north-south from the upper basin through the Lakes sub-basin and finally into the Chenier sub-basin via the Mermentau River. The Mermentau River provided a freshwater head to the project area and, to a lesser extent, the Calcasieu River and the Vermilion River to the West and East, respectively. Beginning in the late 1800s, significant hydrologic changes in the Chenier Plain began affecting water level fluctuation and water circulation patterns in the project area. This has inhibited the freshwater head from flowing north to south and has diverted it to a bidirectional east and west flow via the Gulf Intracoastal Waterway (GIWW) (LCWCRTF 2002). Hydrologic alteration first began with the construction of the Old Intracoastal Waterway in 1912 to provide navigation to the Mermentau River from Franklin, La. The channel was dredged through Schooner Bayou and Grand and White Lakes, linking the two lakes together and allowing water to flow east/west through the Basin. The construction of the GIWW between 1925 and 1944 continued this pattern. Drainage improvements on the upper Mermentau River and its four major tributaries took place throughout the 1900's, facilitating rapid transport of storm water and agricultural runoff into the Lakes sub-basins, and further altering historic flow patterns. Dredging of the lower Mermentau River in the 1950's and again in the 1970's allowed significant saltwater intrusion and marsh loss within the region.

Modifications to Calcasieu Pass such as the removal of the Calcasieu Pass oyster reef (1876) and maintenance of a deep (40 ft) and wide (400 ft) Calcasieu Ship Channel has increased the magnitude and duration of tidal fluctuations causing higher salinity and a broader range of water level fluctuations throughout the lake and the surrounding marshes (LDNR 1993). Construction of the Gulf Intracoastal Waterway established an east-west hydrological connection between the previously distinct Calcasieu and Mermentau basins, disrupting the natural north-south flow and allowing the saline waters of the Calcasieu Basin to encroach on the fresher Mermentau Basin. The U.S. Army Corps of Engineers (USACE) constructed three major water control structures in the 1950's. The Calcasieu lock, Catfish Point control structure, and Schooner Bayou control structures were constructed for water level control and to prevent saltwater intrusion, but are also periodically operated for flood water evacuation and to allow estuarine ingress, when conditions permit. Two additional control structures were added in later years. The Freshwater Bayou lock and Leland Bowman lock were constructed in 1968 and 1985, respectively, and are operated in conjunction with the other three control structures to maintain the Lakes sub-basin as a freshwater reservoir for primarily agricultural and navigation interests. The structures are operated collectively to achieve a target water level of 2.0 ft Mean Low Gulf (MLG). Louisiana Highway 82 was constructed in 1958 from Pecan Island to Grand Chenier, creating a barrier between the two Sub-basins and further altering the historic sheet flow pattern. Water level fluctuations are also highly influenced by local meteorological factors. A strong north wind can cause drastic de-watering of marshes, while a strong sustained southerly wind can result in drastic increases in water levels and salinities blown in from the Gulf of Mexico outside of the Lakes sub-basin. The extensive system of navigation channels, locks, and expanded river channels, have allowed increased water level fluctuations and salinities outside of the project area, while causing extensive long term fresh water flooding inside the project area (USDA 1997). Most of the land loss in the project area and surrounding marshes occurred between 1956 and 1978

(Barras et al. 2008), as both large and small scale changes have resulted in basin wide hydrologic alterations.

The Black Bayou Culverts Hydrologic Restoration Project includes structural measures designed to allow elevated levels of freshwater from the Mermentau Lakes sub-basin to be released through the GIWW, near its confluence with Calcasieu Lake and the Calcasieu River, when the receiving basin's hydrologic conditions allow, both independently of and additional to the Calcasieu locks, which was previously the only westward drainage component of the Mermentau Lakes sub-basin. The culverts reconnected the historic Black Bayou channel to the Calcasieu Lake Basin. Black Bayou Culverts structural features construction was completed in January 2010 and became fully operational as repairs were completed in May of 2016. Structural features and their intended functions are listed below:

As Originally Constructed:

1. Ten - 10 ft. x 10 ft. concrete box culverts with aluminum flapgates were constructed at HWY 384, between the Calcasieu basin and the Mermentau Lakes sub-basin, to increase drainage during high water events or lock closures. A hinged flap gate was installed over each culvert on the Calcasieu side of the structure with buoyancy capabilities to increase the flow rate under low head differentials.

2. 11,825 SF of steel sheet bulkhead constructed along the Southwest bank of Black Bayou to secure this area from additional erosion occurring from increased velocities.

3. 1,500 tons of rock rip rap was installed on both sides of the structure to prevent undermining and erosion of the structure and roadbed.

As Repaired:

1. Ten (10) - 10 ft. x 10 ft. concrete box culverts equipped with aluminum flapgates on the west side and trash racks with a receiving slot for a sluice gate on the east side of the structure. The box culverts are supported by 110, 12 in butt diameter timber piles 50ft in length (to elevation -60 ft.) and 128, 4.5 in (transitioned to 3.5 in. below the top 15ft.) diameter push piers to an elevation -70 ft.

2. At approximately 17 ft from the headwall, a steel sheet pile cutoff wall was constructed on the West side of the structure to an elevation -35 ft and steel sheet pile toe wall on the East side of the structure to an elevation -25 ft was constructed with a tie-in concrete slab to the culvert structure.

3. Rock rip rap (R-700) channel lining was placed 25 feet east and 50 ft west of the structure. Rock rip rap (R-300) wingwall revetment was placed on either side of the structure.

4. 11,825 SF steel sheet pile bulkhead (approx. 550 LF) with a galvanized steel pile cap was constructed along the southwest channel bank of Black Bayou.

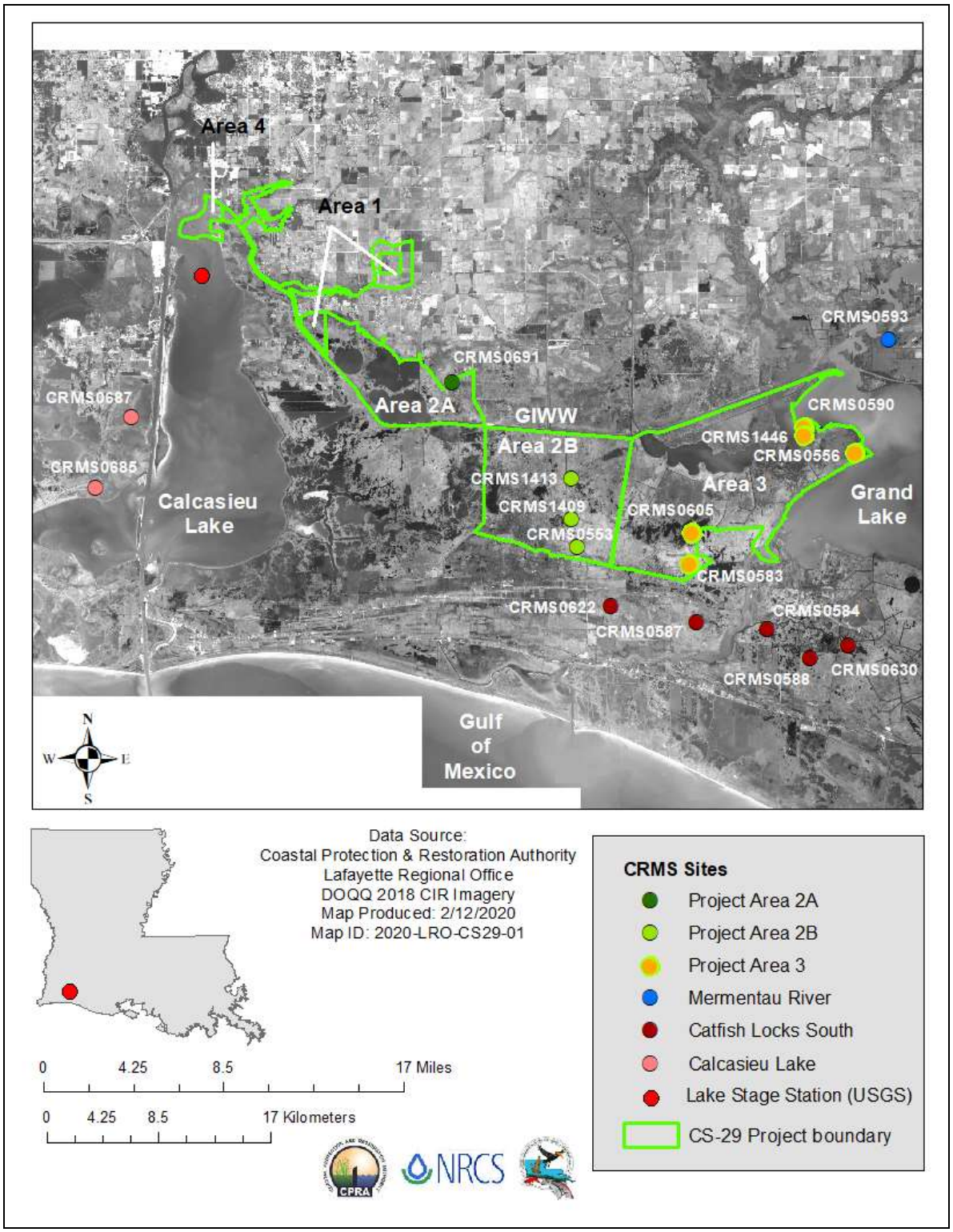


Figure 1. Black Bayou Culverts project area and boundaries, along with associated CRMS sites, color coded by project sub-areas and reference locations.

Figure 2. Black Bayou culverts project structure flowing rapidly, from east to west, out of the Mermentau Lakes sub-basin into the Calcasieu basin.

II. Maintenance Activity

a. Project Feature Inspection Procedures

The purpose of the annual inspection of the Black Bayou Culverts Hydrologic Restoration Project (CS-29) 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. The annual inspection report also contains a summary of maintenance projects, if any, which were completed since completion of 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 C.

An inspection of the Black Bayou Culverts Hydrologic Restoration Project (CS-29) was conducted on November 29, 2022. In attendance were Jody White and Phillip Parker, CPRA and, Richard Evely, Kyle Cappotto and Carol Clement of NRCS and the Contract Operator, Chris Simon of Simon and Delany, with four individuals for support and boat operation. Crane services were provided by United Crane services, a sub-contractor to the operations Contractor. The Contractor deployed traffic control measures for the closure the southbound lane per the approved permit issued for this purpose by the LaDOTD. This lane closure is necessary to allow the crane to stage for the purposes of lifting the gates for inspection.

The field inspection began at 11:00 AM at the culvert structure on Hwy 384. This entailed a complete visual inspection of the following features:

1. Earth embankments
2. Rock armor installments
3. Trash screens
4. Warning signs in channel
5. Lifted flap gates, bays 1 thru 10

Photographs were taken at each project feature (see Appendix A) and Field Inspection notes to record measurements, observations and deficiencies have been included (see Appendix C).

b. Inspection Results

<u>Concrete Box Culverts w/ Flapgates</u>

The flap gates were free flapping as intended; however, six gates have broken locking rings and/or stop plates which will require eventual repair. The stop plate welds that are broken may be the result of board/pipes or other objects inserted behind the gate arms where they connect to the hinges in an effort to keep the gates open. See photos: Appendix A, Gates 1, 3, 6, 7, 8 and 9 and Appendix D, Inspection Report and Notes.

Two of the gates, 5 & 9 have missing locking rings which will make it difficult to lock theses gates closed should the need arise. Repairs to these gates will need to be considered in the near future. All other gates can be locked closed if need be.

Trash Screen

The trash screens on the east side of the structure were working as intended. There was floating vegetation and debris collecting at the trash screens. During previous, additional visits, it was found the debris does migrate back into the GIWW as the hydraulics fluctuate. (Photos: Appendix A).

Steel Sheet Pile Bulkhead

The steel sheet pile bulkhead was in good condition. (Photos: Appendix A)

Rock Rip Rap Along Channel

The visible rock rip rap was in good condition. (Photos: Appendix A)

Locking Pins for Flap Gates

The locking pins were used to lock the gates closed in March of this year. The operations Contractor reported no issues with these pins. The locking pins were not visually inspected.

c. Maintenance Recommendations

i. Immediate/ Emergency Repairs

Estimates are being obtained to repair Gates No. 5 and 9. Sluice gates will be installed during this operations to isolate the culverts while the flapgates are removed from the structure.

ii. Programmatic/ Routine Repairs

- Flapgate repairs extend into FY24.

d. Maintenance History

General Maintenance: Below is a summary of completed maintenance projects and operation tasks performed since January 2010, the construction completion date of the Black Bayou Culverts Hydrologic Restoration Project (CS-29).

May-2010 Simon and Delany: This maintenance project included providing a boom truck to lift Gate No. 2 for inspection on May 5, 2010. During a prior operation on April 15, 2010, this gate was not able to be pinned closed with the other nine gates. The gate was found to be in good condition. Bent eyelets had prevented from closing and once corrected it was pinned

closed. With all gates closed, it was noted that water was still flowing at the structure. The costs associated with this event are as follows:

Provide Boom Truck and Crew: (Coordination handled by OCPR)	$2,200.00
TOTAL COST:	**$2,200.00**

June-2010 Simon and Delany: This maintenance project included providing a two man dive team to perform an underwater inspection of all ten gates on June 1, 2010. Undermining of the structure was confirmed between Gates No. 1 & 2, and at Gates No. 5 and No. 8. The costs associated with this event are as follows:

Provide two man dive team and perform inspection: (Coordination handled by OCPR)	$1,850.00
TOTAL COST:	**$1,850.00**

June-2010 American Contractor and Technology, Inc (ACT): This maintenance event included furnishing and placement of 240 supersize sand bags (approx. 1 CY per bag) in front of the flapgates on the lake side of the structure to reduce flow into the basin at high tide conditions as a result of undermining that has occurred. This work began on June 15, 2010 and was completed on June 23, 2010. Saltwater infiltration into the basin was reduced by this action. The costs associated with this event are as follows:

Construction Costs: (Coordination handled by NRCS)	Approximately $99,081.91
TOTAL COST:	**$99,081.91**

June- 2010 NRCS Investigation Committee: A committee was authorized by the NRCS State Conservationist to review and investigate the failures experienced at the structure. The committee began a design and construction review of the compiled records. A preliminary engineering report was prepared and a physical inspection was recommended.

April- 2011 Healtheon: This contract included construction of two earthen cofferdams on each side of the structure with clay fill. The intent was to dewater the interior to allow for a physical inspection and re-flood the site once complete. Work began on April 26, 2011 and was completed September 2, 2011. The physical inspection by the NRCS National Design Center Committee out of Fort Worth, TX occurred August 24-25, 2011.

TOTAL COST: **$1,096,322.93**
(Coordination handled by NRCS)

June- 2015 Tarpan:
Once funds were approved by the CWPPRA task force, a repair project was led by NRCS. Lonnie Harper and Associates were tasked with the design. The structure was repaired by constructing a steel sheet pile cutoff wall with wing walls on the west side of the structure and a steel sheet pile toe wall with wing walls on the east side of the structure. Existing timber piles were inspected for damage and flowable fill grout was pumped into the voids beneath the structure. The sheet pile was capped with a concrete tie-in slab to the structure sill (approximately 17ft from the structure headwall). For additional structural support, push piers were driven through the box culverts and fastened with stainless steel mounting plate assemblies. A concrete chamfer was installed over the mounting plates to form a smooth bottom surface. The trash racks were refurbished and slots were added to accept a sluice gate. The flapgates and frames were refurbished and coated with coal tar epoxy. The box culverts were cleaned and refurbished. Two 6 in. vents were installed near the west side in each box culvert. R-700 stone lined the channel bottom 50 feet on the west side and 25 feet from the sheet pile wall on the east side. R-300 stone was used as revetment on the wingwall embankments. The inlet and outlet channels were dredged. The work was completed July 7, 2016.

E&D and Construction S&I	$616,747
Construction Contract (Tarpan)	$6,900,963.61
TOTAL COST:	**$7,517,710.61**

April 2017 Simon and Delany: This maintenance event included parts and labor to replace the stainless steel nuts on the flapgate anchor rods with Teflon stop nuts to prevent the nuts from loosening and backing off the anchor rod.

TOTAL COST: **$1,625.00**

August 2018 Sealevel Construction: The Contract included fabrication of three aluminum sluice gates measuring 10’4” x 12’ 5 ¼”, for use on the East side of the structure. The gates were test fit and stored at the NRCS Lake Charles Field Office at 5417 Gerstner Memorial Drive.

TOTAL COST: **$63,250.00**

III. Operation Activity

a. Operation Plan

CS-29 BLACK BAYOU CULVERTS HYDROLOGIC RESTORATION

WATER MANAGEMENT PLAN/OPERATIONAL SCHEDULE
PROPOSED WATER CONTROL STRUCTURE IN THE
BLACK BAYOU AREA
CALCASIEU PARISH, LOUISIANA

With the construction of Louisiana Highway 384, the Black Bayou drainage path to the Calcasieu River was effectively blocked. In conjunction with the poor water relief offered by the Calcasieu Lock, the barrier created in Black Bayou has hindered the release of flood waters from the Mermentau Basin. Coupled with upstream drainage improvements, clearing of adjacent lands, subsidence, and relative sea level rise, the area is experiencing even longer periods of inundation from flood waters.

This project would re-open Black Bayou and alleviate some of the high water levels in the Mermentau Basin, as well as reduce water velocities through the Calcasieu Lock resulting in safer navigation. The removal of excess water in this area would allow an increase in emergent vegetation, while decreasing stresses on existing vegetation. The proposed flap gated structure would also maintain the deterrence of saltwater intrusion from the Calcasieu River.

Elevation observations in the marshes located near the project site revealed that the average mud line elevations were approximately +0.8 feet NAVD88. The top of the marsh plant root crown mass ranged in elevation from +0.9 feet NAVD88 to +1.2 feet NAVD88 (survey data as per On Target Surveying, Inc. and referenced in the 'Hydrologic Investigation of the Louisiana Chenier Plain' report dated October 2002). The applicant proposes to allow the structure to operate without human intervention, i.e. flap gates operating without restriction, unless the water level upstream of the structure reaches the previously stated average mud line elevation (+0.8 feet NAVD88). If this condition occurs, flow through the structure would be eliminated by manually locking closed the flap gates. A tide gauge referenced to the NAVD88 datum will be maintained upstream of the structure and the water surface elevation at this gauge will be used to determine the appropriate time for restriction of flow through the structure. The structure will remain closed until the water surface elevation at the gauge is +1.0 feet NAVD88; at which time the pins will be removed from the flap gates and the structure will be allowed to operate as designed.

STRUCTURE OPERATION SCHEDULE:

DATE	WATER LEVEL	STRUCTURE OPERATION
Jan. 1 – Dec. 31	above +0.8 ft*	Normal operation, i.e. unrestricted flap gates
Jan. 1 – Dec. 31	below +0.8 ft*	Structure closed, i.e. no flow through structure

*In the event that the water level upstream of the structure drops below +0.8 ft NAVD88 the flap gates will be closed in order to eliminate flow through the structure. After such an event, the structure will remain closed until the water level increases to +1.0 ft NAVD88, at which time the flap gate restriction will be removed and the structure will operate as designed.

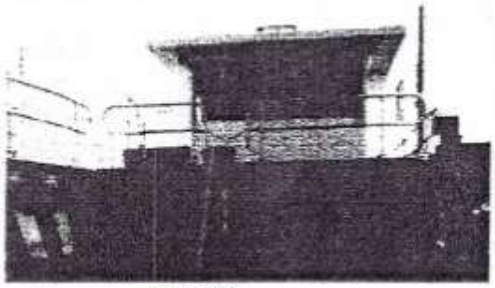
5/7/2004

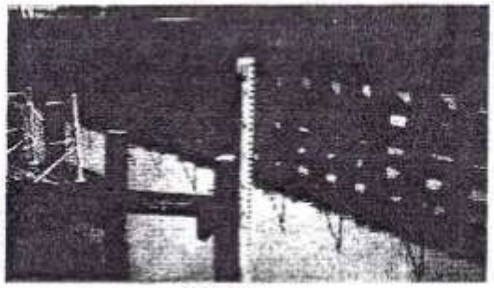

USACE
Calcasieu Lock
Calcasieu Ship Channel
Bazile Rd
Calcasieu Lock Rd
Calcasieu Lock East Gauge
GIWW
Hwy 384
384
Black Bayou
CS-29 Black Bayou
Culverts Structure
© 2016 Google
Tour Guide
1998
Imagery Date: 3/13/2017 30°04'55.60" N 93°17'16.69" W

Calcasieu Locks Gauge Data Sheet (2005) in NAVD88
Conversion from MLG to NAVD88 – Subtract 1.293ft

VICINITY MAP

Reproduced from USC&GS "MOSS LAKE" Quadrangle





WEST
STAFF GAUGE 3
(EXISTING)

Adjusted NAD 83 (1992) Geodetic Position (RTK)
Lat. 30°05'19.78129" N
Long. 93°17'41.39782" W

Adjusted NAD 1983 Datum(1992)
LSZ (1702) Feet (RTK)
N = 583,105.13
E = 2,660,539.46

Elevation of 7.0 foot mark on
Gauge No. 3(NAVD 88) (Feet) (RTK)
Elevation = + 5.707

EAST
STAFF GAUGE 4
(EXISTING)

Adjusted NAD 83 (1992) Geodetic Position (RTK)
Lat. 30°05'12.32111" N
Long. 93°17'28.38764" W

Adjusted NAD 1983 Datum(1992)
LSZ (1702) Feet (RTK)
N = 582,332.08
E = 2,661,669.33

Elevation of 6.0 foot mark on
Gauge No. 4 (NAVD 88) (Feet) (RTK)
Elevation = + 4.707

NGS Monument F226
(SEE ATTACHED NGS DATA SHEET)

Adjusted NAD 83 (1992) Geodetic Position (RTK)
Lat. 30°05'11.62589" N
Long. 93°17'11.66667" W

Adjusted NAD 1983 Datum(1992)
LSZ (1702) Feet (RTK)
N = 582,236.79
E = 2,663,136.84

Adjusted NAVD88 (Feet)(RTK)
Elevation = +3.377

b. Actual Operations

Structure Operations: CPRA Engineering staff monitor water levels at the Calcasieu Lock and within the Mermentau Basin to make recommendations to the project stakeholders, i.e. NRCS, CPRA, and USACE, with respect to locking or unlocking the flapgates. A trend in water level elevations of 2.09ft MLG (0.8ft NAVD88) at the Calcasieu Lock East Gauge is the target for locking/closing the flapgates.

CPRA currently contracts gate operations through a public bid process. Simon & Delany LLC. is the current Operations Contractor through the end of the contract period in June 2025. Upon agreement from the project stakeholders to lock or unlock flapgates, CPRA contacts the Contract Operator to prepare equipment and traffic control devices needed for the operation. When traffic lanes are interrupted, CPRA is required to submit a project permit to DOTD for those operations.

April 15, 2010	9 of 10 gates pinned closed, Gate No. 2 could not be pinned (Joint effort between OCPR, NRCS and USACE)
May 5, 2010	Lifted Gate No. 2, found bent eyelets, pinned closed (performed by Simon and Delany)
May 12, 2016	Removed cofferdams, removed pins, all gates free flapping (performed by Tarpan under NRCS contract)
March 7, 2017	Lifted gates No. 4 & 5 with crane truck, removed board from support bracing on gate no. 5. Board was jammed under gate no. 4 preventing it from closing and gate no. 5 from opening. Board broke locking ring on gate no. 4. (performed by Simon and Delany with Crane Ceaux)
May 11, 2018	Closed all Flapgates
September 11, 2018	Opened all Flapgates
January 16, 2020	Lifted all 10 gates for inspection and found Gate No. 1, 3, 4, 6, 8, & 9 with broken locking rings. Gates No. 6 & 8 have broken welds on stop plates. Gate No. 7 had a missing stop plate.
July 22, 2021	Lifted all 10 gates for inspection and found Gate No. 1, 3, 6, 8, & 9 with broken locking rings. Gates No. 6, 7, & 8 have broken welds on stop plates.

March 10, 2022	Closed all Flap Gates
May 6, 2022	Opened all Flap Gates
November 29, 2022	Lifted all 10 gates for inspection and found Gates No. 1, 3, 5, 6, 8, & 9 with broken locking rings. In addition, gates 5 and 9 have missing locking rings.
August 21, 2023	Closed all Flap Gates

IV. Monitoring Activity

The CS-29 project represents a large spatial area and the necessary reference conditions are equally expansive, therefore leveraging of the CRMS network is beneficial for monitoring. There are many CRMS sites located in the CS-29 project area, and many positioned outside the project area, which can be used for reference locations in generally hydrologically, separated habitats (Table 1).

Table 1. Project areas and reference locations with the associated CRMS sites; all project areas were compared to all reference locations when congruent data was available.

Location/Area	**CRMS Sites**				
Project Area 1	NA				
Project Area 2A	0691				
Project Area 2B	0553	1409	1413		
Project Area 3	0556	0583	0590	0605	1446
Project Area 4	NA				
Reference North -Mermentau River	0593				
Reference West - Calcasieu Lake	0685	0687			
Reference South - Catfish Locks	0584	0587	0588	0622	0630

a. Monitoring Goals

The following goals will contribute to the evaluation of the project objectives:

1. Reduce flood duration within the project area.
2. Increase percent cover, stem height, and species richness of emergent vegetation.

The goals will be assessed by:

1. Evaluating duration of flooding in the project area.
2. Evaluating percent cover, stem height, and species richness of emergent vegetation.

b. Monitoring Elements

Aerial Photography

High-resolution aerial photography (1 m, color infrared, CIR) and satellite imagery (30 m, Landsat Thematic Mapper, TM) are collected every three years for the entire coast through the CRMS program. The aerial photography is used to classify land and water within the square kilometer that surrounds each CRMS site. The satellite imagery is analyzed to evaluate changes in land and water areas within the CS-29 project area at a coarse (30m) resolution. The CRMS spatial viewer provides historic data for land water quantification in the project area starting in 1985. Land values are displayed for available cloud free Landsat images during the late fall for 1985-2016. The data provided by this tool is at a large spatial scale and is designed to show trends in land loss, not exact acreages or locations.

Water level:

CRMS continuous hourly water level monitoring in the project area began in November 2006 and seventeen CRMS sites were used to monitor project and reference water levels. All water level and marsh elevation data in this report are reported in GEOID 12A to compare between locations. Note CRMS elevations were updated to GEOID 12B after this analysis was performed. Actual elevations may differ in 12B but between site relationships remain the same.

Salinity

CRMS continuous hourly salinity monitoring in the project area began in November 2006 and seventeen CRMS sites were used to monitor project and reference salinities.

Emergent Vegetation:

Beginning in 2006 vegetation was monitored at seventeen CRMS sites inside and outside of the project boundaries. Individual species' cover data from CRMS stations were summarized according to species cover, total cover, height of dominant species, and sum of individual species cover (Visser et al. 2002). The CRMS percent cover and layer height vegetation data were transformed into a three dimensional vegetation volume and then indexed by marsh type to generate a 0-100 score for the vegetation volume present (Wood et al. 2015). This metric focuses on the quantity of vegetation present irrespective of species and can aid in the separation of similar marsh types with different growth potential.

Hydrologic Index

The Hydrologic Index (HI) assesses the relationship between the combined effect of mean salinity and percent time flooded on vegetation primary productivity for five different marsh classifications in coastal Louisiana (swamp, fresh, intermediate, brackish, and saline). The index score ranges from 0 - 100, representing the percent of maximum vegetation productivity expected to occur if the separate effects of salinity and inundation on productivity interact in a multiplicative fashion (Snedden and Swenson, 2012).

Soil Properties

Soil cores were collected to describe major soil properties such as bulk density and percent organic matter. Three, 4" (10.16-cm) diameter cores were collected to a depth of 24 cm and divided into 6, 4-cm sections at each site. The soil was processed by the Department of Agronomy and Environmental Management at Louisiana State University. Soil cores were only collected at the project and reference CRMS sites during station establishment in 2005-2007 and again in 2018. Cores were collected at nine sites inside the project area, and reference conditions were collected from eight sites outside the project area.

Soil Surface Elevation Change

Soil surface elevation change utilizing a combination of sediment elevation tables (RSET) and vertical accretion from feldspar marker horizons are being measured twice a year at each of the project and reference CRMS sites. These data will be used to describe the general trends in elevation change. The RSET was surveyed to a known elevation datum (ft, NAVD 88) so it could be directly compared to other elevation variables such as water level. Data collected over at least 5 years was used to calculate rates for the project and reference conditions; therefore, the displayed elevation change rates are an estimation of that temporal trend.

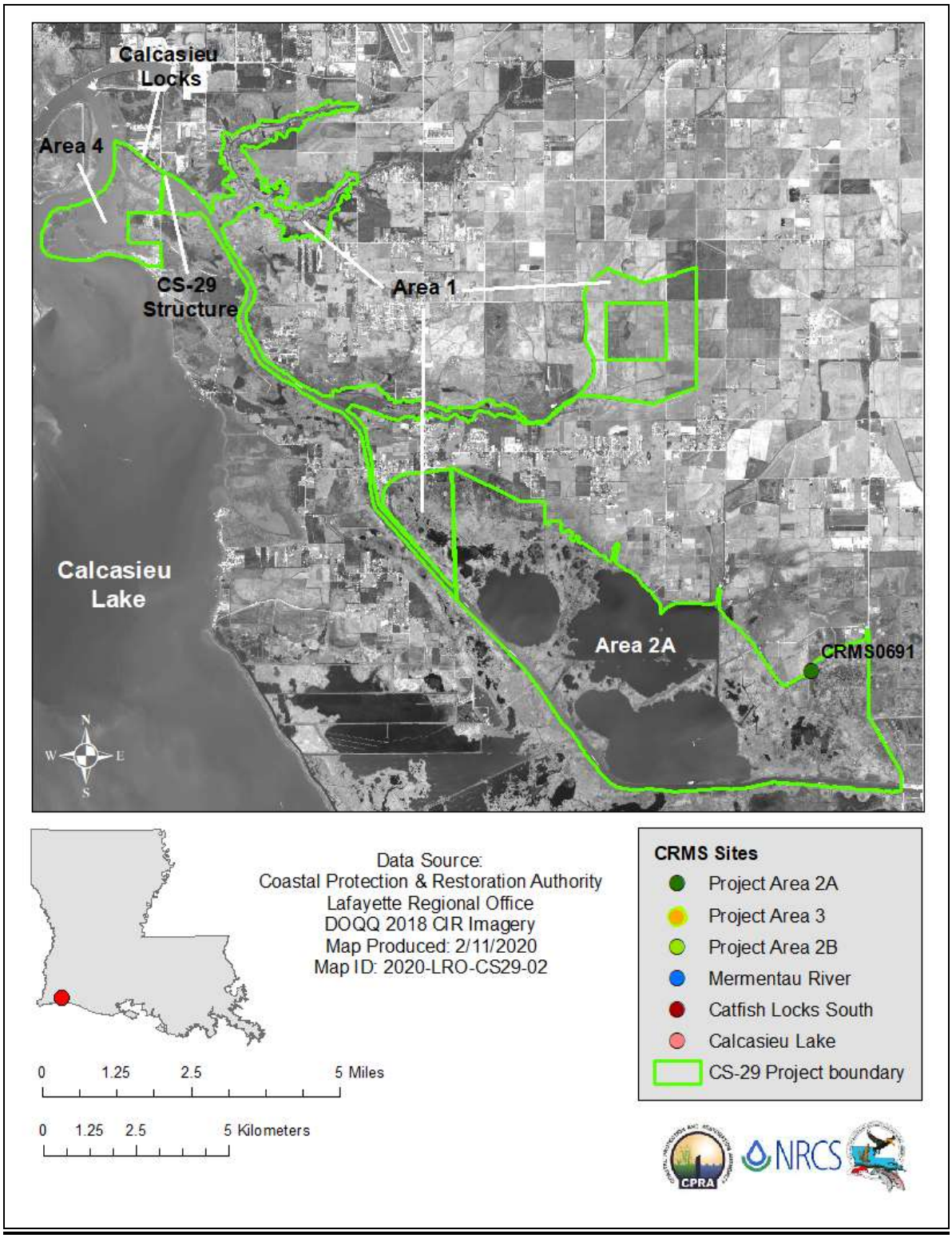


Figure 3. CS-29 sub areas 1, 2A, and 4 along with associated CRMS sites located within the project and reference areas. Not all locations have represented CRMS sites in which to display relative information.

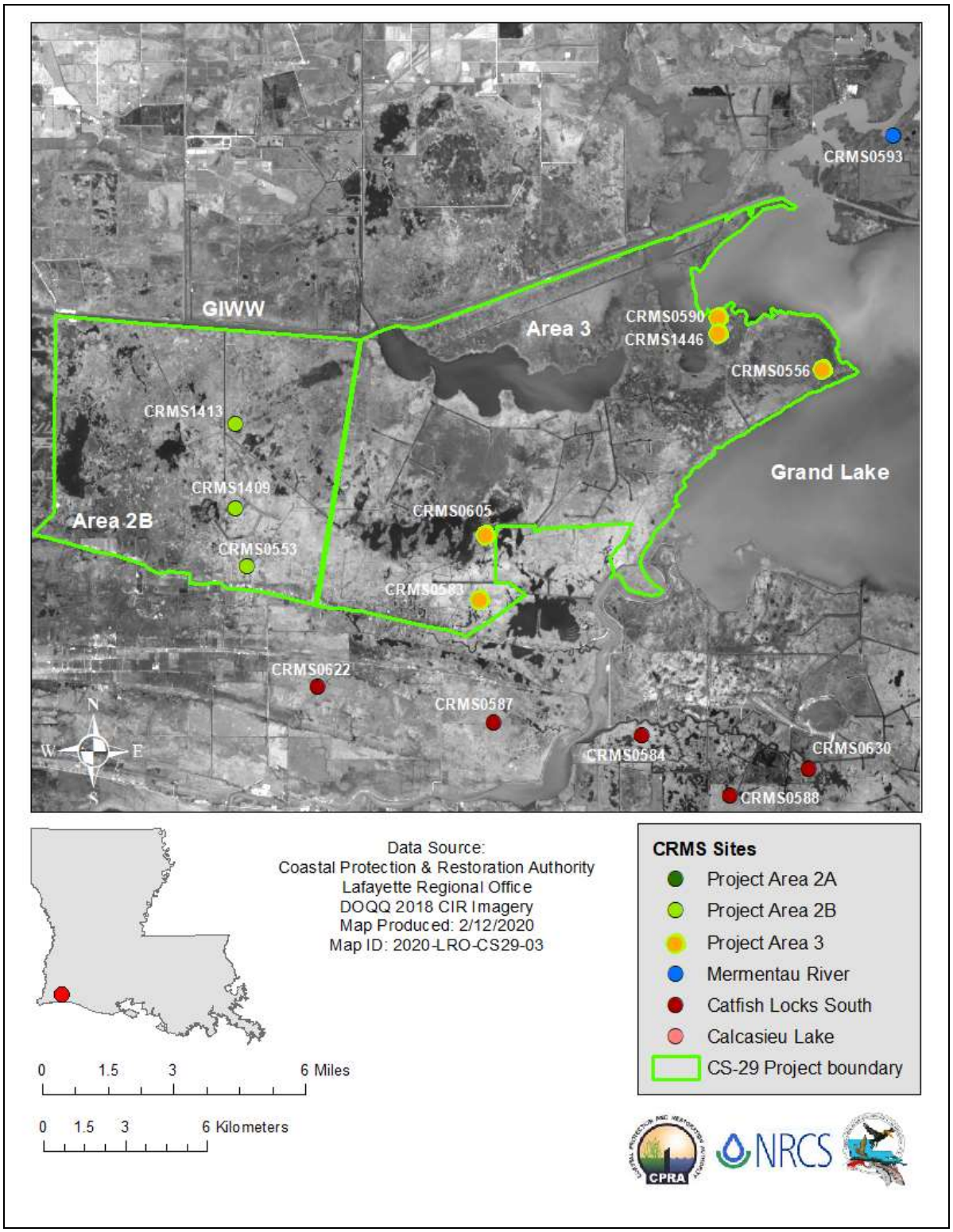


Figure 4. CS-29 sub areas 2B and 3 along with associated CRMS sites located within the project and reference areas. Not all locations have represented CRMS sites in which to display relative information.

IV. Monitoring Activity (continued)

c. Monitoring Results and Discussion

Aerial Photography

The most recent coastal satellite imagery available through CRMS is in 2016 (Couvillion et al 2017). No new aerial photography data is available for interpretation. The previous analysis indicated a slight increase in percent land within the project area while the Mermentau Basin displayed a minimal reduction in land (Figure 5) (Wood and White, 2020).

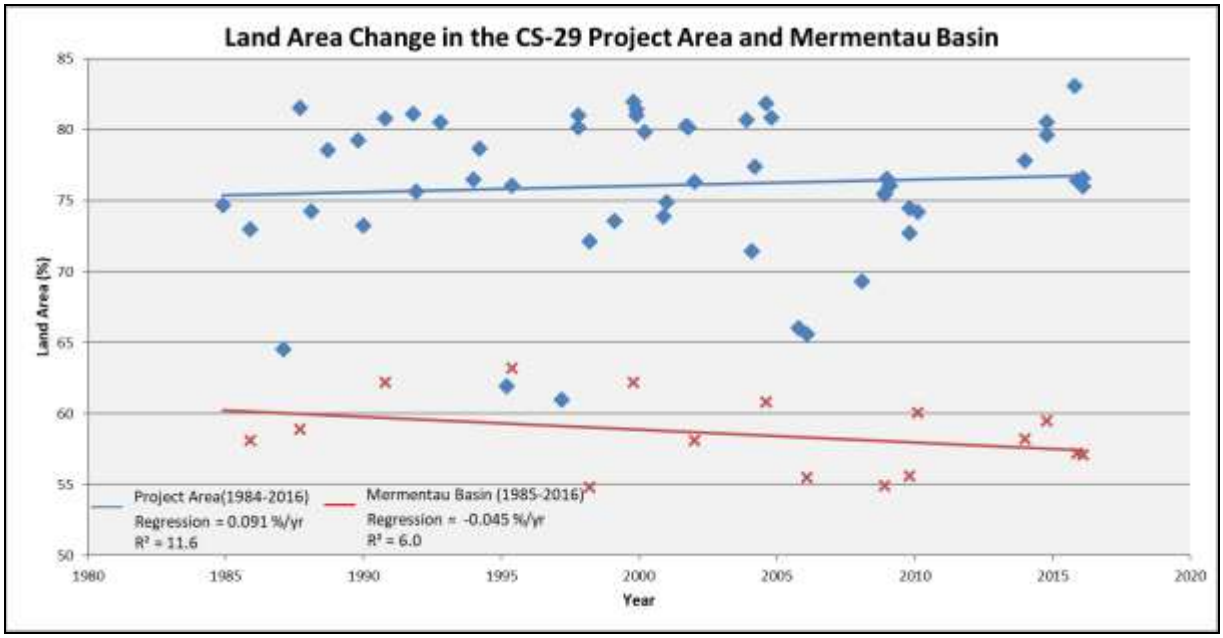


Figure 5. Project and basin scale percent land analysis for years 1985 to 2016 of cloud free Landsat images, CRMS spatial viewer land/water.

Water Level:

The project hydrologic control structure on Black Bayou near Calcasieu Lake separates the Mermentau Lakes wetlands east of the lake from the frequently saline waters of Calcasieu Lake, while allowing for additional gravity drainage under favorable conditions, and when the Calcasieu locks are closed. A consequence of this dependence on gravity drainage is the reduced hydrologic capacity for drainage under heavy upland rainfall conditions and the dependence on external receiving basin water levels for drainage opportunities. The USACE management target, which is consistent with the water elevation management target at the project structure, was to maintain a water level at or above 0.27 feet NAVD 88 GEOID 12A (0.8ft NAVD88 GEOID 99), which is consistent with marsh elevation in the area (Project Operations Plan 1992, LCWCRTF 2002, and Mouledous et al. 2016).

One project goal is to reduce flood duration. The previous project report from 2020 showed that the three project areas along with the Mermentau River reference were routinely flooded more than 80% of the time between 2014 - 2019. The Calcasieu Lake and Catfish Lock references were flooded far less (Wood and White, 2020).

Current data analyses show comparable results in that the project areas and the Mermentau River reference continue to be consistently flooded, on average, greater than 90% of the time, while the Calcasieu Lake and Catfish Locks South reference sites are flooded less frequently (Figure 7). A two way ANOVA on weekly percent inundation from 2014-2022 of the three project areas and three reference locations was performed. The model tested the effects of location and pre or post project construction to isolate and identify the major sources of variability in marsh inundation. The main effects as well as the interaction were significant but location was more influential on inundation than pre or post project and the interaction ($F_{5, 3205} = 408.57$, $p < 0.0001$). This makes sense as marsh elevation along with drainage potential play critical roles in flooding potential. The Calcasieu Lake marshes were flooded significantly less than all other locations (50.0%), with the Catfish locks south locations being intermediary (76.7%).

The pre-post project effect had less of an impact on marsh inundation, yet was still significant. This can be attributed to water level variability in the Gulf of Mexico and regional precipitation cycles affecting this area in unison ($F_{1, 3205} = 12.61$, $p < 0.0001$). Pre project flooding from 2014 – 2016 was less (83.2%) than post project marsh inundation from June 2016 – 2022 (85.9%) across all locations. The interaction of the two main effects of location and pre post project construction, although statistically meaningful ($F_{5, 3205} = 5.79$, $p < 0.0001$), is not a result of project effects. This is indicated by Calcasieu Lake reference increasing in flooding post project (55.7%) compared to pre project (44.3%). Irrespective of marsh elevation, which drives inundation, water levels do show a relationship within the project areas and among the outside reference conditions with proximity to drainage.

Across all years, the Mermentau River reference area and project area 3 have had the highest water levels amongst all locations (Figure 7). Project areas 2A and 2B tracked very closely with water levels at Calcasieu Lake. All areas saw a drop in water levels in years when the region experienced droughts during 2018 and 2022, which prompted closure of the project

structures to maintain water levels and prevent salt water intrusion from Calcasieu Lake. Water levels south of the Catfish Locks were discernably lower than the project locations. This is due to more efficient drainage, a shorter distance to the Gulf of Mexico; lower water volume inputs, as well as being hydrologically managed. Average marsh elevations in the project sub areas are low but in alignment with the rest of the Mermentau lake sub-basin ranging between -0.13 ft to 0.31 ft (NAVD88 GEOID 12A). These elevations are near or below the USACE minimum management water level goal leading to these areas being flooded a larger portion of each year as well as making management goals difficult to accomplish.

On a larger spatial scale, water level data analysis from the 2020 report show the reference sites fluctuating in tandem with one another, especially Calcasieu Lake and the Gulf of Mexico. The Mermentau River is consistently higher than the other two sites, which coincides with it being farther from drainage opportunities and receiving upland waters from south central Louisiana (Wood and White, 2020). This trend continues into 2022 (Figure 8). Rarely do water levels in these areas drop below the target water level of 0.26 ft. The Gulf of Mexico, which is measured by CRMS0600 south of Rockefeller NWR, closely tracks water elevations of Calcasieu Lake. Water elevations only get close to the target water level during winter months and drought conditions. On the project level scale, water elevation is lower in areas that are in closer proximity to the structure. Project areas 2A and 2B, which are closer to the structure, have similar average monthly water levels and both are lower than Project area 3 and the Mermentau River reference (Figure 9). Project area 3 water levels are only marginally lower than the Mermentau River reference and all sites were consistently higher than the target water elevation of 0.26 ft except during drought conditions (Figure 9). These high water elevations in addition to low average marsh elevation, roughly 0.25 ft NAVD 88 GEOID 12A (CPRA CIMS 2022), results in nearly permanent fresh, flooded conditions with flood tolerant vegetation in the project areas.

In 2018 during the drought of spring and summer, both the Black Bayou Culverts and the Calcasieu Locks closed for an extended period in order to maintain fresh conditions and minimum water levels in the Mermentau Lake sub-basin. This occurred again in 2022 while Louisiana experienced severe drought conditions a good portion of the year (Figures 10 and 11). The Calcasieu Locks were closed 84% of the year for an average of 20.8 hours per day. The Black Bayou Culverts closed from 3/10/2022 to 5/5/2022 during the extreme time of drought conditions. Water levels in Project Area 3 dropped below target water level down to -0.5 ft right before the Black Bayou Culvert was closed. Levels then rose above target water level and mostly remained there until dipping below for a short period in May and again in June before rising again. Project Area 2A however, experienced a slower drop and remained above target water level until April but then flat lined around 0.1 ft. Data was limited for the Mermentau River site but what is reflected is above target water level and mostly above 0.5 ft.

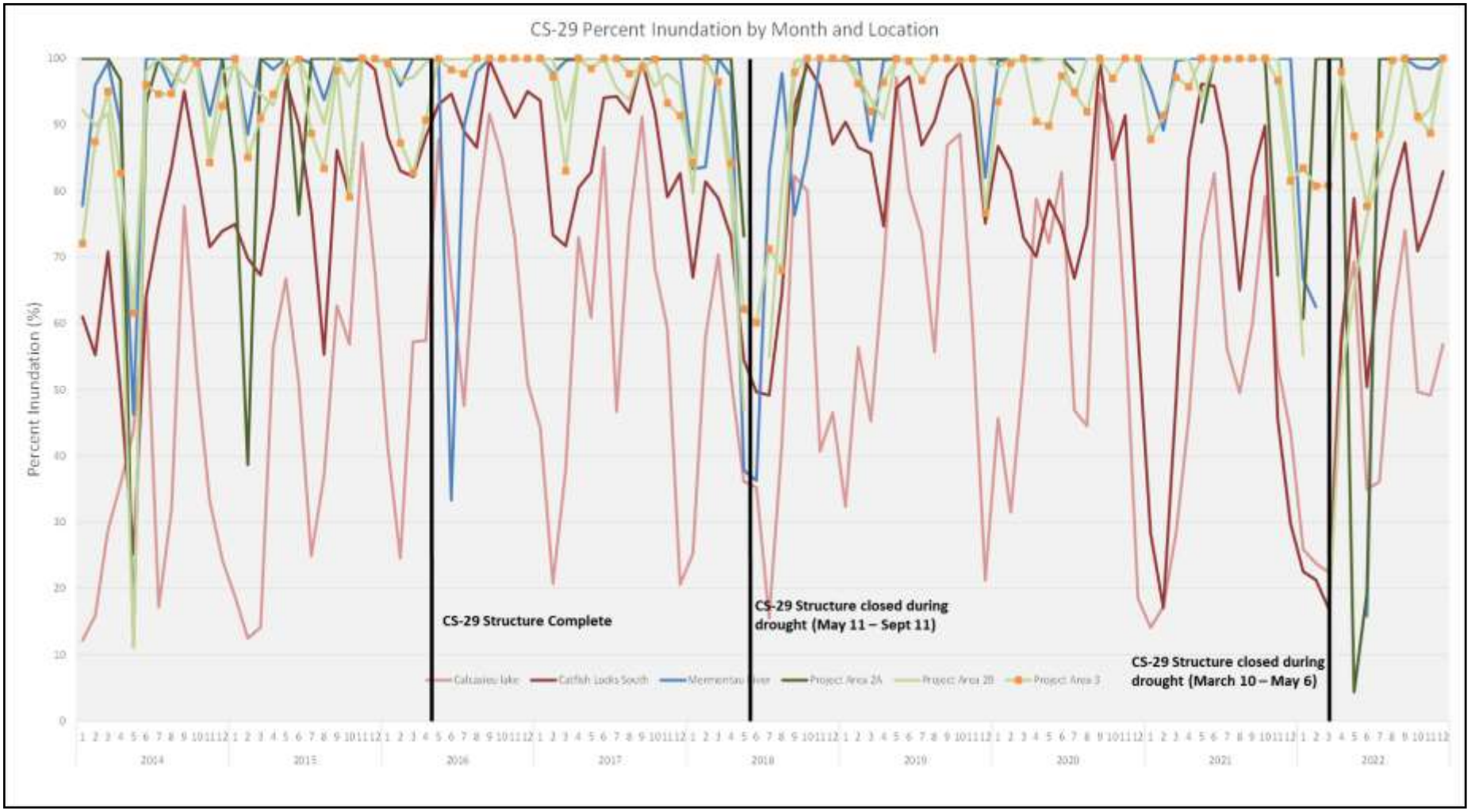


Figure 7. Percent Inundation inside the project subareas and the local reference conditions outside the project area showing near permanent flooded conditions from 2014-2022 in most areas except Calcasieu Lake. At the monthly scale, only Calcasieu Lake and Catfish locks south have water levels routinely below marsh elevation.

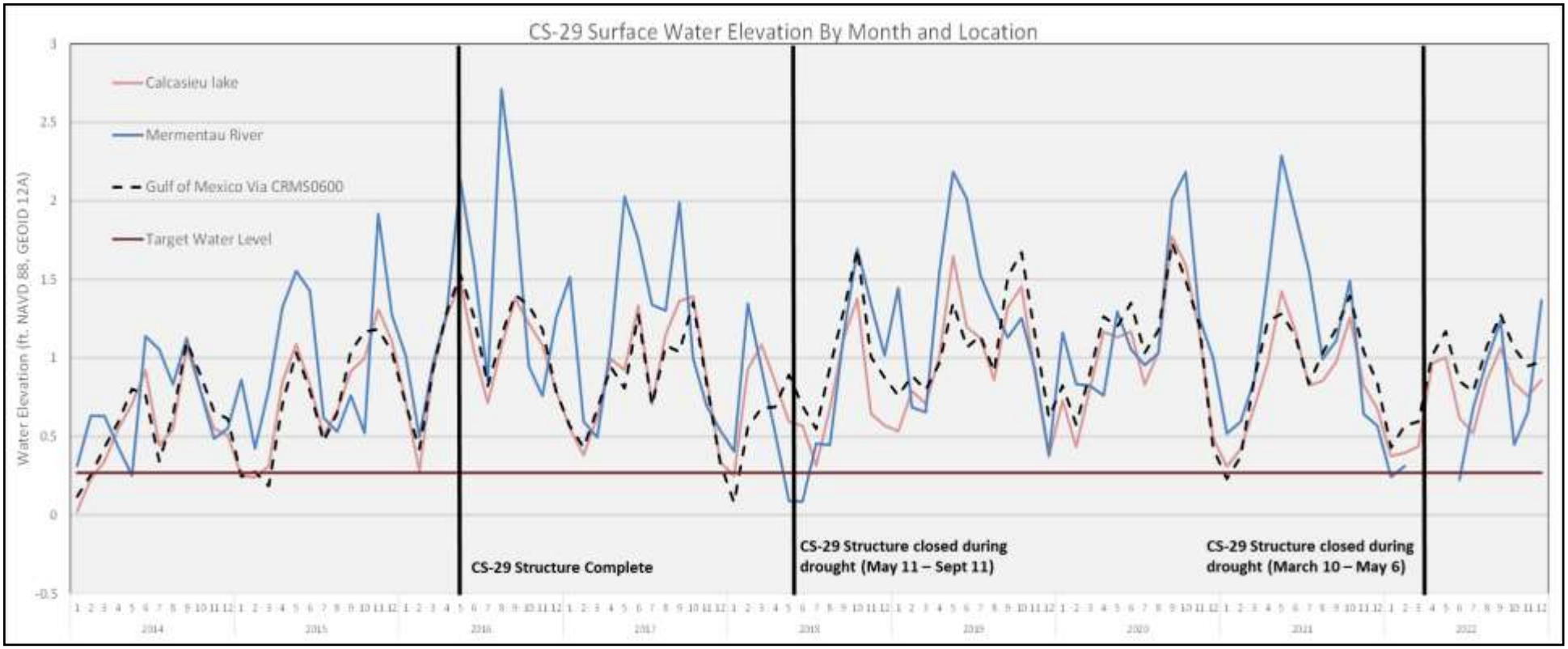


Figure 8. Monthly mean water levels outside the project area in the Mermentau River, Calcasieu Lake, and Gulf of Mexico (CRMS0600). These three locations generally track similarly to one another except during extreme events. The 2016 flooding shows the hydraulic separation of the northern Mermentau Lakes sub-basin and limited drainage as water levels remained elevated for much of the year.

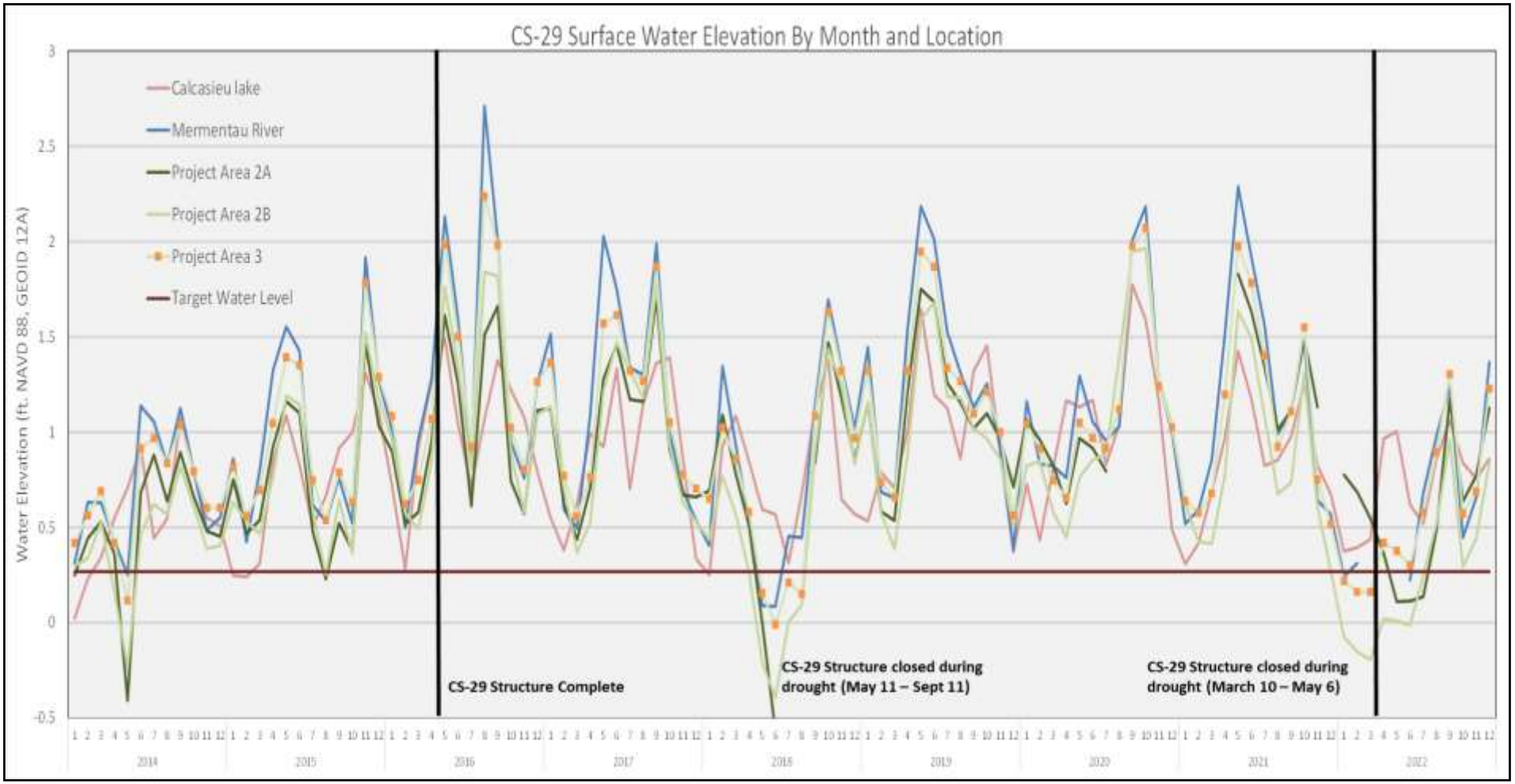


Figure 9. Monthly mean water levels inside and outside the project area in CS-29, the Mermentau River, and Calcasieu Lake. The project sub areas fall into a narrow range between the higher Mermentau River and the lower Calcasieu Lake, striated based on distance from the structure and locks; this relationship only breaks down during drought conditions, with the project area water elevation dropping below Calcasieu Lake.

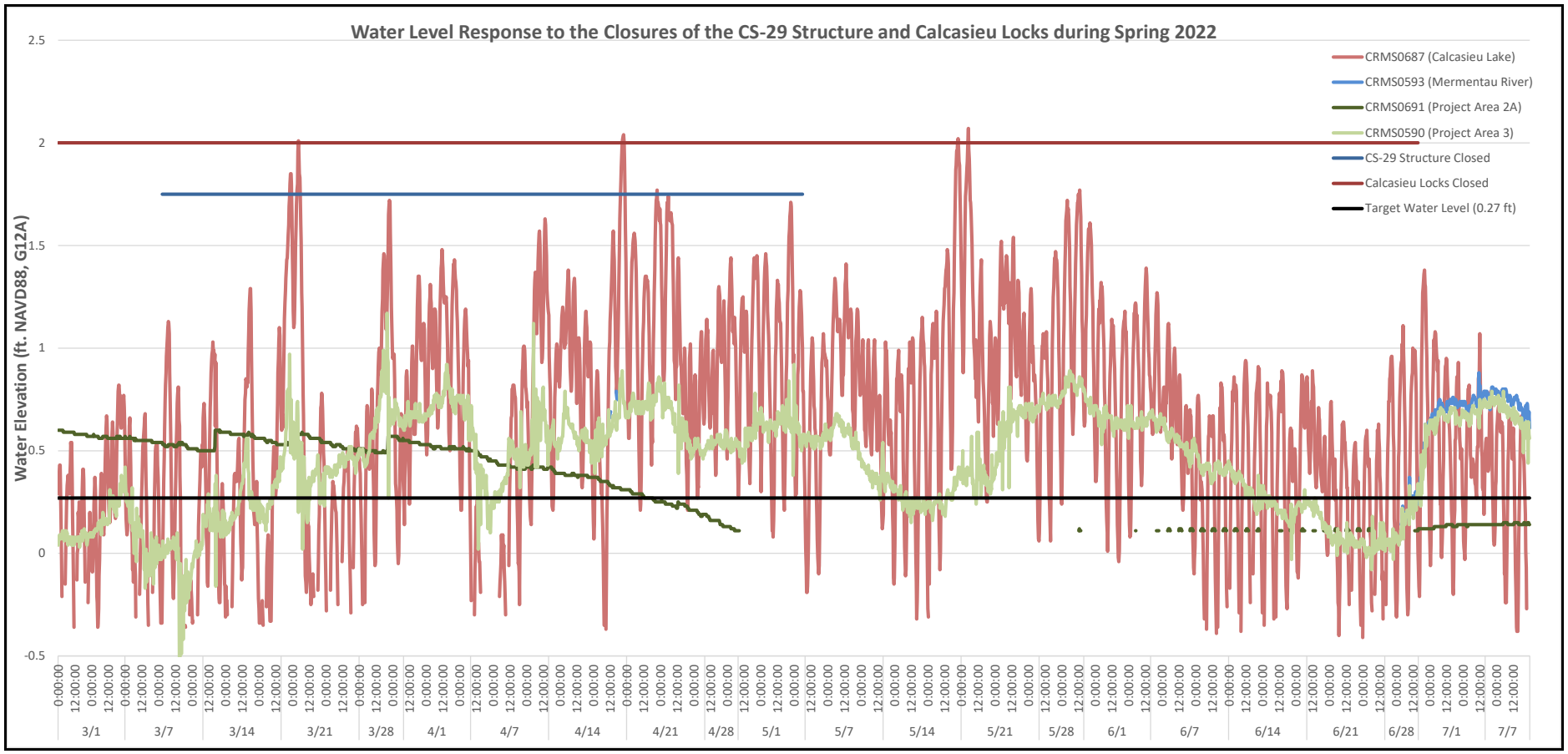


Figure 10. Hourly water levels inside and outside the project area in CS-29, the Mermentau River, and Calcasieu Lake. The drought of 2022 prompted the closure of both the CS-29 structure and the Calcasieu locks for an extended period.

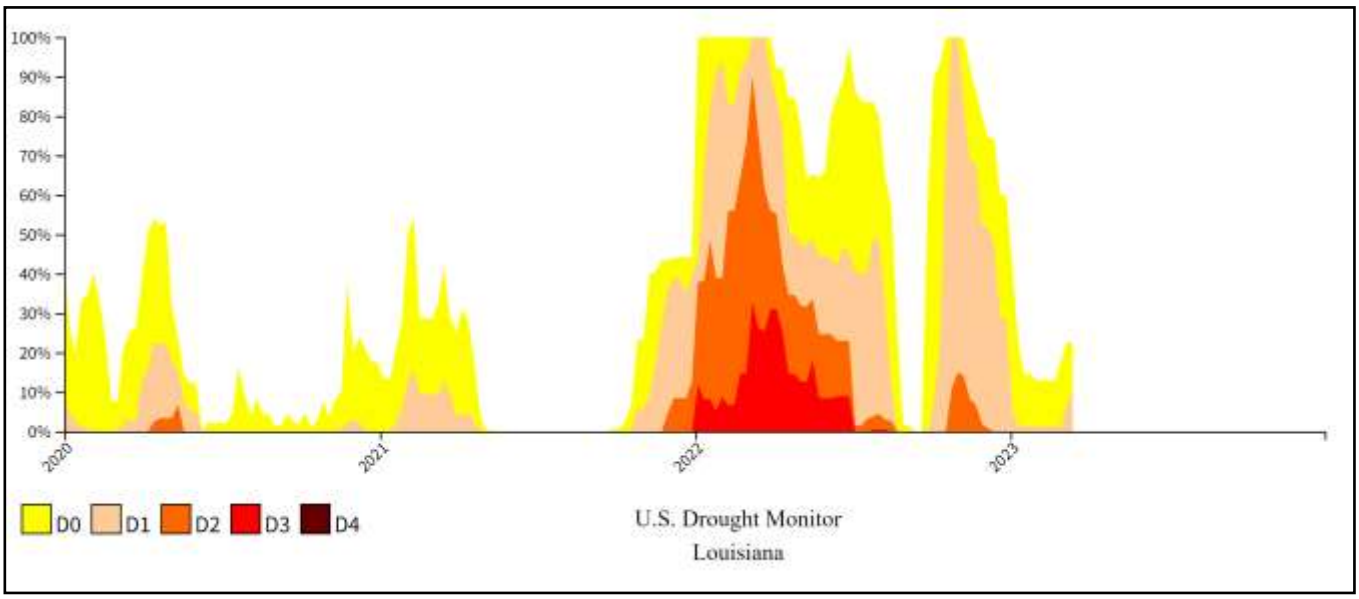


Figure 11. NOAA U.S. Drought Monitor (USDM) data for Louisiana from 2020-2023.

Salinity

There is no specific salinity goal for this project but available data were summarized here. CRMS continuous salinity stations located within the project areas have typically recorded low average annual salinity levels since 2014, under 2 ppt. The exception was during the active hurricane season of 2020, which caused salinity levels to rise slightly to 4 ppt in one of the project areas. Reference area salinities, particularly to the south (Catfish Locks) and to the west (Calcasieu Lake) are higher than the project areas across all years (Figure 12) with salinity in Calcasieu Lake being significantly higher than all other areas at 10 ppt or higher. This is an indicator that the Black Bayou Culverts are effectively maintaining separation between the Mermentau Lakes sub-basin and the Calcasieu Basin.

On a monthly period, project area salinities are still normally low, except in 2018 when salinity in project area 3 rose during drought conditions and in the latter part of 2020 when salinities in several areas spiked due to storm events. Outside of these environmental factors, salinities in the reference areas are consistently higher than those in the project areas (Figure 13). Calcasieu Lake often sees salinity levels upwards of 10 ppt, holding that level for periods of time. These higher levels of salinity are prevented from entering project areas 2A and 2B due to project design and Calcasieu Lock operations. Salinity introduced via the Calcasieu Ship Channel (CSC) is the entry point the Black Bayou Culverts are designed to impede, while still allowing opportunistic drainage. Successfully maintaining salinity separation between the Calcasieu Basin and Mermentau Lakes sub-basin, especially given water elevation relative to marsh elevation in these areas, is crucial for vegetative growth and cover.

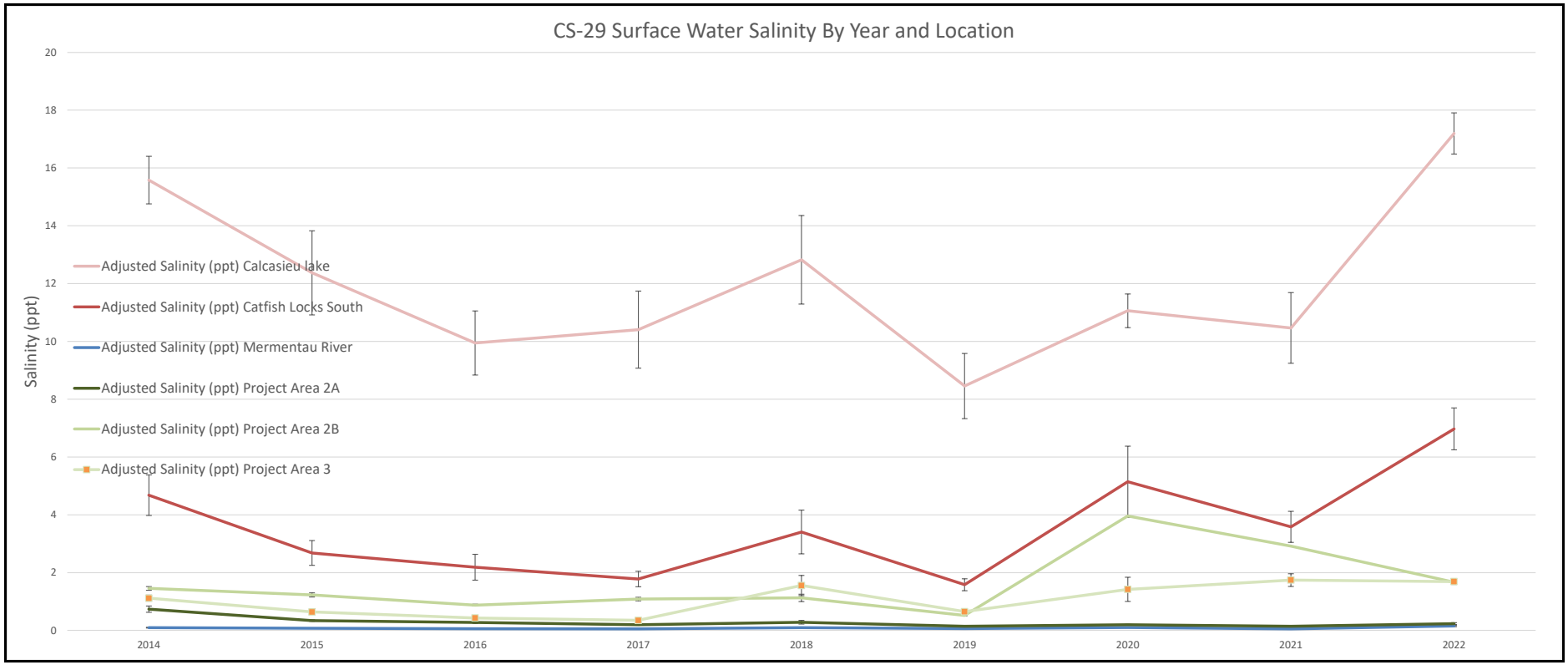


Figure 12. Yearly means and standard errors of surface water salinity collected in the project and reference locations from 2014-2022.

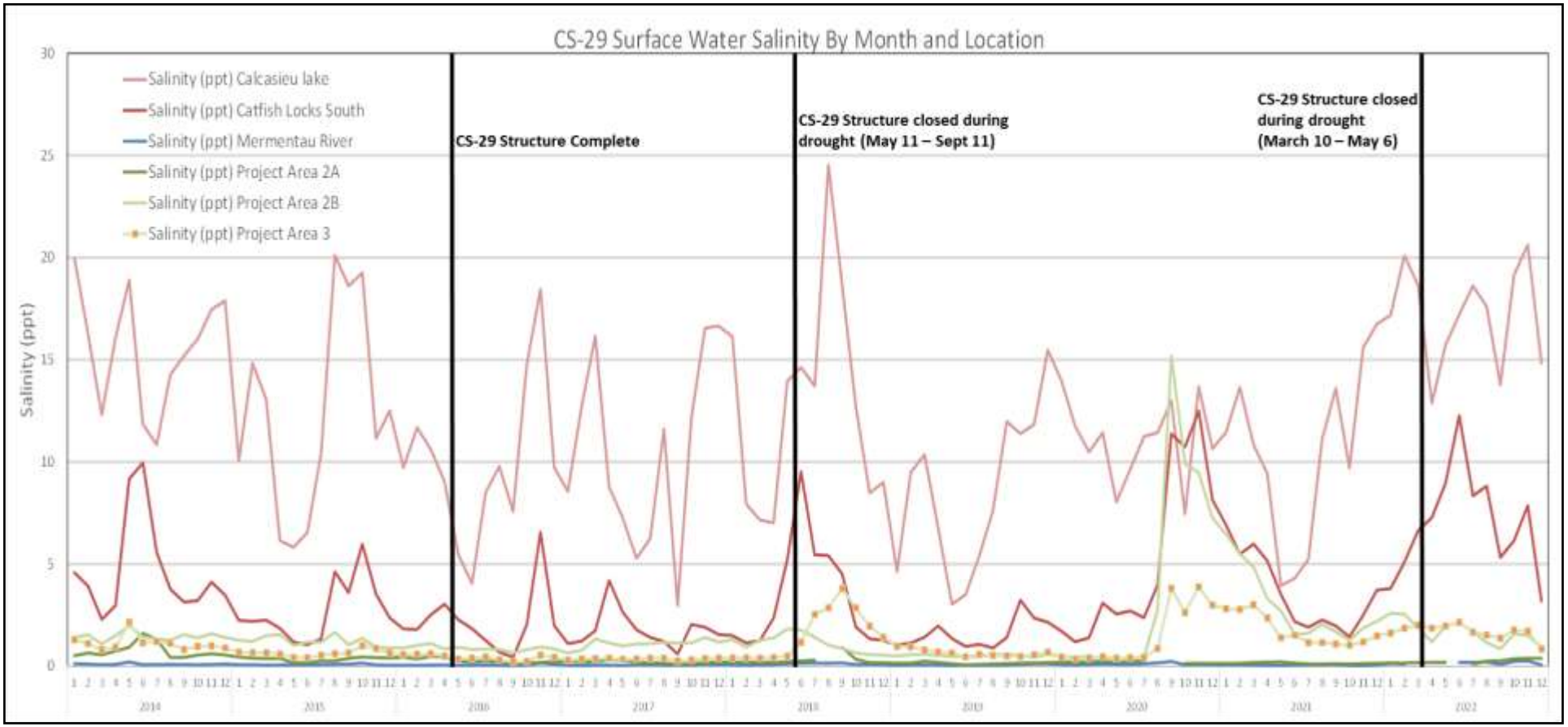


Figure 13. Monthly means of continuous salinity collected at stations in the project areas and reference conditions from 2014-2022.

Vegetation

One project goal was to increase cover, height and richness of emergent vegetation in the project area. Vegetation in the CS-29 project and reference areas are highly influenced by salinity, water level and current marsh elevations. The culverts at Black Bayou and the Calcasieu Locks keep the saline waters of Calcasieu Lake from entering the project area, which lends to distinct vegetation differences but also, high water levels in the receiving basin leads to high water levels and thus flooded conditions a good portion of time in the project area. These environmental factors also affect vegetation parameters measured at CRMS sites in the project and reference areas such as height of species, species richness, percent cover of species and species assemblages.

In addition to large-scale environmental factors affecting vegetation, local-scale factors also influence plant height such as species present, nutrient availability, salinity regimes and flood stress adaptability. Data analysis of plant height collected at CRMS sites within the project and reference areas showed there were no statistical differences in plant height pre (112.3 cm) and post (114.5 cm) project construction across all of the project sub areas based on a two way ANOVA of data collected between 2014-2022 ($F_{1, 141} = 0.195$, $p = 0.6596$). There was an affect regarding location with project area 2A (146.5 cm) which had significantly taller vegetation than the other project locations, area 2B (109.3 cm) and area 3 (114.9 cm), which did not differ from one another ($F_{5, 141} = 7.295$, $p < 0.0001$). These differences are reflective of the aforementioned environmental factors and not solely the project structure. Area 2A is dominated by *Schoenoplectus californicus* (bullwhips) which have a taller growth form than other dominant species. The project areas generally maintain taller vegetation than all the reference areas on an annual basis, irrespective of marsh type (Figure 14).

Factors that affect plant heights also influence species richness and number of species present. Locations with higher salinities tend to have fewer species while locations with lower salinities tend to have a greater number of species. Calcasieu Lake had a significantly lower number of species present, around 4.0, than any of the other areas, averaging below five species during the summer ($F_{5, 141} = 29.5$, $p < 0.0001$), based on a two way ANOVA testing location and project construction from 2014-2022 on species with % cover. Areas that are more flooded with fresh conditions such as the Mermentau River area, exhibited 20.2 distinct species annually on multiple occasions, and the majority of the project areas averaged between 10-15 species during CRMS summer vegetation surveys. Among the project sub areas, based on a two way ANOVA of data collected between 2014-2022 by project area, there was no change in species richness pre (12.1) versus post (12.5) project construction. Project area 2A did have fewer (10.9) species than project areas 2B (14.5) and 3 (14.6) but this was not a significant effect (Figure 15). Temporary changes in species richness can be caused by large-scale disturbances such as droughts and hurricanes and this is reflected in the project area. There was a drastic decrease in species present in project area 2B in 2021 but it rebounded the following year. Favorable species shift as marsh conditions fluctuate over time and species that were once dominant are pushed into niches.

Even though species assemblages change, total cover and sum of species cover remained relatively stable in the project and reference areas. Overall, all locations occupied the same range of total species cover, averaging around 80% annually ($F_{5, 141} = 5.2$, $p = 0.0002$), except

the Mermentau River which was significantly higher at 113.3 % (Figure 16). Higher values are typically found under drought conditions (2010-2012 and 2021); during the beginning of the growing season in fresher locations such as project areas 2A, 2B and 3 as well as the Mermentau River reference area. A two way ANOVA testing location and pre and post project construction was performed and results ($F_{1, 141} = 0.02$, $p = 0.87$) indicated there was not a significant difference of total species cover post construction (87.2%) than pre construction (86.6%) from 2014-2022. This effect is likely driven more by drought than project construction because as ponds dry up, soils become aerobic and species expand and compete for resources. The more established and dominant marsh species are resistant to change and temporary variations in local environmental parameters. As such, these species are conserved through time, though the quantity (%) may fluctuate. There was no differences among the project areas 2A (77.9%), 2B (74.4%), and 3 (82.1%) with regards to total species cover as they all maintain near 80% cover. Though as of the most recent high water events, project area 2B has under gone a minor crash and recovery annually in sum of cover, dropping down to below 50% in 2021.

In fresher, more frequently flooded conditions, such as project Area 2A, the dominant species over the last decade are *Schoenoplectus californicus* (California bulrush), *Zizaniopsis miliacea* (giant cutgrass), and *Sagittaria lancifolia* (bulltongue arrowhead), varying in percent cover as conditions dictate (Figure 17). This species assemblage reveals the area to be very fresh and typically inundated for long periods during the growing season. Project Area 2B shows a slightly less fresh and less flooded species assemblage, along with higher diversity. The area is predominantly composed of *Spartina patens* (saltmeadow cordgrass), *Schoenoplectus californicus* (California bulrush), and a mix of other niche species, depending on flood depth, such as *Echinochloa walteri* (coast cockspur grass) or *Ipomoea sagittata* (saltmarsh morning-glory) (Figure 18). This suggests an intermediate to fresh marsh, with seasonal but variable flood stress. Project area 3 conditions are similar to 2B, with *Spartina patens* as the dominant species present followed by *Sagittaria lancifolia* and *Typha domingensis*. These areas experience similar environmental factors and in response have maintained a more flood tolerant species assemblage over time as the project area has received higher water levels for longer periods of time (Figure 19). This trend is also evident in the reference area of the Mermentau River. Species assemblages over time have transitioned from several species into an assemblage made up of mainly *Zizaniopsis miliacea* (giant cutgrass) and *Polygonum sagittatum*, again showing a more flood adapted species selection (Figure 20). The final two reference locations, Calcasieu Lake and Catfish locks south, are outside the project area's freshwater impoundment and are significantly different due to salinity, water levels, and to a lesser extent tidal fluctuations. The Catfish locks south area continues to be dominated by *Spartina patens* (saltmeadow cordgrass) as it is an intermediate marsh with lower water levels present for much of the year through management practices, proximity to the Gulf of Mexico, and lack of exterior fresh water input (Figure 21). The marshes of the Calcasieu Lake area are brackish with a mix of high salinity tolerant plants that also thrive with tidal movement and intermittent low water levels such as *Spartina alterniflora* (smooth cordgrass), *Juncus roemerianus* (needlegrass rush), and *Spartina patens* (saltmeadow cordgrass) (Figure 22). These species assemblages are indicative of current and recent historic hydrologic conditions in the project and reference areas, displaying the near complete elimination of saline waters entering the Mermentau Lakes sub-basin and the elevated water levels within the sub-basin due to boundary conditions and management practices.

This is visualized by the CRMS Vegetation Volume Index data (VVI) (Wood et al. 2015) (Figure 23). VVI scores are a measurement of the amount of vegetation present, regardless of species. The VVI uses the volume of vegetation present and scales it by marsh type from 0-100. The CRMS reference sites have remained rather consistent with VVI scores ranging between 40 and 60 since 2010. The CRMS project sites, however, show drastic increases in VVI scores post-drought years (2012 and 2019) which leads to the conclusion that extensive colonization and increased covers were results of lower water levels and soil oxidation. That being said, should the project area continue to experience intermittent droughts, the vegetation volume should continue to increase in response. Conceivably, there will be another increase post-drought year of 2022.

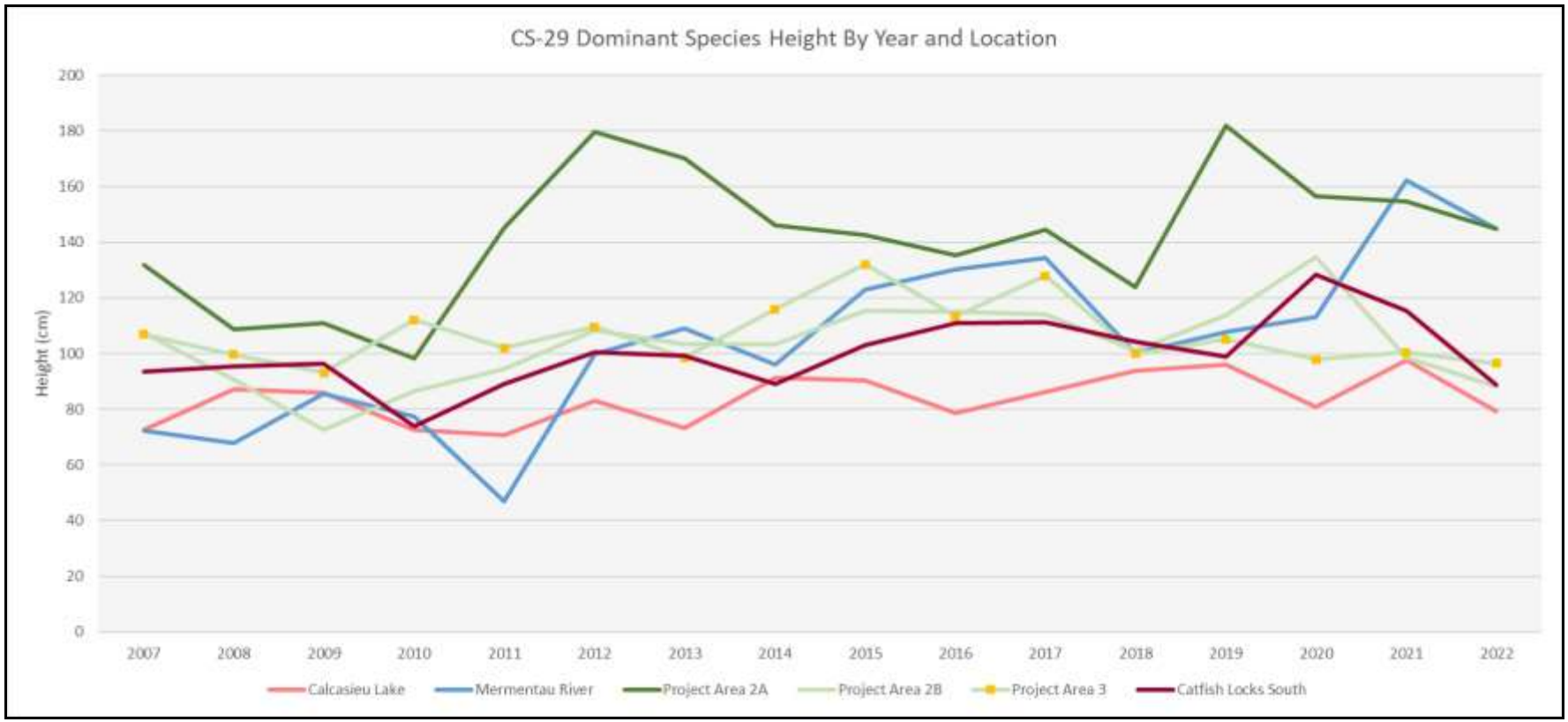


Figure 14. The height of the dominant species in the project sub areas and reference areas from 2006-2022.

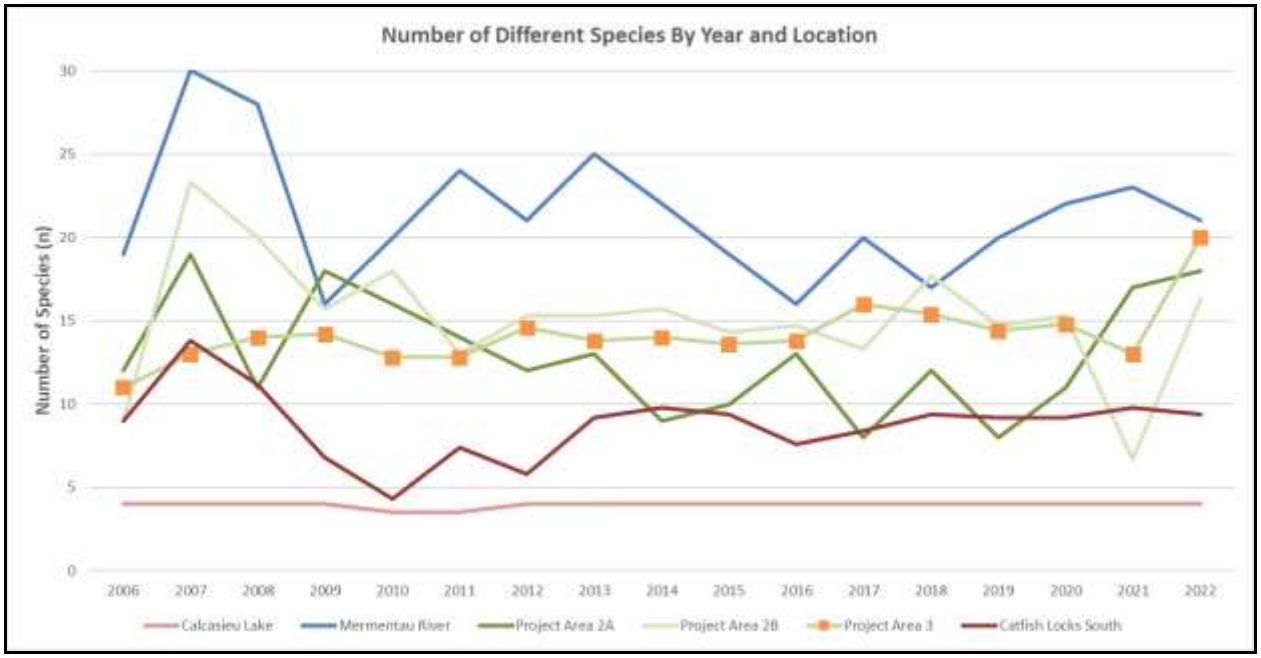


Figure 15. The number of distinct species in the project sub areas and reference areas from 2006-2022. The reference area of the Mermentau River annually contains the most species and the trends generally follow the areas' salinity stratifications, with an increase in salinity leading to a decrease in species.

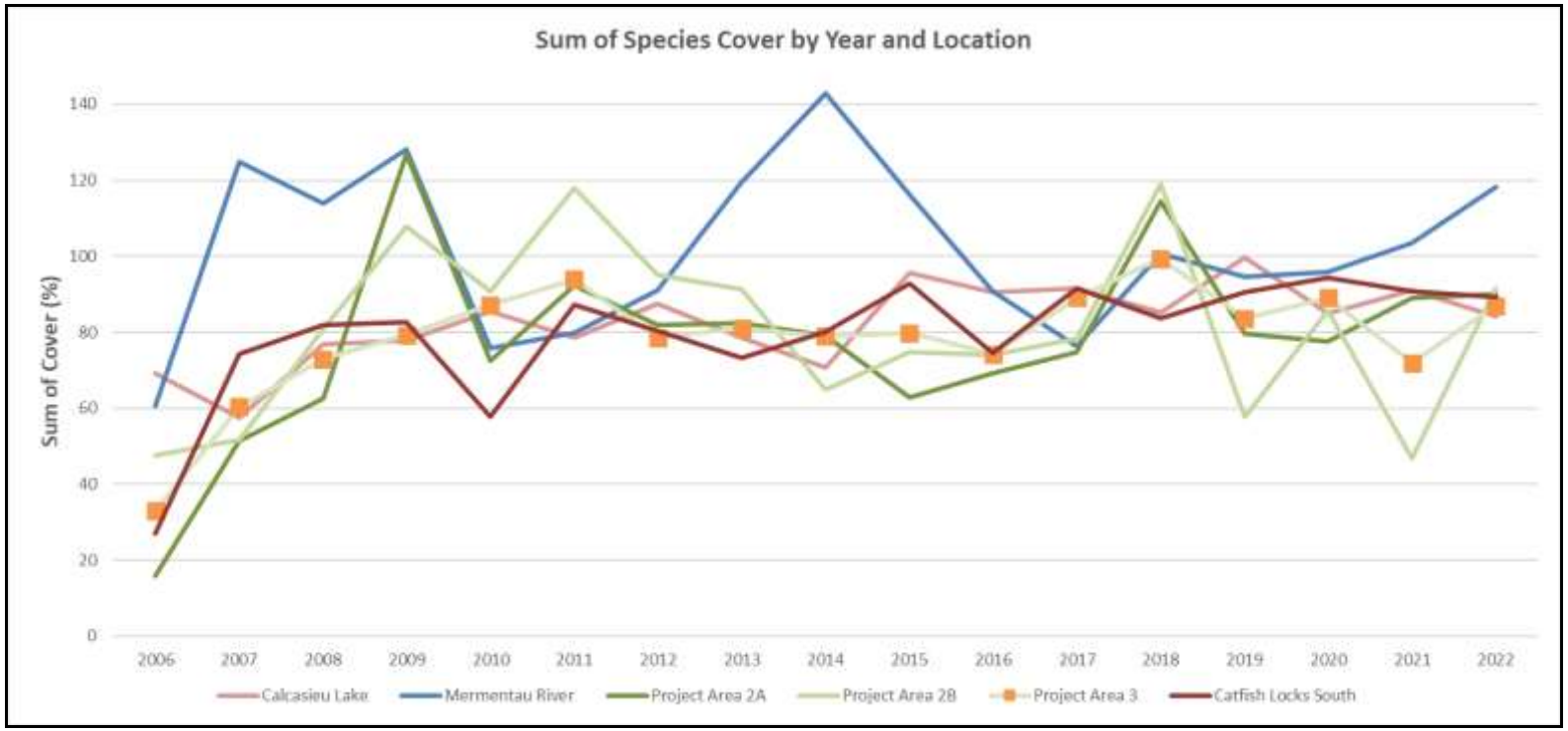


Figure 16. The sum of the individual species percent cover in the project sub areas and reference areas from 2006-2022. Note: Sums are > 100 when plants occupy the same space in layers.

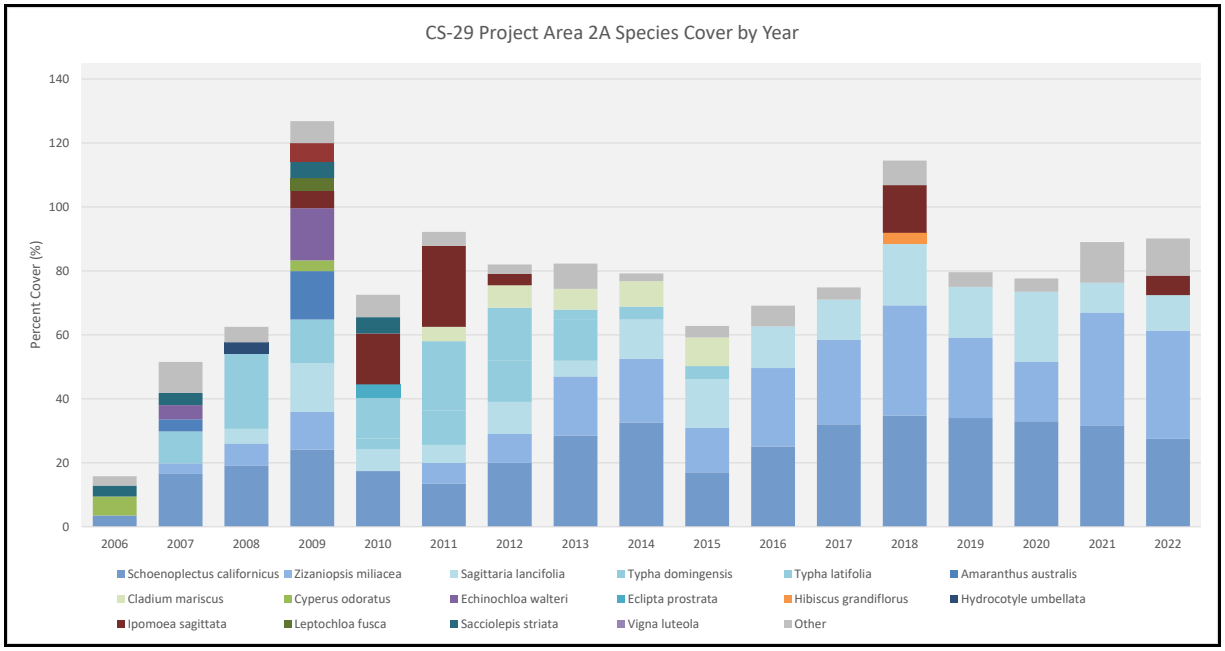


Figure 17. The percent cover of major species in the project Area 2A from 2006-2022, displaying mostly flood tolerant fresh species.

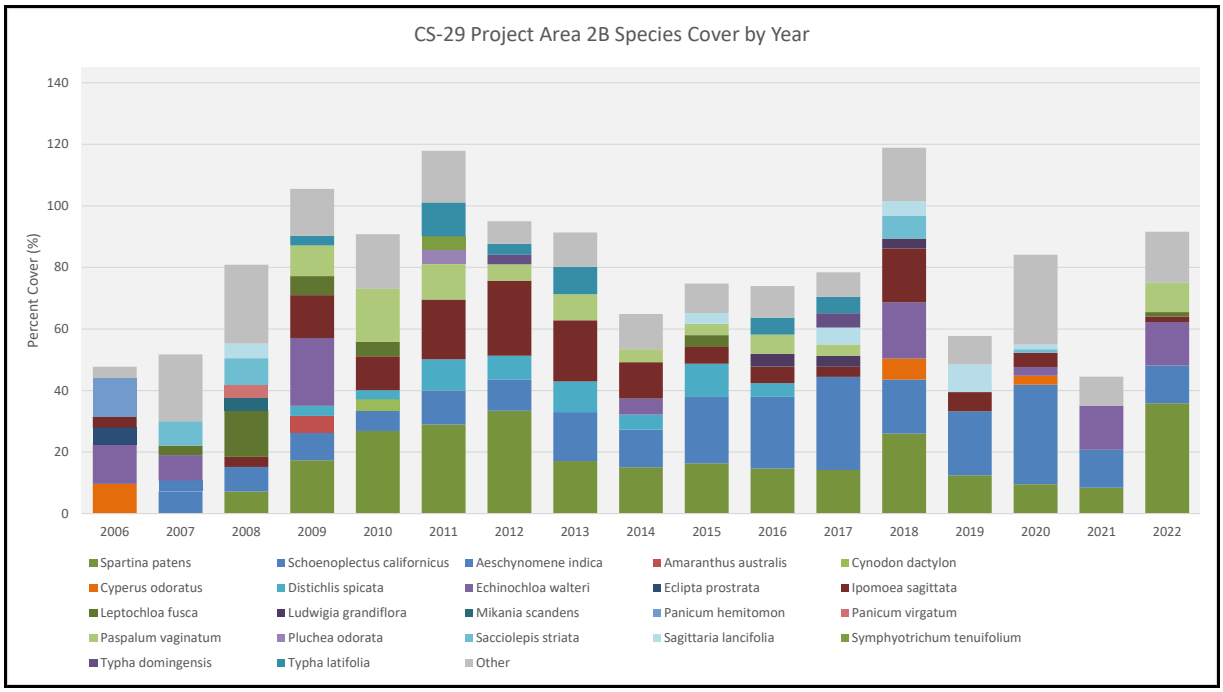


Figure 18. The percent cover of major species in the project Area 2B from 2006-2022, displaying mostly intermediate and flood tolerant species.

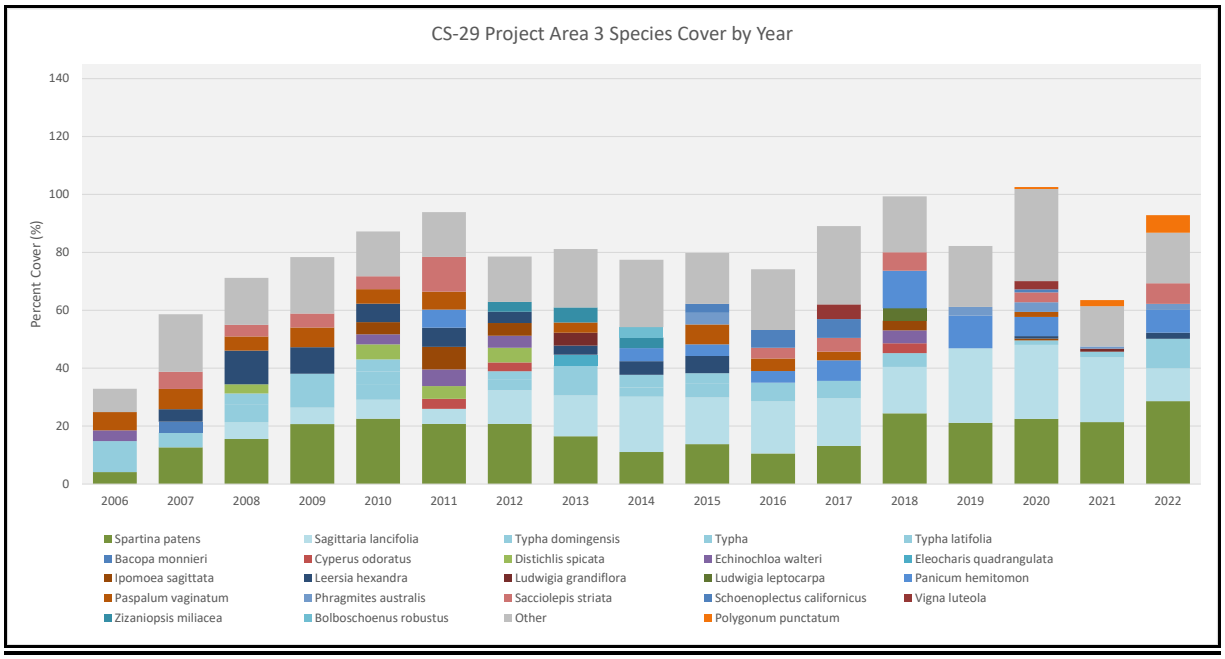


Figure 19. The percent cover of major species in the project Area 3 from 2006-2022, displaying mostly intermediate and flood tolerant species.

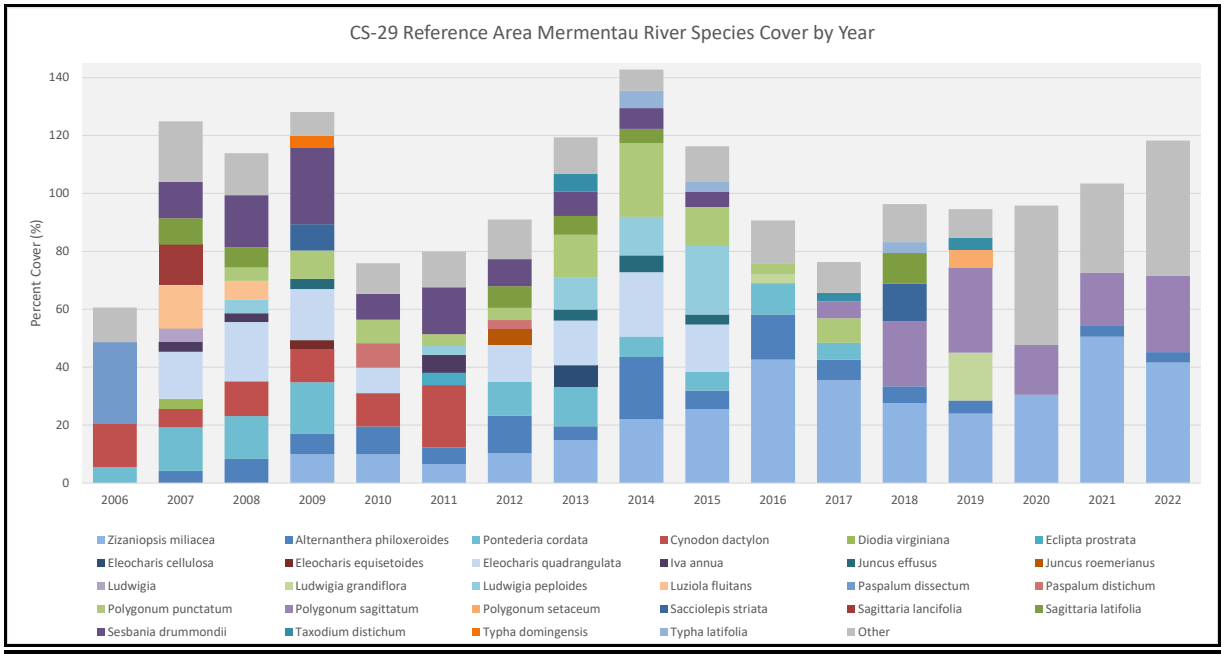


Figure 20. The percent cover of major species in the reference area Mermentau River from 2006-2022, displaying mostly flood tolerant fresh species.

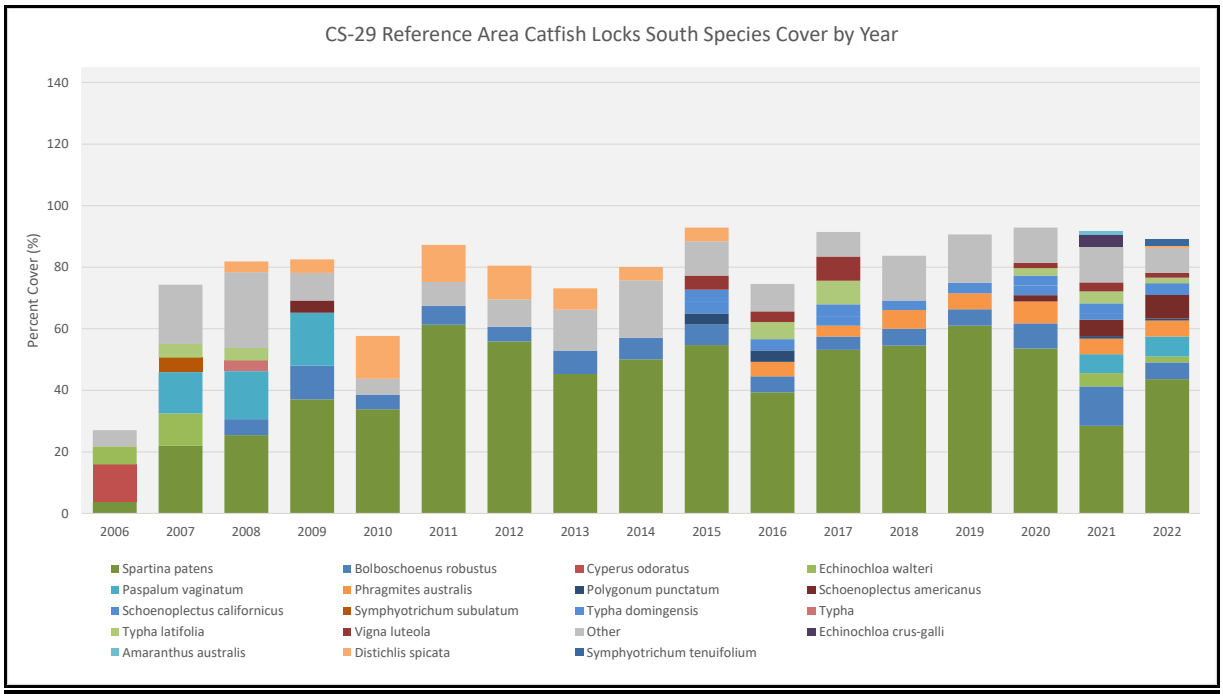


Figure 21. The percent cover of major species in the reference area Catfish locks south from 2006-2022, displaying mostly intermediate species.

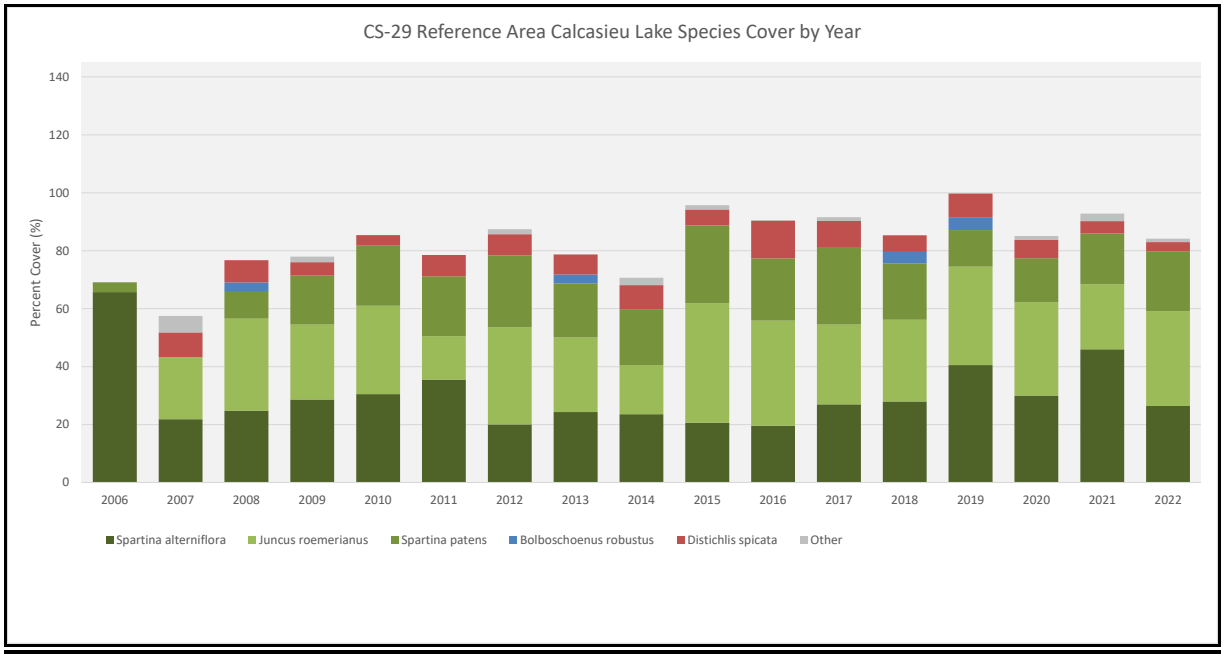


Figure 22. The percent cover of major species in the reference area Calcasieu Lake from 2006-2022, displaying mostly brackish to saline species.

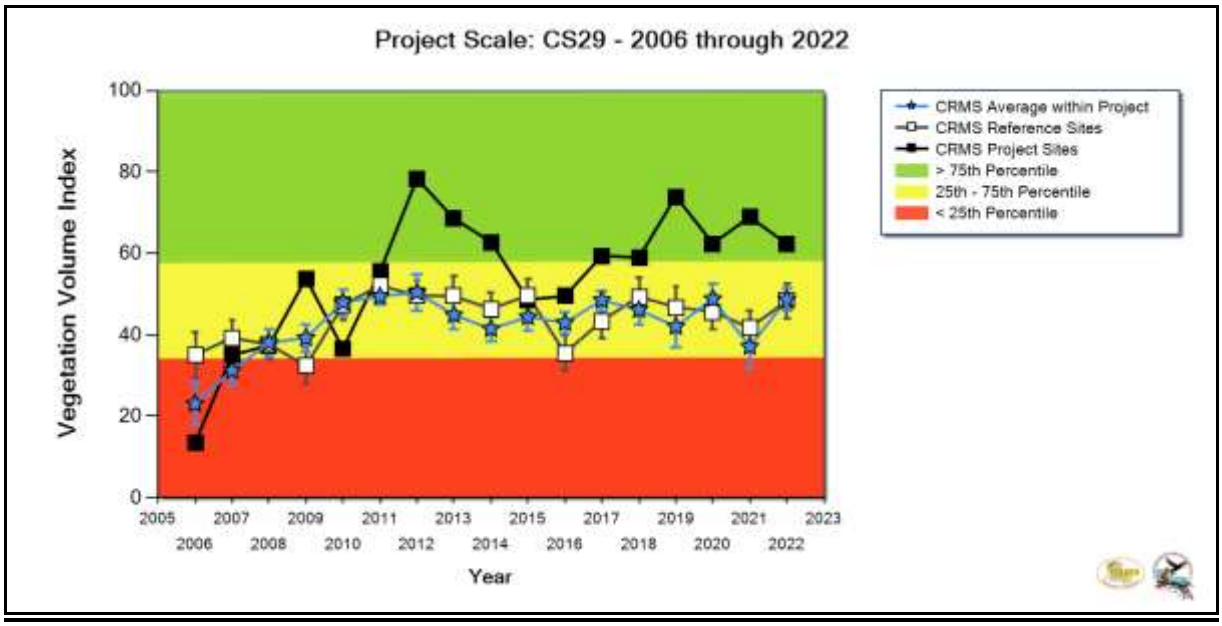


Figure 23. Vegetation volume scores for CRMS sites in the CS-29 project areas through time relative to all other CRMS sites (CWPPRA project and reference) within similar marsh types.

Hydrologic Index

High Hydrologic Index (HI) scores indicate that flooding and salinity conditions are ideal for vegetation growth in a given marsh type. HI scores at CRMS sites within the project area have been comparable to those at CRMS sites outside the project area as well as other CWPPRA project areas in the same basin and marsh type except during 2018 when HI scores at CRMS project sites were higher (Figure 24). This was due to the separation between the Mermentau Lakes sub-basin and the Calcasieu basin as provided by the Calcasieu Locks and the CS-29 project structure during a growing season drought that allowed fresh water in the project area to drain below marsh elevation. HI values in the project area then decreased in 2019 to values similar to those before the drought of 2018 and have remained relatively stable through 2020. The project was not fully operational until mid-2016. Therefore, previous large differences during the extreme drought of 2011 were not related to project features, but to the hydrologic management of the Mermentau Lakes sub-basin as a whole.

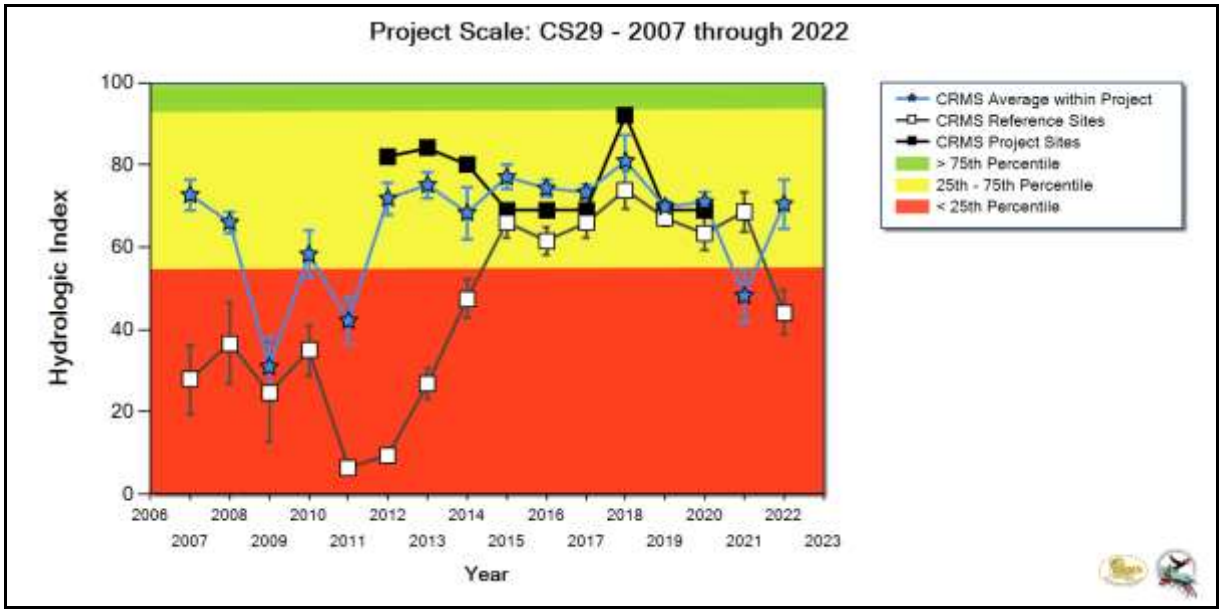


Figure 24. Hydrologic Index scores for CRMS sites in the CS-29 project areas through time relative to all other CRMS sites (CWPPRA project and reference) within similar marsh types. These sites are either fresh or intermediate and are indexed by marsh type before a project average HI is calculated.

Soils

Soil cores were collected during CRMS station establishment in 2005-2007 and again in 2018. No further cores were collected. Physical soil properties were analyzed from three 24 cm deep soil cores collected from each site in the three sub-areas inside the project area and three reference locations outside of the project area. Data analyses from these collections show that soil properties differ between managed and unmanaged locations but the project areas were similar in bulk density values and soils in the reference locations were much more dense (Wood et al, 2020) (Figure 25).

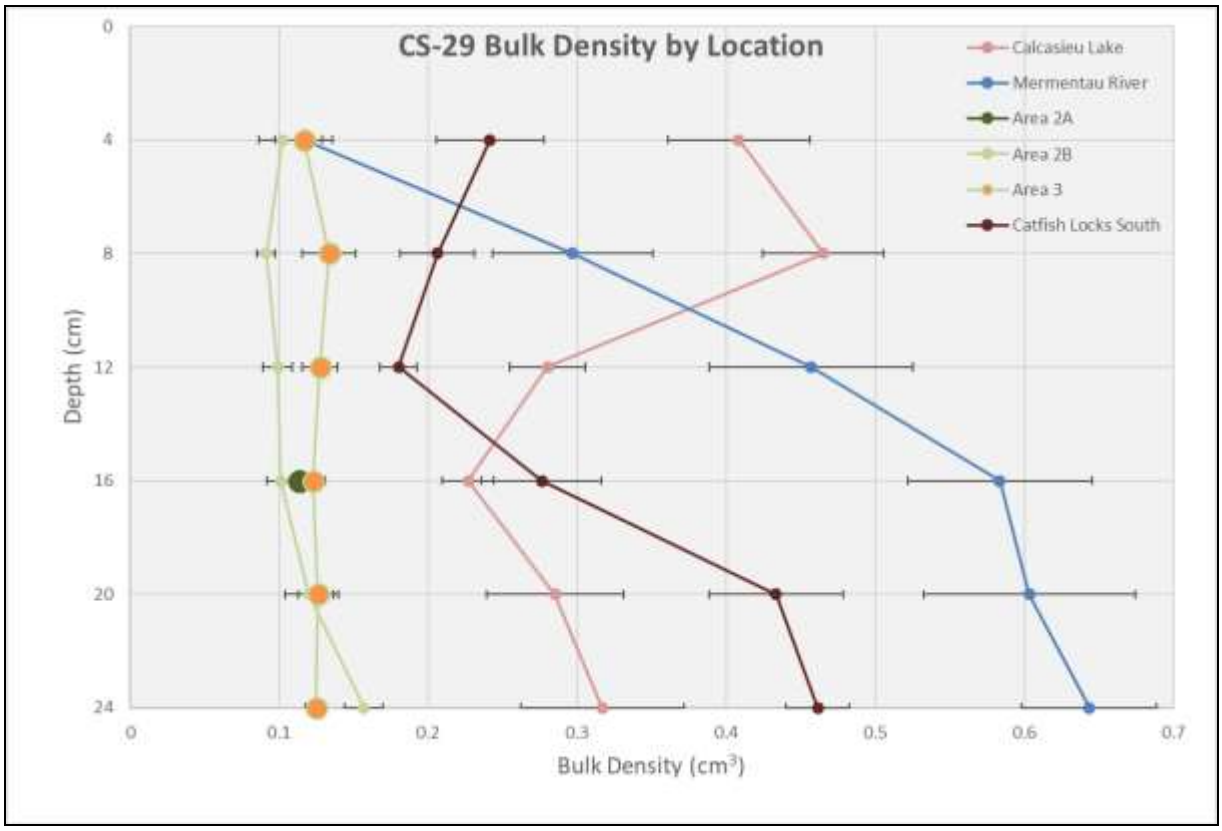


Figure 25. Soil bulk density collected at CRMS sites in the project and reference areas. Note project Area 2A only has data for the 12-16 cm depth profile, which is an average for the entire depth profile.

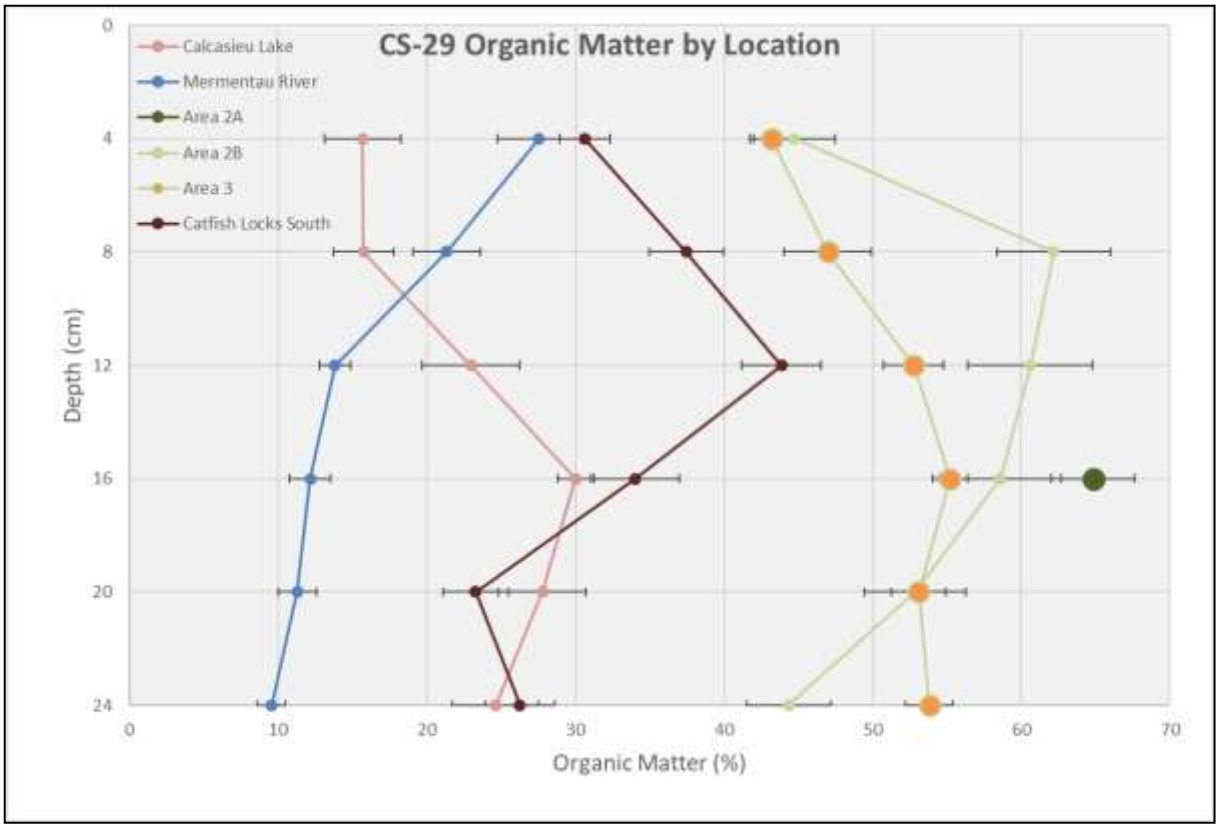


Figure 26. Soil percent organic matter collected at CRMS sites in the project and reference areas. Note project Area 2A only has data for the 12-16 cm depth profile, which is an average for the entire depth profile.

Elevation Change

Current elevation change data compiled from CRMS showed an overall increase in elevation across most CRMS sites associated with the CS-29 project and reference areas, ranging from +0.95 to -0.1 cm/yr (Figure 27). All sites except for two in Project Area 3 remained below the Galveston NOAA tide gauge sea level rise estimate of 0.663 cm/yr. Soils in Project area 3 are more organic perhaps allowing for greater expansion during periods of extended flooding. On a broader scale, between 2006 and 2022, there has been an upward trend in elevation at most of the project and reference areas, except the Mermentau River despite prolonged inundation, storms, and most recently, drought conditions. Project areas 2A and 2B declined in elevation until 2017 but are now at elevations similar to when the project began (Figure 28). These elevation gains may be attributed to soil expansion during flooded periods followed by belowground production during dry periods, which has taken place several times since 2018. However, CRMS593, which is representative of the Mermentau River may have received a large sediment deposition during the 2016 flood and has since been compacting thus expressing a decrease in elevation post flood. Overall, the project area has experienced elevation gain, though not enough to offset sea level rise and as the organic soils stretch and expand mechanical damage becomes more probable from land-falling tropical systems.

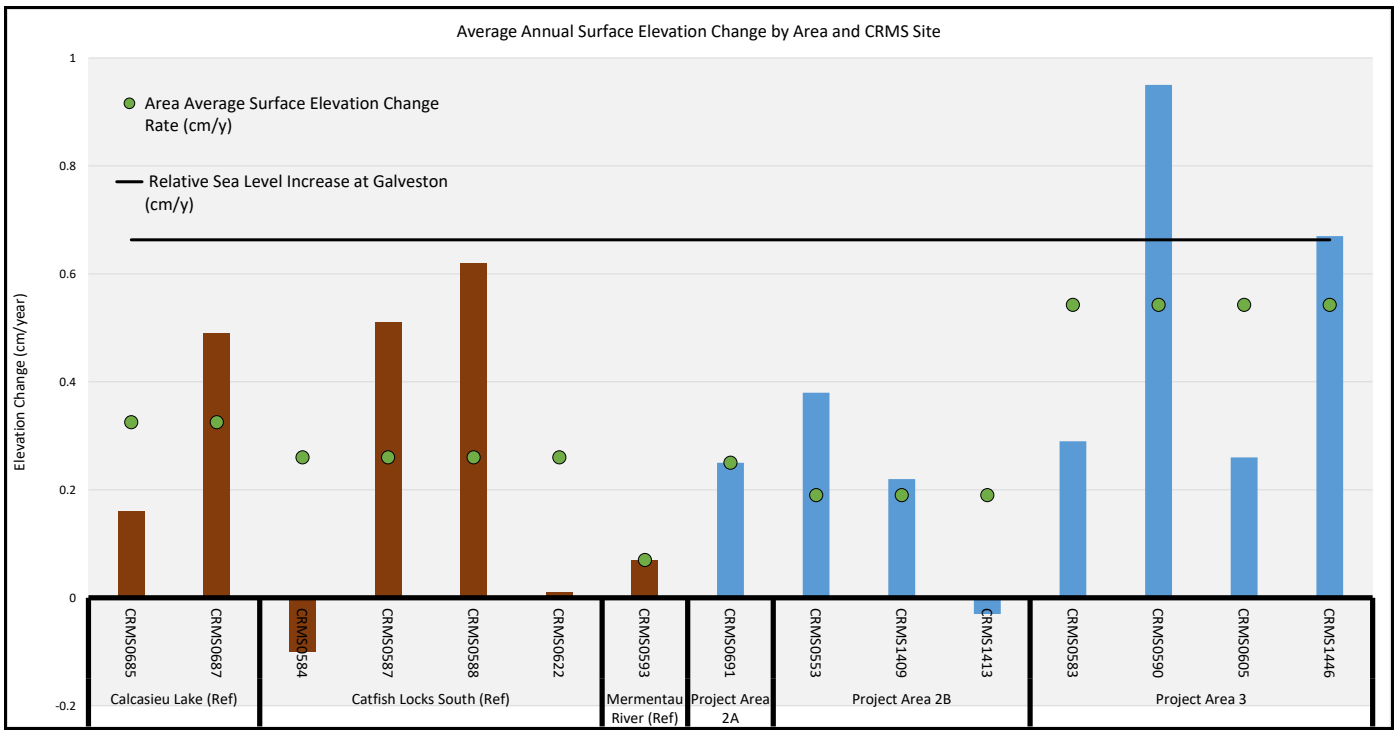


Figure 27. Elevation change per year experienced in the project CRMS sites and reference condition CRMS sites, along with sea level rise rates from Galveston, TX. Catfish Locks South (CRMS0622) is almost directly on the axis at 0.01 cm per year long term average.

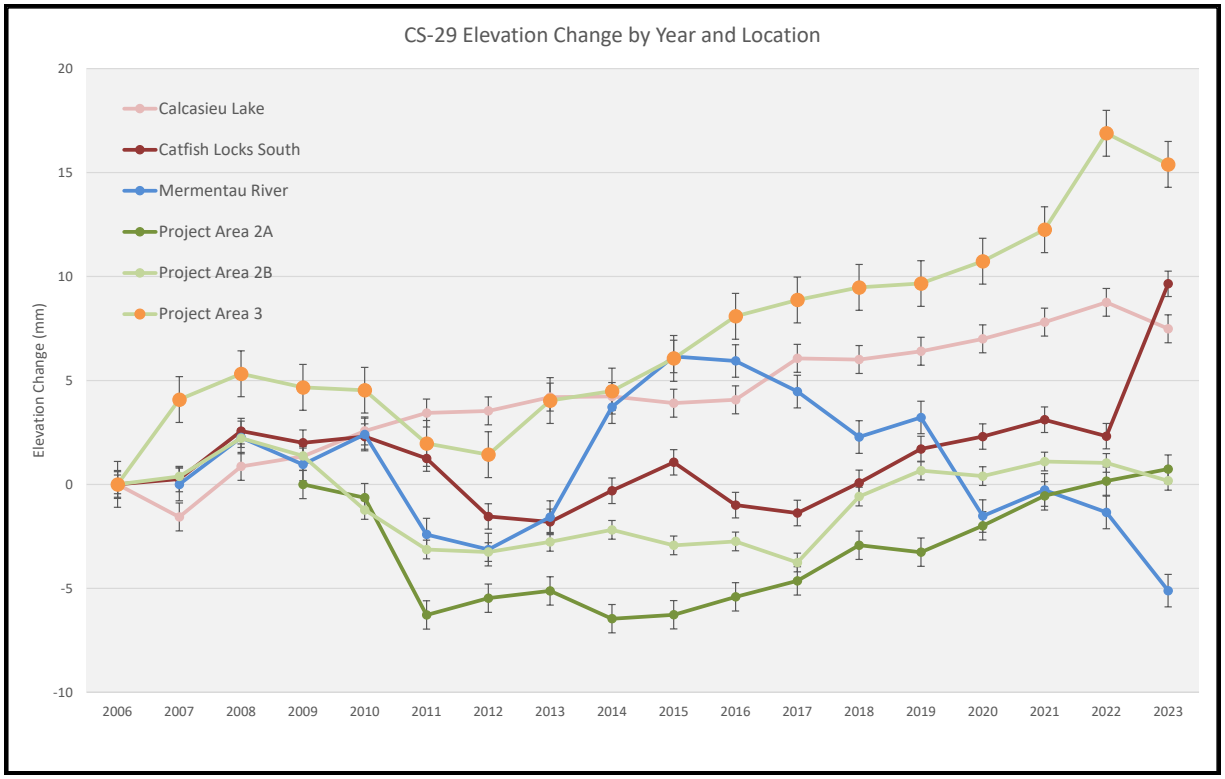


Figure 28. Elevation change from 2006-2022, experienced at project area CRMS sites in CS-29 project area and in reference locations.

V. Discussion

a. General Discussion

Hydrology of the CS-29 project area is largely influenced by outside environmental forces. However, the Black Bayou culverts, along with the Calcasieu Locks, aid in diminishing salinity intrusion and tidal amplitude in the project area. While the project areas and the Mermentau River reference areas continue to be consistently flooded, those project areas closer in proximity to the culverts do experience reduced water levels. During times of drought, all project and reference areas see a drop in water elevation. This leads to expansion of vegetation into previously un-vegetated areas, which in turn has helped to keep the land mass in the project area relatively stable over time. The CS-29 project areas have a wide array of plant species but are mainly comprised of *Zizaniopsis miliacea* (giant cutgrass), *Schoenoplectus californicus* (California bulrush), and *Spartina patens* (saltmeadow cordgrass), typical species found in fresh marshes along the Louisiana coastline.

Over the last 17 years, the project area has seen an overall increase in elevation of 23.19 mm. Organic soils that are low in bulk density allow for flexibility as water levels change, especially during times of drought and times of high water. The project structure in conjunction with the Calcasieu Locks help to maintain these freshwater marshes while also aiding in drainage opportunities should conditions allow.

VI. Conclusions

a. Project Effectiveness

The CS-29 project goals were to reduce flood duration and increase vegetation. Flood duration has increased due to sea level rise and vegetation has remained about the same. The CS-29 project has successfully provided drainage opportunities for the Mermentau Lakes sub-basin without allowing saltwater intrusion. Areas in closer proximity to the structures do experience higher drainage potential. The project areas continue to support freshwater vegetation and high species diversity.

Over the life of the project, which has experienced many episodic environmental events as well as a prolonged drought, the emergent marsh has remained in stable condition. These marshes have been able to adapt to fluctuations in water level as well as continuous inundation.

Sea level rise of the Gulf of Mexico in addition to rising water levels in Calcasieu Lake are cause for concern because as these rise the potential for gravity drainage through the Black Bayou Culverts and Calcasieu Locks is reduced. Maintaining the structures is critical in order to remove excess water from not only the project area but the larger Mermentau Lakes sub-basin as well.

b. Recommended Improvements

The CS-29 project area is large and bounded by the immense impoundment of the Mermentau Lakes sub-basin. The project area can drain excess water from local marshes via the project structure but there is considerable freshwater available to replenish the dewatered wetlands. For this reason, coordination with the USACE and its management plan and objectives are a key concern for project success and has been the management practice of the LRO of CPRA.

Timely and continued maintenance of the Black Bayou Culverts is critical for future project success but also as a backup structure to the Calcasieu Locks. Should the locks ever fail or become damaged, the Black Bayou Culverts are the only westerly drainage point for the Mermentau Lakes sub-basin. Maintenance should extend to the channels that feed the structure from the GIWW, making sure they are of adequate depth and width to maximize the function of a structure of this size. Bathymetric surveys would be very beneficial in this regard.

With sea level rise being of great concern, future hydrologic modeling and installation of supplementary drainage avenues will be essential to this area.

The location of the structure lends it vulnerable to vandalism. Various materials have been used to prop open the flapgates to allow water movement in turn damaging the gate hinges and locking rings. Alternative measures may be warranted.

c. Lessons Learned

Previous armoring of the structure by adding sheetpile cutoff walls to each side has continued to be effective at preventing the structure from being breached and replacement of the original nuts with locking nuts that have a Teflon insert have kept the Black Bayou structure in working order to present date.

The CS-29 structure has been successful in allowing for additional drainage from the project area when conditions are favorable as well as inhibiting salt water from flowing into the project area.

VII. Literature Cited

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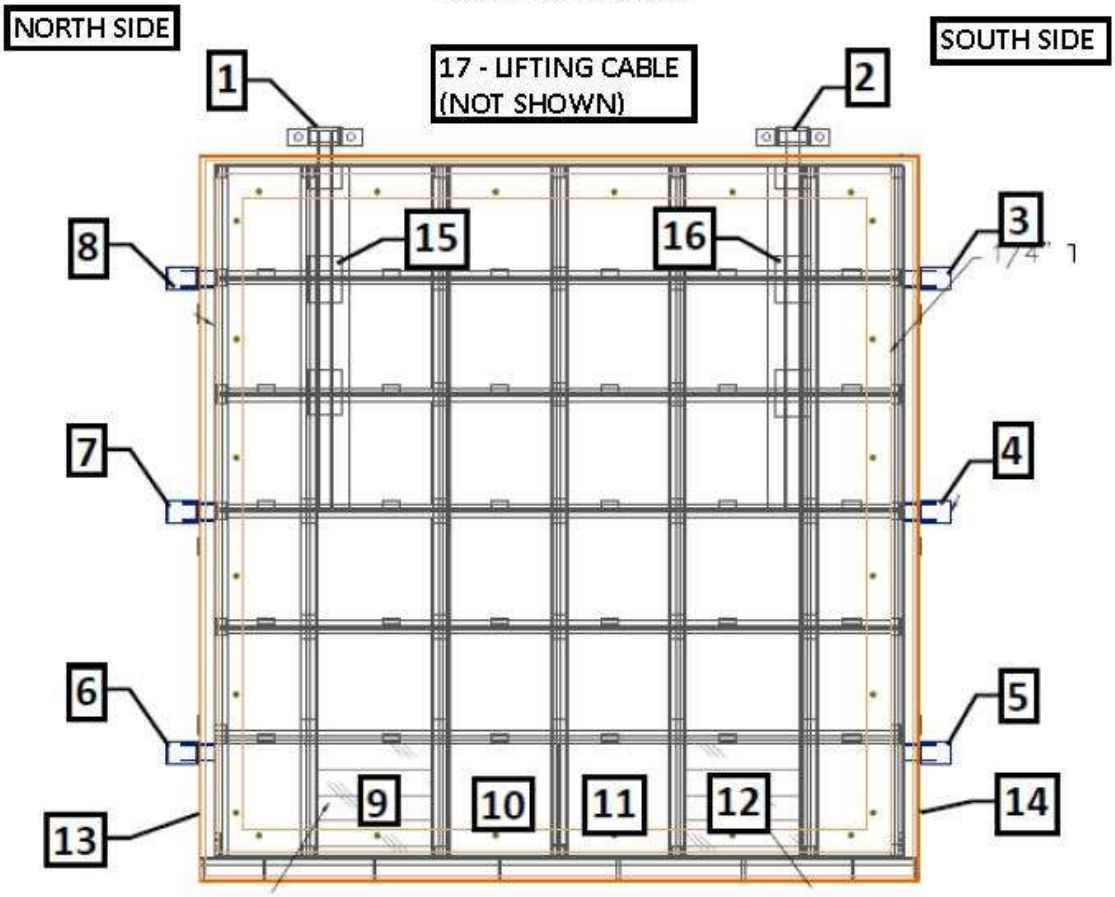
APPENDIX A
(Field Inspection Notes and Photographs)

CS-0029 BLACK BAYOU CULVERTS HYDROLOGIC RESTORATION
TYPICAL FLAPGATE AND FRAME INSTALLATION DIAGRAM
CHECKLIST FEATURES TO NOTE FOR O&M FIELD INSPECTION
November 29, 2022



ELEVATION VIEW

EXISTING FLAP GATE (TYPICAL)

GATE NO. 1

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 1

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)		X	3/4 of this ring is mising
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all but one locking ring on the gate intact, barring issues with the rings on the receiver gate frame, there should be no problems locking the gate in the closed position. In March of this year, this gate was locked in the closed position with no issues.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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1a. Gate No. 1 – North side of Gate

1b. Gate No. 1 – Damaged Locking Ring, Feature No. 7 - North side of Gate

1c. Gate No. 1 – Lifting eye, shackle and cable - North side of Gate

1d. Gate No. 1 – South side of Gate

1e. Gate No. 1 – Lifting eye, shackle and cable - South side of Gate

1f. Gate No. 1 – Lifting eyes, shackle and cables- from South side of Gate

GATE NO. 2

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 2

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all the locking rings on the gate intact, barring issues with the rings on the receiving gate frame, there should be no issues locking this gate in the closed position. In March of this year, this gate was locked in the closed position with no issues.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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2a. Gate No. 2 – North side of Gate

2b. Gate No. 2 – Lifting eye, shackle and cable - North side of Gate

2c. Gate No. 2 – Gate Hinge at Headwall - North side of Gate

2d. Gate 2 – South side of Gate

2e. Gate No. 2 – Lifting eye, shackle and cable - South side of Gate

2f. Gate No. 2 – Gate No. 2 – Gate Hinge at Headwall - South side of Gate

GATE NO. 3

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 3

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)		X	Approximately 1/3 of the outer portion of this ring is missing. However the portion remaining should serve to help hold the locking pin in place if deployed.
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)		X	This ring except for the portion welded to the gate frame is missing. As such, it will not provide any support should the locking pins need to be installed.
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)		X	Some flaking of the metal coatingt apparent. The function of the plate is unaffected.
16	Stop Plate (Right)		X	Some flaking of the metal coating apparent. The function of the plate is unaffected.
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	While one of the lock rings on the gate is totally missing and another partially missing, barring issues with the rings on the gate frame, there should be no problems locking this gate in the closed position. In March of this year, this gate was locked in the closed position with no issues. Repair/replacement is not recommended at this time.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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3a. Gate No. 3 – North side of Gate

3b. Gate No. 3 – Damaged Locking Ring, Feature No. 8 - North side of Gate

3c. Gate No. 3 – Lifting eye, shackle and cable - North side of Gate

3d. Gate 3 – South side of Gate

3e. Gate No. 3 – Damaged Locking Ring, Feature No. 3 - South side of Gate

3f. Gate No. 3 – Lifting eye, shackle and cable - South side of Gate

GATE NO. 4

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 4

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all the locking rings on the gate intact, barring issues with the rings on the receiving gate frame, there should be no issues locking this gate in the closed position. In March of this year, this gate was locked in the closed position with no issues.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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4a. Gate No. 4 – North side of Gate

4b. Gate No. 4 – Lifting eye, shackle and cable - North side of Gate

4c. Gate No. 4 – South side of Gate

4d. Gate 4 – Lifting eye, shackle and cable - South side of Gate

GATE NO. 5

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 5

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)		X	Locking ring is missing.
4	Flap Gate Lock Ring, Middle(Rt.)		X	Ring has been elongated/mis-shapened
5	Flap Gate Lock Ring, Lower (Rt.)		X	Ring has been elongated/mis-shapened
6	Flap Gate Lock Ring, Lower (Lt.)		X	Locking ring separating from the gate frame.
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	The operations Contractor had difficulty locking this gate in the closed condition in March of 2022 and could only partially install the locking pin on the south side of this gate and north side of the adjacent gate (No. 6). This may have been due to an obstruction below the water line blocking the rings on the respective receiving frames. This may be also be partially explained by the missing and mis-shaped rings along the south side of this gate. During the inspection, a round wooden pole was able to be inserted through the locking rings on the south side gate frame with the gate in the open position. Repairs to the rings on this gate will need to be done in order for the gate to operate properly.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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5a. Gate No. 5 – North side of Gate

5b. Gate No. 5 – Damaged Locking Ring, Feature No. 6 - North side of Gate

5c. Gate No. 5 – Lifting eye, shackle and cable - North side of Gate

5d. Gate 5 –South side of Gate

5e. Gate 5 – Damaged Locking Ring – Feature No. 5 - South side of Gate

5f. Gate 5 – Damaged Locking Ring – Feature No. 4 - South side of Gate

5g. Gate 5 – Missing Locking Ring – Feature No. 3 - South side of Gate

5h. Gate 5 – Lifting eye, shackle and cable - South side of Gate

GATE NO. 6

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 6

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)		X	All but the welded connection to the gate portion of this lock ring is missing.
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)		X	Cracked weld
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all but one locking ring on the gate intact, barring issues with the rings on the receiver gate frame, there should be no problems locking the gate in the closed position. Note that the operations Contractor had trouble locking the gate in the closed position in March of 2022. The locking pin could not be inserted to its full length through the locking rings on the north side of the gate. It's believed that an underwater obstruction may have prevented the proper installation of the locking pin. Repair/replacement is not recommended at this time.			
C	The pin for the lifting eye shackle on the south side of the gate was missing at the time of inspection, therefore the lifting cable was not connected to the gate at this point. The gate was able to be lifted for the inspection as the lifting cable on the north side of the gate was still attached. A replacement pin from a shackle supplied by the crane operator was installed to reconnect the cable on the south side.			
D	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
E	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
F				

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6a. Gate No. 6 – North side of Gate

6b. Gate No. 6 – Damaged Locking Ring, Feature No. 7 - North side of Gate

6c. Gate No. 6 – Lifting eye, shackle and cable - North side of Gate

6d. Gate 6 –South side of Gate

6e. Gate 6 – Lifting Eye – Shackle Pin Missing – South side of Gate

6f. Gate 6 – Lifting Eye – Shackle Pin Replaced – South side of Gate

6g. Gate 6 – Lifting Eye – Shackle Pin Replacement in Place – South side of Gate
(Replacement shackle pin supplied by Crane Operator)

6h. Gate 6 – Cracked Weld – Stop Plate, Feature No. 16 - South side of Gate

GATE NO. 7

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 7

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)		X	Missing
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all the lock rings on the gate intact, barring issues with the rings on the receiving gate frame, there should be no issues locking this gate in the closed position. In March of this year, this gate was locked in the closed position with no issues.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

File: H:\Shared\OpsLaf\Group\Engineering-Ops\O&M Inspections\2022-2023 O&M Inspections\CS Basin\CS-29\2022 Report\Field Inspection Forms\CS-29 Flap Gate Inspection Checklist 11-29-22

7a. Gate No. 7 – North side of Gate

7b. Gate No. 7 – Lifting eye, shackle and cable - North side of Gate

7c. Gate No. 7 – South side of Gate

7d. Gate 7 – Lifting eye, shackle and cable – South Side of Gate

7e. Gate 7 – Missing Stop Plate, Feature No. 16 – South side of Gate

7f. Gate 7 – Gate in Lifted Position

GATE NO. 8

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 8

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)		X	Approximately 1/3 of the outer portion of this ring is missing. However the portion remaining should serve to help hold the locking pin in place if deployed.
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)		X	Cracked weld
16	Stop Plate (Right)		X	Cracked weld
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all but one locking ring on the gate intact, barring issues with the rings on the receiver gate frame, there should be no problems locking the gate in the closed position. In March of this year, this gate was locked in the closed position with no issues. Repair/replacement is not recommended at this time.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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8a. Gate No. 8 – North side of Gate

8b. Gate No. 8 – Damaged Locking Ring, Feature No. 8 - North side of Gate

8c. Gate No. 8 – Lifting eye, shackle and cable – North Side of Gate

8d. Gate 8 – Cracked Weld, Stop Plate, Feature No. 15 – North Side of Gate

8e. Gate 8 – South side of Gate

8f. Gate 8 – Lifting eye, shackle and cable – South Side of Gate

8g. Gate 8 – Cracked Weld, Stop Plate, Feature No. 16 – South Side of Gate

8h. Gate 8 – Gate in Lifted Position

GATE NO. 9

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 9

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)		X	Locking ring on gate frame is missing.
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)		X	This ring is split.
7	Flap Gate Lock Ring, Middle (Lt.)		X	Locking ring on gate frame is missing.
8	Flap Gate Lock Ring, Upper (Lt.)		X	Locking ring on gate frame is missing.
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With two of the locking rings on the left (north) side of the gate missing and the remaining locking ring on the lower left side of the gate damaged, it will not be possible to properly lock this gate in the closed postion should the need arise. However, in March of this year, this gate was locked in the closed position with no issues. Repairs to the rings on this gate will need to be done in order for the gate to operate properly.			
C	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
D	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
E				
F				

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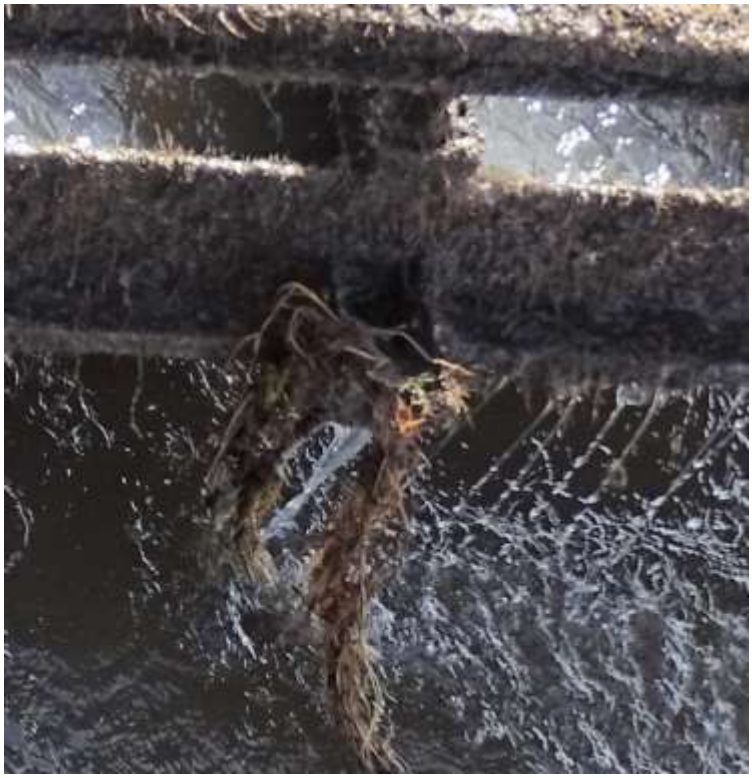
9a. Gate No. 9 – North side of Gate

9b. Gate No. 9 – Damaged Locking Ring, Feature No. 6 - North side of Gate



9c. Gate No. 9 – Damaged Locking Ring, Feature No. 7 - North side of Gate

9d. Gate 9 – Damaged Locking Ring, Feature No. 8 - North side of Gate

9e. Gate 9 – Lifting eye, shackle and cable – North Side of Gate

9f. Gate 9 –South Side of Gate

9g. Gate 9 – Missing Lock Ring, Feature No. 3 – South Side of Gate

9h. Gate 9 – Lifting eye, shackle and cable – South Side of Gate

GATE NO. 10

Date: 11/29/22
By: P. W. Parker, P.E.

CS-0029 Black Bayou Culverts Hydrologic Restoration Project
Flap Gate Inspection Summary
Gate No. 10

Feature No.	Description	Intact	Damaged	Comments
Flap Gate Features				
1	Hinge Assembly (Left)	X		
2	Hinge Assembly (Right)	X		
3	Flap Gate Lock Ring, Upper (Rt.)	X		
4	Flap Gate Lock Ring, Middle(Rt.)	X		
5	Flap Gate Lock Ring, Lower (Rt.)	X		
6	Flap Gate Lock Ring, Lower (Lt.)	X		
7	Flap Gate Lock Ring, Middle (Lt.)	X		
8	Flap Gate Lock Ring, Upper (Lt.)	X		
9a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
9b	Styrofoam Floatation Block	X		
10a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
10b	Styrofoam Floatation Block	X		
11a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
11b	Styrofoam Floatation Block	X		
12a	Aluminum Plate for Retaining Styrofoam Floatation Block	X		
12b	Styrofoam Floatation Block	X		
13	Aluminum Angle (Lt.)	X		
14	Aluminium Angle (Rt.)	X		
15	Stop Plate (Left)	X		
16	Stop Plate (Right)	X		
17	Lifting Cables	X		
Additional Comments				
A	Water levels in the channel did not allow for visual inspection of the locking rings attached to the gate frames.			
B	With all the lock rings on the gate intact, barring issues with the rings on the receiving gate frame, there should be no issues locking this gate in the closed position.			
C	During a previous inspection, the Contractor replaced the missing shackle pin on the lower right hand (south side) lift cable eye with a bolt he had on hand at the time. This bold it still in place and is functioning to allow the gate to be lifted.			
D	A new padlock was installed through the shackle of the lifting cables once the gate was lowered.			
E	Observed an increase in the growth of marine vegetation on the gate surface from that observed during last year's inspection.			
F				

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10a. Gate No. 10 – North side of Gate

10b. Gate No. 10 – Lifting eye, shackle and cable – North Side of Gate

10c. Gate No. 10 – South side of Gate

10d. Gate 10 – South side of Gate

10e. Gate 10 – Lifting eye, shackle and cable – South Side of Gate

10f. Gate 10 – Gate in Open Position

GATE (WEST) AND TRASH RACK (EAST) SIDES OF STRUCTURE

B1. West Side of Structure – Looking North

B2. West Side of Structure – Preparing to Lift Gate No. 1

B3. West Side of Structure – Navigation Warning Sign Installation

B4. West Side of Structure – Bulkhead

B5. East Side of Structure – Looking North

B6. East Side of Structure – Looking Northeast

B7. East Side of Structure – Trash Racks -Looking North

B8. East Side of Structure – Navigation Warning Sign Installation

APPENDIX B
(Three Year Budget Projection)

BLACK BAYOU CULVERTS H R/ CS-29 / C.140029.8/ PPL 9

Three-Year Operations & Maintenance Budgets 07/01/2023 - 06/30/2026

Project Manager	O & M Manager	Federal Sponsor	Prepared By
Philip Parker	*Philip Parker*	*NRCS*	*Jody White*

	2023/2024 (-14)	2024/2025 (-15)	2025/2026 (-16)	
O&M Inspection & Admin	$ 14,800.00	$ 17,800.00	$ 17,800.00	
State Administration (IDC)	$34,740.00	$ 41,780.16	$ 41,780.16	
Admin Notes:	Gate Maintenance Event & Admin Ops Contract	Administer Survey Task & Ops Contract	Administer Channel Maintenance & Ops Contract	
Structure Operation	$ 28,300.00	$ 22,500.00	$ 23,800.00	based on anticipated operations
Federal Administration		$ -	$ -	

2023/2024 Description: Flapgate repairs, locking ring repairs, traffic control, and debris removal

E&D		
Construction	$ 8,000.00	***Note: O&M Contract is used for a portion of this work.***
Construction Oversight		
Sub Total - Maint. And Rehab.	$ 8,000.00	

2024/2025 Description: Survey Channel

E&D	$ 12,000.00	
Construction		
Construction Oversight	$ -	
Sub Total - Maint. And Rehab.	$ 12,000.00	

2025/2026 Description: Channel Maintenance Dredging (20 % of original)

E&D	$ 45,000.00	
Construction	$ 236,340.00	
Construction Oversight	$ -	
Sub Total - Maint. And Rehab.	$ 281,340.00	

	2023/2024 (-14)	2024/2025 (-15)	2025/2026 (-16)
Total O&M Budgets	$ 85,840.00	$ 94,080.16	$ 364,720.16

O &M Budget (3 yr Total)	**$ 544,640.32**	
Existing O & M Budget	**$ 1,039,801.59**	per USACE (LANA) report & LAGov (PBEC) Expenditure
Remaining O & M Budget (Projected)	**$ 495,161.27**	

OPERATION AND MAINTENANCE BUDGET WORKSHEET

BLACK BAYOU CULVERTS H R/ CS-29/ C.140029.8 / PPL 9 / 2023-2024

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$14,800.00	**$14,800.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	1	$28,300.00	**$28,300.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

STATE Admin. (IDC)	LUMP	1	$34,740.00	$34,740.00
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
SURVEY Admin.	LUMP	0	$0.00	$0.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$34,740.00**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Marsh Elevation / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:	Repair Rings on Aluminum Flap Gate					
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		LUMP	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Traffic Control		LUMP	0	$1,300.00	$0.00
	Repair Rings on Aluminum Flap Gate		LUMP	1	$8,000.00	$8,000.00
	Weld repairs on 2 Aluminum Flap Gates		LUMP	0	$12,000.00	$0.00
	Debris Removal		LUMP	0	$3,000.00	$0.00
	Slide Gate Installation		LUMP	0	$3,000.00	$0.00
	Contingency		LUMP	0	$0.00	$0.00
	General Structure Maintenance		LUMP	0	$0.00	$0.00
	BOARDED FOUNDATION PAD			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
						$8,000.00

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$85,840.00**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

BLACK BAYOU CULVERTS H R/ CS-29/ C.140029.8 / PPL 9 / 2024-2025

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$14,800.00	**$14,800.00**
Engineering and Design	LUMP	0	$0.00	**$0.00**
Operations Contract	LUMP	1	$22,500.00	**$22,500.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

STATE Admin. (IDC)	LUMP	1	$41,780.16	$41,780.16
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
STATE Survey Contract Admin.	LUMP	1	$3,000.00	$3,000.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$44,780.16**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION	Surevey Channel (20% of original)				
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Bathymetry / Topography	LUMP	1	$12,000.00	$12,000.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$12,000.00**

GEOTECHNICAL

GEOTECH DESCRIPTION					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION						
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	General Excavation / Fill		LUMP	0	$0.00	$0.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Corrugated Alum. Pipe (30")		LF	0	$0.00	$0.00
	Repair Rings on Aluminum Flap Gate		LUMP	0	$0.00	$0.00
	Fabricate & Install 2 SS Flap Gates		LUMP	0	$0.00	$0.00
	Materials		LUMP	0	$0.00	$0.00
	Mob / Demob		LUMP	0	$0.00	$0.00
	Contingency		LUMP	0	$0.00	$0.00
	General Structure Maintenance		LUMP	0	$0.00	$0.00
	BOARDED FOUNDATION PAD			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
						$0.00

TOTAL OPERATIONS AND MAINTENANCE BUDGET: **$94,080.16**

OPERATION AND MAINTENANCE BUDGET WORKSHEET

BLACK BAYOU CULVERTS H R/ CS-29/ C.140029.8 / PPL 9 / 2025-2026

DESCRIPTION	UNIT	EST. QTY.	UNIT PRICE	ESTIMATED TOTAL
O&M Inspection and Report	EACH	1	$14,800.00	**$14,800.00**
General Structure Maintenance	LUMP	0	$0.00	**$0.00**
Engineering and Design	LUMP	1	$45,000.00	**$45,000.00**
Operations Contract	LUMP	1	$23,800.00	**$23,800.00**
Construction Oversight	LUMP	0	$0.00	**$0.00**

ADMINISTRATION

STATE Admin. (IDC)	LUMP	1	$41,780.16	$41,780.16
FEDERAL SPONSER Admin.	LUMP	0	$0.00	$0.00
STATE Channel Dredging Contract Admin.	LUMP	1	$3,000.00	$3,000.00
OTHER				$0.00
			TOTAL ADMINISTRATION COSTS:	**$44,780.16**

MAINTENANCE / CONSTRUCTION

SURVEY

SURVEY DESCRIPTION:					
	Secondary Monument	EACH	0	$0.00	$0.00
	Staff Gauge / Recorders	EACH	0	$0.00	$0.00
	Bathymetry / Topography	LUMP	0	$0.00	$0.00
	TBM Installation	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL SURVEY COSTS:	**$0.00**

GEOTECHNICAL

GEOTECH DESCRIPTION:					
	Borings	EACH	0	$0.00	$0.00
	OTHER				$0.00
				TOTAL GEOTECHNICAL COSTS:	**$0.00**

CONSTRUCTION

CONSTRUCTION DESCRIPTION:	Channel Maintenance dredging - 20%				
	Rip Rap	LIN FT	TON / FT	TONS	UNIT PRICE	
		0	0.0	0	$0.00	
		0	0.0	0	$0.00	$0.00
		0	0.0	0	$0.00	$0.00
	Filter Cloth / Geogrid Fabric		SQ YD	0	$0.00	$0.00
	Navagation Aid		EACH	0	$0.00	$0.00
	Signage		EACH	0	$0.00	$0.00
	Channel Maintenance dredging		LUMP	1	$186,340.00	$186,340.00
	Dredging		CU YD	0	$0.00	$0.00
	Sheet Piles (Lin Ft or Sq Yds)			0	$0.00	$0.00
	Corrugated Alum. Pipe (30")		LF	0	$0.00	$0.00
	Repair Rings on Aluminum Flap Gate		LUMP	0	$0.00	$0.00
	Fabricate & Install 2 SS Flap Gates		LUMP	0	$0.00	$0.00
	Materials		LUMP	0	$0.00	$0.00
	Mob / Demob		LUMP	1	$50,000.00	$50,000.00
	Contingency		LUMP	0	$0.00	$0.00
	General Structure Maintenance		LUMP	0	$0.00	$0.00
	BOARDED FOUNDATION PAD			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
	OTHER			0	$0.00	$0.00
						$236,340.00

TOTAL OPERATIONS AND MAINTENANCE BUDGET: $364,720.16

APPENDIX C
(Field Inspection Notes)

MAINTENANCE INSPECTION REPORT CHECK SHEET

Project No. / Name: CS-29 Black Bayou Culverts Hydrologic Restoration

Date of Inspection: 11/29/2022 Time: 11:00 AM - 2:00 PM

Structure No. ___ N/A

Inspector(s): Jody White, Phillip Parker - CPRA - LRO
Richard Evely, Kyle Cappotto, Carol Clement - NRCS

Structure Description: Conc. Box Culverts with Flapgates, Sheet Pile Wall

Water Level Inside:_____ Outside: _____

Type of Inspection: Annual

Weather Conditions: Fair/Partly Cloudy, Warm

Item	Condition	Physical Damage	Corrosion	Photo #	
Rip Rap Shore Protection	Good				
Steel Bulkhead/ Cap	Good				
Alum. Flapgates	Good				Free flapping at time of inspection. Six (6) gates (1, 3, 5, 6, 8, & 9) have damaged/broken locking rings. Three of the gates (5, 7 & 8) have broken welds on stop plates. Gate 3 has two damaged top rings however these still provide support for closing the gate. Gate 5 has four locking rings that are damaged or missing. Gate 9 has three locking rings missing. Gates 5 and 9 will need repairs in order to be pinned in the closed position
Concrete Box Culverts	Good				
Signage/sign supports	Good				
Hardware	Good				
Trash Guard	Good				Debris has collected against these racks and was observed moving away from the screens with the reversal of the tide
Flap Gate Locking Pins	Good				The 20 locking pins (2 - per gate) are currently securely stored at the USACE Calcasieu Lock yard, approximately 1.2 miles from the Black Bayou Culvert location.

What are the conditions of the existing levees?
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 additional signs of vandalism beyond that documented during previous inspections were observed

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