APPENDIX U: SUMMARY OF SELECT NATURAL AND MAN-MADE DIVERSIONS IN SOUTHEASTERN LOUISIANA

Mid-Barataria Sediment Diversion Project EIS

Appendix U: Summary of Select Natural and Man-made Diversions in Southeastern Louisiana

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US Army Corps of Engineers®
New Orleans District

GEC

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Acronym List

AHP	above head of passes
CFD	Caernarvon Freshwater Diversion
cfs	cubic feet per second
CPUE	catch-per-unit-effort
CRMS	Coastwide Reference Monitoring System
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
DNWR	Delta National Wildlife Refuge
DPD	Davis Pond Freshwater Diversion Project
DWH	Deepwater Horizon
EIS	Environmental Impact Statement
FIM	fisheries-independent monitoring
FV-COM	Finite Volume Coastal Ocean circulation Model
GIWW	Gulf Intercoastal Waterway
LDWF	Louisiana Department of Wildlife and Fisheries
LPBF	Lake Pontchartrain Basin Foundation
MBSD	Mid-Barataria Sediment Diversion
MGP	Mardi Gras Pass
MR-09	Delta-wide Crevasses Project
MRGO	Mississippi River Gulf Outlet
NMFS	National Marine Fisheries Service
PALWMA	Pass A Loutre Wildlife Management Area
ppt	parts per thousand
RM	River Mile
SAV	submerged aquatic vegetation
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WLD	Wax Lake Delta
WMA	Wildlife Management Area

1.0 INTRODUCTION

This summary of diversions and diversion-like features in southeastern Louisiana was developed in response to public comments regarding how various diversions and diversion-like constructed or natural features have affected their receiving environments. The diversions and diversion-like features discussed below were chosen through review of public comments on the Draft Environmental Impact Statement (Draft EIS).

Coastal Louisiana has numerous diversions and diversion-like features along major rivers and distributaries that allow freshwater and/or sediment to move between the source and receiving waterbodies. These features have been created through either natural or anthropogenic forces (sometimes both) and each is unique in terms of location, purpose, origin, and impacts to its particular receiving basin. Varying characteristics among these diversions and diversion-like features contribute to their effects on the landscape, including controlled or uncontrolled water flow; differing (higher or lower) flow rates; differing purposes (land-building/marsh restoration or flood or salinity control); or differing channel or receiving area geometry, morphology, and bathymetry. Detailing how each diversion/diversion-like feature's combined characteristics produce its individual effects is beyond the scope of the EIS. Similarly, detailing how each diversion/diversion-like feature's characteristics are similar to or different from the proposed MBSD is also beyond the scope of the EIS. Instead, this discussion is intended only to provide a high-level summary of select diversions and diversion-like features in southeastern Louisiana to broadly distinguish their purposes and/or characteristics from the proposed MBSD Project. Where relevant and potentially analogous, more specific information or data from these other diversions and diversion-like features and their recorded impacts on the natural environment is included in the impact evaluations in the body of the EIS. While the following descriptions are based on a limited number of reports for each feature, multiple lines of evidence were used in the development of the EIS, including professional field experience in coastal Louisiana, reviews of available scientific literature, and the results of the Delft3D Basinwide Model, which are based on the site-specific conditions and design parameters of the proposed Project.

Table 1 lists key features and operational components of both the proposed MBSD Project and the selected diversions. For the selected diversions, additional detail is provided below regarding how these key features translate into effects on the environment. For example, diversions with a purpose of freshwater delivery are not intended to build land.

Table 1
Key Features and Operational Components of Selected Diversions and Diversion-like Structures, in Comparison with the Proposed Mid-Barataria Sediment Diversion

Diversion Name	Origin	Purpose/ Characteristics	Max Throughput (cfs)	Operational Period
MBSD	Man-made (proposed)	Freshwater, sediment	75,000 (preferred Alternative)	Proposed to be ongoing, with a base flow of up to 5,000 cfs
Caernarvon Diversion	Man-made	Freshwater	7,500	Pulsed as needed to maintain target salinities with base flow of 500 cfs
Naomi Siphons	Man-made	Freshwater	2,144	Ongoing, with an average of 977 cfs when operating
West Bay Sediment Diversion	Man-made	Sediment, freshwater	70,000	Ongoing (uncontrolled diversion)[a]
Davis Pond	Man-made	Freshwater	10,000	Ongoing as needed to maintain target salinities, with a base flow of 1,000 cfs
Mardi Gras Pass	Predominantly natural	Freshwater, sediment	14,000	Ongoing
Bonnet Carré Spillway	Man-made	Freshwater	250,000	Episodic/Emergency Use
Delta Management at Fort St. Philip	Man-made (following a natural levee breach)	Freshwater, sediment	Varies	Ongoing (uncontrolled diversion)[a]
Delta-wide Crevasses in the Birdfoot Delta	Man-made	Freshwater, sediment	Varies	Ongoing after establishment, until natural crevasse closure
Atchafalaya/ Wax Lake Delta Complex	Natural (with a man-made water control structure)/ Man-made	Freshwater and sediment/ Flood control	388,460/ (30% of Atchafalaya)	Ongoing/ Ongoing
Mississippi River Gulf Outlet (MRGO)	Man-made	Shipping canal	Not applicable	1968 to 2008

[a] Uncontrolled diversions (natural or artificial crevasses) provide variable flow to the outfall area that is dependent on the water volumes within the diversion source (such as the Mississippi River) at any given time. In contrast, controlled diversions include gates or pumps that allow for active management of flow volumes.

2.0 SELECT NATURAL AND MAN-MADE DIVERSIONS

2.1 CAERNARVON DIVERSION

Establishment history and summary data for Caernarvon Freshwater Diversion was taken from Sable, Watkins and Henkel 2020a; and the 2021 Caernarvon Operations Plan (CPRA 2021), and references within these sources, unless otherwise noted.

2.1.1 Establishment History

The Caernarvon Freshwater Diversion (CFD) was authorized by U.S. Congress through the Flood Protection Act of 1965, and the Water Resources Development Acts of 1974, 1986 and 1996. The diversion is located on the east bank at Mississippi River Mile (RM) 82 in Plaquemines Parish, just southeast of New Orleans. The CFD was constructed between 1988 and 1991, and began operations in August of 1991 (although excessive rainfall resulted in limited operations in 1991). The diversion includes five 15-foot gated box culverts capable of diverting up to 8,000 cubic feet per second (cfs) of Mississippi River water into the outfall channel of Breton Sound.

The CFD project objectives are to enhance emergent marsh vegetation growth, reduce marsh loss and increase productivity of significant commercial and recreational fish and wildlife through the re-introduction of freshwater and nutrients from the Mississippi River. The diversion operations are based on maintaining the 5 and 15 parts per thousand (ppt) isohalines in Breton Sound (Figure 1). The 2021 Caernarvon Operational Plan states that from December through May, the intent is to operate the diversion to maintain the seasonal average salinity at the 15 ppt line within Breton Sound. From June through November, operations are based on the monthly salinity range at the 5 ppt line, using the Crooked Bayou gauge. The diversion is operated when the 14-day moving average salinity is within the mean and one standard deviation of the long-term data range for the gauge(s) in use. When the moving average drops below the low trigger (the greater of the long-term average minus 1 standard deviation or 5 ppt) the diversion operations are maintained at the minimum of 500 cfs until the moving average re-enters the operational range. Operational settings are not to exceed a maximum flow of 7,500 cfs through the diversion.

In winter-early spring from 1993 through 2012, the CFD was operated regularly with pulsed higher flows reaching 5,000 to 7,000 cfs in the ascending limb of the Mississippi River (https://nwis.waterdata.usgs.gov/nwis/). Higher operations in 2006 and 2012 were run to help combat salinity intrusion in the drought years, and maintain the seasonal isohalines. The CFD was operated outside normal bounds from April through August in 2010 due to the Deepwater Horizon (DWH) oil spill in an attempt to limit intrusion of oil into the Breton Sound Basin. Since 2013, the annual diversion operations have been at or near baseflow (500 cfs) for most of the year except for a pulse in January of 2013 at 5,000 cfs, early pulsing in 2017 and 2018 with increasing Mississippi River stage, and early pulsing between 5,000 and 7,000 cfs in February of 2021 and again in 2022.

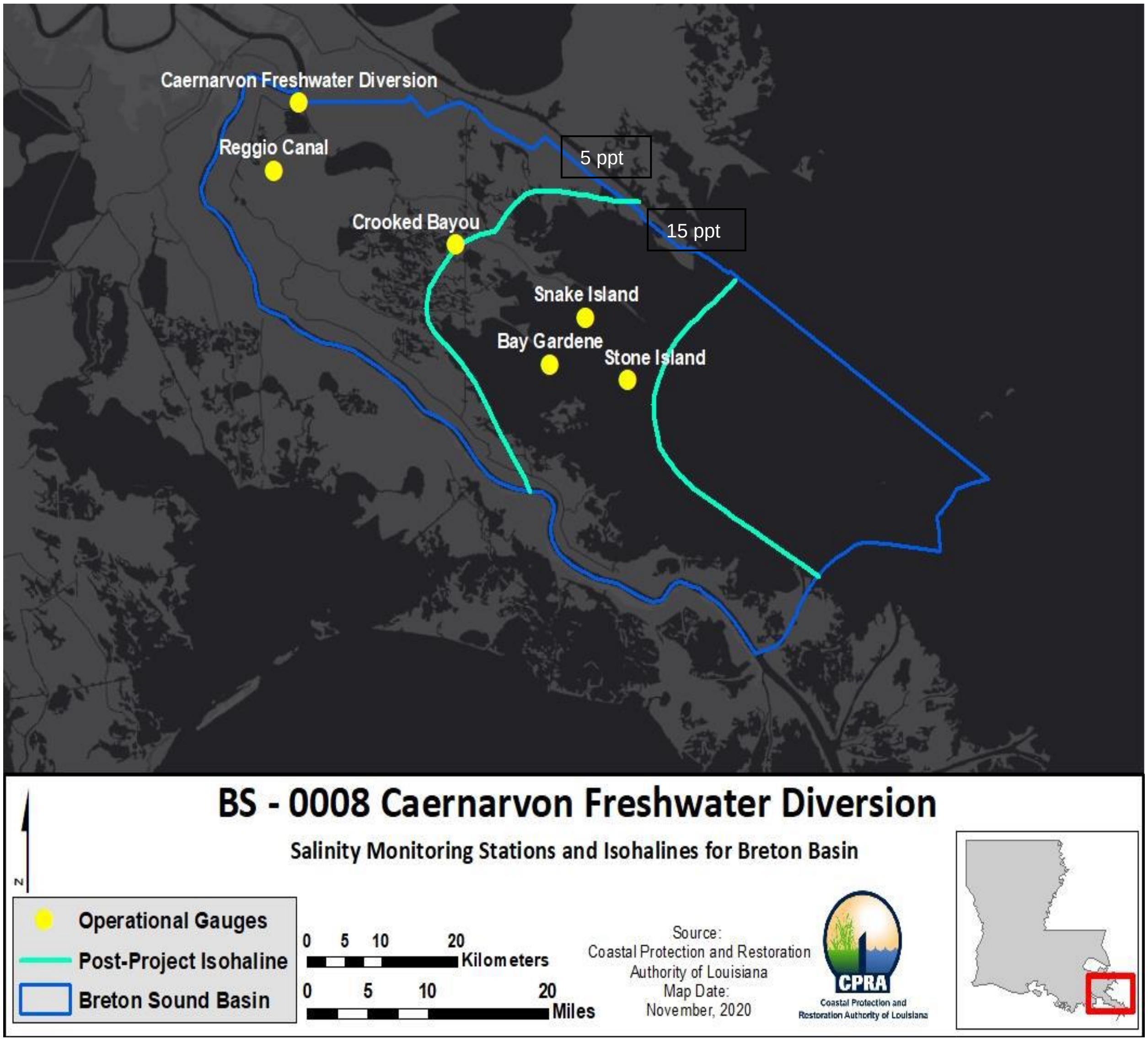

Figure 1. Salinity gauges and isohalines lines in Breton Sound Basin used by CPRA to guide operations of the CFD. (Figure from CPRA 2021, Figure 1; text boxes added to identify the isohaline lines)

2.1.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2019 are noted below.

Freshwater and nutrient flows:

- Field studies surrounding pulsed diversion operations showed that the CFD delivered mineral sediments and nutrients to Breton Sound when operated on the rising limb of the Mississippi River stage.

- Nearly 99 percent of the diverted water flows through two channelized flow routes when flows are about 3,500 cfs or less. The east flow is through Big

Mar and Lake Lery down Bayou Terre aux Boeufs, carrying about 2/3 of the diversion flow. The western flow is through Big Mar down Manuel's Canal and River aux Chenes, carrying about 1/3 of the diversion flow.

  - When the diversion discharge exceeds the capacity of the east and west flow routes (greater than 3,500 to 4,200 cfs), the river water overbanks and sheet flows across the marshes in the upper estuary.

- A 2-week lag between the CFD discharge and freshening of salinities at the end of Bayou Terre aux Boeufs was estimated when pulsed operations exceeded 7,000 cfs in spring of 2001 and 2002. Diverted river water took a long time to make it to open waters, even under high operations, because it must move through 18 to 25 miles of the two major channelized routes before reaching the open sound.

- Other natural crevasses and overbank flooding from the Mississippi River affect Breton Sound salinity gradients. There are no federal levees south of Bohemia on the east bank of the Mississippi River.

  - Located down river from CFD, the Bohemia Spillway is an 11-mile stretch created in 1926 by the removal of existing artificial river levees, which allows flows up to 30,000 to 50,000 cfs from the river during high river stage.

  - Recent flood years and the natural breaching and continued widening of Mardi Gras Pass on the lower west side of Breton Sound off the Mississippi River has reduced salinity so that the CFD was rarely operated above base flow in 2015 and 2016, 2018 and 2019.

Sediment deposition and land-building:

- The field monitoring studies of water levels, Total Suspended Solids (TSS), and salinity demonstrated that the influence of CFD outflow was somewhere between about a 6-kilometer- and 15-kilometer-radius under higher operations above 3,500 cfs.

- The majority of land change directly attributable to the CFD is in the upper basin with a radius of about 6 kilometers from the diversion outfall.

- Wetland surface elevation, vertical accretion, and shallow subsidence were measured annually from 1996 to 1999/2000 at three study sites located 3.5, 10.5, and 13.7 miles downstream of the CFD. Taking into account the effects of both vertical accretion and shallow subsidence, wetland elevation at the three sites increased over time, averaging 0.42 centimeters per year (cm/y), 0.16 cm/y, and 0.36 cm/y, respectively, at the three sites, indicating that all CFD sites were keeping pace with regional relative sea-level rise during the study period. (Lane and Day 2006).

- U.S. Geological Survey (USGS) analyzed 30-m land/water imagery data and converted it to acres for CPRA (Figure 2). For Big Mar, the estimated overall land change from 2002 through 2016 was an increase of 716.4 acres. For the larger affected area or footprint, the estimated net land change between 2002 and 2006 was a loss of 535.75 acres (including extensive marsh loss from Hurricane Katrina in 2005); between 2006 and 2016 there was a gain of 786.1 acres. The overall land change from 2002 through 2016 was a gain of 250.37 acres within the larger footprint. Figure 3 further depicts aerial imagery of land changes over time.

- The area around Big Mar experienced extensive loss due to Hurricane Katrina in 2005, but recovered some of this loss by 2016.

- In another study that compared land change (gain or loss) rates between a site in the diversion flow path to an adjoining reference site, Turner et al. (2019) indicated that comparing the land loss rate in the Caernarvon area against the land loss rate at the reference site, the rate was not different at the two sites before or in the first 10 plus years after the diversion opened. However, once Hurricane Katrina passed over both areas, the percent land in the diversion flow path dropped relative to that in the reference area and had not recovered by 2015. The authors state that the Caernarvon diversion had no effect on land loss rates in the flow path immediately after the diversion opening; however, the loss rates increased substantially in the diversion flow path after Hurricane Katrina. This increased loss rate was attributed to a number of factors, including plant stress from diverted waters (which inundated the plants) and the increased nutrient availability, which may have decreased belowground biomass and subsequent loss in soil strength.

- The Lake Pontchartrain Basin Foundation (LPBF) reported land gain and vegetative growth in Big Mar, with the delta in 2011 occupying 35-50 percent of the pond (LBPF 2014).

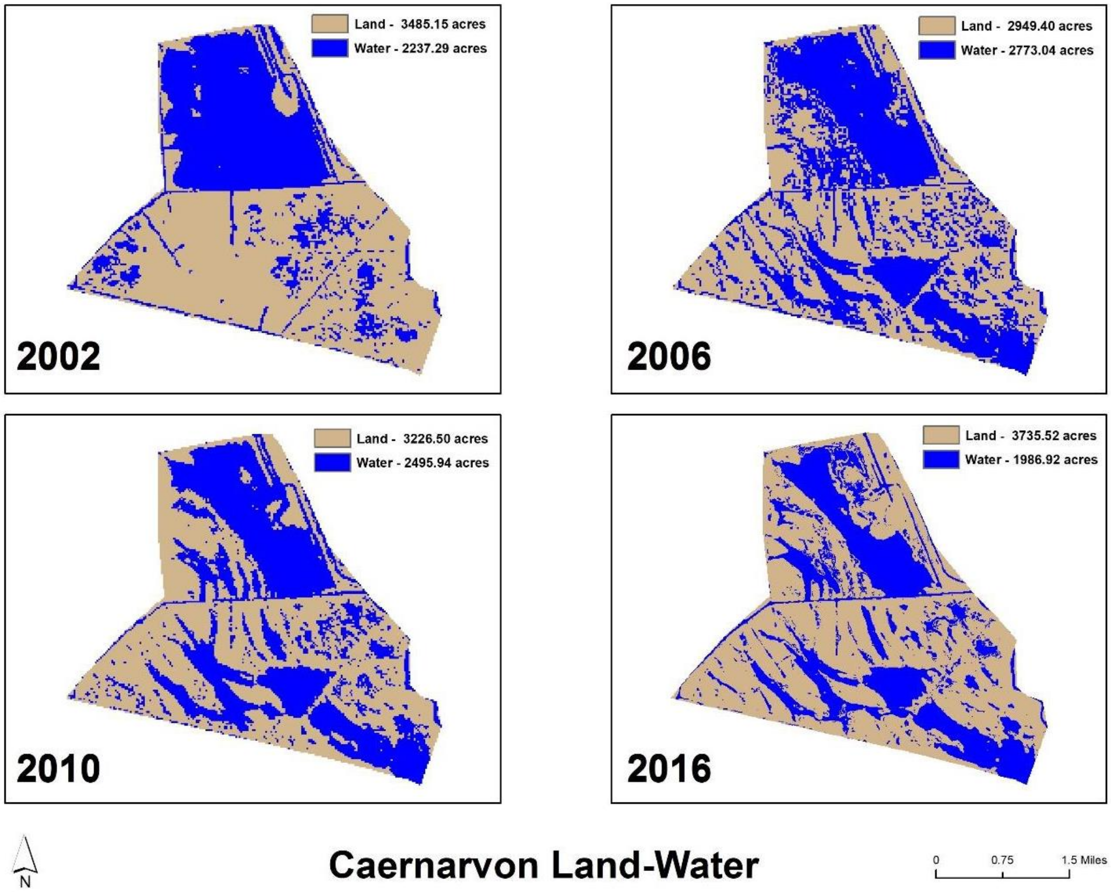

Figure 2. Land/water classification for 2002, 2006, 2010, and 2016 for the larger CFD project area including Big Mar (open waterbody at north end of map) and the wetlands off the western side off Lake Lery to Manuel's Canal (southeast boundary of the map). (Figure and caption from Sable, Watkins, and Henkel 2020a, Figure 3.3)

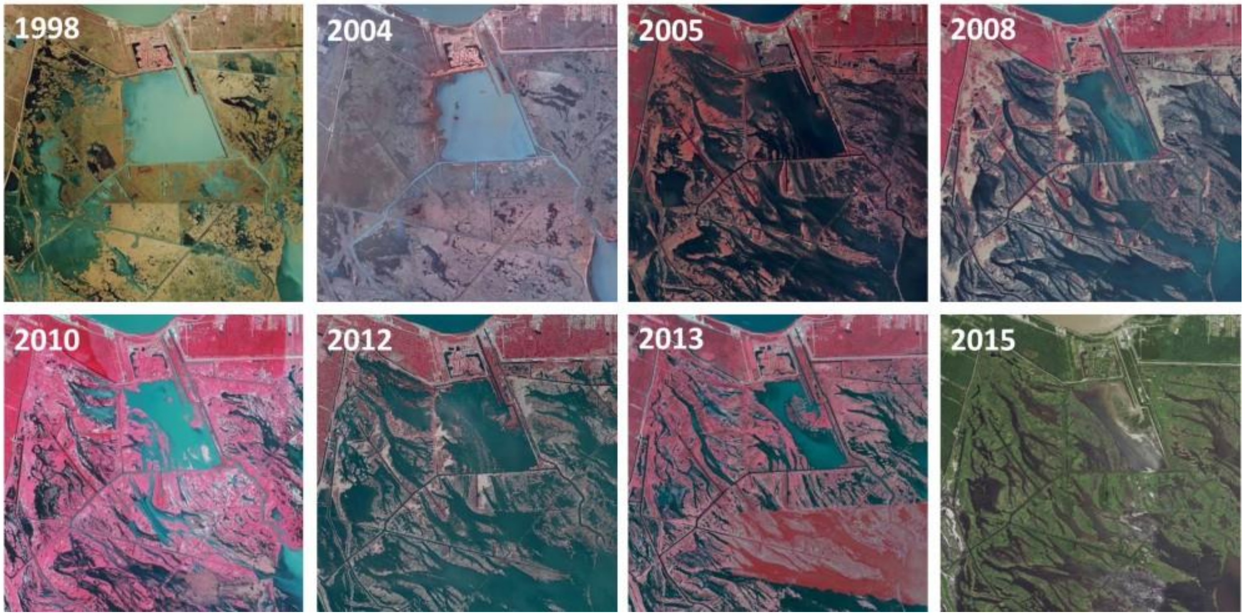

Figure 3. The changing landscape around the CFD from 1998 to 2015. Land gain was not visible until 2005. Prior to that Big Mar was filling in with sediment and a threshold was finally reached where land emerged above water and became vegetated. Also noticeable is the substantial land loss that occurred between 2004 and 2005 due to Hurricane Katrina. The delta continues to expand over time. (Photos and caption taken from the Pontchartrain Conservancy 2022a)

Flora and Fauna

- A plant survey of the Big Mar pro-delta in 2011 showed the region to largely be covered by bulltongue, cattails, giant cutgrass, and alligator weed (an invasive plant), and a continued presence of black willow trees, indicating elevation gains and vegetative growth rather than just floating marsh (LPBF 2014).

- Coastwide Reference Monitoring System (CRMS) 117, about 3.7 miles south of the CFD and closest to Big Mar, has transitioned from intermediate to fresh marsh. CRMS 117 most likely received some flow from the diversion, especially during high discharges.

- From 2010 through March 2014, the LPBF and the Coalition to Restore Coastal Louisiana planted 2,300 bald cypress (*Taxodium distichum*), green ash (*Fraxinus pennsylvanica*) and water tupelo (*Nyssa aquatica*) trees on the Caernarvon Delta, with the goal of establishing a bald cypress swamp in the newly created wetlands. Planting locations considered site suitability. Tree survival of all plantings through 2013 was 68 percent (LPBF 2014) and was 70 percent through 2017 (LPBF 2018). The decline of south Louisiana wetlands and wetland tree species has partly been attributed to altered hydrological regimes, such that plantings were conducted in the vicinity of the CFD to document the potential impact of pulsed river water on tree survival and growth over time (LPBF 2018). Therefore, the presence of these trees is not through natural establishment.

- The number and locations of the Louisiana Department of Wildlife and Fisheries (LDWF) fisheries-independent monitoring stations were expanded after the 2010 DWH oil spill in Breton Sound. Despite the expanded monthly sampling station efforts by LDWF, catch of brown and white shrimp, blue crab, Gulf menhaden, Atlantic croaker, largemouth bass, and blue catfish has generally been lower than the longer-term average since the 1980s. Red drum is the only species to show some increasing trends beyond 2010 for the Breton Sound stations. Eastern oyster densities have been well below the long-term average since 2007.
    - The LDWF noted that the decline in oyster abundance in Breton Sound (since at least 2009) is partially due to occasional extreme events (oil spills, tropical storms), extended periods of low spring salinities, harvest pressure, poor hydrologic conditions, degradation to reef areas, and possible periods of hypoxia which decreases spawning success and increases mortality.
- There were no strong, consistent salinity effects due to the CFD operation on the abundance patterns or distributions of select fishery species in Breton Sound based on analysis of the LDWF fisheries-independent monitoring data. The analysis showed that during the time CFD was constructed and operating, some species appeared to increase (for example, white shrimp in the trawls), or decrease then increase (for example, brown shrimp in trawls), or increase then decrease (for example, eastern oysters, blue crab in trawls) in the system, while some species re-distributed among the stations over time (for example, spotted seatrout in gillnets). However, the patterns for the species were not commensurate with the diversion operation periods, and the salinity changes at the sampling stations were rarely related to the species catch.
- Alligator nests have continued to increase since the aerial surveys began in the 1990s, with increasing alligator nests counted in the intermediate salinity zone of Breton Sound year after year.

Other Considerations:

- Breton Sound Basin has freshened along the western side from Bohemia Spillway down through the birdfoot delta with the river reaching flood stage causing overbank flooding in several recent years and with similar increased river flow and overbank flooding through Mardi Gras Pass, Fort St. Philip and Baptiste Collette during high flow years.
- The majority of land change directly attributable to the CFD is in the upper basin within a radius of about 3.7 miles from the diversion outfall, with the

delta (evidence of land/freshwater vegetation) in 2011 occupying 35-50 percent of Big Mar.

2.1.3 Conclusions

The CFD opened in August 1991 and continues to be operated seasonally based on maintaining the 5 ppt and 15 ppt isohalines. Since 2012, the diversion generally operated at or below base flow (500 cfs), largely because Breton Sound Basin has freshened along its western side and along the Mississippi River due to increasing natural freshwater diversion flows and overbank flooding from the river. The CRMS station data show some general freshening for much of the basin based on vegetation data and riverine minerals in the soils. However, the LPBF conducted field studies of the CFD outflow in Big Mar through Lake Lery that showed delta expansion into Big Mar with fresh marsh vegetative growth and woody shrubs becoming established. The CFD has provided limited land-building and wetland maintenance in the vicinity of the outfall, and may have resulted in decreased soil strength in the path of the water flow.

2.2 NAOMI SIPHONS

Establishment history and summary data for the Naomi Siphon was taken from Richardi and Richard (2011), Boshart and Richard (2005), and Richard (2019), and references within these sources, unless otherwise noted.

2.2.1 Establishment History

The Naomi Siphons are a set of eight siphon pipes that were installed in 1992 to reintroduce freshwater from the Mississippi River into adjacent marshes south of Naomi on the west bank of the Mississippi River, and is operated by the Plaquemines Parish Government. The Naomi Siphon discharges a maximum of 2,144 cfs of freshwater into a ponding area, which is then distributed to the surrounding marshes via a single channel.

The original plan for the siphons included operation of all eight pipes in January, February, and May through December, with two pipes operating in March and April. During reporting from February 1993 through December 2010, the siphons most frequently operated between 500 and 1,000 cfs (averaging 977 cfs) and operated 48 percent of the time. Limited siphon operation is due to low river stages and drought, as well as tropical storms, oil spills, maintenance issues, fisheries management, and staff limitations at the Plaquemines Parish Government. The siphons were also inoperable between August 30, 2005 and December 30, 2006 due to damage from Hurricane Katrina.

Two related projects support the management of freshwater flows from the Naomi Siphon (Naomi Outfall Management and Barataria Bay Waterway East Side Shoreline Protection projects). The hydrologic control features (or outfall management features) were installed under the Naomi Outfall Management Project in 2002 and comprise two fixed crest rock weirs designed to retain fresh water, sediment, and nutrients in the outfall area of the siphons, and help prevent saltwater intrusion into the area. In addition, the Barataria Bay Waterway East Side Shoreline Protection Project was constructed in 2001 to protect marshes in the vicinity of the Naomi Siphon from shoreline erosion, and consists of approximately 17,100 linear feet (3.2 miles) of foreshore rock dike bank line protection and an earthen hydrologic barrier created from dredged material from the Barataria Bay Waterway placed to the east along a rock dike. The project area for the Naomi Siphon is 13,130 acres; however, the overall project area assessed includes an additional 13,000 acres associated with the Naomi Outfall Management Project and 2,790 acres associated with the Barataria Bay Waterway East Side Shoreline Protection projects. The overall project area is about 28,920 acres and is depicted in Figure 4.

2.2.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2010 are noted below.

Freshwater and nutrient flows:

- Based on data from three continuous recorders (one near the outfall canal, one in northwest portion of the Project area in The Pen, and one in the southern portion of the Project area), mean daily salinity was lower during periods when all siphons were in either major or minor operation vs. no-flow, indicating that the siphons are capable of reducing salinity in the project area; however, salinity is also influenced by seasonal variability in the Barataria Basin. Differences are greatest near the outfall canal, and freshening effects decrease with distance from the outfall canal.

- Because siphon operation depends on river stage, the ability to control salinity in the project area during drought or low river stage is limited. During a drought from September 1999 through December 2000, mean yearly salinity levels in the project area increased greatly while siphon operation decreased substantially due to low river stage.

- Water elevations from monthly staff gauge readings collected during siphon operations were significantly higher nearest the outfall structure, but water elevations dissipated quickly with distance from the discharge area, and few differences in water elevation were observed for stations outside the immediate outfall area. Differences were not significant under no-flow conditions.

- It is unclear whether significant freshwater from the siphons is flowing far enough to reach the hydrologic control features associated with the Naomi Outfall Management Project, given the limited operation of the siphons.

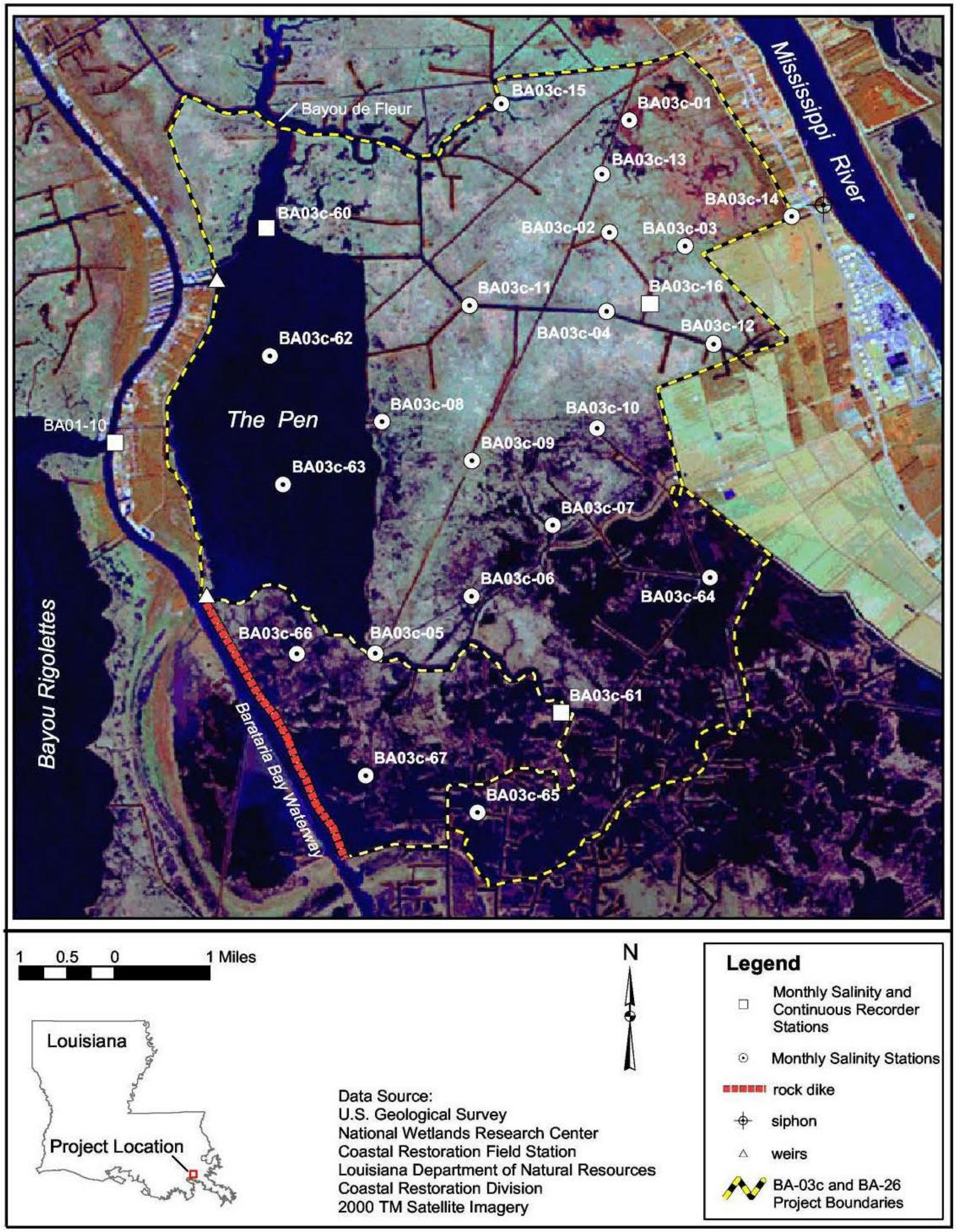

Figure 4. **Naomi Siphons Project Features Map.** (Figure from Richard 2019, Appendix A)

Sediment Deposition and Land Changes:

- Preconstruction aerial photography was collected on November 5, 1991 and compared with post-construction aerial photography collected in 2009. The acres of land increased from 8,175 acres in 1991 to 8,289 acres in 2009 (114 acres), while the acres of water decreased from 4,956 to 4,842 in 2009 (114 acres).

Flora and Fauna:

- Vegetation surveys conducted in 1992 and 1995 (immediately before and after siphon operations began) indicated that the northeast portion of the project area was comprised of fresh-to-intermediate marsh with *Sagittaria lancifolia* (bulltongue) as the dominant species. The southern portion of the project area was comprised of brackish marsh with *Spartina patens* (marshhay cordgrass) as the dominant species. Although vegetation changes were noted during surveys in 2000 (pre-weir) and 2003 (post-weir), shifts between fresher and saltier plant communities appear to be influenced more by basin-wide environmental factors than by siphon operation or the installation of the weirs.

- While direct comparisons with subsequent surveys are not possible due to differences in survey locations and methodologies, surveys were also conducted in 1997, 2000, 2003, 2006, and 2009. The abundance of fresh−intermediate and intermediate/brackish−salt species varied between years, with 1997 having the highest percent cover of fresher species and 2000 having the lowest.

- Invasive plant species documented in the Naomi Siphons outfall area during surveys between 1997 and 2009 included common salvinia (*Salvinia minima),* tidal marsh amaranth *(Amaranthus cannabinus),* water hyacinth (*Eichhornia crassipes),* and narrow-leaved cattail *(Typha latifolia).*

- Significant events such as drought and hurricanes, especially Hurricane Katrina in 2005, affect the plant community composition and percent cover. Shifts between fresher and saltier plant communities appear to be influenced more by basin-wide environmental factors than by siphon operation or the installation of the weirs.

- Between 2000 (before implementation of the Naomi Outfall Management Project) and 2003 (after implementation of the Naomi Outfall Management Project) vegetation surveys, there was a significant increase in the percent cover of fresh-to-intermediate species (30 percent to 73 percent). However, 2000 was a drought year and the vegetation community reflected higher salinities in the basin by transitioning to a more salt-dominated community.

2.2.3 Conclusions

The Naomi Siphons are a relatively small, man-made diversion designed to transport fresh water from the Mississippi River into marshes in the Barataria Basin. Operation of the siphons has been observed to reduce salinity near the mouth of the outfall canal, and Richardi and Richard (2011) note there was no net loss of land (and about 114 acre of land gains) over the outfall area during the monitoring period through 2009. However, the researchers note that it was difficult to assess any effects from the weirs on project monitoring goals as they were unable to determine if significant freshwater from the siphons was reaching the weirs, no reference site was designated prior to project construction, and there were changes to project components over time, including weir settlement and rock removal (Richardi and Richard 2011).

2.3 WEST BAY SEDIMENT DIVERSION

Establishment history and summary data for the West Bay Sediment Diversion was taken from Plitsch 2017, Sharp et al. 2013, and Kolker et al. 2012, unless otherwise noted.

2.3.1 Establishment History

The West Bay Sediment Diversion is a Coastal Wetlands Planning Protection and Restoration Act (CWPPRA) project located on the west bank of the Mississippi River in Plaquemines Parish, Louisiana at RM 4.7 above head of passes (AHP), and also involves a number of beneficial use areas for placement of dredged material under other programs. A crevasse south of Venice, Louisiana opened in 1839, which led to the development of 73,390 acres of land by 1932; those lands subsequently deteriorated and West Bay was an open water area by about 1980. The West Bay Sediment Diversion was cut through the Mississippi River levee to counteract this land loss.

The project outfall area is a large, shallow, open-ended interdistributary basin, situated between the main river channel to the east, Grand Pass to the west, and the Gulf of Mexico to the south. Construction of the diversion channel was completed in November 2003. The West Bay Sediment Diversion is an artificial crevasse, an uncontrolled diversion with a designed capacity of 50,000 cfs at the 50 percent duration stage of the Mississippi River (the water level at which the river flows about 50 percent of the time, or the median discharge) and was designed to convey sediment-rich water from the Mississippi River to restore vegetated wetlands in an area that was shallow open water (CWPPRA 2004).

The sediment diversion channel was constructed at an angle designed to optimize the concentration of bed sediment per unit volume of water diverted, in two phases: 1) construction of an interim diversion channel to accommodate a discharge of 20,000 cfs at the 50 percent duration stage of the Mississippi River, and 2) modification of the interim diversion channel design in 2006 to accommodate full-scale diversion of 50,000 cfs at the 50 percent duration stage of the Mississippi River.

Since its construction, there have been at least eight hydrographic surveys that examined the geometry and morphologic evolution of the diversion. As of 2012, the orientation of the inflow channel changed such that its major axis was now closer to a right angle relative to the direction of river flow in the main channel. In January 2004, shortly after construction was completed, the channel was 7.6 meters deep. By January 2009, the depth had increased to 15.2 meters in many locations, with depths exceeding 19.5 meters in several locations.

2.3.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2017 are noted below.

Freshwater and nutrient flows:

- Flow rates are largely dependent upon river flow with some influence from meteorological events (fronts, precipitation, winds, etc.) and tidal exchange. Measured discharges range from negative flow (flow from West Bay into the Mississippi River) to approximately 70,000 cfs, with an average of about 27,000 cfs.

Sediment Deposition and Land Changes:

- While the West Bay project area gained a total of 557 acres from 2002 to 2014, much of that gain can be attributed to beneficially placed material. An estimated 665 acres of material had been placed within the land/water analysis boundary at the time of the 2014 survey; some areas of known beneficially placed material experienced loss or no net change over the analysis period. Some of the difference between placement estimates and land gain acreages might also be attributed to settlement and distribution of sediment after placement.

- A majority of the sediment transported through the West Bay Diversion apparently was deposited in the bay, and contributed to subaerial land formation. As of 2012, most sediments were distributed over a 13.5-kilometer area, with the maximum deposition occurring at the seaward end of this field. These results indicate substantial sediment deposition downstream of project boundaries and run counter to simple sedimentary models, which predict that maximum sediment deposition should occur closest to the riverbank.

- The scour area within the crevasse channel increased slightly in depth between the 2011 and 2015 survey. Change analyses, however, show areas of both accretion and erosion in the channel, with a net gain of 19,063 cubic yards of material overall. The crevasse channel itself displayed an initial period of scouring and self-optimization, followed by filling in of some areas of the crevasse along with areas of the greater basin area.

- In addition to placement sites, one area of land directly in the path of the crevasse flow has eroded over time, though other areas in the upper portion of the basin show signs of deposition and land gain. Considering the orientation of the crevasse and path of flow into the receiving basin, the erosion of the island directly in that path was not unexpected.

- While the land/water analysis did not reflect significant land gain via the crevasse or other natural processes as of the 2014 photography event (see Figure 5), the strategic placement of material throughout the basin aids in the retention of sediments delivered through the crevasse.

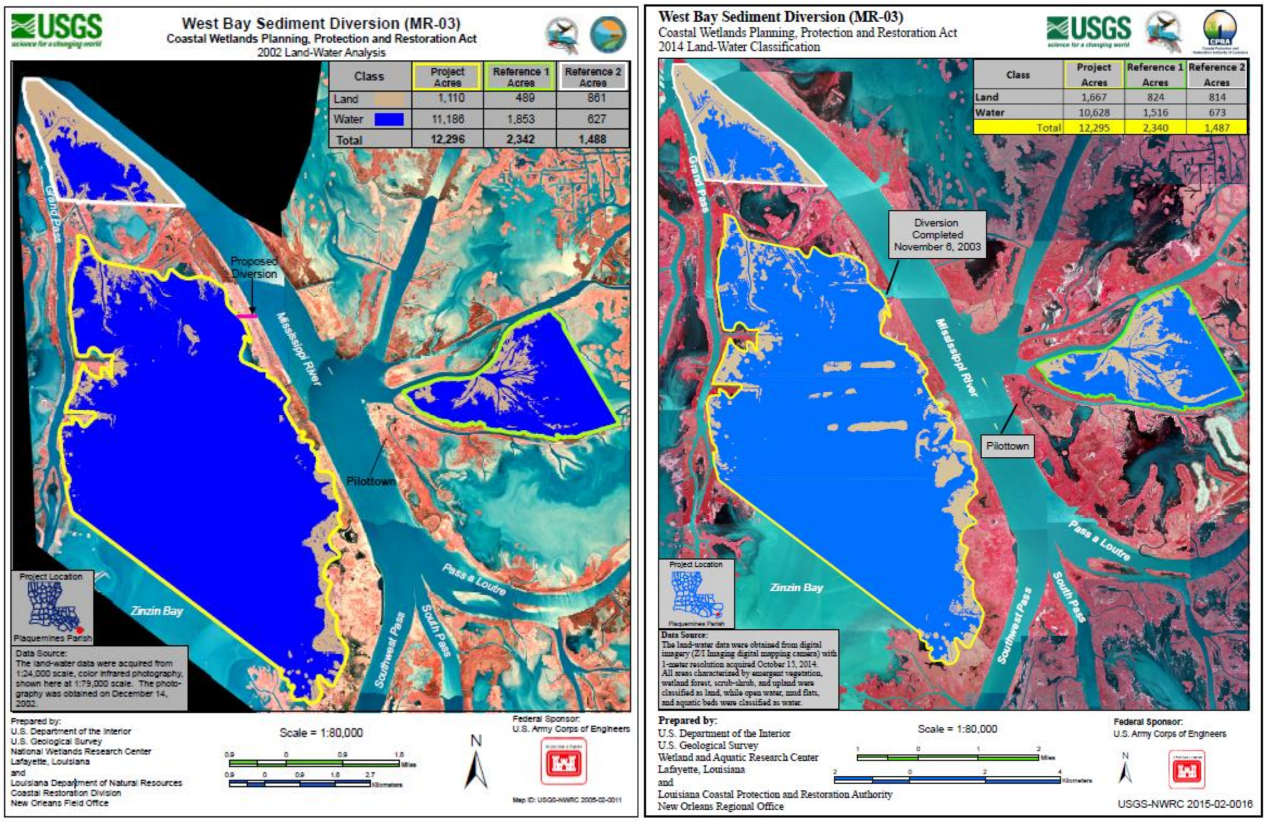

Figure 5: **West Bay Sediment Diversion Land/Water Analysis, 2002 and 2014.** (Figures from Plitsch 2016, Figures 4 and 5)

Flora and Fauna

- Plant species composition, percent cover, and relative abundance were evaluated to document vegetation on newly created land in the receiving bay. Surveys conducted in 2015 indicated that areas of deposition were vegetated, as were areas of newly placed dredged material. Based on the species present, the marsh classification for the area was defined as fresh-intermediate.

- In 2015, there were 48 plant species observed within 16 established vegetation plots, and percent cover ranged from less than 1 percent to 15.5 percent. Species richness was greatest at the most established (oldest) beneficial use sites.

2.3.3 Conclusions

The West Bay Sediment Diversion is a relatively large, man-made diversion designed to replicate natural crevasse-splay land-building and transport sediment and fresh water from the Mississippi River into West Bay. While smaller than the MBSD Project, the West Bay Sediment Diversion is considered a large diversion. A majority of the sediment transported through the diversion apparently was deposited in West Bay, and contributed to subaerial land formation; dredged material was also deposited in the Project area and contributed to land gains. However, significant land gains were not observed as of 2016. Further, fresh-intermediate marsh vegetation was established on areas of deposition and dredged material placement.

2.4 DAVIS POND

Establishment history and summary data for Davis Pond diversion was primarily taken from Sable, Watkins, and Henkel 2020b and the 2021 Davis Pond Operational Plan, unless otherwise noted.

2.4.1 Establishment History

The Davis Pond Freshwater Diversion Project (DPD) was authorized by U.S. Congress through the Flood Protection Act of 1965 and the Water Resources Development Acts of 1974, 1986 and 1996. The structure is located on the west bank of the Mississippi River at RM 118 in St. Charles Parish, Louisiana. The DPD was constructed between 1997 and 2002, though later modification of the project features was required to facilitate drainage and re-support the guide levee on the west side. The diversion became fully operational in 2009. The structure includes four 14-foot gated box culverts together capable of diverting up to 10,650 cfs of water into the 9,311-acre ponding area in upper Barataria Basin.

The DPD project objectives are to enhance emergent marsh vegetation growth, reduce marsh loss and increase productivity of significant commercial and recreational fish and wildlife through the re-introduction of freshwater and nutrients from the Mississippi River. The diversion operations are based on maintaining the 5 and 15 ppt isohalines in Barataria Basin (Figure 6). The 2021 Davis Pond Operational Plan states that from December through May, the intent is to operate the diversion to maintain the seasonal average salinity at the 15 ppt line. December through May operations would be based on data from the Barataria Bay N Grand Terre gauge (Figure 6). From June through November, operations would be based on the monthly salinity range at the 5 ppt line, using the Little Lake Bay Dos Gris gauge as the primary gauge and the Barataria Waterway S of Lafitte as a secondary gauge. Davis Pond would be operated when the 14-day moving average salinity is within the mean and one standard deviation of the long-term data range for the gauge(s) in use. When the moving average drops below the low trigger (the greater of the long-term average minus 1 standard deviation or 5 ppt) the diversion operations would be maintained at the minimum of 1,000 cfs until the moving average re-enters the operational range. Operational settings are not to exceed 10,000 cfs.

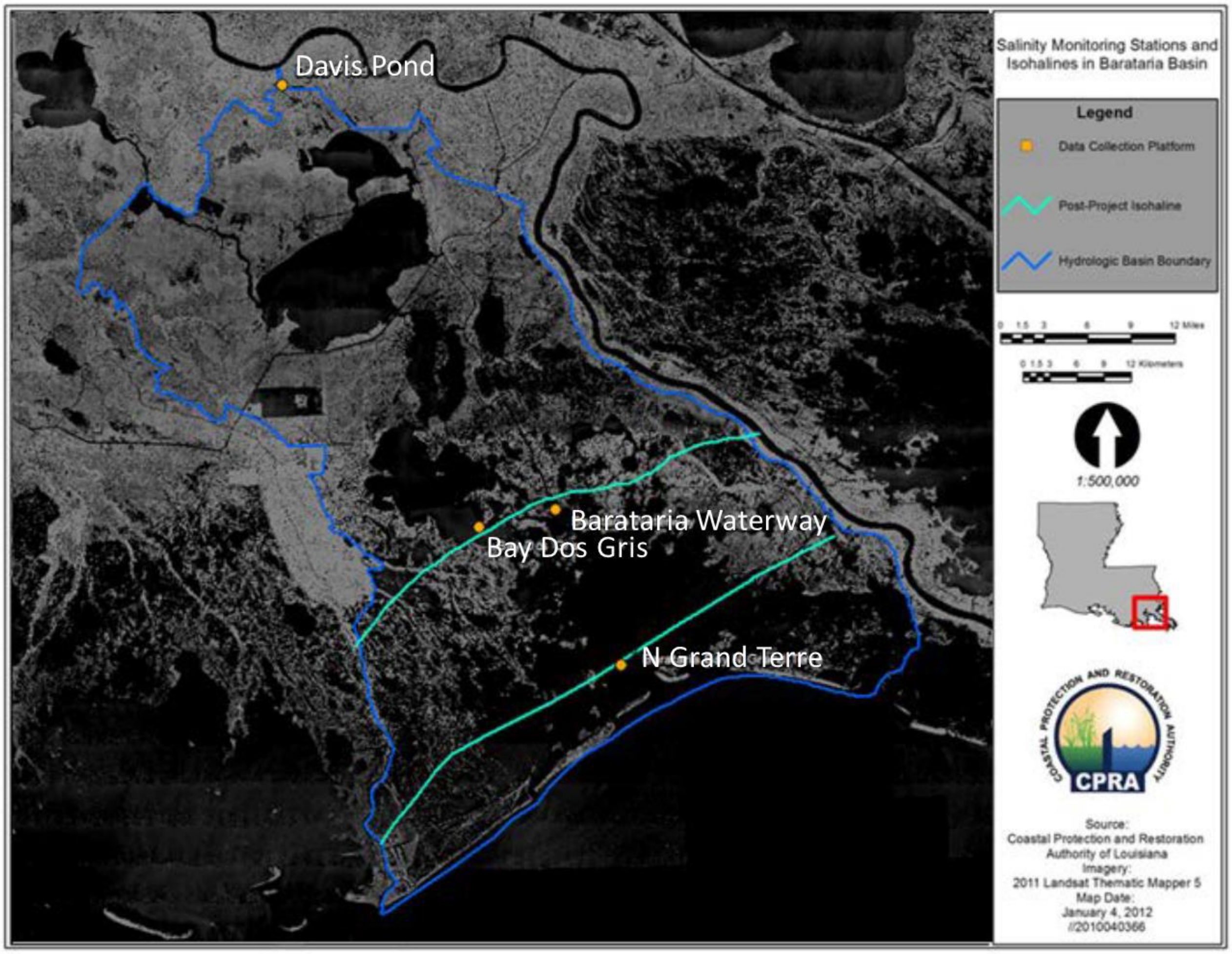

Figure 6. **Salinity gauges and isohalines in Barataria Basin used by CPRA to guide operations of the DPD.** (Figure from Sable, Watkins, and Henkel 2020b, Figure 4.1)

DPD operations in 2003 to 2005 were low with an average flow ≤ 1,000 cfs. Higher flows were sustained in 2006 to help combat salinity intrusion during the drought year, and averaged flow was at 3,000 cfs for the first time since opening. The highest flows for Davis Pond were from 2008-2010, and partially in 2011, which coincided with the highest average Mississippi River stages for sequential years since the DPD opened. The DPD was operated outside normal bounds in 2010 due to the DWH oil spill. Years 2015, 2018, and 2019 had the highest Mississippi River stages to date, higher than 2009/2010, however the diversion was largely run at base operations around 1,000 cfs since 2014, outside of a few pulsed operations in late 2016 to early 2017, and early 2018. In early 2020, 2021, and now in 2022, the DPD has been run with sustained pulsed operations around 5,000 to 7,000 cfs (https://waterdata.usgs.gov/usa/nwis/295501090190400).

2.4.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2019 are noted below.

Freshwater and nutrient flows:

- Salinity near the diversion outfall is always fresh with CRMS 3169 and CRMS 3166 monthly salinity less than or equal to 0.5 ppt around Lake Cataouatche.

- Determining the extent of the diversion influence on salinity and water level changes outside of the immediate project area in Barataria Basin has not been straightforward, so hydrodynamic models have been used to evaluate salinity changes and water movement or residence time in Barataria Basin under simulated operations by the diversion.

- An FV-COM (Finite Volume Coastal Ocean Circulation Model) developed for Barataria Basin estimated residence time without any diversion operations on the order of 15 days, compared to simulated higher diversion operation scenarios under dry summer conditions that decreases residence time to approximately 6 days. High 2008 diversion flows were used to simulate basin-wide salinity gradients from June through August, compared to no diversion flow and maximum flow scenarios. The simulated discharge changed summer salinity at mid-basin stations by 2 to 3 ppt using the 2008 flow time series that ran from 8,000 cfs in January and February, to about 6,400 cfs in March through May, to about 5,300 cfs from June through August.

- When DPD was operated outside of normal conditions in 2010 to help keep DWH oil out of Barataria Bay, prolonged salinities below 5 ppt were demonstrated for much of Barataria Basin.

- Water quality analysis of field data from 1997-2012 suggests that the DPD has increased the flushing rate in the basin to help control the accumulation of excessive algal biomass that was a common occurrence in the years before the diversion became operational.

Sediment deposition and land-building

- The majority of land change directly attributable to the DPD is in the upper basin, in the project outfall area or the 9,311-acre ponding area. USGS analyzed 30-m land/water imagery data and converted it to acres for CPRA (Figure 7). The estimated land change between 2002 and 2006 was equal to -82.3 acres, the estimated land change between 2006 and 2010 was +670.3 acres, and the land change between 2010 and 2016 was -150.3 acres (Figure

7, CPRA, unpubl. data). The overall land change from 2002 through 2016 was an increase of 437.7 acres in the ponding area, indicating land is being built even though major storm events such as Katrina, Gustav, and Hurricane Isaac in 2012 caused increased marsh fragmentation and shoreline erosion with elevated water levels and precipitation.

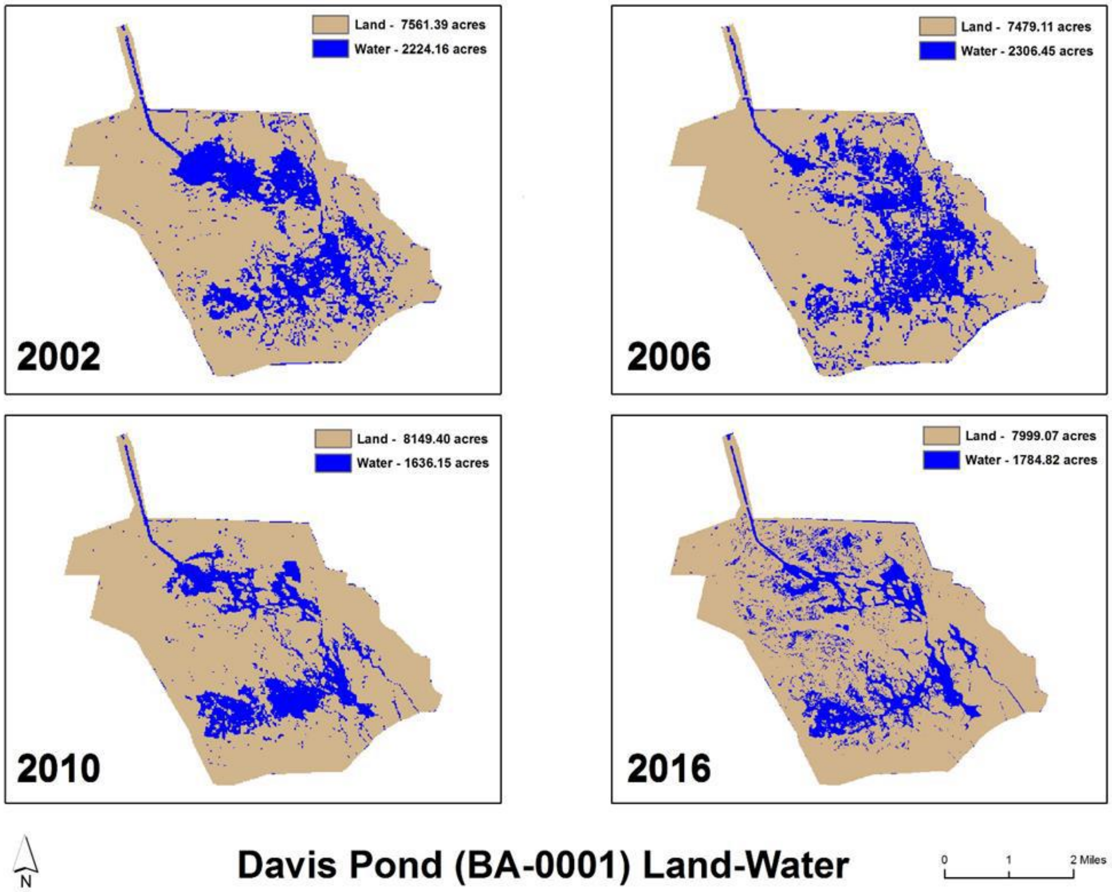

Figure 7. **Land/water classification for 2002, 2006, 2010, and 2016 for the DPD ponding area above Lake Cataouatche and encompassing CRMS 3169 and 3166.** (Figure from Sable, Watkins, and Henkel 2020b, Figure 3.3)

- In another dataset (land cover data from 1985 to 2014) Turner et al. (2019) concluded that the percent land loss at DPD remained stable at a reference site outside of the flow path, but decreased significantly within the diversion flow path after DPD was opened, at an enhanced loss rate of −0.49 percent per year (see Figure 8).

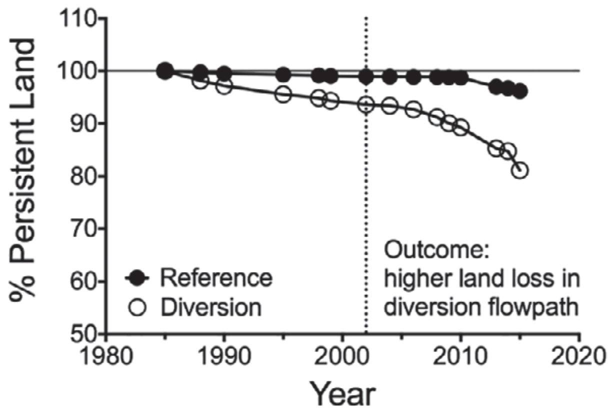

Figure 8. The percent land in the flow path of the diverted water (open circles) and in the reference (filled circles) site for the dataset. The data were normalized to the land area in 1985. The dotted vertical line indicates when the diversion was first opened. (Figure and caption from Turner et al. 2019, Figure 2)

Flora and Fauna

- CRMS 3169, in the most direct path of diverted water in the DPD project area, has consistently supported fresh marsh herbaceous vegetation such as knotweed and bulltongue. Black willow (*Salix nigra*) was colonizing during the 2013 survey and was becoming more predominant in the community. Black willow is a pioneer species and often colonizes newly built land or disturbed environments.

- CRMS 3166 (directly south of CRMS 3169) had a more consistent cover of bulltongue over time than CRMS 3169, and giant cutgrass from 2008 to 2018. The predominately freshwater marsh species usually compose greater than 60 percent of the total community cover each year.

- The LDWF fisheries-independent monitoring (FIM) stations increased in number and spatial extent in 1998 for the DPD project monitoring. In 2010, LDWF stations were added to expand the sampling extent in Barataria Basin.

- Similar to the CFD, there were no strong, consistent salinity effects due to the DPD operation on the abundance patterns or distributions of fishery species in Barataria Basin based on the LDWF FIM data analysis. The analysis showed that during the time the DPD was constructed and operating, some species appeared to increase (for example, white shrimp and blue crab in the trawls), or decrease (for example, spotted seatrout in gillnets and seed oysters in meter square samples) in the system, while some species re-distributed among the stations over time (for example, blue crab in trawls and spotted seatrout in gillnets). However, the patterns for the species were not commensurate with the diversion operation periods, and the salinity changes at the sampling stations were rarely related to the species catch. (Sable and Villarrubia 2011).

- Catch of shrimp, crab, Gulf menhaden, Atlantic croaker, and red drum were lower and less variable during the early period of DPD operations than before operation. However, catches have increased and become more variable since 2011.

- Even with the expanded FIM, it appears spotted seatrout and Eastern oyster abundance continue to remain lower compared to their peak abundances recorded in the 1990s.

- Largemouth bass catch has expanded and increased in the freshwater lakes and along the Mississippi River in inland electrofishing samples since 2015.

- Alligators and ducks have benefitted from the slight general freshening and overall maintenance of the wetland zones in Barataria Basin. Alligator nest counts have remained highest in freshwater marsh over time in Barataria Basin. Fresh marsh is also most important for total duck counts by LDWF, although more ducks in brackish and saline marsh zones have been counted in recent years.

Other Considerations:

- Seasonal salinity gradients are primarily controlled by Mississippi River stage and discharge along the eastern side of the basin at the river banks and delta, and secondarily by precipitation and surface runoff (Swenson 2003).

2.4.3 Conclusions

The main purpose of the DPD is to introduce freshwater in order to help maintain salinity in the basin as measured by the 5 ppt and 15 ppt isohalines (CPRA 2021 Davis Pond Operational Plan). Salinity from the ponding area through Lake Salvador has remained fresh over time, and salinities to the top of Little Lake have remained below 3 ppt for the most part. However, whether DPD operations affect the 5 ppt isohaline is difficult to determine given the dominating influence of the Mississippi River and two freshwater siphons below DPD on the eastern side of the basin. The overall general freshening of Barataria Basin over time has apparently helped maintain freshwater and intermediate vegetation, and benefitted alligators and ducks, while generally not adversely affecting key freshwater and estuarine fish and shellfish species. However, other accounts (Turner et al. 2019) have indicated that there is no evidence of net land gain or conservation after the diversion operation began and there is clear evidence of higher land loss rates (comparing loss rates between a site within and one outside of the DPD flow path) within a few years after the DPD opened.

2.5 MARDI GRAS PASS

Establishment history and summary data for Mardi Gras Pass was taken from Lopez et al. 2014 and Henkel et al. 2018, and references within these sources, unless otherwise noted.

2.5.1 Establishment History

Mardi Gras Pass (MGP) is a small, free-flowing distributary on the east bank of the Mississippi River at RM 43.7 that breached the Mississippi River levee in March 2012. MGP first began to develop during the significant Mississippi River flood in May 2011, when overbank flow during the waning flood cut a new, 630-foot-long channel across the crest of the river's natural levee, which resulted in the connection of two small, pre-existing conveyance canals associated with the Bohemia Spillway. MGP is defined as four channel segments (acting as a single hydrologic feature) extending 0.85 mile from the Mississippi River to the Back Levee Canal.

MGP discharges freshwater, nutrients, and sediment from the Mississippi River, which are then distributed by canals over a large wetland area.

During early reporting (between initial establishment of MGP in March 2012 and December 2013), the maximum hypothetical flow-through the MGP was 6,000 cfs, with a maximum observed flow-through of 3,840 cfs. The average width of the MGP expanded by about 18 feet (from 77.9 feet to 95.8 feet) from May 2012 to August 2013, with one reach expanding more than 50 feet. The MGP also deepened by up to 5.5 feet. The sediment flowing through MGP is obtained from both the Mississippi River as well as from the erosional processes within the MGP itself.

During later reporting (May through July 2017), the MGP discharge was about 14,000 cfs during the period of high river flows. Sediment moving through MGP was estimated, on average, to be 67 percent river sediment and 33 percent MGP erosion.

2.5.2 Summary of Changes to the Receiving Environment

The dynamics of the MGP have changed over time. Key results of monitoring activities through 2017 are noted below.

Freshwater and nutrient flows:

- Freshwater flow and sediment are being captured by MGP and conveyed into the receiving basin, including the Back Levee Canal, John Bayou, Fucich Bayou and Lower Grand Bayou.
- The data from CRMS 0148 (about 2 miles from the MGP) revealed that the receiving basin did not immediately freshen when MGP became free flowing (2012), but has freshened over time, especially starting in 2016. In 2016 and 2017 this CRMS station was fresh for most of the year and the peak salinities were not as high as they were before MGP opened.

- In the 2017 surveys, nitrate was elevated in the Mississippi River and MGP (between 4 to 6 milligrams/liter) and remained elevated into some of the bays around and east of the MGP, as well as within an oil and gas field that is 5.9 miles north of the MGP. Nitrate decreased in concentration in Long Bay and approximately 10 miles up the Back Levee Canal, past the oil and gas field. Phosphate followed a similar pattern to nitrate, elevated in MGP (between 0.2 and 0.25 milligrams/liter) and decreasing when reaching some of the bays at the same distance down the Back Levee Canal.

- The “sediment depleted nutrient zone” (where sediment levels decrease but nutrients are still elevated) existed between 7 and 9 miles in the later survey while the earlier survey was between 3 and 7 miles. In the later survey, both TSS and nutrients were higher than in the earlier survey. The shift of these zones further into the basin can be explained by higher MGP discharge at the time of the surveys. These zones most likely change throughout the year as MGP discharge rises and falls, and as nutrient and sediment loads in the Mississippi River fluctuate.

Sediment deposition and land-building:

- The sediment that is deposited in-channel is available for re-distribution into the surrounding marshes during storm events. The marshes in the Bohemia Spillway have experienced little land loss and appear to be very healthy, especially in recent years (aside from loss due to the dredging of navigation and oil and gas canals) and one hypothesis for this is that the sediment entering the system through the Bohemia Spillway, and now MGP, is helping to sustain these marshes (Lopez et al. 2013).

- During the earlier surveys (2012 to 2013), much of the sediment deposition occurred in the conveying bayous and canals and minimal deposition occurred in the outer bays.

- The area of greatest deposition (4.8 centimeters/month; see Figure 9) was noted in the John Bayou system where there is observational evidence of deposition indicated by the presence of new mud flats, often colonized with submerged aquatic vegetation (SAV) and/or emergent vegetation. This can be seen on Google Earth imagery from January 27, 2015 and November 20, 2016 (see Figure 10). These mudflats weren’t observed in 2014.

- Even though sedimentation rates reported here are reported as centimeters/month, this does not imply a constant rate of deposition; rates are most likely lower during times of low water and/or low sediment concentration in the Mississippi River.

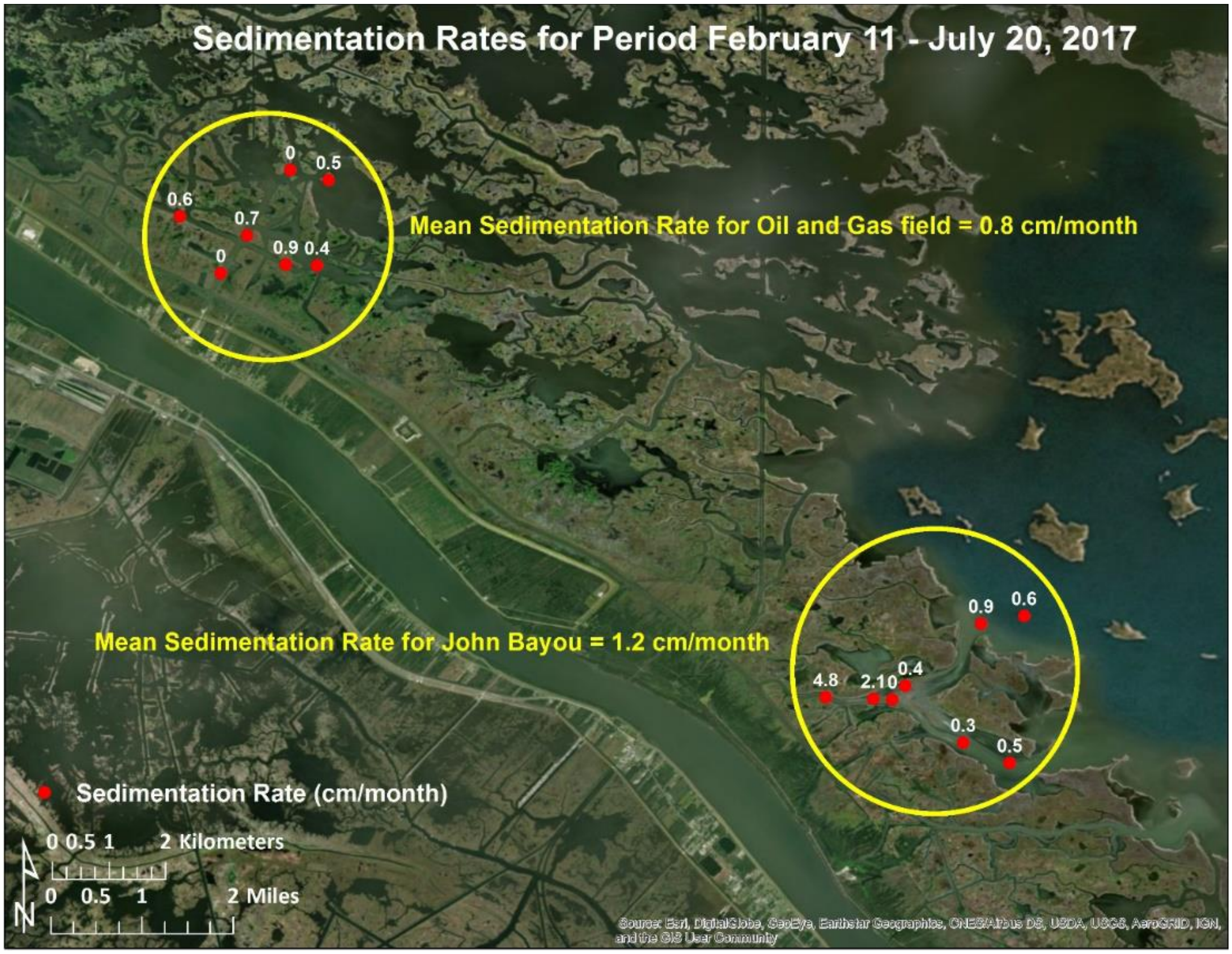

Figure 9. **Sediment deposition rates in the Mardi Gras Pass receiving basin.** These rates cover the period of February 11 through July 20, 2017. There was a higher mean rate of deposition (1.2 cm/month) in the John Bayou area than the oil and gas field (0.8 cm/month). (Photo and caption from Henkel et al. 2018, Figure 21)

Figure 10. Aerial view of John Bayou from January, 2015 and November, 2016. In the almost two years between these photos, there is noticeable deposition on the edges of John Bayou and the development of a large mudflat in Uhlan Bay. Much of the areas of deposition have been colonized by submerged aquatic and/or emergent vegetation. (Photos and caption from Henkel et al. 2018, Figure 22)

- The area of second highest deposition (0.7 centimeters/month) is about 0.5 mile north of the Back Levee Canal, at a location almost 6 miles north of MGP (see Figure 9). This deposition is also evidenced by the presence of new mud flats, often colonized with SAV and/or emergent vegetation. These mudflats weren't observed in 2014.

- Deposition in the oil and gas fields shows the potential for repairing damage done by navigation and oil and gas activities, when diversions are used to divert sediment-laden water. Observationally, there are other canals in the Bohemia Spillway that have filled in (Lopez et al. 2013). Overall, large depositional events in the receiving basin are most likely episodic, not constant.

- Sediment from the water column could remain in suspension in the middle of the channel where water is fast moving but deposit on the edge where friction slows the water down.

Flora and Fauna

- Nearly 50 juvenile Gulf menhaden (*Brevoortia tyrannus*), seven black crappie (*Pomoxis nigromaculatis*), four lady fish (*Elops saurus*) (2 to 3 inches in length), and three spotted gar (*Lepisosteus oculatus*) (less than 12 inches in length), were captured in one cast of a 7-foot-radius cast net on August 22, 2013, suggesting MGP is a suitable nursery for some fresh and saltwater species of fish.

Other Considerations:

- Henkel et al. 2018 states that, in general, hydrological, sedimentological, and water quality data portray a clear and consistent description of MGP as an effective sediment delivery system. It can be described as a channelized, asymmetric, radial plume delivering MGP discharge and sediment through 36 pre-existing channels extending through an area of 15,000 acres.

- The Back Levee Canal is the most important feature influencing the delivery of water, sediment, and nutrients from MGP because it disperses sediment into a channel network over a very large area of marsh instead of being transported directly to the sound, where sediment would be deposited in deep water and would be less likely to benefit the marsh.

2.5.3 Conclusion

MGP is a relatively small, semi-natural channel that developed over time and is continuing to expand. The sediment input provided (sourced from both the Mississippi River and erosional forces within MGP itself) has been observed to create mudflats with SAV and emergent vegetation. These mudflats appeared within 5 years of MGP establishment. Increased nutrients and freshwater extend beyond the influence of sediment deposition and salinities in the receiving bays have decreased over time. Henkel et al. (2018) noted that the presence of MGP has helped to maintain and create land in its outfall area.

2.6 BONNET CARRÉ SPILLWAY

Establishment history and summary data for the Bonnet Carré Spillway was taken from GEC 2009 (and references therein) unless otherwise noted.

2.6.1 Establishment History

The Bonnet Carré Spillway is a Corps of Engineers flood control project located about 25 miles upriver from New Orleans, Louisiana on the site of an old crevasse (levee breach) (Figure 11). It is designed to divert water from the Mississippi River to Lake Pontchartrain during high water events to alleviate pressure on the Mississippi River levees. The Bonnet Carré Spillway is designed to divert up to 250,000 cubic feet per second (cfs) (design capacity) of the main channel flow and is opened, when necessary, to prevent the Mississippi River from reaching 1,250,000 cfs in New Orleans (USACE 2012).

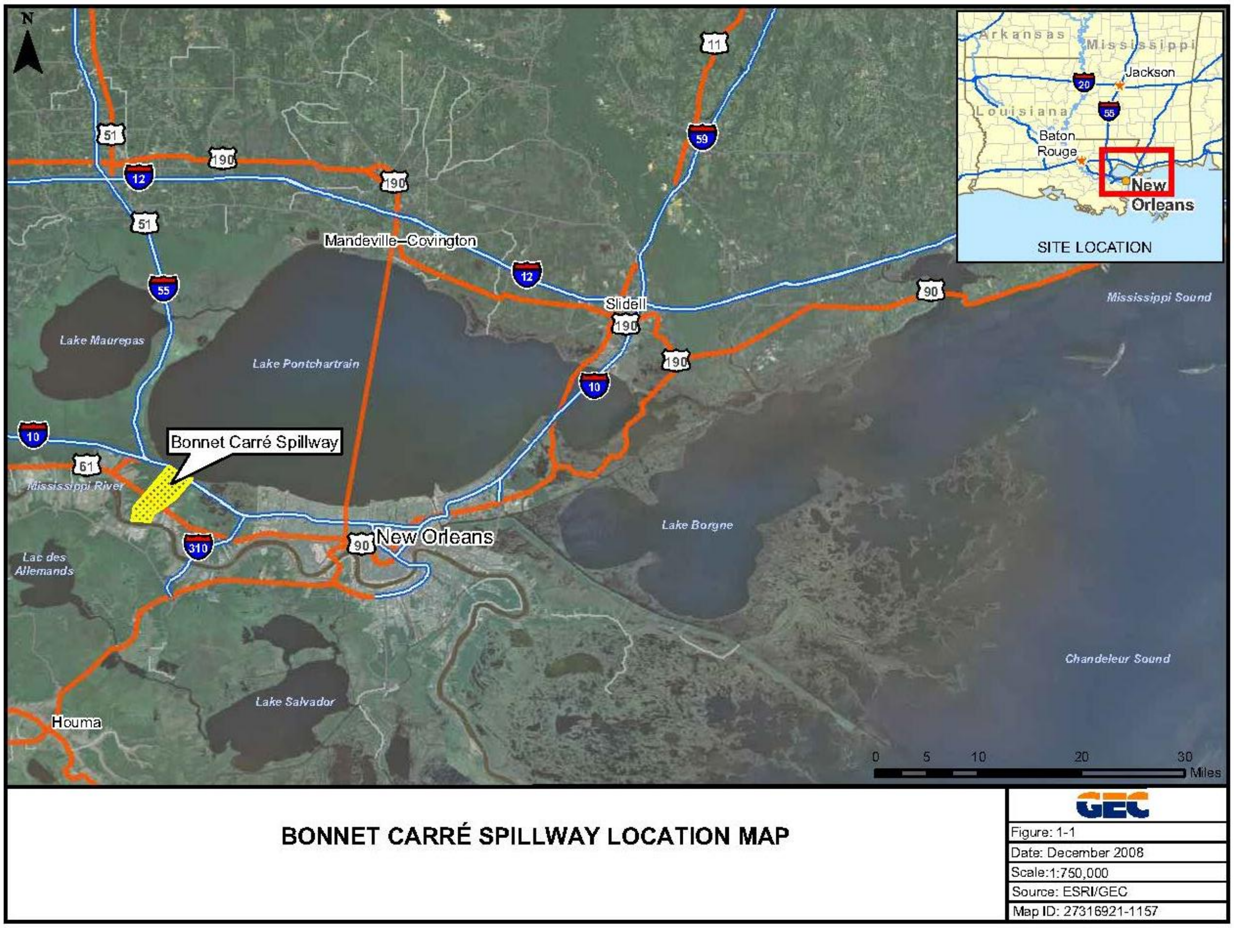

Figure 11. Bonnet Carré Spillway Location Map. (Figure from GEC 2009)

Construction of the Bonnet Carré Spillway began in 1928 and was finished in 1931. The spillway structure is a 7,000-foot-long concrete weir consisting of 350 bays. Each bay holds 20 pine needles (timber pins) that can be lifted out of the structure by two cranes. The pins do not fully seal the structure and water constantly leaks into the floodway when the river is above the level of the weir. The spillway between the river and Lake Pontchartrain is 5.7 miles long and is bordered on the north and south by 19-foot-high guide levees. Water released into the spillway flows from the Mississippi River into Lake Pontchartrain and then through an 8-mile-long strait (called the Rigolets) and Chef Menteur Pass into Lake Borgne. Lake Borgne, because of land loss, is a bay with an open connection to the Gulf of Mexico.

As of the 2008 report, the spillway had been opened nine times during high water events since construction: 1937, 1945, 1950, 1973, 1975, 1979, 1983, 1997, and 2008. During each of these events, the spillway was open between 13 and 75 days (average of about 39 days), with a maximum throughput between 110,000 and 318,000 cfs (average of about 212,000 cfs). In 2008, the spillway was partially opened on April 11 and remained open until at least May 8. The maximum flow during the 2008 opening was 160,000 cfs with an average flow of 113,000 cfs. Subsequently, the spillway has been opened in 2016, 2018, 2019 (twice), and 2020.

2.6.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2008 are noted below, with additional notations for the 2016 and 2019 openings, where identified.

Freshwater and nutrient flows:

- Freshwater inputs to Lake Pontchartrain, Lake Borgne, and the Mississippi Sound from other rivers make it difficult to attribute environmental conditions to effects of the Bonnet Carré Spillway. Although low salinities (0.2 ppt) were observed at several stations in Lake Pontchartrain in 2008 after the spillway was opened, salinities were low at some stations before the spillway was opened.

- After the 1997 spillway opening (from March 17 to April 16), salinities in Lake Pontchartrain were lower than the historical average, particularly during the spring, although summer salinities were higher than the historical average. Surface salinities of 0 ppt were recorded at the westernmost stations in Mississippi Sound during March and were recorded at all stations in the Mississippi Sound by the week of April 16. The salinities then gradually increased at all stations. Mississippi Sound bottom salinities did not reach 0 ppt in all places. Surface and bottom temperatures decreased through the middle of April then increased. However, there was also high river flow from the Pearl River into Mississippi Sound during this time period, making separation of the influences of the spillway and the Pearl River impossible.

- The 2016 spillway opening did not appear to influence the phytoplankton community as conditions were not favorable for a bloom (cold mixed water column). Cyanobacteria blooms were extensive during the second Bonnet Carré Spillway opening in 2019 that spanned from mid-May through the end of July (which had a maximum discharge of 213,000 cfs; USACE 2022a).

- After the 2019 openings, dissolved oxygen levels were extremely low in many areas (including hypoxic areas); LDWF noted additional fish kills were likely until water temperatures cooled, in the fall (LDWF 2019). Whether LDWF identified additional fish kills is unknown.

Sediment deposition and land-building:

- There did not appear to be an obvious difference in Secchi disk depths (a measurement of turbidity) in Lake Pontchartrain after the 2008 spillway opening. River output before and after the spillway opening likely affected turbidities in the lake, as did the passage of Hurricanes Gustav and Ike in late August and September. During the 1997 spillway opening, Secchi disk visibilities were lower than the historical averages (through the 2008 reporting period), although summer visibilities were higher than historical averages.

- The Bonnet Carré Spillway is an emergency flood control structure that is intended to divert fresh water to relieve pressure on downstream levees; the diversion of sediments is not part of its operational design.

Flora and Fauna

- The 1997 and 2008 openings did not appear to have any obvious effects on oyster numbers in the samples collected, at least on a short-term basis. Oyster mortalities were reported after the 1945 and 1973 openings; however, Dugas and Perret (1975) indicated that there was a net increase in oyster production after the 1973 opening. Another study found that oysters farther away from the spillway (such as those in southern Louisiana and eastern Mississippi Sound) may benefit from the spillway opening, whereas reefs closest to the spillway opening (northern Mississippi Sound and near the mouth of the Pearl River, which also discharges freshwater) may be adversely affected.

- The 2008 opening had little overall effect on the distribution of fishes and aquatic organisms, with only three species identified as having significantly lower catches than other years tested, including Atlantic croaker, and sand seatrout in Lake Pontchartrain (catches of these species in Lake Borgne were higher in 2008 than in other tested years) and spot in Lake Borgne.

- Although blue crab landings data for 2008 were incomplete at the time of the referenced report, catches for the first 9 months suggest that 2008 landings would be similar to other years. Previous studies have reported higher catches of blue crabs in Lake Pontchartrain during high river flow years when the spillway was open and in Lakes Pontchartrain and Maurepas during other low salinity periods. As noted in Chapter 3, Section 3.10.5.2.3 (Blue Crab) in the Final EIS, a general decline in adult blue crab abundance has been observed in trawl data (West et al. 2016); however, observed landings for Louisiana have remained high since the late 1980s.

- The spillway was opened twice in 2019, for a total of 123 days. Those openings occurred during the 2018 through 2019 Mississippi River flood, which was the longest lasting flood on record since 1900, when records became available. That flood event resulted in a declared fisheries disaster that, per LDWF's preliminary sampling results in September 2019 (LDWF 2019) caused:
    - Mortality on public oyster reefs (up to 100 percent mortality, with the lowest recorded 2019 stock in history), recorded in: St. Bernard Parish: 77-100 percent
        - East side of the Vermilion/Atchafalaya Basin: 87-100 percent
        - West side of the Vermilion/Atchafalaya Basin: 76-80 percent

  - Calcasieu Lake: 2-89 percent, with the higher mortality found in the northern part of the lake

  - Sabine Lake: up to 74 percent.

- Statewide brown shrimp catch per effort was 70 percent below average in LDWF 6-foot trawl samples in April and 62 percent below average in LDWF 16-foot trawl samples from March through June. White shrimp catch per effort in LDWF samples from July through August was 27 percent below average. Volume of brown shrimp landings was down 74 percent in the Pontchartrain Basin and 72 percent in the Calcasieu Basin.

- Statewide monthly blue crab catch per effort in LDWF sampling was down more than 46 percent from March through May, above average in June and July, and down approximately 13 percent in August. Catch-per-unit-effort (CPUE) declined in most individual basins; the largest declines were in the Vermilion-Teche and Terrebonne basins.

- CPUE of spotted seatrout was 66 percent below average in the Vermilion-Teche Basin, 50 percent below average in the Pontchartrain Basin, and 48 percent below average in the Calcasieu Basin. Statewide CPUE was 2 percent below average.

- Black drum landings were down (42 percent) in the Vermilion-Teche Basin and the Calcasieu Basin (44 percent). Statewide commercial landings were down 2 percent in 2019.

- Commercial sheepshead landings in the Terrebonne and Calcasieu basins were down 50 percent and 48 percent, respectively. Statewide commercial sheepshead landings were up 57 percent.

- Few invasive species were collected in the Bonnet Carré impact area, though Asian carp were abundant in the outfall area.

- Measurable negative impacts on freshwater fisheries were minimal during the sampling period; only small fish kills were reported in the upper and lower Atchafalaya Basin and in Spring Bayou (Avoyelles Parish).

- Wild crawfish landings decreased by 18 percent in the Atchafalaya Basin and by 16 percent statewide. High catches have been reported east of the Mississippi River where floodwaters have inundated nearby marsh habitat.

- Following the closure of the Bonnet Carré Spillway, the USACE, U.S. Fish and Wildlife Service (USFWS), and LDWF collected 17 pallid sturgeon and 208 shovelnose sturgeon entrained below the spillway and released them back into the Mississippi River. In addition, one Gulf sturgeon was released into Lake Pontchartrain; one pallid sturgeon and 43 shovelnose sturgeons were found dead.

  - Four black carp were collected, marking the southernmost collection location of black carp.

Other Considerations:

- According to the respondents of a use survey for Lake Pontchartrain in 2008, the spillway opening had a negative effect on the quality of fishing from May through July and caused a modest reduction in the number of fishing trips taken and a modest shift in the areas fished. The shift was primarily from the west to east. Crabbing was also negatively affected, but partly because many of the interviewed crabbers operated from banks or piers. Pleasure boating was not affected. The results of the opening in 2008 are similar to those of the 1997 opening.

- Use of the spillway tended to be continuous, with frequent users concentrated in the New Orleans area. The primary uses are crabbing, bank fishing, ATV riding, motorcycling, picnicking, and boating and water skiing. The spillway was unusable for many activities while the diversion of water from the Mississippi River occurred. When the spillway gates were closed, many people enjoyed the improvements in fishing and crawfishing. Once all of the areas that had been open prior to the flooding were reopened, spillway users continued with their normal activities. The primary effects of spillway opening were a minor reduction in the number of trips that would have been made and a temporary reduction in the number of people per group. The results of the opening in 2008 are similar to those of the 1997 opening.

2.6.3 Conclusions

The Bonnet Carré Spillway is a man-made emergency flood control structure that is not operated for ecological purposes and is not intended to move sediments and build land. Spillway operation has both positive and negative impacts, with the nature and significance of those impacts dependent on the timing, volume, and duration of freshwater flows.

2.7 DELTA MANAGEMENT AT FORT ST. PHILIP

Establishment history and summary data for Delta Management at Fort St. Philip was taken from Hymel and Blanche 2019 and Suir et al. 2014, and references within these sources, unless otherwise noted.

2.7.1 Establishment History

The Delta Management at Fort St. Philip project is at the southern end of the Breton Sound Basin across two areas (Subarea 1 and Subarea 2) near Mississippi RM 19.5 AHP in Plaquemines Parish, Louisiana. The Fort St. Philip diversion comprises artificial crevasses (uncontrolled diversions) designed to convey sediment-rich water from the

Mississippi River. The project combines marsh terracing with the artificial crevasse features. The crevasses and associated subareas are depicted on Figure 12.

Subarea 1 is 856 acres with 19,600 linear feet of terraces and three dredged crevasses. Subarea 2 is located near Little Coquille Bay approximately 4.5 miles east of Subarea 1, and consists of 490 acres with three dredged crevasses. Construction of the Project was completed in November 2006.

As summarized by Hymel and Blanche (2019), during a 1973 flood event, a natural crevasse formed on the eastern bank of the Mississippi River in the vicinity of Fort St. Philip causing the establishment of intermediate marsh in the area by 1978; by 1988, a band of fresh and intermediate marsh had formed adjacent to the river, with the remainder of the area classified as brackish and saline. However, there was an overall net loss of land in the years following the 1973 crevasse formation due to physical scouring of the diverted water combined with regional subsidence and episodic storm events. In 1997 (prior to the construction of the Delta Management Project), the overall area affected by the 1973 crevasse was classified as fresh and intermediate marsh, with the two Delta Management Subareas entirely intermediate marsh and supporting a diverse assemblage of vegetative species across a broad salinity gradient due to the influences of both the Mississippi River and Breton Sound.

The Delta Management at Fort St. Philip Project was designed to create 244 additional acres of emergent marsh through the construction of crevasses (174 additional acres were projected to accrete naturally without the project) and create 25-acres of emergent marsh through terrace construction. The objective was to enhance natural marsh growth by diverting fresh, sediment-laden water through the dredged crevasses into shallow, open water receiving areas. The earthen terraces constructed in Subarea 1 are designed to reduce the fetch distance for wind-induced waves while also trapping sediment, thereby promoting the marsh-building processes. Vegetative plantings were also conducted on the terraces. Since construction (completed in 2006), significant infilling has been observed in the crevasse channels and was expected.

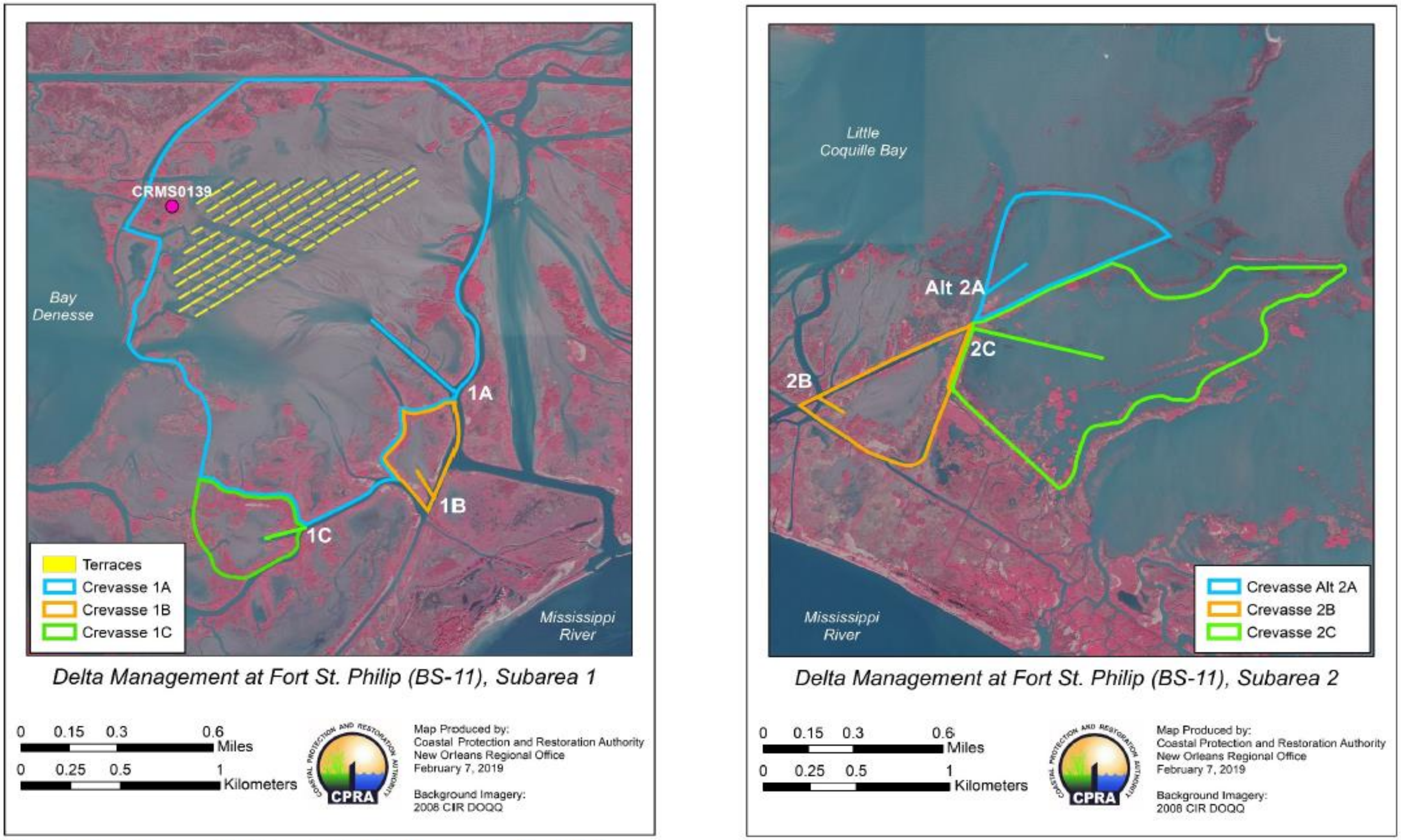

Figure 12. **Project Features within the Fort St. Phillip Delta Management Project Area.** (Figures taken from Hymel and Blanche 2019, Figures 2 and 3)

2.7.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through 2019 are noted below.

Freshwater and nutrient flows:

- The project objective is to enhance natural marsh growth by diverting fresh, sediment-laden water through the dredged crevasses into shallow, open water receiving areas.
- The project is an uncontrolled diversion such that flow is variable.
- Above average annual river stage from 2015 to 2018 (measured at USACE Gauge 01480 near Venice, Louisiana) most likely enhanced the performance of the project through increased sedimentation and scouring of the crevasse channels (which allows continued flow into the receiving bays).

Sediment deposition and land-building:

- The initial formation of natural crevasses near Fort St. Philip (in 1973) resulted in diverted river water physically removing significant marsh areas around Fort St. Philip (a 7,391-acre study area). These initial direct impacts were succeeded by several decades of larger regional loss patterns driven by subsidence and other episodic events (for example, hurricanes and floods), and recent (1998 through 2008) localized land gains. These increases in land area are potentially the long-term results of the Fort St. Philip crevasses, and the short-term impacts of delta management activities. However, for the majority of the 1956-2008 period of analysis, the crevassing of the eastern bank of the Mississippi River levee was noted as a loss accelerant in the Fort St. Philip area.
    - Since the beginning of the period of analysis in 1956, the final of five study periods (1998-2008) was the only period with observed net land gain; an 18 percent increase in 1998 land acreages, and a 6 percent increase in 1956 land acreages. The authors presume that the gains are the effects of the crevasses (gains were in close proximity to crevasse channels) and the results of the CWPPRA BS-11 restoration project.
- Land/water analysis results show that land gains since the Fort Saint Philip Delta Management Project was constructed were minimal by year 5 post-construction (2011) but increased dramatically between year 5 and year 11 (2011 to 2017). The project area gained 75 acres of land (6 percent) from 2002 to 2006, due in part to direct land creation through terrace construction (completed in 2006) and spoil deposition along the crevasse channels. Fifteen more acres of land (1 percent) were gained within the project area from 2006 to 2011 (years 1 to 5) for a net gain of 90 acres from 2002 to 2011.

Reference Area 1 gained more land from 2006 to 2011 than any of the project receiving bays.

- Significant land gains were observed within all six crevasses between years 5 and 11 (2011 to 2017), and increased sedimentation was observed through elevation surveys. The project area gained 125 acres from 2011 to 2013 and 328 acres from 2013 to 2017 for a total gain of 453 acres of land (+34 percent) during this period.

- Despite significant infilling observed within the crevasse channel, Crevasse 2C (see Figure 12) experienced the greatest percent change of 46 percent with an increase of 139 acres from 2011 to 2017. It is possible that the Crevasse 2C receiving basin is also receiving sediment input at multiple openings along its eastern boundary.

- Crevasses 1B and 1C, which are the smallest of the six crevasses, showed land gains from 2011-2013 but no further land gains from 2013 to 2017; however, these two crevasses now contain 77 percent and 78 percent land in 2017, respectively, with significant infilling of the crevasse channels by 2016. Therefore, further land gains within these crevasses may be self-limiting.

- The total land acreage within the project area by 2017 was 797 acres (59 percent) and the overall land gain in the project area from 2002 to 2017 was 543 acres (+40 percent) with 332 acres gained in Subarea 1 and 211 acres gained in Subarea 2, which surpassed the project goals.

Elevation surveys within analyzed receiving bays also showed gains in sediment volume and surface elevation between years 5 and 10 post-construction, although there was an initial loss in volume between years 1 and 5 as splay formation and scour occurred.

Flora and Fauna

- As surface elevation increased, all six receiving bays showed a progression toward the optimum flooding range for marsh productivity (10 to 90 percent inundation) by year 10. This was reflected by an increase in vegetative colonization of the newly formed crevasse splays by 2016.

- *Sagittaria platyphylla* (delta arrowhead) was generally the first species to establish as surface elevation became subaerial. Within the terrace field, the percent composition of vegetative species has become increasingly similar to the natural surrounding marsh at CRMS 0139 from 2007 to 2016.

2.7.3 Conclusions

Delta Management at Fort St. Philip involves a combination of six man-made crevasses and construction of march terraces in the vicinity of a natural levee breach and crevasse that formed during flooding in 1973. The crevasses are uncontrolled; however, the project was documented to reduce Mississippi River flow by about 10,930 cfs during one measurement. Although the initial river breaching in 1973 resulted in land loss, the sediment input provided by the Fort St. Philip Delta Management Project crevasses has been observed to create land and emergent marsh, with most gains observed between 5 and 11 years post-construction.

2.8 DELTA-WIDE CREVASSES IN THE BIRDFOOT DELTA

Establishment history and summary data for the Delta-wide Crevasses (MR-09) project was taken from Gossman and Gisclair 2018, and references within these sources, unless otherwise noted.

2.8.1 Establishment History

The Delta-wide Crevasses Project, funded through the CWPPRA and sponsored by the National Marine Fisheries Service (NMFS) and CPRA, is a series of small, uncontrolled sediment diversions located in Plaquemines Parish to the southeast of Venice, Louisiana on the active Mississippi River Delta (see Figure 13). The project consists of maintaining presently existing crevasses, the construction of new crevasses, and future maintenance of selected crevasses in both the Pass A Loutre Wildlife Management Area (PALWMA) and the Delta National Wildlife Refuge (DNWR). The PALWMA covers 66,000 acres between Pass A Loutre and South Pass and is owned and managed by the LDWF. The DNWR covers 48,000 acres from just north of Main Pass southward to Pass A Loutre and is owned and managed by the USFWS. Implementation of this project is ongoing in phases, with initial construction of a set of crevasses completed by 1999 (Phase I) and additional crevasses completed in 2005 (Phase II) , 2014 (Phase III), and 2021 (Phase IV). The objective of the Delta-wide Crevasses Project is to promote the formation of emergent freshwater and intermediate marsh in shallow open water areas through the construction of new and maintenance of new and existing crevasse splays.

2.8.2 Summary of Changes to the Receiving Environment

Key results of monitoring activities through October 2018 are noted below.

Sediment deposition and land-building:

- The total land gain recorded for the MR-09 Project area since construction is 739 acres, with an average land gain of 32 acres per crevasse and the largest single crevasse gain of 164 acres.
    - The largest land gains were observed in the oldest crevasses with an average of 44 acres built per Phase I (1999) crevasse and 13 acres per Phase II (2005) crevasse. Phase III (2014) crevasses had an average gain of 8 acres per crevasse from 2012 (preconstruction) to 2016.

    - Certain crevasses were no longer delivering much sediment or fresh water to the receiving bays, although conditions still exist that allow for land creation through vegetative expansion of the existing marsh. This is not unexpected, as it is understood that crevasse-splay development is a temporary event that is rarely active for more than 10 to 15 years.

- Eleven of the 12 crevasses surveyed showed increases in elevation within the receiving bays. Individual crevasses had increases of as much as 2.96 feet in elevation (Crevasse 20, a Phase I crevasse).

Flora and Fauna

- For the most part, vegetative percent cover decreased in the 2007 and 2012 surveys, and recovered in the 2017 survey, although not to levels seen in the early surveys following construction. Some of this decline is attributable to the survey methodology itself, in which stations without vegetation are still surveyed and included in the mean. Although percent cover has been variable, the total vegetated area has increased within the receiving bays, as evidenced by increases in land/water ratios and the addition of new vegetation plots along transects.

- Percent vegetation cover data of individual species across all survey plots in 2017 indicated a shift in species composition, with a general trend of *Phragmites australis* (common reed) dominated coverage as the crevasse splays age. Other dominant species included *Zizaniopsis miliacea* (giant cutgrass) and *Sagittaria* spp. (including *S. lancifolia*, *S. latifolia*, and *S. platyphylla*) in the 2017 surveys.

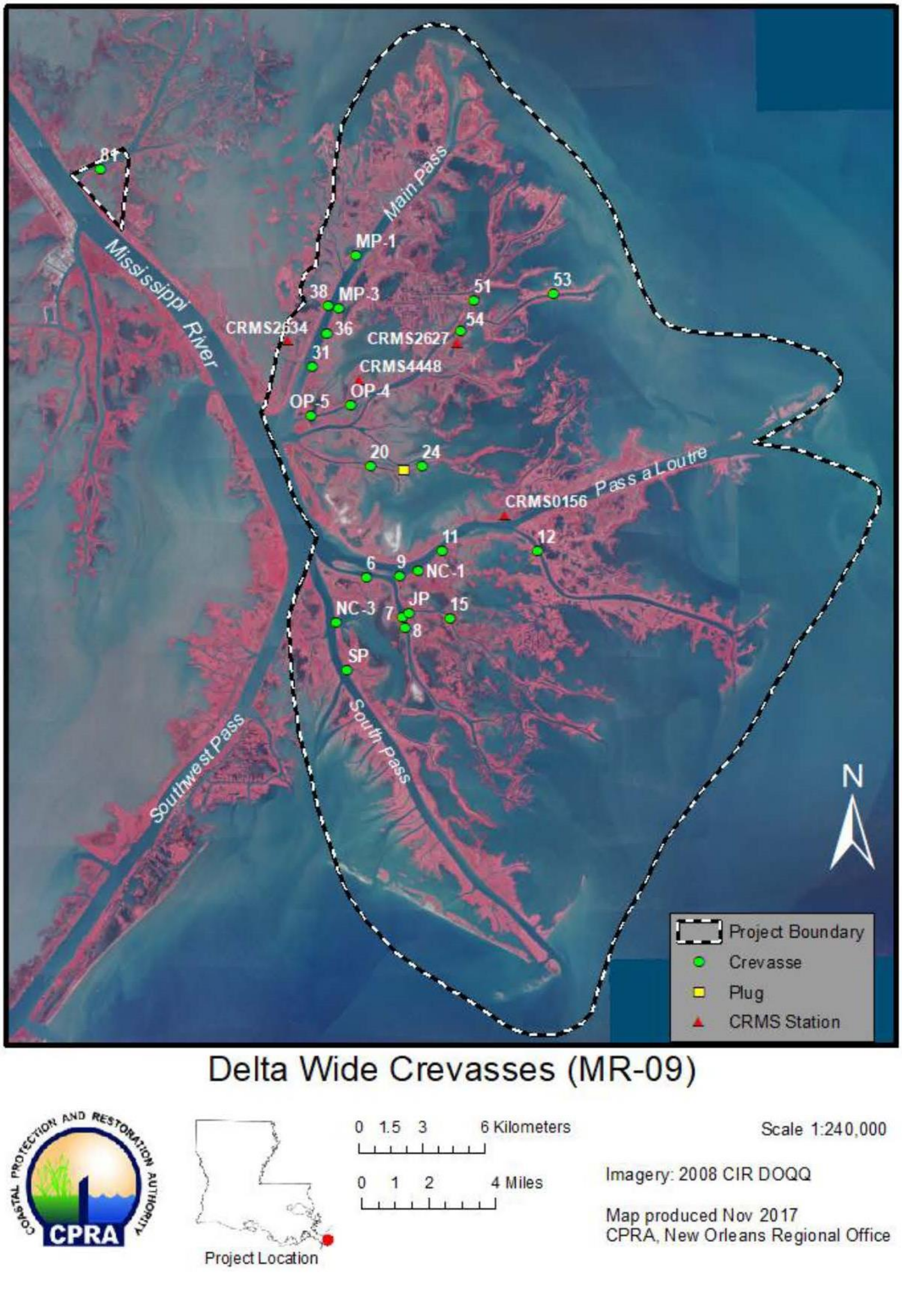

Figure 13. Delta-Wide Crevasses (MR-09) Project Boundary and Features (Figure and caption taken from Gossman and Gisclair 2019, Figure 1).

2.8.3 Conclusions

The Delta-wide Crevasses Project includes the construction and maintenance of man-made crevasses that allow for land-building and vegetation growth in both the outfall areas, and within the crevasses themselves. Land-building within the crevasses results in their eventual closure, with the throughput of fresh water and sediment expected to occur for 10 to 15 years. Water and sediment throughput was not included in the referenced report, but would be expected to increase or decrease naturally along with Mississippi River flow.

2.9 WAX LAKE AND ATCHAFALAYA DELTAS

Establishment history and summary data for Wake Lake and Atchafalaya Deltas was taken from Twilley et al. 2019, and references therein, unless otherwise noted.

2.9.1 Establishment History

2.9.1.1 Wax Lake Delta

Wax Lake Delta (WLD), as depicted in Figure 14, is a bayhead delta forming at the mouth of the Wax Lake Outlet (a flood control channel constructed in 1942) located in the Wax Lake-Atchafalaya Delta lobe complex, which is the most recent of the Mississippi River early Holocene delta lobes. The Wax Lake Outlet conveys about 30 percent of the Atchafalaya flow since the canal was expanded in the 1970s.

As the Wax Lake Outlet emptied into the proximal sedimentation region of Atchafalaya Bay, the resulting bed friction and decreasing flow velocities resulted in the formation of distributary mouth bars and bifurcating distributary channels. The Wax Lake-Atchafalaya Delta lobe complex began developing sub-aqueously in the early 1950s, but subaerial land exposure was achieved by elevated sand transport during the flood of 1973.

The present settlement load to the delta is 25 to 38 metric tons/year of which 18 percent is sand. WLD subaerial land growth rate is estimated to be 2.62 square kilometers/year with a current areal extent of 70 square kilometers. The WLD, in contrast to the Atchafalaya Delta forming to the east, had very little maintenance dredging during its growth and none after the early 1980s. Therefore, its growth has proceeded “naturally” as the result of river re-occupation with a maximum sediment retention efficiency of approximately 19 percent between 1981 and 1989.

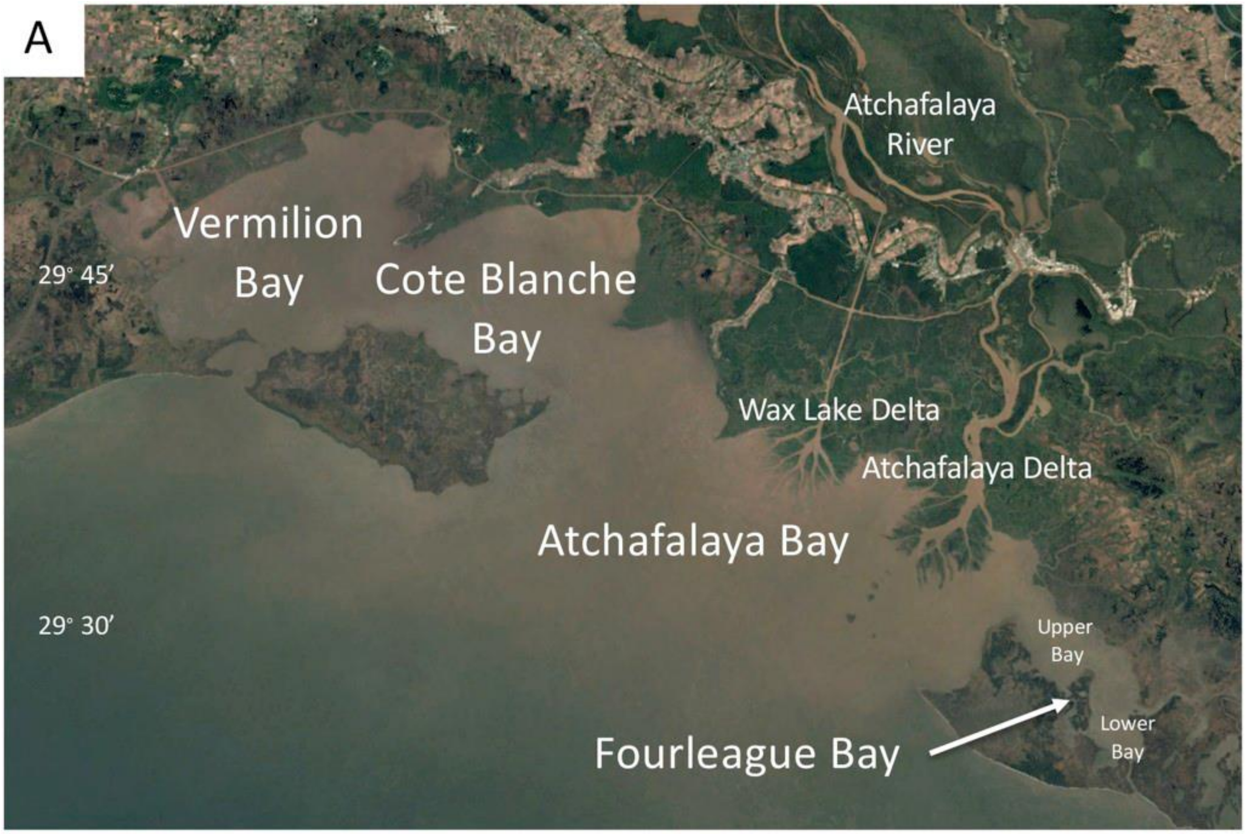

Figure 14. Map of the large delta estuaries of the Atchafalaya River that include Fourleague Bay, Atchafalaya Bay, Cote Blanche Bay and Vermilion Bay. (Figure and caption from Twiley et al. 2019, Figure 4a.)

2.9.1.2 Atchafalaya Delta

The Atchafalaya Coastal Basin represents the largest river diversion along the Lower Mississippi River that controls alluvial processes forming the emergence of an active coastal basin in the Mississippi River Delta. During the 1950s it became clear that a natural delta-switching event was occurring, and the Mississippi River would soon take the course of the Atchafalaya River. U.S. Congress authorized the construction of the Old River Control Structure in the upper region of Atchafalaya Coastal Basin in 1954, designed to prevent the Mississippi River from changing its course, serving as a river diversion that enhanced sediment supply to the Atchafalaya Coastal Basin. The Old River Control Structure represents the only location where a distributary outlet has been maintained in the lower deltaic plain of the Mississippi River, emptying 30 percent of the combined flow of the Red and Atchafalaya Rivers down to Atchafalaya Bay. The Atchafalaya River has a mean flow of about 180,100 cfs with a flood peak from December to June with a mean of about 388,460 cfs. On an annual basis, this diversion at the Atchafalaya River delivers about 40 metric tons/year of sediment (estimates for 2008 to 2010), which represents approximately 31 percent of total Atchafalaya and Mississippi discharge. Longer-term (1976 to 2006) estimates of sediment delivery of the Atchafalaya River are higher (about 69 metric tons/year; Blum and Roberts 2009). The Atchafalaya River Delta is depicted in Figure 15.

2.9.2 Summary of Changes to the Receiving Environment

Key results from Twilley et al. (2019) are noted below.

Freshwater and nutrient flows:

- River discharge represents nearly 98 percent of the freshwater into both delta estuaries and only 2 percent from local precipitation and runoff.
- Less than 5 percent of Atchafalaya River discharge enters Fourleague Bay but it exerts a strong influence on material fluxes and biogeochemistry in both wetland and tidal channel systems on the time scale of days to weeks.

Sediment deposition and land-building:

- The Wax Lake Outlet emptying into Atchafalaya Bay resulted in bed friction and decreasing flow velocities resulting in the formation of distributary mouth bars and bifurcating distributary channels. The Atchafalaya-Wax Lake Delta complex began developing sub-aqueously in the early 1950s, but subaerial land exposure was achieved by elevated sand transport during the flood of 1973. In studies from 2009, the sediment load to the delta was estimated to be 2.62 kilometers^2/yr.
- Water level changes during switching of winds from south to north can be 1- to 2-meter differences, increasing the inundation of adjacent marshes in Fourleague Bay, leading to sheet flow and sedimentation on the marsh surface.
- Sedimentation in both proximal and distal delta wetlands are influenced by river discharge in combination with meteorological and astronomical tides.
- The WLD is advancing at a rate of about 0.27 kilometer per year (National Audubon Society 2013).
- Fairly even amounts of emergent marsh and emergent woody vegetation are growing on land newly formed from sediments entering through the mouth of the Atchafalaya River and Wax Lake Outlet. Some land has also been formed from beneficial use of dredged material by the USACE. Most of this newly formed land is in the Atchafalaya Delta Wildlife Management Area (WMA; National Audubon Society 2013).

Flora and Fauna

- The newly created land with the WMA provides important cover and stopover habitat for migrating birds (National Audubon Society 2013).

- Freshwater vegetation expanded in the Atchafalaya Coastal Basin since 1949 on newly emergent landscapes in contrast to migration of intermediate and brackish marshes landward in the Terrebonne Coastal Basin (east of the Wax Lake and Atchafalaya Deltas). Salt marsh vegetation increased by 25 percent in the Terrebonne Coastal Basin compared to a 90 percent decrease in the Atchafalaya Coastal Basin since 1949.

- The Atchafalaya Basin is unique among the Louisiana coastal basins because it has a growing delta system with nearly stable wetlands. Wetland loss is minor in the areas north of Atchafalaya Bay when compared to the other basins (CWPPRA 2022).

- 101 species of nekton have been documented in waterways and flooded tidal marsh habitats on the Atchafalaya and Wax Lake details. High rates of nekton productivity on the deltas are driven by seasonal riverine flooding that inundates large areas of marsh habitat and the abundance of SAV. Flood marsh and areas with submerged vegetation both provide critical areas of high-quality habitat for resident species and optimum nursery conditions for juvenile marine transient nekton (Piazza 2014, and references therein).

Other Considerations:

- The sequential passage of cold fronts when peak river discharge occurs during winter-spring, followed by lower water stands from calm winds and low river discharge in summer-fall form a cyclic hydrological pattern in the Atchafalaya River Delta estuaries. Basically, Fourleague Bay undergoes a transformation from a near-riverine estuary in the winter-spring season to a near-marine lagoon in the summer-fall season.

2.9.3 Conclusions

The Wax Lake and Atchafalaya Deltas are the product of natural (Atchafalaya River, with a man-made water control structure) and man-made (Wax Lake Outlet for flood control) features that supply fresh water and sediment to the Atchafalaya Coastal Basin. Collectively, these deltas have contributed to the growth of a coastal deltaic floodplain in the proximal sedimentation region of Atchafalaya Coastal Basin along with stable estuarine marshes in distal sedimentation region, demonstrating the value of long-term riverine influence by preventing loss of wetland platform elevation.

2.10 MISSISSIPPI RIVER GULF OUTLET (MRGO)

Establishment history for the Mississippi River Gulf Outlet (MRGO) was taken from USACE 2022b and summary data was taken from the Pontchartrain Conservancy 2022b and USACE 2008, and references within these sources, unless otherwise noted.

2.10.1 Establishment History

The MRGO was authorized by U.S. Congress in 1956, and completed in 1958, to provide an emergency outlet from the Mississippi River in the interest of National defense and general commerce and as a safer and shorter route than the Mississippi River between the Port of New Orleans and the Gulf of Mexico. The MRGO extends 76 miles from the Inner Harbor Navigation Canal in New Orleans (which is connected to the Mississippi River by a lock) and the Gulf Intracoastal Waterway to the 38-foot depth contour in the Gulf of Mexico. All reaches of the MRGO navigation channel were authorized as a 36-foot deep, 500-foot bottom width waterway with the exception of the Bar Channel in the Gulf of Mexico which was authorized as a 38-foot deep, 600-foot bottom width waterway. The channel was dredged through shallow bays, coastal marshes and cypress swamps (see Figure15).

When Hurricane Katrina hit the Gulf Coast in August 2005 with storm surge of up to 28 feet (NOAA 2022), the parishes of Southeast Louisiana and counties of coastal Mississippi suffered widespread flooding and severe wind damage. Hurricane Katrina caused shoaling in the MRGO channel which limited its depth to 22 feet, and thus restricted deep-draft vessel access. Many deep-draft reliant businesses were severely impacted by storm damages and the limited navigability on the channel. Some companies chose to relocate while others were left to decide how to recover. Following Hurricane Katrina, in June 2006, the U.S. Congress requested a plan for de-authorization of the MRGO (see Public Law 109-234). On June 5, 2008 the Assistant Secretary of the Army for Civil Works forwarded the Final MRGO Deep-Draft De-authorization Report to Congress, officially de-authorizing the MRGO from the Gulf Intracoastal Waterway (GIWW) to the Gulf of Mexico as a federal navigation project and allowing construction of a closure structure across the channel at Bayou La Loutre.

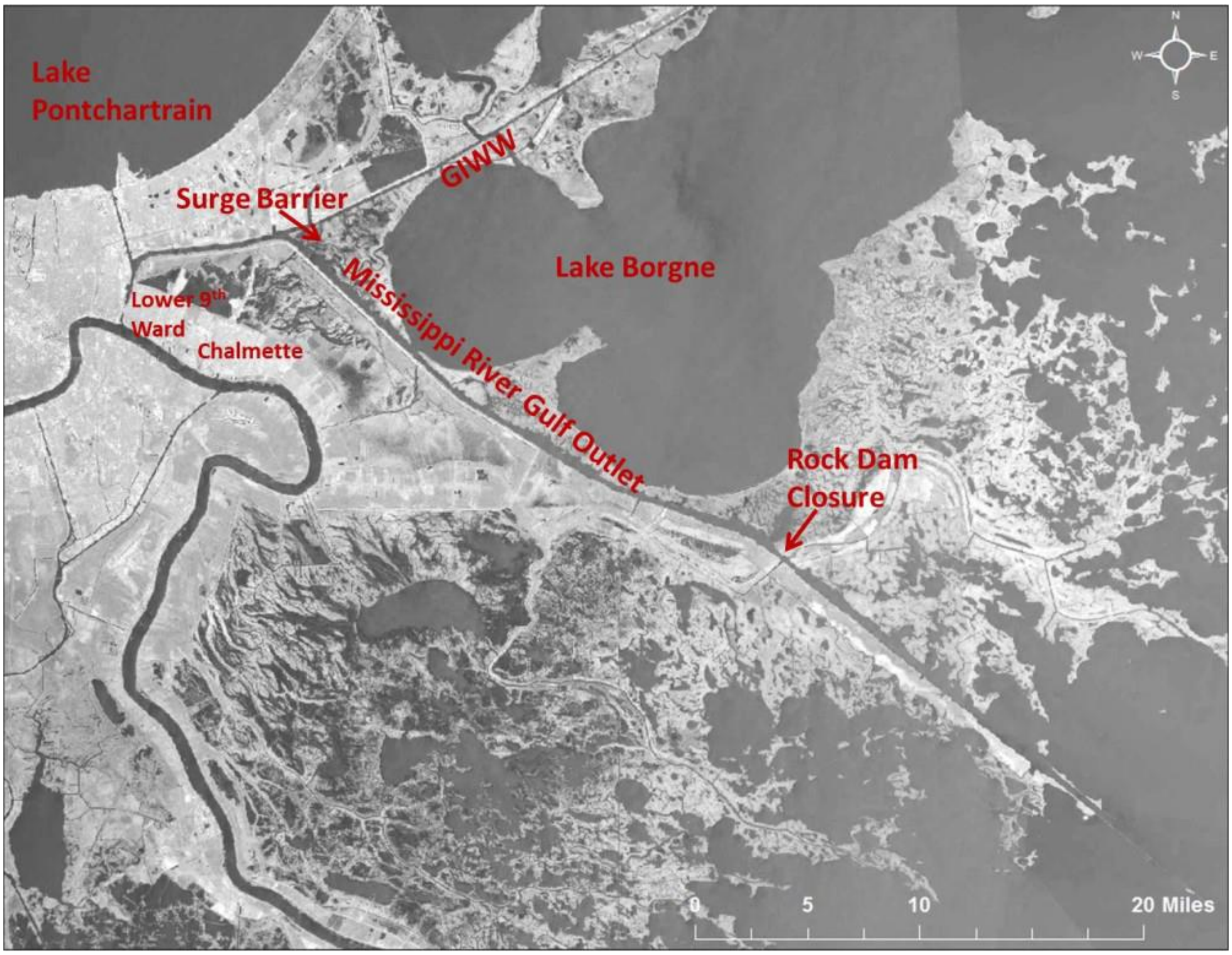

Figure 15. Location of the Mississippi River Gulf Outlet. (Photo from Pontchartrain Conservancy 2022b)

2.10.2 Summary of Changes to the Receiving Environment

When the MRGO Project was built, approximately 3,150 acres of marsh, 100 acres of wetland forest and 830 acres of shallow open water were converted to the deep water navigation channel between the GIWW and the Gulf of Mexico. When the USACE dredged the channel, it allowed saltwater to flow inland from the Gulf. The saline waters brought in by the MRGO may have caused the following habitat shifts in areas adjacent to the MRGO: 3,350 acres of fresh/intermediate marsh and 8,000 acres of cypress swamp converted to brackish marsh and 19,170 acres of brackish marsh and swamp became saline marsh. Between 1964 and 1996, 5,324 acres of marsh was lost adjacent to the MRGO channel (mile 66 to 21). By 2005, erosion along the channel's banks had expanded the MRGO to a width of 3,000 feet in some areas, bringing it in close proximity to the hurricane protection levee. Saltwater moving up the channel also damaged or destroyed freshwater cypress forests of Orleans and St. Bernard Parishes and created a dead zone in Lake Pontchartrain.

2.10.3 Conclusions

The MRGO was a man-made shipping channel; its purpose was not related to coastal restoration and there are reports of freshwater from the MRGO harming (then benefitting) oysters in the oyster grounds east of the MRGO outfall (Chatry and Millard 1986). The impacts of MRGO are primarily reported as being related to channel creation and saltwater intrusion through the channel. During the MRGO channel's operation, increased salinity expanded usable habitat for many marine/estuarine sportfish and commercial species and for oysters westward toward and into Lake Pontchartrain (LDWF 2018). Closure of the MRGO with a rock dam at Bayou La Loutre has resulted in reductions in salinities in Lakes Pontchartrain and Borgne. This freshening has led to the loss of oyster production in Lake Borgne (LDWF 2018).

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