Oyster Bayou Marsh Restoration

Candidate Project
for the
Twenty First Priority Project List
of the
Coastal Wetlands Planning, Protection and Restoration Act

Proposed by

NOAA National Marine Fisheries Service

Final Project Information Sheet for Wetland Value Assessment

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Project Name: Oyster Bayou Marsh Creation and Terracing

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Project Location:
Region 4, Calcasieu-Sabine Basin, located west of the Calcasieu Ship Channel and south of the west fork of the Calcasieu River

Problem:
Altered hydrology, drought stress, saltwater intrusion and hurricane induced wetland losses have caused the area to undergo interior marsh breakup. Recent impacts from Hurricane Rita in 2005 and Hurricane Ike in 2008 have resulted in the coalescence of Oyster Lake with interior water bodies increasing wave/wake related erosion. Based on USGS hyper temporal data analysis (1984 to 2011), land loss for the area is -0.74% per year. The subsidence rate is estimated at 0.0-1.0 ft per century (Coast 2050, Mud Lake mapping unit).

Goals: The project boundary encompasses 843 acres. Specific goals of the project are: 1) create 491 acres of saline marsh in recently formed shallow open water; 2) nourish 90 acres of existing saline marsh; 3) create 14,140 linear feet of terraces; and, 4) reduce wave/wake erosion.

Proposed Features:
Approximately 491 acres of marsh would be created and 90 acres would be nourished. Material would be placed to achieve a settled target elevation of +1.4 feet NAVD 88 based on CRMS station 0655; 2003 Gotech data is +1.3 NAVD 88. Temporary dikes would be constructed to contain the fill. If the dikes do not naturally degrade to marsh elevation within three years, they would be gapped 25 ft wide, every 250 ft, to pre-project elevation. Sediment needed for the fill would be mined approximately one and half miles offshore from the Gulf of Mexico. Half of the created acres (246 acres) would be planted with smooth cordgrass plugs or other appropriate saline marsh type species. Project features include the pre-excavation of tidal creeks (10,000 linear feet) and ponds (10 acres) developed from differential settlement (total 19 acres).

A total of 14,140 feet of earthen terraces would be constructed by marsh buggy to a settled elevation of +2.5 feet NAVD 88, 15 foot crown, and 1V:4H side slopes. The terraces would produce approximately 12 acres of emergent marsh (70 foot per linear acre on 300 feet spacing). The material for terrace construction would be borrowed from adjacent open water in the project area. The constructed terrace acres would be vegetated along the crown and side slopes with one row each of saline marsh type species.

Monitoring Information:

<u>Marsh Creation:</u>
Monitoring data collected thus far for marsh creation projects is of little help in determining the benefits for this project. Much evidence exist that open water areas can be filled to create marsh since several such projects have been constructed across the state. However, there is still ongoing debate on the success of created marsh and whether created marshes are functionally equivalent to natural marshes.

Queen Bess Island (BA-05b) - This project involved pumping 152,000 yd^3 of dredged material into containment dikes to create vegetated wetlands. Island size was increased by 15.3 acres and 8 acres of vegetated wetlands were created. Approximately 18 months post-construction, natural colonization by smooth cordgrass covered 28% of the dredged material pond.

Barataria Bay Waterway Wetland Creation (BA-19) - The goal of this project was to create 9 acres of vegetated wetlands via confined disposal of dredged material and to increase the marsh surface elevations in existing marsh on Queen Bess Island by routing the dredge effluent through that area. The project was completed in November 1996. The BA-19 site is a poorly drained saline environment encircled by a 5.22ft (NGVD 29) aggregate shell levee essentially creating an impounded basin with exchange between the project area and Barataria Bay occurring only during storm surges. Smooth cordgrass has been found to grow in wetlands that are flooded 87% of the time as long as those low lying marshes are periodically drained during low tides (Eleuterius and Eleuterius 1979). The low elevation and poor drainage of the project area are the primary causes for poor vegetative cover in the project area.

Lake Chapeau Marsh Creation and Hydrologic Restoration (TE-26) - This project created 168 acres of marsh but was originally planned to create 260 acres. After one growing season, post construction, the area had 0% vegetative cover. The site was planted in May 2000 with approximately 40,000 plugs of smooth cordgrass, which in a plant spacing of about 15X15 ft. Vegetative cover the following year was 40% consisting mainly of smooth cordgrass. Percent cover in the natural marsh was approximately 80%. However, in those areas within the fill site that were above the mean water level, cover was 80%.

Bayou Labranche Wetland Restoration Project (PO-17) - This project, constructed in 1994, was designed to create approximately 305 acres of marsh at a ratio of 70% emergent marsh to 30% open water in 5 years. The target elevation for the created marsh was estimated at +0.65 to +1.62 feet NAVD88. The average elevation was +1.6 ft after construction and dropped to +1.0 ft three years after construction, which matched the elevation in the reference marsh. Although the target elevation was generally met during construction, most of the project area was constructed in the upper elevation range and was not suitable for establishment of marsh. Percent cover two years after construction was approximately 70%.

Terracing Projects

There are different terrace designs for different applications and project goals. Bay terraces and interior terraces are the two general categories. These designs differ by cross section and alignment based on project objectives and site-specific conditions. Depending on the design, application, and location, terrace benefits range from protecting marsh, trapping sediment, increasing SAV coverage, and reducing turbidity. Of these benefits, only some have been quantified due to limited monitoring and the short time terraces have been constructed. Generally, terraces in bays are intended to trap sediments in addition to creating marsh, reducing shoreline erosion, and promoting SAV growth. Terraces in interior marsh areas generally are not assumed to create marsh from accretion, although early projects anticipated that effect. Monitoring information from constructed terraces is provided in Table 1 below.

Table: 1. Benefits Specific to Terrace Construction

Marsh creation	Sabine - created marsh above the waterline with some lateral spread due to sedimentation and plant growth or sloughing (4.3 m as-built vs. 9.6 m 3 yrs post construction) Galveston Island State Park – 1 yr. post construction colonization along edge, but not on the crown plugs (multi-stem) out performed sprigs (single stem) two years after planting in terms of survival and cover both at Galveston and Sabine; within 2 yrs of planting terraces completely covered by vegetation LVB CWPPRA – mixed results with % vegetation cover; limited coverage on crowns and dense coverage around perimeter	Turner and Streever, 2002 John Foret (observations)
Percent Cover	Pecan Island CWPPRA – limited coverage on crowns where perimeter planting conducted Penny Rhodes (Venice) - 4 months post construction ~40% cover; 90% survival on the protected side of the terraces and around 70% survival on the exposed side	John Foret (observations) Cheryl Brodnax (observations)
Terrace Expansion	LVB CWPPRA - strip of needlerush then a strip of smooth cordgrass colonized outside of the original planting and terrace limits on some terraces	John Foret (observations)
Accretion/Trappi ng	Sabine - initial accretion; no long term accretion documented; expected to vary by terrace design, water depth, and sediment load LVB CWPPRA – many borrow areas have filled in	Steyer, 1993 John Foret (observations)
Shoreline Protection	Sabine – 1990, 1991, and 1993 photography compared to pre-project photography showed a decrease in shoreline erosion (may be due to inter-annual fluctuation in rates or water levels) Pecan Island Terracing monitoring suggests a reduction in wind fetch allowing colonization.	Steyer, 1993 Thibodeaux and Guidry, 2007
Increase SAV	Sabine - no evidence of increased even with experimental transplanting SAV frequency higher in terraced vs. un terraced ponds Little difference (during drought Sept 2001 – Sept 2002) Pecan Island CWPPRA – 30% increase in SAV in overall project area	(Rozas and Minello, 2001) and (Steyer 1993, Caldwell 2003) Cannaday (in draft) Caldwell. 2003 2004 OM&M report
Nekton	NAWCA inspection (Cameron Creole) increase in SAV in terrace field post construction Documented significant greater numbers of shrimp and crabs in terrace marsh than on non-vegetated water bottoms, but not functionally equivalent to natural marsh; terrace crowns not intertidal and don’t provide fisheries habitat Increase abundance and alter diversity	Courville (observations) Rozas and Minello 2001 Rozas and Minello 2001, Rozas et al. 2005, Bush Thom 2004

Theories on Monitoring Data Results

Dense perimeter colonization with shoreline planting may limit wind dispersal of seeds and colonization of the crown. Drought limited natural colonization of the crowns. Plugs perform as well as gallon containers. Acid sulfate soils used to construct terraces may oxidize lowering the pH and prevent establishment of plants. Terrace expansion is due to sloughing or flattening of the terrace. Accretion may be possible where there are substantial sediment sources. Anecdotal information and limited imagery data suggest terraces reduce the wind-wave erosion of marsh. Borrow areas within terraces fields may create depths that exceed the photic zone necessary for SAV growth; and, borrow and fill placement may affect the availability and viability of natural seed source.

Historical and present vegetative community

Historical record indicates the area has fluctuated in dominance between intermediate, brackish and saline marsh from 1949 to 2010 (see Table 2 below). This fluctuation in habitat type could be a result of manmade disturbances and natural influences in the area.

Table: 2. Historic Vegetation

	CRMS 0655	**CRMS 0655**	**CRMS 0672**	**CRMS 0672**	**CRMS 0685**	**CRMS 0685**
	Helicopter Survey	CRMS survey	Helicopter Survey	CRMS survey	Helicopter Survey	CRMS survey
1949	Brackish		Brackish		Brackish	
1968	Brackish		Intermediate		Brackish	
1978	Brackish		Brackish		Brackish	
1988	Brackish		Brackish		Saline	
1997	Brackish		Brackish		Saline	
2001	Brackish		Brackish		Brackish	
2006		Brackish		Intermediate		Saline
2007	Saline	Saline	Saline	Brackish	Saline	Saline
2008		Saline		Brackish		Saline
2009		Brackish		Brackish		Saline
2010		Brackish		Brackish		Saline

Observations from site visits during, May 2011, suggest the project area would support a saline marsh community dominated by smooth cordgrass (*Spartina alteniflora*) and marshhay cordgrass (*Spartina patens*). Salinity readings during were recorded to range between 25-33 ppt. The area was considered to be in drought conditions. According to the 2007 marsh type survey (Sasser, C.E., et al.) the area is saline. See Figure 1 below.

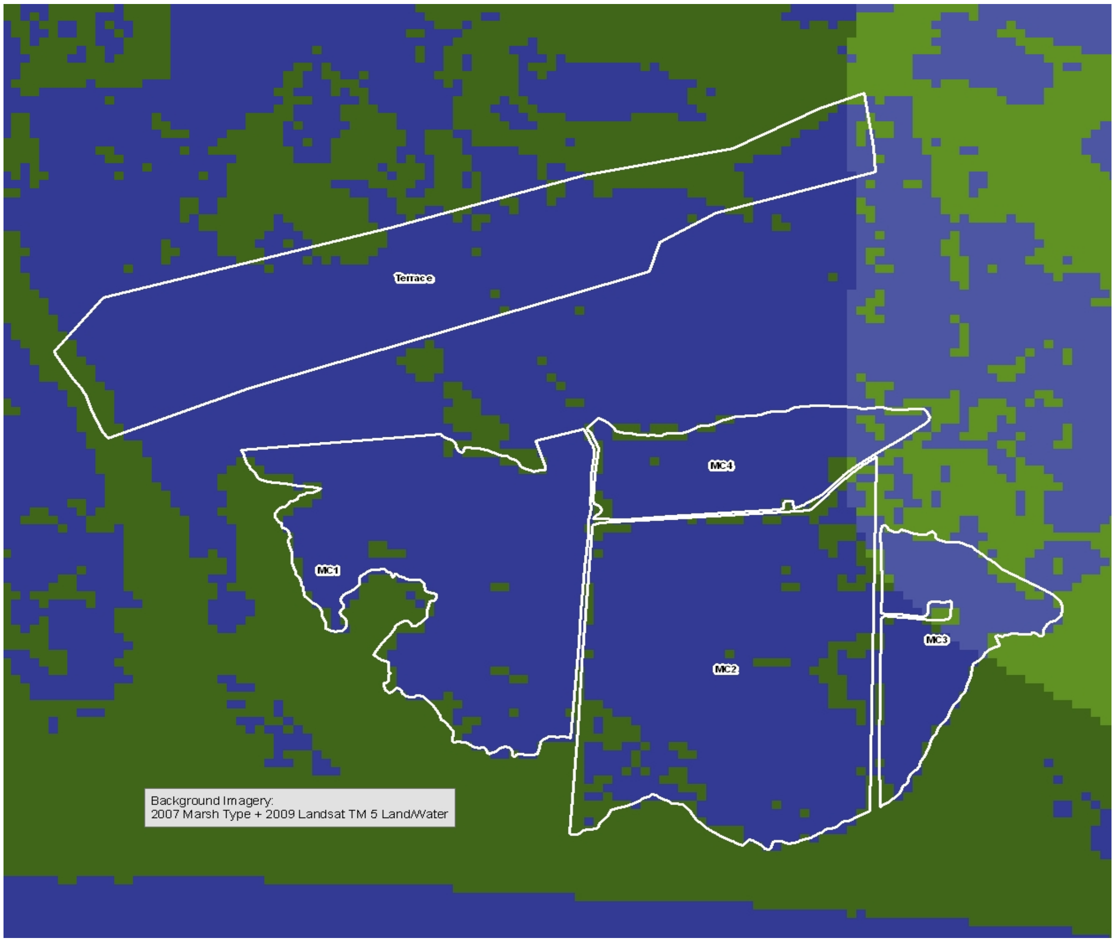


Figure: 1. 2010 Vegetation Classification, USGS.

<u>Soil Types</u> -
According to the Cameron Parish Soils Survey, the soils in the project area are equally composed of the Bancker and Clovelly series. The Bancker series is found along the historic Calcasieu Lake rim while the Clovelly series is found in the interior marshes of the project area. Both series are very fluid, organic soils typically found in brackish marsh that is poorly drained and ponded most of the time. Both soils support native vegetation and are considered well suited for wildlife habitat (USDA 1995).

Land Loss Data
The project area boundary (terrace field and marsh creation/nourishment) encompasses 843 acres. The extended project boundary (delineated by USGS) totals 2,531 acres (see Figure 2 below).

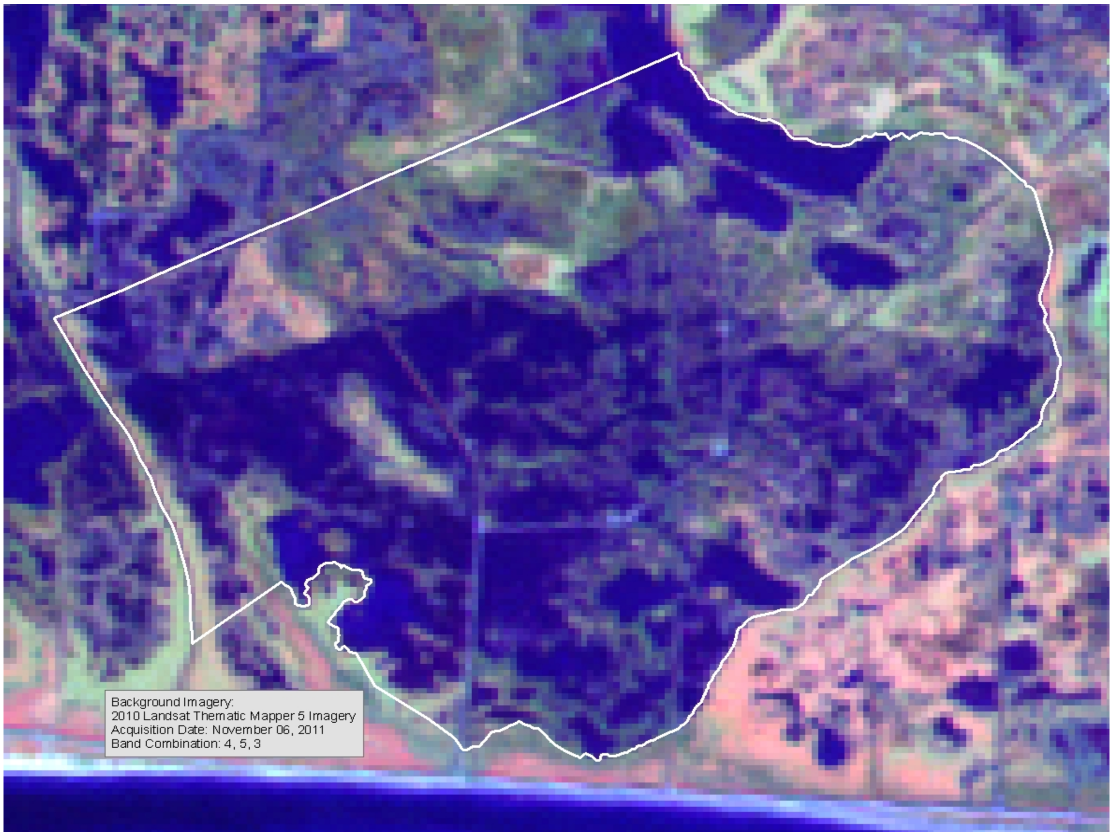


Figure: 2. Oyster Bayou Extended Project Boundary, USGS.

For interior marsh loss, USGS derived a loss rate from a linear regression using the 1984-2011 hyper temporal analysis (see Figure 3 below). This loss rate was calculated from percent land values in acres and was calculated to be -0.745 % per year. USGS excluded some data points from the regression analysis due to low and high water events. A preliminary evaluation of shoreline erosion in the project area indicated a low shoreline loss rate and break up as much recession was occurring in the proximity of the proposed project features. Therefore, shoreline erosion was not utilized for further consideration.

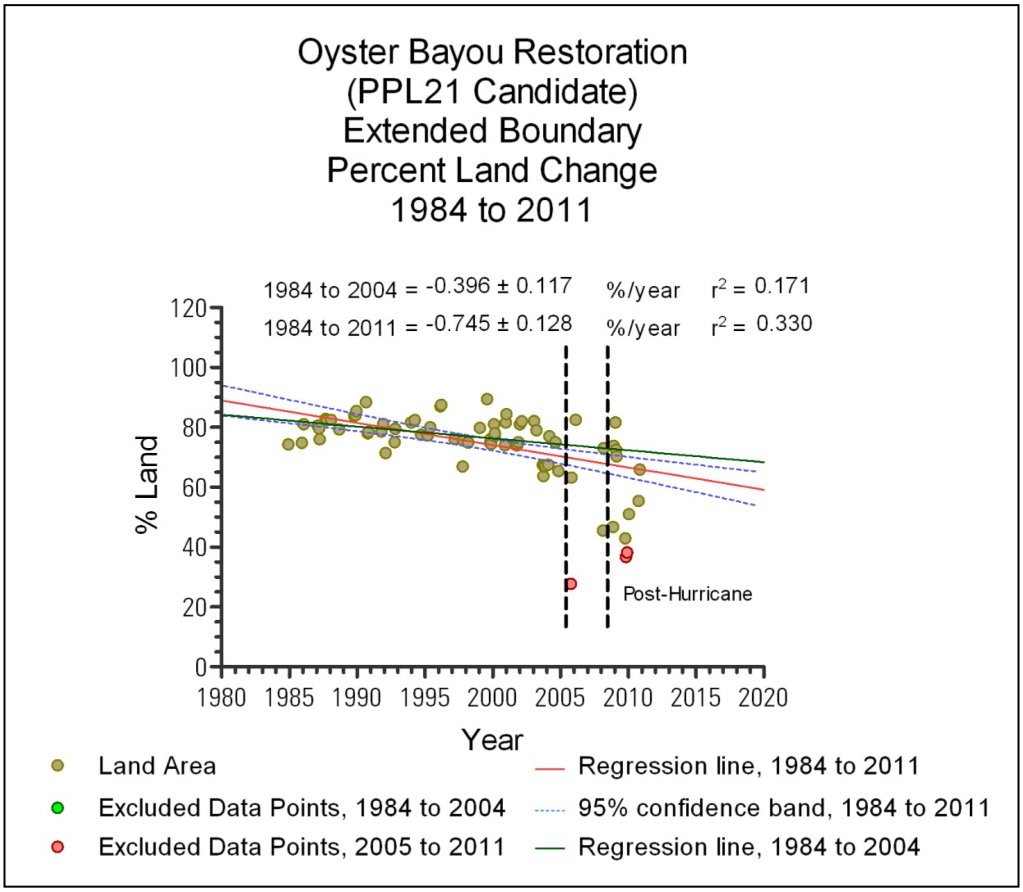


Figure: 3. Linear Regression of Land Loss for the Extended Boundary, USGS

The marsh creation/nourishment acres and the terrace field acres were lumped together to produce one WVA marsh model (saline) run for the project area.

Marsh creation/nourishment polygon total (600 acres) + terrace field polygon (200 acres) = 843 acres is the total project area.

Marsh Creation/Nourishment

V1 - Emergent Vegetation

USGS provided 2010 land/water acreages for each of the polygons in the project area (see Table 3 below).

Table 3. 2010 Land/Water, 2010 NAIP photography

	ACRES					
LAND COVER TYPE	**MC1**	**MC2**	**MC3**	**MC4**	**Terrace**	**Total**
Land	18	54	8	10	41	131
Water	181	205	62	62	202	712
Total	199	259	70	72	243	843

2010 acreages: Marsh = 131 acres; Water = 712 acres; Total = 843 acres

One year of loss was applied to the 2010 land acreage to arrive at TY0 project acreages.

TY0 acreages: Marsh = 130 acres; Water = 713 acres; Total = 843 acres

<u>FWOP</u>
This evaluation assumes the 1984-2011 extended project area boundary loss rate (-0.745%/yr) continues. Applying this loss rate, land/water acres and percentages for target years 0, 1, and 20 were calculated using the ENV WG standard land loss spreadsheet (See Appendix A).

TY0: Marsh 130 acres = 15 % Water = 713 acres
TY1: Marsh 129 acres = 15% Water = 714 acres
TY20: Marsh 112 acres = 13% Water = 731 acres

<u>FWP</u>

Table: 4. Target year "1" acres separated by project feature type

marsh created	510 – 19 (creeks/ponds) = 491 acres			
marsh nourished	90 acres			
terrace field	243 acres	9 acres (terrace above water)	41 acres (existing marsh)	193 acres (existing water)
total	843 acres			

Approximately 19 acres of the created marsh is converted to open water due to the pre-excavation of tidal creeks and ponds. Therefore, under the FWP scenario, 491 acres of open water will be filled to +1.4 ft NAVD 88 and 90 acres of existing marsh will be nourished. Fifty percent of the created marsh acres will be planted. Approximately 9 acres of terrace will be constructed above water. There are a total of 41 acres of marsh and 193 acres of open water remaining in the terrace field.

TY1: Marsh = 173 acres = 21%; Water = 214 acres

Marsh creation (assume 17.5% credit for marsh function with 50% plantings; and 50% reduction in background loss rate);

Marsh nourishment (assume 50% credit for marsh function; and, 50% reduction in background loss rate);

Terraces (assume 25% credit for marsh function with 100% vegetative plantings; and, 50% reduction in background loss rate);

Existing marsh in terrace field (assume 33% reduction in background loss rate) (Morton et al. 2005)

TY3: Marsh = 381 acres = 45% Water = 219 acres

Marsh creation (assume 50% credit for marsh function with 50% plantings; and 50% reduction in background loss rate);

Marsh nourishment (assume 100% credit for marsh function; and, 50% reduction in background loss rate);

Terraces (assume 100% credit for marsh function with 100% vegetative plantings; and, 50% reduction in background loss rate);

TY5: Marsh = 619 acres = 73% Water = 224 acres

Marsh creation (assume 100% credit for marsh function; and 50% reduction in background loss rate);

TY20: Marsh = 585 acres = 69% Water = 258 acres

Net acres (FWOP-FWP) at TY20 = **473 acres**

V2 - Submerged Aquatic Vegetation
SAV cover was observed in the project area on May 9, 2011, and, May 31, 2011, site visits. This cover was noted to be sporadic in the open water areas (712 acres). *Ruppia maritima*, commonly known as widgeon grass was the only SAV species identified in the project area. Based on data collected during the site visits, SAV % is estimated to be 10%.

FWOP
TY0: 10%
TY1: 10%
TY20: 5% (assume some loss due to increase in wave fetch in open water and continued high salinity)

FWP
With the restoration of marsh, the open water will decrease, reducing fetch in the project area. It is assumed that SAV percentages would recover post construction and increase slightly over time. With the exception of the borrow footprint for terrace field (5%), the remainder of open water in the project area (95%) is considered shallow.

TY1: 5% (disturbed habitat conditions)
TY3: 10% (return to baseline conditions)
TY20: 15% (slight increase from baseline conditions, limited due to high salinities)

V3 – Interspersion

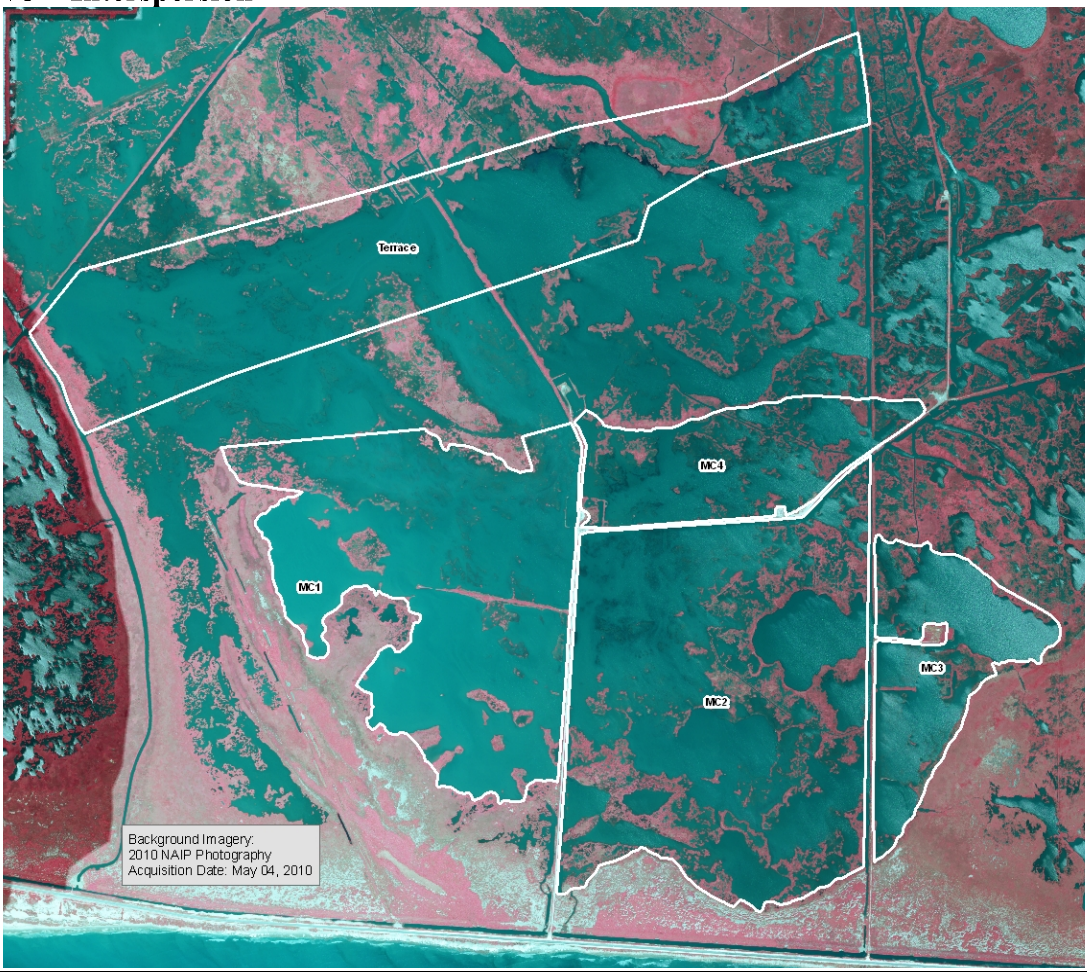


Figure: 3. Map of FWOP Conditions

Table: 5. Project Area Percent Cover, USGS

	PERCENT					
LAND COVER TYPE	MC1	MC2	MC3	MC4	Terrace	Total
Land	9.0%	20.8%	11.4%	13.9%	16.9%	15.5%
Water	91.0%	79.2%	88.6%	86.1%	83.1%	84.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

FWOP

The interspersion variable was determined using Figure 3 and Table 5 above. Marsh creation/nourishment Area 1 (199 acres) and Area 3 (70 acres) are considered to be a Class 5. Marsh creation/nourishment Marsh creation/nourishment Area 2 (259 acres) and Area 4 (72 acres) are considered to be a Class 4. The terrace field was split into 90% Class 4 (219 acres) and 10% Class 1 (24 acres).

Class 1 = 3% (24*100/843 acres)
Class 4 = 65% (259 + 72 + 219 = 550*100/843 acres)

Class 5 = 32% (199 + 70 = 269*100/843 acres)
TY0: 3% Class 1; 65% Class 4; 32% Class 5
TY1: 3% Class 1; 65% Class 4; 32% Class 5
TY20: 3% Class 1; 65% Class 4; 32% Class 5

The marsh creation/nourishment areas were assumed to receive the standard ENV WG standards for TY1-5, and remain a Class 1 at TY20. The terraces would be on a design of 300 ft spacing in the terrace field. Therefore, it is assumed this area would become a Class 3 with the exception of the existing Class 1 acres (3%).

<u>FWP</u>
TY1: 3% Class 1; 26% Class 3; 71% Class 5
TY3: 3% Class 1; 97% Class 3
TY5: 74% Class 1: 26% Class 3
TY20: 74% Class 1: 26% Class 3

V4 - Shallow Open Water Habitat
Water depths were taken throughout the project area on May 10, 2011, and May 31, 2011 to assist in a calculation of the shallow water habitat. Water level data from CRMS gages close to the project area were also obtained and evaluated to estimate 1) a daily average for time period that depths were taken on both days; and, 2) mean water levels over long term period of record, if available. This information would then be used to adjust all water depths taken in order to obtain a mean water level average in the project area.

It was determined that water depths taken on both days and information obtained from the CRMS station 0685 were considered to be the "best available information" and used to calculate shallow open water habitat for the project area. A total of 155 water depths were recorded collectively between both days and the average water level during that timeframe for that gage was 1.13 ft NAVD 88. Mean water level for the gage on May 10, 2011, was 0.34 ft NAVD 88; and, 0.57 ft NAVD 88 on May 31, 2011. Therefore, the adjustment of the daily water level minus the mean water level for this gage was (0.34 ft -1.13 ft) = 0.79 ft for depths collected on May 10, 2011 and (0.57ft -1.13 ft) = 0.56 ft for depths collected on May 31, 2011 (see Appendix C).

<u>FWOP</u>
After applying the adjustment to the depths, all 155 points were less than the 1.5 feet water depth. Therefore 100% of water acres in the project area are considered shallow for TY0-1 (see Appendix C).

It is assumed that these open water areas will increase in size by TY20. In the Coast 2050 Document, Appendix D-Region 4 Supplemental Information (LDNR 1999), historical land loss evaluated from 1932 to 1990 provided a subsidence rate of 0.0 to -1.0 ft/century (Mud Lake mapping unit). The average of this rate (0.0 ft/century + 1.0 ft/century/ 2) was calculated to be (0.5 ft/ century). This converts to a project life subsidence rate of 0.1 ft / 20 years.

After applying the 0.1 ft subsidence rate to all water depths, 2 of the 155 points were converted to deep water = [(2 x 100) x 155] = 1%. In addition, 18 acres of marsh will convert to open water (calculated from the V1) at TY20. However, because the shallow open water percentage is 99% at TY20 from including subsidence, the additional shallow water acres (2.5%) from marsh loss is not assumed to make a difference.

TY0: 100%
TY1: 100%
TY20: 99%

<u>FWP</u>
Tidal creeks (9 acres) and ponds (10 acres) will be excavated in the marsh creation/nourishment features at TY1. It is assumed that 50% of the tidal creeks and ponds will be shallow open water and 50% greater than 1.5 ft (19/2 = 9.5 acres each). In addition, a total of 12 acres of open water would also become greater than 1.5 ft of water in the terrace field from excavation for terrace construction.

(9.5 + 12 = 21.5x100/202) = 10.6 ~ 11% of the open water is assumed to be greater than 1.5 ft water depths.

The remaining acres of open water 89% is considered to be less than or equal to 1.5 ft assuming standard assumptions for marsh creation/nourishment, terracing, and FWOP conditions (100% shallow TY0-1).

TY1: 89%
TY3 89%
TY5: 89%

For TY20, it is assumed a portion of open water will subside over the project life reducing the percentage of open water that is <= 1.5 ft deep. However, due to low subsidence and FWOP conditions, it is assumed to only reduce by 1% (as with baseline conditions) at TY20.

TY20: 88%

V5 – Salinity
Three year mean salinity averages were obtained from hourly data across two CRMS stations closest to the project area (See Figure 4 below).

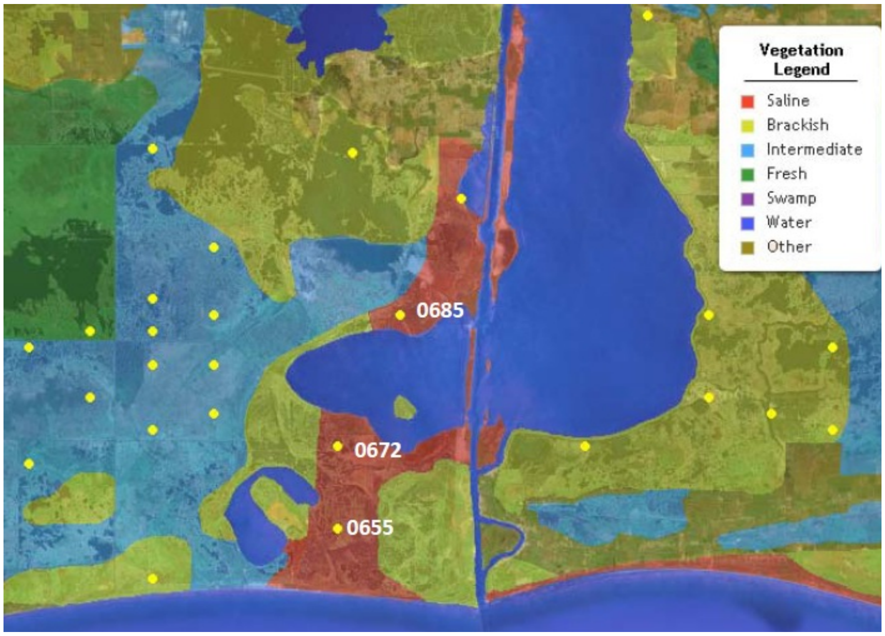


Figure: 4. Nearby CRMS stations to PPL21 Oyster Bayou project area

CRMS station 0685 is located north of the project area at the north side of West Cove. CRMS station 0655 is also located north of the project area in the Mud Lake management unit. The average salinity of the two CRMS stations yielded a value of 17 ppt. The range of salinities that were recorded during the 2011 site visits fell in the range of 25 ppt. to 33 ppt. (See Table 6 below).

Table: 6. Surface Water Mean Salinities (ppt.) at nearby CRMS stations

CRMS station	Long Term (2008-2011)	Field data 5/09/2011 and 6/02/2011 (1 day)	2010 Habitat Type
0685	16.5		Saline
0655	17.3		Brackish
0672	NA		Brackish
Average	**16.9 ~ 17.0**		
PPL21 project area		*25-33 range*	*Saline*

FWOP:
TY0: 17 ppt.
TY1: 17 ppt.
TY20: 17 ppt.

FWP conditions are expected to remain the same.

FWP:
TY1: 17 ppt.
TY3: 17 ppt.

TY5:   17 ppt.
TY20: 17 ppt.

V6 - Fish Access

Access was observed utilizing 2010 LDNR SONRIS mapping and numerous previous field inspections. There is only one access point into the project area remaining located Oyster Bayou (Figure 5). There is a sill located in Oyster Bayou to the north of the proposed project area (Figure 6). The 'r" structure rating that is closest to a sill is 0.8 (Rock weir set at 1ft below marsh level (BML), w/ boat bay). Oyster Bayou and this structure are considered to be the "major" access point. However, there are other impediments to access and therefore, the Oyster Bayou structure is assumed to provide perimeter access to 50% of the project area giving it a "P" value of 0.50. Other impediments include a breach in the spoil bank of the perpendicular slip off the West Fork of the Calcasieu River prior to Oyster Bayou has been plugged, disposal areas along the Calcasieu ship channel and the stair-step levee that pre-dates the East Mud Lake marsh management area.

The marsh creation/nourishment features are located at the south end of the project area, and are considered to have no other access (west or south). Therefore, this portion of the project area is considered to have an "r" value of a plug = 0.0001 and, would receive a "P" value of 0.50.

$$R = (0.5)*0.8 + (0.5)*0.0001 = 0.4 + 0.00005 = 0.40005 \sim 0.4$$

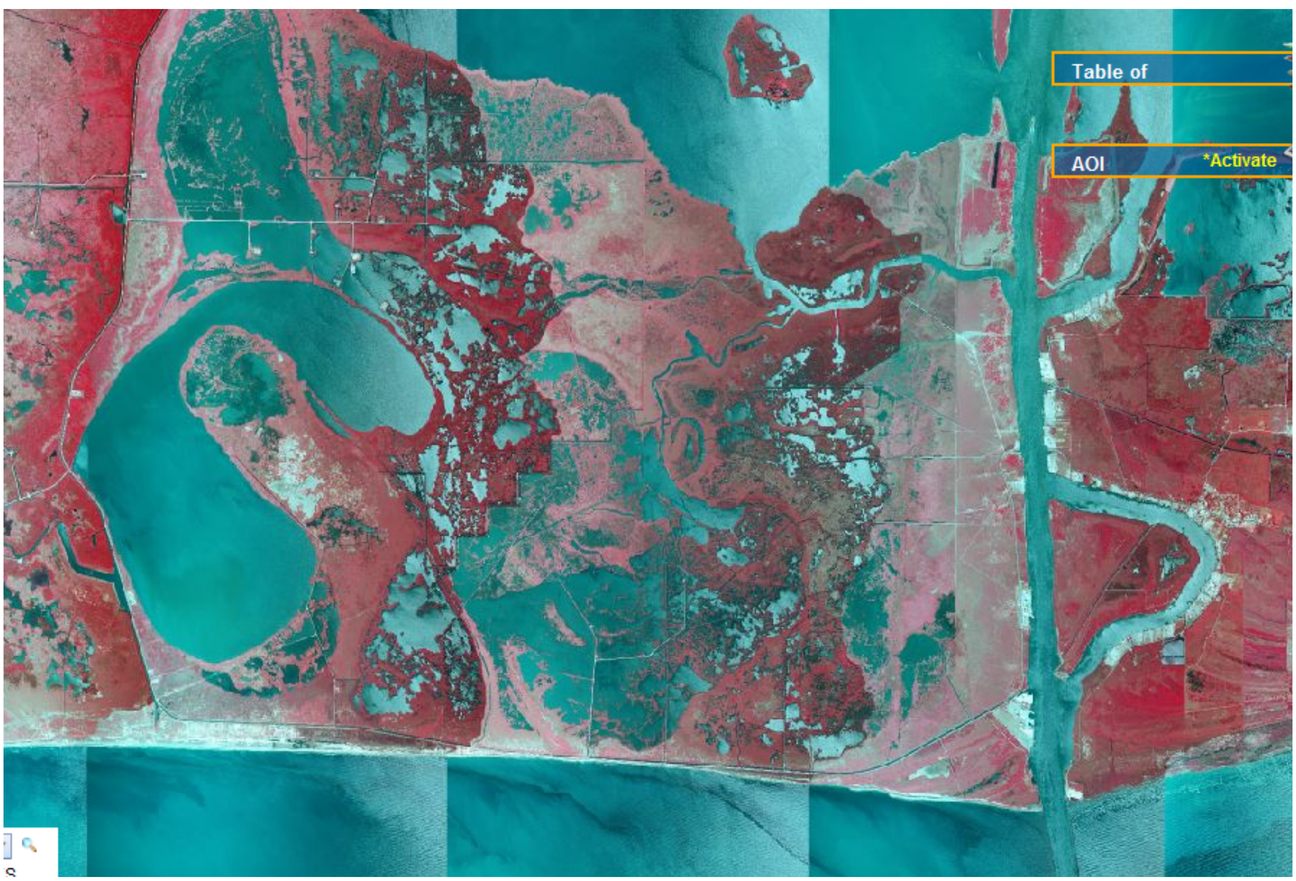


Figure: 5. 2010 SONRIS Imagery

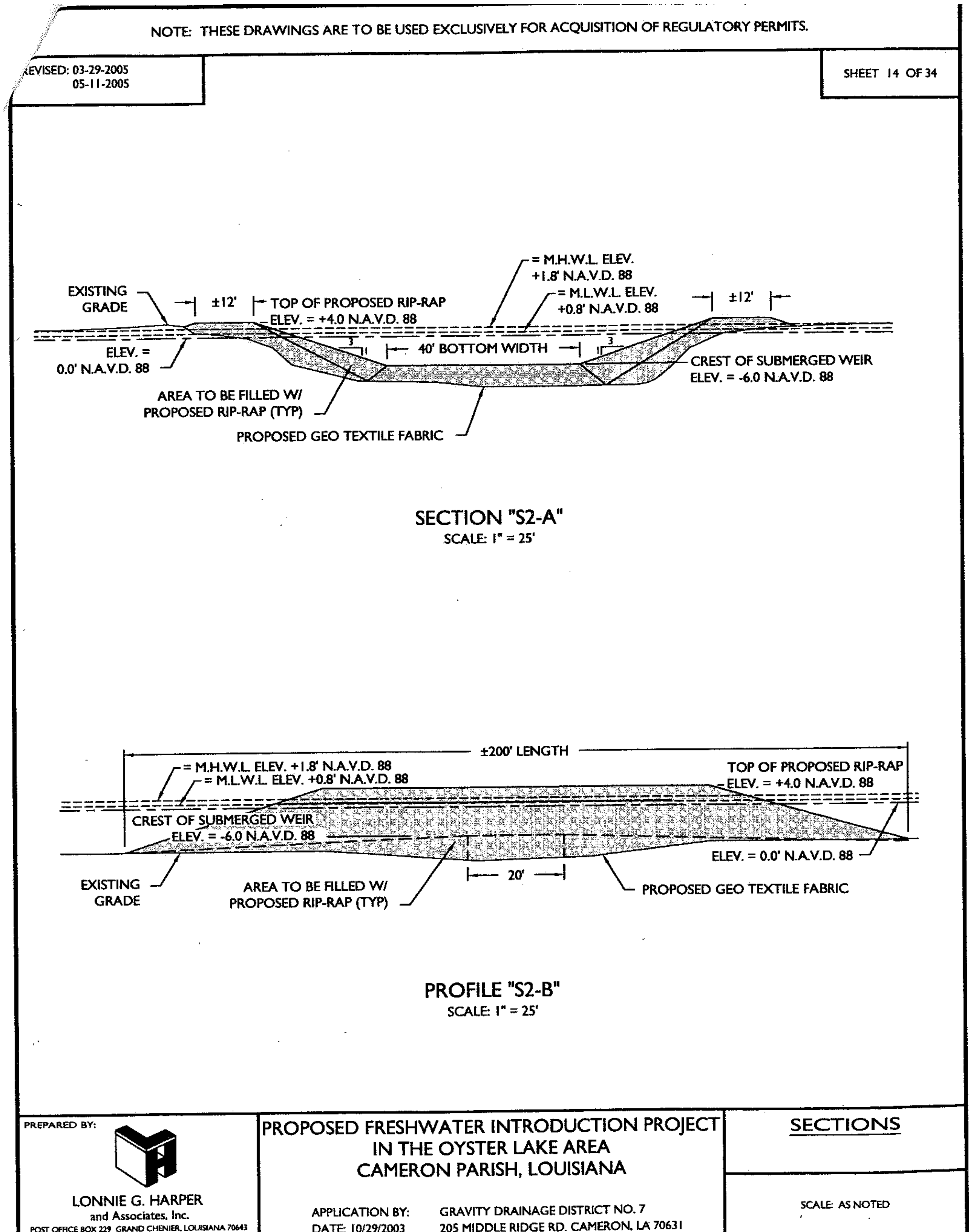


Figure: 6. Permit MVN-2004-4348 WDD section view (S2-A) of the sill structure installed in Oyster Bayou.

FWOP
TY0: 0.4
TY1 0.4
TY20: 0.4

FWP
With the construction of the marsh creation/nourishment features, the project area will receive an aquatic organism access value at 0.0001 at TY1 (assume full containment). At TY3, the exterior containment dikes are expected to naturally degrade or become manually degraded to existing marsh elevation under O & M. Once the marsh edge has returned to intertidal elevation, aquatic organism access FWP for 50% of the project area will return to a value of 0.8, and the remainder of the project area, 50%, will continue to receive a plug value as seen in FWOP.

TY1: 0.0001
TY3: 0.4
TY5: 0.4
TY20: 0.4

Literature Cited

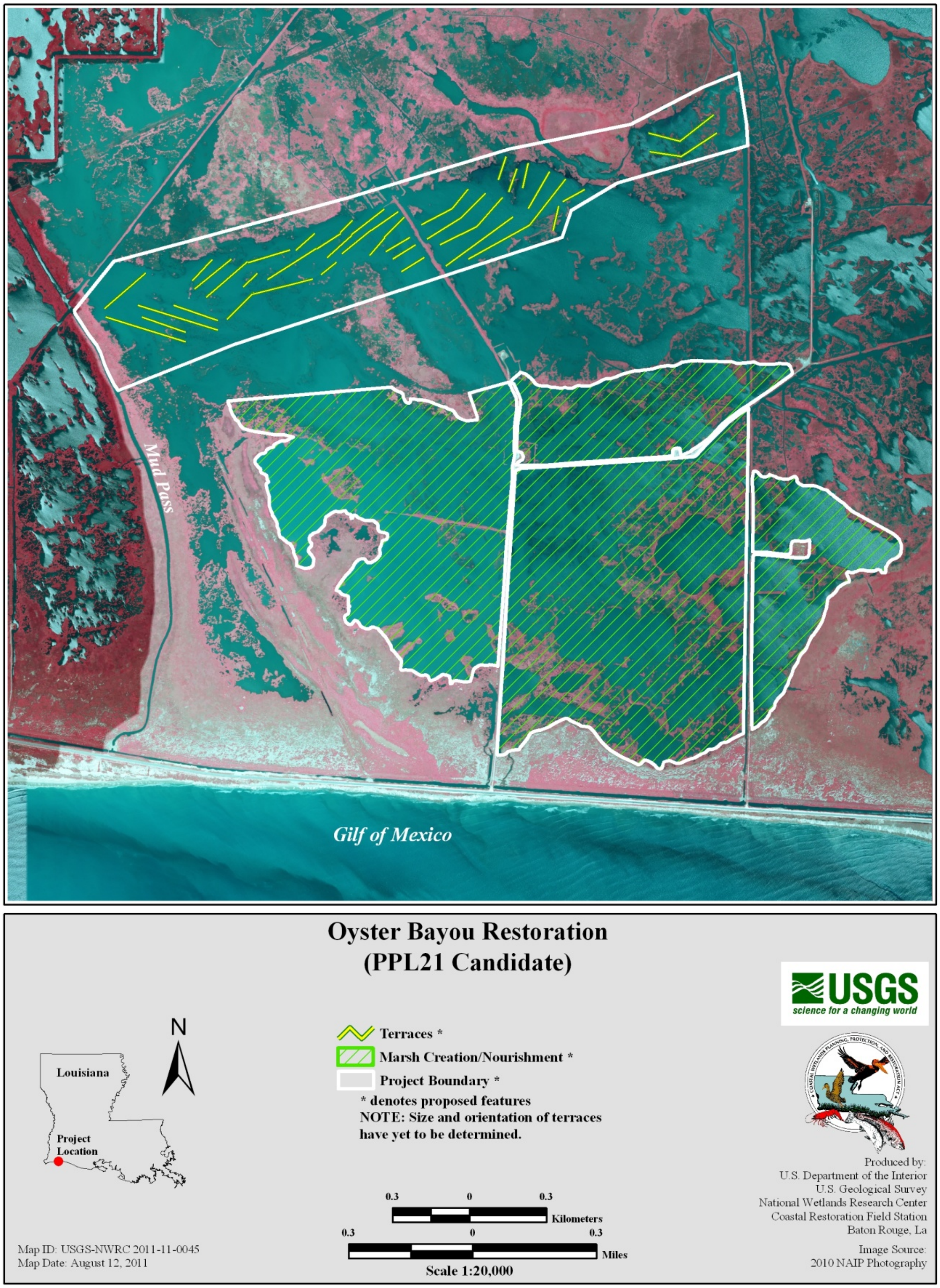
Louisiana Department of Natural Resources, 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, Appendix D-Region 2 Supplemental Information.

Morton, R.A., J.C. Bernier, J.A. Barras, and N.F. Ferina. 2005. Rapid subsidence and historical wetland loss in the Mississippi delta plain: likely causes and future implications. U.S. Geological Survey Open-File Report 2005-1216.

Sasser, C.E., Visser, J.M., Mouton, Edmond, Linscombe, Jeb, and Hartley, S.B., 2008, Vegetation types in coastal Louisiana in 2007: U.S. Geological Survey Open-File Report 2008–1224, 1 sheet, scale 1:550,000.

U.S. Department of Agriculture. 1995. Soil Survey of Cameron Parish, Louisiana. Soil Conservation Service, Alexandria, LA. 135 pp, plus appendix.

Appendix A. Oyster Bayou Project Feature Map



Appendix C. Shallow Open Water

Recon Data from 5/10/2011 | Avg. water level 0.34
CRMS data available 0685 | Avg. water elevation 1.13

MARSH CREATION CELL 1	sounding	water elevation ad	<1.5 ft	TY20	<1.5 ft
cell 1	1	0.66	1	0.76	1
	1.1	0.76	1	0.86	1
	0.7	0.36	1	0.46	1
	1.2	0.86	1	0.96	1
	1.2	0.86	1	0.96	1
	0.9	0.56	1	0.66	1
	1.2	0.86	1	0.96	1
	1.3	0.96	1	1.06	1
	1.3	0.96	1	1.06	1
	1.4	1.06	1	1.16	1
	0.9	0.56	1	0.66	1
	1.3	0.96	1	1.06	1
	1.3	0.96	1	1.06	1
cell 2	1	0.66	1	0.76	1
	1	0.66	1	0.76	1
	0.7	0.36	1	0.46	1
	0.7	0.36	1	0.46	1
	0.9	0.56	1	0.66	1
	1.2	0.86	1	0.96	1
cell 3	none				
Average	1.07	0.73	19		19
			100.00%		100.00%

TERRACE FIELD	sounding	water elevation ad	<1.5 ft	TY20	<1.5 ft
	1.2	0.86	1	0.96	1
	1.3	0.96	1	1.06	1
	1.4	1.06	1	1.16	1
	1.3	0.96	1	1.06	1
	1.3	0.96	1	1.06	1
	1	0.66	1	0.76	1
	1	0.56	1	0.66	1
	1	0.66	1	0.76	1
	1	0.66	1	0.76	1
Average	1.16	0.82	9		9

			100.00%		100.00%

WVA Data from 5/31/2011 — Avg. water level 0.57

CRMS data available 0685 — Avg. water elevation 1.13

MARSH CREATION	sounding	water elevation ad	<1.5 ft	TY20	<1.5 ft
CELL 1	1.2	0.58	1	0.68	1
	1.3	0.73	1	0.83	1
	1.3	0.73	1	0.83	1
	1.3	0.73	1	0.83	1
	1.3	0.73	1	0.83	1
	1.4	0.83	1	0.93	1
	1.4	0.83	1	0.93	1
	1.5	0.93	1	1.03	1
	1.6	1.0	1	1.13	1
	1.7	1.13	1	1.23	1
	1.4	0.83	1	0.93	1
	1.1	0.53	1	0.63	1
	1.6	1.03	1	1.13	1
	1.1	1	1	0.63	1
	1.1	0.53	1	0.63	1
	1.3	0.68	1	0.78	1
	1.5	0.93	1	1.03	1
	1.4	0.83	1	0.93	1
	1.5	0.93	1	1.03	1
	1.4	0.83	1	0.93	1
	1.1	0.53	1	0.63	1
	1.4	0.83	1	0.93	1
	1.4	0.83	1	0.93	1
	1.2	0.63	1	0.73	1
cell 2	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.5	0.93	1	1.03	1
	1.6	1.03	1	1.13	1
	1.3	0.73	1	0.83	1
	1.3	0.73	1	0.83	1
	1.5	0.93	1	1.03	1
	1.2	0.63	1	0.73	1
	1.2	0.63	1	0.73	1
	0.9	0.33	1	0.43	1

	1.1	0.53	1	0.63	1
	1.3	0.73	1	0.83	1
	1.3	0.73	1	0.83	1
	1.9	1.33	1	1.43	1
	1.8	1.23	1	1.33	1
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	2.0	1.43	1	1.53	0
	1.9	1.33	1	1.43	1
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	1.6	1.03	1	1.13	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.6	1.03	1	1.13	1
	1.5	0.93	1	1.03	1
	1.4	0.83	1	0.93	1
	1.3	0.73	1	0.83	1
	1.2	0.63	1	0.73	1
	1.2	0.63	1	0.73	1
	1.1	0.53	1	0.63	1
	1.2	0.63	1	0.73	1
	1.3	0.73	1	0.83	1
	1.4	0.83	1	0.93	1
	1.2	0.63	1	0.73	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.3	0.73	1	0.83	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.0	0.43	1	0.53	1
cell 3	1.6	1.03	1	1.13	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.6	1.03	1	1.13	1
	1.3	0.73	1	0.83	1

	1.3	0.73	1	0.83	1
	1.4	0.83	1	0.93	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.45	0.88	81.00		80.00
			100%		99%

TERRACE FIELD	sounding	water elevation ad	<1.5 ft	TY20	<1.5 ft
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	2.0	1.43	1	1.53	0
	1.9	1.33	1	1.43	1
	1.9	1.33	1	1.43	1
	1.6	1.03	1	1.13	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.2	0.63	1	0.73	1
	1.2	0.63	1	0.73	1
	1.5	0.93	1	1.03	1
	1.5	0.93	1	1.03	1
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	1.8	1.23	1	1.33	1
	1.8	1.23	1	1.33	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.8	1.23	1	1.33	1
	1.7	1.13	1	1.23	1
	1.7	1.13	1	1.23	1
	1.5	0.93	1	1.03	1
	1.9	1.33	1	1.43	1
	1.8	1.23	1	1.33	1
	1.8	1.23	1	1.33	1
	1.7	1.13	1	1.23	1
	1.2	0.63	1	0.73	1
	1.5	0.93	1	1.03	1
	1.1	0.53	1	0.63	1
	1.2	0.63	1	0.73	1
	1.1	0.53	1	0.63	1
	1.1	0.53	1	0.63	1
	1.5	0.93	1	1.03	1

	1.4	0.83	1	0.93	1
	1.6	1.03	1	1.13	1
	1.7	1.13	1	1.23	1
	1.5	0.93	1	1.03	1
	1.3	0.73	1	0.83	1
	1.2	0.63	1	0.73	1
	1.2	0.63	1	0.73	1
	1.0	0.43	1	0.53	1
	1.4	0.83	1	0.93	1
	1.5	0.93	1	1.03	1
	1.4	0.83	1	0.93	1
	1.4	0.83	1	0.93	1
	1.5	0.93	1	1.03	1
			46		45
			100%		98%

TY20 subsidence		0-1.0		ft/century
(Mud Lake)			0.5	Avg. ft/cent
			0.1	ft/20 years
2 day totals	TY0-1	TY20		
Marsh creation	100%		99%	
terrace field	100%		98%	