THE WATER INSTITUTE
OF THE GULF®

FUTURE COSTS OF MARSH CREATION PROJECTS IN COASTAL LOUISIANA

SUMMARY OF METHODOLOGY

Fall 2016

Introduction

The main objective of this study is to provide the Coast Builders Coalition and the Restore the Mississippi River Delta Coalition with some illustrative examples of how project costs can change over time and some of the factors that influence those cost changes. The study is based on previous analyses and estimates of controlling factors and included no new data collection. Specifically, this report summarizes the approach used to provide plausible estimates of how costs could escalate if marsh creation using dredged material is delayed for 10, 20, 30, 40, or 50 years. First, the report describes the controlling factors considered in the analysis, followed by an outline of how the example coastal sites were identified. The report continues with the methods used to estimate future changes in coastal condition and their influence on marsh creation project construction. This information is then used to estimate how project costs change. Lastly, the report outlines how either borrowing money or investing it could alter the timing of restoration and construction costs. The work conducted by The Water Institute of the Gulf built on previous analysis for the 2017 Coastal Master Plan, already publicly available and used with permission of Louisiana Coastal Protection and Restoration Authority (CPRA).

Controlling Factors

The analysis assumed that a number of different factors influence the cost of future marsh creation in Louisiana. While other factors may also be important, those selected were deemed to reflect multiple facets of the changing coast and project delivery issues. The study included assessments of the following factors:

- The location of the marsh creation project in terms of local subsidence rates and distance to potential borrow sources;
- Future coastal configuration as influenced by sea-level rise and other climate-related factors;
- The time elapsed from the current condition until the marsh creation occurs;
- Inflation rates of money; and
- The cost of borrowing funds to expedite project implementation (i.e., selling bonds), and the amount of interest accrued if available funds were not used due to implementation delays (e.g., permitting, land rights, etc.).

Site Selection

Marsh creation by placing dredged material into open water or onto existing low marshes is a common practice in Louisiana and was recommended for use in multiple instances as part of Louisiana's 2012 Coastal Master Plan. For this study, seven locations (Table 1), located across the coast, were chosen for analysis. These locations were chosen to account for the varying rates of subsidence across the coast, the varying amounts of initial land area, and the various distances to sediment sources (Figure 1). At each of the seven locations, a 2,000-acre square polygon template was placed on a land-water map such that all of the area within the template would be converted to marsh if the project was implemented during the first year. Therefore, all area within the polygon had to be pre-existing land or shallow water, as defined in the following section.

Table 1: Marsh creation template locations.

Location Code	Location Name	Location Description
BLL	Bayou La Loutre	Project location is on east bank of Bayou La Loutre in Biloxi Wildlife Management Area.
EDA	East of Delacroix - Site A	Project location is east of Delacroix, just east of Hwy 300. Starts with higher portion of land than water, as compared to EDB.
EDB	East of Delacroix - Site B	Project location is east of Delacroix, just east of Hwy 300. Starts with lower portion of land than water, as compared to EDA.
WLL	West of Little Lake	Project location is between Little Lake and Bayou LaFourche, due east of Galliano.
EDL	East of DuLarge	Project location is between Bayou du Large and Bayou Grand Calliou, south of Falgout Canal and due southwest of Dulac.
NWL	North of White Lake	Project location is north of White Lake.
SAB	Sabine National Wildlife Refuge	Project location is in Sabine National Wildlife Refuge.

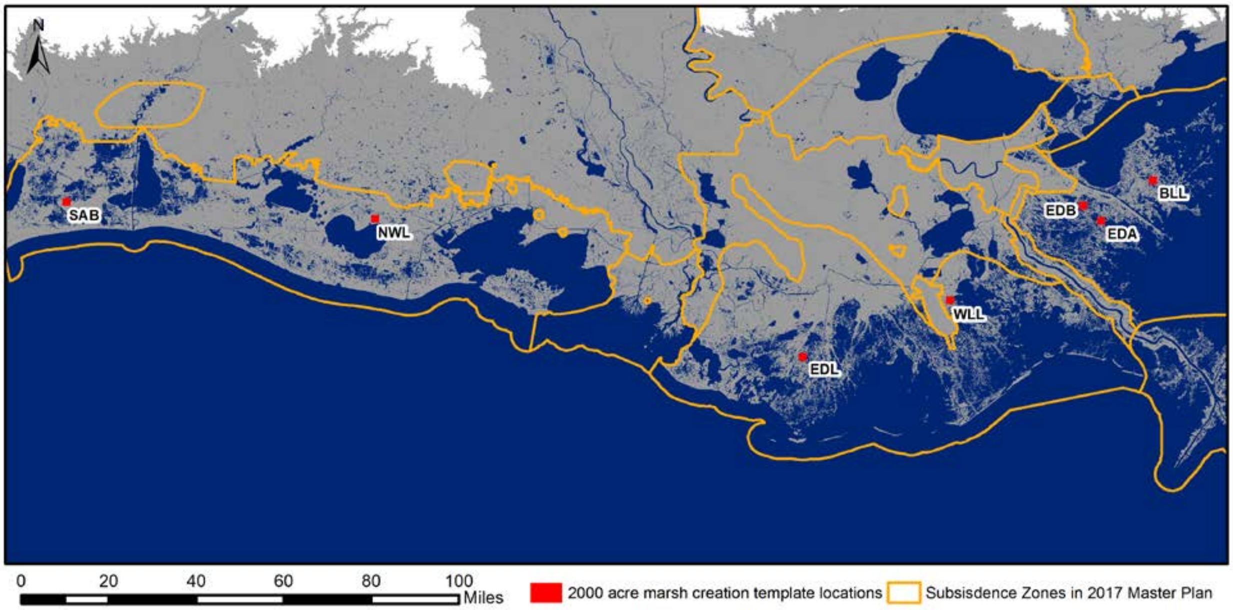

Figure 1: Locations chosen across the coast.

Future Coastal Conditions

The Integrated Compartment Model (ICM) (Meselhe et al., 2015) had previously been used to generate output for five different 50-year simulations of a Future Without Action (FWOA). The five different simulations predicted 50 years of landscape change as a result of five separate environmental scenarios (Table 2). The conditions used were those that were tested as part of the process to identify which scenario values should be used in the 2017 Coastal Master Plan. The names of the scenarios have been changed for ease of use in this document, with the cross referencing to master plan scenario numbers noted in Table 2. Details of the FWOA analysis for these scenarios are described in Chapter 2 of Appendix C of the 2017 Coastal Master Plan (Meselhe et al., 2015). Mean water level, elevation, and land/water coverage (the data required for the implementation procedure described below) were extracted from the FWOA model output for each of the five scenarios for each implementation period (years 1, 10, 20, 30, 40, and 50).

Table 2: Values used for environmental scenarios (see Meselhe et al., 2015 for more details).

Scenario	**Precipitation**	**Evapotranspiration**	**ESLR (m/50yr)**	**Subsidence**
A (S01)	>Historical	<Historical	0.43	20% of range
B (S04)	>Historical	Historical	0.63	20% of range
C (S05)	>Historical	Historical	0.63	35% of range
D (S02)	>Historical	Historical	0.63	50% of range
E (S03)	Historical	Historical	0.83	50% of range

Current Cost of Marsh Creation Projects

This study assumed there are two main components of the cost of the marsh creation projects:

- The volume of material required (i.e., extraction costs); and
- The distance the material is conveyed from the source area (i.e., transport costs).

ESTIMATING VOLUMES AND AREAS CREATED

This analysis used two values for marsh creation threshold depth, 2.5-feet and 5-feet. The 2012 Coastal Master Plan used a threshold depth of approximately 5-feet for cost estimating. Any area within the project footprint that had an elevation below –5 NAVD88 feet was not filled (CPRA, 2012). This approach has the advantage of focusing the master planning effort on areas that can be filled fairly cost-effectively and avoiding channels important for marsh hydrology. For the 2017 Coastal Master Plan, the minimum elevation threshold was replaced with a threshold based on water depth; a value of 2.5 feet was used for the depth threshold (Meselhe et al., 2015). These are planning level assumptions only and are meant to provide a consistent framework for assessing fill volumes and areas created under various conditions across the coast and into the future. An example of the depth thresholds in the Bayou La Loutre region are depicted in Figure 2.

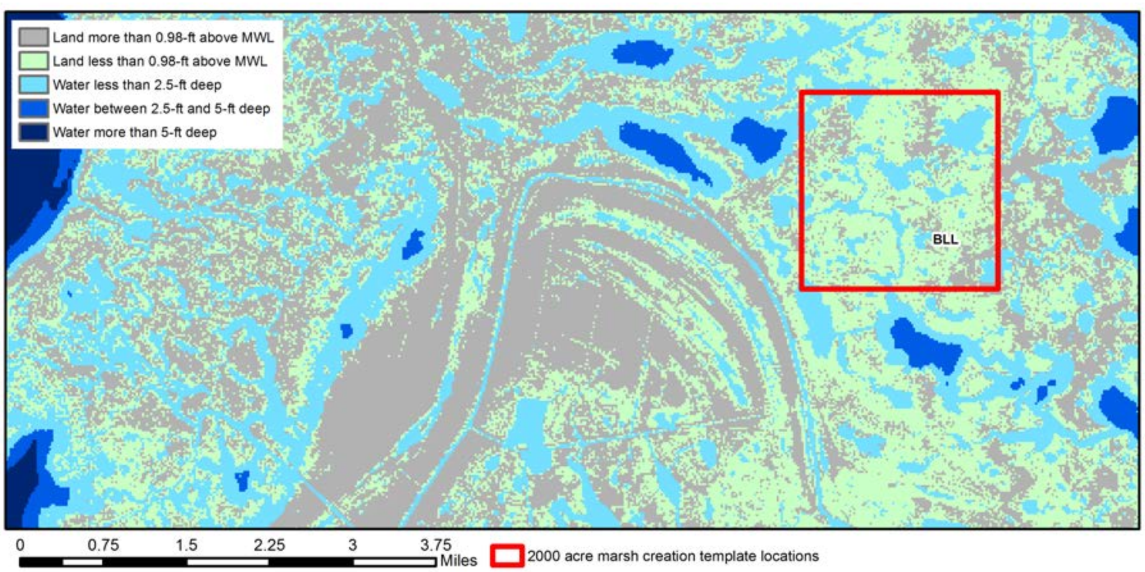

Figure 2: Water depth thresholds in the Bayou La Loutre region, southeast of Lake Borgne.

The thresholds were used to determine what areas, within each marsh creation template, should be defined as *shallow* or *deep water*. If a land/water pixel (pixels used in this analysis are determined by satellite imagery) located within the marsh creation polygon was considered *deep water*, that pixel would not be included in the marsh creation polygon; only existing land pixels and shallow water would be built to the post-construction elevation of the marsh creation template. The annual mean water level model output for FWOA was used in conjunction with the annual elevation model output to determine the mean water depth for any given pixel. Water level data were calculated within the hydrology module of the ICM).The elevation of each pixel within the topo-bathymetric dataset was updated annually to account for sediment deposition, organic accretion, marsh collapse, and subsidence.

The volume of sediment required to build each marsh creation template was determined by subtracting the post-construction elevation from the pre-construction elevation and by multiplying it by the representative area of each pixel, 0.22 acres (900 sq. meter). The pre-construction elevation was taken from the model output topo-bathymetric elevation at the start of the assumed project implementation year. Then, the post-construction elevation was chosen to be 0.98 feet (0.3 meters) above the annual mean water level during the project implementation year, which is consistent with the assumptions used in the master plan. Any area within the marsh creation template that was classified as *deep water* was excluded from the build area.

This analysis was conducted for each site for the initial model condition and at 10-year intervals into the future for each of the five scenarios. For each time period/scenario, the volume required and the area created within the polygon template were recorded.

COST APPROACH

The volume of material needed is only one of the costs of marsh creation project implementation. However, volume is one cost factor that will vary as future coastal conditions change. Determining the present cost of placing these volumes of material involved several steps:

- Each of the study sites were associated with a designated dredged material source area as referenced in the 2017 Coastal Master Plan and based on Larenas et al. (2015). Distances from each of the sites to the closest borrow area were calculated;
- A generalized relationship, based on project costs and locations in the 2012 Coastal Master Plan (Clark et al., 2015), was developed between cost per cubic yard, and distance conveyed (Figure 3) was used to estimate the cost per yard for each of the sites. These values were used to estimate the cost of the project at each site for the initial condition in 2010 dollars (the basis of the cost estimates used in the 2012 Coastal Master Plan); and
- These were converted to costs in 2015 dollars (the basis used in the 2017 Coastal Master Plan) using a readily available construction cost index (https://www.fhwa.dot.gov/policyinformation/nhcci/pt1.cfm). This resulted in cost increasing from those calculated based on Clark et al. (2015) by a factor of 1.03.

The result was an estimate of the initial cost of marsh creation at each of the sites, which was also used to calculate the cost per acre.

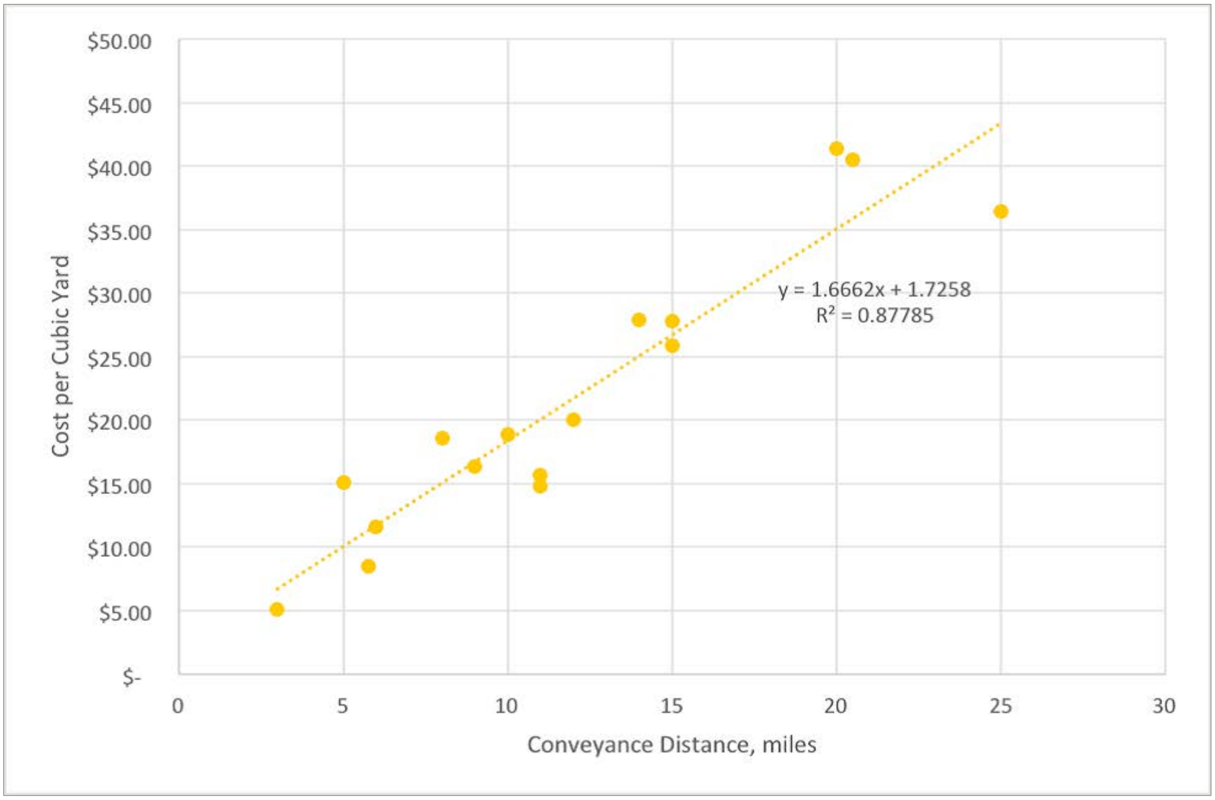

Figure 3: Cost per yard versus distance based on projects included in the 2012 Coastal Master Plan (from Clark et al., 2015).

Estimating Future Costs

Estimates of cost changes for construction at future time intervals used changes in volume and considered inflation. Changes in volume were calculated for each decade for each scenario and for each site. An example of the changes in volume is shown in Figure 4. Note that the volume needed increases for all scenarios through year 30, and then for the scenarios with higher sea-level rise and subsidence rates (i.e., D and E volumes) decrease at year 40. This is because the increase in water depth has exceeded the depth threshold and some parts of the polygon are no longer filled. For scenario A, volumes continue to increase through year 50, and even though the depth to be filled is increasing over time, the threshold exceedance does not lead to the decrease in volume seen in other scenarios.

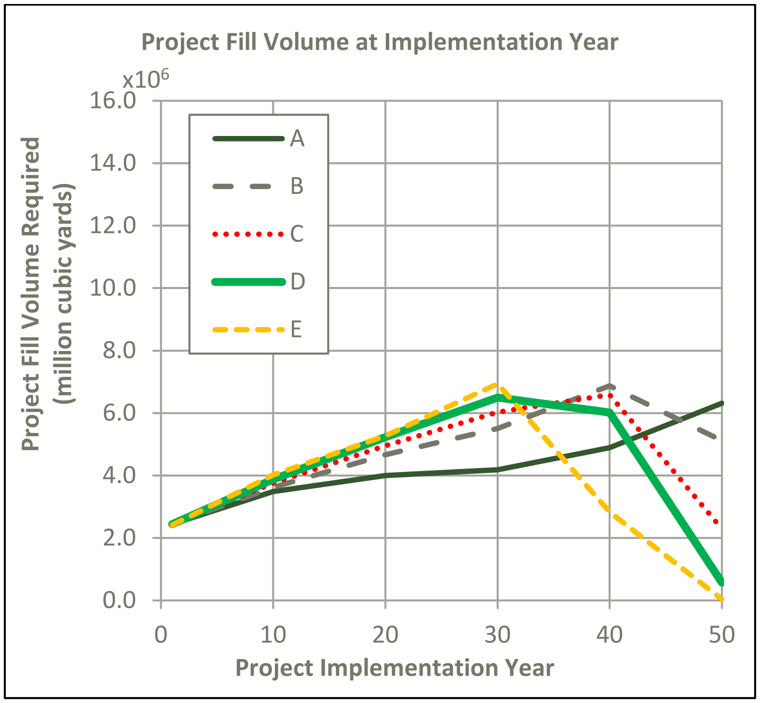

Figure 4: Example from West Little Lake locations of changes in volume over time for each scenario.

The proportional change in volume over time was used in combination with inflation rates to estimate the cost of constructing the project at 10, 20, 30, 40, and 50 years into the future. A linear trend in construction cost inflation was used assuming either 1% per year or 2% per year. This analysis assumed the funds needed to complete future construction will be available in that future year and will come from revenues (e.g., tax and fees) collected at the future dates when the projects are constructed. An example of how costs change using 2% per year is shown in Figure 5.

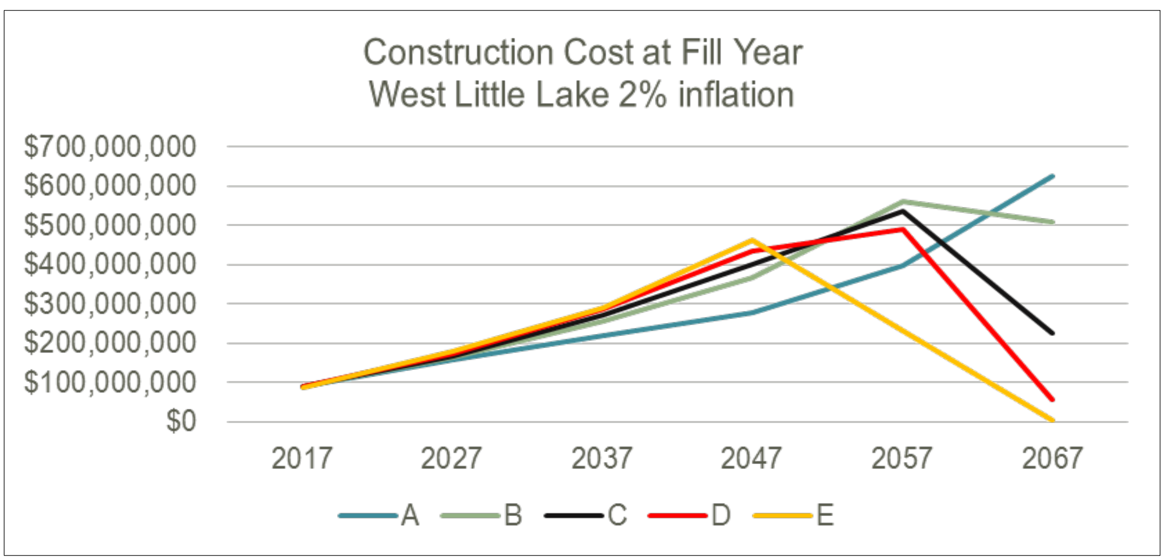

Figure 5: Example using of future changes in construction costs using 2% per year inflation.

Cost of Delay vs. Cost of Hastening

The analysis above assumed that the funds available to build the projects at the future time periods were generated at the time they were needed for construction. The sooner projects are built, the sooner their ecological benefits can be realized. Thus, two other circumstances were explored:

- Can selling bonds to build projects sooner lead to overall cost savings?
- How much do long delays in construction, when funds are in hand, cause costs to increase?

SELLING BONDS

A financial (cash flow) analysis was conducted in order to consider the potential of bond financing for constructing marsh creation projects. The analysis assumes that:

- In year 0, funds are not available and that the marsh creation will be implemented in a future year (10, 20, 30, 40, or 50);
- The funds needed to complete future construction will be available in that future year and will come from revenues (e.g., tax and fees) collected at the future dates when the projects are constructed;
- Any funds needed to pay off a bonded debt will come from revenues collected at the future dates of project construction; and
- Costs for the projects will increase in future years a) as construction costs increase and b) as sediment volumes needed to complete the project (sediment demand) increase.

If there are no funds to build any given project today, there is the option to sell bonds (in effect, take a loan) in order to accelerate construction of a future project scheduled for year 10 (or 20 or 30). If the amount needed to build the project in year 0 is bonded then the cost to build now rather than in the future year will include the cost for the interest on the bond that is paid in the future year 10, 20 or 30. There are no general market offerings of bonds with a maturity of more than 30 years so the financial analysis has a 30-year time horizon. Bond rates were used based on those available on August 8, 2016. Examples of the results of this analysis for West Little Lake and 1% inflation are shown in Table 3.

Table 3: Example analysis of savings potential by selling bonds to expedite projects for West Little Lake.

A – Low Scenario	**Cost to Construct in year 0 ($k)**	**Cost to Construct in year 10 ($k)**	**Cost to Construct in year 20 ($k)**	**Cost to Construct in year 30 ($k)**
Construction Cost	$90,086	$141,507	$179,920	$208,070
Cost to Bond and Construct in year 0		10 year bond $105,707	20 year bond $131,706	30 year bond $179,488
Savings by borrowing to to build now		$35,800	$48,213	$28,582

DELAYING CONSTRUCTION

Analysis was conducted to assess the implications of delays in implementation. This involved comparing project cost increases over time (due to volume increases and inflation) versus potential interest earnings of funds in hand, which could not be expended due to delays. As stated above, the assumption was made that construction costs for the projects will increase in future years as a) construction costs increase and b) sediment volumes needed to complete the project increase. Additionally, the assumption was made that interest rates paid on invested funds would be similar to interest rates paid for bonds and that delays would be limited to 10 years. Table 4 provides example results for this analysis.

Table 4: Example of Interest Earnings Calculations for West Little Lake.

A – Low Scenario	**Cost to Construct in year 0 ($k)**
Construction Cost in 2017	$90,086
Interest earnings by year 10	$15,620
Deficit due to 10 year delay in construction	($35,800)

References

Clark, F.R., Bienn, H.C., & Willson, C.S. (2015). Assessing the Cost of Coastal Land Creation Using Dredged Material. The Water Institute of the Gulf. Science & Engineering Plan – Project Implementation Support Task. Baton Rouge, LA.

CPRA, Coastal Protection and Restoration Authority of Louisiana. (2012). Louisiana’s Comprehensive Master Plan for a Sustainable Coast. Coastal Protection and Restoration Authority of Louisiana – Appendix A: Project Definitions. Baton Rouge, LA.

Larenas, M.; Forrest-Vandera, B.M.; & Andrews, J.L., 2015. Report on Louisiana Surficial Sediment Distribution Map Compilation and Sand/Sediment Volume Estimates. Boca Raton, Florida: CB&I Environmental & Infrastructure, Inc., 31p. (Prepared for Coastal Protection and Restoration Authority of Louisiana).

Meselhe, E., Reed, D. J., & Grace, A. O. (2015). 2017 Coastal Master Plan: Appendix C: Modeling. Version I. (p. 120). Baton Rouge, Louisiana: Coastal Protection and Restoration Authority. http://coastal.la.gov/wp-content/uploads/2016/05/Appendix-C-Ch123_052516.pdf