2.0 PLAN FORMULATION

Plan formulation supports USACE water resources development missions. A systematic and repeatable planning approach ensures sound decision making. The Principles and Guidelines describe the process for Federal water resource studies requiring formulation of alternative plans contributing to Federal objectives. This chapter describes the process to identify the TSP and shows work performed after public and agency comments on the revised draft report released in March 2015.

Plans or alternatives are composed of measures. Measures consist of features which are structural elements that require construction or assembly and/or activities which are nonstructural actions implemented to address planning objectives. Each feature and/or activity represents a measure that can be implemented to address planning objectives at a specific geographic site.

This study considered measures consistent with NED and NER objectives. All measures were evaluated and screened for capability to meet objectives and avoid constraints, for engineering and economic feasibility, and to maximize benefits provided over the 50-year period of analysis from 2025-2075. Measures that warranted continued consideration and met the success thresholds were assembled into alternative plans. In the evaluation process, each alternative plan was required to meet study-specific minimum standards and qualifying criteria in order to merit further consideration. Each plan was evaluated individually to determine whether it qualified for additional consideration.

> Note: This chapter describes the alternative development, formulation, and evaluation process that led to the identification of the NED and NER TSPs. The information contained herein was presented in the 2015 Revised Draft Report that was released for public review in March 2015. Changes to the NED and NER TSPs have occurred since that public review which are briefly described at the end of the NED and NER sections in this chapter. The changes to the TSPs resulted in the Recommended Plan presented in this final report. Descriptions of these plans appear in Chapter 4.

<u>Risk Reduction</u>

The term "100-year level (1% ACE) of risk reduction," refers to a level of reduced risk of hurricane and storm surge wave driven flooding that the project area has a 1 percent chance of experiencing each year. The 1 percent chance is based on the combined chances of a storm of a certain size and intensity following a certain track. Different combinations of size, intensity, and track could result in a 100-year surge event. The 50-year level (2% ACE) of risk reduction refers to a level of reduced risk of hurricane and storm surge wave driven flooding that the project area has a 2 percent chance of experiencing each year. The 200-year level (0.5% ACE) of risk reduction refers to a level of reduced risk of hurricane and storm surge wave driven flooding that the project area has a 0.5 percent chance of experiencing each year.

2.1 Goals and Objectives

Generally, the planning goals of the NED Plan are to reduce damages associated with hurricane and coastal storm surge flooding. The NED storm damage risk reduction plans were formulated to achieve NED principles and objectives. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the Nation.

The general planning goals of the NER Plan are to significantly and sustainably reduce land loss and coastal erosion, restore environmental conditions for the Chenier Plain ecosystem, and evaluate a range of coastal restoration components to address a multitude of ecosystem problems. Plans were formulated to achieve NER principles and objectives. Contributions to NER are increases in the net quantity and/or quality of desired ecosystem resources, and are measured in the study area and nationwide.

The Project Delivery Team (PDT) developed the following planning objectives to apply to the entire study area over the 50-year planning horizon (2025-2075):

- NED Objective 1. Reduce the risk of damages and losses from hurricane and storm surge flooding.
- NER Objective 2. Manage tidal flows to improve drainage, and prevent salinity from exceeding 2 parts per thousand (ppt) for fresh marsh and 6 ppt for intermediate marsh.
- NER Objective 3. Increase wetland productivity in fresh and intermediate marshes to maintain function by reducing the time water levels exceed marsh surfaces.
- NER Objective 4. Reduce shoreline erosion and stabilize canal banks to protect adjacent wetlands.
- NER Objective 5. Restore landscapes, including marsh, shoreline, and cheniers to maintain their function as wildlife habitat and improve their ability to serve as protective barriers.

2.2 Constraints

The NED and NER plans are limited by the following constraints that are to be avoided or minimized:

- **Commercial navigation.** The Calcasieu and Sabine Ship Channels and the GIWW carry significant commercial navigation traffic. Measures that would cause shipping delays would result in negative NED impacts. In addition, the ability of authorized navigation projects to fulfill their purpose, such as the operation of locks along the GIWW, may be impacted by project features.
- **Federally listed threatened and endangered species and their critical habitats.** Construction schedules may be restricted due to T&E species including, but not limited to piping plover, Gulf sturgeon, red-cockaded woodpecker, red knot, whooping crane, West Indian manatee, and several species of sea turtles.
- **Essential fish habitat (EFH), especially intertidal wetlands.** Conversion of one EFH type to another should be done without adversely impacting various fish species.
- **Cultural and historic resources.** Prehistoric and historic archeological sites, buildings, structures, districts, and properties that may be of religious and cultural significance to Indian tribes are located in the study area, including properties included in or eligible for inclusion in the NRHP.

2.3 Study Authorizations

2.3.1 NED Study Authorization

A survey of the coast of Louisiana in Cameron, Calcasieu, and Vermilion Parishes, with particular reference to the advisability of providing hurricane and storm damage risk reduction and related purposes, including the feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway was authorized by a Resolution of the Committee on Transportation and Infrastructure, U.S. House of Representatives, Docket 2747, on December 7, 2005.

The U.S. Army Corps of Engineers, Mississippi Valley Division, New Orleans District (CEMVN) initiated a Section 905(b) reconnaissance study in April 2006. NED alternatives to reduce hurricane-induced damages within Calcasieu, Cameron, and Vermilion Parishes were formulated through a series of planning meetings with the State of Louisiana, local parishes, and other stakeholders. The following three structural alternatives were initially determined to be sufficiently economically justified with a benefit-to-cost ratio (BCR) greater than 1.0, which would warrant further Federal investigation:

- Armored 12-foot earthen levee that allows for overtopping constructed along the GIWW alignment on the south side across Calcasieu, Cameron, and Vermilion parishes (height and alignment specified in the study resolution), with control structures constructed across waterways.
- Non-armored 12-foot earthen levee that allows for overtopping constructed along the north side of the GIWW providing storm damage risk reduction to the Lake Charles area.
- Non-armored 12-foot earthen levee that allows for overtopping constructed along the north side of the GIWW providing storm damage risk reduction to the Abbeville area.

2.3.2 NER Study Authorization

The 2004 LCA Restoration Study Report and Programmatic Environmental Impact Statement (2004 LCA Study) was developed to identify cost-effective, near-term (ten year implementation period) restoration features to reverse the degradation trend of the coastal ecosystem of Louisiana. The Near-Term Plan that resulted from the 2004 LCA Study focused on restoration strategies that would reintroduce historical flows of river water, nutrients, and sediments; restore hydrology to minimize saltwater intrusion and maintain structural integrity of coastal ecosystems. The 2004 LCA Study identified critical projects, multiple programmatic authorizations, and ten additional required feasibility studies. The Report of the Chief of Engineers dated 31 January 2005 (2005 Chief's Report) approved the Near-Term Plan substantially in accordance with the 2004 LCA Study. Title VII of the Water Resources Development Act of 2007 (WRDA 2007) (Public Law 110-114) authorized an ecosystem restoration Program for the Louisiana Coastal Area substantially in accordance with the Near-Term Plan.

The Chenier Plain Freshwater Management and Allocation Reassessment Study (Chenier Plain Study), recommended in the 2005 Chief's Report was one of six large-scale restoration concepts that were purported to have the ability to "significantly restore environmental conditions that existed prior to large-scale alteration of the natural ecosystem" upon construction. WRDA 2007 authorizes fifteen near-term features to address critical restoration needs of coastal Louisiana, demonstration projects, a beneficial use of dredged material program, project modifications, and a science and technology program. Guidance provided by the Director of Civil Works on December 19, 2008 states that "*the coastal restoration components proposed as part of the LCA Chenier Plain study will be evaluated as part of the Southwest Coastal Louisiana feasibility study*".

A Feasibility Cost Share Agreement between USACE and the CPRAB, as the non-Federal Sponsor, was executed on January 14, 2009 for the study and analysis of the NED and NER study alternatives.

2.4 Prior Studies

Table 2-1 lists relevant reports and studies that were considered in the development of the NED and NER plans.

Table 2-1: Relevant prior studies, reports, programs, and projects for the SWC Louisiana feasibility study.

Prior Studies, Reports, Programs, and Water Projects	Parish	Potential Data Source	Consistency	Source of Measures
Planning Studies				
Coast 2050 Plan, 1999	All	✓	✓	
LCA, Louisiana Ecosystem Restoration Study, 2004	All	✓	✓	✓
Louisiana's Comprehensive Master Plan for a Sustainable Coast,-2012	All	✓	✓	✓
Louisiana Coastal Protection and Restoration (LACPR) Technical Report, 2009	All	✓	✓	✓
Calcasieu River Basin Feasibility Study (Draft)	Calcasieu	✓		
Calcasieu River and Pass, Louisiana, Dredged Material Management Plan and Supplemental EIS	Calcasieu, Cameron	✓	✓	✓
Federal Laws and Programs				
CWPPRA 1990	All	✓	✓	✓
USACE Continuing Authorities Program (WRDA Sec. 204), 1996	All			✓
CIAP, 2001 & 2005	All	✓		✓
Second Emergency Supplemental Appropriations Act to Meet the Immediate Needs Arising from the Consequences of Hurricane Katrina, 2005 (Public Law 109-062)	N/A	✓	✓	

Prior Studies, Reports, Programs, and Water Projects	Parish	Potential Data Source	Consistency	Source of Measures
Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic Influenza Act, 2006 (Public Law 109-148)	N/A	✓	✓	
State Laws and Programs				
Louisiana Coastal Wetlands Conservation, Restoration and Management Act, 1989	All		✓	
Act 8 of the Louisiana Legislature First Extraordinary Session of 2005	All	✓	✓	
Parish Coastal Wetlands Restoration Program (Christmas Tree Program)	All	✓		
Vegetation Planting Program	All	✓		
Ecosystem Restoration Projects By Funding Source				
CWPPRA Projects	All	✓	✓	
CIAP Projects	All	✓	✓	
State Projects	All	✓	✓	
WRDA Section 204/1135 Projects	All	✓	✓	
Federal Emergency Management Agency Projects	All	✓	✓	
Federal Navigation Projects				
Bayou Teche and Vermilion River	Vermilion		✓	
Freshwater Bayou and Freshwater Bayou Lock	Vermilion	✓	✓	
GIWW	All	✓	✓	
Calcasieu River, Pass and Bar Channel	Calcasieu, Cameron	✓	✓	
Mermentau River	Cameron	✓	✓	
Sabine-Neches Waterway	Calcasieu, Cameron	✓	✓	

2.5 NED Alternative Formulation

A broader description of the process used to formulate the initial array is captured in Table C-3 in Appendix C. Early modeling was performed to determine where hurricane storm surge damage potential exists in the study area. Figure 2-1 depicts red dots that represent structures within the structure inventory that are included within the 100-year floodplain and thus, are at risk of hurricane or storm surge-induced flood damages. At-risk structures are concentrated in several areas where levee systems could potentially reduce risk. The remainder of the study area (outside of Lake Charles, Delcambre, Abbeville, and Erath) is less densely populated and at-risk structures are dispersed over large areas. Therefore, nonstructural measures were considered for these less populated areas.

To assess the benefits of any structural or nonstructural alternative, measure, or feature, the preventable physical damages to existing residential, commercial, industrial, and public buildings and facilities were considered. There are other physical damages, and/or disruptions, associated with broadly dispersed physical infrastructure and natural resources, that may be integral to economic sectors, such as oil and gas production (e.g., pipelines, production facilities, etc.) or agriculture (e.g., livestock, field crops, etc.). However, because no assurance of reduction in damage or associated loss of productivity can be determined through a dedicated, site-specific application of the measures and features available, these damages could not be included.

The structure inventory was supplemented with additional residential and non-residential properties that are expected to be placed in service in FWOP conditions. These supplemental properties generically represent "future growth" with respect to economic assets. Flood plain regulations, mandated by the NFIP (managed by FEMA) and executed through local government ordinances, building codes and permits, require that the first floor elevation of any new structure be placed at or above the base flood elevation as indicated by the corresponding FIRM. Therefore, while structures that are expected to be placed into service in the future are included in the structure inventory, their exposure to the risk of flooding from hurricane storm surge is significantly less than many structures found in the inventory under existing conditions.

The reduction in expected future damages to the physical facilities and industrial facilities, including oil and gas facilities, was considered as an NED benefit for BCR computations. To achieve this, direct telephone contact was initiated to all 71 owners/operators of industrial facilities in the area requesting information relating to the replacement cost of at-risk facility components and associated depth-percent-damage relationships. Of these 71 inquiries, 44 provided data that is required in the economic analysis. However, no information was provided by the remaining 27 owners/operators. Lacking these data, no speculative estimation of depth-damage relationships to these facilities was made and as a result, the structure inventory used to evaluate damages and benefits for levee plans does not include these facilities.

Plan Development Strategies. Prior to developing specific measures and features for alternative formulation, the PDT identified two broad categories to address study goals: a comprehensive levee plan and a comprehensive nonstructural plan. The reconnaissance report recommendation (12-foot levee along the GIWW) was also used as a starting point to achieve study objectives.

- **Armored 12-foot levee along the GIWW (Reconnaissance Report Recommendation).** Study authority requires assessing the "feasibility of constructing an armored 12-foot levee along the Gulf Intracoastal Waterway." This 122-mile levee was determined to be marginally justified for further Federal investigation in the 2007 reconnaissance report. Nonstructural measures would be applied to communities south of the GIWW, including Cameron, Hackberry, Holly Beach, Creole, Grand Chenier, Pecan Island, and Intracoastal City. This plan is not included in the 2012 State of Louisiana Comprehensive Master Plan for a Sustainable Coast (State Master Plan).

- **Comprehensive Levee Plan.** Individual levees would be built around the largest population centers, and nonstructural measures would be applied in all other areas. Levees could be located around the areas of Lake Charles, Abbeville (including Erath and Delcambre), Kaplan, and Gueydan. The Lake Charles metropolitan area is the largest urban center with a population of approximately 194,000 (U.S. Census, 2009). From west to east, the communities of Gueydan, Kaplan, Abbeville, Erath, and Delcambre are located in northern Vermilion Parish along Highway (Hwy) 14 and have estimated populations of 1,600, 5,200, 12,300, 2,200, and 2,200, respectively (U.S. Census, 2010). The State Master Plan includes plans for levees in the greater Lake Charles and Abbeville areas. Plans for levees around Kaplan and Gueydan are included in the Louisiana Coastal Protection and Restoration (LACPR) study.

- **Comprehensive Nonstructural Plan.** Nonstructural measures were considered as alternatives that could be implemented in the entire study area. Owners of eligible residential and commercial structures (including public buildings but excluding warehouses and industrial facilities) would participate in implementing measures such as structure elevating, flood proofing, and localized storm surge risk reduction measures. Property acquisition may also be considered if circumstances warrant.

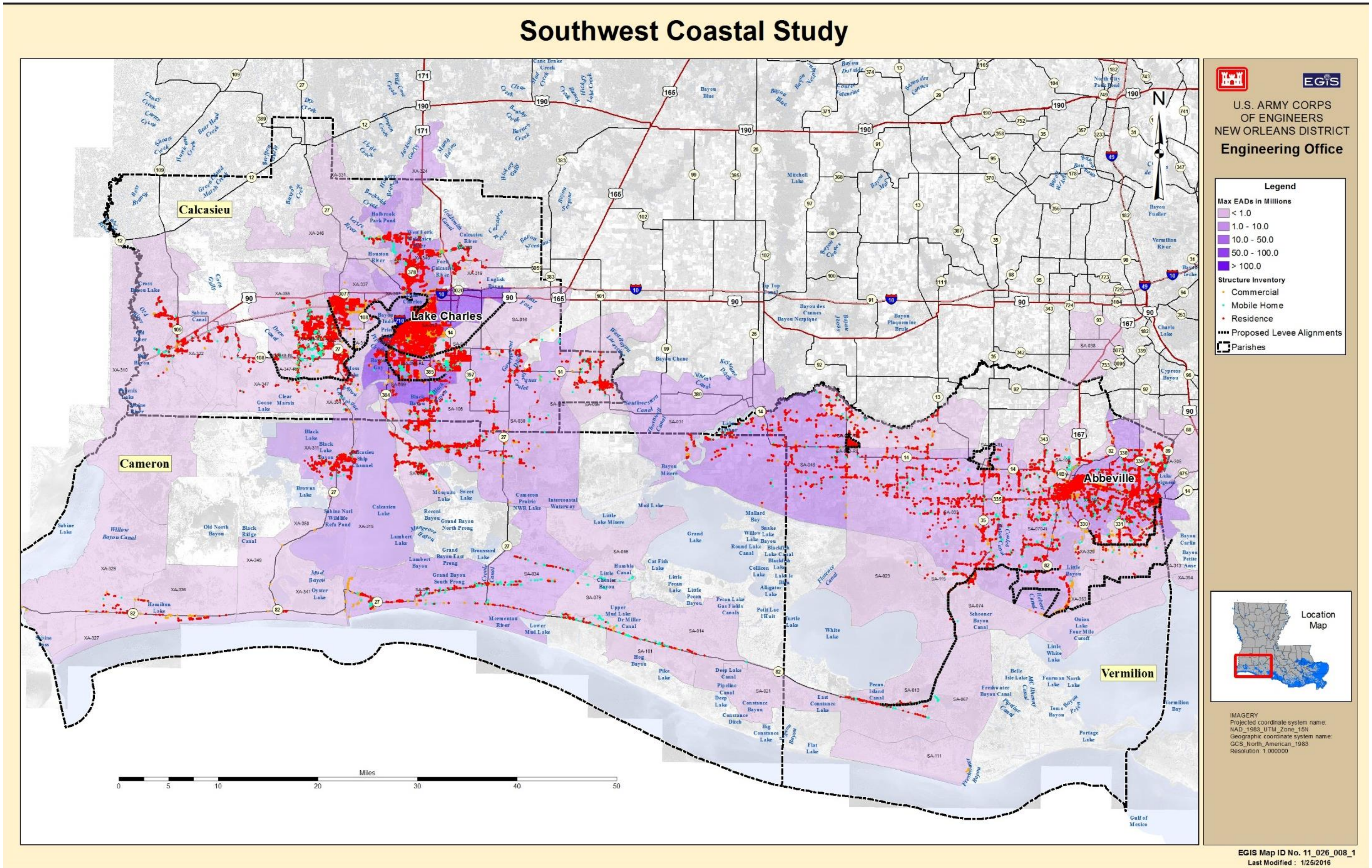

Figure 2-1: Structure inventory and density.

2.5.1 NED Measures (*NEPA Required)

Ten NED measures were developed from various sources including the PDT and the State Master Plan.

Table 2-2: Potential NED measures.

Earthen Levees	Elevation-in-Place
Floodgates	Property Acquisition
Floodwalls	Flood proofing
Pumps	Localized Storm Surge Risk Reduction Measures
Highway Armoring	Floodplain Management Plans, Public Information Campaigns, local government building and zoning code requirements, developmental controls, restrictive covenants, etc.

Measures were evaluated to form comprehensive risk reduction alternatives for the entire study area. North of the GIWW, combinations of structural and nonstructural measures were based on existing Federal, State, and local plans (i.e., Southwest Coastal Reconnaissance Study, LACPR, State Master Plan, and the Vermilion Parish Hurricane Protection Plan). South of the GIWW, structural plans were determined to be technically unfeasible because of broadly dispersed (rural) populations.

2.5.2 Initial Array of NED Alternative Plans (*NEPA Required)

Fifteen HSDRR alternatives were identified for further analysis (Table 2-3):

Table 2-3: NED initial array of alternatives.

Independent Variations	
Armored 12-Foot Levee Along the Length of the GIWW	
Gueydan Ring Levee	
Kaplan Ring Levee	
Louisiana Hwy 333/82 Armoring	
Nonstructural Measures	
Lake Charles Levee Variations	**Abbeville Levee Variations**
Lake Charles – Southern (east and west)	Abbeville Marsh/Upland Interface
Lake Charles – Southern/Eastern only	Abbeville along GIWW
Lake Charles – Southern/Western only	Abbeville along LA Hwy 330
Lake Charles – Northern (east and west)	Abbeville (shortened variation) – Excludes Erath and Delcambre
Lake Charles – Northern (east only)	
Lake Charles – Northern (west only)	

The following assumptions were used in a screening process for the initial array of the 15 NED alternatives.

- Ninety hydrologic reaches characterized by unique relationships between storm surge elevations and frequencies were identified. Of these 90 reaches, only 63 were shown to include economic assets that were subject to inundation damages.
- An inventory of structure values, types, and first floor elevations was compiled for all residential and non-residential structures which totaled approximately of 52,000 structures. These included industrial structures for which owners/operators provided information with respect to the vulnerability of damageable property. Warehouses were considered at this stage for the structural plans only, but were included in a subsequent detailed analysis of nonstructural plans.
- A range of low and high costs were developed for the structural features considered.
- Without-action damage estimates were developed and multiplied by a rule of thumb based on the reciprocal of interest and amortization (in this case 20) and used as a surrogate for potential benefits. These values

were then used to determine the level of construction costs that could be supported. Stage-probability curves were calculated using Hydrologic Engineering Center-River Analysis System (HEC-RAS) (for rainfall) and Advanced Circulation (ADCIRC) (surge) model results. They represent 2012 existing conditions.

- An estimating approach was used to determine the potential first construction cost that could be supported by the potential project benefits expressed as an expected annual value. The amortization factor for a Federal discount rate of 3.5 percent is 0.04263. The inverse of that number (23.5) was used as a multiplying factor to develop the initial estimate. However, this figure is a rough estimate of total project costs that could be supported, rather than project first costs. The PDT rounded the factor to 20.0 to account for additional non-construction components of total project costs [interest during construction, operations and maintenance (O&M), engineering and design, and supervision and administration costs].
- The difference between the benefits and costs represents net benefits.
- Simplifying assumptions were made that allowed the PDT to more easily compare alternatives:
  - No induced damages from hurricane storm surge induced flooding outside of levees. No damages from hurricane storm surge induced waves.
  - Though this study was not authorized to address damages from rainfall events, an assumption was made that structural alternatives would reduce risk for all potential hurricane storm surge or rainfall damages for events between 25 and 200 years, which represent events dominated by storm rather than predominantly rainfall flooding. Net benefits less than zero were used to screen alignments.
- Intermediate RSLR was used for future conditions.
- Under without-project conditions, structures at or below the 10-year stage are considered to be repetitively-flooded properties in the evaluation of both structural and nonstructural plans. Therefore, the structure inventory used in the economic analysis (for both structural and nonstructural plans) reset these properties to an elevation beyond the limits of the 100-year floodplain.
- For levee plans that provide hurricane storm surge risk reduction up to the base flood elevation for a 100-year event (1% ACE), few if any benefits would accrue to these structures. Therefore, their addition to the structure inventory has a minor impact on BCR estimates.

2.5.2.1 Initial NED Alternative Plan Screening Considerations

Results of how the 15 initial NED alternatives were assessed and eliminated are presented in Table 2-4. The complete set of structural plans evaluated at this level of screening is described in Table C-4 of Appendix C.

Table 2-4: NED initial screening.

Feature Name (ID)	Levee Length (miles)	Best Estimate Benefits x 20 in mil $[1]	"Low Cost Scenario" Levee + Pumps in mil $[2, 3]	"High Cost Scenario" Levee + Pumps in mil $[4]	Are best estimate benefits x 20 greater than "Low" costs?	Are best estimate benefits x 20 greater than "High" costs?	Screening Decision
Armored 12-ft Levee along the GIWW (per study authority and Recon Alternative S-1)	122	1,835	3,372	4,714	No	No	Eliminated; not enough benefits (once repetitive damages removed) to justify structural solution cost.
Gueydan Ring Levee	6	8	120	180	No	No	Eliminated; damages would have to increase by orders of magnitude to justify structural solution cost.
Kaplan Ring Levee	11	0.7	215	325	No	No	Eliminated; damages would have to increase by orders of magnitude to justify structural solution cost.

Louisiana Hwy 333/82 Armoring	29	N/A	551	841	N/A	N/A	Eliminated; not enough damages to justify structural solution cost
Abbeville Levee along the Marsh/Upland Interface	33	441	990	1,320	No	No	Eliminated; not enough damages to justify structural solution cost[5]
Abbeville Levee along Hwy 330	13	336	275	405	Yes	No	Although benefits are less than high cost estimates, they are within a margin of error. Consider further for reformulation.

1: Multiplication by "20" represents the amortization factor over 50 years based on existing and future-without project expected annual damage (EAD) from floods. First screening used unadjusted inventory; rainfall, and frequent and repetitive damages were not removed. Damages didn't account for industrial structures or future RSLR. Second screening refined the damages to eliminate frequent, repetitive damages. Based on the results from the Morganza to the Gulf of Mexico study, adjustment for RSLR estimated that damages would increase by 50% over existing damages.
2: "Low" levee cost used $21,000,000/mile armored and $19,000,000/mile unarmored (grass only). The unarmored cost is based on indexing the LACPR estimates to current levels. Assuming the existing ground elevation is +5-feet, a 12-foot levee elevation equals +17-feet; with contingency, the cost per mile would be about $15,500,000 for the levee only. It would be around $18,600,000 including engineering and design, and supervision and administration (rounded to $19,000,000 per mile). Additional cost of $2,000,000 per mile for armoring.
3: Pumping costs for the alternatives based on what was developed for LACPR. Pumping costs for GIWW alignment based on the sum of the largest Lake Charles and Abbeville ring levees.
Other studies: Morganza 35-yr levees cost over $60,000,000 per mile for 10- to 20-ft levees (total cost including structures, mitigation, E&D, S&A, etc.). Morganza to the Gulf of Mexico 100-yr levees costs over $100,000,000 per mile for 15- to 26.5-ft levees (total cost including structures, mitigation, E&D, S&A, etc.). Southwest Coastal Reconnaissance Study used $14,000,000 to $20,000,000 per mile but these values were considered extremely low. After initial screening, 10 hurricane and storm surge damage risk reduction alternatives remained.
4: "High" levee cost used $32,000,000 per mile armored; $29,000,000 per mile un-armored (grass only). High costs based on 50% increase over Low costs rounded up to nearest million.
5: Although this particular alternative was screened, its value as a set of smaller individual levees was evaluated for Abbeville and Delcambre. The incrementalized alternatives were made a part of the focused array.

The initial screening removed all alternatives with net benefits of less than zero including the following:

- **Armored 12-foot levee along the GIWW:** Eliminated from further consideration because potential benefits do not justify estimated costs.
- **Kaplan and Gueydan ring levees:** Eliminated from further consideration. Benefits were an order of magnitude less than the costs and as a result only nonstructural measures were evaluated.
- **Louisiana Hwy 333/82 armoring:** Eliminated from further consideration. Since NED benefits are unclear and the highway is maintained by the Louisiana Department of Transportation and Development (LADOTD), it may be more cost effective for the State to construct this measure.
- **Abbeville Levee along the Marsh/Upland Interface:** Eliminated from further consideration because potential benefits do not justify estimated costs.

2.5.3 Focused Array of NED Alternative Plans (*NEPA Required)

The initial screening left 10 alternatives (the focused array) that warranted additional evaluation (see Table 2-5). A full description of all features and screening is available in Appendix C.

Table 2-5: Initial alternatives that comprise the NED focused array

Independent Variations
Nonstructural Measures
Abbeville Levee Variations
Abbeville along GIWW
Abbeville along LA Hwy 330
Abbeville (shortened variation) – Excludes Erath and Delcambre
Lake Charles Levee Variations
Lake Charles – Southern (east and west)
Lake Charles – Southern/Eastern only
Lake Charles – Southern/Western only
Lake Charles – Northern (east and west)
Lake Charles – Northern (east only)
Lake Charles – Northern (west only)

2.5.3.1 Evaluation and Refinement of Focused Array

The PDT assessed the focused array of alternatives and as a result, some levee alignments were incrementalized and formulated into new alternatives. Although some Abbeville structural alternatives have little to zero marginal benefits, the PDT considered whether a set of smaller individual levees for Abbeville and Delcambre could provide a more cost-effective solution. Since levees around rural areas tend to drive down benefits significantly, the PDT developed smaller, incrementalized alternatives that showed the potential for higher benefits and lower costs for the more densely populated areas. Additionally, since a structural solution for Abbeville is included in the State Master Plan, new configurations of the Abbeville levee were developed for additional analysis.

Benefits outweigh costs for the east Lake Charles levees, but for the western Lake Charles levees, costs outweigh benefits. As a combined set of structural features, the east and west Lake Charles levees had marginal benefits to justify costs, however, reconfigured Lake Charles west levees were carried forward since the PDT felt new levee alignments could be drawn to better focus on more densely populated areas and since a 500-year structural solution for Lake Charles is included in the State Master Plan.

These steps allowed the PDT to identify levee alignments that would more precisely target populated areas adjacent to Lake Charles and Abbeville because only the largest population centers had the potential BCR to support structural measures. Three alignments were drawn at a small scale, using existing USACE maps and Google Maps, to protect major residential neighborhoods, while minimizing crossings that would result in major real estate, relocation, and other costs such as pipelines, major roadways, and industrial areas. The alignments depicted in the graphics below comprise the focused array (along with no action and the nonstructural plan) and were carried forward for additional analysis. Figures 2-2, 2-3, and 2-4 show the locations of the proposed alignments with respect to Lake Charles, Abbeville, Delcambre, and Erath.

The focused array consists of the alternative plans listed below. Each structural plan was evaluated at three levels of risk reduction [50-year (2% ACE), 100-year (1% ACE), and 200-year (0.5% ACE) levels] along the same alignment during these comparisons.

Plan 0: No Action
Plan 1: Lake Charles Eastbank Levee
Plan 2: Lake Charles Westbank/Sulphur Extended Levee
Plan 3: Lake Charles Westbank/Sulphur South Levee
Plan 4: Delcambre/Erath Levee
Plan 5: Abbeville Levee
Plan 6: Abbeville to Delcambre Along Hwy 330 Levee
Plan 7: Nonstructural Measures

2.5.4 Evaluation of the NED Structural Alternative Plans

Ninety hydrologic reaches throughout the study area were developed and characterized by unique relationships between storm surge elevations and frequency. With-project damages were developed for the base and future conditions utilizing existing data, current and future without-project damages, and parametric costs. The alternatives were screened based on the 50 year (2% ACE), 100 year (1% ACE), and 200 year (0.5% ACE) levels of risk reduction.

Using the damage probability relationship from the Hydrologic Engineering Center-Flood Damage Analysis (HEC-FDA) model for the six structural alternatives in the reaches receiving damage, it was estimated that a 50 year (2% ACE) project, would eliminate damages for the 25 and 50 year events. The 100 year (1% ACE) project would eliminate damages for the 25, 50 and 100 year events and the 200 year (0.5% ACE) project would eliminate damages for the 25, 50, 100 and 200 year events. The six alternatives would not eliminate damages from rainfall for more frequent events (1 and 10 year events) because limited topographic relief results in rainfall driven flooding that structural risk reduction measures cannot prevent at higher frequency events.

A percentage was applied to the overall benefits by reach for each of the remaining six structural alternatives to reflect the estimated percentage of the total structures in a reach that are receiving risk reduction from each alternative. For example, approximately 40 percent of the residential and non-residential structures in reach XA-305 lie behind the proposed levee alignment. Therefore, the estimated total benefits calculated for that reach are multiplied by 40 percent to determine the benefits for the Abbeville to Delcambre alternative for reach XA-305. This methodology was applied to all proposed alternatives.

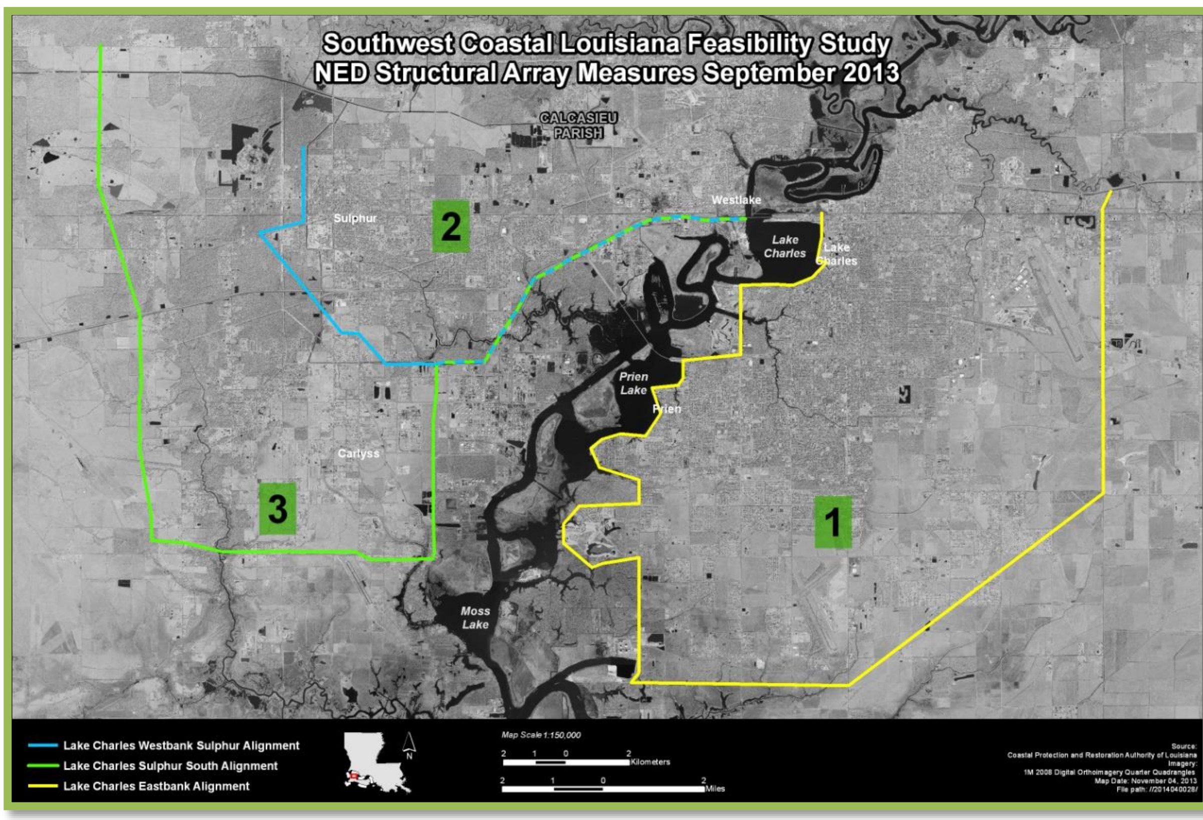

Figure 2-2: Lake Charles conceptual structural alignments.

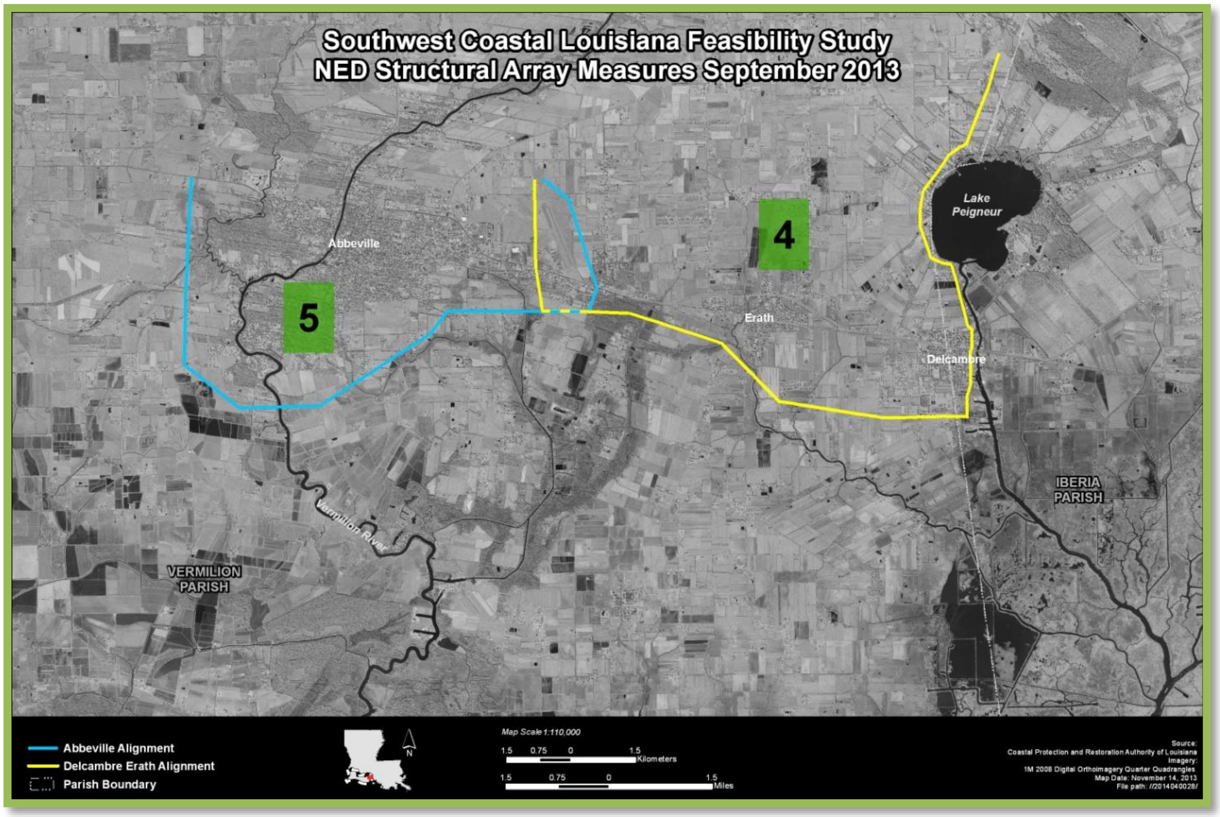

Figure 2-3: Abbeville, Delcambre, and Erath conceptual structural alignments.

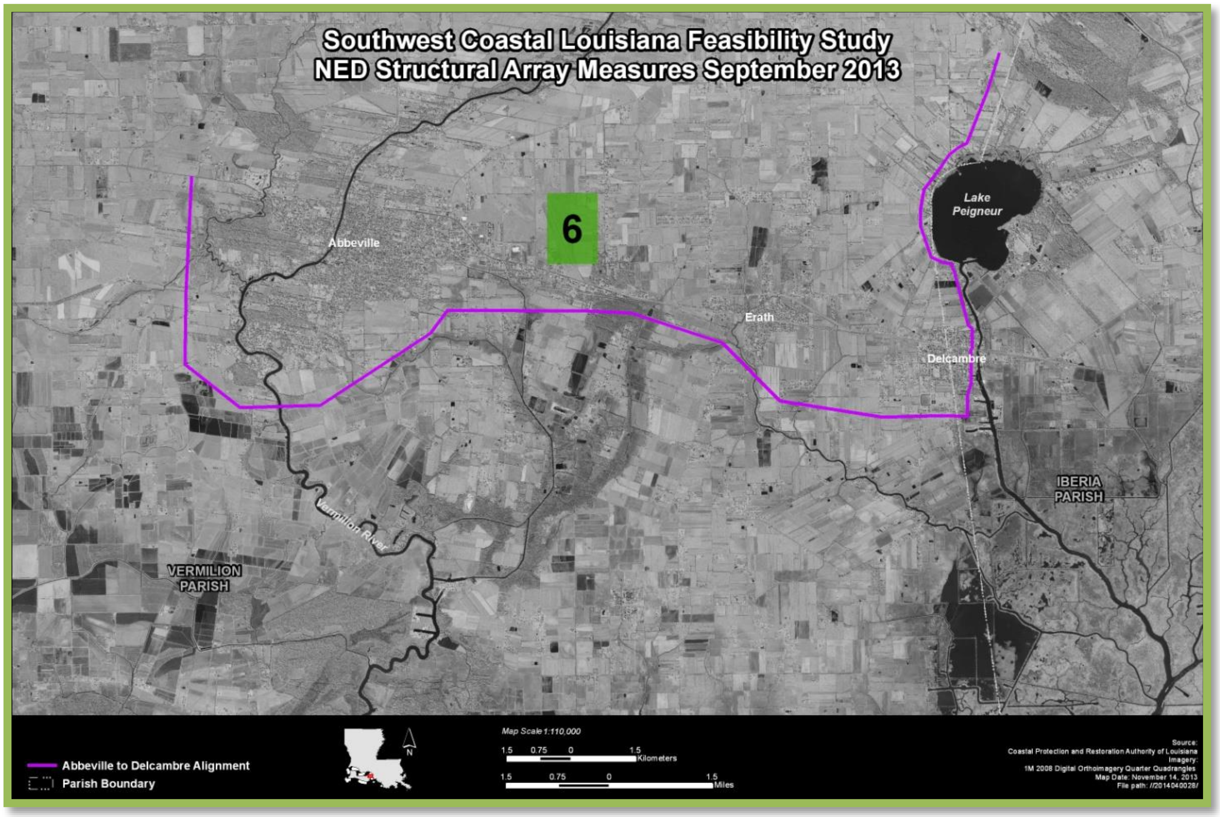

Figure 2-4: Abbeville to Delcambre combined conceptual structural alignment.

2.5.4.1 Economic Analysis of NED Structural Alternative Plans

A benefit/cost analysis was conducted to evaluate the economic feasibility of each of the structural plans. Expected annual benefits for 2025 and 2075 were converted to an equivalent annual value using the previous FY14 Federal interest rate, 3.5 percent, and a 50-year period of analysis. Total cost and estimated annual costs for the project alternatives included the construction costs, and O&M costs for the three levels of risk reduction. Construction costs, along with the schedule of expenditures, were used to determine the interest during construction and gross investment cost at the end of the installation period. For the purposes of this study, construction was assumed to begin in 2017 and continue through 2024 with additional levee lifts (to maintain levee height due to sinking and subsidence) beginning in 2067 and construction ending six to seven years later. The first levee lifts would be overbuilt and allowed to settle for several years before the latter levee lift is added for each alternative. Later levee lifts would account for the RSLR and subsidence that is projected to occur throughout the period of analysis.

Tables 2-6 through 2-8 show the first construction costs, average annual costs, average annual benefits, BCR, and net benefits for each alternative in the focused array. As shown in the tables, the Lake Charles Eastbank alternative was the only one with a justified BCR (value >1.0). The Lake Charles Eastbank alternative was justified at each level of risk reduction. The highest net benefits were for the Lake Charles Eastbank alternative at the 100 year (1% ACE) level of risk reduction.

Table 2-6: Economic analysis of alternatives with 50-year (2% ACE) level risk reduction.

Alternatives	First Costs (in Mil $)	Average Annual Costs (in Mil $)	Average Annual Benefits (in Mil $)	Benefit/Cost Ratio	Net Benefits (in Mil $)
Plan 1: Lake Charles Eastbank*	779.4	35.8	37.6	1.05	1.9
Plan 2: Lake Charles Westbank - Sulphur Extended	142.8	6.5	1.4	0.22	-5.0
Plan 3: Lake Charles Westbank - Sulphur South	456.3	20.7	3.0	0.14	-17.7
Plan 4: Delcambre/Erath	359.4	15.5	11.1	0.72	-4.4
Plan 5: Abbeville	286.0	12.9	2.6	0.20	-10.3
Plan 6: Abbeville to Delcambre Along Hwy 330	628.5	27.8	19.4	0.70	-8.4

Table 2-7: Economic analysis of alternatives with 100-year (1% ACE) level risk reduction.

Alternatives	First Costs (Mil $)	Average Annual Costs (Mil $)	Average Annual Benefits (Mil $)	Benefit/Cost Ratio	Net Benefits (Mil $)
Plan 1: Lake Charles Eastbank*	979.1	43.9	50.7	1.16	6.8
Plan 2: Lake Charles Westbank Sulphur Extended	199.3	8.6	3.3	0.39	-5.2
Plan 3: Lake Charles Westbank Sulphur South	629.1	27.6	7.2	0.26	-20.4
Plan 4: Delcambre/Erath	470.8	20.3	14.5	0.72	-5.8
Plan 5: Abbeville	344.1	15.4	7.2	0.47	-8.2
Plan 6: Abbeville to Delcambre Along Hwy 330	784.2	34.4	27.1	0.79	-7.3

Table 2-8: Economic analysis of alternatives with 200-year (0.5% ACE) level risk reduction.

Alternatives	First Costs (Mil $)	Average Annual Costs (Mil $)	Average Annual Benefits (Mil $)	Benefit/Cost Ratio	Net Benefits (Mil $)
Plan 1: Lake Charles Eastbank*	1,224.1	54.2	61.1	1.13	6.9
Plan 2: Lake Charles Westbank Sulphur Extended	327.1	13.9	5.5	0.39	-8.4
Plan 3: Lake Charles Westbank Sulphur South	883.9	38	12.5	0.33	-25.5
Plan 4: Delcambre/Erath	589.5	25.4	17	0.67	-8.5
Plan 5: Abbeville	447.7	19.9	9.7	0.49	-10.2
Plan 6: Abbeville to Delcambre Along Hwy 330	1,000	43.6	32.5	0.75	-11.1

* Although preliminary assessments identified a positive BCR for this alignment, further analysis revealed a negative BCR.

Refinement of the Levee Alternative

The assessment of economic feasibility for six independent structural measures was conducted in the focused array analysis. Initial results of the structural assessment showed that only one alternative was economically justified: the Lake Charles Eastbank Levee Alternative, Plan 1. However, additional economic assessments were conducted to refine costs for this alignment. Mitigation costs (costs any structural alternative must account for due to unavoidable habitat impacts) were calculated for the levee alternative. The USFWS and USACE determined programmatic costs for proposed structural alternatives based upon visual inspection of habitat types potentially impacted along proposed structural alternative routes, professional judgment, and experience with similar hurricane storm surge risk reduction structural systems, and based on engineering assumptions of right-of-way footprints. With mitigation costs of approximately $100,000,000 included for each risk reduction level, the 100-year (1% ACE) level of risk reduction yielded a revised BCR of 1.01 and the 200-year (0.5% ACE) level of risk reduction yielded a revised BCR of 1.04 (adding the mitigation costs made the 50-year (2% ACE) level of risk reduction not economically justified).

In addition, a review of the largest economic drivers of damages and benefits for the Lake Charles Eastbank Levee was conducted. The structure inventory used to calculate data for this alternative was modified to adjust the first-floor elevation (FFE) for a large commercial structure that was capturing a large share of benefits but was also not represented correctly within the 100-year (1% ACE) floodplain. This structure accounted for an unusually high percentage of damages and benefits in initial evaluations. Once this adjustment was completed, the BCR for Plan 1 fell to 0.61 for the 100-year (1% ACE) level of risk reduction and to 0.30 for the 200-year (0.5% ACE) level of risk reduction. As a result of this additional evaluation, none of the structural levee alignments were found to be economically justified and none were carried into the final array of alternatives.

2.5.5 Nonstructural Plan Evaluation

The following nonstructural measures were evaluated:

- Elevation of residential structures to predicted 2075, 100-year base flood elevation (BFE) unless the required elevation is greater than a maximum of 13 ft above ground level*.
- Acquisition/relocation of residential structures that would require elevation over 13 ft above ground level. Property owners would receive fair market value for the property acquired and relocation benefits.
- Flood proofing of non-residential and public structures (excluding industrial buildings and warehouses) for flood depths not greater than 3 ft above the adjacent ground.

**- Raising structures greater than 13 ft above ground level introduces damage risk from winds during tropical events as a new condition. This height generally serves as a differentiator for insurance rates for wind/hail coverage as well and is therefore used as the upper limit for elevating structures.*

2.5.6 Economic Analysis of NED Nonstructural Alternative Plans

The total number of structures inventoried in 2012 (defined by the footprint of the 2075, 500-year (0.05% ACE) floodplain) is approximately 52,000. The number of expected at-risk structures in the 100-year (1% ACE) floodplain, in the base-year 2025, total approximately 16,000 residential, commercial, and public buildings (but excluding warehouses and industrial buildings).

Nonstructural plans were initially evaluated using 90 hydrologic reaches within the study area as the unit of analysis. Structures were included in the inventory if their FFE fell below the expected 2075, 100-year (1% ACE) floodplain and evaluated for potential damages over the 50-year period of analysis. Benefits and costs were calculated on a reach-by-reach basis. Economic justification of each reach was determined by a comparison of average annual benefits to average annual costs. Reaches with a BCR greater than 1.0 were carried forward for additional consideration. Justification was determined by comparing expected annual benefits to expected annual costs. Net benefits were calculated by subtracting the expected annual costs from expected annual benefits. The initial analysis found that 11 of 90 reaches were economically justified. The data extracted from the justified reaches demonstrates the Federal interest in a nonstructural plan and provides definition of the potential magnitude of the plan.

Analysis found that 11 of the 90 hydrologic reaches had a BCR of 1.0 or greater and were economically justified. Ratios for the other 79 reaches fall at or below unity. The combined expected annual benefits for the justified reaches, hereafter referred to as the **Nonstructural - Justified Reaches Plan (Plan 7)**, was estimated at $20.67 million assuming 100% property owner participation, the total cost for implementing a nonstructural alternative based solely on the justified reaches is approximately $388 million. The corresponding average annual cost is approximately $16.5 million; with net benefits of $4.17 million resulting in a BCR of 1.25. As a result, benefits and costs were calculated on a reach-by-reach basis. The results of this analysis demonstrated that there is a Federal interest in implementing nonstructural alternatives which warranted a more focused analysis to consider only those structures within the 2075, 100-year floodplain. Continuing the economic analysis and improving upon the benefits of Plan 7 led the PDT to further refine the nonstructural project. From this effort, Plan 8 evolved.

This more focused evaluation of the economic feasibility of nonstructural measures was also conducted for all structures within the 2075, 100-year (1% ACE) floodplain, irrespective of their location within a reach. This assessment is referred to as the **Nonstructural - 100-year Floodplain Plan (Plan 8)**. The total expected annual benefits for addressing all of the structures within the 2075, 100-year (1% ACE) floodplain are $74.6 million. The total cost for implementing the nonstructural alternative throughout the 2075, 100-year (1% ACE) floodplain is approximately $3.2 billion. The corresponding average annual cost is approximately $138.2 million. After evaluating the entire 90 reach study area, (Plan 8), it was determined that the BCR for addressing all structures within the 2075 100-year floodplain was 0.54.

Two nonstructural plans, Plan 7 and Plan 8, were carried into the final array of alternatives for evaluation.

2.5.7 Summary of Accounts & Comparison of Alternative Plans in the Initial Draft Report

To facilitate alternatives evaluation and comparison of the alternatives, the 1983 Principles and Guidelines lay out four Federal Accounts that are used to assess the effects of alternatives. The accounts are National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

- The NED account displays changes in the economic value of the national output of goods and services. The 1983 Principles and Guidelines require the identification of an NED plan from among the alternatives.
- The EQ account displays non-monetary effects on significant natural and cultural resources.
- The RED account registers changes in the distribution of economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.

- The OSE account registers plan effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

2.5.8 Final Array of NED Plans

Plan 0: **No Action.** There would be no NED benefits associated with the No Action alternative. There would continue to be adverse impacts to the EQ account as salinity levels increase in the area and existing wetlands continue to degrade and disappear. These impacts would also continue to affect residents and infrastructure through the encroachment of open water exacerbating potential storm damage risk and increasing life/safety risk (OSE). Reducing the protective wetlands in the area could have negative effects to RED by impacting major oil refineries, shipping channels, and industrial uses in the study area.

Plan 7: **Nonstructural - Justified Reaches Plan.** This plan provides positive net NED benefits and has a BCR greater than or equal to 1.0. Impacts to EQ would be minimal as no significant features would be constructed and structures to be elevated, acquired, or flood proofed already exist. Effects to RED would be beneficial due to the implementation of risk reduction features and the resulting reduction in risk of hurricane storm-surge related damages to those structures located within the identified reaches which ultimately benefit by the risk reduction measures. Regarding OSE, depending on the manner in which the nonstructural measures would be implemented, there could be an improvement in the area of social vulnerability for populations benefiting from the nonstructural measures. That notwithstanding, the potential for inundation and other storm surge related damages will continue unabated for structures that are not addressed under this alternative. Implementing this alternative would not address the most populated communities.

Plan 8: **Nonstructural - 100-Year Floodplain Plan.** This plan provides negative net NED benefits and has a BCR less than 1.0. However, it is recognized that there are significant individual increments of positive net benefit throughout the study area. Impacts to EQ would be minimal as no significant features would be built and structures to be elevated, acquired, or flood proofed already exist. Effects to RED would be beneficial due to the implementation of risk reduction features and the resulting reduction in risk of hurricane storm-surge related damages to those structures benefiting by the risk reduction measures. Regarding OSE, depending on the manner in which the nonstructural measures would be implemented, there could be an improvement in the area of social vulnerability for the larger population that would benefit from the nonstructural measures. That notwithstanding, the potential for inundation and other storm surge related damages would continue unabated for structures that are not addressed under this alternative. This alternative does address the most populated communities.

2.6 2013 Draft Report TSP

The NED TSP identified in the 2013 Initial Draft Report was Plan 7 (See Appendix M). Technical and policy comments received during the concurrent review phase of the 2013 report suggested more economic work could be completed that would yield a more efficient plan than on a reach-by-reach basis. Plan 7 and Plan 8 were both based on structures located within the 2075, 100-year (1% ACE) floodplain and were carried forward, however only Plan 7 was economically justified. Plan 7 applied nonstructural measures (i.e. structure raising, flood proofing, and property buy-outs) to structures within the 11 justified reaches and consisted of elevation of existing residential structures or acquisition of properties that require significant elevation, and flood proofing measures for non-residential structures for at-risk properties within the 2075, 100-year (1% ACE) floodplain. The preliminary estimated cost of Plan 7 as presented in the initial draft report was $388,000,000 for nonstructural measures benefiting a total of 3,915 structures.

2.7 Nonstructural Plan Optimization

The nonstructural evaluation indicated promising results that warranted further investigation. All structural alternatives were eliminated from further consideration, leaving only nonstructural alternatives as the preferred method for reducing hurricane storm surge risk across the study area. Plan 8 represents a different methodology from Plan 7 for assessing how the study area, structure inventory, floodplain, and evaluation criteria could be partitioned to identify the most effective hurricane storm surge damage risk reduction solution. Plan 8 offered the greatest flexibility for further evaluation and hence was used as the starting point for optimization. Structures in the 0-10-year floodplain were added to the structure inventory and additional economic calculations were performed to determine whether the addition of these repetitive hurricane storm surge damage risk structures resulted in positive net NED benefits and a BCR greater than or equal to 1.0. This additional assessment consisted of evaluating every structure in the updated inventory with a FFE below the 100-year stage for WSEs prevailing in the year 2025 rather than the year 2075. Warehouses were also added to the structure inventory for benefit evaluation where localized storm surge risk reduction measures represented the most appropriate nonstructural measure to reduce the risk of damage from hurricane storm surge. While RSLR is expected to raise the 100-year stage throughout the 50-year period of analysis and bring the FFEs for other structures that are not in the 100-year floodplain in the 2025 base year into the 100-year floodplain by the year 2075, economic benefits for implementing such plans for these additional structures were found to be small and heavily discounted; relative costs were high given the significant fixed costs for structure elevation, and were therefore found to lack economic justification.

Next, using the inventory of structures with FFEs identified within the 2025 100-year floodplain, the nonstructural analysis was stratified on the basis of flood zones. Structures located in between the 0-25-year flood zones were deemed to be exposed to the highest level of risk from hurricane storm surge and were considered the first increment. The second increment consists of structures with FFEs higher than the 25-year stage, but lower than or equal to the 50-year stage. The third increment encompasses all remaining structures located within the 100-year floodplain. This analysis created refined incremental variations of the previously assessed Plan 8 which was now divided into separate flood zone benefit categories. These increments differentiated structures between the 0-25-year; 25-50-year; and 50-100-year floodplains.

Table 2-9 shows the results of this analysis. Net benefits remain positive for the first two increments (0-25 year and 25-50 year) and support the Federal interest for subsequent implementation. In contrast, net benefits for the 50-100-year increment are negative due to the fact that properties within these flood plains do not suffer the same magnitude of inundation as structures grouped into the 0-25 and 25-50-year increments. Given the high fixed costs of elevating a structure, the accrued benefits were insufficient to compensate for the high mobilization costs.

The economic appendix (Appendix D) describes the specific methodology used to evaluate increments of the new nonstructural plan ("Modified Plan 8") within the separate 100-year floodplain increments so that net benefits could be optimized.

Table 2-9: Optimized Net NED benefits.

Optimized Net Benefit Analysis FY15 Price Level; 3.375% Discount Rate ($1,000s)			
Floodplain Increment	0–25-Year	25–50-Year	50–100-Year
First Cost	$824,025.22	$581,538.88	$915,876.78
Equivalent Annual Project Benefits	$265,963.65	$24,976.54	$17,239.18
Average Annual Cost	$34,342.49	$24,236.68	$38,171.09
Annual Net Benefits	$231,621.16	$739.86	$(20,931.92)
B/C Ratio	7.74	1.03	0.45

2.8 2015 Revised Draft Report TSP and EIS

The additional work completed since release of the 2013 Initial Draft Report and EIS led to the identification of a new TSP in the 2015 Revised Draft Report and EIS. The optimization of net benefits based on increments of the 100-year floodplain led to a **new TSP** (**Modified Plan 8**). In sum, the highest level of net benefits are associated with the 0-25-year floodplain increment of Modified Plan 8. This plan implements nonstructural measures to only those structures with FFEs between the 0-25-year flood stage predicted to occur in year 2025 and is the NED TSP. While it is possible that an additional recommendation could be made to add in the 25-50-year increment since it does have positive net benefits, the recommendation for the Nonstructural 0-25 Year Floodplain Plan focuses the Federal investment on the most at-risk properties in the study area. It also indicates a clean break between increments due to the large disparity between the BCRs. As described in the 2015 Revised Draft Report, Modified Plan 8 offers the greatest net benefits and best BCR of all nonstructural alternatives and increments evaluated in this study.

A brief summary of the components of the revised NED TSP includes:

1. Acquisition and demolition (involuntary component). Structures that meet certain criteria would be acquired and demolished. Owners of these structures would receive just compensation for the structure, would be provided with a similarly sized structure, and would be provided relocation benefits.
2. Elevation of remaining eligible residential structures (voluntary component). This measure would provide eligible owners with the opportunity to lift the entire structure or the habitable area to the predicted 2075, 100-year BFE unless the required elevation is greater than a maximum of 13 ft above ground level.
3. Dry flood proofing of eligible non-residential structures (excluding large warehouses and industrial complexes). Dry flood proofing consists of sealing all areas below the hurricane storm surge damage risk reduction level of a structure to make it watertight and ensure that hurricane storm surge cannot get inside by making walls, doors, windows, and other openings impermeable to water penetration as a result of hurricane storm surge.
4. Construction of localized storm surge risk reduction measures less than six feet in height around non-residential structures (primarily industrial complexes and warehouses). These measures are intended to reduce the frequency of flooding from hurricane storm surge but not eliminate floodplain management and flood insurance requirements.
5. Floodplain Management Plans. The Non-Federal Sponsor (NFS) would be required to prepare a Floodplain Management Plan in coordination with USACE to maintain the integrity of the project. The NFS will be obligated to ensure that governing bodies within the three parishes enact local development plans and building codes, land use and zoning regulations that are compliant with the requirements of the floodplain management plan and that they enforce those regulations and the prevent encroachment upon the requirements of the floodplain management plan and the project's goals and objectives.
6. Adoption and enforcement of more stringent local floodplain regulations. Although communities within the study area cannot change the minimum NFIP standards, the NFS should work with the local governments to adopt local standards that achieve higher levels of hurricane storm surge risk reduction, such as replacing elevation requirements based on the 100-year to the 500-year; implementing a zero rise floodway; and adopting cumulative damages as the trigger for substantial damage determination.
7. Adoption of more restrictive parish and municipal building codes, land use and zoning regulations and other developmental controls. Local governments within the floodplain would be encouraged to adopt and implement and enforce stricter building and housing code requirements, and land use and zoning regulations and other developmental controls aimed at reducing hurricane storm surge damage risk.

2.8.1 2015 Revised Draft Report TSP and EIS – Updated Analyses

Once again, concurrent review phase technical and policy comments led the PDT to refine the NED TSP. This time, two economic adjustments were made for each structure in the 25-year floodplain increment since that was the TSP. The structure inventory was adjusted to account for future severe damage mitigation under FWOP conditions and each structure was evaluated for individual economic justification. This analysis considered likely nonstructural measure costs as applied to a particular structure against the damages avoided over the 50-year period of analysis. If nonstructural measure costs were lower than predicted incurred damages, the structure was individually justified. Not all structures identified as eligible in the 2015 Revised Draft Report and EIS met this criteria and approximately 950 structures initially deemed eligible fell out of the updated TSP. However, even with this economic adjustment, the 0-25-year floodplain increment still represents the highest net benefits and best BCR for all increments evaluated.

The NED TSP would provide reduced hurricane storm surge damage risk for all eligible structures in the study area with a FFE at or below the 25-year stage based on predicted year 2025 hydrologic conditions. The TSP identifies a total of 3,961 impacted structures comprised of 3,462 residential structures, 342 commercial structures and public buildings, and 157 warehouses. Table 2-10 displays the costs and benefits of the TSP and maps of eligible structures can be found in Appendix N. Figure 2-5 displays the location and type of preliminarily eligible structures.

Table 2-10: Net NED benefits for the updated TSP

Optimized Net Benefit Analysis FY15 Price Level; 3.375% Discount Rate	
Floodplain Increment	0–25-Year
First Cost	$678,126,000
Equivalent Annual Project Benefits	$200,100,000
Average Annual Cost	$28,262,000
Annual Net Benefits	$171,838,000
B/C Ratio	7.1

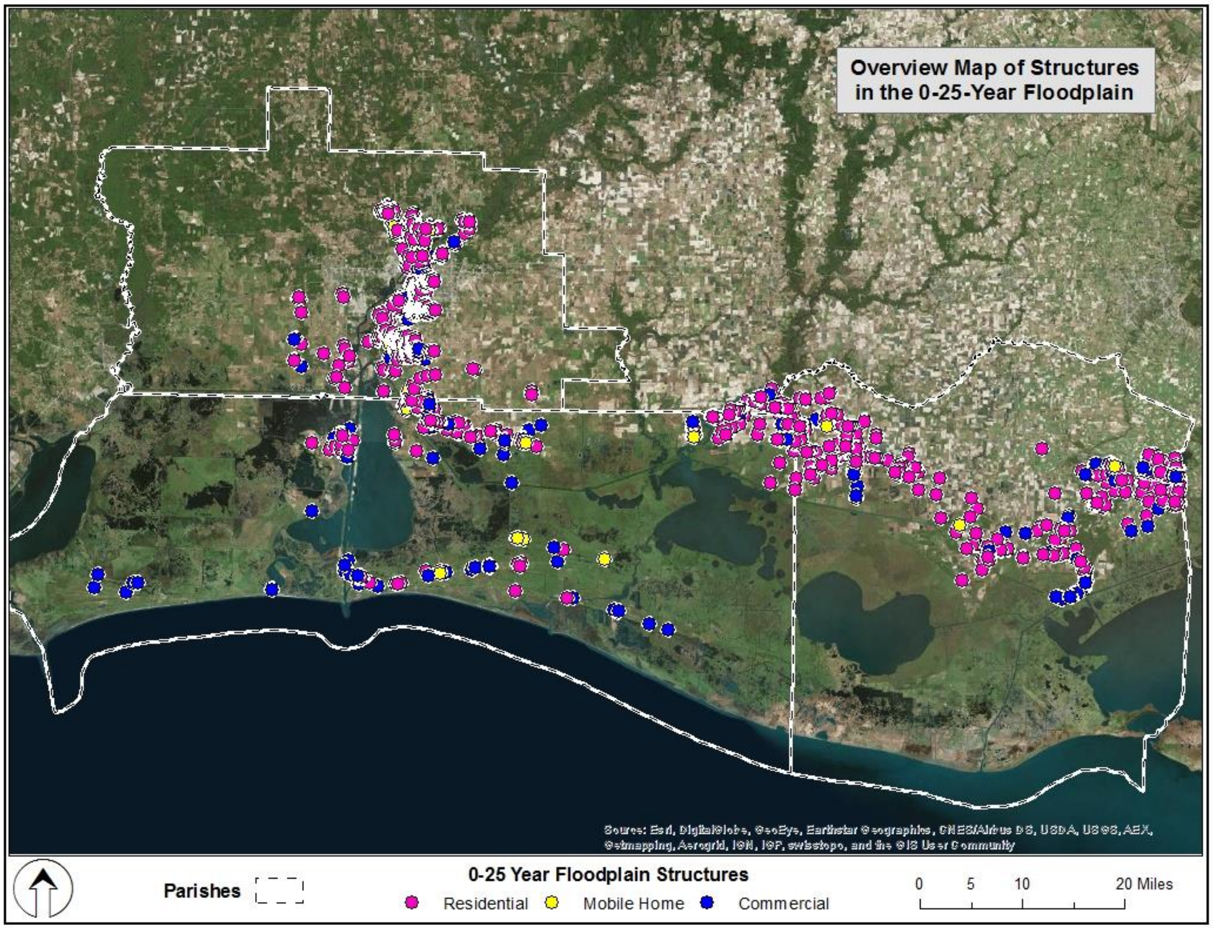

Figure 2-5: TSP Eligible structures in the 0-25-year floodplain.

Additional updates and changes to the TSP occurred after release of the 2015 Revised Draft Report for public review. The most noteworthy change consists of elimination of the involuntary component from the nonstructural plan and making any structure requiring elevation greater than 13 feet above ground level ineligible for participation in the NED RP due to engineering and risk related factors. The entire project is now 100% voluntary. Other changes to the plan consist of updating costs and benefits. These updates and a summary of comments received are described in Chapter 4 and in Appendix L.

2.9 NER Alternative Plan Formulation

The Louisiana Chenier Plain extends from the western bank of Freshwater Bayou westward to the Louisiana-Texas border in Sabine lake, and from the marsh areas just north of the GIWW south to the Gulf of Mexico in Calcasieu, Cameron, and Vermilion parishes. Coastal erosion in the Chenier Plain accounts for approximately 20 percent of the land loss in Louisiana. The January 31, 2005 Chief's Report for the ecosystem restoration of the LCA suggested reducing wetlands losses by 50 percent as a possible desirable outcome from restoration efforts, including the development of a comprehensive restoration plan for the Chenier Plain ecosystem. The entire study area was considered for NER plan formulation. Although a significant portion of the area within the Coastal Zone Management Area has already received funding from other sources to address coastal land loss (Figure 2-6), this study does consider overlapping features in those areas.

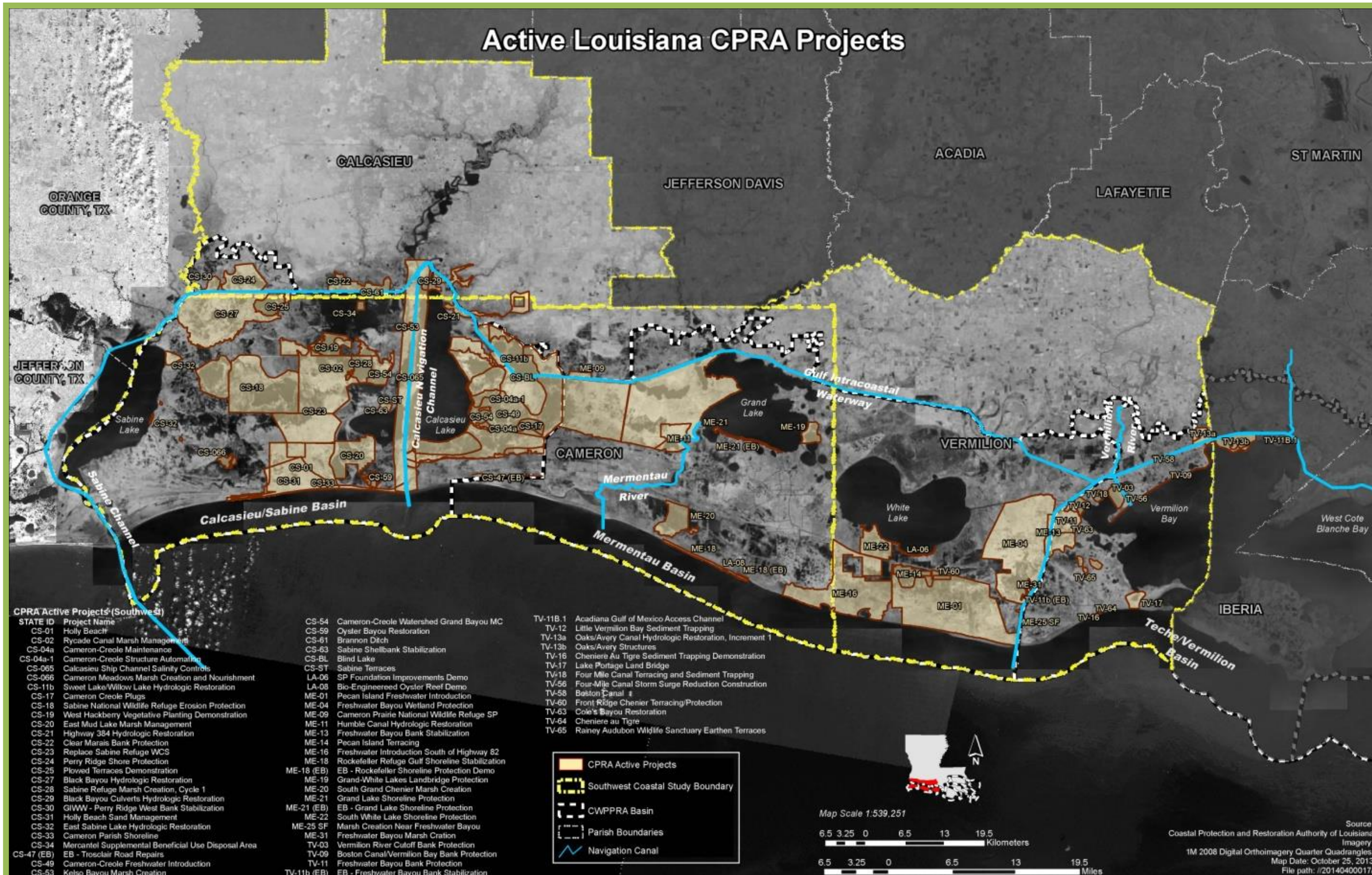

Figure 2-6: Restoration projects in the study area.

The principle areas of focus for the LCA plan formulation are the Calcasieu-Sabine Basin located between the GIWW and the Gulf of Mexico, primarily in the vicinity of Calcasieu and Sabine Lake and the Mermentau/Teche-Vermilion Basins between the GIWW and Gulf of Mexico, Vermilion Bay, and LA-27 to the west.

As part of the adaptive management and project planning process, a conceptual ecological model ("CEM") (Appendix A; Annex L) was developed to help explain the general functional relationships among the essential components of the Southwest Coastal Louisiana area. CEMs are a means of:

(1) Simplifying complex ecological relationships by organizing information and clearly depicting system components and interactions;
(2) Integrating to more comprehensively implicit ecosystem dynamics;
(3) Aiding in identifying which species will show ecosystem response;
(4) Interpreting and tracking changes in restoration/management targets; and
(5) Communicating these findings in multiple formats.

This CEM assists with identifying those aspects where the project can effect change. Specifically, the CEM identifies those major stressors, ecosystem drivers, and critical thresholds of ecological processes and attributes of the natural system likely to respond to restoration features. The project CEM was used to assist in identifying problems and opportunities, refining project objectives and restoration management actions, selecting those attributes to be used as performance measures, modeling for alternative analysis, and monitoring for project success. The project CEM represents the current understanding of these factors and will be updated and modified, as necessary, as new information becomes available to assist with developing adaptive management and monitoring during project planning and implementation.

The CEM (Figure 2-7) was developed in conjunction with the USACE Engineering Research and Development Center (ERDC) and identified five drivers, seven ecological stressors, and four ecological effects. The most serious problem is the rate of land and habitat loss.

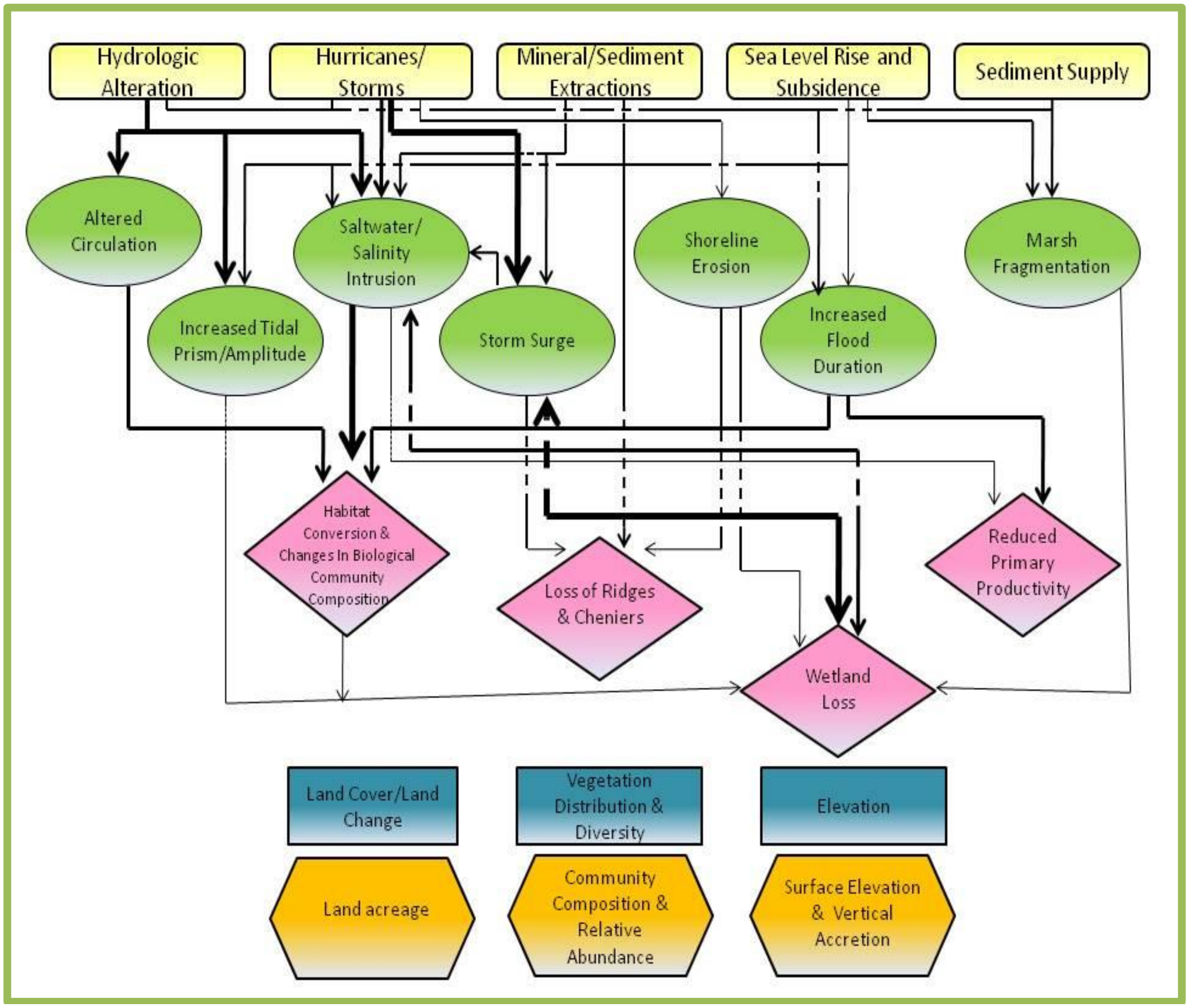

Figure 2-7: Conceptual ecological model.

2.9.1 NER Measures (*NEPA Required)

The PDT used a number of prior studies and reports to identify potential measures and screening criteria, including Federal projects authorized or constructed by the CWPPRA program; the USACE Continuing Authorities Program; the LCA Ecosystem Restoration Study (USACE 2004); and the LACPR Study (USACE 2009); 2012 State Master Plan (SMP), and the U.S. Department of Interior's CIAP.

The PDT recommended five measures to meet the NER goals and objectives:

1. **Marsh restoration.** Consists of marsh restoration and/or nourishment to increase land coverage in the area, and improve terrestrial wildlife habitat, hydrology, water quality, and fish nurseries. Vegetative plantings and herbivory control were deemed unnecessary for this feature.
2. **Bank and shoreline protection/stabilization.** Protection/stabilization features to reduce the rate of erosion at canal banks and shorelines in critical areas and to improve hydrology.
3. **Hydrologic and salinity control structures.** Control structures to manage water flow and minimize saltwater intrusion into marshes.
4. **Chenier reforestation.** Reforestation to restore native trees to the Chenier ecosystem, and reduce land loss rates and control for invasive plant and animal species.
5. **Oyster reef preservation.** To restore and preserve these native features, and reduce shoreline erosion rates.

2.9.1.1 Initial Screening of NER Measures

Initial data collection included over 200 features which were mostly basin and/or location specific, but some applied to the overall study area. The first screening removed features that did not address project goals and objectives. The marsh restoration and shoreline protection/stabilization features were evaluated with the Wetland Value Assessment (WVA) model, and compared to costs to evaluate cost-effectiveness. Measures that were not cost-effective were eliminated unless the location served a critical geomorphologic function.

Measures were screened using the following criteria:

- **Constraints and Goals.** Measures that were not expected to be sustainable were eliminated such as marsh restoration measures located in currently open water areas where water depth is greater than 2 ft or in high subsidence areas along with chenier reforestation in locations with elevations less than 5 ft and areas with high shoreline erosion rates.

- **Objectives.** These criteria were used to ensure that the measures being considered for inclusion were applicable to at least one study objective. Each of the measures was found to support a particular objective. Although an evaluation of each measure against the objectives took place, no measures were eliminated due to their lack of meeting objectives.

- **Effectiveness.** Measures which were more effective in meeting the objectives were carried forward. In areas where marsh is deteriorating and shoreline protection, marsh restoration, or hydrologic and salinity control measures could potentially benefit the areas, the measure that would most benefit the area was retained, and the others were screened. Oyster reef preservation measures were all considered to be effective measures. These thresholds were qualitatively developed by the PDT to establish a minimum criterion for success, to eliminate features that were not worth the Federal investment, and to avoid creating a grossly over-manipulated system.

- **Efficiency.** The final criteria compared cost per acre within the measure categories. If two measures produced the same benefits but one was less expensive to construct, the cheaper option was carried forward. For example, the West Cove marsh restoration measures were eliminated because the Mud Lake measure would provide restoration at a cheaper cost. Additionally, marsh restoration measures that benefitted more than 100 acres were more cost-effective (efficient) than those with a benefit of less than 100 acres, due to economies of scale with the costs of mobilization and demobilization.

The results of the NER screening evaluation are presented in Table 2-11.

Table 2-11: NER screening evaluation.

Screening Criteria		Application to Each NER Measure Category				
		Marsh Restoration	**Bank and Shoreline Protection/ Stabilization**	**Chenier Reforestation**	**Hydrologic & Salinity Control**	**Oyster Reef Preservation**
Constraints and Goals	Measure violates one of the study planning constraints or goals.	Features that are not sustainable do not meet the sustainability goal and were eliminated e.g. marsh areas where water depth is > 2 ft or local subsidence is high.	None of the shoreline stabilization features were eliminated.	Features that did not meet the sustainability goal were eliminated. Elevations < 5 ft NAVD88 and areas exposed to high rates of shoreline erosion were screened.	None of the hydrologic or salinity control features were eliminated.	None of these features were eliminated.
Objectives	Measure does not address one or more of the study planning objectives.	All marsh restoration measures meet Objective 5. No marsh restoration features were eliminated.	All shoreline protection/stabilization measures meet Objective 4. No shoreline stabilization features were eliminated.	All chenier reforestation measures meet Objective 5. No Chenier features were eliminated.	All hydrologic and salinity control measures meet Objective 2. No control features were eliminated.	All measures meet Objective 5. No oyster reef preservation features were eliminated.
Effectiveness	Measure found to be ineffective.	Marsh restoration features were more effective in areas with severe marsh degradation. Shoreline protection features were more effective in areas with existing marsh that was subjected to erosion from adjacent waterways.		Features were eliminated where existing canopy coverage deemed substantially intact (i.e., >50%) or if the presence of development would prohibit reforestation.	A small number of hydrologic and salinity control features were eliminated as ineffective because they did not exhibit large-scale hydrologic benefits to wetlands in the Chenier Plain.	None of the oyster reef preservation features were eliminated. Reef restoration is an effective method of using natural barriers against storm surges and saltwater intrusion.
Efficiency	Measure found to have below average efficiency.	The average cost of all marsh and shoreline features based on the initial evaluation was approximately $125,000/net acre. Features were considered inefficient and eliminated if they had greater than average cost/net acre. Features that are considered critical components of the system were not eliminated Features that are located adjacent to significant resources, such as cheniers and wildlife refuges were also not eliminated. Marsh restoration or shoreline protection/ stabilization measures producing or protecting less than 100 net acres were considered to be inefficient.		All chenier reforestation features were found to be relatively cost efficient in comparison to each other.	All control features were found to be relatively cost efficient in comparison to each other.	All reef preservation features were found to be relatively cost efficient in comparison to each other.

After the initial screening there were too many potential combinations of features for the PDT to effectively assess and evaluate, therefore, the PDT developed an additional methodology through plan development strategies (ways to classify and combine NER features according to a predefined strategy) to further screen features and develop an initial array of alternatives.

2.9.2 Initial Array of NER Alternative Plans categorized by measure type (*NEPA Required)

Individual features were developed for each of the five NER measures and formed into five separate plan development strategies. Each was based on the measure type and the associated features for that particular measure. In keeping with the overall study purpose of addressing ecosystem degradation in the entire Chenier Plain, one integrated restoration plan was developed that integrated all of the measure types across all basins. Because the coastal zone is the area in greatest need of environmental restoration, the locations for the implementation of all of the five measures types being considered are located south of the GIWW.

- **Hydrologic and Salinity Control Plan.** This plan contains 49 hydrologic and salinity control features.
- **Marsh Restoration Plan.** This plan contains 52 marsh restoration and/or nourishment features.
- **Shoreline Protection/Stabilization Plan**. This plan contains 50 bank and shoreline protection features.
- **Chenier Reforestation Plan**. This plan contains 35 reforestation features (with invasive species control).
- **Oyster Reef Preservation Plan.** This plan contains 10 oyster reef preservation features.
- **Integrated Restoration Across Basins Plan**. This plan consists of features from all five measure categories. It contains a variety of basin-specific and study area-wide features.

2.9.2.1 Screening of the Initial Array of NER Alternative Plans

Another screening (outlined below and more fully explained in Appendix C) was conducted and more features were removed from further consideration. Land loss analyses were conducted by the USGS to assess whether an area is experiencing high land loss and in critical need of ecosystem restoration.

The following additional screening criteria were applied to the remaining features:

- **Reinforcement of Critical Landscape Features**. Features on or adjacent to a landscape feature designated as critical.
- **Reinforcement of Critical Infrastructure**. Features that restore wetlands from open water and that protect the continuity and function of critical infrastructure.
- **Synergy with Other Projects**. Features that protect or contribute to the benefits of other projects.
- **Scarcity/Diversity**. Features that reduce the loss of freshwater marsh (considered imperiled by the LNHP).
- **Robustness/Sustainability**. Features that are attached to land that will persist through the period of analysis.
- **Implementability Issues**. Features with no serious impediment precluding its timely implementation.

Features were subjected to more detailed analysis and WVAs were conducted using all available data (such as SMP analyses) and assumptions based on professional experience and knowledge. The results of the WVAs (see Appendix A) were combined with cost estimates to select cost-effective features. The following plan features were screened (with more information available in Appendix C):

- **Marsh Restoration.** Marshes that reinforce critical geomorphic land forms (i.e., lake rims, navigation banklines, gulf shoreline), which would protect interior reaches, were given greater priority than interior marshes.
- **Bank and Shoreline Protection/Stabilization.** A single shoreline protection/stabilization feature consisting of a foreshore rock dike along the toe of the Cameron-Creole levee was eliminated due to lack of marsh between the proposed rock dike and the levee. Stabilization at this location did not supply many NER benefits and therefore the feature was removed from further consideration.
- **Hydrologic and Salinity Control.** A WVA analysis was not completed under initial screening because the WVA model cannot adequately describe the benefits of these features across such a large area using preliminary information. In general, the features that were carried forward were those that had larger-scale benefits, such as those that helped maintain greater than 500 net acres as determined by the SMP models. Eight features that met these criteria were carried forward into the final array.
- **Chenier Reforestation.** Although strategic project areas to reforest cheniers were identified and evaluated, due to the relative affordability of this measure type no specific features were screened. It was decided that

all chenier reforestation features would move forward as part of a consolidated chenier reforestation program.

- **Sabine Lake Oyster Reef Preservation.** Several oyster reef projects were removed from further consideration due to very modest benefits and existing or planned funding through other programs. The PDT determined that the Sabine Lake Oyster Reef should be preserved because its 3-dimensional structure provides valuable habitat for various fisheries species and it also provides some hydrologic benefits to the remainder of Sabine Lake. The feature carried forward consists of protecting and preserving the Sabine Lake Oyster Reef by prohibiting the harvesting of oysters from the reef.

NER Alternative Plan Evaluation. The NER features that were eliminated in the secondary screening reduced the overall size of the initial array of alternative plans. The comprehensive effects of these alternatives (including the "No Action" alternative) were estimated using the SMP models (i.e., Wetland Morphology, Eco-Hydrology, Vegetation, and various land loss analysis and hydrodynamic models). The outputs of these models supply the data for subsequent analysis using the WVA model. Hydrodynamic modeling using the MIKE FLOOD model was used concurrently to evaluate the restoration alternatives and help refine the features included in the alternatives (specifically the type, size, and operation of the hydrologic and salinity control features). Results from the additional models indicated that the NER objectives could not be met through the implementation of single-measure alternative plans and as a result, the single measure plans were eliminated. The Integrated Restoration Across Basins alternative was the only plan capable of meeting the study goals and objectives and was carried forward. Variations of the Integrated Restoration Across Basins alternative were developed in the formulation of the focused array to more thoroughly address study area problems. See Appendix A for more information on the modeling for restoration alternatives.

2.9.3 Focused Array of NER Alternative Plans

Using seven restoration strategies (set forth below) developed from the findings from the initial array, plus the "No Action" alternative, a focused array of 27 alternative plans (Table 2-13) was developed containing different combinations of the features. The restoration strategies were applied both comprehensively across basins and individually to the Calcasieu-Sabine Basin and Mermentau/Teche-Vermilion Basin. Plans that were derived from the SMP are identified as such. The PDT also determined that a Calcasieu Ship Channel (CSC) Salinity Control Structure was worth evaluating as a stand-alone strategy/alternative.

The locations of the NER focused array of alternative plans are: (1) the Calcasieu-Sabine Basin between the GIWW and the Gulf of Mexico and primarily in the vicinity of Calcasieu Lake and (2) the Mermentau/Teche-Vermilion Basins which are primarily clustered south of Grand and White Lakes, and in the area surrounding Freshwater Bayou.

For analysis purposes, each alternative plan was divided into two geographic parts. Plans denoted with a "C" contain features located in the Calcasieu-Sabine Basin. Plans denoted with an "M" contain features located in the Mermentau and Teche-Vermilion Basins. The CSC Salinity Control Structure is the sole component of the seventh restoration strategy and a standalone alternative designated as Plan "A". The CSC Salinity Control Structure (Plan "A") is also combinable with any plan containing a Calcasieu-Sabine Basin, or "C" component. Collectively, all of the features for each basin that comprise a restoration strategy are considered unique alternatives. Descriptions of each restoration strategy are presented below.

A listing of the specific features that are contained within each restoration strategy can be found in Table 2-12. Unique alternatives were generated based on restoration strategy and basin location.

NER Strategies

Strategy 0: **No Action Plan.**

Strategy 1: **Large Integrated Restoration (SMP).** The results of the State Master Plan Models were used to select only those hydrologic and salinity control features that showed the greatest benefits. For marsh restoration, features were selected that would best reinforce critical landscape features, with particular emphasis on areas that are exposed to saltwater, tidal, and wave action. Bank and shoreline protection/stabilization features were retained that protected the areas of greatest erosion. Strategy 1 is composed of 6 hydrologic and salinity control features, 19 marsh restoration features, 7 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 2: **Moderate Integrated Restoration (Hydrologic Emphasis) (SMP).** This restoration strategy has less investment in marsh restoration and bank and shoreline protection/stabilization features, but retains the same level of hydrologic and salinity control features as Strategy 1 due to the philosophy that hydrologic restoration is of great importance to the Chenier Plain. Marsh restoration features were focused on areas of critical importance for restoration. Bank and shoreline protection/stabilization features that protected the areas of greatest erosion were retained. Strategy 2 is composed of 6 hydrologic and salinity control features, 13 marsh restoration features, 4 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 3: **Moderate Integrated Restoration, Including Gum Cove (SMP).** This Strategy is identical to Strategy 2 except it includes the Gum Cove Lock feature. Strategy 3 was formulated to investigate the hydrologic restoration benefits and cost-effectiveness of the Gum Cove Lock combined with the Calcasieu Ship Channel Salinity Control Structure. Strategy 3 is composed of 6 hydrologic and salinity control features, 13 marsh restoration features, 4 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 4: **Small Integrated Restoration (SMP).** The focus of Strategy 4 is to use a minimal range of features focused at stabilizing perimeter geomorphology. This Strategy includes marsh restoration and bank and shoreline protection/stabilization features that could reinforce perimeters. Strategy 4 is composed of 2 hydrologic and salinity control features, 9 marsh restoration features, 2 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 5: **Interior Perimeter Salinity Control.** The focus of Strategy 5 is the control of salinity levels within the interior areas of the Calcasieu-Sabine basin and the Cameron-Creole Watershed. There are no hydrologic and salinity control structures at the main passes, with the expectation that salinity control around the perimeter of Calcasieu Lake and the GIWW could result in lower salinities in the interior marshes at a lower cost than entry salinity control. Strategy 5 includes those marsh restoration and bank and shoreline protection/stabilization features that could reinforce perimeters. Strategy 5 is composed of 6 hydrologic and salinity control features, 9 marsh restoration features, 2 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 6: **Marsh and Shoreline (Minimal Hydrologic & Salinity Control).** Strategy 6 includes minimal hydrologic and salinity control features and focuses on restoring marsh and protecting/stabilizing shorelines. Strategy 6 was formulated to evaluate the effectiveness of ecosystem restoration with the existing salinity regime and is composed of 5 hydrologic and salinity control features, 18 marsh restoration features, 5 bank and shoreline protection/stabilization features, and all chenier reforestation features.

Strategy 7: **Entry Salinity Control (Stand-alone measure).** Strategy 7 would manage salinity introduced through the CSC into Calcasieu Lake and surrounding wetlands through a CSC Salinity Control Structure (Plan "A"). It is combinable with Calcasieu alternatives and is also evaluated as a stand-alone plan.

Table 2-12: Features within each Restoration Strategy

Feature Location: Mermentau Basin (blue); Calcasieu Basin (green)

Measure	Feature	No Action	Strategy 1/1A Large Integrated Restoration across Basins	Strategy 2/2A Moderate Integrated Restoration across Basins	Strategy 3/3A Moderate Integrated Restoration + Gum Cove	Strategy 4/4A Small Integrated Restoration	Strategy 5 Interior Perimeter Salinity Control	Strategy 6 Marsh & Shoreline Focus	Strategy 7 (or A) Entry Salinity Control
Hydrologic & Salinity Control									
	7#	0	0/X	0/X	0/X	0/X	0	0	X
	13*	0	0	0	0	0	0	0	0
	17a-c*	0	0	0	0	0	0	0	0
	48	0	0	0	0	0	0	0	0
	74a	0	X	X	X	X	X	X	0
	407	0	0	0	X	0	X	0	0
Marsh Restoration									
	3a1	0	0	0	0	X	X	0	0
	3c1	0	X	X	X	X	X	X	0
	3c2	0	X	X	X	0	0	X	0
	3c3	0	X	X	X	0	0	X	0
	3c4	0	X	X	X	0	0	X	0
	3c5	0	X	X	X	0	0	X	0
	47a1	0	X	X	X	X	X	X	0
	47a2	0	X	X	X	X	X	X	0
	47c1	0	X	X	X	X	X	X	0
	47c2	0	X	0	0	0	0	X	0
	124a	0	X	0	0	0	0	X	0
	124b	0	X	0	0	0	0	X	0
	124c	0	X	X	X	X	X	X	0
	124d	0	X	X	X	X	X	X	0
	127c1	0	X	0	0	0	0	X	0
	127c2	0	X	X	X	0	0	X	0
	127c3	0	X	X	X	X	X	X	0
	306a1	0	X	X	X	X	X	X	0
	306a2	0	X	0	0	0	0	X	0
Shoreline Protection/Stabilization									
	5a	0	X	X	X	X	X	X	0
	6b1	0	X	X	X	X	X	X	0
	6b2	0	X	X	X	X	X	X	0
	6b3	0	X	X	X	X	X	X	0
	16b	0	X	0	0	X	X	0	0
	99a	0	X	0	0	0	0	X	0
	113b2	0	X	0	0	0	0	0	0
Chenier Reforestation (both basins)									
	CR	0	X	X	X	X	X	X	0

#Feature 7 functions both as a stand-alone Strategy/Alternative and an additive feature. *Following refinement of the benefit assessment as a result of technical comments, these features were found to lack positive outputs and were dropped from all plans. Note: Green cells denote features found in the Calcasieu Basin. Blue cells denote features in the Mermentau Basin. An 'X' in a cell indicates the feature is a component of the strategy while a '0' indicates it is not a component of the strategy.

2.9.4 Comparison of the Focused Array of NER Alternative Plans

The calculated WVA benefits are measured in average annual habitat units (net AAHUs) and cost estimates were examined using the Institute for Water Resources Planning Suite (IWR Plan), the results of which helped guide the identification of a TSP. The SMP Models were used to compare benefits among alternatives in acres and AAHUs, and compared them to the FWOP conditions or "No Action" Alternative. The WVA analysis used to generate the benefits in AAHUs has six variables that must be projected into the future for the FWOP and Future With Project (FWP) condition or "Action" alternatives.

The focused array of alternatives consists of alternative plans that align with a restoration strategy and contain the features the PDT identified as most supportive of achieving the goals of that restoration strategy. For the focused array of alternatives, the SMP modeling effort was used with input from the Eco-hydrology module to estimate land and water changes. The alternatives were run under the intermediate RSLR scenario to predict salinity, water levels, and flows. The results of this modeling effort were input into the Vegetation and Wetland Morphology modules of the SMP modeling system to predict wetland loss and other trends over time. The SMP model included accretion and subsidence projections. For marsh restoration and shoreline protection/stabilization projects, the WVA analysis process used inputs from these models, and was performed using basic assumptions from the CWPPRA program (see Appendix A).

Table 2-13: NER Focused array of Alternative Plans

AlternativePlan/ Strategy#	IWR label	ALTERNATIVE PLAN NAME
A	A	Entry Salinity Control
C-1	C1	Calcasieu Large Integrated Restoration
M-1	M1	Mermentau Large Integrated Restoration
CA-1	C1A	Calcasieu Large Integrated Restoration w/ Entry Salinity Control
CM-1	C1+M1	Comprehensive Large Integrated Restoration
CMA-1	C1A+M1	Comprehensive Large Integrated Restoration w/ Entry Salinity Control
C-2	C2	Calcasieu Moderate Integrated Restoration
M-2	M2	Mermentau Moderate Integrated Restoration
CA-2	C2A	Calcasieu Moderate Integrated Restoration w/ Entry Salinity Control
CM-2	C2+M2	Comprehensive Moderate Integrated Restoration
CMA-2	C2A+M2	Comprehensive Moderate Integrated Restoration w/ Entry Salinity Control
C-3	C3	Calcasieu Moderate Integrated Restoration
M-3	M3	Mermentau Moderate Integrated Restoration
CA-3	C3A	Calcasieu Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
CM-3	C3+M3	Comprehensive Moderate Integrated Restoration
CMA-3	C3A+M3	Comprehensive Moderate Integrated Restoration w/ Gum Cove & Entry Salinity Control
C-4	C4	Calcasieu Small Integrated Restoration
M-4	M4	Mermentau Small Integrated Restoration
CA-4	C4A	Calcasieu Small Integrated Restoration w/ Entry Salinity Control
CM-4	C4+M4	Comprehensive Small Integrated Restoration
CMA-4	C4A+M4	Comprehensive Small Integrated Restoration w/ Entry Salinity Control
C-5	C5	Calcasieu Interior Perimeter Salinity Control
M-5	M5	Mermentau Interior Perimeter Salinity Control
CM-5	C5+M5	Comprehensive Interior Perimeter Salinity Control
C-6	C6	Calcasieu Marsh & Shoreline
M-6	M6	Mermentau Marsh & Shoreline
CM-6	C6+M6	Comprehensive Marsh & Shoreline

Alternative plans are delineated by Strategy, geographic location (C=Calcasieu, M= Mermentau), and the potential inclusion of the CSC Salinity Control Structure (Plan "A").

2.9.4.1 Cost Estimates

The construction cost and schedule estimates were developed from similar projects in the study area (such as through the CWPPRA program), with input as needed from other recent projects coast-wide. This includes mobilization and demobilization costs, price per cubic yard of dredged material or per ton of rock, depending on the measure type, and other line items as appropriate. The maintenance schedule for shoreline protection/stabilization was based on anticipated settlement rates calculated from the existing nearby geotechnical data, as available, and similar projects in the vicinity. The renourishment schedule for the marsh restoration features was developed through an optimization process by which the total costs and benefits for different maintenance schedules were considered at five-year intervals. This process determined that a 30-year renourishment cycle optimized costs per unit benefit [in average annual acres (AAA)]. Costs for hydrologic and salinity control features were calculated, along with the features from the SMP. The costs of alternative plans are the sums of the costs of the individual features (see Table 2-14). While some cost-savings may be realized through synergistic execution of adjacent or nearby project features, for a conservative cost estimate this synergy was not assumed. Since the NER plan is intended to reasonably maximize environmental benefits, and since NER planning promotes the avoidance of environmental features that require mitigation, any features that would require mitigation were screened from further consideration and no costs for unavoidable wetland impacts have been factored into the preliminary cost estimates. All restoration features in the various alternatives have been designed to not require mitigation. Preliminary high and low cost estimates for plans that contain Plan "A" (CSC Salinity Control Structure) were developed as starting points to account for potential navigation impacts.

Table 2-14: NER Cost Estimates and Benefits

Plan #	Cost $ Low Nav	Cost $ High Nav	AAA
CMA-1	$3,049,836,909	$3,104,429,860	29,070
CM-1	$2,465,675,681	$2,465,675,681	23,101
CA-1	$1,591,668,028	$1,646,260,979	12,844
C-1	$1,007,506,800	$1,007,506,800	6,875
M-1	$1,458,168,881	$1,458,168,881	16,226
CMA-2	$2,390,030,484	$2,444,623,435	25,187
CM-2	$1,901,658,190	$1,901,658,190	19,218
CA-2	$1,495,879,094	$1,550,472,045	13,898
C-2	$1,007,506,800	$1,007,506,800	7,929
M-2	$894,151,390	$894,151,390	11,289
CMA-3	$2,697,850,484	$2,752,443,435	18,959
CM-3	$2,113,689,256	$2,113,689,256	12,990
CA-3	$1,803,699,094	$1,858,292,045	7,982
C-3	$1,219,537,866	$1,219,537,866	2,013
M-3	$894,151,390	$894,151,390	10,977
CMA-4	$1,903,984,167	$1,958,577,118	22,508
CM-4	$1,319,822,939	$1,319,822,939	16,539
CA-4	$1,041,573,707	$1,096,166,658	11,005
C-4	$457,412,479	$457,412,479	5,036
M-4	$862,410,460	$862,410,460	11,503
CM-5	$1,664,058,939	$1,664,058,939	15,537
C-5	$801,648,479	$801,648,479	4,457
M-5	$862,410,460	$862,410,460	11,080
CM-6	$2,321,547,245	$2,321,547,245	23,026
C-6	$1,005,766,800	$1,005,766,800	9,240
M-6	$1,315,780,445	$1,315,780,445	13,786
A	$584,161,228	$638,754,179	5,969

Price level for feature costs – June 2013 and Discount rate of 3.5% (FY 2014) for navigation delays

2.9.4.2 CE/ICA Results

The focused array of alternative NER plans were compared considering Cost Effectiveness and Incremental Cost Analysis (CE/ICA) to inform environmental investment decision making. Cost effectiveness is determined based upon a finding that no other plan provides a higher output level of acres restored for the same or less cost. Incremental cost analysis is the determination of the greatest increase in output (acres restored) for the least increase in cost. Use of these tools helps decision makers determine the most desirable level of outputs (restored acres) compared to costs.

In the CE/ICA analysis shown in Figure 2-8, a Rough Order of Magnitude (ROM) average annual cost of $10,000,000 was added to plans that include CSC Salinity Control Structure (Plan "A") to represent the potentially high navigation impact cost resulting from the operable closure structure. The cost in this analysis represents traffic delays to all 2011 deep draft traffic in the CSC. All alternatives with Plan "A" were run through CE/ICA both with and without the structure in place in order to isolate the relative performance of the structure. Plans in blue are cost-effective (no other plan produces more benefits for the same or less cost as another plan) and plans in red are best-buys (subset of cost-effective plans that offer the lowest incremental cost per benefit).

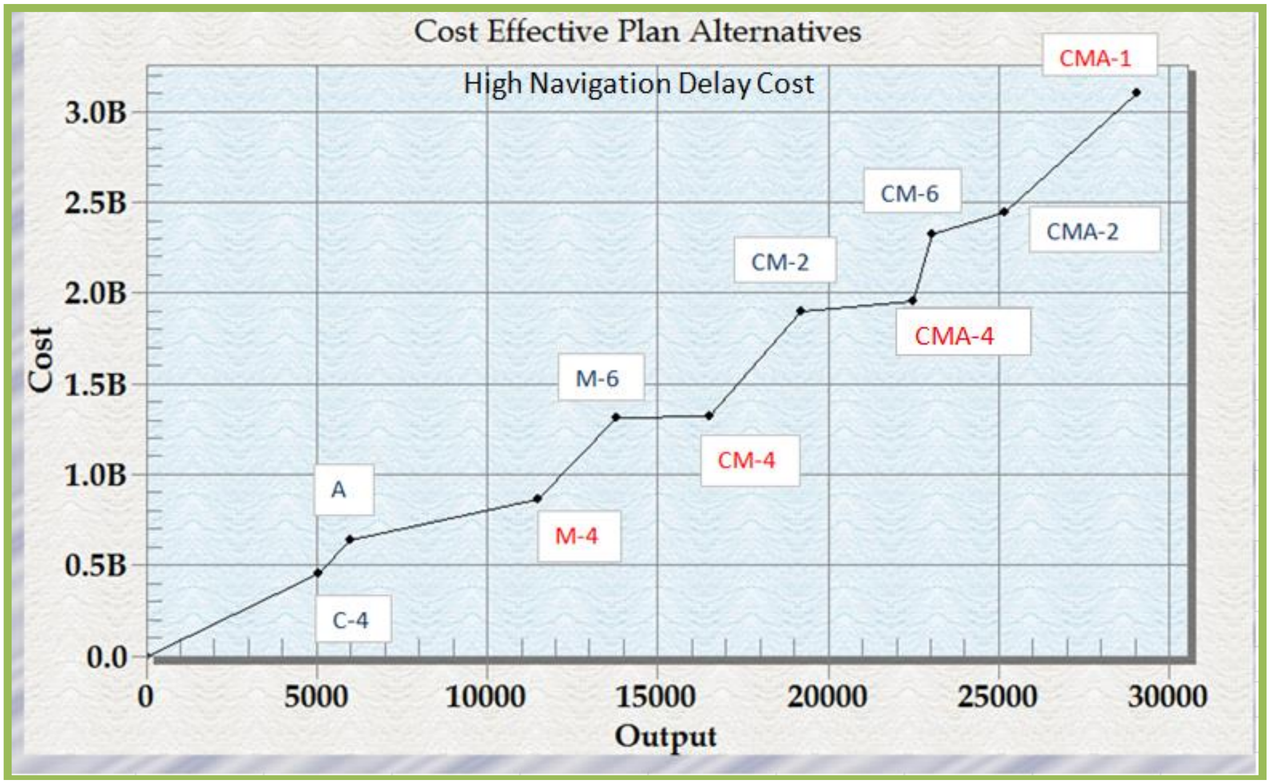

Figure 2-8: CE/ICA analysis using high navigation cost.

The second CE/ICA analysis is shown in Figure 2-9. Identical sets of plans were run, but they used a lower ROM average annual cost of $7,672,500 to represent navigation delay costs caused by the CSC Salinity Control Structure. The lower cost accounts for delays to vessels that transited on the CSC in 2011 with drafts between 15 and 35 ft. The purpose of using this lower cost estimate is to represent an operating scheme that would allow the CSC Salinity Control Structure to remain open during high tide, which is when the deepest draft vessels transit. Thus, a minimum representation of the impact of the structure closure is to add traffic delays for only non-deep-draft vessels. The cost does not include tug assistance costs or any other ancillary impacts of a closure of the CSC Salinity Control Structure. In both analyses, in order to be consistent with the cost provided for the measures, the average annual cost was converted to a present value of $179,963,228. This present value cost was added to the cost of the plans that contain the CSC Salinity Control Structure, which includes any Plan with an "A" designation.

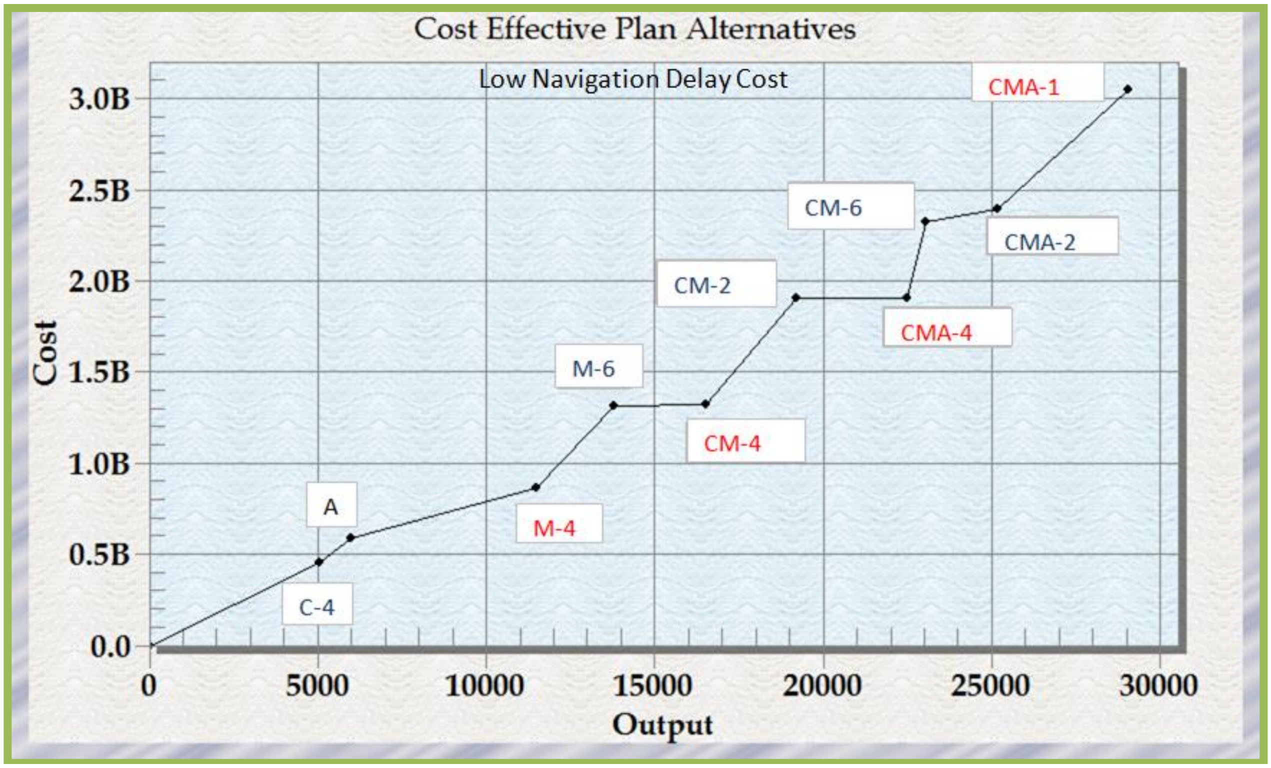

Figure 2-9: CE/ICA analysis using low navigation cost.

For all focused array alternatives, the number of hydrologic and salinity control structures, marsh restoration features, and bank and shoreline protection/stabilization features varied depending on the plan scale and restoration strategy. The plans were estimated to produce between 5,000 and 29,000 AAA, and their costs range from $500,000,000 to over $3,000,000,000.

The CSC Salinity Control Structure (Plan "A") Considerations

As part of the evaluation, plans with and without the CSC Salinity Control Structure were compared. The salinity control structure could potentially provide significant environmental benefits (5,700 AAA) even as a stand-alone plan (Plan "A"). The applications of both low and high preliminary rough order of magnitude estimates of navigation impacts indicated the salinity control structure to be potentially cost-effective. However, Best-Buy plans that contain the CSC Salinity Control Structure, (which includes any Plan with an "A" designation), are significantly more expensive than plans without the CSC structure. Other cost-effective and Best-Buy comprehensive plans containing the CSC structure exist only on the upper most portion of the cost efficient frontier.

When the CSC structure is evaluated as a stand-alone plan, it is anticipated that a more detailed level of analysis would reveal higher navigation impact costs. As a result, the CSC structure as a stand-alone alternative, does not indicate that it could be a Best-Buy plan or be selected as part of a TSP and may in fact fall completely out of consideration should costs be found to be higher than what was estimated by the PDT and fed into the IWR planning suite.

However, if additional benefits are desired, alternatives that include the CSC structure are worth considering. In the long-term there is a good chance that the addition of the CSC structure could provide the next best increment of benefit, even if costs are found to be higher. In the end, the only Best Buy plans that produces greater benefits than comprehensive plans are those which include the CSC salinity control structure as a component.

2.9.5 Final Array of NER Alternative Plans (*NEPA Required)

The final array of alternatives is comprised of the No Action Plan, Plan M-4, and Plan CM-4. The IWR analysis indicates that the only Best Buy plans that do not contain the CSC Salinity Control Structure are plans M-4 and CM-4. Since the negative effects of the CSC structure to navigation are a study constraint and due to the significant cost of the CSC structure, those Best Buy plans on the upper portion of the cost-efficient frontier were dropped from the final array. The components of the final array plans are presented in the table below. Plan M-4 features are those that are located in the Mermentau/Teche-Vermilion basin. Plan CM-4 consists of all the features listed in Table 2-15.

Table 2-15: Features of the NER Final Array Alternative Plans

Basin (Final Array Plan Name)	Category	Feature	Description
Mermentau/Teche-Vermilion (Plan M-4)	Hydrologic/ Salinity Control	13	Little Pecan Bayou Saltwater Sill. Construction of a rock weir with a crest (top) elevation of -3.1 ft and an opening of 60 ft at a bottom invert of -11.1 ft.
	Marsh Restoration*	47a1	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 933 marsh acres would be restored and 88 acres would be nourished from 3M cubic yards of dredged material with one future renourishment cycle.
		47a2	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 1,297 marsh acres would be restored and 126 acres would be nourished from 8.8M cubic yards of dredged material with one future renourishment cycle.
		47c1	Marsh restoration using dredged material south of Hwy 82 about 4.5 miles west of Grand Chenier. 1,304 marsh acres would be restored and 4 acres would be nourished from 8.6M cubic yards of dredged material with one future renourishment cycle.
		127c3	Marsh restoration at Pecan Island west of the Freshwater Bayou Canal and about 5 miles north of the Freshwater Bayou locks. 832 marsh acres would be restored and 62 acres would be nourished from 7.3M cubic yards of dredged material with one future renourishment cycle.
		306a1	Rainey marsh restoration at Christian Marsh east of the Freshwater Bayou Canal and about 5 miles north of the Freshwater Bayou locks. 627 marsh acres would be restored and 1,269 acres would be nourished from 8.1M cubic yards of dredged material with one future renourishment cycle.
	Shoreline Protection/ Stabilization*	6b1	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 11.1 miles of shore protection consisting of a reef breakwater with a lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 2,140 acres of existing marsh.
		6b2	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 8.1 miles of shore protection consisting of a reef breakwater with a lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 1,583 acres of existing marsh.

		6b3	Gulf shoreline protection/stabilization from Calcasieu River to Freshwater Bayou. 6.3 miles of shore protection consisting of a reef breakwater with a lightweight aggregate core. Located ~150 ft offshore with geotextile fabric and stone built to an 18 ft crest width. The breakwater would protect 1,098 acres of existing marsh.
		16b	Fortify Freshwater Bayou with 13.4 miles of rock revetment at three critical spots to prevent breaching. Revetment would be built to +4 ft with a 4 ft crown. Two maintenance lifts will be required. The breakwater would protect 1,288 acres of existing marsh.
	Chenier Reforestation	CR	Replant 13 chenier locations. Approximately 435 seedlings per acre, at 10 ft x 10 ft spacing, with invasive species control incorporated.
Calcasieu/ Sabine (Plan CM-4) (Includes all features in Plan M-4)	Hydrologic/ Salinity Control	74a	Cameron-Creole Spillway. Located at the breach in the levee south of Lambert Bayou. The canal would act as a drainage manifold. The outfall channel into Calcasieu Lake would be rock-lined for scour protection and built to +4 ft.
	Marsh Restoration*	3a1	Beneficial use of dredged material from the Calcasieu Ship Channel. Adjacent to the south shore of the GIWW west of the ship channel near Black Lake. 599 marsh acres would be restored from 5.3M cubic yards of dredged material with one future renourishment cycle.
		3c1	Beneficial use of dredged material from the Calcasieu Ship Channel. Adjacent to the east rim of Calcasieu Lake within the Cameron-Creole Watershed. 1,765 marsh acres would be restored and 450 acres would be nourished from 10.2M cubic yards of dredged material with one future renourishment cycle.
		124c	Marsh restoration at Mud Lake. Located adjacent and north of Highway 82 and east of Mud Lake. 1,908 marsh acres would be restored and 734 acres would be nourished from 11.1M cubic yards of dredged material with one future renourishment cycle.
		124d	Beneficial use of dredged material from the Calcasieu Ship Channel for marsh restoration at Mud Lake. Located west of the Calcasieu Ship Channel and adjacent to the southern rim of West Cove. 159 marsh acres would be restored and 448 acres would be nourished from 1.4M cubic yards of dredged material with one future renourishment cycle.
	Shoreline Protection/ Stabilization*	5a	Holly Beach Shoreline Stabilization Breakwaters. Construction of approximately 8.7 miles of rock and low action breakwaters and is a continuation of existing breakwaters. Crown elevation of +1.5 ft with a crown width of 30 ft. Two maintenance lifts will be required. The breakwater would protect 26 acres of beach and dune habitat.
	Chenier Reforestation	CR	Replant 22 chenier locations. Approximately 435 seedlings per acre, at 10 ft x 10 ft spacing, with invasive species control incorporated.
	Oyster Reef Preservation	ORP	Preservation of a large oyster reef in Sabine Lake through the enforcement of oyster dredging restrictions.

**- Renourishment and maintenance lifts are considered an Operations and Maintenance (O&M) cost and are a 100% NFS responsibility.*

2.10 Summary of Accounts and Comparison of Alternatives

To facilitate alternatives evaluation and comparison, the 1983 Principles and Guidelines set up four Federal Accounts to assess the effects of alternatives. The accounts are National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED).

All NER alternative plans provide positive net EQ benefits that contribute to the regional ecosystem outputs and functions, and provide coastal sustainability. All plans considered provide synergy with NED objectives by providing resilience to key elements of regional geomorphic structure that facilitate storm risk management. The alternative plans also support RED benefits in maintaining the regional geomorphic structure that in turn maintains an existing hydrology which supports a regional agricultural economy. The plans also support RED objectives by providing resiliency to natural risk reduction features. Regarding OSE, all alternative plans address the southern-most portion of the study, which is comprised largely of coastal wetlands and ridges. The populations of this portion of the study area has a long and rich history of utilizing the natural landscape as the source of their economy. All the plans considered facilitated that continued use and history and provide the possibility of social as well as physical resiliency for the area.

NER TSP

The Corps objective in ecosystem restoration planning is to contribute to NER. Contributions to NER (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. The TSP must be shown to be preferable to taking no action (if no action is not recommended) or implementing any of the other alternatives considered during the planning process. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, shall be selected. The TSP must be shown to be cost-effective and justified to achieve the desired level of output.

Plan 0: **No Action.** As detailed in Chapter 1, under this alternative, no ecosystem restoration would take place. Coastal wetlands would continue to degrade and disappear, further weakening the coastal landscape resulting in significant impacts to important habitats. Infrastructure, populations, industry, and businesses would continue to become vulnerable to the increased effects of storm surge and RSLR through the loss of a protective wetland buffer. Ecosystem restoration projects would take place under CWPPRA, SMP, RESTORE Act, and Parish plans but at a smaller scale.

Plan M4: **Mermentau Small Integrated Restoration.** This alternative was formulated for NER so specific NED or RED benefits were not calculated. Effects to EQ are increased but only for the Mermentau Basin. These include benefits to the flora and fauna of the study area through the restoration and protection of important imperiled habitat. Aquatic, terrestrial, and bird species would benefit from the restored ecosystem. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and improvement to the coastal landscape. Restoring the ecosystem also has positive benefits for surrounding communities through a preservation of cultural values, community cohesion, economic vitality, and leisure and recreation.

Plan CM-4: **Comprehensive Small Integrated Restoration (TSP).** This alternative was formulated for NER so specific NED or RED benefits were not calculated. Effects to EQ increase in the Calcasieu and Mermentau Basins. Effects of restoring the ecosystem would be similar to Plan M4, but would be on a much larger scale. Positive effects to OSE are expected through the restoration of wetland habitat and its associated benefits to plant and wildlife species, salinity reduction, and improvement to the coastal landscape. Additional benefits to OSE, such as those described for Plan M4, would occur but on a much larger scale. This alternative provides the most cost-effective and comprehensive benefit.

2.11 Additional Evaluation of the Final Array of Alternatives

Both the 2013 Initial Draft Report and the 2015 Revised Draft Report identified Plan CM-4 as the TSP. However, during technical reviews and based on new information from the feasibility level design phase of the study, additional work and other assessments were completed for several of the features in each alternative. These efforts required a reevaluation of each alternative against one another to confirm Plan CM-4 remained the TSP.

In order to use the best available data and models, alternative plan feature benefits (AAHUs) were updated with the certified version of the WVA model. Refined annualized costs were also developed and input into the IWR Planning Suite model with the new AAHU calculations. The PDT completed a new analysis of the NER focused array of alternatives based on the refinements in benefits and costs for all features in each alternative. This effort helped identify features that fell short of initial benefits projections. For example, the Little Pecan Bayou Saltwater Sill (Feature 13) had significantly fewer benefits than originally projected and was therefore removed as a component from all alternatives. Other features that comprised the alternative plans were also evaluated. The Sabine Lake Oyster Reef Preservation feature was removed from further consideration since there is no cost for its implementation, it lacks quantifiable benefits, and it can be handled administratively by the agency in charge of its management. The PDT also determined that the CSC Salinity Control Structure and the Cameron-Creole Spillway (feature 74a) should be assessed through additional studies because there are too many uncertainties about potential effects on salinity, habitat, and navigation. These features also need complex and detailed hydrodynamic and navigation economics modeling that this study effort is not scoped to support at this time. Given these adjustments, the focused array of alternatives was re-run to calculate the CE/ICA without these features and based on the updated annualized benefits and costs. The outputs from these adjustments are presented below (see Table 2-16 and Figure 2-10).

Table 2-16: NER cost efficient alternative plan comparison.

Plan Name	Total Cost x 1,000	Annual Cost	AAHUs	Cost/AAHU	Annual Cost/AAHU	Cost Effective Status
CM-1	$2,159,512	$85,933,395	8,623	$250,430	$9,965	Best Buy
CM-6	$2,032,615	$80,883,760	8,285	$245,324	$9,762	Best Buy
CM-3	$1,874,080	$74,575,197	7,170	$261,388	$10,401	Yes
CM-2	$1,588,626	$63,216,127	6,990	$227,278	$9,044	Best Buy
CM-5	$1,460,681	$58,124,842	5,156	$283,297	$11,273	Yes
CM-4	$1,175,227	$46,765,771	4,976	$236,176	$9,398	Yes
C-1	$826,903	$32,904,915	4,129	$200,289	$7,970	Best Buy
C-2	$740,684	$29,474,025	3,688	$200,821	$7,991	Yes
C-5	$671,458	$26,719,300	1,980	$339,172	$13,497	Yes
C-4	$386,003	$15,360,229	1,800	$214,475	$8,535	Yes
No Action Plan	$0	$0	0	$0	$0	Best Buy

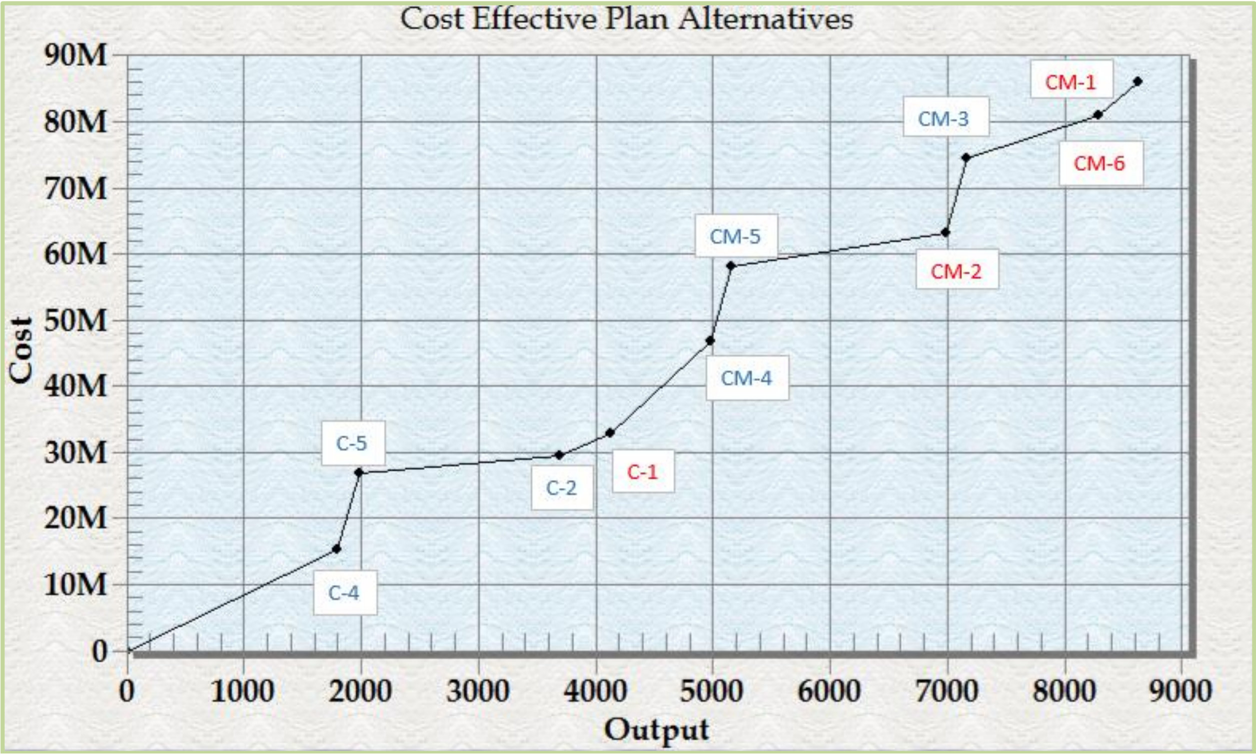

Figure 2-10: CE/ICA analysis using updated annualized costs and benefits.

2.12 Confirmation of the NER TSP

The relative ranking of alternatives to one another as expressed in the first IWR runs was altered with the updated set of outputs. Plan A did not perform as a cost efficient plan in the refined CE/ICA despite continuing to demonstrate the potential to deliver a relatively significant magnitude of benefits (975 AAHUs). Note that for CE/ICA runs after the initial alternative screening process AAHUs were used in lieu of AAAs in the benefits calculations.

Several features included in the TSP appear, on an individual basis, to lack adequate restoration performance to justify their inclusion. The basis/rationale for the inclusion of those features, specifically 124d, 5a, & 306a1, in various alternative plans including the TSP is important. These features, as well as all of the features in the TSP, titled Small Integrated Restoration, represent the minimum critical components necessary for providing restoration in a manner that protects the geomorphic integrity and resiliency of the larger Chenier Plain system. While the features of the TSP were assessed for their individual outputs and are not interdependent, they do support a holistic objective. That is to provide long-term resilience to the overall ecosystem structure of the Chenier Plain. Each feature, in addition to restoring valuable habitat, enhances the resilience to a structural element of the larger ecosystem.

In the case of features 124d and 5a, these features are anchor pieces that also work with feature 124c to prevent the long-term failure of a heavily deteriorated land bridge in the vicinity of Mud Lake, which lies between the Gulf of Mexico and the western extent of Calcasieu Lake. Feature 5a is particularly critical to this area since the beach and dune ridge represents the sole contiguous chenier crossing the area. The breakdown of this land bridge would ultimately result in the establishment of an open estuary reaching approximately 20 or more miles inland from the coast and elevating salinities and coastal storm effects throughout the area. Feature 306a1, in addition to creating valuable marsh, stabilizes the eastern ridge associated with the Freshwater Bayou channel. Feature 127c3 provides similar support for the western side of this ridge. Loss of one, or both sides of this ridge would result in a rapidly expanding embayment that could threaten the remainder of the Mermentau Basin.

Plan CM-4 is the plan that reasonably maximizes ecosystem restoration benefits compared to costs, and consistent with the Federal objective. CM-4 is the TSP because it is cost-effective, it contains restoration features in both hydrologic basins, and it is the least cost alternative that contains an integrated suite of restoration types including chenier reforestation, marsh restoration, and shoreline protection/stabilization. While there are larger-scale alternatives that would cost more and would contain more features, implementation of alternative CM-4 would achieve all study objectives with the exception of NER Objective 2 ("Manage tidal flows to improve drainage and prevent salinity from exceeding 2 ppt for fresh marsh and 6 ppt for intermediate marsh."). NER Objective 2 would be partially achieved because the CSC Salinity Control Structure and the Cameron-Creole Spillway, the only features that would manage tidal flows and prevent salinities from increasing, are recommended for additional study. CM-4 achieves most of the study objectives for the least cost. This makes it the NER plan.

Based on the data presented in Table 2-16, the financial investment required to select the first comprehensive Best Buy plan, CM-2, represents an additional cost of over $400M. Additionally, in direct comparison with the Best Buy plan CM-2, CM-4 produces 71.2 percent of those benefits at 74.0 percent of the cost. This proportionality demonstrates that the two plans are virtually identical in efficiency. For these reasons, the PDT maintains that the lower cost plan, Plan CM-4 is the TSP.

Description of the NER TSP:

- **Marsh Restoration.** Nine marsh restoration and nourishment features consist of delivering sediments to former marsh areas and eroding marsh areas (minimum of 100 acres efficiency criteria) that have water levels of less than two ft and that have been optimized to preserve or restore critical geomorphologic features to restore vegetated wetlands. This involves excavation of significant quantities and delivery of borrow material to restoration sites through designated access corridors. Some restoration sites may require containment to hold sediments in place. The marsh restoration locations include: (a) three areas on the south side of LA-82 approximately 4.5 miles west of Grand Chenier; (b) Pecan Island west of the Freshwater Bayou Canal approximately 5 miles north of the Freshwater Bayou locks; (c) Christian Marsh located east of Freshwater Bayou Canal and approximately 5 miles north of Freshwater Bayou locks; (d) southern shoreline of GIWW west of the CSC near Black Lake; (e) eastern rim of Calcasieu Lake within the Cameron-Creole Watershed (to be constructed by the USFWS); (f) east of Mud Lake and north of Highway 82; (g) Mud Lake west of the CSC adjacent to southern rim of West Cove (to be constructed by the USFWS). Dredged material sources would be the CSC (both beneficial use and dedicated dredging) and the Gulf of Mexico.

A table summarizing details of these features is included at Table 2-17a. Construction of marsh restoration features would typically involve placement of dedicated borrow material by hydraulic dredging. Placement would generally involve over-placement of material to achieve a typical marsh elevation of approximately +1.5 ft NAVD88 (or as dictated by adjacent marsh elevation) following post construction settlement. As necessary earthen containment dikes would be employed to efficiently achieve the desired initial construction elevation. Dikes would be breached following construction to allow dewatering and settlement to the final target marsh elevation. All marsh restoration locations would have one future renourishment cycle (as part of O&M and a 100% NFS responsibility). Subsequent marsh renourishment would employ similar techniques and specifications as developed for the initial construction. For a detailed description of each of the proposed marsh restoration projects see Appendix K. See also Appendix A, Annex V for information concerning corresponding marsh restoration project borrow sources.

- **Shoreline Protection/Stabilization.** The five Gulf shoreline protection/stabilization features span approximately 252,000 linear ft and would be used to reduce erosion of canal banks and shorelines in critical areas in order to protect adjacent wetlands and critical geomorphic features. Multiple locations of Gulf of Mexico shoreline from the Calcasieu River to Freshwater Bayou consist of reef breakwaters with a lightweight aggregate core that would be located approximately 150 ft offshore with geotextile fabric and stone built to an 18 foot crest width. In addition, approximately 13.4 miles of rock revetment built to +3 ft NAVD88 with a 4 foot crown would be placed at three locations to fortify spoil banks of the GIWW and Freshwater Bayou. Two future maintenance lifts would be required (as part of O&M and a 100% NFS responsibility). Rock and breakwaters would also be placed at Holly Beach as a continuation of existing breakwaters; two future maintenance lifts would be required (as part of O&M and a 100% NFS responsibility). Details of these features are included in Table 2-17b.
- **Chenier Reforestation.** Chenier restoration consists of replanting of 435 seedlings per acre at 10 foot x 10 foot spacing, in 35 Chenier locations on 1,400 acres in Cameron and Vermilion parishes. Invasive species control and eradication are also included. Details of these features are included in Table 2-17c.
- **Hydrologic and Salinity Control.** The Cameron-Creole Spillway salinity control structure south of Lambert Bayou is recommended for additional study. It would serve as a drainage manifold and the outfall channel into Calcasieu Lake would be rock-lined for scour protection The SMP model used to evaluate this feature needs additional refinement to properly evaluate the benefits over the 6,600-acre area of influence. The modeling indicated a slight decrease in acreage under the FWP condition (0.8% reduction), but indicated a positive benefit in habitat quality (267 AAHUs). Nevertheless, the modeling performed for this feature would not be able to adequately measure the potential benefits of this feature because it would only operate in extreme conditions (e.g., after a high storm surge). Therefore it would be prudent to examine this measure in more detail under a new study effort.
- The **CSC Salinity Control Structure** is recommended as an additional long-range study feature to adequately account for potential environmental benefits, navigation impacts, and engineering.
- O&M costs for all NER features (a NFS responsibility) are estimated at approximately $311,573,000.
- First construction costs only are estimated at $1,175,227,000.
- **Changes and updates to the NER TSP since release of the 2015 Revised Draft Report are minor and consist of providing more details about each feature in the fact sheets (Appendix K), and updating costs and benefits. These changes can be found in Chapter 4.**

2.13 NER TSP Feature Details

Table 2-17a. Details of the marsh restoration features of the TSP (See Appendix K for fact sheets and maps detailing each NER TSP marsh restoration feature).

Measure Number	Measure Name	Basin	Marsh Type	Acres Restored	Acres Nourished	Total Acres	Net Benefits (acres)	Average Annual Habitat Units (AAHU)	Borrow Volume (cy)	Borrow Area (acres)	Renourishment Volume (cy)	Initial Construction Costs (US $)	TY 30 Renourishment (US $)
3a1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	Calcasieu	Brackish	599	-	599	454	191	5,339,286	139	1,000,000	$66,593,748	$17,759,470
3c1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	Calcasieu	Brackish	1,347	734	2,081	1,324	607	9,458,313	314	3,651,841	$168,194,346	$70,984,253
47a1	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	933	88	1,021	895	272	3,022,782	1,716[1]	1,500,000	$105,234,982	$21,239,680
47a2	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	1,297	126	1,423	1,218	381	8,831,084	1,716[1]	1,500,000	$97,348,440	$17,585,890
47c1	Marsh Restoration Using Dredged Material South of Highway 82	Mermentau	Brackish	1,304	4	1,308	1,135	353	8,557,120	1,716[1]	1,800,000	$95,372,834	$14,981,607
124c	Marsh Restoration at Mud Lake	Calcasieu	Saline	1,077	708	1,785	1,228	500	10,369,956	531	2,001,611	$112,219,520	$24,680,885
124d	Marsh Restoration at Mud Lake	Calcasieu	Brackish	159	448	607	168	4	1,420,943	378	1,200,000	$28,882,160	$17,636,205
127c3	Marsh Restoration at Pecan Island	Mermentau	Brackish	832	62	894	735	241	7,301,057	3,950[2]	781,000	$61,662,041	$15,683,451
306a1	Rainey Marsh Restoration Southwest Portion (Christian Marsh)	Mermentau	Brackish	627	1,269	1,896	743	151	8,128,181	3,950[2]	3,500,000	$75,885,692	$37,551,555
	Totals			8,175	3,439	11,614	7,900	2,700	62,428,722	7,028	16,934,452	$811,393,763	$238,102,996

1- *This borrow source provides the sediment for all three restoration features but the full amount of available material will not be dredged each cycle. Therefore this total acreage is only counted once in the column total.*
2- *This borrow source provides the sediment for both restoration features but the full amount of available material will not be dredged each cycle. Therefore this total acreage is only counted once in the column total.*

(Table 2-17a continued)

Measure Number	Measure Name	Impact to State Water Bottoms permanent (acres)	Floatation Footprint (acres)	Disposal Footprint (acres)	Dike Footprint (feet)	Dike Footprint (acres)	Impact to State Water Bottoms (temporary)	Dredge Pipeline Route (feet)	Dredge Pipeline Route (acres)	Piping Plover Critical Habitat (temporary impact acres)	Construction Period
3a1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	139	132	-	44,700	30.8	-	43,942	30	-	16 months
3c1	Beneficial Use of Dredged Material from Calcasieu Ship Channel	314	182	-	97,250	51.4	-	61,497	42	-	33 months
47a1	Marsh Restoration Using Dredged Material South of Highway 82	1,716[1]	47	-	68,300	47.0	-	35,519	24	0.14	23 months
47a2	Marsh Restoration Using Dredged Material South of Highway 82	1,716[1]	47	-	41,000	28.2	-	30,898	21	0.14	24 months
47c1	Marsh Restoration Using Dredged Material South of Highway 82	1,716[1]	47	-	35,200	24.2	-	29,858	21	0.14	23 months
124c	Marsh Restoration at Mud Lake	531	28	-	78,100	31.5	-	9,485	7	1.8	27 months
124d	Marsh Restoration at Mud Lake	314	182	-	32,500	22.4	-	21,452	15	-	9 months
127c3	Marsh Restoration at Pecan Island	3,950[2]	110	-	46,000	31.7	-	37,074	26	-	12 months
306a1	Rainey Marsh Restoration Southwest Portion (Christian Marsh)	3,950[2]	178	-	108,000	74.4	-	59,731	41	-	17 months
	Totals	6,964	953		551,050	341.6		329,456	227	2.2	---

1- *This borrow source provides the sediment for all three restoration features but the full amount of available material will not be dredged each cycle. Therefore this total acreage is only counted once in the column total.*
2- *This borrow source provides the sediment for both restoration features but the full amount of available material will not be dredged each cycle. Therefore this total acreage is only counted once in the column total.*

Table 2-17b. Details of the shoreline protection features of the TSP (See Appendix K for fact sheets and maps detailing each NER TSP shoreline protection feature).

Measure Number	Measure Name	Basin	Marsh Type	Net Benefits (acres)	Average annual habitat units (AAHU)	Shoreline Feature Length (ft)	Rock (tons)	Grade Rock (lbs)	Geotextile Fabric (sq yds)	Lightweight Aggregate (tons)	1st Mainten-ance Lift (tons)	2nd Mainten-ance Lift (tons)	Initial Construct-ion Costs (US $)	TY15 Mainten-ance (US $)
5a	Holly Beach Shoreline Stabilization – Breakwaters	Calcasieu	Saline	26	56	46,014	860,540	250	386,460	0	129,081	86,054	$144,044,021	$16,786,222
6b1	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	2,140	625	58,293	868,480	250	447,830	479,150	86,848	0	$198,480,921	NA
6b2	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	1,583	466	42,883	687,140	250	363,270	357,010	68,714	0	$145,876,561	NA
6b3	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	Mermentau	Brackish	1,098	312	33,355	561,530	250	244,205	279,030	56,153	0	$115,270,890	NA
16b	Fortify Spoil Banks of the GIWW and Freshwater Bayou	Mermentau	Brackish	1,288	279	70,983	617,640	250	516,860	0	92,646	61,764	$36,018,600	$5,695,468
	Totals			6,135	1,738	251,528	3,595,330		1,958,625	1,115,190	433,442	147,818	$639,690,993	$22,481,690

(Table 2-17b continued)

Measure Number	Measure Name	TY 25 Maintenance (US $)	Impacts to State Water Bottoms (permanent)	Breakwater Footprint (feet)	Flotation Footprint* (acres)	Temporary Disposal Footprint* (acres)	Impact to State Water Bottoms (temporary acres)	Critical Habitat (acres)	Temporary Staging Area (acres)	Crown Elevation (feet NAVD88)	Crown Width (feet)	Slopes	Aprons (feet)	Construction Period
5a	Holly Beach Shoreline Stabilization – Breakwaters	$11,247,740	57.4	57.4	479	462	941	-	-	3.50	24	2:1	10-ft front & 6-ft back	19 months
6b1	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	$15,389,345	65.9	65.9	725	711	1436	-	21	3.25	18	2:1	10-ft front & 6-ft back	31 months
6b2	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	$11,343,672	40.2	40.2	507	497	1004	-	21	3.25	18	2:1	10-ft front & 6-ft back	23 months
6b3	Gulf Shoreline Restoration: Calcasieu River to Freshwater Bayou	$9,041,421	37.8	37.8	372	289	661	-	21	3.25	18	2:1	10-ft front & 6-ft back	18 months
16b	Fortify Spoil Banks of the GIWW and Freshwater Bayou	$3,966,404	77.1	77.1	358	-	-	-	-	3.00	4	4:1	none	13 months
	Totals	$50,988,582	278.4	278.4	2,441	1,959	4,042	-	63	-	-	-	-	---

**- Access for heavy equipment to construct shoreline stabilization features consists of dredging a channel in open water to allow construction equipment to reach shoreline areas and placing the dredged material alongside the channel so the necessary channel depth is maintained. This material stored adjacent to the channel will be returned to the access channel after construction. These impacts are temporary and will naturally revert to existing conditions over time.*

(Table 2-17b continued)

Linear Feet for Access and Temporary Disposal

Measure	5a	6b1	6b2	6b3	16b*	Total Feet	Miles
Disposal	159,741	239,001	168,533	98,683	0	665,958	126.1
Equipment Access	161,957	244,857	173,050	126,542	0	706,406	133.8

**- No dredging or temporary disposal is anticipated for Feature 16b since Freshwater Bayou has adequate water depths to allow the necessary construction equipment access.*

Table 2-17c. Details of the chenier reforestation features of the TSP (see Appendix K for fact sheets and maps detailing the NER TSP chenier reforestation features).

Measure Name	Net Benefits (acres)	Benefits (AAHU)	Species	Total Fence Length (feet)	Fence Height (feet)	Planting Density (#/acre)	Spacing (feet)	Min. Survival % at Year 4*	Equip-ment Access Corridor (feet)	Equip-ment Access Corridor (acres)	State Water Bottoms (permanent)	State Water Bottoms (tempor-ary)	Critical Habitat (acres)	Staging Area (acres)
Chenier Reforestation (CR)	1,413	538	Live Oak; Hackberry	150,000	7.5	435	10 x 10	57%	13,867	10	0	0	0	0

**- For a given planting, a minimum of 250 seedlings/ saplings per acre must be present (with a 60 to 40 hard mast to soft mast ratio) at the end of the fourth year (i.e., Year 5) following successful attainment of the one-year survivorship criteria. Costs to ensure the minimum survival percent are considered 'construction' and will be cost-shared accordingly.*

2.14 Views of the Non-Federal Sponsor

CPRAB recognizes the importance of hurricane and storm surge risk reduction and ecosystem restoration as evidenced by the fact that the 2012 State Master Plan includes this study. Implementation of the NED Plan would provide hurricane and storm surge risk reduction to eligible properties. The NER Plan would help to restore and protect the critical Chenier Plain providing multiple environmental benefits to southwest coastal Louisiana. CPRAB and numerous local stakeholders participated with CEMVN in the PDT process and have given input to develop the various measures and alternatives to formulate the plans. CPRAB currently has expressed no objection to the features of the NER and NED plans, and both plans are consistent with the State Master Plan. However, CPRAB continues to support construction of structural risk reduction features like levees across the study area as the most efficient way to reduce flood damage risks to residents of the study area.