4.0 ENVIRONMENTAL CONSEQUENCES

This chapter is divided into 16 sections. Section 4.1 describes how the HS and WVA models were used to evaluate project impacts. Section 4.2 discusses risk and uncertainty in the application of these models. This is followed by separate sections that discuss project impacts to each category of physical, natural, cultural, and socioeconomic resources in the SNWW study. The chapter ends with a discussion of cumulative impacts in Section 4.16.

Environmental consequences analysis of the Preferred Alternative includes the assumption that the eight Neches River Turning and Anchorage Basins (Alternative G, Table 2.3-1) are a component of the SNWW CIP.

4.1 MODELING FUTURE WITHOUT AND WITH-PROJECT CONDITIONS

The evaluation of ecological impacts to the extensive wetland habitats in the study area was performed primarily with WVA models. These models provide quantitative estimates of changes to the quality and quantity of fish and wildlife habitat in the SNWW's wetland communities. The WVA is primarily driven by salinity predictions from the HS model. Both FWOP and FWP effects must be determined using the WVA models and the differences between the two calculated in order to determine the effects of the proposed project.

The HS model is described in detail in a separate report (Brown and Stokes, 2009). In brief, the HS model is a 3-dimensional TABS-MDS code that propagates flow and salinity throughout the model domain in response to many factors (e.g., tides, Gulf boundary conditions, winds, freshwater inflows). A 3-dimensional simulation was employed in the navigation channels and Sabine Lake, and 2-dimensional simulation (vertically integrated) was used in the shallow tributaries.

As described in Brown and Stokes (2009), the HS model was calibrated and verified using field observations collected by the ERDC during a long-term data collection effort at 16 stations in the study area from May 16, 2001, through January 10, 2002 (Fagerburg, 2003). The model tidal elevations, discharge measurements, current velocities, and salinities were compared to field data obtained during the period, and figures showing these comparisons can be reviewed in Brown and Stokes (2009). In general, the model performed reasonably well. The tidal elevations were comparable to field data near the coast with the level of agreement reduced somewhat in the upper reaches. Discharge and current velocity observations were also similar to model output at most but not all stations. The salinity comparisons were also reasonably close. It was noted that while salinity stratification was qualitatively correct, the model was somewhat more diffusive than observed and the amount of upstream salinity transport may at times be underestimated. However, a sensitivity analysis was conducted to investigate how well the model behaves under conditions when the flow is not changing rapidly. Since flow changes associated with the project would not be rapid, the behavior of the model under these conditions provides a better reflection of the gradual changes expected with the project. The model was found to behave better at most gages under these conditions. Overall, the model provides a very detailed representation of the system and appears to be a suitable tool for evaluating project effects.

With the model developed and performance demonstrated against field data, the next step was using the model to quantify changes in the FWP and FWOP conditions. Two key components of this future evaluation are freshwater inflows and relative sea level change. After these components are described, the FWOP and FWP conditions are presented.

4.1.1 Freshwater Inflows

Freshwater inflow for the SNWW HS model's future conditions were developed using model outputs from Run 8 of the TCEQ Water Availability Models (WAM) for the lower Sabine and Neches rivers. For existing conditions, "Run 8 uses modified diversion amounts (maximum use for the last 10 years), year 2000 area-capacity parameters for major reservoirs, and assumed return flows. It also includes term water rights and provides the most realistic assessment of current streamflow conditions" (TWDB, 2007). The TWDB projected flows for the year 2060 by modifying Run 8 "to include projected increased demand from existing water rights, expected change to return flows, projected new strategies to come online before 2060, and estimated year 2060 storage capacities for major reservoirs" (TWDB, 2007).

The 2060 WAM runs were selected for use in the SNWW HS modeling because they were developed by the State's lead water planning agency, and they include future water supply strategies approved by the 2007 Texas State Water Plan (TWDB, 2007). The SNWW study area is included in Regional Plan I for the East Texas Region. The Region I water plan takes into consideration existing flows that are dedicated to the State of Louisiana as prescribed by the Sabine River Compact. All existing and proposed future strategies for meeting Texas's demand must be met by the Texas firm-yield share (750,000 acre-feet) of the total Sabine River flow, as appropriated under the use provision of Certificate of Adjudication No. 05-4658 (March 5, 1958). The 2060 WAM model does not attempt to predict future demand in the Louisiana portion of the Sabine Basin. This should not significantly affect future projections because the Louisiana portion of the basin is comprised primarily of undeveloped, coastal wetlands.

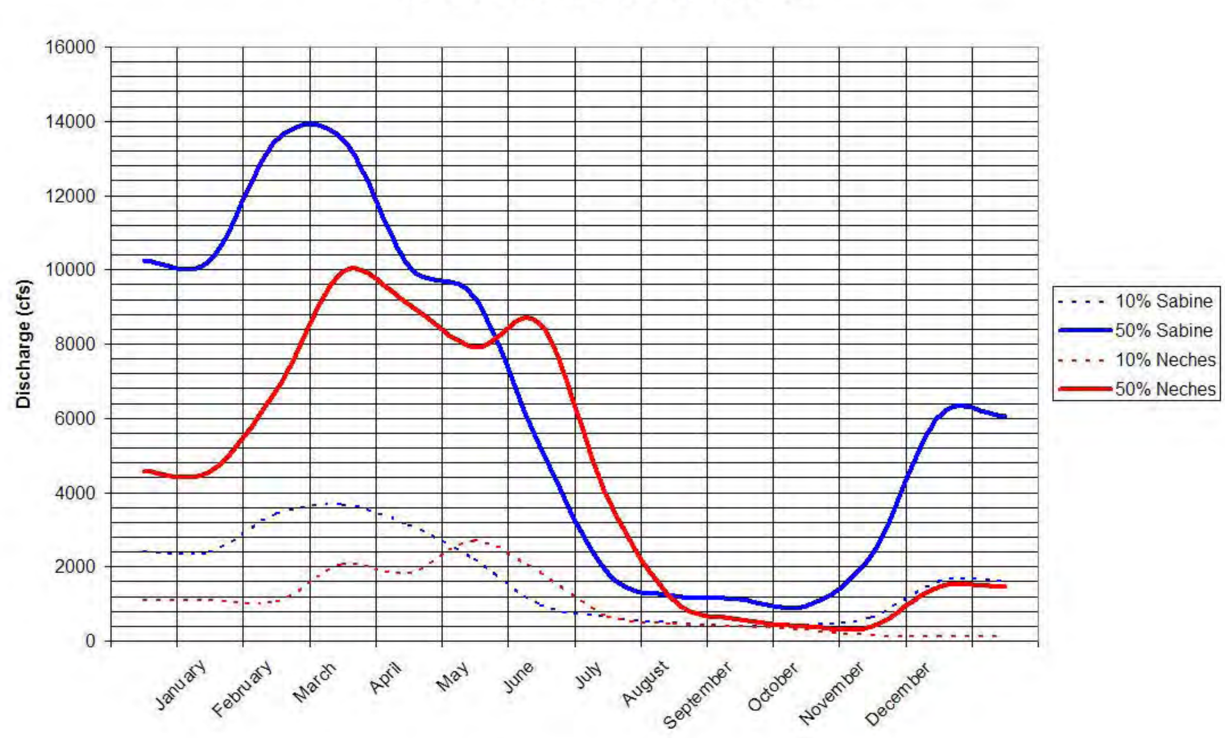
By 2060, Region I's population is projected to grow 36 percent, and water demands are projected to increase by 41 percent. The greatest increase (48 percent) is expected in the demand for water for manufacturing. Municipal demand is expected to grow 24 percent. The existing water supply is projected to decrease slightly by 2060, due primarily to reservoir sedimentation and a small decline in groundwater supply. Although the region as a whole appears to have enough supply to meet demands through 2060, the total water supply is not readily available to all users.

The regional plan recommends the following strategies to provide the additional water supply projected to be needed by 2060: (1) the construction of Lake Columbia reservoir in the Neches River watershed; (2) cooperation with Region C, which includes the Dallas-Fort Worth metropolitan area, in the use of surface water from Toledo Bend Reservoir and proposed Lake Fastrill; (3) expanded groundwater use by smaller communities; and (4) municipal conservation throughout the region.

The WAM outputs were developed using current patterns of precipitation and evaporation. The USACE did not modify the models to use projected precipitation or evaporation for SNWW future conditions because the Texas State Climatologist has recently concluded that it is impossible to predict with confidence what precipitation trends would be in Texas over the next half century (Nielsen-Gammon, 2009). Unlike precipitation, there is more consensus for a predicted temperature increase in Texas of close to 4°F by 2060. No attempt was made to change future temperatures in the model because resulting changes in evapotranspiration would be so small as to negligibly change modeling results.

Two freshwater inflow conditions, median and low, were developed for project evaluation. For both flow conditions, the ERDC provided salinities for all model stations and nodes for WVA modeling. Figure 4.1-1 illustrates the inflow values employed for the two major inflow sources for both the 10th percentile, low flow (dotted lines), and 50th percentile, median flow (solid lines), obtained from the WAM monthly output files.

Figure 4.1-1. SNWW Low and Median Inflow Hydrographs



These inflows were used for all impact analyses. The low inflow runs were conducted for 5 months, June through October, with June and July used for model spin-up. The spin-up months allow the model to reach a dynamic equilibrium for salinity and are not used in the analysis. The model output for the 3-month period from August through October was used for the low-flow sensitivity analysis. The median-flow simulation covered 6 months, April through September, with only 1 month, March, used for spin-up. The shorter spin-up period for the median flow was because the higher flow resulted in lower water residence times in the system. The median-flow output was used for all impact analyses.

Additional boundary conditions include flows in and out of the GIWW on the east and west boundaries of the study area, direct precipitation inputs, and the Gulf boundary condition salinity. Details are provided in Brown and Stokes (2009).

4.1.2 Relative Sea Level Rise

While the future rate of RSLR at the Sabine-Neches Estuary is very uncertain, it must be considered in project planning. Current USACE guidance (ER 1105-2-100; April 2000) stipulates that NRC (1987) should be used to determine the potential impacts of sea level rise on plan formulation and engineering structures. RSLR consists of two components: global (eustatic) sea level rise and local subsidence. The uncertainty inherent in the rates of eustatic sea level rise is evident in the variability of the different modeled rates given for the NRC (1987) projections and the Intergovernmental Panel on Climate Change (IPCC, 2007). A similar degree of uncertainty exists with the rate of local subsidence.

A detailed review of both eustatic and local subsidence rates was performed by the ERDC (Brown and Stokes, 2009). This review found the eustatic rate estimates range from 1.8 mm/year to 6.45 mm/year for the next 50 years. This study employs an estimate for eustatic rise (4.5 mm/year) that is in the middle of the range projected by NRC (1987) and in the high middle range of that predicted by IPCC (2007). In coastal Louisiana, estimates of the local subsidence component of RSLR were found to range from 0.4 to 0.6 mm/year based on basal peat measurements (Törnqvist et al., 2006), 2 to 5 mm/year as averaged from 48 years of tide gage data (Morton et al., 2006), and to 10 to 15 mm/year as measured from settling rates of established benchmarks (Shinkle and Dokka, 2004). The ERDC's review concluded that the lower rates were the most technically valid. These lower rates represent long-term trends in the subsidence rate, and seem to be the closest approximation of consensus concerning the local subsidence rate that is currently available.

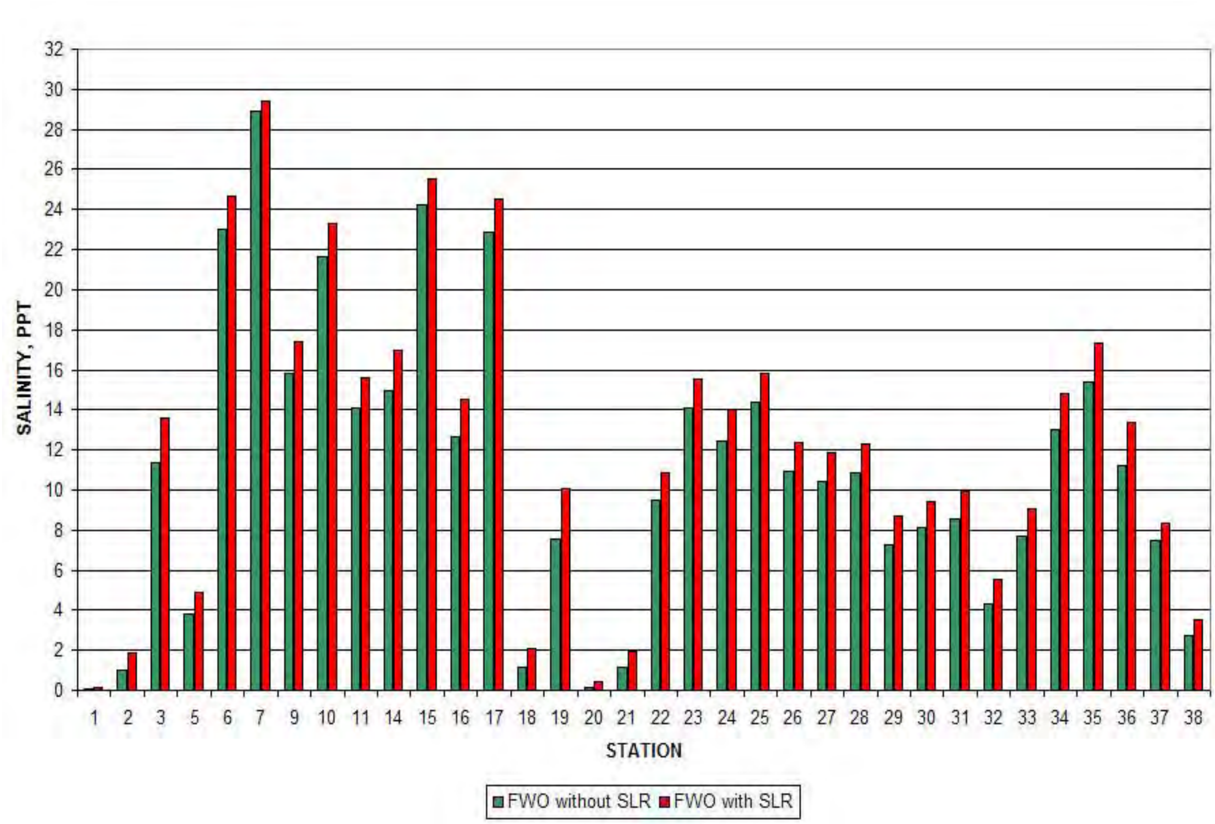
Adding these to the NRC II projections for eustatic sea level rise yields a value for the RSLR in the SNWW study area over 50 years of 4.9 to 5.1 mm/year. The average of these, 5.0 mm/year is used for modeling purposes.

Therefore, the "most likely" value of RSLR to be used for the SNWW deepening study's 50-year period of analysis is 250 mm (0.82 foot). Adjusting this to account for the period of analysis beginning in 2019 and ending in 2069 (the new period of analysis for the SNWW reformulation), the "most likely" amount of RSLR by the year 2069 is 335 mm (1.1 feet).

Figure 4.1-2 illustrates the effect of RSLR on predicted FWOP salinity in the system with the low (10th percentile) flows. The two simulations illustrate the salinity difference between the FWOP salinities without RSLR and the FWOP salinities with RSLR. Both simulations use the same inflows (WAMs 2060 inflows). At most stations, the RSLR is predicted to cause average salinity to increase about 1 ppt.

Incorporating RSLR in the HS model raises water elevation uniformly by 1.1 feet, which in turn allows greater salt transport through the system. At Bessie Heights, the salinity increase with the low-flow inputs is 2.0 to 2.5 ppt. At the median inflows, the salinity increase from RSLR is 1.0 to 1.5 ppt.

Figure 4.1-2. Mean Salinity Values, Low-Flow Conditions



4.1.3 Application of HS Model to Predict Project Effects

Having established the HS model's performance against field data and future conditions expected for freshwater inflows and RSLR, the next step is to use the model to predict changes in water elevations and salinity associated with project alternatives (the FWP condition). All simulations were performed using the low and median freshwater inflows and the 1.1 feet RSLR increase. Three types of project alternatives are considered: the 48-foot depth, other depth alternatives, and the effect of salinity mitigation measures.

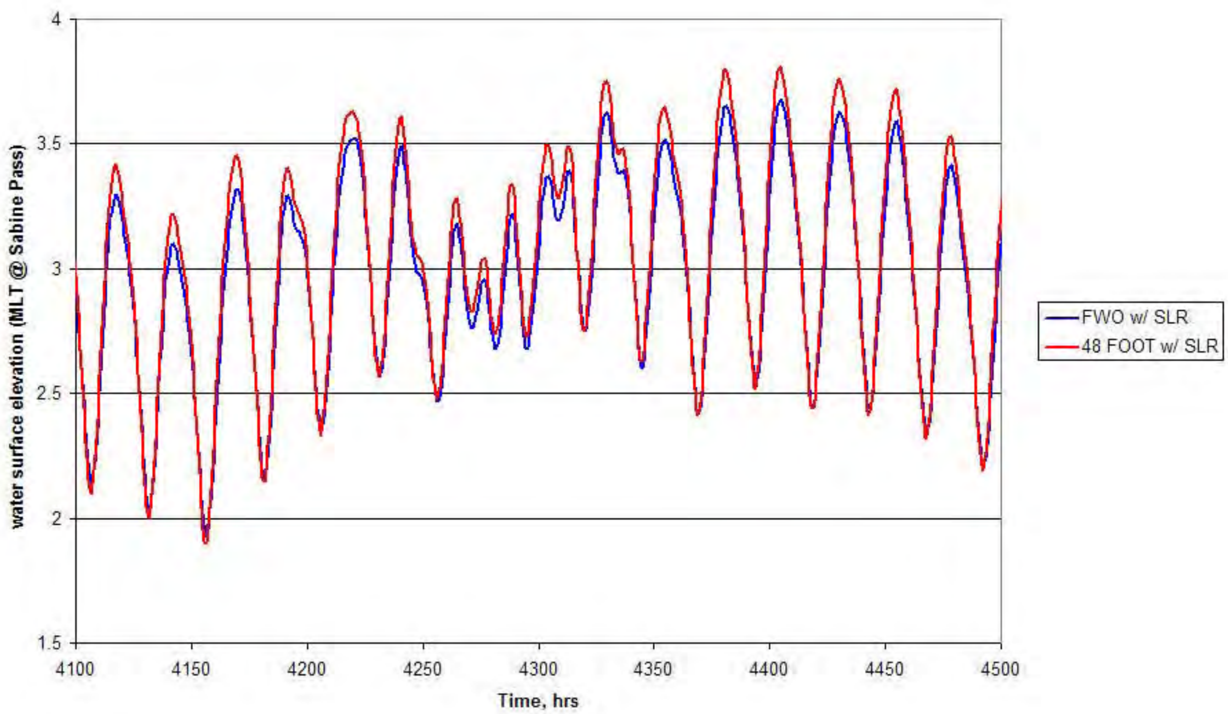
4.1.3.1 Water Surface Elevations – 48 Foot Channel

Water surface elevation over the study area was largely unaffected by the deeper navigation channel. An exception to the general result is the upper end of the Neches River near the saltwater barrier. Figure 4.1-3 provides a sample of the tides with and without the 48-foot channel at this location. The average high-water elevation appears to increase by 0.067 foot.

4.1.3.2 Salinity Changes – 48-Foot Channel

The effect of the 48-foot navigation channel is to increase salinity over most of the study area. The increase is greater for the median flows than for the low flows, reflecting a greater salinity gradient at high inflows, which allows a greater effect from the density current. Tables 4.1-1 and 4.1-2 provide a statistical analysis of salinity differences at 17 stations throughout the system for the low- and median-flow conditions. The tables provide the average differences between FWP and FWOP for surface, mid-depth, and bottom depths at each station.

Figure 4.1-3. Time Series of Tide at Neches River Salt Water Barrier – Low-Flow Case



The model salinity results are used for WVA modeling. The WVA requires input of "mean salinity" during the growing season and "mean high salinity" for impacts to fresh and intermediate habitats. The term "mean high salinity" is defined as the average of the highest 33 percent of consecutive salinity readings during a specified period of record. These two outputs of the HS model: mean and highest 33 percent, are the primary inputs to the WVA modeling.

4.1.3.3 Salinity Changes – Other Channel Depths

A model run with a 45-foot channel indicated that the salinity differences from the FWOP were similar to those with a 48-foot channel but lower in magnitude. To address salinity changes at other channel depths besides 48 and 45 foot, a quadratic equation was developed at each station based on model results at 0-, 5-, and 8-foot channel depth increase. This allowed the salinity change for each channel depth alternative to be predicted without having to model each deepening scenario independently.

Table 4.1-1
Statistical Analysis of Salinity Differences – Low Flow

	Average Differences												
Station Number	1	2	3	5	6	7	9	10	11	14	15	16	17
Surface Salinity	0.14	0.68	0.41	0.89	0.08	–0.31	1.03	–0.10	1.01	0.96	–0.05	1.01	0.02
Mid-depth Salinity	0.14	0.83	0.69	0.68	0.06	–0.25	1.03	–0.11	0.99	0.96	–0.04		0.01
Bottom Salinity	0.14	0.85	0.55	0.58	0.00	–0.21	1.03	–0.12	0.99	0.97	–0.05		0.00

	Standard Deviation of the Differences												
Station Number	1	2	3	5	6	7	9	10	11	14	15	16	17
Surface Salinity	0.15	0.20	0.36	0.49	0.45	0.32	0.17	0.55	0.18	0.13	0.40	0.20	0.23
Mid-depth Salinity	0.15	0.18	0.20	0.32	0.47	0.27	0.17	0.55	0.15	0.13	0.40		0.23
Bottom Salinity	0.15	0.23	0.25	0.35	0.47	0.26	0.17	0.55	0.15	0.14	0.41		0.23

Note: Statistics calculated after the spin-up period (hr 5088-7296)

Table 4.1-2
Statistical Analysis of Salinity Differences – Median Flow

	Average Differences												
Station Number	1	2	3	5	6	7	9	10	11	14	15	16	1.62
Surface Salinity	0.00	0.13	0.79	0.23	1.60	0.11	1.37	1.18	1.09	1.61	1.41	1.38	1.60
Mid-depth Salinity	0.00	0.16	1.18	0.22	1.78	0.25	1.37	1.16	1.11	1.62	1.42		1.58
Bottom Salinity	0.00	0.26	1.18	0.21	1.70	0.29	1.38	1.12	1.11	1.62	1.41		

	Standard Deviation of the Differences												
Station Number	1	2	3	5	6	7	9	10	11	14	15	16	17
Surface Salinity	0.01	0.22	0.64	0.44	1.20	1.01	0.73	0.90	0.73	0.59	0.88	0.61	0.83
Mid-depth Salinity	0.01	0.28	0.69	0.38	1.24	0.98	0.73	0.92	0.73	0.59	0.92		0.83
Bottom Salinity	0.01	0.43	0.63	0.37	1.26	0.95	0.73	0.97	0.73	0.60	0.97		0.83

	Highest 10 Percent of Differences												
Station Number	1	2	3	5	6	7	9	10	11	14	15	16	17
Surface Salinity	0.01	0.55	1.63	0.91	3.04	1.53	2.26	2.14	2.01	2.42	2.47	2.24	2.79
Mid-depth Salinity	0.01	0.68	1.92	0.89	3.33	1.63	2.26	2.15	2.00	2.44	2.51		2.78
Bottom Salinity	0.01	1.03	1.87	0.84	3.26	1.65	2.26	2.14	2.00	2.47	2.51		2.78

Note: Statistics calculated after the spin-up period (hr 2136-6552)

4.1.3.4 Salinity Changes – Salinity Mitigation Measures

Three types of salinity mitigation measures were considered: large scale, small scale, and local. The large-scale measures are those such as Rose City, Bessie Heights East and West, and Old River Cove. These large-scale measures have the potential to influence the entire system and were modeled with the TABS-MDS model. The small-scale features were evaluated with a desktop model, and the local measures such as shoreline restoration or plugging of a logging canal were not modeled. The salinity results were used to develop WVA benefits for the wide array of mitigation measures that were evaluated during the preliminary screening of mitigation measures. The model runs for the large-scale measures were primarily concerned with reclamation of wetlands along the Neches River. Salinity reductions predicted by the modeling would only be effective if all of the proposed measures were adopted. Least-cost analyses resulted in the exclusion of Bessie Heights West, a large feature that contained about one-third of the proposed reclamation area. An FWP reduction in salinity is not forecast in conjunction with reclamation of the remaining components of the Neches River BU Feature because salinity effects of this revised BU plan have not been modeled, and the removal of Bessie Heights West would be expected to significantly reduce salinity benefits.

4.1.4 Application of the WVA Model

4.1.4.1 Comparison of the FWOP and FWP Conditions

The WVA methodology provides a comprehensive, quantitative estimate of FWP changes in the quality and quantity of emergent marsh, cypress-tupelo swamp, and bottomland hardwood forests.

Each WVA model consists of variables considered important to each habitat type and suitability indices (SI) for each variable. All of the variable SIs for a specific community (i.e., fresh/intermediate, brackish, or saline marsh; swamp; bottomland hardwood) are combined in a mathematical formula to calculate the Habitat Suitability Index (HSI), which represents the composite habitat quality of the wetland being evaluated. Within each HSI formula, important variables may be weighted relative to other variables in the formula. The HSI formulae employed for the SNWW ecological modeling are based on those developed by the CWPPRA Environmental Work Group (USFWS, 2002a, 2002b, 2002c).

The WVA methodology quantifies changes in specific wetland structural and functional characteristics determined to be significant indicators of habitat health and quality. It combines the effects of changes in wetland productivity and structure to calculate impacts measured as AAHU values. Future without project and FWP conditions for the period of analysis were projected using salinities from the HS model as input into the WVA model. The FWOP condition predicts changes expected to occur under the No-Action Alternative described in Section 3. The FWP condition addresses the changes expected to result from project construction, including impacts from the placement of dredged material, benefits of the BU features, and effects of the compensatory mitigation plan.

HSIs are established for the FWOP and FWP conditions for selected target years (TY) throughout the life of the project. Habitat units are calculated by multiplying these HSIs by the affected acreage at each target year. The habitat units for the FWOP and FWP conditions totaled over the project life are divided by the total years of the project to determine AAHUs. Small changes in some variables like salinity, when applied to thousands of acres in the large hydrologic units in this study area, produce the changes in AAHUs shown tables 4.1-3 and 4.1-4 for Texas and Louisiana, respectively. The impacts or benefits of the project are then quantified by comparing AAHUs between FWP and FWOP conditions. This procedure fulfills the USACE requirement that compensation be evaluated using a unit of comparison that measures quality and quantity of habitat values over time.

The same procedure used to estimate FWP land loss was used to quantify the compensation associated with mitigation measures, which is described in detail in Chapter 5. Screened mitigation measures affected salinities in some areas, blocked shoreline retreat, and restored emergent marsh elevations in others. These changes were reflected in land loss tables specific to each mitigation measure as follows: (1) revised FWP land loss rates were calculated by substituting salinity values predicted by the HS model (Brown and Stokes, 2009) in the land loss rate formula for hydro-units on the Neches River; (2) acreages were adjusted in the land loss tables to account for the effect of mitigation measures, such as breakwaters or shoreline nourishment, which stopped or slowed existing shoreline retreat; and (3) acreages were adjusted in the land loss tables to add emergent marsh acres restored by the placement of dredged material or in-situ marsh terracing. Credit for marsh acreage was generally delayed by 1 year to allow time for planted and volunteer marsh vegetation to become established. This is based upon recent experience with CWPPRA and other marsh restoration projects in the lower Sabine and Neches watersheds where marsh plantings and natural vegetation rebounded quickly and robustly to create a stable marsh landscape.

Procedures to estimate the effects of mitigation measures deviate from the FWP land loss method in the specific instances where mitigation measures add mineral soils to degraded areas of former marsh. In these cases, the ICT projected that the loss rate for the mitigation areas would be lower because the addition of denser, mineral soils and the increase in marsh elevation would create a more stable landform. Accordingly, land loss rates due to the project were reduced by 50 percent in the land loss change spreadsheets for these areas. Other mitigation measures that did not involve the creation of a higher, more-stable landform were modeled using a land loss rate equivalent to the FWP rate.

4.1.4.2 Emergent Marsh Community Models

The EMCMs were used to evaluate saline, brackish, intermediate, and fresh marsh habitats in the study area. Variables included in the models were selected based upon their importance to fish and wildlife in coastal marsh ecosystems. A large number of species-specific HSI models for a variety of fish and shellfish, freshwater fish, birds, reptiles and amphibians, and mammals were reviewed and considered in the development of model assumptions. Six variables represent wetland habitat quality in the model:

Table 4.1-3
SNWW WVA Impacts Summary – Before DMMP Benefits and Mitigation (Louisiana Impacts Sorted by AAHUs)

HU #	Hydrologic Unit	Habitat Type	FWOP Net Change Acres	FWP Net Change Total Acres	FWP Net Change % Acres	FWOP Net Change AAHUs	FWP Net Change AAHUs	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Salinity Change (ppt)
LA 3	Black Bayou	Intermediate Marsh	–1,713	–130	–0.3	14,734	–509	4.00	5.10	1.1
LA 2	Willow Bayou	Intermediate (Brackish lumped)	–2,116	–102	0.3	11,249	–328	6.30	7.20	0.9
LA 4	West Johnson's Bayou	Intermediate Marsh	–1,703	–142	–0.8	5,729	–269	6.30	7.50	1.2
LA 5	Sabine Lake Ridges	Intermediate Marsh	–1,103	–93	–0.7	4,868	–218	6.30	7.50	1.2
LA 9	East Johnson's Bayou	Intermediate Marsh	–895	–46	–0.2	13,820	–190	4.20	5.20	1.0
LA 1	Perry Ridge	Fresh Marsh	–921	–50	–0.2	8,947	–65	0.90	1.24	0.3
LA 1	Perry Ridge	Intermediate Marsh	–191	–12	–0.1	1,873	–53	0.90	1.24	0.3
LA 5	Sabine Lake Ridges	Saline Marsh	–398	–10	–0.5	2,184	–35	17.00	18.40	1.4
LA 8	Southwest Gum Cove	Fresh Marsh	–152	–8	–0.3	2,170	–2	1.20	2.10	0.9
LA 5	Sabine Lake Ridges	Brackish Marsh	–2,567	–43	–0.1	9,113	–14	8.00	8.60	0.6
LA 7	Southeast Sabine	Fresh Marsh	–40	0	0.0	1,231	–11	1.80	2.30	0.5
LA 6	Johnson's Bayou Ridge	Brackish Marsh	–707	–22	–0.3	1,285	–6	6.00	6.70	0.7
LA 8	Southwest Gum Cove	Intermediate (Brackish lumped)	–233	–15	–0.2	3,253	–4	2.40	3.30	0.9
LA 6	Johnson's Bayou Ridge	Saline Marsh	–93	–5	–1.0	195	–2	12.00	13.80	1.8
LA 3	Black Bayou	Brackish Marsh	–803	–4	0.0	1,643	–1	3.00	3.80	0.8
LA 4	West Johnson's Bayou	Brackish Marsh	–1,189	–6	–0.2	768	–1	6.00	6.70	0.7
LA 2	Willow Bayou	Brackish Marsh	–695	–2		498	–1			1.4
LA/TX 1	Sabine Island	Cypress/Tupelo Swamp	0	0	0.0	4,499	0	0.69	1.10	0.4
LA/TX 2	Blue Elbow	Cypress/Tupelo Swamp (BH lumped)	0	0	0.0	300	0	1.00	1.60	0.6
LA 7	Southeast Sabine	Intermediate (Brackish lumped)	–96	–1	0.0	3,204	0	1.80	2.00	0.2
LA 1	Perry Ridge	Bottomland Hardwood	0	0	0.0	2,080	0	0.90	1.24	0.3
LA/TX 1	Sabine Island	Bottomland Hardwood	0	0	0.0	999	0	0.69	1.10	0.4
Total			–15,615	–691		94,642	–1,709			

Table 4.1-4
SNWW WVA Impacts Summary – Before DMMP Benefits
and Mitigation (Texas Impacts Sorted by AAHUs)

HU #	Hydrologic Unit	Habitat Type	FWOP Net Change Acres	FWP Net Change Total Acres	FWP Net Change % Acres	FWOP Net Change AAHUs	FWP Net Change AAHUs	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Salinity Change (ppt)
TX 7	GIWW North	Fresh (Intermediate lumped)	–539	–63	–0.4	2,602	–140	0.70	1.20	1.6
TX 6	Old River Cove	Brackish Marsh	–1,518	–46	–0.3	3,061	–116	10.00	11.00	1.8
TX 3	Rose City PA24A	Fresh Marsh	–3	–86	–63.3	53	–32			0.3
TX 8	Texas Point	Intermediate (Fresh lumped)	–245	–6	–1.3	940	–19	5.50	8.00	0.8
TX 12	Blue Elbow South	Cypress/Tupelo Swamp	0	0	0.0	418	–18	1.67	2.60	0.6
TX 10	Cow Bayou	Fresh Marsh	–75	–6	–0.1	824	–18	2.00	2.20	1.0
TX 11	Adams Bayou	Fresh Marsh	–28	–3	–0.7	305	–15	2.10	4.10	1.5
TX 5	Bessie Heights	Intermediate (Brackish lumped)	31	–1	0.0	1,273	–14	4.20	4.70	0.3
TX 10	Cow Bayou	Intermediate Marsh	–59	–3	0.0	741	–12	2.00	2.20	1.0
TX 7	GIWW North	Brackish Marsh	–62	–2	–0.1	380	–8	9.00	9.60	1.6
TX 8	Texas Point	Brackish Marsh	–252	–5	–0.4	1,464	–7	8.50	11.00	0.8
TX 8	Texas Point	Saline Marsh	–2,446	–17	–0.9	2,480	–5	12.50	15.00	0.8
TX 11	Adams Bayou	Cypress/Tupelo Swamp	0	0	0.0	44	–4	2.10	4.10	0.8
TX 13	Groves	Intermediate Marsh	–68	–3	–0.7	220	–3			1.0
TX 3	Rose City	Fresh Marsh	–93	–3	–0.1	1,365	–1	0.25	0.55	0.3
TX 2	Neches-Lake Bayou	Cypress/Tupelo Swamp	0	0	0.0	1,977	0	2.00	2.90	0.0
TX 1	North Neches River	Cypress/Tupelo Swamp	0	0	0.0	2,399	0	0.90	1.70	0.0
LA/TX 2	Blue Elbow	Cypress/Tupelo Swamp (BH lumped)	0	0	0.0	1,261	0			0.3
TX 2	Neches-Lake Bayou	Fresh Marsh	–24	0	–0.1	808	0	2.00	2.90	0.1
LA/TX 1	Sabine Island	Cypress/Tupelo Swamp	0	0	0.0	896	0			0.0
TX 5	Bessie Heights	Fresh Marsh	–40	–2	–0.1	1,313	0	1.00	1.50	0.5
TX 1	North Neches River	Fresh Marsh	–8	0	0.0	249	0	0.90	1.70	0.0
TX 10	Cow Bayou	Cypress/Tupelo Swamp	0	0	0.0	55	0	2.00	2.20	1.0
TX 4	West of Rose City	Fresh Marsh	–24	–1	–0.1	238	0	0.10	0.40	0.4
TX 5	Bessie Heights	Bottomland Hardwood	0	0	0.0	225	0	1.00	1.50	0.5
TX 3	Rose City	Cypress/Tupelo Swamp	0	0	0.0	217	0	0.25	0.55	0.3
TX 1	North Neches River	Bottomland Hardwood	0	0	0.0	277	0	0.90	1.70	0.0
LA/TX 1	Sabine Island	Bottomland Hardwood	0	0	0.0	503	0			0.0
TX 3	Rose City	Bottomland Hardwood	0	0	0.0	698	0	0.25	0.55	0.3
TX 6	Old River Cove	Bottomland Hardwood	0	0	0.0	149	0	1.00	1.50	0.5
TX 10	Cow Bayou	Bottomland Hardwood	0	0	0.0	286	0	2.00	2.20	1.0
TX 11	Adams Bayou	Bottomland Hardwood	0	0	0.0	402	0	2.10	4.10	0.8
TX 2	Neches-Lake Bayou	Bottomland Hardwood	0	0	0.0	1,164	0	2.00	2.90	0.0
	Totals		–5,453	–247		28,124	–412			

V_1 percent of the wetland covered by emergent vegetation

V_2 percent of the open water covered by SAV

V_3 marsh edge and interspersion

V_4 percent of the open-water area less than or equal to 1.5 feet deep

V_5 salinity

V_6 aquatic organism access

The reader is cautioned that straightforward comparisons of impacts associated with changes in salinity or other variables are not easily made between hydro-units. The varying AAHUs and acreage results are due to differences in project impacts, underlying conditions (i.e., existing land loss rate, marsh interspersion, SAV), and the size of the hydro-unit. Salinity is not the only determinant; changes in other variables can also have significant effects. Additional information about the weighting of variables is provided below. However, refer to Appendix C of the FEIS for detailed narratives of the FWOP and FWP conditions in each hydro-unit.

The primary focus of the SNWW application of the EMCM is the preservation of vegetated wetlands, but it is also recognized that some marsh restoration or protection strategies could have an adverse effect on aquatic organisms. Therefore, variables V_1 (percent emergent vegetation), V_2 (percent SAV), and V_6 (aquatic organism access) are grouped together and weighted more than the remaining variables. For all marsh models, V_1 receives the greatest weighting; however, the relative weights of V_1, V_2, and V_6 vary by marsh model to reflect different levels of importance between the marsh types.

The EMCM employs a split model format to account for the value of both marsh and open-water habitats. Two HSI formulas are calculated for each marsh type – one for emergent marsh habitat and one for open-water habitat. The HSI formula for emergent marsh contains the variables important for evaluating its habitat quality (V_1-percent coverage of emergent vegetation, V_3-marsh edge and interspersion, V_5-salinity, and V_6-aquatic organism access). The HSI formula for open-water habitat contains only the variables important to that habitat component (V_2-percent open water with SAV, V_3-marsh edge and interspersion, V_4-percent open water <1.5 feet deep, V_5-salinity, and V_6-aquatic organism access).

4.1.4.3 Swamp Community Model

The SCM uses variables that evaluate the ability of swamps to provide resting, foraging, and nesting habitat for a wide variety of wildlife species. In general, the swamp model can be applied if woody canopy cover is at least 33 percent of the surface area, and at least 60 percent of the canopy consists of any combination of bald cypress, tupelo gum, red maple, buttonbush, and/or planertree (*Planera aquatica*). The following four variables represent swamp habitat quality in the model:

V_1 stand structure

V_2 stand maturity

V_3 water regime

V_4 mean high salinity during the growing season

All of the SIs are combined in a mathematical formula, the HSI, which represents the composite habitat quality. Variables V_1 and V_3 (stand structure and water regime) are considered the most important variables in characterizing swamp habitat quality and therefore are weighted more than other variables. Variables V_1 and V_2 were adjusted for the dampening effect of salinity on tree growth, using output from the HS model. Variable V_4 (salinity) is weighted lower than the other variables.

4.1.4.4 Bottomland Hardwood Model

The BHM applies to forested wetlands that support a canopy of woody vegetation of which more than 40 percent of tree species consist of oaks, hickories, American elm, cedar elm, green ash, sweetgum, sugarberry, boxelder (*Acer negundo*), common persimmon (*Diospyros virginiana*), honeylocust (*Gleditsia triacanthos*), red mulberry (*Morus rubra*), eastern cottonwood (*Populus deltoides*), black willow (*Salix nigra*), and American sycamore (*Platanus occidentalis*). Variable selection for the model was based upon a review of various USFWS HSI models for bottomland hardwood wildlife. The following variables represent bottomland hardwood habitat quality in the model:

V_1 tree species composition

V_2 stand maturity

V_3 midstory/understory

V_4 hydrology

V_5 size of contiguous forested area

V_6 surrounding land uses

V_7 disturbance

The model incorporates site-specific habitat quality features (tree species composition, forest stand structure, stand maturity, and hydrology) and landscape parameters (forest size, surrounding land use, and disturbance). Because the primary application of this model is to quantify the loss of ecological values due to changes in the site-specific conditions, variables that are likely to be affected by these changes (V_1, V_2, V_3, and V_4) are considered more important than the landscape variables. Of the site-specific variables, V_1 (tree species composition) and V_2 (stand maturity) are considered equal and of greater importance than the other variables. Variable V_3 (understory/midstory) and V_4 (hydrology) are weighted less than V_1 and V_2. The “landscape” variables (V_5, V_6, and V_7) are not weighted. Variables V_1, V_2, and V_3 were adjusted for the dampening effect of salinity on tree growth, using output from the HS model.

4.1.5 Storm Surge Sensitivity Modeling

The potential for proposed project features to increase storm surge impacts in the study area was analyzed with a storm surge sensitivity analysis (Wamsley et al., 2010). The ADCIRC model was run to estimate water levels for two worst-case hypothetical storms, both with and without proposed SNWW CIP project features in place. Project features evaluated by the modeling are the deeper navigation channel, proposed PAs with maximum levee heights, and two expanded PAs. The two simulated storms exhibited minimum central pressures of 900 millibars, offshore pressure radii between 14.9 and 18.4 nautical miles, and forward speeds of 11 knots. Each produced water levels near or higher than the estimated 500-year level, and both would be considered extreme events. One storm tracked in the northwesterly direction, producing maximum surges of 18 feet near the coast at Sabine Pass and surges of 13–14 feet in Sabine Lake near Port Arthur, Texas. The second storm tracked in a north-northeasterly direction, producing maximum surges of over 20 feet near Sabine Pass and surges of 15 to 17 feet in Sabine Lake near Port Arthur.

The sensitivity analysis concluded that the greatest changes would occur north of Port Arthur along the Neches River. These changes are primarily due to the proposed increase in depth of the navigation channel. All changes are local, and there are no project-induced increases in surges away from the immediate vicinity of the navigation channel. Water levels in the marshes and open-water areas immediately north of the river would increase on the order of 4 to 8 inches or less. The modeling indicates some interior flooding would occur within the City of Port Arthur with both storms, both with and without the project. Changes in peak surge within the city for these two events, with the project in place, are caused by a slight increase in surge elevation and/or duration causing additional overtopping of the surrounding levee or internal topographic features. Peak surges for 100-year events are estimated to be approximately 9 feet in the Port Arthur area. Although simulations of less-intense events were not made as part of this study, in light of the 14- to 24-foot levees surrounding Port Arthur, significant interior flooding is not expected for the base condition. Any changes in peak surge on the order of inches should not cause any significant change in interior flooding for the with-project condition.

The Preferred Alternative for the SNWW CIP also includes ODMDS and marsh restoration measures. All of the existing and proposed ODMDSs are located several miles from the Gulf shoreline in water too deep to affect wave setup on the shoreline. The influences of marsh restoration on hurricane surge have been documented by Wamsley et al. (2009a, 2009b). Surges tend to slightly increase over and just seaward of the marsh as the surge propagation is slowed, which may result in reductions in peak water levels landward of marsh features. The impact of the proposed SNWW CIP marsh restoration features is relatively small and expected to modify peak surge levels locally by a minimal amount (Wamsley et al., 2010). No significant reductions or increases in surge level would be expected from either the marsh restoration or ODMDS.

4.2 UNCERTAINTIES ASSOCIATED WITH ECOLOGICAL MODELING FOR THE SNWW CIP

An analysis of risk and uncertainty associated with the WVA model application to the SNWW CIP has been performed in consideration of recommendations contained in the Actions for Change directive (USACE, 2006d). This analysis will facilitate risk-informed decision-making regarding the levels of ecological impacts and resulting recommended compensatory mitigation that were established using the models. The primary risks associated with ecological modeling for the SNWW CIP relate to the accuracy of the impact assessment and the cost of mitigation. Risks to human health or safety associated with ecological impacts are small. Incremental marsh loss attributable to the Preferred Alternative (approximately 691 acres or about 2/5th of 1 percent of emergent marsh in the study area) would not affect the overall effectiveness of the coastal wetlands in buffering inland areas from storm surge effects.

An evaluation of the risks and uncertainties involved in application of the ecological model, on which the amount of proposed compensatory mitigation is based, is necessary to evaluate the adequacy of the recommended amount of ecological mitigation, and to support the recommended Federal investment. The reader is referred to Appendix C of this FEIS for the complete sensitivity analysis, including detailed methodology and analysis. A brief summary of the results of the analysis is presented below.

There are two types of uncertainty that have been identified for the predictive ecological modeling conducted in this study—uncertainty associated with model quality and performance, and uncertainty associated with model predictions. In regard to the first type of uncertainty, extensive technical review of the WVA models has been conducted to ensure that they are technically sound and defensible (LBG and TEA, 2008). The assessment determined that the concept and application of the models are sound for planning efforts. Theoretical approaches of the WVA models use scientifically established structural surrogates to evaluate wetland quality. The models' variables provide a reasonable description of the emergent marsh, swamp, and bottomland hardwood habitats, and are capable of evaluating project effects to habitat-based, functional processes that may be affected by the project. Based upon the results of this assessment, the Deep Draft Navigation Planning Center of Expertise, in consultation with the National Ecosystem Planning Center of Expertise, concurred with the findings of this assessment and approved the use of the WVA EMCM, BHM, and SCM for the SNWW feasibility study (Memorandum for Commander, HQ USACE [CECW-PC] and Commander, Southwest Division [CESWD-PDS] from the Director of Deep Draft Navigation Planning Center of Expertise [CESAD-PDS-P], dated June 30, 2009). This satisfies the requirements of EC 1105-2-407, as the WVA models were developed by a Federal agency other than the USACE, and are therefore subject to approval for use rather than certification.

Uncertainty associated with predictions of the WVA models (i.e., how different predictable outcomes could affect ecological impacts and costs) was evaluated by varying input values for the most significant variables. The WVA models do not include a direct way to measure risk, i.e., the model does not calculate a probability distribution that provides a statistically significant confidence level for the model projections. Since salinity is the driving force influencing WVA model predictions, salinity-related variables were targeted in one sensitivity analysis. The other analysis focused on an assumption underlying the valuation of the percent of emergent marsh cover. A range of possible outcomes associated with variable V_1 (percent of emergent marsh) in the EMCM, and variables V_4 and V_5 (salinity) in the SCM and EMCM, respectively, were evaluated to determine how uncertainties related to variable assumptions and values could affect impact predictions and compensatory mitigation decisions. Since the analysis was conducted to evaluate uncertainties with the recommended level of compensatory mitigation, the analysis was performed for the Louisiana hydro-units in which unavoidable impacts would occur.

4.2.1 Salinity Sensitivity

Because of uncertainties associated with HS model predictions of salinity impacts, a sensitivity analysis was performed to evaluate the full range of potential project effects. Salinity changes predicted with implementation of the Preferred Alternative were provided by the HS model. High- and low-salinity values bracketing the 95 percent confidence level were entered into WVA model for all habitats in Louisiana hydro-units. Ranges of AAHU impacts were then produced based on the 95 percent salinity range.

For cypress-tupelo swamps, the sensitivity analysis yielded a range of potential loss from 0 to 9 AAHUs, with no impact predicted to be most likely. The uppermost reaches of the Sabine River would remain essentially fresh; however, the Blue Elbow swamp near the GIWW could experience suboptimal salinities at the high end of the salinity range. Even at the maximum salinity, levels would not be suboptimal to the extent that sustainability of the swamp forest would be threatened. No impacts would be expected in the bottomland hardwood habitats at the maximum range of salinity predicted by the sensitivity analysis.

The largest range of potential impacts could occur within the intermediate marsh communities located east of Sabine Lake. AAHU losses for the intermediate marshes could range from 312 to 2,407 AAHUs, as compared to the FWP’s most likely loss of 1,571 AAHUs. The highest potential salinities are suboptimal for most of the intermediate marshes east of Sabine Lake, and some exceed the maximum tolerance range. At the highest potential salinities, intermediate marshes in Willow Bayou, West Johnson’s Bayou, and Sabine Lake Ridges would likely convert to brackish marsh about 20 years after project construction.

Impacts at the highest potential salinities would not threaten the sustainability of any of the other marsh communities over the period of analysis. Salinities remain within or close to the optimal range. For fresh marsh communities, AAHU losses could range from 8 to 477, as compared to the most likely loss of 78 AAHUs. For saline and brackish marshes combined, AAHU losses could range from 20 to 253, as compared to the FWP’s most likely loss of 60 AAHUs.

The salinity sensitivity analysis of the WVA models demonstrated that there is a wide range of potential outcomes in AAHU losses attributable to uncertainties in salinity predictions. These outcomes range from a loss of 340 to 3,146 AAHUs within the 95 percent confidence range of salinity, the primary driver in the EMCM and SCM. After adjustments for the Gulf Shore BU Feature benefits (210 AAHUs) and the BU offset of impacts to Federal lands (340 AAHUs), losses could range from zero to 2,596 AAHUs. Based on the cost per AAHU of the recommended mitigation plan ($77.5 million; 1,181 AAHUs), the cost of compensatory mitigation could range from $0 to about $170 million. The total predicted FWP loss of 1,499 AAHUs in Louisiana is based upon forecasts of the most likely salinity levels, and takes into account the potential FWOP effects of RSLR and changes in future freshwater inflows.

4.2.2 Percent Emergent Marsh Sensitivity Analysis

Ninety-nine percent of Louisiana impacts predicted by the ecological model were made using the EMCM. The most highly weighted variable in this model is V_1 (percent emergent marsh). This parameter is considered most significant because persistent emergent vegetation provides foraging, resting, and breeding habitat for a variety of coastal fish and wildlife species. Detritus from coastal marshes also provides a source of mineral and organic nourishment for organisms at the base of the food chain. Without the structure provided by the emergent marsh, the majority of the ecological benefits provided by this system disappears. Changes in the value of this parameter were predicted by relating changes in salinity to changes in marsh loss using a process that is described in Section 4.10. This sensitivity analysis explores the effects of an assumption that underlies the valuation of emergent marsh in this variable. The SNWW application of this model uses the same assumptions adopted by the EnvWG in its application of the model to CWPPRA restoration projects (USFWS, 2002b). In this model, optimal vegetative coverage is assumed to be 100 percent (SI = 1.0) for all marsh types. This assumption diverges from the general biological understanding that optimal cover falls in the 60 to 80 percent range, but it was adopted by the EnvWG to reflect CWPPRA's objective of long-term marsh creation and restoration. Questions have arisen as to whether maximizing the value of marsh coverage is appropriate for the SNWW application in which the primary purpose is the identification of project impacts and compensatory mitigation.

Selection of 100 percent marsh cover as the optimal habitat condition (V_1-Original) for the SNWW application was based upon several factors. Maximizing the value of emergent marsh over associated shallow-water habitat is based upon the important ecological concept of long-term sustainability. With the SNWW project, marshes would continue to degrade over the 65-year period of analysis due to the effects of RSLR. Without the associated marshes, the small open-water areas would lose their value as nursery habitat, becoming open-bay or open-Gulf habitat. Restoration or mitigation projects generally need to maximize the creation of emergent marsh, so as to ensure the sustainability of the land itself.

To evaluate the effect of this assumption on the SNWW application, the EMCM was rerun for all of the Louisiana marsh communities using a revised formula for the variable in which optimal vegetative coverage (SI = 1.0) is assumed for a marsh coverage of 60 to 80 percent (V_1-Revised). Overall, impacts using V_1-Revised dropped by 3 percent. As would be expected, the smallest percentage changes occurred in marshes where the percent emergent marsh remained between 60 and 80 percent for both the FWOP and FWP conditions. If the V_1-Revised formula were used to calculate the mitigation target for the recommended mitigation plan, the net loss would be 244 AAHUs. If V_1-Revised were used to compute compensatory mitigation as it is currently designed, mitigation costs would increase by at least 42 percent to meet the V_1-Revised mitigation target.

If the same mitigation measures were redesigned so that marsh fill would never exceed 80 percent, the amount of restored acres would drop from 2,696 to 2,215 acres. However, compensation as measured with the V_1-Revised formula would increase and the net loss would be 167 AAHUs. Based upon the cost of the recommended mitigation plan, it is estimated that the total mitigation cost would be about 3 percent greater than the recommended mitigation plan. More significantly, the modified plan would restore about

18 percent fewer acres and do less to ensure the long-term sustainability of the marsh than the recommended mitigation plan.

4.2.3 Recommendations Resulting from WVA Model Sensitivity Analysis

The recommended compensatory mitigation plan is based upon the most likely range of salinity change as established by the HS model, scientifically based projections of changes in habitat resulting from the predicted salinity change, and the professional judgment and knowledge of the area by the large team of natural resource and engineering professionals who applied the WVA model to the SNWW CIP. The ICT HW contained professionals with expertise in wetland impact evaluation, marsh restoration, wetland forest management, aquatic habitat evaluation, freshwater and marine fisheries, terrestrial and avian wildlife biology, as well as natural resource management personnel from all of the protected lands in the study area.

In addition, the recommended mitigation plan maximizes the value of emergent marsh when measuring impacts and determining compensatory mitigation for project-related losses to this nationally significant, endangered resource. Without the structure provided by the emergent marsh, the majority of the ecological benefits provided by these systems disappear. For these reasons, no changes to the recommended mitigation plan are proposed as a result of this sensitivity analysis. It is recommended that Best Buy Plan #6 mitigation plan (described in Chapter 5) be selected as it incorporates the level of compensation needed to address the most likely impacts of the SNWW CIP.

4.3 PHYSIOGRAPHY AND GEOLOGY

4.3.1 No-Action Alternative

The No-Action Alternative would not impact physiography or geology within the study area. Alterations to bathymetry from maintenance dredging of existing ship channels, in addition to topographic changes from the placement of dredged materials at PAs, would continue under the No-Action scenario.

4.3.2 Preferred Alternative

The total estimated amount of dredged material generated from the proposed project would be approximately 98 mcy of new work material and approximately 650 mcy of maintenance material over 50 years after the project is constructed. This material would be placed in BU features, PAs, and ODMDSs, as described in Section 2.5.

Impacts on local geology during dredging associated with the Preferred Alternative would include redistribution of existing sediment, local increases in turbidity, and potential changes in local scouring and shoaling rates. Net impacts on local geology would be minimal from these operations. Additionally, no impacts or modifications to geologic hazards such as faulting and subsidence are expected.

Two PAs would be created. The area where PA 24A would be created is currently a wetland habitat with a central upland ridge, which is set back from the shoreline of a Neches River oxbow and does not block overland flow to bottomland hardwoods along the shore. A critical section of marshhay cordgrass wetland was excluded from the proposed PA, and the boundaries were drawn to exclude bottomland hardwoods that line the Neches River oxbow west of the PA. The area where PA 18A would be created is already an upland area so there should be no topographic impact. Further information pertaining to specific PA descriptions and quantities of new work and maintenance material involved are presented in Section 2.4.

Three miles of shoreline located at Texas and Louisiana Points would be affected by the proposed Gulf Shore BU Feature (see Figure 2.5-2). Over the 50-year period of analysis, 16 placement episodes are expected, occurring in 3-year cycles, alternating between Texas and Louisiana. The Gulf Shore BU Feature would provide a regular source of predominantly fine-grained sediment that should contribute to mudflat accretion and periodically move onshore to become shore-attached through a process described by PIE (2003). On the western Louisiana and east Texas coasts, sediments accumulate as mudflats and underwater mudshoals (or "fluid mud") in the nearshore region. Nearshore, fluid mud can be trapped against the shoreline by prevailing south and southwesterly winds, and storms carry the trapped muddy ooze onto the chenier shoreline. The presence of additional fine-grained sediments in the littoral system that would be provided by the BU feature should reduce the current erosion rate, and minimize the small increase in shore erosion predicted with the project (Gravens and King, 2003). In systems that have an abundant supply of fine-grained sediments, the nearshore seabed can be blanketed with fluid mud. The presence of additional muddy sediment in the nearshore environment may attenuate waves and lessen wave-induced erosion (Hsiao and Shemdin, 1980; Tubman and Suhayda, 1976; Wells and Kemp, 1986). Although the BU sediments would be largely fine grained, approximately 18 percent of maintenance material is expected to be sand. Sands that are deposited on shore would nourish and stabilize eroding marshes; sand deposited in the nearshore zone should stay in the nearshore environment, moving back and forth across the shoreface (Wamsley, 2008). More details on the expected behavior of the material can be found in subsection 2.5.3.2.

Three degraded marsh areas along the Neches River would be combined into the Neches River BU Feature. This large BU feature would use new work material and future maintenance material to benefit a total of 4,958 acres of degraded marsh on the lower Neches River by restoring 2,853 acres of emergent marsh; improving 871 acres of shallow water by creating shallower ponds and interconnecting channels; and nourishing 1,234 acres of existing fringing marsh by winnowing fine-grained material from unconfined flows of dredged material effluent. It would fulfill 53 percent of the restoration target set by the CEPRA 2004 plan update for the lower Neches River (GLO, 2004). Further information pertaining to this BU feature can be found in subsection 2.5.3.2.

Construction of mitigation measures in Louisiana would use sediment obtained from nearby waterbodies to restore marsh. The Willow Bayou Mitigation Measure would use sediment obtained from dredging the bottom of Sabine Lake to restore soils and marsh elevation to open-water areas in the marsh east of Sabine Lake. A 1.8-mile-long borrow trench in Sabine Lake would be dredged about 1,000 feet from the Sabine NWR shore and would average 1,030 feet wide by 7.5 feet deep. The borrow trench would be continuous and parallel the current shoreline; the common longshore circulation pattern in Sabine Lake is expected to eventually fill the trench with Sabine River sediments. An access channel from the GIWW near the mouth of the Sabine River would be needed for the dredge to reach the proposed borrow trench area. The exact locations of the borrow trench and access channel would be determined in consultation with the ICT after PED bottom surveys of potential locations. Black Bayou Mitigation Measures LA 3-15B and LA 3-18B would hydraulically dredge accumulated material from the 30-foot-deep Lake Charles Deepwater Channel (co-located with GIWW in Louisiana) and use it to restore marsh in open-water areas south of the GIWW. While changes would occur to local bathymetry and topography during construction of the proposed project, these alterations would be expected to have negligible impacts on the regional physiography of the submerged and subaerial portions of the study area. No impacts associated with geologic hazards are expected, and impacts on local geology are expected to be minimal.

4.4 WATER QUALITY

4.4.1 No-Action Alternative

Under the No-Action Alternative, there would be no construction dredging; therefore, there would be no new work material for placement. While no turbidity or possibility for the release of undesired chemicals would occur, there would also be no opportunity for the creation of marshes using dredged material beneficially.

Under the No-Action Alternative, water quality would be as it is presently, as described in Section 3.3, with a gradual increase in salinity from RSLR in the future without the proposed project. There would be short-term increases in turbidity and the possibility of release of undesired chemicals during maintenance dredging, as there is now. All maintenance material is currently placed into PAs or ODMDSs.

4.4.2 Preferred Alternative

USACE has received §401 State Water Quality Certification from Texas and Louisiana for this action. A CWA §404(b)(1) evaluation of the proposed action, provided in Appendix E, describes the effects of the proposed discharges. All relevant sediment and water quality data for both new work and maintenance dredging material were reviewed by a team of State and Federal resource agencies (ICT CW), including the TCEQ and LDEQ, and they found no cause for concern over water or sediment quality in any channel reach. New work sediments were deemed suitable for use in constructing restoration or mitigation sites, BU features, placement in ODMDSs, and upland confined PAs. Maintenance material would be handled according to the DMMP. The DMMP measures, to the greatest degree possible, the use of dredged material as a beneficial resource. The Gulf Shore BU feature shares the material from Sabine Pass equally between the states. The new work and maintenance material used in the BU features of the Preferred Alternative would allow the restoration of approximately 4,958 acres of emergent marsh in Texas. It would also be used for beach nourishment on Texas and Louisiana Points.

The Preferred Alternative is the least environmentally damaging practicable alternative. As noted above, there should be little, if any, difference in inland turbidity or DO levels between the No-Action

Alternative and the Preferred Alternative. Best Management Practices would be employed during construction of restoration and mitigation areas. Significant detrimental environmental effects have not been noted in past construction and maintenance operations and are not expected with the Preferred Alternative since much of the construction and maintenance material would be used beneficially, and the rest would go into PAs or ODMDSs. Short-term increases in turbidity may be caused by the unconfined flow of dredged material during construction of BU features and mitigation measures. There would be temporary, minor impacts from ocean placement at the new proposed ODMDSs, as discussed in detail in Appendix B. Temporary water quality impacts may occur during borrow trench and access channel dredging in Sabine Lake and the Lake Charles Deepwater Channel for mitigation measures (see also sections 5.5.1, Willow Bayou Mitigation, and 5.5.2, Black Bayou Mitigation).

There is the possibility of contamination of the maintenance material by a spill or other event, as there is now, but deepening of the channel should reduce the probability of a spill by reducing the number of vessel trips. Additionally, the USACE routinely tests the elutriates prepared from maintenance material according to ITM and RIA protocols before dredging to ensure that there is no contamination. As noted in Section 3.3, past Tier I, Tier II, and Tier III evaluations of maintenance material elutriates with chemical analyses and water column bioassays have indicated no cause for concern.

4.5 SEDIMENT QUALITY

4.5.1 Surficial Sediments

4.5.1.1 No-Action Alternative

There would be no change in the quality of the surficial sediments of the project area unless there is an impact in the future without the proposed project.

4.5.1.2 Preferred Alternative

The quality of surficial sediments that would be dredged during construction of the Entrance Channel Extension is discussed in Appendix B. Extensive chemical analyses, bioassays, and bioaccumulation studies of this material were conducted in accordance with EPA Regulations and the *Ocean Testing Manual*. The data indicate that there are no causes for concern related to chemical contaminants and that these sediments are suitable for ocean placement. Similar testing was performed numerous times on maintenance material dredged from the 22-mile existing SNWW entrance channel, and these sediments were always found to be acceptable for ocean placement. The sediments to be dredged for the Extension Channel are located from 22 to 35 miles from shore, and thus are sufficiently far removed from known existing and historical sources of pollution on the inland portion of the SNWW to provide reasonable assurance that the material is not contaminated. The ICT CW (which included representatives from the EPA and USFWS) approved the use of the grab samples for SNWW bioassay and bioaccumulation samples, and agreed that the materials were suitable for ocean placement.

4.5.2 Maintenance Material

4.5.2.1 No-Action Alternative

The existing maintenance material was described in Section 3.4. The quantity and quality of this material would not be expected to change with the No-Action Alternative.

4.5.2.2 Preferred Alternative

The quantity of maintenance material is expected to increase by roughly 60 percent in the SNWW with the Preferred Alternative but the quality of this material would not be expected to change. While more maintenance material is expected to be dredged with the Preferred Alternative, the source and the method of placement would not change, except that much more of the maintenance material would be used beneficially. As noted above, project actions should decrease the probability of a spill. The USACE also routinely tests the maintenance material according to ITM and RIA protocols before dredging to ensure that the material is environmentally acceptable under all applicable regulations.

4.5.3 Summary

As summarized in subsection 3.4.2, recently tested sediment quality data presented in PBS&J (2004a) and from March 2008 and April 2009 indicates no cause for concern, related to the new construction dredging and dredged material placement. Although it was identified that one reach within the Neches River contained elevated levels of PAHs within the tested sediments, the elutriate tests for those sediment sampling stations did not reveal high concentrations of PAHs. Therefore, it can be concluded that PAHs are not expected to be released during dredging and/or placement, and it can be further concluded that there are no channel reaches within the SNWW that exhibit a chemistry cause for concern.

4.6 HYDROLOGY

4.6.1 No-Action Alternative

Under the No-Action Alternative that includes 1.1 feet of RSLR, there should be an increase from the present condition in the tidal circulation and water exchange with the Gulf, and a corresponding increase in sediment transport in the navigation channels. No significant change is expected in the direction or amount of longshore sediment transport. Longshore transport and wave modeling have been performed, and a sediment budget has been prepared for the study area in conjunction with a shoreline erosion study of the Texas coast from Sabine Pass through Galveston Island (King, 2007; Morang, 2006).

Shorelines will continue to retreat due to RSLR, and the rate can be expected to increase with an increase in the rate of RSLR. The highly erodible and weakly compacted soil on Pleasure Island and the east shore of Sabine Lake would likely continue to erode from tidal currents and wind waves. Vessel-generated waves and surges would continue to accelerate the process on Pleasure Island as in the past. Existing Gulf shoreline erosion of up to 40 to 50 feet/year on the Texas shoreline (King, 2007) and an erratic pattern of accretion and erosion on the Louisiana shoreline (USACE, 2004a) would also continue, with the potential for significant increases due to climate change and sea level rise (IPCC, 2007).

The FWOP does include expected changes in water demands and supply strategies that are part of the 2007 Texas State Water Plan (TWDB, 2007) and permitted flows from upstream reservoirs. Existing Sabine River flows that are dedicated to the State of Louisiana by the Sabine River Compact are also taken into consideration.

4.6.2 Preferred Alternative

4.6.2.1 Circulation, Exchange, Inflows, Velocities

Under the Preferred Alternative, the same RSLR and inflow changes assumed in the FWOP will apply, and there would be a deeper navigation channel that will allow a greater amount of tidal circulation and exchange with the Gulf than is currently the case. The deepening project would cause only a minimal increase of water surface elevation over the study area; the average increase would be 0.8 inch (Brown and Stokes, 2009). The channel deepening results generally in increases in velocity along the entire channel; however, magnitudes are quite small, less than 0.5 foot per second in most cases (Parchure et al., 2005). The largest changes are observed in the Sabine-Neches Canal, but the absolute magnitudes are still small.

The potential for proposed project features to increase storm surge impacts in the study area was analyzed with a storm surge sensitivity analysis (Wamsley et al., 2010). The ADCIRC model was run to estimate water levels for two worst-case hypothetical storms, both with and without proposed SNWW CIP project features in place. Project features evaluated by the modeling are the deeper navigation channel, proposed PAs with maximum levee heights, and two expanded PAs. The sensitivity analysis concluded that the greatest changes would occur north of Port Arthur along the Neches River. These changes are primarily due to the proposed increase in depth of the navigation channel. All changes are local and there are no project-induced increases in surges away from the immediate vicinity of the navigation channel. Water levels in the marshes and open-water areas immediately north of the river would increase on the order of 4 to 8 inches or less. The modeling indicates some interior flooding would occur within the City of Port Arthur both with and without the project. Changes in peak surge on the order of inches should not cause any significant change in interior flooding for the with-project condition.

The Preferred Alternative for the SNWW CIP also includes ODMDS and marsh restoration measures. All of the existing and proposed ODMDSs are located several miles from the Gulf shoreline in water too deep to affect wave setup on the shoreline. The influences of marsh restoration on hurricane surge have been documented by Wamsley et al. (2009a, 2009b). Surges tend to slightly increase over and just seaward of the marsh as the surge propagation is slowed, which may result in reductions in peak water levels landward of marsh features. The impact of the proposed SNWW CIP marsh restoration features are relatively small and expected to modify peak surge levels locally by a minimal amount (Wamsley et al., 2010). No significant reductions or increases in surge level would be expected from either the marsh restoration or ODMDS.

The Preferred Alternative would not have an effect on freshwater inflows to the system. However, by increasing slightly the amount of tidal exchange, the inflows would be conveyed to the Gulf marginally faster than would be the case in the No-Action Alternative.

4.6.2.2 Sediment Transport

There are two main types of sediment transport in the system—sediment carried into the channels by heavy rains in the watershed and conveyed through the navigation channels, and sediment transport along the coast. Both are addressed here.

The low velocities near the bottom of the navigation channel offer conditions favorable for sediment deposition. The amount of sediment-laden runoff would be unchanged between the FWOP and FWP (Parchure et al., 2005). The slightly larger cross sections and lower current velocities would offer slightly better conditions for sediment to settle. This is one reason why the Preferred Alternative would require more maintenance dredging than the No-Action Alternative. Another reason is that the deeper channel will have a larger volume below the existing seabed, making it function as a larger sediment trap. Furthermore, the increased length of the channel results in higher dredging quantities for the offshore channel extension. Changes in salinity that also affect shoaling quantities are discussed in a later section.

The effect on Gulf shoreline change was investigated by Gravens and King (2003). Their shoreline impact study addressed the effects of changes in the wave climate produced by the deeper offshore channel and the changes in longshore sediment transport that would be expected from the altered wave climate. Under the Preferred Alternative, a deeper and longer entrance channel would have some effect on waves moving from the Gulf to the shore, and that would in turn exert an effect on the rate of longshore sediment transport.

The Gravens and King (2003) study also addressed a 45-foot alternative and noted that the effect of the Preferred Alternative (48-foot channel) would be intermediate and somewhat less than the 50-foot alternative. The direction of sediment transport is to the west on the Texas side of the channel and to the east on the Louisiana side, with little difference between existing conditions and the 50-foot channel. The effect of channel deepening is to reduce the westward transport on the Texas side and increase the eastern transport on the Louisiana side. The effect of channel deepening is to slightly reduce the net westward transport on the Texas side and the net eastern transport on the Louisiana side.

The Gulf Shore BU Feature proposes to restore 0.86 mcy of sediment to the littoral environment every 3 years using maintenance material from dredging the Sabine Pass Channel. Material placement during each 3-year dredging cycle would alternate between Texas and Louisiana, so that material would be placed on each state’s shoreline every 6 years. Some material is expected to flow into the existing marsh while the remainder would flow into nearshore waters. This recurring action would nourish eroding marsh, restore sediment to the littoral zone, minimize projected FWP shoreline impacts, and potentially create new marsh. The BU dredged material is expected to be composed largely of unconsolidated muds. The fine-grained sediments are expected to initially be highly mobile, and some portion of the material would be rapidly lost from the vicinity of the shoreline. Because of the prevailing wave climate, the mobile material within the surf zone should generally migrate to the west at both Texas and Louisiana Points (Wamsley, 2008). Transport processes identified by the Sabine Pass sediment budget (Morang, 2006) indicate that the material west of Sabine Pass would move toward the eroding shoreline at Texas Point. There, the additional fine-grained sediments could lower erosion rates through mudflat accretion and wave attenuation. A small quantity of material may migrate to the east and contribute to the Sabine Fillet at the west jetty (King, 2007; Morang, 2006). In Louisiana, the sand bar formed by BU sediments from the Cheniere LNG project may shelter the shoreline from wave energy sufficiently to allow fine-grained sediments to form a mudflat behind the sandbar (Nairn and Willis, 2002; PBS&J, 2004b). While a significant percentage of the sediment would be rapidly carried offshore, some is likely to move downcoast with the littoral current, enlarging the sand and mudflat already present at the east jetty.

4.6.2.3 Coastal Shoreline Erosion Impacts

The changes in sediment transport, while very small, can be expected to have some effect on the rates of shoreline erosion. Under the Preferred Alternative, there is a slight reduction in the erosion rate near the jetties. Near the jetties, the average rate of shoreline accretion was calculated to be as much as 60 feet/year. However, between 0.5 mile and 3 to 4 miles on either side of the jetties the erosion would be increased by less than 0.5 foot/year for a 50-foot project, and farther from the jetties than that, the change in the shoreline change would decrease to zero. The effect of the 48-foot channel on the Gulf shoreline between 0.5 mile and 3.5 miles from each jetty was estimated to be 0.42 foot/year based upon the 45- and 50-foot project effects.

The Gulf Shore BU Feature should have a positive effect on reducing shoreline erosion. The presence of additional fine-grained sediments in the littoral system, which would be provided by the BU feature, should reduce the current erosion rate and minimize the small increase in shore erosion predicted with the project. In systems that have an abundant supply of fine-grained sediments, the presence of additional muddy sediment in the nearshore environment may attenuate waves and lessen wave-induced erosion (Hsiao and Shemdin, 1980; Tubman and Suhayda, 1976; Wells and Kemp, 1986). Furthermore, the predominantly fine-grained sediment provided by this BU feature should contribute to mudflat accretion by periodically moving onshore and becoming shore-attached. On the western Louisiana and east Texas coasts, sediments accumulate as mudflats and underwater mudshoals (or “fluid mud”) in the nearshore region. Nearshore, fluid mud can be trapped against the shoreline by prevailing south and southwesterly winds, and storms carry the trapped muddy ooze onto the chenier shoreline (Morgan et al., 1958; Wells and Kemp, 1982, 1986). Accretion of the shoreline can then occur by poorly understood processes (Huh et al., 1991; King, 2007; PIE, 2003).

Although the BU sediments would be largely fine grained, approximately 18 percent of maintenance material is expected to be sand. Sands that are deposited onshore would nourish and stabilize eroding marshes, and sand deposited in the nearshore zone should stay in the nearshore environment, moving back and forth across the shoreface (Wamsley, 2008). Sand placed at Louisiana Point should remain on the shoreface where it was deposited; no significant amounts of sand are expected to enter the Jetty Channel. On erosive mud shorelines like those in the BU area, the sand percentage should increase and it would form sandy lenses or a veneer over the mud shoreline substrate. As the sand lenses thicken, the sands help protect the underlying mud from further erosion (Nairn, 1992). However, in smaller quantities, sand can also accelerate erosion of a mud beach. If the consolidated mud is not covered by a sand veneer, any sand that is mobilized by wave action would act as a scouring agent (King, 2007).

4.6.2.4 Inland Shoreline Erosion Impacts

The primary area of concern for inland shoreline impacts is Pleasure Island along the confined channels of the Port Arthur and Sabine-Neches canals (Parchure et al., 2005). No increase in the existing erosion rate is predicted with the project for the eastern shore of Sabine Lake. The primary mechanism for shoreline erosion associated with the project is from passage of large vessels. Maynord (2003) investigated the mechanisms of ship-induced bank recession (shoreline erosion). The analysis employed a numerical model (HIVEL2D) to simulate the ship-induced velocity at the bank and employed information on the vessels in the existing and future fleets and information on the speeds that would be needed in both the No-Action and Preferred alternatives. The analysis focused on two sites on Pleasure Island; the north site is in the Sabine-Neches Canal, and the south site is in the Port Arthur Canal. The north site has no existing erosion protection, while the south site has riprap protection. Neither site will have a change in channel width. The analysis was calibrated to the existing rates of bank recession, and it used the model to account for differing numbers of vessel trips projected for the years 2030 and 2060 for both the No-Action and 50-foot alternatives. The Preferred Alternative is expected to have a lesser effect than the 50-foot alternative.

Maynord (2005) found that the rates of erosion are lower for the 50-foot alternative than for the No-Action Alternative at both the north and south sites for both 2030 and 2060 traffic levels. Overall, the effect of the Preferred Alternative should be to reduce the rate of erosion on inland channels relative to the No-Action Alternative because of fewer vessel trips that are predicted with the Preferred Alternative than in the No-Action Alternative.

4.6.3 Salinity

4.6.3.1 No-Action Alternative

Under the No-Action Alternative, the modeled RSLR of 1.1 feet is expected to increase salinity levels from the present condition. RSLR is expected to increase salinities up to 2 ppt in portions of the project area in the FWOP area. The complicated circulation and salinity patterns of the SNWW system would change substantially. Freshwater enters the system via several tributaries, including the Sabine River, the Neches River, and other smaller inflows. The Neches River flows directly into Sabine Lake and the Sabine-Neches Canal. The Sabine River flows into Sabine Lake, the Sabine NWR, and into Calcasieu Lake via the GIWW. During times of low flow, the direction of flow in the GIWW is reversed and higher salinity Calcasieu waters flow westward into the Sabine basin (Gammill et al., 2002).

The Sabine-Neches Canal connects the Neches River Channel to Sabine Pass, flowing through a narrow, confined channel between Pleasure Island on the east and Port Arthur on the west. This canal conducts both fresh water from the rivers and Gulf waters intruding via tidal propagation through Sabine Pass. As a result, substantial salinity stratification forms in the Sabine-Neches Canal. Stratification contributes to salt water intruding up the Sabine-Neches Canal, into the northwest corner of Sabine Lake, and the lower reaches of the Neches River Channel. Consequently, observed salinity in Sabine Lake is highest at both the southern end (where it connects to Sabine Pass) and at the northern end (where it connects to the Sabine-Neches Canal). Lowest salinities are observed in the central and eastern portions of Sabine Lake, farthest from the hydraulic connection to sources of saline water.

Wide swings in salinity associated with shifts from periods of drought to high freshwater inflows would continue. Hydrologic conditions in some wetlands in the study area are managed with passive water control structures (rock weirs, flap-gate culverts, rock plugs, and rock dikes). FWOP conditions were developed using field salinity data collected with these structures in place. It is assumed these would continue to operate as they do today. A summary of water controls is below and they are described more fully in Section 3.5.

- In Louisiana, one large, rain-fed, freshwater impoundment (Pool 3) is located in the center of the SNWR, at the eastern edge of the SNWW study area (Gammill et al., 2002). A containment levee was constructed in 1951 around a large area of unbroken marsh. It is managed to hold fresh water at high levels, increasing the water-to-marsh ratio for wintering waterfowl habitat. Pool 3 was not included in the study area because it is hydrologically isolated from the surrounding wetlands. Two CWPPRA hydrologic restoration projects in the Black Bayou and Willow Bayou marshes east of Sabine Lake have been constructed (USFWS-LDNR, 2008a, 2008b). FWOP conditions in the Willow Bayou hydro-unit assume that all elements of Construction Unit 1 of the Willow Bayou Hydrologic Restoration Project are in place. The FWOP condition reflects a small reduction in the land loss rate due to the effects of the breakwater and in-situ terracing. Likewise, FWOP conditions in the Black Bayou hydro-unit include the projected effects of the Black Bayou Hydrologic Restoration Project. In WVA computations, land loss throughout the unit was reduced by two-thirds for the 20-year CWPPRA project life to reflect erosion protection and flow reductions with the GIWW shoreline protection. In addition, FWOP salinity in the intermediate marshes was expected to increase to 4.2 to 5.1 ppt, the salinity level projected to result from the Black Bayou hydrologic management measures (rock dike, rock weirs, and self-regulating tide gate).
- In Texas, saltwater barriers restrict saltwater intrusion from the GIWW into Taylor Bayou to the north and into the J.D. Murphree WMA to the south. Low rock weirs restrict flow on some smaller channels in the Texas Point NWR. FWOP conditions for the GIWW North, Salt Bayou, and Texas Point hydro-units were developed using field salinity data collected with these structures in place. Restrictions to the access of marine organisms caused by these structures were reflected in the EMCM variable (V_6) for aquatic organism access.

Mean salinities used in the FWOP condition of the WVA model are presented in tables 4.6-1 (Mean Salinity at Median Inflow) and 4.6-2 (Mean High Salinity at Median Inflow). The tables show salinities modeled at field sampling stations, and include a range of salinities calculated for the 95 percent confidence level. In general, empirical salinity data were used, when available, for the FWOP salinity parameter in the WVA model. HS model output was used when empirical data were not available. For marshes inland and far from model nodes, the salinity gradient was estimated based upon empirical data from adjacent hydro-units, and local resource managers' knowledge of the magnitude of water exchange with the larger channels and waterbodies.

Table 4.6-1
FWOP and FWP Mean Salinities and 95 Percent Confidence Range

Mean Salinity (ppt)/Median Flow					
				FWP Mean Salinity 95% Confidence Range	
Station Number	Data Collection Station	FWOP Mean Salinity	FWP 48-Foot Project Mean Salinity	Salinity (–2 SD)	Salinity (+2 SD)
1	Upper Neches River	0.0	0.0	0.0	0.0
2	Beaumont Turning Basin	0.1	0.2	0.0	0.7
3	Mouth of Neches River	3.4	4.2	2.9	5.5
5	Sabine River at Orange	0.4	0.6	0.0	1.5
6	Sabine-Neches Canal	12.8	14.4	12.0	16.8
7	Mouth of Sabine Pass	22.7	22.9	20.8	24.9
9	Mouth of Sabine River	5.3	6.6	5.2	8.1
10	South Sabine Lake	10.4	11.6	9.8	13.4
11	Black Bayou	4.1	5.2	3.7	6.6
14	Mouth of Johnson's Bayou	5.1	6.7	5.5	7.9
15	Keith Lake Fish Pass	14.6	16.0	14.8	17.2
16	Mouth of Willow Bayou	4.3	5.7	4.5	6.9
17	GIWW West at Taylor Bayou	13.0	14.6	13.0	16.3

Table 4.6-2
FWOP and FWP Mean High Salinities and 95 Percent Confidence Range

Mean High 33 Percent Continuous Salinity (ppt)/Median Flow					
				95% Confidence Range	
Station Number	Data Collection Station	FWOP Mean High Salinity	FWP Mean High Salinity	Salinity (–2 SD)	Salinity (+2 SD)
1	Upper Neches River	0.0	0.0	0.0	0.1
2	Beaumont Turning Basin	0.2	0.6	0.4	0.9
3	Mouth of Neches River	8.0	9.4	8.6	10.3
5	Sabine River at Orange	1.1	1.7	0.5	2.9
6	Sabine-Neches Canal	20.5	21.3	19.6	22.9
7	Mouth of Sabine Pass	27.6	27.6	26.4	28.7
9	Mouth of Sabine River	11.8	13.7	12.6	14.8
10	South Sabine Lake	17.5	18.7	16.3	21.1
11	Black Bayou	9.5	11.2	9.7	12.7
14	Mouth of Johnson's Bayou	10.5	12.7	11.9	13.5
15	Keith Lake Fish Pass	21.2	22.1	20.9	23.4
16	Mouth of Willow Bayou	8.7	10.6	8.3	13.0
17	GIWW West at Taylor Bayou	20.2	21.0	20.1	21.9

Although expected to occur only infrequently, when low flows, considered drought flows for the purpose of this analysis, occur during late summer and fall of some years, the HS model predicts substantially higher salinities (Table 4.6-3 Mean Salinity at Low Inflow). The HS model defines drought conditions as the 10th percentile of the WAM Run 8 2060 flows. At the upper reaches of the Neches River, the relative salinity increase as a result of low inflow is relatively small, only 0.1 ppt under the FWOP condition. Salinity in the Sabine River at Orange would increase from 3.8 ppt under the modeled existing condition to 4.9 ppt under the FWOP condition. The HS model predicts salinities throughout the remainder of the project area would range from 0.5 to 2.2 ppt higher during droughts under the FWOP condition than under existing conditions. Modeled FWOP salinity at Black Bayou during median flow is 4.1 ppt increasing to 15.6 ppt under drought conditions. Likewise, at the mouth of Willow Bayou, the predicted salinity increases from 4.3 ppt at median inflows to 14.6 ppt during drought under the FWOP condition. The HS model analysis (Brown and Stokes, 2009) reports that the largest salinity differences would occur in the Neches River near Bessie Heights and along the western shore of Sabine Lake. These analyses indicate that drought conditions cause substantial increases in salinity in the project area and that RSLR associated with the FWOP condition has relatively little additional affect on salinity during droughts.

Table 4.6-3
Mean Salinity Predicted by the Hydrodynamic-Salinity Model*

Mean Salinity (ppt)/Low Flow						
Station Numbers	Data Collection Station	Modeled Existing Condition	FWOP Mean Salinity	FWP 48-Foot Project Mean Salinity	FWP Mean Salinity Range	
					Salinity (–2 SD)	Salinity (+2 SD)
1	Upper Neches River	0.0	0.1	0.26	0.0	0.6
2	Beaumont Turning Basin	1.0	1.9	2.6	2.2	3.0
3	Mouth of Neches River	11.4	13.6	14.0	13.3	14.7
5	Sabine River at Orange	3.8	4.9	5.8	4.8	6.8
6	Sabine-Neches Canal	23.0	24.6	24.7	23.8	25.6
7	Mouth of Sabine Pass	28.9	29.4	29.1	28.4	29.7
9	Mouth of Sabine River	15.9	17.4	18.4	18.1	18.7
10	South Sabine Lake	21.7	23.3	23.2	22.1	24.3
11	Black Bayou	14.1	15.6	16.6	16.2	16.9
14	Mouth of Johnson's Bayou	15.0	16.9	17.9	17.6	18.2
15	Keith Lake Fish Pass	24.2	25.5	25.5	24.7	26.3
16	Mouth of Willow Bayou	12.7	14.6	15.6	15.2	16.0
17	GIWW West at Taylor Bayou	22.9	24.5	24.5	24.1	25.0

* Brown and Stokes (2009) – Under low-flow conditions (based on WAM Run 8 output for 2060 [TWDB, 2007]). All conditions assume intermediate RSLR of 1.1 feet.

4.6.3.2 Preferred Alternative

4.6.3.2.1 FWP Salinity Impacts

The Preferred Alternative would deepen the navigation channel and allow more tidal circulation and exchange with the Gulf than at present. Salinity would increase in much of the system, and the salinity wedge would extend farther upstream in the Neches River Channel. Increased salinity is expected to reduce health and biological productivity of a large area of intertidal marsh in Louisiana and Texas.

Salinity changes in the SNWW estuarine system were projected with the HS model described in sections 3.1 and 4.1 of this FEIS (Brown and Stokes, 2009). The HS model also determined that the average water surface elevation would be altered slightly by the channel deepening. The water surface is lower by less than an inch at Sabine Pass. The average water surface elevation is somewhat higher in the upper reaches of the Neches River, where the average elevation increase is about 0.8 inch. The change likely results from an increase in the landward extent of tidal propagation.

Two scenarios (low flow and median flow) were developed in the HS model to evaluate changes resulting from the project (see tables 4.6-1, 4.6-2, and 4.6-3). The HS modeling indicated that the highest average salinity increases for the Preferred Alternative over the FWOP condition are found in the following locations:

Low Flow:

- Neches River, near Rose City (approximately 0.7 ppt)
- Sabine River at Orange (approximately 0.9 ppt)
- Eastern shore of Sabine Lake (approximately 1.0 ppt)

Median Flow:

- Neches River near Bessie Heights (approximately 1.8 ppt)
- Keith Lake Fish Pass (approximately 1.4 ppt)
- Eastern Shore of Sabine Lake (approximately 1.4 to 1.6 ppt)

In addition to changes in salinity and stratification within the navigation channels and Sabine Lake, salinities in interior marshes were predicted with the HS model. The hydrologic effect of smaller channels in the marshes was included and salinity gradients were projected for wetland areas set back from the primary waterbodies. Modeling results indicated that salinity increases in the interior marshes, based upon average salinities, would be 1.0 ppt higher in the marshes east of Sabine Lake, and 0.1 to 1.8 ppt higher in the Neches River marshes. Salinities in the cypress-tupelo swamps in the upper Neches and Sabine River reaches were predicted to be about 0.3 ppt and 1.0 ppt higher, respectively. Salinity impacts are not expected to result from borrowing material from Sabine Lake and the Lake Charles Deepwater Channel/GIWW (for Willow and Black Bayou mitigation measures) because the borrow areas do not connect to the Sabine River Channel or the Calcasieu Ship Channel.

The potential for salinity impacts to be magnified in areas subjected to hydrologic management was considered by the ICT during application of the WVA model. In the Black Bayou hydro-unit, the new structures would not restrict flow sufficiently to impound water and exacerbate impacts of the 1.4 ppt increase in salinity within the intermediate marsh. Flow is considered to be essentially unrestricted because of the many remaining hydrologic access points. In Willow Bayou, water control structures proposed for Construction Unit 2 were eliminated when HS modeling determined that they would be ineffective. Control structures built in Construction Unit 1 would not restrict flow sufficiently to impound water. Like Black Bayou, flow is considered unrestricted because of the many remaining hydrologic access points. In Texas, saltwater barriers on Taylor Bayou and along the GIWW are actively managed and can be opened to accept flows from the GIWW when salinity levels inside the marshes are higher than the GIWW. Furthermore, flows in and out of the marshes affected by these barriers remain through smaller drainages and the larger Keith Lake Fish Pass and Texas Bayou.

An extensive literature review conducted for the Louisiana Coastal Areas Ecosystem Restoration Study (LCA Study) documented that increases in salinity negatively affect primary productivity of selected indicator species found in typical wetlands of the Louisiana coastal zone (Visser et al., 2004). These studies used measurements of productivity, including total biomass, stem/leaf elongation, and photosynthesis, gathered in greenhouse experiments on saturated soils. Linear regression equations were developed to predict percentage changes in habitat productivity per 1 ppt salinity increase for each major coastal vegetation community, regardless of inundation. For every 1 ppt increase in salinity, total primary productivity of swamps was reduced by 8.4 percent, fresh marsh by 11.1 percent, intermediate marsh by an average of 6.8 percent, brackish marsh by 2.6 percent, and saline marsh by 2.1 percent. These relationships were used to predict land loss rate changes in the current study. The method and results of that analysis are presented in Section 4.10. Habitats in the SNWW study area are dominated by the same marsh and swamp vegetation species found in the western Louisiana coastal zone. Supporting references for salinity-related productivity changes in vegetation include:

- **Swamp** – co-dominant species bald cypress and tupelo gum (Conner et al., 1997; Megonigal et al., 1997; Mitsch et al., 1991; Pezeshki et al., 1987a, 1990)
- **Fresh marsh** – co-dominant species maidencane and bulltongue (Greiner LaPeyre et al., 2001; Hester et al., 2001; Howard and Mendelssohn, 1999; McKee and Mendelssohn, 1989; Pezeshki et al., 1987b, 1987c; Spalding and Hester, 2007; Willis and Hester, 2004)
- **Intermediate marsh** – co-dominant species bulltongue and marshhay cordgrass (Baldwin and Mendelssohn, 1998; Greiner LaPeyre et al., 2001; Howard and Mendelssohn, 1999, 2000; Pezeshki et al., 1987b; Spalding and Hester, 2007; Webb and Mendelssohn, 1996)
- **Brackish marsh** – co-dominant species marshhay cordgrass and seashore saltgrass (Bertness et al., 1992; Broome et al., 1995; Ewing et al., 1995; Greiner LaPeyre et al., 2001; Hester et al., 2001; Kemp and Cunningham, 1981; Parrondo et al., 1978; Warren and Brockelman, 1989)
- **Saline marsh** – Smooth cordgrass and blackrush (Bradley and Morris, 1992; Eleuterius, 1989; Gosselink, 1970; Linthurst and Seneca, 1981; Parrondo et al., 1978; Pezeshki and DeLaune, 1995).

4.6.3.2.2 WVA Model Evaluation of Salinity Impacts

The impact of salinity changes on the estuarine habitats in the SNWW study area was assessed with the WVA model. Optimal salinity ranges assumed by the WVA model for the various habitat types are as follows:

- Swamp and Bottomland Hardwood (≤1 ppt)
- Fresh Marsh (≤2 ppt) (upper limit of 4 ppt during March–November growing season)
- Intermediate Marsh (≤4 ppt) (upper limit of 8 ppt during March–November growing season)
- Brackish Marsh (≤10 ppt) (upper limit of 16 ppt as an annual average)
- Saline Marsh (≥9 and ≤21 ppt) (upper limit in excess of 24 ppt as an annual average)

The optimal salinity ranges in the WVA model were based upon established salinity tolerances of common vegetation communities and salinity ranges associated with life history requirements of fish and wildlife species utilizing the habitats. Information from 32 HSI species models (USFWS, 1980) for estuarine fish and shellfish, reptiles and amphibians, birds and mammals was relied upon in establishing the optimal ranges (USFWS, 2002a).

The WVA model assumes that periods of high salinity are most detrimental in fresh/intermediate marsh and swamp when they occur during the growing season. This assumption is supported by a recent summary of annual primary productivity by season and habitat type that was developed for the habitat-switching module of the LCA Study (Visser et al., 2004). In swamps, 75 percent of annual primary productivity occurs from March 1 through June 30, and no primary production occurs from November 1 through February 28 (Keeland and Sharitz, 1995). The seasonal productivity of fresh marsh is longer, with approximately 38 percent of annual productivity occurring from March 1 through June 30, and 48 percent occurring from July 1 through October 31 (Sasser and Gosselink, 1984). Seasonal productivity of intermediate marsh is very similar to that of fresh marsh, with somewhat lower productivity in the July through October months (Hopkinson et al., 1978).

Median flow has been used to model the effects of FWP salinity changes for all vegetative communities. Run 8 of the TCEQ's WAM was used to represent the median-flow condition for salinity modeling. The TWDB (2007) projected flows for the year 2060 by modifying Run 8 "to include projected increased demand from existing water rights, expected change to return flows, projected new strategies to come online before 2060, and estimated year 2060 storage capacities for major reservoirs" (TWDB, 2007). These WAM Run 8 inflows were developed using current patterns of precipitation and evaporation. The median-flow condition was modeled for the period from approximately April through September.

Model output included mean salinities used to model impacts to brackish and saline wetlands during their growth season. These marshes are most influenced by long-term, prevailing salinity conditions. The productivity of brackish marsh is relatively stable throughout the year, with only slightly lower productivity from November 1 through February 28 (Hopkinson et al., 1978). Nearly half of the annual productivity of saline marsh occurs from July 1 through October 31, 29 percent in late spring and summer, and 24 percent in late fall and winter.

The median flow was also used to evaluate possible effects on fresh and intermediate marshes and forested wetlands. However, because these systems are more sensitive than brackish and saline wetlands to relatively small seasonal salinity changes, mean high salinity is used as the salinity parameter for the WVA models. Mean high salinity is the roaming mean of the highest 33 percent of consecutive daily salinity values during the growing season calculated for a specific period of record. This statistic is applied to model effects of high salinity during the growing season, when episodes of sufficient duration would reduce productivity of these freshwater habitats (Hester et al., 1996, 2001; McKee and Mendelssohn, 1989).

In the EMCM, effects of salinity changes are reflected most directly by two variables: V_1 (percent emergent marsh) and V_5 (salinity); however, changes in salinity can also result in changes to variables V_2 (percent SAV coverage), V_3 (marsh edge and interspersion); and V_4 (percent shallow water). The model assumes even small changes beyond the optimal salinity range of a marsh result in a small change to the land loss rate. This effect is captured in V_1 and described in relation to vegetation impacts in Section 4.10. Variable V_5 focuses on the effects of salinity on vegetation; changes within the optimal salinity ranges of each regime are not considered an impact and do not change the SI score of "1.0." However, even small salinity increases outside of the optimal range reduce the SI below “1.0.” This impact is based upon the assumption that small changes in salinity beyond the optimal range (suboptimal) for a specific hydrologic regime and its habitats affects the primary productivity of marsh grasses and forested wetlands.

FWOP and FWP salinities are presented for each hydro-unit in Texas and Louisiana in tables 4.6-4 and 4.6-5, respectively. Tables 4.6-6 and 4.6-7 present an acreage analysis by state and habitat type that identifies areas where FWOP and FWP salinities, respectively, are predicted to remain within, or extend into the suboptimal salinity range.

4.6.3.2.3 Salinity Impacts by Vegetation Community

Bottomland Hardwoods

Bottomland hardwoods in the study area are located on elevated ridges and natural river levees, as well as on upland terrace margins, most often separated from the navigation channels by fringing marsh or swamp. The study area contains 3,206 acres of bottomland hardwoods in Louisiana, and 5,458 acres in Texas. In the FWOP condition, this habitat is projected to remain within the optimal salinity range. The upper reach of the Sabine River is generally fresh, with salinity intruding only during times of drought and low freshwater inflow, or with tidal surges during hurricanes. Prevailing conditions are reflected in the median-flow scenario of the HS model, in which a FWOP salinity of 0 ppt is predicted in the Sabine River just south of IH 10. During FWP conditions, salinities would rise near the GIWW from a FWOP salinity of 2.5 ppt to a FWP salinity of 4.1 ppt. Upstream at the confluence of the Sabine and Old rivers, salinity is predicted to rise about 0.1 ppt under both the FWOP and FWP conditions.

The Sabine River watershed also contains bottomland hardwood communities located on the Texas side of the river in the Sabine Island (524 acres), Blue Elbow (189 acres), Cow Bayou (388 acres), and Adams Bayou (640 acres) hydro-units. FWOP and FWP salinity conditions for the Texas portions of Sabine Island and Blue Elbow are identical to those in Louisiana. Cow and Adams bayous enter the Sabine River south of the GIWW and receive runoff from developed areas south and west of the city of Orange. They have been rectified and deepened to provide shallow-draft access for oil field development vessels. The HS model projects FWOP mean salinity of about 0 ppt in Cow Bayou and 3.1 ppt in Adams Bayou. FWP salinities are predicted to range from about 1.0 ppt in Cow Bayou to 3.9 ppt in Adams Bayou. Although modeled salinities predicted under both the FWOP and FWP conditions are above the optimal range (≤1.0 ppt), in Adams Bayou the bottomland hardwoods are located on higher ridges or terrace margins, and are buffered from bayou salinities by intervening swamp and marsh.

In the Neches River watershed, the Neches River just south of IH 10 is normally fresh. The HS model predicts salinities in areas with bottomland hardwoods will remain near 0 in both the FWOP and FWP conditions. Several bottomland hardwood communities also occur south of IH 10 along the Neches River—1,775 acres in the Rose City hydro-unit, 293 acres in the Bessie Heights hydro-unit, and 197 acres in the Old River hydro-unit. FWOP mean annual salinities in these areas range from 0.3 ppt near Rose City to 1.5 ppt near Bessie Heights and Old River Cove. The bottomland hardwood stands are located well east of the river on the upland terrace margin and are not affected by salinity in the Neches River.

Table 4.6-4
Salinity Changes in Texas Hydro-units

#	Hydrologic Unit Name	Habitat Type	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Change (ppt)
Bottomland Hardwoods (optimal salinity range ≤1 ppt)					
Neches River Watershed					
TX 1	North Neches River	Bottomland Hardwood	0.0	0.0	0.0
TX 2	Neches-Lake Bayou	Bottomland Hardwood	0.0	0.0	0.0
TX 3	Rose City	Bottomland Hardwood	0.3	0.6	0.3
TX 5	Bessie Heights	Bottomland Hardwood	1.5	2.0	0.5
TX 6	Old River Cove	Bottomland Hardwood	1.5	2.0	0.5
Sabine River Watershed					
TX 10	Cow Bayou	Bottomland Hardwood	0.0	1.0	1.0
TX 11	Adams Bayou	Bottomland Hardwood	3.1	3.9	0.8
LA/TX 1	Sabine Island	Bottomland Hardwood	0.1	0.1	0.0
Cypress-Tupelo Swamp (optimal salinity range ≤1 ppt)					
Neches River Watershed					
TX 1	North Neches River	Cypress-Tupelo Swamp	0.0	0.0	0.0
TX 2	Neches-Lake Bayou	Cypress-Tupelo Swamp	0.0	0.0	0.0
TX 3	Rose City	Cypress-Tupelo Swamp	0.3	0.6	0.3
Sabine River Watershed					
TX 10	Cow Bayou	Cypress-Tupelo Swamp	0.0	1.0	1.0
TX 11	Adams Bayou	Cypress-Tupelo Swamp	3.1	3.9	0.8
TX 12	Blue Elbow South	Cypress-Tupelo Swamp	1.1	1.7	0.6
LA/TX 1	Sabine Island	Cypress-Tupelo Swamp	0.1	0.1	0.0
LA/TX 2	Blue Elbow	Cypress-Tupelo Swamp	0.6	0.9	0.3
Fresh Marsh (optimal salinity range ≤2 ppt)					
Neches River Watershed					
TX 1	North Neches River	Fresh Marsh	0.0	0.0	0.0
TX 2	Neches-Lake Bayou	Fresh Marsh	0.0	0.1	0.1
TX 3	Rose City	Fresh Marsh	0.3	0.6	0.3
TX 4	West of Rose City	Fresh Marsh	0.2	0.6	0.4
TX 5	Bessie Heights	Fresh Marsh	1.5	2.0	0.5
TX 7	GIWW North	Fresh Marsh (Intermediate lumped)	2.5	4.1	1.6
Sabine River Watershed					
TX 10	Cow Bayou	Fresh Marsh	4.0	5.0	1.0
TX 11	Adams Bayou	Fresh Marsh	3.5	5.0	1.5
Intermediate Marsh (optimal salinity range ≤4 ppt)					
Neches River Watershed					
TX 5	Bessie Heights	Intermediate (Brackish lumped)	4.4	4.7	0.3
TX 8	Texas Point	Intermediate (Fresh lumped)	7.0	7.8	0.8
TX 13	Groves	Intermediate Marsh	4.0	5.0	1.0
Sabine River Watershed					
TX 10	Cow Bayou	Intermediate Marsh	4.0	5.0	1.0
Brackish Marsh (optimal salinity range ≤10 ppt)					
Neches River Watershed					
TX 6	Old River Cove	Brackish Marsh	11.2	13.0	1.8
TX 7	GIWW North	Brackish Marsh	10.8	12.4	1.6
TX 8	Texas Point	Brackish Marsh	9.8	10.6	0.5
Saline Marsh (optimal salinity range ≥9 to ≤21 ppt)					
Neches River Watershed					
TX 8	Texas Point	Saline Marsh	13.8	14.6	0.8

Table 4.6-5
Salinity Changes in Louisiana Hydro-units

#	Hydrologic Unit Name	Habitat Type	FWOP Salinity (ppt)	FWP Salinity (ppt)	FWP Net Change (ppt)
Bottomland Hardwoods (optimal salinity range ≤1 ppt)					
LA 1	Perry Ridge	Bottomland Hardwood	1.7	2.3	0.6
LA/TX 1	Sabine Island	Bottomland Hardwood	0.1	0.1	0.0
LA/TX 2	Blue Elbow	Bottomland Hardwood	0.6	0.9	0.3
Cypress-Tupelo Swamp (optimal salinity range ≤1 ppt)					
LA/TX 1	Sabine Island	Cypress-Tupelo Swamp	0.1	0.1	0.0
LA/TX 2	Blue Elbow	Cypress-Tupelo Swamp (Bottomland Hardwoods lumped)	0.6	0.9	0.3
Fresh Marsh (optimal salinity range ≤2 ppt)					
LA 1	Perry Ridge	Fresh Marsh	1.7	2.3	0.6
LA 7	Southeast Sabine	Fresh Marsh	2.1	2.4	0.3
LA 8	Southwest Gum Cove	Fresh Marsh	1.4	2.0	0.6
Intermediate Marsh (optimal salinity range ≤4 ppt)					
LA 1	Perry Ridge	Intermediate Marsh	4.5	5.6	1.1
LA 2	Willow Bayou	Intermediate Marsh	6.8	7.7	0.9
LA 3	Black Bayou	Intermediate Marsh	5.1	6.5	1.4
LA 4	West Johnson’s Bayou	Intermediate Marsh	5.5	7.3	1.8
LA 5	Sabine Lake Ridges	Intermediate Marsh	5.5	7.3	1.8
LA 7	Southeast Sabine	Intermediate Marsh	2.1	2.4	0.3
LA 8	Southwest Gum Cove	Intermediate (Brackish lumped)	2.8	3.9	1.1
LA 9	East Johnson’s Bayou	Intermediate (Brackish lumped)	3.8	4.8	1.0
Brackish Marsh (optimal salinity range ≤10 ppt)					
LA 2	Willow Bayou	Brackish Marsh	7.2	8.6	1.4
LA 3	Black Bayou	Brackish Marsh	4.2	5.3	1.1
LA 4	West Johnson’s Bayou	Brackish Marsh	5.3	7.0	1.7
LA 5	Sabine Lake Ridges	Brackish Marsh	7.1	8.3	1.2
LA 6	Johnson’s Bayou Ridge	Brackish Marsh	5.3	7.0	1.7
Saline Marsh (optimal salinity range ≥9 to ≤21 ppt)					
LA 5	Sabine Lake Ridges	Saline Marsh	16.6	17.3	0.7
LA 6	Johnson’s Bayou Ridge	Saline Marsh	16.6	17.3	0.7

Table 4.6-6
FWOP Optimal Salinity Range – Acreage Analysis by Habitat Type*

	Bottomland Hardwoods (acres)		Cypress-Tupelo Swamp (acres)		Fresh Marsh (acres)		Intermediate Marsh (acres)		Brackish Marsh (acres)		Saline Marsh (acres)	
	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range
Texas												
Neches River Watershed	3,717	0	5,501	0	12,592	731	37,651	344	30,469	1,832	3,262	2,446
Sabine River Watershed	1,552	0	4,656	0	2,271	103	1,522	59	0	0	0	0
Total Acres of Habitat Type	5,269	0	10,157	0	14,863	834	39,173	403	30,469	1,832	3,262	2,446
Percentage	100.0	0	100.0	0	94.6	5.4	99.0	1.0	94.2	5.8	57.1	42.9
Louisiana												
Sabine River Watershed	3,206	0	6,641	0	23,995	1,113	125,227	8,050	19,200	5,961	3,646	491
Percentage	100.0	0	100.0	0	95.6	4.4	94.0	6.0	76.3	23.7	88.1	11.9
Total Project												
Project Total – Habitat Type	8,475	0	16,798	0	38,858	1,947	164,400	8,453	49,669	7,793	6,908	2,937
Percentage	100.0	0	100.0	0	95.2	4.8	95.1	4.9	86.4	13.6	70.2	29.8

Total FWOP Project Acres Within Optimal Range = 285,040 acres (93.1%)

Total FWOP Project Acres Within Sub-optimal Range = 21,198 acres (6.9%)

*Calculated using WVA Impacts Summaries from tables 4.1-3 and 4.1-4 and Habitat Acreage from Table 7 in Appendix C.

Table 4.6-7
FWP Optimal Salinity Range – Acreage Analysis by Habitat Type*

	Bottomland Hardwoods (acres)		Cypress-Tupelo Swamp (acres)		Fresh Marsh (acres)		Intermediate Marsh (acres)		Brackish Marsh (acres)		Saline Marsh (acres)	
	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range	Within Optimal Range	Sub-optimal Range
Texas												
Neches River Watershed	3,717	0	5,501	0	12,437	886	37,641	354	30,416	1,885	3,245	2,463
Sabine River Watershed	1,552	0	4,656	0	2,262	112	1,519	62	0	0	0	0
Total Acres of Habitat Type	5,269	0	10,157	0	14,699	998	39,160	416	30,416	1,885	3,245	2,463
Percentage	100.0	0	100.0	0	93.6	6.4	98.9	1.1	94.2	5.8	56.9	43.1
Louisiana												
Sabine River Watershed	3,206	0	6,641	0	23,937	1,171	124,686	8,591	19,123	6,038	3,631	506
Percentage	100.0	0	100.0	0	95.3	4.7	93.6	6.4	76.0	24.0	87.8	12.2
Total Project												
Project Total – Habitat Type	8,475	0	16,798	0	38,636	2,169	163,846	9,007	49,539	7,923	6,876	2,969
Percentage	100.0	0	100.0	0	94.7	5.3	94.8	5.2	86.2	13.8	69.8	30.2

Total FWP Project Acres Within Optimal Range = 284,170 acres (92.8%)

Total FWP Project Acres Within Sub-optimal Range = 22,068 acres (7.2%)

*Calculated using WVA Impacts Summaries from tables 4.1-3 and 4.1-4, Habitat Acreage from tables 4.1-3 and 4.1-4, Habitat Acreage from Table 7 in Appendix C.

The HW considered potential effects of brief salinity increases by adjusting growth rates of woody and herbaceous vegetation at rates correlated to the salinity SI in the SCM. Changes in salinity were reflected with changes in variables V_1 (tree species composition), V_2 (stand maturity), and V_3 (midstory/understory coverage) in consideration of potential impacts. Trees species found in the bottomland forest community such as oaks (*Quercus* spp.), hickories (*Carya* spp.), American elm, green ash, sweetgum, boxelder, etc., are generally sensitive to even low levels of salinity. Among many other adverse effects, salinity is known to cause a reduction in seed germination, with germination in many nonhalophytes inhibited by very small percentages of salt (Kozlowski, 1997). Woody plants usually are very sensitive during emergence and young seedling stages, but become progressively more tolerant with increasing age (Shannon et al., 1994). Given the small FWP salinity increase, only small reductions in growth rates were forecast, and no AAHU losses were projected by the BHM.

Cypress-Tupelo Swamps

Cypress-tupelo swamps in the study area occur streamside or in abandoned channels or other low areas within the floodplain. Approximately 6,641 acres of cypress-tupelo swamp are located in the Louisiana portion of the study area, and 10,157 acres in the Texas portion. Large continuous stands of swamp are present in the upper reaches of both the Sabine and Neches rivers, with thousands of acres protected in the Sabine Island and Blue Elbow Swamp WMAs. Smaller, isolated stands are found in the bottoms of small drainages along the upland margins, generally buffered from exposure to higher salinities by intervening marsh. Swamps are located in the same reaches of the river systems as the bottomland hardwoods, and experience the same FWOP and FWP predicted salinity conditions. Louisiana swamps in the study area are located in the Sabine Island (5,998 acres) and Blue Elbow (643 acres) hydro-units north of IH 10. During FWOP and FWP conditions, swamps in the Sabine Island hydro-unit would experience a salinity of 0.1 ppt. In the Blue Elbow hydro-unit, predicted salinity would increase from 0.6 ppt during FWOP conditions to 0.9 ppt during FWP conditions. No impacts to swamps in these areas are expected.

Swamps in the Texas portion of the study area occur in both the Sabine and Neches river watersheds. Swamps in the Sabine Island (1,194 acres) and Blue Elbow (2,548 acres) hydro-units straddle the border between the states, and thus the salinity changes reported for Louisiana swamps in these areas are the same in Texas. These predicted salinity changes are not expected to impact swamps in these areas. Swamps also occur in three hydro-units on the Texas side of the Sabine River watershed—Blue Elbow South (689 acres), Cow Bayou (110 acres), and Adams Bayou (115 acres). In the Neches River watershed, swamps occur in the hydro-units north of IH 10 (North Neches, 2,760 acres, and Neches-Lake Bayou, 2,277 acres), and a small swamp is located south of IH 10, at the upland margin of the Rose City hydro-unit (464 acres).

Under the median-flow condition, swamps in the Blue Elbow South hydro-unit are generally fresh with predicted salinities of 1.1 ppt in the FWOP condition and 1.7 ppt in the FWP conditions. Predicted salinity increases in Cow Bayou swamps from 0.0 ppt for the FWOP condition to 1.0 ppt for the FWP condition. The predicted salinities for Adams Bayou are higher, up to 3.1 ppt for the FWOP condition and

3.9 ppt for the FWP conditions. In total, FWP salinity increases in these swamps would result in the loss of 22 AAHUs.

The habitat switching module of the LCA Ecosystem Model projects that loss of swamp acreage would not be expected to occur until average annual salinities exceed 4 ppt, based on the literature review discussed above (Visser et al., 2004). None of the increases in salinity reported for the swamps in the Sabine River watershed would be expected to result in the conversion of swamp to marsh, and therefore the same swamp acreages were entered into the FWOP and FWP conditions of the SCM worksheets.

Fresh Marshes

Fresh marshes are widespread, but represent a smaller percentage of all marsh in the study area than intermediate and brackish marshes. Approximately 25,108 acres of fresh marsh occur in the Louisiana portion of the study area, and 15,697 acres occur in the Texas portion. In general, fresh marsh occurs along the Neches River, north of the GIWW in Louisiana and Texas, and in protected interior pockets of intermediate marsh throughout the study area. In the FWOP condition, 95 and 96 percent of this habitat in Texas and Louisiana, respectively, remain within the optimal salinity range. The proportion of fresh marsh predicted to remain in Texas within optimum salinities is 95 percent, with 94 percent remaining under the FWP condition. The WVA model predicts FWP AAHU losses of 173 AAHUs in the Neches River watershed and 111 AAHUs in the Sabine River watershed.

In Louisiana, fresh marshes are located in the Perry Ridge (18,859 acres), Southeast Sabine (2,634 acres), and Southwest Gum Cove (3,615 acres) hydro-units. Located north of the GIWW, Perry Ridge is by far the largest expanse of fresh marsh in the Louisiana study area. During most of the year, the Sabine River and the GIWW are fresh in the reaches adjacent to Perry Ridge. The Vinton drainage ditch provides hydrologic access to the eastern part of this area. However, in the FWP, salinities could increase in Perry Ridge from 1.7 ppt (FWOP) to 2.3 ppt (FWP).

The Southwest Gum Cove and Southeast Sabine hydro-units are located at the eastern edge of the SNWW study area, north and south of Pool 3, respectively. The northern hydro-unit is hydrologically connected to the GIWW through the Black Bayou Cutoff, and the southern unit is hydrologically connected to Sabine Lake through Willow Bayou. Average salinities during the growing season range from 1.2 ppt in the Southwest Gum Cove marsh to 1.7 ppt in the Southeast Sabine fresh marshes. Salinity in Southwest Gum Cove is projected to rise from 1.4 ppt (FWOP) to 2.0 ppt (FWP). Located closer to the coast, salinity in the Southeast Sabine hydro-unit is projected to rise from 2.1 ppt (FWOP) to 2.4 ppt (FWP).

In Texas, most of the fresh marshes are located in the Neches River watershed. However, smaller pockets occur in the Cow Bayou (1,775 acres) and Adams Bayou (599 acres) hydro-units in the Sabine River watershed. Mean annual salinities in these smaller bayous range from 0 ppt in the uppermost reaches to 3.5 ppt near the mouth of Cow Bayou. Adams Bayou salinity averages about 2.5 ppt. The HS model predicts salinity will increase to 4.0 ppt (FWOP) and 5.0 ppt (FWP) in Cow Bayou. In Adams Bayou, modeled salinities rise to 3.5 ppt (FWOP) and 5.0 ppt (FWP). FWP salinity would move from the maximum of the fresh marsh optimal range to roughly the maximum of the optimal range for intermediate marsh in Adams Bayou.

In the Neches River watershed, all of the fresh marsh is located north of the GIWW. North of IH 10, approximately 436 acres of fresh marsh occur in the North Neches River hydro-unit, and 1,535 acres in the Neches-Lake Bayou hydro-unit. On the lower Neches River, fresh marsh occurs in the Rose City (3,327 acres), West of Rose City (492 acre), and Bessie Heights (2,147 acres) hydro-units. Nineteen percent of Rose City is open water, and a central expanse of tidally influenced mud flats is the site of eroded wetlands that were formerly fresh marsh and cypress-tupelo swamp. About half of the Bessie Heights hydro-unit is open water, averaging 2 to 3 feet in depth, that has developed in what was historically a large, mostly emergent, intermediate marsh. Salinities in these Neches River fresh marshes under the FWOP condition range from 0.0 in the North Neches River and Neches-Lake Bayou hydro-units to 1.5 ppt in Bessie Heights. Salinities would not be expected to change in the North Neches fresh marsh under the FWP condition. The greatest salinity increase projected for these marshes under the FWP condition is 0.5 ppt for the Bessie Heights marsh.

The GIWW North hydro-unit comprises three separate areas on the north side of the GIWW. All are located within the largest remaining coastal freshwater marsh in Texas (USFWS, 2005a). Most of this area is not hydrologically connected to the waterways, which form its southern and eastern boundary, the GIWW, and the Taylor Bayou Diversion Channel, respectively. FWOP salinities predicted by the HS model for the GIWW North fresh marsh average 2.5 ppt. PAs along the GIWW and levees, created when the waterways were originally dredged, serve as barriers along the banks of the waterway that protect the marshes from bank overwash. The TPWD data indicate that salinities in the fresh and intermediate marsh average 0.7 ppt. Areas selected for inclusion in the hydro-unit are likely to be affected by salinity increases associated with SNWW channel improvements. They are influenced by breaks in the levees and PAs, or through natural bayous that allow higher-salinity waters to enter the marsh system. Predicted salinity would increase to 2.5 ppt (FWOP) and 4.1 ppt (FWP) in portions of the fresh and intermediate marsh.

Intermediate Marshes

Intermediate marshes comprise the largest percentage of marshes throughout the study area, and most occur in Louisiana east of Sabine Lake. In total, approximately 133,000 acres of intermediate marsh occur in the Louisiana portion of the study area, and 39,500 acres in the Texas portion. Approximately 99 percent of Texas intermediate marsh (the majority of which is located in the Salt Bayou hydro-unit) is predicted to have salinities in the optimum range in the FWP condition. In Louisiana, about 94 percent of the intermediate marsh is predicted to have salinities in the optimum range under FWP conditions. The WVA model predicts FWP AAHU losses of 36 AAHUs in the Neches River watershed and 1,583 AAHUs in the Sabine River watershed.

In Louisiana, all but one of the hydro-units (Perry Ridge, 4,704 acres) are located south of the GIWW. Salinity in Perry Ridge intermediate marshes would rise from 4.5 ppt (FWOP) to 5.6 ppt (FWP).

Extensive intermediate marshes occur in the Louisiana portion of the study area south of the GIWW. These marshes are found in Willow Bayou (35,109 acres), Black Bayou (34,941 acres), West Johnson's Bayou (11,110 acres), Sabine Lake Ridges (9,270 acres), Southeast Sabine (5,400 acres), Southwest Gum Cove (6.605 acres), and East Johnson's Bayou (26,138 acres). The primary hydrologic connections to these marshes are the Black Bayou Cutoff/GIWW, Black Bayou/upper Sabine Lake, Willow Bayou/central Sabine Lake, and Johnson's Bayou (south-central Sabine Lake). Mean annual salinities at these hydrologic connections are 0.4 ppt in the GIWW, 2.8 ppt in Black Bayou, 4.3 ppt at Willow Bayou, and 6.3 ppt at Johnson's Bayou. However, mean annual salinities within these interior marshes are generally lower, ranging from 1.3 ppt in the northern marshes, through 2.0 ppt in the central marshes, to 6 ppt in the southern marshes. Black Bayou has the lowest projected salinity of these three marshes under the FWOP condition with a modeled salinity of 5.1 ppt and Willow Bayou has the highest with a FWOP salinity of 6.8 ppt. FWP salinities in these marshes are predicted to increase to 6.5 ppt in Black Bayou, 7.3 ppt in West Johnson's Bayou, and 7.7 ppt in Willow Bayou.

In hydro-units located farther from Sabine Lake (Southwest Gum Cove, Southeast Sabine, and East Johnson's Bayou), salinity increases of 0.3 to 1.1 ppt are expected under the FWP condition. However, salinities within the Southwest Gum Cove and Southeast Sabine hydro-units would remain within the optimal range. Salinity in East Johnson's Bayou is predicted to rise from 3.8 ppt (FWOP) to 4.8 ppt (FWP). For most of the intermediate marshes in this area, FWOP salinities during these higher-salinity periods are already at or beyond the high end of the optimal range, and FWP conditions move them further into the brackish range for at least several weeks a year.

In Texas, intermediate marshes are located on the lower Neches River (Bessie Heights – 6,913 acres, and Groves – 437 acres) and at Texas Point (1,631 acres). The Bessie Heights and Groves hydro-units are adjacent to the Neches River and fed by several hydrologic connections. Average salinity in Bessie Heights intermediate marsh is about 4.2 ppt during the growing season. Intermediate marshes in Bessie Heights are primarily located along its southern fringe, but are separated from the Neches River by upland PAs. About half of the Bessie Heights hydro-unit is open water, averaging 2 to 3 feet in depth, which has developed in a formerly large, mostly emergent, intermediate marsh. Salinity in Bessie Heights intermediate marsh is predicted to be 4.4 ppt (FWOP), increasing to 4.7 ppt (FWP). In the Groves hydro-unit, shallow, meandering streams cross the marsh and drain into the Star Lake Canal and Neches River. Mean annual salinities within the marshes themselves are close to the Neches River levels. In the portions of the Groves hydro-unit, FWP salinities are expect to rise from 4.0 ppt (FWOP) to 5.0 ppt.

At Texas Point, approximately 1,742 acres of intermediate marsh (with small pockets of fresh marsh) are located inland of the extensive brackish marsh in this hydro-unit. Marshes are hydrologically connected to the Sabine Pass Channel through Texas Bayou and a large, interconnected man-made canal. FWOP modeled salinities are 7.0 ppt. FWP salinity would increase to 7.8 ppt.

Intermediate marsh is also located along the lower third of Cow Bayou (1,144 acres) in the Sabine River watershed. Salinity under the FWP condition is projected to increase to 5.0 in parts of the Cow Bayou marshes from 4.0 ppt in the FWOP condition.

Brackish and Saline Marshes

Brackish marshes occur just inland of saline marshes along the coast and at Sabine Pass, and form fringing marsh around Sabine Lake, Keith Lake, Salt Bayou, and Old River Cove. In total, approximately 25,161 acres of brackish marsh occur in the Louisiana portion of the study area, and 32,201 acres in the Texas portion. Little to no change would be expected between the FWOP and FWP conditions with respect to the percentage of both brackish and saline marsh remaining within the optimal range. The WVA model predicts FWP AAHU losses of 131 AAHUs in the brackish marshes of the Neches River watershed and 23 AAHUs in the Sabine River watershed. For saline marsh, a FWP loss of 5 AAHUs would be expected at Texas Point, and a loss of 37 AAHUs would be expected at Louisiana Point.

In Louisiana, brackish marshes are found in the Willow Bayou (1,182 acres), Black Bayou (3,195 acres), West Johnson's Bayou (2,078 acres), Johnson's Bayou Ridge (2,744 acres), and Sabine Lake Ridges (15,962 acres) hydro-units. The hydrologic connections and mean annual salinities are generally the same as reported for intermediate marshes located east of Sabine Lake. However, brackish marshes in Sabine Lake Ridges and Johnson's Bayou Ridge are hydrologically connected to Sabine Pass through Lighthouse Bayou. Under average annual conditions, FWP salinities would remain within the optimal range (≤10 ppt), increasing an average of 1.4 ppt, and ranging from 5.3 ppt at Black Bayou to 8.6 ppt at Willow Bayou.

In Texas, brackish marshes occur in the Old River Cove (8,530 acres), GIWW North (647 acres), and the Texas Point (2,546 acres) hydro-units. About 30 percent of the Old River Cove hydro-unit is open water, and mean annual salinities are about 10.0 ppt. At GIWW North, salinity in some of the brackish marsh during late summer months is expected to rise from 10.8 ppt (FWOP) to 12.4 ppt (FWP) At Texas Point, FWOP mean salinity in the brackish marshes averages 9.8 ppt and FWP salinity is projected to rise to 10.6 ppt, just into the suboptimal range.

Saline marshes in the study area are restricted to the immediate coastal zone. In Louisiana, they occur in the Sabine Lake Ridges (3,767 acres) and Johnson's Bayou Ridge (370 acres) hydro-units. In the FWOP condition, 100 percent of this habitat in both Texas and Louisiana remains within the optimal salinity range. In Texas, 5,708 acres of saline marsh occur in the Texas Point hydro-unit. These areas are hydrologically connected to Sabine Pass and are generally protected from saltwater incursion from the Gulf by low shoreline ridges. FWP mean annual salinity is projected to rise an average of 0.8 ppt above the FWOP condition in these marshes, while remaining within the optimal range for saline marsh (≥9 and ≤21 ppt).

4.6.3.2.4 Sensitivity to Potential Salinity Changes during FWP Drought Condition

The HS model predicts salinities at 13 locations at median and low flow under the FWOP and FWP conditions (see tables 4.6-1 and 4.6-3). FWP salinities ranged from 0 to 22.9 ppt at median flows and from 0.26 to 29.1 ppt at drought flows. Salinities under the modeled existing condition during drought ranged from 0 to 28.9 ppt. The average salinity increase from FWOP to FWP conditions at the 13 stations was 1.0 ppt at median flows and only 0.5 ppt at low flows. This suggests that the relative effect of RSLR on salinities is lower as drought conditions cause salinities to increase. The greatest salinity increases from FWOP to FWP conditions at low flow were estimated for the east shore of Sabine Lake, near Rose City on the Neches River, and the Sabine River at Orange, areas where the salinity is predicted to increase 0.7 to 1.0 ppt from the FWOP to the FWP condition. Predicted salinities in the portion of Sabine Lake adjacent to the Louisiana shore are projected to reach levels ranging from 15.6 to 17.9 ppt, under the FWP drought condition compared to a range of 12.7 to 15.0 ppt under the modeled existing drought condition.

FWP salinities under drought flows would average 8.2 ppt above FWP salinities at median flows. FWOP salinities under drought flows would average 8.9 ppt higher than FWOP salinities under median flows. Drought flows in the upper Neches River and Sabine River under the FWP condition are not likely to affect marshes in these areas since predicted salinities in the upper Neches River would be 2.6 and 5.8 ppt in the Sabine River at Orange. Salinities in adjacent marshes would be expected to be lower.

Possible impacts that may occur if predicted FWP salinities occur in the project area during drought will depend on the extent, frequency, and duration of low inflows. These possible impacts are difficult to predict because of the complexity of the project area ecosystem; uncertainty about future changes in major variables like inflow, temperature changes, and sea level rise; and limited understanding of ecosystem structure and function in the project area. There is currently substantial discussion in the scientific community regarding the role of tipping points in determining effects of ecosystem stressors. However, there are no current, reliable, studies describing salinity tipping points for marshes or wetlands in this part of Texas. It is clear that FWOP drought flows will substantially increase salinities above the modeled existing condition, over 8 ppt, but the FWP contribution to the additional salinity increase is small, averaging 0.5 ppt.

4.6.4 Groundwater Hydrology Impacts

4.6.4.1 No-Action

The No-Action Alternative would have no additional direct impacts to groundwater resources at or near the proposed study area beyond those that may result from existing dredging activities or placement of dredged material independent of this project. Any direct effects of those projects may result in local and regional changes (i.e., sedimentation, altered hydrology, or a relative rise in sea levels) over time and would be common to all alternatives considered in this FEIS. Their effects would be evaluated under their own environmental studies.

With the projected future effects of climate change, there is a potential for saltwater intrusion into shallow groundwater aquifers at or near the SNWW area due to a rise in sea levels. The USACE, Galveston District analyzed the potential for RSLR to affect aquifers in the study area (USACE, 2009b). If the sea level rises half an inch (0.04 foot), the freshwater/saltwater interface could potentially rise as much as 1.67 feet, which would not have a significant impact on a freshwater aquifer. However, for a 50-year assessment, sea level rise of 1.1 feet would cause the interface to rise up to 44 feet. For every foot the saltwater level rises, the height of free ground surface water reduces by a foot. As a result, the interface between saltwater and freshwater underground rises approximately 40 feet for every foot the sea level rises. This could have a significant effect on the amount of fresh water in deep aquifers in the study area with or without the proposed project.

4.6.4.2 Preferred Alternative

The potential to affect groundwater hydrology in this project is related to construction and maintenance dredged material placement in 16 existing and 2 expanded upland PAs, as proposed in the Preferred Alternative. Groundwater hydrology potential effects may result in physical (ability to infiltrate and/or contact groundwater in area aquifers) and chemical (TDS or salinity) attributes of the dredged material.

In the area, the Gulf Coast aquifer is subdivided into the Chicot aquifer (uppermost) and the underlying Evangeline aquifer, separated by differences in lithology and permeability. Higher permeabilities are usually associated with the Chicot aquifer. The Chicot aquifer has been divided into an upper unit and lower unit, separated by a clay bed in some areas and, in other areas, merged into one large mass of interbedded and interconnected sand and clay.

No effects are anticipated to the lower unit of the Chicot, any portion of the Evangeline, or the massive portions of the upper Chicot aquifers because clay barrier layers are anticipated to prevent contact with dredged material. Therefore, no adverse effects are anticipated to groundwater wells documented by the TWDB in the area counties.

Dredged material produced by construction of the Preferred Alternative would be managed in accordance with the DMMP. PAs would be able to accommodate material from both construction and maintenance dredging over the 50-year period of analysis. More details can be found in the DMMP (Appendix D). The upper stratigraphic units of the upper Chicot aquifer may become saturated from newly discharged dredged material and/or precipitation stored within the PA. With time and as material is discharged into the PA, the water would evaporate and the solids of the dredged material would compact to form a low permeability cap over the substrate within the PA. This cap, composed of new work material, would form an effective barrier to future dredged material infiltration.

SNWW dredge elutriate, water, and sediment data were collected and archived by the USACE within 5 years of this project’s initiation. Data from this set collected within the area’s footprint were compared to the regulatory thresholds set through Texas and Louisiana WQS. These findings are discussed in detail in sections 3.3 and 3.4. Water and sediment samples were collected at locations that are most likely to have been impacted by industrial properties undergoing remedial action. No WQS or WQC was exceeded by water or elutriate samples from any of the three sampling sites, and none of the concentrations was noticeably higher in the channel samples than the reference samples. Therefore, no adverse potential effects are expected if groundwater in the upper Chicot aquifer comes into contact with water or elutriate from construction and maintenance dredged material.

In general, water from the SNWW project area ranges in salinity from essentially zero to that of 30 ppt. Groundwater quality data from the TWDB database indicates that groundwater from water wells completed in the Chicot aquifer within the project vicinity generally has TDS concentrations less than

200 mg/L (fresh) to more than 3,000 mg/L (brackish). Most of the groundwater from the Chicot aquifer has an average TDS concentration of less than 1,500 mg/L. In general, storage of saline/brackish water on an upland impoundment would suggest that impacts to the uppermost contact with land surface could occur. Additionally, if groundwater occurs in this uppermost level, then saline/brackish water may blend with shallow-occurring groundwater. Greater permeability of the land surface would contribute to faster surface water entry into the subsurface, and potentially into the groundwater. This would suggest that impacts to groundwater may be likely during the first placement of dredged material into the PA; however, over the life of a PA, solids in the dredged material settle to the bottom and create a layer of low-permeability material. This physical barrier would, in time, minimize the intermixing of surface and groundwater in that area. Most of the PAs in the project area are existing, previously used impoundments, with an established layer of low-permeability material. Two new areas are proposed in upland areas adjacent to the Neches River where salinity levels in the navigation channel are lower overall. No domestic or livestock wells are in the vicinity of the PAs, and no reported complaints by groundwater users have been registered in the area. No prior use of the PAs has resulted in known groundwater resource impacts, and no impacts are anticipated from additional placement through this project. Salinity increases from dredged material water infiltration to the upper Chicot is not a concern.

With the projected future effects of climate change, there is a potential for saltwater intrusion into shallow groundwater aquifers at or near the proposed study area due to a rise in sea levels. These impacts would be the same as the No-Action Alternative discussed above in subsection 4.6.4.1.

4.7 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

4.7.1 No-Action Alternative

The No-Action Alternative would have no impact on hazardous materials associated with regulated facilities in the region. However, maintenance dredging of existing ship channels and from future channel deepening and/or widening projects, in addition to the placement of dredged materials at PAs, would continue under the No-Action Alternative. In the absence of project activity, the existing historic impacts related to area industry are also expected to continue.

4.7.2 Preferred Alternative

According to a review of regulatory agency database records and interviews conducted with regional TCEQ personnel, industrial activity has caused measurable impacts to the surface water, sediment, soil, and groundwater in localized areas within the study area. However, chemical analysis of sediment and surface water samples collected from the waterway indicate that these impacts have apparently been limited to the industrial facilities and adjoining properties (PBS&J, 2002). The nature and potential for any HTRW site to impact the surrounding environment varies considerably. The majority of the regulated facilities and incident locations identified in the regulatory agency database review do not pose an environmental concern for the project. However, several facilities within the study area do pose a greater potential to impact the environment. These facilities pose a potential concern based on the nature and extent of contaminants at the site, their location relative to the PAs and the waterway, and the number of pathways in which the contaminants could reach the PAs and the waterway. The facilities that are considered priority HTRW sites of concern are summarized in Table 4.7-1; their locations on shown on Figure 4.7-1.

Table 4.7-1
Summary of Priority HTRW Sites within Sabine-Neches Waterway

Site Name	Site ID	Constituents of Concern	Media Impacted	Status
Bailey Waste Disposal Site	512	Arsenic compounds, benzene, phenols, pyridenes, naphthalenes, and chlorinated hydrocarbons	Surface water, groundwater, soil	Cleanup complete in 1998; Operation and Maintenance underway since 1999
State Marine	203	PAHs, metals	Surface water	Evaluation and cleanup are underway, but the nature and extent of contamination and the risks posed to human health and the environment are unknown
Palmer Barge Lines	548	Aluminum, barium, chromium, cobalt, iron, lead, magnesium, nickel, zinc, pesticides, VOCs, PAHs, PCP, and benzene	Surface water	Evaluation and cleanup underway since 2000; the EPA is considering various remedial alternatives
Star Lake Canal	471	Chromium, copper, PAHs, and PCBs	Surface water, sediments	Evaluation and cleanup underway since 2001, but the nature and extent of contamination and the risks posed to human health and the environment are unknown
International Creosoting	30	Arsenic, chromium, lead, creosote compounds, SVOC, and VOCs	Groundwater, sediment, soil, surface water	Clean up underway
Maintech International	410	PAHs	Groundwater, soil	Cleanup completed in 2000; undergoing Operation and Maintenance
Excell	28	TPH, benzene, toluene, ethylbenzene, and xylene	Groundwater	Investigation underway
Port of Beaumont, Beaumont Elevator	113	VOCs, herbicides, and pesticides	Groundwater, soil	Investigation underway
Woodcrest Site	584	VOCs	Soil	Investigation underway

Source: Banks Information Solutions (2002).

The USACE has determined that the 316-acre PA 17 is needed for future material disposal in conjunction with the Preferred Alternative and that PA 17 would be included in the DMMP; however, issues related to contaminated materials in a capped landfill and other waste disposal areas within this PA remain unresolved at this time. Pursuant to Department of the Army Engineering Regulation 1165-2-132, HTRW Guidance for Civil Works Projects, construction of civil works projects in HTRW-contaminated areas should be avoided. The non-Federal local sponsor has been notified that they are responsible for the investigation and remediation of HTRW issues for use of PA 17 for the project. Additional information is needed to fully identify and delineate onsite contaminants, and the EPA remedial investigations planned for the Star Lake Canal Superfund Site, which could potentially affect parts of PA 17, need to be completed. Surface and subsurface sampling and analysis would be necessary to identify and delineate contaminants of concern and to determine whether contaminates are present at levels of concern. Based upon available information at the time of this document’s production, it is expected that PA 17 contaminant concerns would be resolved in time for its scheduled use in maintenance dredging; however,

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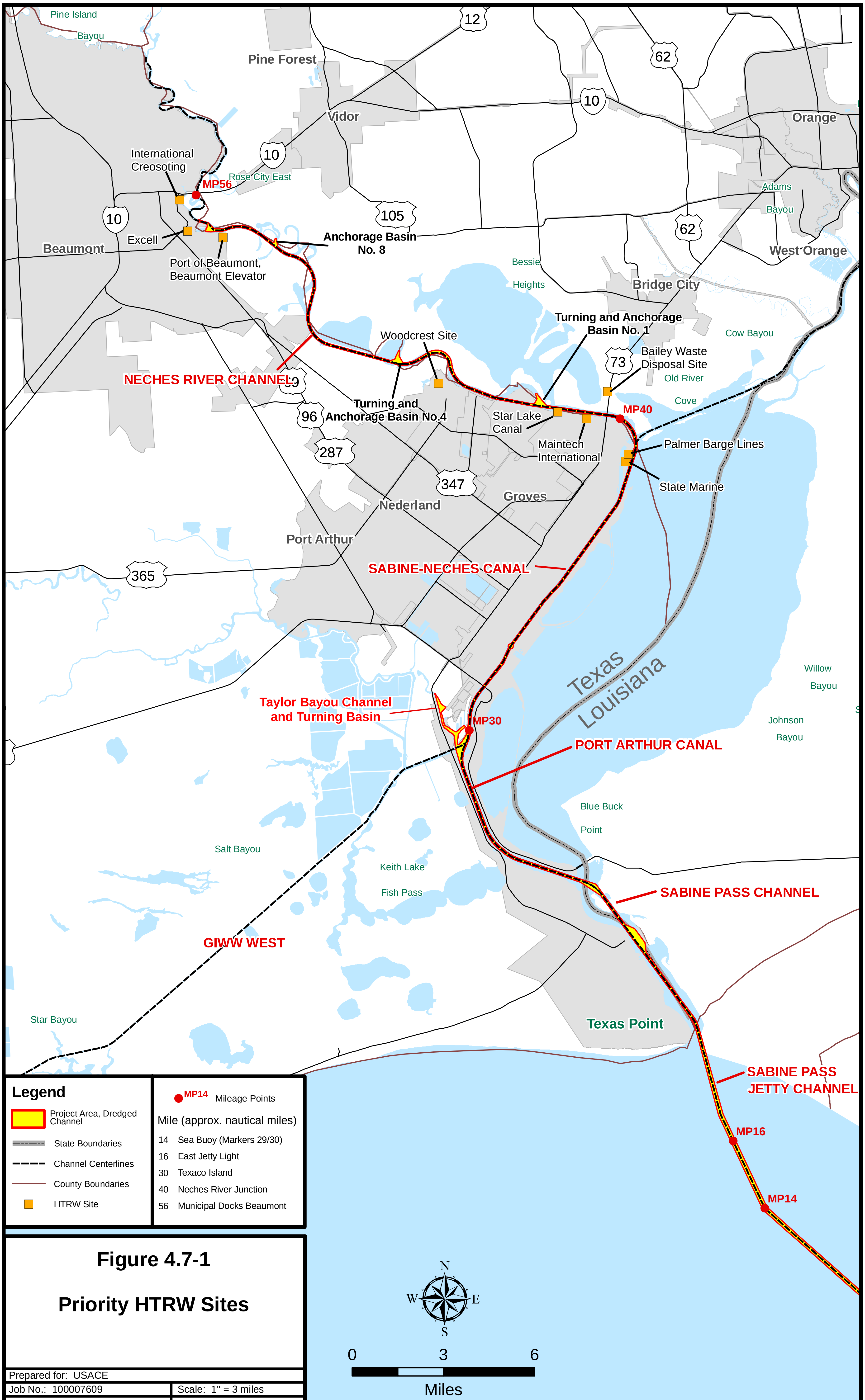

Figure 4.7-1

Priority HTRW Sites

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if these issues are not resolved and PA 17 is not available, National Environmental Policy Act (NEPA) analysis and coordination would be performed to designate a new PA or expand an existing PA to replace the lost capacity.

A baseline evaluation of facilities that pose a potential concern to the project must also consider whether the release of contaminants is ongoing or has been effectively eliminated through remedial efforts. Based on these criteria, State Marine, Palmer Barge Lines, Star Lake Canal, and Beaumont Elevator continue to present on ongoing threat to impact the environment of the project area since these sites have not completed remedial activities. The remaining priority sites present a lesser threat due in part to either effective corrective action or distance to the waterway.

Based on the findings of the HTRW survey, there is the potential of encountering contaminated material during construction of the project. The contaminated material could increase project cost and/or lost time from discovery and remediation of the contaminated materials within the project area. The potential of encountering contaminated material appears to be greatest in areas adjacent to priority HTRW sites and in outfall canals adjacent to the SNWW. Surveys have been conducted to locate oil and gas wells and petroleum pipelines crossing the navigation channel (PBS&J, 2005). Prior to construction, additional pipeline surveys would be necessary for proposed BU features and mitigation measures.

The highest probability of residual contamination in water and sediments would be in the area of the Star Lake Canal outfall, the northern end of Pleasure Island, and near Taylor Bayou. According to TCEQ personnel, the Star Lake Canal and Taylor Bayou convey industrial wastewater effluent and stormwater to the SNWW. The sediment adjacent to the mouths of these canals could contain elevated levels of organic and inorganic compounds. Similarly, sediment adjacent to the State Marine and Palmer Barge Lines sites located near the north end of Pleasure Island could contain a variety of organic and inorganic compounds. These sources of potential contaminants are a result of migration and runoff of impacted groundwater and surface water into the waterway. However, based upon the recent chemical analysis of water and sediment collected within these channels, the potential for encountering contaminated material during dredging operations is considered minimal.

4.8 AIR QUALITY

This section provides a discussion of the air quality impacts associated with the No-Action and Preferred alternatives. The evaluation of air quality impacts associated with the proposed SNWW CIP was based on the identification of air contaminants and estimated emission rates for the Preferred Alternative. The air contaminants considered are those covered by the NAAQS (except for lead, which is not relevant to project emissions) including CO, O_3, NO_x, PM_{10}, $PM_{2.5}$, and SO_2. Air emissions were considered for channel improvement activities and placement of dredged material as well as emissions from vehicular traffic associated with the project employee commute. Project emissions were estimated based on preliminary assumptions regarding construction timing and equipment developed for this project. It is not within the scope of this analysis to perform the refined dispersion modeling necessary to predict concentrations for each contaminant and alterative. Rather, the impact of emissions was analyzed relative to the existing inventory for air contaminant emissions in the BPA nonattainment area and the parishes of Cameron and Calcasieu.

The estimated air contaminant emissions, except O_3, were compared to the 2002 emissions inventory for the BPA ozone nonattainment area and for Cameron and Calcasieu parishes. Assuming an increase in air emissions would result in a corresponding increase in the ambient air concentration for that air contaminant, the ratio of the estimated emissions to the existing 2002 emissions for that contaminant provided a relative indication of the potential increase in ambient concentrations for the air contaminant. That difference was then compared to the NAAQS. As shown in Table 3.7-3 in subsection 3.7.3, monitored values indicate that concentrations of air contaminants (except O_3) for BPA are below the NAAQS over the period from 2004 to 2008. Because air emissions are generally dispersed with distance and time, a relatively small increase in emissions may be assumed to cause a correspondingly small increase in ambient air quality concentrations for that air contaminant, and it is therefore expected that the increase in emissions would not cause an exceedance of the NAAQS. Because authorization for the project is considered a Federal action, estimated emissions from the project were also considered in terms of the General Conformity Rules.

4.8.1 No-Action Alternative

No construction or new operating emission sources are associated with the No-Action Alternative. However, it is expected that air contaminant emissions would increase due to continued operational constraints on the existing system and projected increased ship traffic resulting both from growth of existing business and from new business.

4.8.2 Preferred Alternative

The evaluation of air quality impacts associated with the Preferred Alternative was based on the identification of air contaminants and estimated emission rates for this project alternative. Emissions inventories were estimated for project-related activities based on the schedule, dredging volumes, and other construction-related assumptions regarding construction timing and equipment developed for this project. The emission sources for this alternative would consist of marine vessel and land-based mobile sources that would be used during the channel improvement activities, as follows:

- **Marine Vessels**. Includes dredges (cutter and hopper), dredge support equipment (tugboats, survey boats, crew boats, and tenders), and shrimp trawlers; and
- **Land based.** Includes off-road (amphibious track hoe, dozer, dragline, excavator, and rolligon) and on-road (employee vehicles).

Air contaminant emissions associated with the channel widening would be primarily combustion products from fuel burned in equipment used for project dredging, support vessels, and dredged material placement equipment. Activities at dredged material placement sites would involve the use of earth-moving equipment. The marine vessel emissions sources are primarily diesel-powered engines. The off-road construction equipment was assumed to be all diesel-powered, and on-road vehicles were assumed to be all gasoline-powered vehicles. Detailed emission estimates are provided in the General Conformity Determination (Appendix F).

4.8.2.1 Air Quality Analysis Results

The project construction emissions represent the estimated emissions from the activities associated with the Preferred Alternative. These activities would be considered one-time activities, i.e., the channel widening activities would not continue past the date of completion. Because of the high moisture content of the dredged material, it is expected that there would be no particulate matter emissions from the placement of dredged material in placement areas.

A summary of the total estimated annual emissions, in tons, resulting from the use of dredging equipment, support vessels, off-road equipment, and on-road equipment is presented in Table 4.8-1. A detailed summary of emissions can be found in the General Conformity Determination (Appendix F).

The total estimated annual emissions for each year of construction were compared to the 2002 emissions inventory for the BPA nonattainment area and the emissions inventory for Cameron and Calcasieu parishes. This comparison is presented in Table 4.8-2.

As shown on Table 4.8-2, air contaminant emissions from the Preferred Alternative would result in a relatively small increase in emissions above those from existing sources in the BPA and for Cameron and Calcasieu parishes. As a result, it is expected that air contaminant emissions from the combustion of fuel in equipment used for dredging and placement activities would also result in correspondingly minor short-term impacts on air quality in the immediate vicinity of the project area and even less as emissions are dispersed over the BPA and Cameron/Calcasieu areas.

4.8.2.2 General Conformity Applicability

For comparison with the thresholds defined in the General Conformity Rule, the estimated emissions of NO_x and VOC for each year for the project activities subject to the General Conformity are summarized in tables 4.8-3 and 4.8-4. For purposes of General Conformity, only air contaminant emissions that might occur within the BPA nonattainment area out to the 9-mile natural resources limit for the State of Texas were considered. The 9 nautical mile boundary is the seaward limit of the submerged lands of Texas as defined in the Submerged Lands Act (U.S. Code Title 43, Chapter 29, Subchapter II, § 1312). Emissions of carbon monoxide, sulfur dioxide, and particulate matter are not considered in the General Conformity evaluation as this area is in attainment with the NAAQS for each of those pollutants.

Table 4.8-1
Estimated Annual Project Construction Emissions – SNWW CIP Preferred Alternative

Year 2011	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	41.56	371.87	8.42	8.89	61.61	4.21
Construction Equipment	28.74	34.67	2.74	2.82	7.27	2.92
Employee Vehicles	4.35	0.285	0.006	0.013	0.004	0.422
Subtotal	**74.65**	**406.83**	**11.17**	**11.72**	**68.87**	**7.55**
Year 2012	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	166.23	1,487.47	33.70	35.55	246.42	16.84
Construction Equipment	52.04	128.65	12.64	13.02	28.39	10.71
Employee Vehicles	19.03	1.246	0.026	0.057	0.018	1.842
Subtotal	**237.29**	**1,617.37**	**46.36**	**48.62**	**274.83**	**29.39**
Year 2013	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	167.80	1,500.92	34.00	35.87	248.65	17.00
Construction Equipment	55.84	123.20	14.69	15.13	28.42	10.28
Employee Vehicles	19.75	1.293	0.027	0.059	0.019	1.912
Subtotal	**243.38**	**1,625.41**	**48.71**	**51.06**	**277.09**	**29.19**
Year 2014	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	172.79	1,540.20	34.89	36.81	255.21	17.54
Construction Equipment	60.84	118.58	17.26	17.79	29.42	10.16
Employee Vehicles	19.44	1.273	0.027	0.058	0.018	1.883
Subtotal	**253.08**	**1,660.06**	**52.18**	**54.66**	**284.65**	**29.58**
Year 2015	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	171.41	1,513.49	34.30	36.18	250.92	17.51
Construction Equipment	60.01	106.21	18.61	19.17	28.33	8.67
Employee Vehicles	19.49	1.276	0.027	0.059	0.018	1.887
Subtotal	**250.91**	**1,620.98**	**52.93**	**55.41**	**279.27**	**28.07**
Year 2016	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	161.73	1,417.91	32.14	33.91	235.16	16.63
Construction Equipment	53.71	91.89	19.44	20.03	26.69	5.92
Employee Vehicles	19.26	1.261	0.026	0.058	0.018	1.865
Subtotal	**234.71**	**1,511.06**	**51.61**	**54.00**	**261.87**	**24.42**
Year 2017	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	155.59	1,363.78	30.92	32.61	226.19	16.00
Construction Equipment	56.96	88.30	22.47	23.16	28.10	6.10
Employee Vehicles	20.05	1.316	0.028	0.061	0.019	1.945
Subtotal	**232.60**	**1,453.40**	**53.42**	**55.84**	**254.31**	**24.05**
Year 2018	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Dredge and Support Equipment	53.29	467.93	10.61	11.19	77.60	5.47
Construction Equipment	24.74	34.07	10.49	10.81	12.07	9.07
Employee Vehicles	6.82	0.446	0.009	0.020	0.006	0.660
Subtotal	**84.84**	**502.45**	**21.10**	**22.02**	**89.68**	**15.20**

Table 4.8-2
Total Annual Project Emissions Compared with BPA/Cameron/Calcasieu 2002 Emissions Inventory

2002 EMISSION INVENTORY	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
BPA	**134,953**	**86,242**	**10,618**	**50,702**	**39,966**	**39,913**
CAMERON/CALCASIEU	**95,016**	**68,265**	**6,319**	**13,098**	**58,397**	**34,553**
BPA/CAMERON/CALCASIEU	**229,969**	**154,507**	**16,937**	**63,800**	**98,363**	**74,467**
ANNUAL PROJECT EMISSIONS	**CO**	**NO_X**	**$PM_{2.5}$**	**PM_{10}**	**SO_2**	**VOC**
Year 2011	**74.65**	**406.83**	**11.17**	**11.72**	**68.87**	**7.55**
% of BPA	0.06	0.47	0.11	0.02	0.17	0.02
% of Cameron/Calcasieu	0.08	0.60	0.18	0.09	0.12	0.02
% of BPA/Cameron/Calcasieu	0.03	0.26	0.07	0.02	0.07	0.01
Year 2012	**237.29**	**1,617.37**	**46.36**	**48.62**	**274.83**	**29.39**
% of BPA	0.18	1.88	0.44	0.10	0.69	0.07
% of Cameron/Calcasieu	0.25	2.37	0.73	0.37	0.47	0.09
% of BPA/Cameron/Calcasieu	0.10	1.05	0.27	0.08	0.28	0.04
Year 2013	**243.38**	**1,625.41**	**48.71**	**51.06**	**277.09**	**29.19**
% of BPA	0.18	1.88	0.46	0.10	0.69	0.07
% of Cameron/Calcasieu	0.26	2.38	0.77	0.39	0.47	0.08
% of BPA/Cameron/Calcasieu	0.11	1.05	0.29	0.08	0.28	0.04
Year 2014	**253.08**	**1,660.06**	**52.18**	**54.66**	**284.65**	**29.58**
% of BPA	0.19	1.92	0.49	0.11	0.71	0.07
% of Cameron/Calcasieu	0.27	2.43	0.83	0.42	0.49	0.09
% of BPA/Cameron/Calcasieu	0.11	1.07	0.31	0.09	0.29	0.04
Year 2015	**250.91**	**1,620.98**	**52.93**	**55.41**	**279.27**	**28.07**
% of BPA	0.19	1.88	0.50	0.11	0.70	0.07
% of Cameron/Calcasieu	0.26	2.37	0.84	0.42	0.48	0.08
% of BPA/Cameron/Calcasieu	0.11	1.05	0.31	0.09	0.28	0.04
Year 2016	**234.71**	**1,511.06**	**51.61**	**54.00**	**261.87**	**24.42**
% of BPA	0.17	1.75	0.49	0.11	0.66	0.06
% of Cameron/Calcasieu	0.25	2.21	0.82	0.41	0.45	0.07
% of BPA/Cameron/Calcasieu	0.10	0.98	0.30	0.08	0.27	0.03
Year 2017	**232.60**	**1,453.40**	**53.42**	**55.84**	**254.31**	**24.05**
% of BPA	0.17	1.69	0.50	0.11	0.64	0.06
% of Cameron/Calcasieu	0.24	2.13	0.85	0.43	0.44	0.07
% of BPA/Cameron/Calcasieu	0.10	0.94	0.32	0.09	0.26	0.03
Year 2018	**84.84**	**502.45**	**21.10**	**22.02**	**89.68**	**15.20**
% of BPA	0.06	0.58	0.20	0.04	0.22	0.04
% of Cameron/Calcasieu	0.09	0.74	0.33	0.17	0.15	0.04
% of BPA/Cameron/Calcasieu	0.04	0.33	0.12	0.03	0.09	0.02

As shown in Table 4.8-3, estimated emissions of VOC for the Preferred Alternative are exempt from a General Conformity Determination because they are below the 100 tpy threshold for each year of anticipated activity. However, estimated NO_x emissions for the Preferred Alternative exceed the general conformity threshold, i.e., greater than 100 tpy, for all years of construction. Therefore, a General Conformity Determination for NO_x emissions would be required for these years.

Table 4.8-3
Summary of VOC Construction Emissions Subject to General Conformity

Year	Dredge and Support Equipment	Construction Equipment	Employee Vehicles	Total
2011	2.57	3.12	0.42	6.10
2012	12.38	11.43	1.84	25.65
2013	12.54	10.99	1.91	25.44
2014	13.82	10.86	1.88	26.57
2015	13.94	9.90	1.89	25.73
2016	14.22	8.69	1.87	24.78
2017	15.40	8.73	1.94	26.07
2018	5.47	34.89	0.66	41.02

Table 4.8-4
Summary of NO_x Construction Emissions Subject to General Conformity

Year	Dredge and Support Equipment	Construction Equipment	Employee Vehicles	Total
2011	217.77	34.05	0.29	252.11
2012	1,106.59	126.17	1.25	1,234.01
2013	1,120.03	120.72	1.29	1,242.05
2014	1,222.80	116.52	1.27	1,340.59
2015	1,208.15	104.22	1.28	1,313.65
2016	1,212.23	90.55	1.26	1,304.05
2017	1,312.36	87.97	1.32	1,401.65
2018	467.93	34.07	0.45	502.45

To initiate the General Conformity process, the USACE, prepared a document entitled, “Draft General Conformity Determination, Sabine-Neches Channel Improvement Project.” This document was noticed for public comment and was submitted by the USACE to the TCEQ, the EPA, and other air pollution control agencies, as appropriate, concurrently with the DEIS. As part of the General Conformity process, the USACE made this document available to the public for review and comment for a period of 30 days. The TCEQ has provided written concurrence that emissions from the Preferred Alternative are conformant with the Texas SIP for the BPA (Appendix A1). Based on the TCEQ's comments, the

USACE has prepared a Final General Conformity Determination for the proposed SNWW CIP (Appendix F).

4.9 NOISE IMPACTS

Project-related noise impacts were evaluated by considering the noise emissions related to dredge and placement operations of the proposed channel improvement project at noise-sensitive land uses (residential, educational, health care, recreational). Potential noise impacts associated with dredging and placement activities were evaluated by modeling predicted noise levels as a function of distance between the noise-generating equipment and noise-sensitive land uses in the vicinity of the project area. Noise levels were calculated based on industry accepted standards and properties of noise attenuation.

4.9.1 No-Action Alternative

Under the No-Action Alternative, the channel would not be deepened to project specifications. However, the existing regime of maintenance dredging, which generally includes a cutterhead suction dredge and various tending/crew boats within the channel, would continue as normal. Table 4.9-1 summarizes dredging-related noise levels produced by equipment type.

Table 4.9-1
Typical Noise Levels

Equipment	Noise Level (dBA)
Cutterhead Dredge (at 160 feet)	79[1]
Hopper Dredge (at 50 feet)	87[2]
Large Tug boat (at 50 feet)	87[3]
Small Tug Boat	72[3]
Bulldozer (at 50 feet)	82[4]
Bucket Crane (at 50 feet)	82[4]

[1] Geier & Geier Consulting (1997).
[2] Assumed same as large tug.
[3] Epsilon Associates (2006)
[4] FHWA (2006).

Potential short-term noise impacts related to the No-Action Alternative would occur during maintenance dredging activities throughout the channel's length. Noise-sensitive land uses exist in various locations along both sides of the channel's banks. These areas are concentrated in the cities of Port Arthur, Port Neches, and Beaumont. Other noise-sensitive land uses include recreational areas (J.D. Murphree State WMA, Sea Rim State Park, Sabine Pass Battleground State Park, and Pleasure Island) in the southern portion of the project. Table 4.9-2 summarizes the estimated noise levels produced by maintenance dredging activities at increasing distances from the ship channel. The No-Action Alternative would not result in permanent noise level increases, however, short-term impacts could be considered potentially significant at noise-sensitive land uses within 600 feet of maintenance dredging activities.

Table 4.9-2
Calculated Noise Levels of Maintenance Dredging

Distance From Center of Channel	Calculated Noise Level From Dredging Activities
160 feet	79 dBA (L_{eq})
300 feet	73 dBA (L_{eq})
600 feet	67 dBA (L_{eq})
1,200 feet	61 dBA (L_{eq})
2,400 feet	55 dBA (L_{eq})

4.9.2 Preferred Alternative

Under the Preferred Alternative, the channel would be deepened as described in Section 2.4. Equipment to be used for the proposed action would include separate crews consisting of a 30-inch hydraulic cutterhead dredge, three 500-horsepower tugboats, and one survey/crew boat within the channel. A large hopper dredge with tending boats would be used beyond the channel in the Gulf. However, noise levels associated with this portion of the project were not calculated since no noise-sensitive land uses are located beyond the channel. Although more than one crew could operate on the channel simultaneously, they would operate on separate reaches of the channel, and therefore would not be within the vicinity of noise-sensitive land uses at the same time. Dredging operations are expected to occur approximately 20 hours per day for a total of 7 years. Dredging activities would generate noise from a variety of equipment sources, however, the primary sources of equipment noise would include the dredges (with their associated pumps and generators) and tugboats (see Table 4.9-1). Smaller vessels, such as tending boats and survey boats, would not substantially contribute to the noise associated with dredging activities.

The proposed action under the Preferred Alternative is not expected to result in long-term noise impacts. No permanent noise sources would be installed as part of this project. In the short term, however, the proposed action could result in temporary elevated noise levels at noise-sensitive land use locations. Because the same type of equipment used for maintenance dredging would be used for the proposed action, short-term noise impacts related to the proposed action would be nearly identical to the short-term impacts that occur during current maintenance dredging, as discussed above in subsection 4.9.1. Table 4.9-2 summarizes the estimated noise levels produced by the proposed action at increasing distances from the ship channel. As is the case with current maintenance dredging, short-term impacts could be considered potentially significant at noise-sensitive land uses within 600 feet of the proposed project's dredging activities.

Reduction of the short-term noise levels could be achieved by using quieter-running equipment and by adding supplemental noise shielding around engines and pumps of the dredging equipment. Additional acoustical shielding panels could be used when the dredges operate in close proximity to residential areas. Additionally, dredging operations could be limited to daytime hours in proximity to residential areas. Limiting the hours of operation, however, would increase the length of the project significantly.

4.10 VEGETATION

4.10.1 No-Action Alternative

Under the No-Action Alternative, the combined effects of RSLR, shoreline recession, and interior marsh loss are expected to result in the significant loss of marsh and expansion of open-water areas, and this is likely to be exacerbated by the effects of global climate change. These processes would continue a trend of wetland loss that has been occurring in the study area in recent decades (Berman, 2005; Morton, 2003; Morton et al., 2005; Shinkle and Dokka, 2004; Titus and Narayanan, 1995). In Louisiana, a net land loss of 21 percent between 1978 and 2000 has been reported in the Chenier Plain subregion of coastal Louisiana, which includes the Sabine estuary (USACE, 2004a). In Texas, the most extensive losses of interior coastal wetlands in the state (12,632 acres between 1930 and 1978) have occurred in the Neches River delta. In total, over 90 percent of the emergent marshes in the Lower Neches River delta have been converted to open water, which is more than half of the total wetland loss in the State of Texas (Morton and Paine, 1990; Sutherlin, 1997; White et al., 1987). During this same period, NOAA documented a historical trend of mean sea level rise at its Sabine Pass tide gage of 0.2 inch/year over 48 years from 1958 through 2006 (USDC-NOAA, 2009), one of the highest on the Gulf Coast.

FWOP land loss projections for the SNWW project are based upon a single “most likely” estimate of 1.1 feet of RSLR by 2069. There is great uncertainty in the prediction of RSLR, which combines rates of global sea level rise and local subsidence. Uncertainties are related to the rate and degree of global climate change, including changes in the accumulation of greenhouse gases in the atmosphere, future trends in temperature and regional precipitation, the timing and quantity of freshwater inflows, sediment delivery to coastal marshes, and the rates of vegetative growth and biomass accumulation (Barras et al., 2004; IPCC, 2007; Langley et al., 2009; Nielsen-Gammon, 2009). In particular, some recent studies of geologic terrestrial and marine records support the plausibility of sea level rise on the order of 3.3 ± 1.64 feet by A.D. 2100 (Carlson et al., 2008; Rahmstorf, 2007; Rohling et al., 2008). Uncertainties in the rate of regional subsidence are related to the effect of anthropogenic factors such as oil, gas, and groundwater withdrawals, the compaction of deep reservoir rocks, the reactivation of surficial faults, and the erosion and/or accumulation of surface sediments (Gonzalez and Törnqvist, 2006; Milliken et al., 2008a, 2008b; Morton et al., 2006). This results in a very wide range of potential RSLR, calculated as stipulated by the most recent USACE relative sea level guidance (EC 1165-2-211, July 2009) to be between 0.3 and 2.8 feet over the period of analysis.

For this study, FWOP projections of land loss include the effects of rising salinities and shoreline recession associated with RSLR. Approximately 5,500 acres (7.5 percent) in Texas and 15,500 acres in Louisiana (10.5 percent) are forecast to be lost by 2069. In the near term, the marsh degradation process provides fisheries organisms with short-term benefits by releasing organic and mineral-rich sediments into the open-water system as the marsh is lost (Minello and Rozas, 2002). In the long term, the important ecological functions of the wetlands in the affected area would decline, resulting in the loss of fish and wildlife and their habitats, adverse effects on water quality, and reductions in erosion protection.

4.10.1.1 FWOP Shoreline Recession

The forecasted RSLR would result in the recession of Gulf and Sabine Lake shorelines in the SNWW study area. Potential problems associated with sea level change can be categorized into two classes; those of the open coast and large waterbodies where both water level and wave action are concerns, and those of inland tidal waters where wave action is usually much less severe (NRC, 1987). The NRC report discusses different approaches that can be used to model the change in shoreline configuration associated with RSLR. Two of those techniques were applied to project shoreline recession in the SNWW study area over the period of analysis (2019 through 2069).

The first technique is recommended for areas of active wave attack and erosion, and was applied to the Texas Gulf shoreline and the eastern shoreline of Sabine Lake. It is a historical trend analysis that includes an adjustment for higher future rates of RSLR. The second method was applied to the shorelines of interior lakes and inland waterways where the wave climate is subdued and the stable or accreting Louisiana Gulf shoreline (as described below). This method involves applying the projected change in sea level over the period of analysis to preexisting topography.

Two major factors influencing erosion and eventual shoreline profiles are fetch and exposure to predominant directions of wave approach (Wilson and Allison, 2008). In the SNWW study area, prevailing winds and wave approach are from the southeast; however, low-pressure weather systems (northers) frequently move across the upper coast from the north during winter months (Anderson, 2007). The portions of the study area most affected by these prevailing wind patterns are the Gulf shoreline and the eastern shore of Sabine Lake. In Sabine Lake, fetch and wave attack associated with prevailing southeasterly winds primarily affect the western shore, an area that is protected from erosion by riprapped levees around PAs 8 and 11. These levees are quite large and sufficiently high such that the rates of RSLR predicted here would have little to no effect. Winter northers, however, do affect the unprotected eastern shore of Sabine Lake (Greco and Clark, 2005; Parchure et al., 2005).

For the Gulf and east Sabine Lake shorelines, the historical trend, modified by the projected RSLR over the period of analysis, was used to project shoreline recession (NRC, 1987). Historical rates of change incorporate the inherent variability of the shoreline response based upon local coastal processes, local subsidence rates, coastline exposure, the local sedimentary environment, and eustatic sea level changes. This method assumes that the amount of recession during the historical record is directly correlated with the rate of sea level rise. Therefore, an accelerated rate of RSLR is assumed to result in a commensurate accelerated increase in shoreline recession. For example, a projected fourfold rise in the rate of RSLR in the study area would result in a fourfold increase in the recession rate. For the SNWW study area, the future rate of RSLR was forecast to be roughly 4.2 times the existing rate.

For this study, rates of existing historical Gulf shoreline change were obtained from several recent studies (Barras et al., 1994; BEG, 2009; USACE, 2004a). Most of the Texas shoreline in the study area experienced very high rates of shoreline retreat from the 1950s through 2002, ranging from –5 to –51 feet/year. However, small reaches near the SNWW west jetty and near Sea Rim State Park are stable or accreting. The BEG (2009) has developed a projected shoreline for the upper Texas coast for the year 2056, based upon historical Gulf shoreline changes. The historical rate of change includes historic rates of RSLR but not the accelerated rates expected in the future. The projected shoreline retreat was adjusted to account for the accelerated rate of future RSLR by multiplying the width of the BEG shoreline retreat by the projected increase in the rate of RSLR and mapping a revised shoreline with GIS, adjusted as needed for controlling features such as roadways or large chenier ridges that are likely to block retreat.

A similar method was followed for Sabine Lake; however, in this case an average annual loss rate provided by the USFWS was applied as the baseline historical rate. Erosion on the east shore of Sabine Lake is caused primarily by wind-induced waves and soft sediments (Parchure et al., 2005). The historical rate was calculated with a GIS analysis of aerial photographs taken between 1978 and 2004 (Greco and Clark, 2005). This analysis estimated an average shoreline retreat rate of 4.5 feet/year for the Sabine Lake shoreline between the Sabine River and Willow Bayou. For the purposes of this analysis, the 4.5 feet/year rate is applied to the entire east Sabine Lake shoreline as shoreline retreat is also a problem along the Sabine Lake shoreline between Willow Bayou and Blue Buck Point (LCWCR/WCRA, 1998). The 4.5-foot/year rate was increased by a factor of 4.2 to account for the accelerated rate of RSLR, resulting in an estimated 1,200 feet of shoreline retreat by the year 2069. The current shoreline was recessed by this width, except where other controlling features such as levees, cattle walkways, or roadways would block retreat, and the lost acreage was calculated by GIS.

For the Louisiana Gulf shoreline in the study area, no change was projected through the year 2050 (Barras et al., 1994). The history of shoreline change for this area, developed in conjunction with the Louisiana Coastal Areas Ecosystem Restoration Report (USACE, 2004a), documented that the segment of the Chenier Plain shoreline between Sabine Pass and Ocean View Beach (located 6 miles beyond the 10-mile SNWW study boundary) prograded seaward at an average rate of +12.9 feet/year between 1883 and 1994. Between 1985 and 1995, the average rate of progradation slowed to +1.2 feet/year. The shoreline in the study area is dominated primarily by the effect of the Sabine Pass jetties, which intercept the westward-moving littoral drift and tend to trap sediment, creating a more stable shoreline than that nearer to Ocean View Beach. For this study, a stable shoreline through the period of analysis was assumed, and the projected RSLR at the Gulf shoreline (1.1 feet in year 2069) was applied to the preexisting topography using the GIS method described below.

For the Louisiana Gulf shoreline and the shorelines of all other major waterways and waterbodies in the study area, the second method was applied. Preexisting topography along shorelines was assumed to be fixed; current shoreline elevation was combined with the projected increase in sea level to project a new shoreline. The increase in sea level at the end of the period of analysis (year 2069) is equivalent to the change in water surface elevation projected by the HS model for the FWOP with RSLR condition; this change is +1.1 feet throughout the study area. Slope is a major controlling variable in the determination of shoreline changes using this method. Steep slopes would experience little shoreline displacement while gentle slopes would show a much larger lateral change. It is assumed that man-made features such as jetties, roads and highways, dikes and levees, bulkheads and fill would continue to be maintained at a sufficient elevation that they would block shoreline retreat, and that current beneficial use projects that use dredged material to isolate interior wetlands from large waterways would be continued.

In the WVA EMCM, hydrologic unit acreages were adjusted to remove acres lost to RSLR-related shoreline recession for the FWOP land loss projection in the WVA model. This adjustment was made in the WVA land loss tables. The rate of acreage lost due to shoreline recession was assumed to be linear. The acres lost per year were subtracted from the base acreage before the revised land loss rate for the interior marsh was applied. This adjustment results in the removal of an equivalent amount of acres (lost due to RSLR only) from both the FWOP and FWP conditions. FWOP and FWP interior land loss rates were then applied to the remaining acreage, as described below, to determine the effect of salinity changes over the period of analysis in both the FWOP and FWP conditions.

In summary, the total acres of marsh forecast to be lost in the FWOP condition due to shoreline recession is 6,394 acres. The loss for each affected hydro-unit is shown in Table 4.10-1.

Table 4.10-1
Acres Lost to FWOP Shoreline Recession

HU #	HU name	Marsh Type	Marsh	Water	Total
Louisiana					
LA 2	Willow Bayou	Brackish	627	20	648
LA 3	Black Bayou	Brackish	621	9	630
LA 4	West Johnson’s Bayou	Brackish	957	130	1,087
LA 5	Sabine Lake Ridges	Brackish	685	49	734
		Saline	106	33	138
	Louisiana Subtotal		2,996	240	3,236
Texas					
TX 7	GIWW North	Fresh	8	0	8
		Intermediate	4	0	4
TX 8	Texas Point	Fresh	1	0	1
		Intermediate	68	2	70
		Brackish	813	40	852
		Saline	2,043	151	2,194
TX 9	Salt Bayou	Fresh	0	0	0
		Brackish	27	3	30
	Texas Subtotal		2,962	196	3,158
Total	**Project Area**		**5,958**	**436**	**6,394**

4.10.1.2 FWOP Interior Marsh Loss

4.10.1.2.1 Interior Marsh Loss

Land loss rates for interior marsh areas were adjusted to account for increasing salinity due to RSLR over the period of analysis using the land loss methodology of the WVA and a productivity-based land loss projection methodology based upon a salinity-vegetation productivity relationship developed for the habitat productivity component of the LCA Ecosystem Model (Visser et al., 2004).

The deepening project would result in a minimal increase in water elevation over the majority of the project area (averaging less than ½ inch). Thus no FWP impacts due to water elevation increases are anticipated. It is, however, assumed that all tidally influenced habitats would see a gradual increase in water elevation associated with a RSLR of 13.2 inches by 2069.

The effects of the projected rate of RSLR on coastal marshes are very difficult to predict. The RSLR rate at which marsh will convert to open water depends on the rate of marsh elevation gain by sediment accumulation and/or biological mechanisms such as biomass accumulation (Langley et al., 2009). Dams on both the Sabine and Neches rivers have decreased sediment deposition downstream in the coastal marshes, making biological processes very important in their long-term sustainability. It is possible that biomass accumulation would offset much if not all of the RSLR change in water surface elevation. "Primary productivity of salt marsh vegetation is regulated by changes in sea level, and the vegetation, in turn, constantly modifies the elevation of its habitat toward an equilibrium with sea level (Morris et al., 2002). A rise in relative sea level brings an increase in production and biomass density that enhances sediment deposition by increasing the efficiency of sediment trapping. This can lead to an absolute increase in the elevation of the marsh platform and result in a landward migration of the marsh (Gardner et al., 1992, Gardner and Porter, 2001). This may change total wetland area, depending upon local geomorphology and anthropogenic barriers to migration, such as bulkheads, canals, etc.

Existing coastal marshes appear to have adapted to historical ranges of mean sea level, and gradual changes in RSLR. There has been a decrease in the loss rate in the Sabine-Calcasieu area from 7.0 to 2.6 square miles (17.1 to 3.3 percent) (Barras et al., 1994). Furthermore, the high rate of RSLR in this region may be ameliorating, as the average increase at the Sabine Pass tide gage was 0.3 inch/year for the 41-year period between 1958 and 1999 compared to 0.2 inch/year for the 48-year period between 1958 and 2006 (USDC-NOAA, 2006, 2009). FWOP projections of coastal land loss in the Louisiana portion of the SNWW study area forecast relatively stable landforms and shorelines through 2050 (Barras et al. 1994), not accounting for the effects of tropical storms and hurricanes. In general, the interior marshes in the Louisiana portion of the SNWW study area appear to have stabilized and are not undergoing rapid conversion of large areas to open water like areas to the east in Louisiana (LCWCR/WCRA, 1998; USACE, 2004a). Recent Louisiana LIDAR data shows that existing marsh is higher than the projected RSLR for the period of analysis and thus should be able to withstand the gradual rise in elevation (Louisiana State University, 2009).

Similar large-scale FWOP land loss projections are not available for the Texas portion of the study area. However, this study assumed that the Texas portion would also remain relatively stable with respect to the effects of RSLR through the period of analysis because the same chenier landforms, marshes, and sediments are present throughout the study area. A GIS study of aerial photographs of the Salt Bayou/Keith Lake system confirmed that the open-water trend has slowed and possibly reversed itself in that area in recent years (TPWD, 2003). Texas interior marshes most at risk to the effects of RSLR are located in the Texas Point NWR and just outside and to the west of the SNWW study area in the McFaddin NWR. Most recently, marshes in these areas have been highly stressed due to the combined effects of Hurricane Ike's storm surge and a subsequent drought, which caused prolonged high salinities throughout these marshes.

However, many different climatic, physical, and biological processes can affect the rate of accumulation. Recent experimental evidence suggests that increasing atmospheric CO_2 concentrations could stimulate biogenic mechanisms of elevation gain in a brackish marsh, and further, that this effect could be enhanced under salinity and flooding conditions expected with future RSLR (Langley et al., 2009). This response is further complicated by variations in sediment supply from river discharges and variations in primary production due to changes in nutrient loading, precipitation, temperature, and other factors (Morris et al., 2002). Gulf shoreline erosion associated with accelerated rates of RSLR may increase the amount of near shore sediment. Wilson and Allison (2008) have shown that material released by Gulf shoreline erosion remains nearshore rather than being dispersed into offshore waters, therefore remaining available for redeposition by tidal flooding or storm surge overwash. In addition to RSLR, future changes in climate would influence the quantity and timing of freshwater delivery to the coastal estuaries. At this time there is no consensus in the direction or amount of changes in precipitation in the study area, while a temperature increase of 4°F is likely by 2059 (Nielsen-Gammon, 2009). Whatever the net effect of climate change on basin runoff, most climate change projections agree that more frequent high-intensity rainfall events are likely. In most drainages, this type of event would most likely produce increased sediment runoff, and thus periodically increase sediment delivery to the coastal marshes. Uncertainties related to all of these processes could result in very different predictions of future marsh conditions.

It must be recognized that large areas of interior marsh could quickly convert to open water under certain extraordinary events. If RSLR accelerates to the extent that the coastal plant community cannot sustain an elevation within its range of tolerance, rates of primary production would decrease, resulting in an unstable and rapidly deteriorating marsh community (Morris et al., 2002). In addition, if shoreline recession cuts existing foredune formations, large areas of interior marsh could quickly be exposed to higher-salinity Gulf waters and wave attack. In this case, large marsh areas could quickly be lost to the Gulf.

The EMCM was used to forecast land loss in the emergent marshes of the study area. Variable V_1 (percent emergent marsh) of this model requires the projection of the number of acres of emergent marsh that would remain at the end of the period of analysis, both without and with the project. The WVA land loss methodology assumes that historical trends can be used to predict future land loss rates. Baseline historical land loss rates were determined by measuring changes over the most recent 15- to 20-year time period for which reliable data were available. These rates include the chronic, regional effects of subsidence, altered sediment delivery, global sea level rise, and tropical storms and hurricanes. They were calculated from a period that postdates high oil and gas extraction in the region and thus exclude subsidence that may be related to the higher rates of extraction, which have waned significantly in recent decades. After changes in acreages were calculated, the amount of emergent marsh that converted to open water was expressed as a percentage loss per year.

Increasing salinity levels associated with accelerating RSLR would be expected to reduce the primary productivity of the marsh and increase the land loss rate. Associating a decrease in primary productivity with an increase in salinity is based upon documented biological responses of inundated vegetation to salinity. The expected reduction in biological productivity of wetlands in the study area as a result of salinity stress is discussed in Section 4.6. Decreased plant productivity has been demonstrated to result from the interaction of excessive submergence and salinity. This interaction leads to a decrease in organic matter accumulation, which, in turn, results in greater submergence because the rate of increase in marsh elevation cannot keep up with the rate of submergence due to RSLR (Day and Templet, 1989; Day et al., 1995; DeLaune et al., 1994; Nyman et al., 1993; Spalding and Hester, 2007). The death of wetland vegetation often results, followed by peat collapse, erosion, and wetland loss (DeLaune et al., 1994; Gough and Grace, 1999; Salinas et al., 1986; Visser et al., 1999; Webb and Mendelssohn, 1996).

FWOP effects of RSLR to interior marsh areas are expected to be limited to the effects of increasing salinity. FWOP land loss rates were adjusted for the gradually rising salinity using the productivity-based land loss projection described below. Although emergent marshes throughout the tidally influenced portions of the study area would experience a gradual increase in water elevation associated with a RSLR of 1.1 feet by 2069, biomass accumulation was assumed to offset all of the RSLR increase in water surface elevation. The total amount of interior marsh expected to be lost in the FWOP condition, exclusive of the approximately 6,000 acres lost to shoreline recession, is approximately 15,000 acres.

4.10.1.2.2 Productivity-Based Land Loss Projection

In order to provide a science-based and systematic evaluation of the project effects for the SNWW WVA model application, the HW applied a productivity-based method of land loss projection that is based upon a salinity-productivity relationship developed for the habitat productivity component of the LCA Ecosystem Model (Visser et al., 2004). In the LCA Ecosystem Model, productivity algorithms were developed for all herbaceous and forested wetlands based on available published and unpublished data. That report documented extensive literature on the effect of salinity on the productivity of the dominant species in each of the habitats in this study area (see Section 4.6). These studies used various measurements of productivity, including total biomass, stem/leaf elongation, and photosynthesis, that were gathered using greenhouse experiments on saturated soils. To better illustrate the relationship of salinity and productivity, linear regression equations were developed that predict percentage changes in habitat productivity per 1 ppt salinity for each major coastal habitat type, regardless of inundation, as shown in Table 4.10-2. These predicted changes in primary productivity for every 1 ppt increase in salinity were used to predict land loss rate changes in the current study.

4.10.1.2.3 Assumptions and Uncertainties of the Productivity-Based Land Loss Projection

Relating changes in salinity to specific amounts of land loss is problematic. While there is extensive literature that relates increases in salinity to decreased productivity, vegetation stress, and eventual wetland loss, the USACE and the ICT are not aware of any studies that have documented specifically how much land loss is associated with specific increases in salinity. Similarly, no data are currently available that relate salinity reduction with a reduction in land loss (Visser et al., 2004). Therefore, the HW assumed a direct linear correlation between decreased primary productivity due to salinity increases and increased land loss rates due the project (see Table 4.10-2). The HW considered increasing land loss rates for salinities that changed from optimal to suboptimal conditions and, conversely, also considered decreasing land loss rates in target years 20 to 50. The latter consideration is based upon historical observations that land loss rates generally stabilize and lessen a few decades after channel deepening projects are completed. Since the effects of these considerations would generally offset one another, the HW opted for the simpler 1:1 relationship.

Table 4.10-2
Productivity-Based Land Loss Projection

Habitat Type	% Productivity Lowered and Land Loss Rates Increased per 1 ppt Increase in Salinity
Fresh marsh	11.1
Intermediate Marsh	11.4 (*Sagittaria*), 2.3 (*Spartina patens*); mean = 6.8
Brackish	2.6
Saline	2.1

The relationship between productivity decreases and land loss rate increases is assumed to be linear; thus, a 1 percent decrease in productivity translates to a 1 percent increase in the land loss rate. For example, in Table 4.10-2, the productivity of fresh marsh decreases by 11.1 percent with every salinity increase of 1 ppt for fresh marshes. This translates to an 11.1 percent increase in the land loss rate for every 1 ppt increase in salinity. The following standard formula was applied to calculate FWP rates used in the WVA land loss spreadsheets.

FWP land loss rate = (((fwp salinity ppt – fwop salinity ppt) x percent productivity decrease per habitat type) + 1) x baseline land loss rate)

4.10.1.3 FWOP SAV

The salinity change occurring with RSLR in the No-Action Alternative would be very gradual, and therefore the SAV community structure in the majority of intermediate marshes would likely change to include more salinity-tolerant species, such as widgeon-grass, pondweed (*Potamogeton pectinatus*), Eurasian watermilfoil, and freshwater eelgrass (USGS, 1997). It is expected that any SAV cover lost as a result of this change would be replaced by the salinity-tolerant SAVs continuing to grow within their tolerance range. As a result, no change in percent SAV cover would be expected during the period of analysis.

4.10.1.4 FWOP Effects of Hydrologic Management Structures

The hydrologic management of emergent tidal marsh has also been shown to contribute to land loss in nearby areas, such as the eastern section of the Sabine NWR, by increasing both salinity and the duration of inundation in managed marshes. The potential for hydrologic management in the study area to contribute to land loss is reviewed in subsection 4.6.3.2.1. None of the current hydrologic management measures in the study area (the western Sabine NWR excluding Pool 3, the Black Bayou area, the Texas Point and McFaddin NWRs) lead to long-term ponding or significant delays in the ability of the wetlands to drain after periodic salinity incursions (i.e., droughts or hurricanes), and thus no adverse FWOP impacts associated with managed marshes would be expected.

4.10.1.5 FWOP Adjustments for CWPPRA Marsh Restoration Projects

FWOP adjustments to acreages for constructed or funded CWPPRA projects in the east Sabine Lake marshes (Clark et al., 2000; USFWS and NRCS, 2008a), at Black Bayou (USFWS and NRCS, 2008b), and at Perry Ridge (USGS-NWRC, 2002a, 2002b) were applied in the WVA land loss spreadsheets as had been done previously. Acres of restored marsh were added in the FWOP and FWP marsh (acres) columns in the target year in which they were completed.

4.10.2 Preferred Alternative

4.10.2.1 FWP Effects on Cypress-Tupelo Swamps and Bottomland Hardwood

The Preferred Alternative would have no direct construction impacts to bottomland hardwoods or swamps, and the FWP "most likely" salinity levels would not result in the loss of any swamp or bottomland hardwood forest acreage. In the swamp communities, salinities would exceed the optimal range at Adams Bayou and in the Blue Elbow South hydro-unit. However, FWP salinities would not exceed 4 ppt and thus would not be high enough to result in the conversion of swamp to marsh, or in the loss of forested wetland acreage (Visser et al., 2004). Bottomland hardwoods on the upland terrace margin near the mouth of the Neches River, along Adams Bayou, and at Perry Ridge would be exposed to occasional insults of salinities exceeding the optimal range, but at levels that are insufficient to cause a significant loss of productivity.

4.10.2.2 FWP Land Loss

4.10.2.2.1 FWP Shoreline Recession

Shoreline recession along the eastern shoreline of Sabine Lake would not be affected by the proposed project (Parchure et al., 2005). The deepening project does not significantly increase tidal amplitude, velocity, or water surface elevation and thus would cause no additional recession of the lake shoreline (Brown and Stokes, 2009).

Bank erosion along the SNWW navigation channels is not expected to increase in the FWP condition, and thus would not contribute to shoreline recession over the period of analysis (Maynord, 2005). Existing erosion of navigation channel banks is caused primarily by vessel wakes. It is predicted that the deeper channel would result in slightly few vessel trips than the FWOP condition and thus not increase erosion.

FWP erosion of the Gulf shoreline is predicted to increase slightly over the FWOP condition. A deeper and longer entrance channel would have some effect on waves moving from the Gulf to the shore, and that would in turn exert an effect on the rate of longshore sediment transport (Gravens and King, 2003). It is predicted that this would result in the loss of 18 acres of Gulf shoreline within 4 miles from the jetties over the period of analysis.

4.10.2.2.2 FWP Interior Marsh Loss

FWP impacts would be expected to result when increased FWP salinities interact with FWOP submergence to cause a marginally higher land loss rate, exacerbating the process already occurring in the FWOP condition. The EMCM was used to forecast FWP land loss; rates were adjusted using the productivity-based projection to include the effect of gradually rising FWOP salinities and the abrupt FWP incremental salinity increase in TY 15 (the year of project completion). See tables 4.1-3 and 4.1-4 for the FWP impacts to wetland acres by habitat type in Louisiana and Texas, respectively, before the application of benefits from BU features.

Table 2.4-16 provides a summary of the project impact analysis and net losses/benefits after application of the BU plan benefits. In Louisiana, the WVA model forecasts that 691 more wetland acres in Louisiana would be lost over the period of analysis in the FWP condition. The highest losses are projected to occur in intermediate marsh (78.5 percent), with 8.5 percent in fresh marsh, 11 percent in brackish marsh, and 2 percent in saline marshes. Wetland losses in Louisiana are fully compensated by marsh mitigation measures described in Section 5.0. In Texas, the overall net change in wetland acreage is positive due to the benefits of the Neches River BU Feature. There is a net gain of 2,606 acres of emergent marsh, 12 percent fresh, 42 percent intermediate, and 46 percent brackish marsh.

4.10.2.2.3 FWP SAV

SAV impacts would be similar to expected changes in the FWOP condition. The SAV community structure in the majority of intermediate marshes would likely change to include more salinity-tolerant species, such as widgeon grass, pondweed, Eurasian watermilfoil, and freshwater eelgrass (USGS, 1997). An increase in salinity would occur with dredging of the Sabine Pass and Sabine Pass Jetty channels. The HS model projects that the incremental salinity increase would average 1.3 ppt near the mouths of Sabine and Keith lakes, 0.8 ppt in the east Sabine Lake marshes, 0.7 ppt on the lower Neches and Sabine rivers, and less than 0.15 ppt on the upper Neches and Sabine rivers. Since salinity change is a function of the total dredging template, the time required to reach a new FWP equilibrium would likely be considerable, ranging from a conservative minimum of several months to even a year, because each wetland would be responding to salinity inputs from multiple sources (Gary Brown personal communication, 2009). The most rapid change (on the order of 2 to 3 months) would likely occur in marshes immediately adjacent and open to tidal exchange with the navigation channel that has just been dredged. Because of the salinity effect of the existing navigation channel, wetlands adjacent to the channel are likely to contain SAVs with greater salinity tolerances, and thus would be able to adapt to the FWP change more easily.

The Neches River BU Feature and the Louisiana mitigation measures would likely cause SAV impacts because of temporary but greatly increased turbidity associated with the hydraulic placement of dredged material for marsh restoration. It was assumed that construction would result in the die-off of SAVs in the vicinity of placement activities during the year of construction, followed by quick rebounds associated with increased nutrient input, and the creation of shallow, protected ponds within the restored marsh. No seagrass would be affected by the Gulf Shore BU Feature, and no impacts to other types of submerged aquatic vegetation are expected from channel deepening. Seagrasses and other types of submerged aquatic vegetation are not found along the margins of SNWW channel because conditions conducive for SAV growth (i.e., calm waters and low turbidity) are not present.

4.10.2.2.4 Adjustments for Land Gains from BU Features and Mitigation Measures

Marsh restoration proposed as BU features or compensatory mitigation adds mineral soils to degraded areas of former marsh. The addition of denser mineral soils and the increase in marsh elevation were assumed to create a more stable landform, and the increase in the land loss rate due to the project was reduced by 50 percent in the WVA land loss change spreadsheets. Other mitigation measures that did not involve the creation of a higher, more-stable landform were modeled using a land loss rate equivalent to the FWP rate.

4.11 AQUATIC ECOLOGY

The following presents a discussion of potential impacts to freshwater and marine communities from the No-Action and Preferred alternatives. A description of each community type discussed below can be found in Section 3.10.

4.11.1 Freshwater

Freshwater fauna adapted to low-salinity environments are generally restricted to the upper reaches of the tributaries of Sabine Lake and their distribution depends on the extent of freshwater inflow into the estuary. Portions of the tidal reaches of the Neches (downstream of the saltwater barrier) and Sabine rivers generally support freshwater fishes. The Rose City Marsh and the upper reaches of Bessie Heights Marsh that are farthest from the study area are also freshwater ecosystems under normal conditions. Other predominantly freshwater streams that flow into Sabine Lake or the tidal reaches of the Neches and Sabine rivers include Taylor, Cow, Adams, and Little Cypress bayous in Texas, and Black and Johnson’s bayous in Louisiana. Additional descriptions of the existing environment are provided in Section 3.10.

Sabine Lake was predominantly a freshwater-dominated ecosystem prior to early navigation improvements, subsidence, oil and gas exploration, and subsequent marsh erosion. Saltwater intrusion into the lake and its tributaries is largely responsible for the transformation of the lake into a euryhaline environment. While most of this change occurred in the early part of the twentieth century, the peripheral marshes and tributaries have continued to change as a result of saltwater intrusion, although at a much slower rate than before.

In particular, specific impacts to the freshwater ecosystems within the study area include the degradation of Bessie Heights, Rose City, and Old River Cove marshes through subsidence, intrusion of salt water, and vegetation loss, which have caused substantial conversion of freshwater marsh to open water. As the organic soils that support marsh vegetation erode because of saltwater intrusion, open-water areas expand

and exposure to salt water increases along the remaining marsh edge. This process further facilitates encroachment of salt water into the tributaries of these marsh areas. These processes also impact other freshwater marsh and tributary areas adjacent to Sabine Lake.

The Rose City Marsh presently consists of freshwater habitats. There is little or no information that describes the present state of this freshwater ecosystem or its recreational benefits. However, anecdotal information indicates that a viable freshwater community exists in the open water, channels, and tributaries of the Rose City Marsh. This area supports some recreational fishing to an unknown extent.

The movement of saline water into Bessie Height Marsh is generally greater than Rose City Marsh since it is farther downstream and has more hydraulic connections to the Neches Ship Channel. The diversity, distribution, and importance of freshwater fauna in this area are not well known but are likely spatially restricted as a result of saltwater intrusion. Species that occur in the open-water portions of Bessie Heights Marsh tend to be euryhaline.

Marshes at Old River Cove are exposed to higher salinities than all other marshes on the Neches River tidal because of their location where the Neches Ship Channel connects with the Sabine-Neches Ship Channel. Like Bessie Heights, the distribution and role of freshwater fauna in this area are not well known; however, intrusion of saline water probably restricts their diversity and distribution. Much of this area is managed by TPWD as the Old River Unit of the Neches River WMA. A 2,500-acre area of controlled, isolated wetlands covers the eastern half of the marsh. Intake and outfall canals for a large power plant draw higher-saline waters from Old River Cove and discharge them into the Neches Ship Channel just upstream of the Rainbow Bridge. Salinities west of the outfall canal tend to be lower because this area is buffered by the bank of the canal and receives lower salinity overland flow from the Bessie Heights area. Widgeon grass is abundant in shallow waters west of SH 87, but SAVs are not common east of the highway. Roadside ditches and the utility canals provide access to estuarine species.

4.11.1.1 No-Action Alternative

Two factors are likely to influence freshwater communities in the FWOP scenario. It is possible there would be a long-term reduction in freshwater inflow to the estuary since the human population of the state is expected to double during the life of the proposed project. The doubling of the population may increase demand for freshwater inflow, which may in turn result in lower freshwater inflows to the estuary. The second factor is relative sea level rise, which is predicted to continue. RSLR would gradually increase salinities in portions of the estuary. In the absence of the project and associated marsh restoration projects, the loss of freshwater marsh habitats would likely continue, in part due to continued RSLR, although RSLR is not expected to significantly change salinities in freshwater portions of the project area. Salinities would likely increase in tributaries to the estuary, causing continued conversion of fresh water to brackish marsh, in turn, favoring colonization by euryhaline species. These changes would occur slowly under most circumstances, although catastrophic changes associated with events like hurricanes might cause changes to occur more rapidly. There is considerable uncertainty regarding freshwater inflows to the estuary in the future.

4.11.1.2 Preferred Alternative

The Preferred Alternative includes the Neches River BU Feature, which is designed to restore the elevation in the Rose City, Bessie Heights, and Old River Cove marshes. The restoration efforts would likely impact short- and long-term, existing open-water communities. A significant portion of the open water of each marsh would be converted to shallow marsh with emergent vegetation. This habitat conversion should reduce intrusion of salt water into portions of those marshes.

Short-term impacts would be associated with marsh construction. Placement of dredged material might result in an initial increase in turbidity in the marsh and nearby tributaries. Increased turbidity might result in a short-term reduction in the distribution of SAV in the Rose City and Old River Cove marshes. The initial placement of dredged material would aid in reducing saltwater intrusion and would create more areas of quiescent water allowing SAV to repopulate the areas quickly after construction of the mitigation marshes.

Long-term impacts include the conversion of open-water habitat to marsh habitat. Some recreational benefits exist in the present open-water areas of the marshes. Under normal conditions, Rose City and Bessie Height marshes are essentially open-water, shallow, brackish to freshwater lakes. The marsh restoration would significantly reduce the amount of open-water area. Additionally, the freshwater ecosystem would be protected from future saltwater intrusion. Restoration efforts in this area would maintain channels, drainages, and some open water, which would greatly improve the complexity and diversity of marsh habitats and improve the ecological and recreational benefits of this marsh.

The upper reaches of the Neches and Sabine rivers and their tributaries in the study area support valuable freshwater habitats. Modeling of potential salinity intrusion into the Neches and Sabine rivers associated with the project indicated that mean salinities on the upper Neches River would remain near existing conditions over most of the study area. However, slightly higher salinities are expected in swamps and fresh marsh communities on or near the Sabine River near the GIWW and in the extensive fresh marsh north of the GIWW in Texas. These potential changes are expected to cause small reductions in the health and biological productivity of freshwater habitats. Increases in salinity are expected to cause additional stress on some fresh and intermediate marsh vegetation, over approximately 173,750 acres of fresh and intermediate marsh in Texas and Louisiana over the study area as a whole. No loss of swamp or bottomland hardwoods is projected. Reduced growth of some trees in the cypress-tupelo swamps, particularly near the Sabine River, is expected as a result of the slight increase in salinity from the project. The loss of freshwater habitat would be expected to increase access to mineral-rich sediments and organic nutrients in the short term for estuarine fauna, leading to a temporary increase in productivity. But the increased productivity would decline as the freshwater habitats disappear, eventually leading to some reduction in freshwater fauna productivity (Minello and Rozas, 2002). The Neches River BU Feature is intended to create 4,958 acres of restored emergent marsh, improved shallow-water habitat, and nourished existing marsh in Rose City East, Bessie Heights East, and Old River Cove. The Neches River BU Feature is also intended to offset the direct loss of 86 acres of freshwater wetland used for the creation of

PA 24A. Once the project, including the DMMP BU features and compensatory mitigation, leads to an overall net gain in marsh habitat, no detrimental impacts to fauna are anticipated.

4.11.2 Marine

4.11.2.1 Estuarine Habitats and Fauna

4.11.2.1.1 No-Action Alternative

Under the No-Action Alternative, estuarine habitats and fauna would continue as described in subsection 3.10.2.1. However, it should be noted that the No-Action Alternative does not imply that there would be no dredging or placement activities. Maintenance dredging will continue as it has in the past.

4.11.2.1.2 Preferred Alternative

Due to the reproductive capacity and natural variation in phytoplankton populations, short-term, localized increases in turbidity associated with dredging within the project area are not expected to be significant (Brannon et al., 1978; May, 1973; Odum and Wilson, 1962). Under most conditions, fish and other motile organisms are only exposed to localized suspended-sediment plumes for short durations (minutes to hours) (Clarke and Wilber, 2000). Should marsh communities benefit from the Preferred Alternative, finfish and shellfish would also benefit. The potential for the deepening to cause widening at the top of cut as the side slopes adjust to the new project depth has been evaluated. The present 40-foot channel has been in existence since the early 1970s and has had adequate time for the dense clay sediments to stabilize. Deepening will be performed by making a box cut in the bottom of the existing channel. Some slumping of the side slope at the base of the channel may occur as the deeper channel stabilizes, but no slumping is expected at the top of cut. Therefore, no impacts to oyster reef located adjacent to the top of cut in Sabine Pass are expected. No emergent marsh or shallow bottom is present adjacent to the top of cut.

There are one-time effects of the borrow trench and access channel in Sabine Lake and dredging of accumulated sediments in the Lake Charles Deepwater Channel. The Preferred Alternative would impact approximately 275 acres (225 acres for the borrow trench and 50 acres for the access channel) of lake bottom within Sabine Lake, a designated Louisiana Public Oyster Area. Dedicated dredging of Sabine Lake would be performed to supply sediment needed to restore 687 acres of emergent marsh, improve 167 acres of shallow water, and nourish 1,112 acres of existing marsh within the 1,966 total acres in Willow Bayou Mitigation Areas LA 2-18B and LA 2-ADD B. Approximately 3.1 mcy of material would be dredged from a 1.8-mile-long trench in Sabine Lake, located at least 1,000 feet from the Sabine NWR shore, averaging 1,030 feet wide by 7.5 feet deep. The borrow trench would be continuous and parallel the current shoreline; the common longshore circulation pattern in Sabine Lake is expected to eventually fill the trench with Sabine River sediments. An access channel, approximately 8 miles long, from the GIWW near the mouth of the Sabine River would be needed for the dredge to reach the proposed borrow trench area. The exact locations of the borrow trench and access channel would be determined in consultation with the ICT after PED bottom surveys of potential locations. Also, accumulated material would be dredged from the 30-foot Lake Charles Deepwater Channel, which is co-located with the GIWW in Louisiana (13 miles long by 125 feet wide beginning just past Pavel Island Channel and extending eastward, removing approximately 15 feet of accumulated sediment). The Lake Charles Deepwater Channel was completed in 1926 (USACE, 1998c) and the last known dredging occurred in 1940. Material would be hydraulically dredged and placed in Black Bayou Mitigation Areas LA 3-15B and 3-18B. The mitigation measure at West Black Bayou (LA 3-10R) would be constructed using maintenance material from the Sabine River Channel to Orange over a 30-year period. The Sabine River Channel dredging is a FWOP impact because it occurs as part of the normal maintenance dredging practices for the Sabine River Channel.

One-time impacts of the borrow trench and access channel dredging in Sabine Lake for the mitigation measures in Willow Bayou include an increase in water column turbidity during dredging activities; however, such effects are temporary and local. No further effects to water quality are expected. Benthic fauna would be removed due to evacuation of sediment during dredging activities; however, benthic organisms can rapidly recolonize, and no long-term effects are anticipated. Details of potential impacts from borrow trench dredging to benthos, salinity, SAV, oysters, and water quality are found in subsections 5.5.1 (Willow Bayou Mitigation) and 5.5.2 (Black Bayou Mitigation).

The potential for the removal of sediments from Sabine Lake for marsh mitigation to affect oyster reef has been evaluated. An oyster assessment was performed in 2006 (T. Baker Smith, Inc., 2006) near the area of the proposed Sabine Lake access channel and borrow trench in conjunction with an unrelated Department of Army permit application. Bottom types were found to consist of 90 percent firm mud and buried shell, 8 percent soft mud, and 0.7 percent exposed shell/reef. No live oyster reefs were found. Similar bottom types are expected in the area of the proposed access channel and borrow trench, which are located directly east of the surveyed area. Optimal salinities for oyster growth are from 10 to 15 ppt (Armstrong et al., 1987). Salinities in this area of Sabine Lake range from 1 to 6 ppt year-round, too fresh for oyster development (Fagerburg, 2003). During construction of the access channel and borrow trench, no impacts to extant live oyster reefs are likely. Nonetheless, prior to project implementation, a full water bottom assessment would be conducted by the USACE in accordance with the LDWF survey standards. This survey would be necessary in order for the LDWF to consider a waiver of compensation for impacts to the water bottoms of the Sabine Lake Public Oyster Area.

With the deepening of the channel, a small increase in salinity would be observed (see Section 4.6). Most organisms occupying these environments are ubiquitous along the Texas and Louisiana coast and can tolerate a wide range of salinities (Parker, 1965; Pattillo et al., 1997). Therefore, no adverse effects on fauna are expected due to changes in salinity that may result from the Preferred Alternative, except loss of habitat due to salinity impacts on marshes. Small increases in salinity under median-flow conditions would affect all tidally influenced brackish and saline marshes in the SNWW study area (approximately 37,000 acres). As discussed in Section 4.6, these potential changes are expected to cause small reductions in the health and biological productivity of these habitats. Increases in salinity are expected to cause additional stress on some marsh vegetation. However, since the project, including the DMMP BU features and compensatory mitigation, leads to an overall net gain in marsh habitat, no detrimental impacts to fauna are anticipated.

There is little difference in the likelihood of oil spills with the No-Action or Preferred Alternative except that inclusion of bend easings should make channel transits safer. In the unlikely event a petroleum product spill should occur, however low the probability, adult crustaceans such as shrimp and crabs and adult finfish are probably mobile enough to avoid most areas of high oil concentrations. Larval and juvenile finfish and shellfish tend to be more susceptible to oil than adults and could be affected extensively by an oil spill during their active immigration periods. Due to their lack of mobility, they are less likely to be able to avoid these areas and could be negatively impacted if a spill were to occur. Benthic fauna may be killed, but phytoplankton may be adversely or favorably affected by oil spills. It is unlikely that an oil spill in the project area would result in significant, long-term impacts to either phytoplankton or benthic communities, since these organisms have the ability to recover rapidly from a spill due primarily to their rapid rate of reproduction and to the widespread distribution of dominant species.

4.11.2.2 Offshore Habitats and Fauna

4.11.2.2.1 No-Action Alternative

Under the No-Action Alternative, Gulf habitats and fauna would continue as described in subsection 3.10.2.2 with maintenance dredging and placement of dredged material in four designated ODMDS sites.

4.11.2.2.2 Preferred Alternative

Construction excavation removes benthic organisms from their habitat and sends them through the dredge into the hopper. Most cannot be expected to survive placement in the adjacent ODMDS. However, the benthic community can rapidly recolonize, both on the channel bottom and in open-water PAs. Since the benthic community occupying the channel bottom is continually disturbed by passing ships, maintenance dredging, while it may kill the organisms dredged, is not expected to change the community living there after recolonization.

Construction of the Extension Channel would physically disturb benthic communities in the proposed channel prism. Impacts to benthic organisms during maintenance dredging are expected to be minor. While there is some recolonization between cycles, sediments in the channel are continuously disturbed by passing ships. Placement of dredged material in the offshore placement site would bury those benthic organisms incapable of escaping or burrowing up through the dredged material. Organisms that are buried must vertically migrate or die (Maurer et al., 1986). Maurer et al. (1986) demonstrated that many benthic organisms were able to migrate vertically through 35 inches of dredged material under certain conditions; however, the species present in early successional stages of recovery are not the same as those buried by the dredged material. Although vertical migration is possible, most organisms at the center of the disturbance do not survive, but survivability was shown to increase as distance from the disturbance increased (Maurer et al., 1986). Benthic organisms would not long survive placement into upland PAs.

Potential beneficial effects of the suspended material associated with dredging operations include a resuspension of nutrients, absorption of contaminants in the water column, and addition of a protective cover allowing certain nekton to avoid predation (Stern and Stickle, 1978). As with the various detrimental effects, the importance of each of these latter effects would vary among groups and with the physiochemical parameters existing at the time and location of dredging and placement operations. Material to be dredged is not contaminated and should not pose contamination issues with respect to aquatic communities. Impacts in the new ODMDSs would be the same as those in the existing ODMDSs and are not expected to be significant.

4.11.2.3 Essential Fish Habitat

4.11.2.3.1 No-Action Alternative

Under the No-Action Alternative, EFH would continue as described in subsection 3.10.2.3 with periodic maintenance dredging and dredged material placement for the existing channel.

4.11.2.3.2 Preferred Alternative

EFH for adult and juvenile brown and white shrimp, red drum, gag grouper, scamp, red, gray, and lane snapper, greater amberjack, king and Spanish mackerel, cobia, and Gulf stone crab occur in the SNWW study area and may include estuarine emergent wetlands, estuarine mud, sand, and sand and shell substrates, SAV, estuarine and offshore water column. Shell substrate in the project area would be dredged with the Preferred Alternative. Open-bay bottom habitat would be impacted by the Preferred Alternative relative to the No-Action Alternative. In addition, Sabine Lake and the GIWW/Lake Charles Deepwater Channel would be impacted in one-time contracts to remove sediment for Willow and Black bayous mitigation measures, causing temporary increases in water column turbidity and removal of benthic fauna.

Initial placement operations would cover benthic organisms with dredged material in the ODMDS sites. Recovery of some benthic organisms would likely occur relatively quickly, although the assemblage in the dredged material might differ from the assemblage that existed at the PA prior to construction. Sheridan (1999) found that recovery of the benthic community would continue for at least 18 months for some parameters and beyond 3 years for others.

With the Preferred Alternative, increased water column turbidity during dredging would be localized and temporary. Teeter et al. (2003) found that the area of high turbidity extended roughly to the edge of the fluid mud flow, or about 1,300 to 1,650 feet from the discharge pipe. Modeling of dredged material discharge in the Laguna Madre determined that turbidity caused by dredging only lasts on the order of weeks to a few months, and therefore impacts to the estuarine and offshore water column would be minimal (Teeter et al., 2003). Material to be dredged is not contaminated and should not pose contamination issues with respect to EFH. Accidental spills have the potential to impact EFH, and larval and juvenile finfish could be affected significantly should a spill occur. Larval and juvenile finfish tend to be more susceptible to spills than adults and could be affected extensively by a spill during their active immigration periods. Due to their lack of mobility, they are less likely to be able to avoid these areas and could be negatively impacted if a spill were to occur; however, there would be no increase in spill chances because of the larger channel and the fewer vessel trips that are predicted with the Preferred Alternative versus the No-Action Alternative.

The Preferred Alternative would temporarily and locally impact EFH species by turbidity; however, these impacts would be minimal since these species are motile enough to avoid areas of high turbidity. Benthos, as a food source, would be lost at the ODMDS sites until recovery occurs; however, these areas are small relative to the benthic habitat near Sabine Pass and any impacts would be negligible. Restored marsh and improved shallow-water habitat in the proposed mitigation and Neches River BU Feature total 13,053 acres of EFH creation, with 43 percent (5,636 acres) being emergent marsh. Approximately 1,828 acres of open water would be improved as EFH habitat by creating smaller, shallow-water pools and channels in which fetch and turbidity are reduced. In addition, another 5,589 acres of existing marsh within the influence areas targeted for mitigation measures and BU would be nourished by the winnowing of fine-grained sediments during unconfined placement of the dredged material.

The DEIS initiated EFH consultation under the MSFCMA. NMFS provided concurrence with the findings on March 8, 2010 (Appendix A3).

4.11.2.4 Ballast Water

4.11.2.4.1 No-Action Alternative

Under the No-Action Alternative, ship traffic in the SNWW would increase at rates predicted by the economic analysis.

4.11.2.4.2 Preferred Alternative

Although ship traffic would increase with the Preferred Alternative, the FWP increase would be less than the predicted growth of ship traffic under the No-Action Alternative, and therefore no additional impacts with respect to ballast water are expected. The economic analysis has determined that the maximum size of vessels using the deepened channel is not expected to increase; rather, vessels would be loaded to deeper drafts to take advantage of the increased depth. Therefore, an increase in the volume of ballast water is not expected. Furthermore, no changes in foreign ports of call are predicted.

4.11.2.5 Recreational and Commercial Fisheries

4.11.2.5.1 No-Action Alternative

Under the No-Action Alternative, recreational and commercial fisheries would continue as described in subection 3.10.2.4. Additional discussion of impacts associated with normal maintenance dredging activities is discussed in subsection 4.11.2.5.2.

4.11.2.5.2 Preferred Alternative

Temporary and minor adverse effects from the proposed project and mitigation measures on recreational and commercial fisheries may result from altering or removing productive fishing grounds and interfering with fishing activity. Sheridan (1999) found that sheepshead, spotted seatrout, brown shrimp, pink shrimp (*Litopenaeus duorarum*), white shrimp, and blue crab numbers increased as SAV coverage improved following dredging, with few species collected at the site of the disturbance. Only spot (*Leiostomus xanthurus*), Atlantic croaker, and southern flounder were somewhat more numerous at the dredged material PA. However, the evaluation of effects on the estuarine habitats and fauna and Gulf habitats and fauna of the region (sections 4.10 and 4.12) concluded that no significant impacts to food sources for nekton were likely. Therefore, reductions of nekton standing crops would not be expected from the No-Action or Preferred Alternative. In particular, major species of nekton, including sciaenid fishes and penaeid shrimp, should not suffer any significant losses in standing crop. Recreational and commercial fishing would therefore not be expected to suffer from reductions in the numbers of important species from the Preferred Alternative.

Repeated dredging and placement operations may temporarily reduce the quality of recreational and commercial fisheries in the vicinity of dredging operations. This may result from decreased water quality and increased turbidity during project dredging and mitigation measures, as well as from a loss of attractiveness to game fishing resulting from loss of benthic prey. This condition is not permanent, and the quality of fishing in the vicinity of the channel and PAs should steadily improve after dredging is completed and would likely be similar to existing maintenance dredging, as under the No-Action Alternative. During project dredging and mitigation measures, game fish would leave prime recreational fishing areas for more-favorable, less-turbid locations; however, once dredging is completed, conditions would improve and game fish would return to the area. The additional habitat created by construction in the BU sites should provide additional recreational fishing opportunities. Construction activity in this portion of the channel should not significantly affect overall fishing in the general project area.

The impacts from the Preferred Alternative to both boat and wade-bank fishing would be temporary, potentially resulting in local disturbances, particularly along the edges of the channels. After dredging is completed, these areas should return to predredging conditions. A significant portion of the overall recreational fishing effort in the project area occurs in Sabine Lake and offshore; however, project dredging activities and mitigation measures should not significantly affect overall fishing.

Commercial fishing for shellfish (specifically blue crab) in Sabine Lake is very important; however, no significant long-term impacts are expected for the No-Action or Preferred Alternative.

4.12 WILDLIFE

4.12.1 No-Action Alternative

Existing dredging activities and placement of dredged material could result in sedimentation and altered hydrology, which could have a temporary, short-term, and localized impact on some species. On larger temporal scales, the No-Action Alternative would result in no immediate direct impacts to the terrestrial wildlife species or wildlife habitats at or near the proposed study area. However, the combined effects of subsidence, saltwater intrusion, and wetland loss from sea level rise would convert estuarine and coastal habitats and their wildlife communities. These habitat changes are likely to be exacerbated by the effects of global climate change. In the absence of the project and associated marsh restoration projects, the loss of freshwater marsh habitats would likely continue due to RSLR. Salinities would likely increase in estuary tributaries, causing continued conversion of freshwater to brackish marsh, in turn favoring colonization by euryhaline species. Last, a long-term reduction in freshwater inflow to the estuary (since the human population of the state is expected to double during the life of the proposed project) could also result in coastal and estuarine habitat conversion.

4.12.2 Preferred Alternative

4.12.2.1 Dredging/Construction Activities

Direct effects of the proposed project are those associated with navigation channel improvements, and the placement of dredged material. They include (1) impacts to benthic organisms and their Gulf, estuarine, and riverine water-bottom habitats resulting from dredging to construct navigation improvements, ODMDSs, borrow areas for mitigation measures, and marsh restoration in shallow, open-water areas for BU features and mitigation measures; (2) dredging impacts to bottom-feeding and pelagic organisms such as sea turtles; (3) impacts to marshes and upland habitats from the enlargement of PAs; and (4) impacts to shorebirds and their habitat from the regular placement of maintenance material on the Gulf shoreline.

While dredging activities from the proposed project are unlikely to have a direct impact on terrestrial wildlife species, they may have an indirect impact. Such activities may cause temporary, local impacts to aquatic communities and habitats, including increased turbidity, which in turn may indirectly affect birds in the immediate vicinity by potentially reducing the availability of the food supply. These impacts are local and temporary and are not likely to be significant considering the overall availability of similar habitats in the general area and the mobility of the birds. The slightly increased possibility of accidental spills of oil, chemicals, or other hazardous materials during construction dredging activities also poses a threat to the aquatic community and, thus, the food source of many coastal birds in the area. Accidental spills could adversely affect phytoplankton and zooplankton assemblages, which make up the foundation of the aquatic food chain. While adult shrimp, crabs, and fish are mobile enough to avoid areas of high concentrations of pollutants, larval and juvenile finfish and shellfish are more susceptible to those threats. Any effects would be short term.

The noise of equipment and increased human activity during dredging activities may disturb some local wildlife, particularly birds, especially during the breeding season. Such impacts, however, should be temporary and without significant long-term implications. Salinity effects are unlikely, and most infaunal organisms in the area are relatively tolerant of salinity fluctuations.

Dredging activities for the channel improvement would occur adjacent to many of the rookeries noted in subsection 3.11.2; however, it is unlikely that dredging activities would result in impacts to these rookeries since no placement would occur in the rookeries and the birds are accustomed to the noise of maintenance dredging.

Dredged material would be used beneficially for marsh creation in the Neches River BU Feature and for shore nourishment in the Gulf Shore BU Feature. Mitigation measures include marsh restoration in the Willow Bayou hydro-unit and in the Black Bayou hydro-unit. In addition, 16 existing and 2 new upland PAs would be used for construction and maintenance of the 48-foot project.

Placement of dredged material at these sites would have similar impacts to the dredging activities in that they would be unlikely to result in direct effects on terrestrial wildlife species but may have indirect effects. Temporary impacts to aquatic communities and habitat from increased sedimentation and turbidity would be expected. This in turn may affect birds and amphibians in the area by potentially reducing the availability of their local food supply temporarily. The impacts may be more noticeable if the sites are located near known bird rookeries. Noise and increased human activities during construction may temporarily affect terrestrial wildlife in areas adjacent to the restoration sites. Construction activities during the placement of material on the beach may temporarily preclude its use by wildlife; however, the duration of the activity would be temporary and the size of the construction area would not be large enough to cause any significant loss of habitat. These impacts would likely be minor and short term. The resultant additional marsh and beach restoration would provide additional habitat for wildlife in the area. Therefore, the proposed activity would not have adverse effects on terrestrial wildlife.

4.12.2.2 Operational Activities

Upon completion of the initial dredging activities associated with the project, few impacts are likely. Maintenance dredging activities would have similar temporary impacts as the initial dredging, but on a much smaller scale and for a shorter term. The number of vessels in the area would not increase or decrease; therefore, the potential for erosion of PAs would not change. The possibility of accidental oil or chemical spills would decrease because of safer navigability. Such spills pose a threat to the aquatic community and, thus, the food source of many coastal birds in the area. Impacts from noise and human activity are unlikely to be a factor.

Construction activities during the placement of dredged material at marsh creation sites and on beaches may temporarily preclude its use by wildlife; however, the duration of the activity would be temporary and the size of the construction area would not be large enough to cause any significant loss of habitat. The resultant additional marsh and beach restoration would provide additional terrestrial habitat for wildlife in the area. Therefore, the proposed activity would not have adverse effects on terrestrial wildlife.

4.13 THREATENED AND ENDANGERED SPECIES

A BA for this project has been prepared to fulfill the USACE requirements as outlined under Section 7(c) of the ESA of 1973, as amended, and is included in Appendix G1. The USACE is consulting with the NMFS and USFWS as required by Section 7(a)(2). NMFS issued a Biological Opinion (BO) on a previous similar project alternative. That opinion found that the proposed action was not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species (Appendix G2). While the project alternative changed, project-related impacts remained the same, and therefore the BO conclusion would remain the same.

4.13.1 No-Action Alternative

The No-Action Alternative would result in no immediate direct impacts to any endangered wildlife species or endangered species habitat at or near the proposed study area. The potential impacts to endangered sea turtles from maintenance dredging are covered by the BO for the USACE's maintenance dredging activities in the Gulf (NOAA, 2003), and therefore are not addressed in this FEIS.

4.13.2 Preferred Alternative

4.13.2.1 Dredging/Construction Activities

No federally or State-listed plant species are of potential occurrence in Jefferson or Orange counties, Texas, or Cameron or Calcasieu parishes, Louisiana (NDD, 2005a, 2005b, TPWD, 2010; USFWS, 2005c, 2009). Thus, the proposed project would not result in impacts to any threatened or endangered plant species.

The proposed project is unlikely to affect any threatened or endangered terrestrial species. Many are inland species that are not likely to occur in the affected areas, while others are migrants that pass through the region seasonally. Federally listed species likely occurring in the study area at some time of the year include the piping plover. Several threatened and endangered sea turtle species, of potential occurrence in study area waters, could be affected by project construction and maintenance activities. Potential impacts to threatened and endangered terrestrial and marine species have been assessed by the USACE in a BA presented in Appendix G1 of this FEIS.

Dredging activities, which would occur in open water, would not directly affect the wintering piping plover. The greatest potential for impacts to the wintering piping plover would be associated with the placement of dredged materials for shoreline nourishment activities in areas of suitable habitat (the Gulf Shore BU Feature). The USFWS has designated the entire shoreline between Constance Beach and Sabine Pass (Unit LA 1, in part) as critical habitat for the piping plover. Proposed beach nourishment activities at Louisiana Point would occur along approximately 3 miles of this unit, beginning approximately 0.5 mile east of Sabine Pass. Details of the Gulf Shore BU Feature beach nourishment activities are included in Section 4.2 of the BA (Appendix G1). A survey of both the Texas and Louisiana shore nourishment sites was conducted in July 2006 (see Attachment A to the BA). No habitat was found on the Texas side; the current shoreline within the proposed nourishment zone in Texas is an eroding marsh and contains no beach. In Louisiana, several areas suitable for piping plovers were identified. Large tidal sand/mudflats and sandbars located just offshore of Louisiana Point appeared to provide wintering piping plover feeding habitat. In addition, sandy beaches beginning 2 miles from the east jetty contain tidal flats with sparse vegetation suitable for feeding and roosting habitat. Placement of dredged materials (i.e., Gulf shoreline nourishment) at Texas Point and Louisiana Point would not adversely affect piping plovers or designated Critical Habitat for the wintering piping plover. These impacts of placement activities would be temporary and local in nature. Some birds could be temporarily displaced, but there is sufficient habitat nearby to accommodate them. In general, the BU feature should result in positive effects on the piping plover by increasing the extent of suitable habitat in the study area. On the Louisiana side, where some Critical Habitat exists, additional beach may allow siltation to create some microtopographic relief on the backbeach, providing another primary constituent element for the Critical Habitat. Based on the facts listed above, the proposed project may affect but is not likely to adversely affect the piping plover or its Critical Habitat.

Loggerhead, Kemp's ridley, hawksbill, leatherback, and green sea turtles may be present in study area waters during certain times of the year. Thus, construction and postconstruction maintenance activities could result in impacts to the sea turtles, should they be present in the project area. A pipeline dredge would be used in those reaches of the SNWW inland of the Jetty Channel, and a hopper dredge would be used in the Sabine Pass Jetty Channel, the Sabine Pass Outer Bar Channel, the Sabine Bank Channel, and the Extension Channel. Sea turtles easily avoid pipeline dredges because of the slow movement of the dredge. The potential for incidental take of sea turtles by hopper dredges would be minimized by the use of draghead deflectors. Since new work dredging would require continuous hopper dredging for approximately 6 years, a winter dredging window for construction cannot be accommodated. Maintenance dredging has been conducted during all seasons between 1996 and 2005. Relocation trawling has been used since 2002, when maintenance dredging in the Sabine Bank Channel resulted in the lethal take of two sea turtles (Rob Hauch, pers. communication, 2006). In 2006, maintenance dredging in the Sabine Bank Channel resulted in the lethal take of one Kemp's ridley sea turtle (USACE, 2006c). Apart from direct mortality, dredging activities could have an impact on sea turtles through an increase in sedimentation and turbidity. There have been no reports of sea turtles nesting in the study area. Feeding opportunities within the proposed channel could attract sea turtles, where they might be exposed to additional risks from boat traffic, contaminants, fishing activities, tangled fishing lines, and accumulated plastic detritus, but that is true at the existing channel.

The effects on sea turtles of placing dredged material at the proposed ODMDSs include (1) a collision potential from the vessel; (2) the deposition of dredged material on turtles and forage areas; and (3) the possibility of trash and debris from the dredge operation. Regarding the deposition of dredged material, modeling indicates that most of the dredged material is confined to a relatively small area. Because this is a short-term effect, and considering the mobility of the turtle species and the lack of limestone ledges in the proposed ODMDSs, the sea turtles should easily be able to avoid a descending plume and available food sources should not be seriously reduced (NMFS, 2003). Regarding the vessel and debris possibility, it is the combined effect of many marine activities (e.g., oil spills, oil and gas operations, commercial fishing, marine transportation, etc.) that constitute the hazard and not a single activity such as a dredge operation. These activities, combined with natural predation and development on land, result in a cumulative adverse effect on sea turtles (Rosman, 1987). The Outer Bar Channel would be deepened at the existing width of 800 feet, and the width would quickly taper to 700 feet in the Sabine Bank Channel.

The dredging operation in the existing offshore channels is similar to, but of longer duration than, routine maintenance dredging. The Entrance Channel Extension would begin 18 miles offshore where sea turtles should be more dispersed than nearer the jetties. Only three lethal takes have been observed during maintenance dredging between 1996 and 2006, a period that entailed water temperatures ranging from 49.0 to 89.6°F. Based on the facts listed above, the proposed project may affect and is likely to adversely affect sea turtles. No critical habitat for sea turtles is present within the study area; therefore, the project is unlikely to adversely affect critical habitat.

4.13.2.2 Operational Activities

Upon completion of the initial dredging activities associated with the project, few impacts to endangered species or critical habitats are likely. Maintenance dredging activities would have similar temporary impacts as the initial dredging for recurring but shorter terms. The probability of accidental oil or chemical spills would decrease because there would be fewer vessel trips. Such spills pose a threat to the aquatic community and, thus, the food source for the piping plover. Impacts from noise and human activity are unlikely to be a factor. Maintenance dredging activities for the proposed project are covered by an existing agreement between the NMFS and USACE regarding the taking of sea turtles with hopper dredges, to ensure that significant impacts do not occur (NOAA, 2003).

4.13.2.3 USFWS Coordination and NMFS Biological Opinion

4.13.2.3.1 Piping Plover, Brown Pelican, and Bald Eagle

Placement of dredged materials (i.e., Gulf shoreline nourishment) at Texas Point and Louisiana Point would not adversely affect wintering populations of piping plovers or designated Critical Habitat for the piping plover. These activities should result in positive effects on the piping plover by increasing the extent of suitable habitat in the study area. On the Louisiana side, where Critical Habitat is designated, additional beach may allow siltation to create some microtopographic relief on the backbeach, providing another primary constituent element of the piping plover Critical Habitat. Based on the information listed above and presented in detail in the BA (Appendix G1), the Preferred Alternative is not likely to adversely affect the piping plover or its Critical Habitat.

The current Preferred Alternative eliminates proposed widening from the Sabine Pass Jetty Channel through the Port Arthur Canal, removes proposed beneficial use of dredged material at Bessie Heights West, and modifies the size and configuration of the Rose City BU feature. However, all other project features remain the same, and effects to threatened and endangered species and Critical Habitat have not changed. The USFWS, in letters dated March 20 and March 22, 2007 (Appendix A2), concurred that the deepening and widening 48-foot alternative was not likely to adversely affect the piping plover or its Critical Habitat. The USFWS Louisiana Field Office stated that no further ESA consultation would be required with its office unless changes are made to the scope or location of the project. Changes to the Preferred Alternative have not affected project impacts; therefore, no change is anticipated to the USFWS's "no effect" determination. The USFWS Clear Lake Field Office letter was silent on the need for further consultation. However, the USACE staff confirmed by telephone that no further ESA consultation would be required unless changes are made to the scope or location of the project. The Clear Lake Field Office did recommend that steps be taken to determine whether bald eagles are nesting within or near the project area since the number of bald eagles in Texas is increasing. Prior to project construction, the USACE will check with the TPWD and local landowners to determine whether there have been recent bald eagle sightings and determine the need for surveys at that time.

The USFWS provided further guidance in a letter dated February 5, 2010, and recommended that all activity in Louisiana occurring within 2,000 feet of a brown pelican rookery be restricted to the non-nesting period (i.e., September 15 through March 31). However, because nesting periods vary considerably among Louisiana's colonies, it is possible that this activity window could be altered based upon the dynamics of the individual colony. Prior to project construction, the LDWF Fur and Refuge Division will be contacted to obtain the most current information about the nesting chronology of individual brown pelican colonies. In Texas, the USFWS recommended all activity occurring within 1,000 feet of a rookery be restricted to the non-nesting season.

4.13.2.3.2 Sea Turtles

Based on the facts listed above and presented in detail in the BA (Appendix G1), the Preferred Alternative may affect and is likely to adversely affect sea turtles. No Critical Habitat for sea turtles is present within the study area; therefore, the Preferred Alternative would not affect sea turtle Critical Habitat.

A BO, prepared by the NMFS for the previous 48-foot deepening and widening alternative, is presented in Appendix G2. The BO (dated August 13, 2007) concluded that the action, as proposed, was likely to adversely affect but is not likely to jeopardize the continued existence of loggerhead, Kemp's ridley, hawksbill, leatherback, or green sea turtles. The effects of the current Preferred Alternative on sea turtles are the same as those previously coordinated, and it is not anticipated that this determination would change. Although some short-term reduction in numbers and reproduction is expected, the anticipated take of sea turtles would not appreciably increase the risk of extinction of these species in the wild. The BO authorizes incidental lethal take of four turtles (three Kemp's ridley and one loggerhead or green sea turtle) during the course of the proposed project's hopper dredging. This estimate is based on the implementation of relocation trawling to prevent additional lethal takes by hopper dredges. Further, this opinion authorizes the per-fiscal-year non-lethal, non-injurious take (minor skin abrasions resulting from trawl capture are considered non-injurious), external flipper-tagging, and taking of tissue samples of 32 sea turtles in any combination, though 7 loggerhead, 21 Kemp's ridley, 1 hawksbill, 1 leatherback, and 2 green sea turtles would be expected in association with any relocation trawling conducted during the course of the proposed project.

NMFS determined that the following reasonable and prudent measures are necessary and appropriate to minimize impacts of the incidental take of sea turtles during the proposed action. Only incidental takes that occur while the following measures are in full implementation are authorized. For brevity, the reasonable and prudent measures are only summarized below. The reader is referred to the BO in Appendix G of this FEIS for the detailed measures, terms, and conditions.

Reasonable and Prudent Measures:

1. **Temperature- and date-based dredging windows**:
   - Hopper dredging activities shall be completed, whenever possible, between December 1 and March 31, when sea turtle abundance is lowest throughout Gulf coastal waters.
   - Pipeline or hydraulic dredges, because they are not known to take turtles, must be used whenever possible between April 1 and November 30.
2. **Observer Requirements**: The USACE shall arrange for the NMFS-approved protected species observers to be aboard the hopper dredges to provide 100 percent monitoring of the hopper bin, screening, and dragheads for sea turtles and their remains between April 1 and November 30, and whenever surface temperature are 52°F or below.
3. **Deflector Dragheads**: A state-of-the-art rigid deflector draghead must be used on all hopper dredges at all times.
4. **Relocation Trawling**: Relocation trawling is required after the take of one sea turtle during the project. In general, it is also recommended as a useful conservation tool. The BO authorizes the per-fiscal-year nonlethal noninjurious take, external flipper-tagging, and taking of tissue samples of 32 sea turtles in any combination, though anticipates 7 loggerhead, 21 Kemp’s ridley, 1 hawksbill, 1 leatherback, and 2 green sea turtles in association with any relocation trawling conducted during hopper dredging.

4.14 CULTURAL RESOURCES

4.14.1 No-Action Alternative

Under the No-Action Alternative, archeological sites around the margins of eroding marsh areas would increasingly be exposed to the erosive effects of wind, tidal action, and RSLR as marshes convert to water, increasing fetch and erosive potential. Archeological sites along the SNWW navigation channel would continue to be exposed to the erosive forces of boat wakes; this would increase in the future as vessel trips rise to support projected imports under the current lightering requirements. Maintenance dredging of the SNWW would continue, with the potential to affect unidentified shipwrecks in or alongside the existing channel.

4.14.2 Preferred Alternative

The proposed CIP would not affect the two properties listed in the NRHP that are located near the project area (the Sabine Pass Lighthouse and the Rainbow Bridge) or the SAL, the USS *Clifton*, nor would it affect the submerged, offshore Sabine River Valley. Although the existing channel and ODMDSs cross the center of the submerged valley, the footprint of the deeper channel and existing ODMDSs would not be enlarged. The channel extension and new ODMDSs are located south of the valley. The Sabine Pass Lighthouse, which is listed in the NRHP, is located in an area that would not be affected by channel improvements to the SNWW. Use of the nearby PA 5 would not limit or remove access to the lighthouse.

All areas that would be impacted by the SNWW CIP have not been assessed for their potential to contain properties eligible for the NRHP in accordance with the National Historic Preservation Act (NHPA). Therefore, the SNWW CIP has the potential to adversely affect eligible historic properties. The USACE has negotiated a Historic Properties Programmatic Agreement (HPPA) under 36 CFR 800.14(b) to govern subsequent investigations, to coordinate surveys of impact areas, to test potentially eligible sites (Table 4.14-1), and to manage data recovery or avoidance measures as necessary. A copy of the signed HPPA is provided in Appendix H of this FEIS.

Table 4.14-1
Terrestrial and Marine Historic Properties Potentially Adversely Affected by the SNWW CIP

Resource	Location	Eligibility
Marine		
TB8.1	Neches River Channel	Potentially Eligible
IS4.2	Neches River Channel	Potentially Eligible
IS4.10s	Neches River Channel	Potentially Eligible
TB4.1	Neches River Channel	Potentially Eligible
TB4.2	Neches River Channel	Potentially Eligible
TB4.3s	Neches River Channel	Potentially Eligible
IS4.6	Neches River Channel	Potentially Eligible
IS4.12s	Neches River Channel	Potentially Eligible
IS4.11s	Neches River Channel	Potentially Eligible
IS4.8	Neches River Channel	Potentially Eligible
IS4.9s	Neches River Channel	Potentially Eligible
IS3.1	Sabine-Neches Canal	Potentially Eligible
IS2.1	Port Arthur Canal	Potentially Eligible
IS2.14s	Port Arthur Canal	Potentially Eligible
Terrestrial		
41JF29	Neches River	Potentially Eligible
41JF43	Neches River	Potentially Eligible
41OR10	Neches River	Potentially Eligible
41OR11	Neches River	Potentially Eligible
16CM26	Near LA 2-19B Mitigation Area	Potentially Eligible
16CM86	Within LA 3-10R Mitigation Area	Potentially Eligible
16CM103	Near LA 2-18B Mitigation Area	Potentially Eligible

Additional investigations are anticipated at this time, including survey of the proposed channel extension, areas affected by construction of the DMMP BU features, and areas affected by the construction of mitigation measures. No surveys are recommended for new or existing ODMDSs as placement activities are not expected to adversely impact unrecorded wrecks that may be present, given the depth of water through which the material would settle, the expected depth of burial at the time of placement, and the dispersive nature of the seabed environment in this portion of the Gulf. Impacts to archeological sites in and around the margins of degraded marsh areas proposed as DMMP BU features or as mitigation measures would be avoided to the greatest extent possible. The restoration of currently eroding marsh areas would prevent the further erosion of sites by stabilizing landforms and creating protective marsh buffers.

Costs for additional terrestrial archeological survey and testing, and nautical archeological survey and dive assessments are included in the Engineering and Design cost of the project estimate. Funds for potential archeological data recovery are also included in the project cost estimate as a full Federal cost per Section 7 of PL 93-291. While no specific historic property impacts have been identified at this time, there is a high potential to affect a significant historic shipwreck. The highest potential for historic property data recovery is associated with channel deepening through Sabine Pass, the site of a significant Civil War naval battle. To cover estimated costs for historic property data recovery, funds have been included in the project cost estimate for potential data recovery projects during the construction phase.

4.15 SOCIOECONOMIC RESOURCES

4.15.1 No-Action Alternative

Under the No-Action Alternative, the study area would continue on its present course of economic development, population growth trends, and residential and industrial development patterns. The demand for community facilities, services, and housing would not increase within the study area since there is low projected population growth. The locations of these resources would generally follow development and land use plans identified by surrounding cities and Hardin, Jefferson, and Orange counties and Cameron and Calcasieu parishes. Because no property is likely to be removed from the tax rolls, the tax base would not be affected. The No-Action Alternative could possibly have a negative effect on the local economy within the study area. Transportation costs and operational inefficiencies with the existing ship channel could possibly change industry trends, thereby changing the number of employed persons.

Under the No-Action Alternative, the counties of Hardin, Jefferson, and Orange in Texas, and Cameron and Calcasieu parishes in Louisiana areas of the proposed project would continue to have slow to moderate population growth and moderately low commercial, residential, and industrial land development (see Section 3.14). The channel areas starting at the Port of Beaumont and continuing to the Gulf would continue to function as a leader in industrial facilities and international commerce in the study area. The ports would also continue to develop their industrial properties but at a slower rate than with the Proposed Alternative. Without the channel deepening, higher transportation costs and operational inefficiencies related to large vessels would continue. As a result, future growth at the ports would likely be slower and less than if the SNWW were improved.

4.15.2 Preferred Alternative

4.15.2.1 Population and Social Characteristics (Demographics)

The Preferred Alternative would not likely have an effect on population growth trends within the study area. Population in this area is projected to grow at a low rate. As a result of the Preferred Alternative, demand for community facilities, services, and housing would not increase in the study area. The location of these resources would generally follow development and land use plans currently identified. Most of the construction workers are likely to come from the labor force that is already living within Hardin, Jefferson, and Orange counties, in Texas, and Cameron and Calcasieu parishes in Louisiana; therefore, immigration to the study area would be small. Over 72 percent of housing within the study area is occupied. Thus it is unlikely there would be an increase in single-family home construction. The projected population growth trend over 60 years for the study area has very little or no increase. Population growth for this area is not expected to change much from present. This alternative would have a minimal effect on the demographics of the study area.

4.15.2.2 Environmental Justice

The population living within the study area is primarily comprised of white persons (59.6 percent), followed by black or African American persons (26.7 percent), and Hispanic or Latino persons (9.6 percent); therefore, the proposed project would not be located within a minority area. Jefferson County consists of the highest minority populations of both African Americans (33.4 percent) and of Hispanic Origin (10.6 percent). In Jefferson County, census tracts 51 and 61 consist of the two highest populations of African American persons at 93.5 and 93.3 percent, respectively. Census tracts 101 and 56 in Jefferson County consist of the highest percentages of Hispanic persons at 45.3 and 41.4 percent, respectively. Both census tracts 51 and 61 in Jefferson County would be considered minority areas. The average median household income for the study area census tracts was $28,884, which is above the Department of Health and Human Services (HHS) 2006 poverty guideline of $20,000 for a family of four (HHS, 2006). The percent of persons living below poverty for the study area was 18.5 percent, which is higher than the State of Texas (15.0 percent), but is not more than 10 percent higher than the percent living below poverty for the Texas counties of Hardin (11.1 percent), Jefferson (16.3 percent), and Orange (13.6 percent), and Cameron Parish (12.2 percent) and Calcasieu Parish (15.0 percent) in Louisiana; therefore, the study area is not considered a low-income area.

The minority and low-income populations living within the study area would likely experience no adverse changes to the demographic, economic, or community cohesion characteristics within their respective neighborhoods as a result of the proposed project. Generally speaking, the populations living within the study area would not likely see any change from the proposed project. Therefore, the Preferred Alternative would not result in disproportionately high and adverse impacts on minority and low-income persons living within the study area.

4.15.2.3 Community Values

The Preferred Alternative would neither divide nor isolate any particular neighborhood nor separate residents from community facilities. It would likely have a negligible effect on population growth trends within the study area, and residential, commercial, and industrial development would likely continue at the same rate. Population in this area is projected to continue with its low growth rate, regardless of the proposed project, and demand for community facilities, services, and housing would continue at a rate that is consistent with the projected population growth. The location of these resources would generally follow development and land use plans identified by local jurisdictions. Therefore, the proposed project would not result in a negative impact to community values.

4.15.2.4 Housing

The Preferred Alternative is not expected to result in a substantial increase in population within the study area. In Calcasieu Parish, 10 percent of total housing is vacant, while in Cameron Parish there is 33 percent vacant housing. Hardin County consists of 10.2 percent vacant housing. Jefferson and Orange counties both have 9 percent vacant housing. Population growth is not expected to increase in the area; therefore, available housing would not affect the proposed project.

4.15.2.5 Economic Characteristics of Area Population

With the Preferred Alternative, as with the No-Action Alternative, the study area would continue to have large industrial facilities of the Neches Channel such as Trinity Industries, ExxonMobile, Mobile Chemical, and North Star Steel located near the Port of Beaumont. Other industries such as Huntsman, Ameripol Synpol/Huntsman, Motiva Enterprises, Air Liquide, and Entergy-Sabine Plant are located just north of Port Neches. The Preferred Alternative would not result in negative impacts to the local economy.

4.15.2.6 Leading Economic Sectors

The “industrial mix” in the study area of manufacturing, port-related, construction, transportation, and public utilities is typically reliant on contract labor. When a project is completed, companies would lay off their workforce until the next contract is awarded. In terms of competition for workers, the port-related, manufacturing, and industrial-related employers of the study area do not have to compete much with other industries because of the higher wages these employers offer over the services, retail, and wholesale trade and government services. Another factor affecting employment among manufacturing and port-related employers is the increased reliance on mechanized means of production. This type of production has a relatively small increase in the number of employees. During project construction, the study area may have a slight increase in construction employment and local purchases of construction materials but would be temporary, if any change at all.

4.15.2.7 Labor Force and Employment

The increase in jobs, economic output, and the tax base would be fairly slow and consistent with historical growth trends. The ports and their associated industries and international commerce currently serve an important role for the study area economy. These industries provide jobs, income, and a tax base for the area, and the effects reverberate within other industries such as housing, retail services, and wholesale trade. The Preferred Alternative would likely promote the development of industrial sites along the ship channel in Hardin, Jefferson, and Orange counties and Cameron Parish. This goal would be consistent with a steady historical trend towards increased reliance on these industries and these types of development within the region.

As previously discussed, the primary economic bases of the study area include petrochemical processing, construction, mineral extraction, tourism, commercial fishing, and agriculture. As a result of the proposed project, the positive economic effects to the study area economy would be moderate at the least and substantial at best.

4.15.2.8 Personal Income

Within the study area census tracts, tract 16 in Jefferson County had the lowest per capita income ($11,833) and tract 223 in Orange County had the highest ($48,586). Tract 16 is located within Beaumont and would benefit very little, if any at all, from the Preferred Alternative.

4.15.2.9 Oil and Gas Production

SNWW refinery capacity presently represents 6 percent of the U.S. total; furthermore, SNWW's 2002–2006 crude petroleum waterborne imports comprised 12 percent of U.S. and 18 percent of Petroleum Administration Defense District (PADD III) imports (USACE, 2008b).

In addition to existing crude oil and petrochemical product facilities on the SNWW, one LNG facility began operation in 2008, and construction of a second facility is nearing completion; a third has received regulatory approval. It is anticipated that oil and gas production would continue to be a major employer and industry within the study area. The Preferred Alternative would provide the necessary transportation improvements that would continue to support the export of petroleum commodities as well as support predicted crude oil imports.

4.15.2.10 Public Finance

No impacts to public finance are anticipated from the Preferred Alternative.

4.15.2.11 Land Use

All proposed channel improvements for the Preferred Alternative occur in open-water locations (they would not affect any shoreline land uses). The only land use implications for the Preferred Alternative relate to upland PAs and indirect future land development, which may occur as a result of the proposed project.

Approximately 1,900 square miles of the study area includes portions of Jefferson, Hardin, and Orange counties, Texas, and Calcasieu and Cameron parishes, Louisiana. The study area includes nine municipalities: Beaumont, Port Neches, Nederland, Groves, Port Arthur, Bridge City, Vidor, Orange, and West Orange.

The greatest long-term land use consequence of the proposed project would likely be a change in future land uses that would occur in response to the improvements to the channel. These future land uses are not considered part of the proposed project but would be less likely to occur without it. When the Preferred Alternative is complete, the ports would have a deeper ship channel providing an incentive for new industrial development at all of the ports' properties, based on navigation cost savings. Future industrial development may include oil and gas refineries or upgrades, petrochemical plants or upgrades, LNG plants, and bulk grain facilities. The long-term land use effects of these industrial facilities are largely unknown; however, given recent trends in the area, they would not likely lead to a substantial increase in demand for new housing development, new roads, commercial services, schools, or other services within Hardin, Jefferson, and Orange counties in Texas or Calcasieu and Cameron parishes in Louisiana.

Proposed land uses for the Preferred Alternative were evaluated to determine if they could increase wildlife hazards to aircraft using public use airports in the study area: the Beaumont Municipal Airport, the Southeast Texas Regional Airport, and the Orange County Airport (see figures 3.14-4a–d). All three airports sell Jet-A fuel, and it was therefore assumed that a separation distance of 10,000 feet for any of the hazardous wildlife attractants would apply, in addition to the 5-mile range to protect approach, departure, and circling airspace. Certain land use practices such as waste disposal facilities, water management facilities, gold courses, agricultural cropland, and dredged material placement areas can act as attractants to wildlife that pose a strike hazard. Some natural areas such as wetlands may attract wildlife species that are associated with aircraft strikes.

Project features of the Preferred Alternatives that could serve as attractants are PAs, BU marsh restoration areas, and marsh mitigation areas. None of these project features are located within the separation perimeters for the Beaumont Municipal Airport and the Orange County Airport. None of the BU and mitigation areas are located within separation areas for any of the three airports. However, all or portions of four PAs are located between the 10,000-foot and 5-mile perimeters of the Southeast Texas Regional Airport. All of PA 23/23A and PA 21 are located between the 10,000-foot and 5-mile perimeter; PAs 18 and 24 straddle the 5-mile perimeter. All are existing designated placement areas for the SNWW navigation project. Although they are designated PAs, at times during the dredging cycle they provide habitat for birds and wildlife species that pose a strike hazard. However, no new PAs would be constructed within the separation perimeters, and no change in land use is proposed in conjunction with the Preferred Alternative.

4.15.2.12 Recreation/Tourism

Among sport-related activities, recreational fishing, wildlife watching, and hunting continue to be major parts of the outdoor recreational activities in the study area. Sabine Lake, numerous wetlands, and the Gulf are sources of recreational fishing and wildlife watching. The construction of the Preferred Alternative would have minimal negative effects on recreation within the study area, and the proposed BU and mitigation marsh restoration areas are expected to have beneficial impacts to recreational activities in the area by providing additional habitat. The Neches River BU Feature will create 2,853 acres of emergent marsh, restore 871 acres of shallow-water habitat, and nourish 1,234 acres of existing marsh. Mitigation in Louisiana’s Black Bayou and Willow Bayou watersheds would restore 2,783 acres of emergent marsh, 957 acres of shallow-water habitat, and nourish 4,355 acres of existing marsh. The Gulf Shore BU Feature at Texas Point and Louisiana Point would nourish 6.0 miles of Gulf shoreline. All of these locations would provide new habitat for native fish and wildlife species, providing more fishing and wildlife watching for this area, thus enhancing the life for recreational use.

4.15.2.13 Aesthetics

The Preferred Alternative would have a minimal effect on the overall visual quality within the study area. There would be no negative effect to the appearance of the shorelines that are adjacent to the proposed channel improvements except for temporary turbidity. The study area includes a variety of land uses, including residential neighborhoods, commercial or CBD, transportation systems (highways and railways), civic uses, parks, schools, port facilities, and heavy industrial areas. Some regions in the study area already show moderated human development. Generally speaking, the study area is not particularly distinguished in aesthetic quality from other adjacent areas within the region. The landscape exhibits a generally moderate to high level of impact from human development and alteration. The study area is not considered scenic as defined by Federal regulations by view or by roadway.

4.16 CUMULATIVE IMPACTS

4.16.1 Introduction

The President's Council on Environmental Quality (CEQ) defines cumulative impacts as those impacts "*on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.*" Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. Impacts include both direct effects (caused by an action, occurring at the same time and place as the action) and indirect effects (caused by the action, but removed in distance or later in time, and reasonably foreseeable). Ecological effects are those on natural resources and on the components, structures, and functioning of affected ecosystems, whether direct, indirect, or cumulative.

4.16.2 Method and Evaluation Criteria

The SNWW CIP FEIS follows a traditional cumulative assessment method as typically addressed under NEPA. To define the evaluation criteria and provide additional resource input to the USACE, SNND, and other project staff, an ICT comprised of resource agency representatives was established. The ICT, USACE, and SNND defined the cumulative impacts study area and evaluation criteria considered in this cumulative impacts assessment. This assessment is limited to the SNWW project area for the Preferred Alternative as defined in the Affected Environment section.

The ICT defined criteria and a project list of key past, present, and reasonably foreseeable actions. Criteria used to select projects identified as "reasonably foreseeable" for the purpose of this cumulative assessment are as follows:

a) a Congressionally mandated study or project authorized by and specifically included in a Water Resources Development Act within the last 20 years, for which there is a readily available report that documents environmental consequences, or;

b) a current or recently initiated Federal study for which there is a readily available report that documents environmental consequences, or;

c) a specific proposed or permitted, private (non-Federal, non-State, non-local government) Section 404 action or any aggregate of individual private Section 404 actions where the private action or actions required an environmental assessment (EA) or EIS for authorization and for which there is a readily available report that documents environmental consequences of the action or actions(s), or;

d) an existing or updated regional water plan or reservoir operating plan specifically related to the project area.

Projects that qualified as past, present, or reasonably foreseeable include several LNG and pipeline projects, regional water planning efforts, maintenance and operating plans and projects, habitat restoration and protection activities, and port improvements from the Gulf to the Port of Beaumont, along the SNWW. Project impacts are determined from the best publicly available information in existing documents. Not all projects are included in the impacts summary table and/or resource impact discussions because publicly available environmental documentation is insufficient to quantify and compare impacts; however, these project-specific influences may in time have additive impacts or benefits to resources in the area.

Using the above-defined criteria, the ICT defined the following projects as relevant past or present actions or existing conditions:

- SNWW 40-foot Project (maintenance dredging);
- GIWW –Texas Section, Main Channel and Tributaries, Maintenance Dredging;
- GIWW – Louisiana Section, Sabine Lake to Lake Charles;
- Neches River Saltwater Barrier Operating Plan;
- Toledo Bend Reservoir Operating Plan;
- Beneficial Uses of Dredged Material for Marsh Preservation, GIWW Port Arthur to High Island, Texas;
- Salt Bayou – McFaddin Ranch Wetlands Salt Water Control Project;
- SNWW Marine Organism Access between PA No. 11 and Sabine Lake, Texas;
- Several CWPPRA habitat protection and restoration projects;
- Sabine Pass LNG and Pipeline;
- Golden Pass LNG and Pipeline;
- Kinder Morgan Louisiana Pipeline; and
- Jefferson County Drainage District No. 6 (Diversion Channel from South Fork of Taylor Bayou, south to the GIWW).

Additionally, the ICT defined the following projects as reasonably foreseeable future actions:

- Port Arthur LNG and Pipeline;
- East Texas Regional Water (ETRW) Plan (as part of the approved Texas 2007 State Water Plan);
- Port of Beaumont Intermodal Improvements Projects, Northside and Southside;
- Keith Lake Section 1135 CAP;
- Sabine Pass to Galveston Bay Shoreline Erosion Feasibility Study; and
- Toledo Bend Reservoir relicensing.

Ongoing regional activities, initiatives, and programs may also affect local and regional drainage, navigation, flood control, and erosion control in the SNWW project area, but these actions/programs occur outside of the study area and/or effects are not project-related and cannot be quantified in this document. Programs under which such activities and initiatives may occur include the following:

- the GLO's Coastal Management Program (CMP), including "Coastal Texas 2020" (a long-term, statewide initiative to promote Texas coastal environmental and economic health);
- Louisiana's CMP;
- the USACE Galveston District navigation, flood control, and hurricane-flood protection programs, and regulatory efforts to protect wetlands and navigation channels;
- Jefferson County Drainage Districts (other than No. 6); and
- the Trinity Bay Conservation District.

Resource evaluation criteria include biological, ecological, physical, chemical, cultural, and socioeconomic resources for projects within the SNWW study area. The following resource parameters are addressed:

Physical Environment	Biological Attributes	Socioeconomic Attributes
Air Quality and Noise	Wetlands	Recreational Facilities/Areas
Topography and Bathymetry	Bottomland Habitat	Commercial/Recreational Fisheries
Soils	Terrestrial Vegetation	Ship Accidents/Spills
Sediment Quality	Submerged Aquatic Vegetation	Oil/Gas Production on Submerged Lands
Water Quality	Plankton/Benthos	Cultural Resources
Nutrients	Finfish/Shellfish	Public Health
Salinity	Mammals	Safety
Turbidity	Reptiles/Amphibians	Land Use
Contaminants	Threatened and Endangered Sp.	
Freshwater Inflow	Essential Fish Habitat	
Circulation/Residence	Migratory Birds	
Tidal Influence		

All impacts in the above categories that can be quantified from existing documents are displayed in Table 4.16-1. If an impact cannot be quantified, a qualification sourced from available documents (i.e., "benefit," "net benefit," No Impact, or Not Applicable) is presented in most instances for comparison. Project descriptions and cumulative impact assessment results follow.

Table 4.16-1

Impact Summary for Past, Present, and Reasonably Foreseeable Projects with Publicly Available Information

	Past and Present Actions[1]										Reasonably Foreseeable Actions[1]	
	Existing SNWW 40-foot Channel	Neches River Saltwater Barrier	Salt Bayou/ McFaddin Ranch	SNWW Marine Organism Access	Beneficial Uses: Port Arthur – High Island	Sabine Pass LNG and Pipeline	Golden Pass LNG and Pipeline	Kinder Morgan Louisiana Pipeline	Habitat Restoration Projects	Taylor Bayou Flood Reduction	Port Arthur LNG and Pipeline	Proposed SNWW CIP
Physical Environment												
Air Quality	NA	NI	UN	UN	NI	NO_x and CO emissions	NI[2]	NO_x and VOC emissions	NA	NI	NI[2]	NO_x emissions; anticipate SIP conformance
Noise	NI	NI	UN	UN	NI	NI	NI[2]	UN	NA	UN	NI	NI
Topography, Bathymetry, Soils, Sediment Quality	NI	Net Benefit	NA	NI[2]	Net Benefit	NI[2]	2.8 ac prime farmland; other impact NI[2]	NI[2]	Benefit emergent marsh acres created	51,000 ac removed from 100 year floodplain	1 ac prime farmland loss; other impact NI[2]	NI[2]
Water Quality	NI	Net Benefit	Benefit	NI[2]	NI[2]	NI[2]	NI[2]	NI[2]	Benefit	NI	NI[2]	Net Benefit
Freshwater Inflow	NI	Net Benefit	NA	UN	NA	NI	UN	NA	NA	NI	UN	NA
Circulation, Tides, Salinity	I	UN	NA	Benefit	Benefit	NI	UN	NA	Benefit	NA	UN	Increased salinity, NI[2]
Biological Attributes												
Wetlands (permanent loss)	I	48.4 ac	NA	NI	NI	79 ac[3]	173 ac	0.8 acres	NA	629 ac of jurisdictional waters directly impacted	679 ac	86 ac offset by DMMP; 691 ac NI[2]
Wetlands (mitigation) and DMMP restoration	NA	5 ac (plug) + 8.5 ac (in fee)	NA	NA	NA	135 ac[3]	500 ac	2.53 acres	Restored 3,695 acres emergent marsh	246 ac preserved; 44 ac created	583 ac	Mitigation-restores 2,783 ac emergent marsh, nourishes 4,355 ac existing marsh; DMMP creates 2,853 ac emergent marsh
Terrestrial Vegetation (conversion and loss)	NI	60.4 ac	Limited Benefit	UN	NI	239 ac	205 ac	NA	NA	Preservation of 1,000+ ac	972 ac	NI[2]

Table 4.16-1
Impact Summary for Past, Present, and Reasonably Foreseeable Projects with Publicly Available Information

	Past and Present Actions[1]										**Reasonably Foreseeable Actions**[1]	
	Existing SNWW 40-foot Channel	**Neches River Saltwater Barrier**	**Salt Bayou/ McFaddin Ranch**	**SNWW Marine Organism Access**	**Beneficial Uses: Port Arthur – High Island**	**Sabine Pass LNG and Pipeline**	**Golden Pass LNG and Pipeline**	**Kinder Morgan Louisiana Pipeline**	**Habitat Restoration Projects**	**Taylor Bayou Flood Reduction**	**Port Arthur LNG and Pipeline**	**Proposed SNWW CIP**
Submerged Aquatic Vegetation	NI	NA	Benefit	UN	Net Benefit	NI[2]	UN	NA	Benefit	NA	UN	Net Benefit
Plankton and Benthos	NI	NI[2]	NA	Benefit	Net Benefit	NI	Minimal[2]	NI[2]	Benefit	UN	NI	NI[2] (net benefit)
Finfish and Shellfish	NI	NI[2]	NA	Benefit	Net Benefit	NI	NA	NI[2]	Benefit	UN	NI	NI[2] (net benefit)
Essential Fish Habitat (permanent)	NI	NA	NA	UN	NI	55 ac	6.3 ac	NI[2]	Benefit	NI	NI2	NI[2]
Essential Fish Habitat (mitigation and/or creation)	NA	NA	NA	UN	NA	28 ac	NA	NA	NA	NI	UN *mitigation plan pending*	13,053 ac restored/nourished marsh and shallow water
Wildlife Habitat	I	NI	Benefit	Benefit	NI	236.6 ac	2,007 ac	NI[2]	Benefit	8,900+ ac protected	1,497 ac	NI[2] (net benefit)
Migratory Birds	NI	Net Benefit	Benefit	UN	NA	NI	Minimal[2]	NI[2]	Benefit	UN	NI[2]	NI[2] (net benefit)
Threatened or Endangered Species	NA	NI	NI	NI	NI	NI	Determination pending	NA	NA	NI	NI	Benefit
Socioeconomic Attributes												
Land Use Change	NA	Benefit to agriculture	NA	UN	NA	341 ac	911 ac	67 ac	NA	246 ac converted to protected status; change in land use to flood control for >9,000 ac	461 ac	May induce industrial development
Economy	Benefit	Benefit	UN	UN	NA	Benefit	Benefit	Benefit	NA	Benefit	Benefit	Benefit
Recreational Facilities/Areas	NA	Net Benefit	UN	Benefit	Benefit	NI	Minimal[2] (16.1 miles)	Viewshed alteration	Benefit	UN	Minimal to recreational boating	Net Benefit

Table 4.16-1
Impact Summary for Past, Present, and Reasonably Foreseeable Projects with Publicly Available Information

	Past and Present Actions[1]										**Reasonably Foreseeable Actions[1]**	
	Existing SNWW 40-foot Channel	**Neches River Saltwater Barrier**	**Salt Bayou/ McFaddin Ranch**	**SNWW Marine Organism Access**	**Beneficial Uses: Port Arthur – High Island**	**Sabine Pass LNG and Pipeline**	**Golden Pass LNG and Pipeline**	**Kinder Morgan Louisiana Pipeline**	**Habitat Restoration Projects**	**Taylor Bayou Flood Reduction**	**Port Arthur LNG and Pipeline**	**Proposed SNWW CIP**
Commercial and Recreational Fisheries	NI	Net Benefit	NI	Benefit	Benefit	NI	NI	NI[2]	Benefit	NA	Minimal	Net Benefit
Ship Accidents/Spills	UN	NA	NA	NA	NA	NI[2]	NI[2]	Potential	NA	NA	NI[2]	Net benefit *probability will decline*
Oil/Gas Production on Submerged Lands	NA	NA	NA	NA	NA	UN	UN	NI[2]	NA	NA	UN	NA
Public Health & Safety	NA	Net Benefit	NA	NI	NI	NI[2]	NI	NI[2]	NI	Benefit	NI[2]	NI[2]
Cultural Resources	NI[2]	NI	NI	NI	NI	NI	Determina-tion pending	NI	NI	NI	UN	I[2]

Benefit or Net Benefit = Results which have an overall positive effect when compared to the FWOP (baseline, existing) conditions of the resource.

NI = no long-term impacts; NA = not available; UN = unavailable; I = impact.

[1] Although not included in the table, several other projects are included in Section 4.16 Cumulative Impacts.

[2]Offset by engineering design, mitigation, data recovery, adaptive management plans/activities based on monitoring, procedures, and project controls.

[3]Includes acreage from permit amendment applications.

4.16.3 Past or Present Actions

Petroleum-related industries, most prominently refining and crude oil terminal operations, dominate the area. These and other shipping-dependent industries, alongside commercial and recreational fisheries, agricultural production, and recreation and conservation areas (NWRs, State Parks, State Historic Sites, and WMAs), have influenced this area's land use history, navigation channel development and maintenance, coastal transportation trends, and regional economic and ecological importance to both Texas and Louisiana. The discussion of baseline conditions discussed in Section 3 of this FEIS presents conditions in the study area resulting from these past actions. Past projects considered in this cumulative impacts analysis include the current SNWW 40-foot Project maintenance and other related activities, which may influence or be influenced by natural and socioeconomic resources of the area.

4.16.3.1 Sabine-Neches Waterway 40-foot Channel (past and current condition)

Two of three major area seaports are included in the SNWW project area: Port Arthur and Beaumont. The Ports of Port Arthur and Beaumont rely on a series of artificially widened and/or deepened channels that were dredged from offshore in the Gulf, through Sabine Pass, around the western shore of Sabine Lake, and up the Neches River. Channel and port improvements began in 1885 when Army Engineers completed construction of the east and west jetties (Alperin, 1977). When the jetties produced a channel depth of 25 feet through Sabine Pass, the Kansas City, Pittsburg, and Gulf Railroad and the Port Arthur Channel and Dock Company dredged a 25-foot-deep by 75-foot-wide channel from Sabine Pass to Port Arthur in 1897. Located near the seminal 1901 Spindletop oil discovery, the cities of Beaumont and Port Arthur underwent rapid and substantial growth to accommodate the new petroleum industry. The Port Arthur International Public Port was established in 1899, and a 9-foot-deep canal was dug in the Neches River from the Port Arthur Ship Channel to Beaumont in 1908. The channel was deepened to 25 feet in 1916, and a turning basin was dredged in a bend of the Neches River. By this time, dock facilities had been developed along the Neches River waterfront, creating an inland port for the City of Beaumont. Beaumont's status as a shipping center was heightened in 1922 when the channel was deepened to 30 feet. In the 1940s, the channel was deepened to 36 feet and finally to 40 feet in the 1960s (Alperin, 1977). In 1912, a 25-foot navigation channel was constructed from the mouth of the Neches River, across the northern edge of Sabine Lake, and up the Sabine River to near the city of Orange, Texas. Called the Sabine River Channel, it was deepened to 30 feet in 1922 and remains that depth today. These deep-draft navigation channels are collectively known as the Sabine-Neches Waterway.

The shallow-draft GIWW coincides with portions of the SNWW in the study area. Construction of the GIWW between the Sabine River and Galveston Bay began in 1925. Originally 9 feet deep by 100 feet wide, it was later enlarged to its current dimensions of 12 feet by 125 feet. The segment of the GIWW from the Sabine River eastward 25 miles to the Calcasieu River in Lake Charles, Louisiana, was deepened to 30 feet by local interests and authorized as a Federal project in 1935 (USACE, 1998c). It provided a deepwater navigation channel to the Port of Lake Charles through the SNWW until the 30-foot depth was abandoned upon completion of the deep-draft Channel to Calcasieu in 1941; it is presently maintained at authorized GIWW dimensions of 12 feet by 125 feet.

The existing 40-foot SNWW project is a federally authorized and maintained waterway approximately 77 miles long, located in Jefferson and Orange counties, Texas, and Cameron and Calcasieu parishes, Louisiana. Currently, SNWW maintenance dredged material, approximately 8 mcy annually, is placed in 16 upland confined PAs and 4 ODMDSs in the Gulf (see Appendix D). There was no NEPA-process document for construction of the SNWW 40-foot project, which would provide information about impacts related to construction activities; however, the operational and maintenance impacts were addressed in an EIS in 1972. The Ecological Modeling Report (Appendix C) also discusses impacts of the current condition and FWOP. From these two sources, effects for this cumulative impacts analysis include the conversion and loss of wetlands, terrestrial vegetation, SAV, and wildlife habitats from the creation of PAs and saltwater intrusion. Relative to other Past and Present Actions, SNWW 40-foot Project impacts are presented in Table 4.16-1.

4.16.3.2 GIWW – Texas Section, Main Channel and Tributaries

The USACE, Galveston District published “Maintenance Dredging, Gulf Intracoastal Waterway, Texas Section – Main Channel and Tributary Channels” (an EIS) in October 1975. This document identified and evaluated the environmental impacts of continued maintenance dredging of the GIWW Texas Section and tributary channels. The proposed action was continued maintenance by periodic dredging of shoal deposits. The main channel was authorized at a 12-foot depth and a 125-foot bottom width. The typical means of dredging is by hydraulic pipeline dredge, with the exception of the Port Mansfield Channel that can be maintained by either pipeline or hopper dredge. At the time of the 1975 EIS, the environmental impact and adverse environmental effects of the proposed action were addressed based on the best available information (USACE, 1975a, 2004c).

As it leaves Louisiana, the GIWW connects with the SNWW approximately 3 miles below Orange, Texas. The GIWW then follows the Sabine River Channel and the Sabine-Neches Canal to the head of the Port Arthur Canal where it exits the SNWW and continues westward to Galveston Bay. Portions of GIWW Reach I (Sabine River to the Matagorda Ship Channel) and tributaries are within the SNWW project area. Specific impacts for the GIWW segments within the SNWW project area are not distinguishable in existing documents, which present impacts of larger reaches of the GIWW. Potential impact presentation of the entire GIWW in this document would not be comparable to other projects presented here; therefore, GIWW impacts are not included in Table 4.16-1.

4.16.3.3 Neches River Saltwater Barrier Operating Plan

From 1975 through 1997, the USACE, Galveston District, with cooperation from the LNVA, pursued a project to prevent saltwater contamination of surface water supplies while maintaining free and reasonable unobstructed use of the Neches River for existing and future navigation (USACE, 1997a). Temporary steel-sheetpile barriers installed and controlled by the local sponsor at two locations downstream from their freshwater intakes were environmentally and navigationally unacceptable. Environmental impacts were described in a 1975 FEIS and updated in a 1981 Supplement and 1997 EA; however, changes in environmental conditions and requirements necessitated an additional supplement.

The proposed project was revised in 1997 and relocated around river mile 29.7, downstream from the confluence of the Neches River and Pine Island Bayou, adjacent to the Big Thicket National Preserve. Installations and construction in approximately 60.4 acres include:

- an overflow dam with crown width of 300 feet in the Neches River;
- a sector gated 1,260-foot-long navigation bypass channel west of the river;
- a tainter gated 2,700-foot-long barrier structure in a diversion channel west of the navigation channel;
- an access levee road; and
- a service area west of the diversion channel.

Approximately 48.4 acres of the 60.4-acre project area involved vegetation removal and wetlands conversion, primarily in the form of cypress-tupelo swamp and bottomland hardwood habitats. The project identified the following environmental beneficial effects:

- set aside and protect 8.5 acres of cypress-tupelo swamp and additional modified mitigation strategy approved by the USFWS and USACE;
- prevent annual erosion and shoreline loss on the Big Thicket National Preserve;
- create 5 wetland acres around the “plug”;
- conserve groundwater; and
- protect an additional 10 miles of river and bayou wetlands from saltwater intrusion and downstream pollutant contamination.

Additional net benefits were found through additional studies (USACE, 1997a): agricultural (primarily rice, cattle, turf grass, and crawfish); recreation (bird-watching, hunting, fishing); industrial (cooling and processing); and municipal uses.

No long-term permanent effects to wildlife, aquatic life, threatened or endangered species, water quality, air quality, noise, floodplains, cultural resources, or prime farmlands were expected (USACE, 2003c). An FEIS supplement was prepared in July 1981. A draft Environmental Assessment (EA), contained in the December 1997 General Reevaluation Report, concluded that the recommended plan would not have significant adverse environmental effects. The final EA was completed in October 1998. Construction of the Saltwater Barrier Project was completed in 2003. Current operational impacts are not known at the time of this document’s production; however, impacts from the FEIS and the General Reevaluation Report are included in Table 4.16-1.

4.16.3.4 Salt Bayou – McFaddin Ranch Wetlands Salt Water Control Project

In 1992, the USACE, Galveston District, proposed modification of the GIWW by construction of a water control structure to improve fish and wildlife habitat on 60,000 acres of the wetlands of the McFaddin NWR, Sea Rim State Park, and J.D. Murphree WMA in Jefferson County, Texas (USACE, 1992). Prior to construction of the GIWW, the SNWW, and the Keith Lake cut, the area contained fresh to brackish marshlands drained by bayous and lakes to Sabine Lake. Disrupted natural drainage patterns and introduced salt water from the Gulf increased salinity in these marshlands causing loss of SAV, erosion, conversion to open water, and reduced wildlife habitat values. Actions to repair these conditions included installation of a concrete water control structure with five gated culverts on the GIWW at Salt Bayou; new channel excavation; training levee construction with stone riprap; and damming the outlet channel. It was determined that this project would have no significant impact on water quality, federally listed threatened or endangered species, National Register eligible properties, or floodplains (USACE, 1992). The project was intended to have a beneficial effect on approximately 60,000 acres of publicly owned wetlands and migratory waterfowl habitat. Although the barrier is functioning as intended, rainwater runoff exiting through the single remaining tidal exchange point at the Keith Lake Fish Pass has been insufficient to block significant saltwater intrusion, and marsh loss is still occurring.

4.16.3.5 Beneficial Uses of Dredged Material for Marsh Preservation, GIWW – Port Arthur to High Island, Texas

In 2003, the USACE Galveston District proposed BU of routine periodic maintenance dredged material along part of the Port Arthur to High Island reach of the GIWW, a 17-mile reach, which crosses the McFaddin NWR and J.D. Murphree WMA in Jefferson County, Texas. For this project, BU included berm creation and restoration along the channel to restrict saltwater intrusion into adjacent freshwater to intermediate marshes. Additionally, dredged material in existing PA No. 4 was allowed to flow over the rear levee into adjoining marsh to offset effects of subsidence. PA No. 4 is located in both the McFaddin NWR and J.D. Murphree WMA; new PAs as a result of this project were located within the McFaddin NWR and consist of narrow discharge corridors along the southern bank of the GIWW (USACE, 2003d). This plan was developed with the USFWS and TPWD, stewards of the NWR and WMA, respectively.

Overall, dredged material discharge impacts to marsh elevation and temporary salinity impacts to vegetation were considered minor relative to preserving and restoring adjacent marshlands. Wildlife disturbance was short term and localized during dredged material discharge operations. It was anticipated that some species of freshwater fish would benefit from the action, and the action would not affect EFH. No federally listed or proposed species were likely to occur at the project site and several State-listed species may have benefited from habitat loss prevention, restoration, and preservation. No historic properties were affected.

The project actions have no significant effect on maritime traffic along this reach of the GIWW. Vehicular traffic to an adjacent hunting lodge was blocked for 1 to 2 weeks, outside of the hunting season, to accommodate the discharge pipe. During dredging, the area immediately around the dredge and pipeline are hazardous (presence of equipment, increase in service boat traffic); however, these impacts to public safety are minor.

The Port Arthur – High Island Beneficial Use of Dredged Material impacts summary is presented in Table 4.16-1 for comparison to the SNWW CIP and other past, present, and reasonably foreseeable projects.

4.16.3.6 Sabine-Neches Waterway: Marine Organism Access between Placement Area No. 11 and Sabine Lake

In 1997, the USACE, Galveston District, proposed relocation of two drop-outlet structures, which allow clarified decanted water to exit PA No. 11 during dredged-material discharge operations. The relocation intended to enhance estuarine connectivity between PA No. 11 and Sabine Lake Estuary System and productivity within PA No. 11, between dredging cycles, by opening PA No. 11 to tidal exchange with Sabine Lake. Additionally, the work included removal of two existing spillways and closure of the connection between the drainage ditches and the Sabine-Neches Canal. The project was determined to have no significant adverse effect on human environment, fish, wildlife, water quality, threatened or endangered species, or historical resources (USACE, 1997b).

4.16.3.7 TxDOT Emergency Action Permit for Fill Along the Sabine River

TxDOT held an emergency permit valid through 2008 to conduct shoreline stabilization activities, as needed. The permit was valid for approximately 9 miles along the east and west shorelines of the Port Arthur Ship Channel, along SH 87 from south of the GIWW to northeast of Keith Lake, and along SH 82 from east of the GIWW to east of Keith Lake, south of Port Arthur in Jefferson County, Texas.

4.16.3.8 Habitat Protection and Restoration Projects

CWPPRA (PL 101-646), also known as the Breaux Act, provides Federal funding through the USACE to five Federal agencies cooperating with local funding-match sponsors to preserve and restore wetlands in Louisiana (LCWCR, 1998). The Breaux Act also established the Coastal Wetlands Conservation Grant Program to help preserve and restore other coastal wetlands with matching Federal funding in the U.S. and to assist programs under the North American Wetlands Conservation Act, passed in 1989. The Breaux Act designates that 70 percent of its authorized funds go to Louisiana restoration projects, 15 percent to the Coastal Wetlands Conservation Grant Program, and 15 percent to North American Wetlands Conservation Act projects. The Breaux Act Louisiana projects typically have a 20-year or less "lifespan" from planning through implementation and monitoring. As of 2004, approximately 129 projects were active from 13 Priority Project Lists (USACE, 2005c). Four recent projects within the SNWW study area were considered for the cumulative impacts assessment. The effects of these projects on land loss were considered in the WVA model analysis of each hydro-unit (Appendix C); they are combined in Table 4.16-1 under "Habitat Restoration Projects" as they are similar in location, type, action, and effect. A brief description of each project included in this analysis follows.

4.16.3.8.1 East Sabine Lake Hydrologic Restoration Project

The USFWS, NRCS, and LDNR designed and implemented a restoration strategy to prevent elevated salinity in freshwater areas of the western Sabine NWR, from Pool 3 to the eastern shoreline of Sabine Lake in Cameron Parish, Louisiana (LCWCR, 2003). Two construction phases started in 2004 and included shoreline armoring, revegetation, terracing, dike and levee systems, and other water control structure installations. Project actions are designed to prevent or restore events that affect the integrity and function of freshwater marsh areas in the refuge:

- prevent saltwater intrusion from the SNWW and the GIWW;
- restore natural water circulation;
- prevent rapid freshwater runoff;
- reduce marsh loss and subsidence, and
- reduce potential increased salinity from the Texas Water Plan (Senate Bill 1), the SNWW enlargement project, and the Neches River saltwater barrier north of IH 10.

The East Sabine Lake Hydrologic Restoration project area contains identified EFH for postlarval, juvenile, and subadult life stages of white shrimp, brown shrimp, and red drum (USFWS, 2004). The project area also provides important habitat for a number of economically important fishery species and migratory birds. The protected brown pelican may use the project area for feeding and/or loafing but is not known to nest in this area. The USFWS completed an intraservice Section 7 ESA consultation prior to issuing the Finding of No Significant Impact (FONSI) and Final EA and determined that the project would not adversely affect any threatened or endangered species within or adjacent to the project area. No cultural resources were identified within the work area. Habitat for fishery resources including EFH, migratory and resident waterfowl, wading birds, alligators, game mammals, furbearers, and brown pelican would be enhanced. Water quality and salinity are expected to show continual improvement. The total project effects/benefits include the following:

- 101.4 acres converted from shallow water to marsh, 1.4 acres filled by rock dike, and 163 acres of shallow water deepened for a total of 265.8 acres of shallow water filled or deepened; and
- 127.4 wetland acres protected and restored (USFWS, 2004).

4.16.3.8.2 Black Bayou Hydrologic Restoration Project

NOAA, NMFS, and LDNR sponsored and implemented a strategy to restore coastal marsh habitat and slow the conversion of wetlands to shallow, open water within a 25,529-acre wetland in Cameron and Calcasieu parishes, Louisiana (LCWCR, 2002a). The project area includes approximately 6,516 acres of fresh/intermediate marsh, 7,353 acres of brackish marsh, and 11,660 acres of open water (LDNR, 2003a). Tidally influenced intermediate and brackish marshes were threatened by saltwater intrusion and wave action amplified by the GIWW. Several actions were implemented:

- 22,600-foot rock dike constructed on the southern spoil bank of the GIWW;
- 70-foot bottom width barge bay weir in Black Bayou Cutoff Canal;
- 10-foot bottom width weirs with boat bays in Burton Canal and Block’s Creek;
- old, collapsed weir replacement with fixed crest steel sheet-pile weir including a self-regulating tidegate; and
- in situ terracing in open-water areas to create elevated marsh and marsh plantings.

Construction activities were completed in December 2001, and marsh planting began in April 2002. Monitoring was conducted in 2003 under a revised plan (LDNR, 2003a). Mean salinity calculated from continuous recorders and discrete data did not show any large differences between project and reference areas or between preconstruction and postconstruction conditions. However, discrete salinities were monitored from June 1999 through March 2004, and data suggest that the impounded hydrologic area 1 was minimally effective in reducing mean salinity and sharp salinity increases compared to the areas outside the influence of the project structures (LDNR, 2007). California bulrush plantings installed in 2002 were variably successful. No significant change in the shoreline location over 3 years was evident from the 2003 data. SAV coverage was very high in most of the ponds sampled in 1999 and remained high in 2003. Dominant species found at both sampling times include Eurasian watermilfoil, southern naiad (*Najas guadalupensis*), and the algae *Nitella* sp. An annual inspection conducted in October 2005 by the LDNR indicated that the project was in good condition and functioning as intended and that features survived Hurricane Rita basically intact (LDNR, 2005a). As of December 2006, an inspection field trip with the LDNR and NMFS detected two small breeches: one on the rock dike along the GIWW and one on a plug along the GIWW. As a result, discussions are underway to develop a plan for corrective actions (LCWCR, 2006). The project created a total of 2,960 acres of wetlands, protected 634 acres for a net total of 3,594 acres; 2,812 AAHUs are expected for this project (LCWCR, 2002a).

4.16.3.8.3 Perry Ridge Shoreline Protection Project

In February 1999, the NRCS and LDNR completed a limestone riprap dike within a 4.3-mile reach of the GIWW north bank and the Vinton Drainage Canal (LCWCR, 2002b). This dike (12,000 linear feet) is offset from the vegetated shoreline by 60 feet and is designed to break navigation-induced wave action, prevent further shoreline erosion, and reduce salinity spikes by maintaining a freshwater pool behind the rocks. The dike protects approximately 1,203 acres of vegetated shoreline, which, in turn, benefits approximately 5,945 acres of intermediate marsh north of the shoreline. The original monitoring plan was implemented following construction and has been revised in 1998 and 2003 to conform to similar monitoring projects (LDNR, 2003b). Approximately 624 acres of AAHUs are expected (LCWCR, 2002b). Results of the 2005 Operations, Maintenance, and Monitoring Report (LDNR, 2005a) indicate that the average rate of shoreline accretion was 1.6 feet/year at project stations, while reference stations showed a continued rate of shoreline erosion at 0.8 foot/year.

4.16.3.8.4 GIWW – Perry Ridge West Bank Stabilization

In 2002, the NRCS and LDNR completed installation of approximately 34,652 linear feet of rock riprap and terraces along the northern bank of the GIWW between Perry Ridge and the Sabine River in Calcasieu Parish, Louisiana (LCWCR, 2002c). This section of the GIWW was dredged to allow the use of doublewide barges, and consequently, wake erosion intensified. In addition, the construction of the Calcasieu Ship Channel and the deepening of Sabine Pass have increased salinity and water currents within the GIWW. These activities have caused the GIWW shoreline to breach, thus impacting the interior marsh of the Perry Ridge West Bank project area. The shoreline protection was accomplished in three phases:

- 9,500 feet of rock riprap along the northern bank of the GIWW from Perry Ridge to its intersection with the Sabine River;
- 2,200 feet of rock riprap from the Sabine/GIWW intersection north along the Sabine River; and
- 22,952 linear feet of terraces in the shallow, open-water areas north of the GIWW to reduce fetch (distance a wave can travel) and allow recovery of the interior marshes. Terraces were vegetated with 9,400 trade-gallon-sized plantings of California bulrush.

The net benefit in the 1,132-acre project area would be protection and restoration of approximately 83 wetland acres over 20 years (LCWCR, 2002c). This project (CS-30) is directly west of the Perry Ridge Shoreline Protection Project (CS-24) discussed above. According to the 2005 Operations, Maintenance, and Monitoring Report (LDNR, 2005b), visual observations indicate an increase in the SAV species in the project area and potential for accretion.

4.16.3.9 Sabine Pass LNG and Pipeline Project

The Federal Energy Regulatory Commission (FERC) issued an Order on December 21, 2004, granting approval under Section 3(a) of the Natural Gas Act (NGA) for Sabine Pass LNG, L.P.'s proposal (FERC Docket No. CP04-47-000) to construct and operate Phase I facilities at the LNG import terminal and granting approval under Section 7(c) of the NGA for 16 miles of 42-inch-diameter pipeline and associated facilities (called the Sabine Pass Pipeline). This order was based on, among other analyses, the FEIS, Sabine Pass LNG, and Pipeline Project (Phase I Project FEIS) published in November 2004 (FERC, 2004). Sabine Pass LNG, L.P., has subsequently applied for, and the FERC issued, an EA in May 2006 to expand facilities at the terminal (Phase II) (FERC, 2006a). The Sabine Pass LNG Terminal received its first shipment of LNG in April 2008.

The Sabine Pass LNG import terminal in Cameron Parish, Louisiana, includes the following:

- LNG ship unloading berths;
- LNG transfer, storage, and vaporization;
- packaged natural gas turbine/generator sets;
- ancillary utilities, buildings, and service facilities; and
- a new 16-mile, 42-inch-diameter pipeline system to deliver natural gas to existing pipeline infrastructure (FERC, 2004).

As documented in the FEIS, the Sabine Pass LNG project was expected to affect approximately 540 acres of open land, consisting of coastal prairie and grasslands, wetlands, and a Dredged Material Placement Area (DMPA). Approximately 35 acres were converted to open water, 36 acres were converted from shallow water to deep water, and 341 acres were affected by operational facilities. Construction and operation were anticipated to have minimal effects to geological and soil resources; no prime farmland soils were affected. No significant effects were anticipated to groundwater resources or public or private water supply wells. Surface water impacts included dredging approximately 4.5 mcy from the berth area and 69,000 cy from the construction dock area. Materials were moved to an unconfined BU area near Louisiana Point. Maintenance dredging is expected to occur every 4 to 7 years. Protective measures would be implemented to minimize impacts to surface waters. Although project actions resulted in temporary decreased water quality during and following dredge placement, potential future dredging benefits may include the following:

- Creation of a wave barrier to decrease wave energy along the shoreline, resulting in decreased shoreline erosion;
- Accretion of shoreline from redeposition of dredged material;
- Increased shallow-water habitat for marine and bird species that use shallow-water areas for foraging;
- Reoxygenation of sediments;
- Increase in wetland vegetation at water/shoreline interface due to increased shallow water and decreased wave energy; and
- Accretion of wetland habitats as high tide or storm events carry sediments into wetland areas

Approximately 156 acres of wetlands were expected to be affected by the LNG terminal development. Permanent wetland impacts included conversion of 17.4 acres of emergent wetland and 30 acres of DMPA to LNG terminal facility and 3.8 acres emergent wetland for a mainline valve on the pipeline. Less than 1 acre of forested wetland was converted to emergent wetland for pipeline operation. Additional wetlands impacts (approximately 27 acres) and mitigation (62 acres) were proposed when the USACE and LDEQ approved a permit amendment for Phase II (USACE, 2006d).

Wetlands in the Sabine Pass LNG and Pipeline project areas are designated as EFH for brown and white shrimp, red drum, and Spanish mackerel. Temporary EFH impacts during construction of the LNG terminal and pipeline totaled approximately 83 acres. Operation of the LNG and pipeline facilities was expected to permanently impact 15 acres of brackish marsh and mudflat wetlands and convert 36 acres of shallow open-water EFH to deep-water habitat. Wetland and EFH mitigation was proposed to enhance or create 73-wetland acres onsite, concurrent with the start of construction.

Of the 12 potentially occurring Federal- and State-listed threatened and endangered species, only the piping plover and brown pelican potentially occurred within the LNG project area. Critical habitat for the piping plover is designated at Louisiana Point, near the BU area for this project. With protective measures, construction and operation of the LNG terminal and pipeline facility were not expected to likely adversely affect either species or designated critical habitat. LNG ship encounters in the open water of the Gulf during transport create potential adverse effects to sperm whales, Kemp’s ridley sea turtles, loggerhead sea turtles, green sea turtles, and leatherback sea turtles. As with the terrestrial species, protective measures and reporting procedures minimize these impacts.

At the time of construction, there were no residences within 1 mile of the LNG terminal location, and no residences within 50 feet of the pipeline work areas. No visual impacts were expected. No recreational facilities were directly impacted by construction or operation. It was anticipated that areas along the LNG ship route and around the terminal slip would be exposed to a potential temporary hazard during ship transit and while at the berth.

No prehistoric or historic cultural resources were located in the area of potential effect at the time of the FEIS publication; however, additional deep-water archeological testing and some remaining testing along the proposed pipeline route were conducted following the issuance of the FEIS. No known archeological sites or historic properties were affected by use of the Louisiana Point BU dredge disposal area. Construction air emissions were expected to be short term without adverse effect to regional air quality. Operational air quality was anticipated to exceed NO_2 and CO thresholds and was subject to State air permitting requirements.

The following plans were implemented to minimize impacts to potentially affected resources:

- Upland Erosion Control, Revegetation, and Maintenance Plan;
- Wetland and Waterbody Construction and Mitigation Procedures;
- Spill Prevention, Containment, and Countermeasures Plan;
- Aquatic Resources Mitigation Plan;
- Environmental Construction Plan and Procedures; and
- NOAA Vessel Strike Avoidance and Injured/Dead Protected Species Reporting (Strike Avoidance Policy).

The Sabine Pass LNG and Pipeline impacts summary is presented in Table 4.16-1, in comparison to the SNWW CIP and other past, present, and reasonably foreseeable projects.

4.16.3.10 Golden Pass LNG and Pipeline

In July 2005, FERC authorized (with conditions) Golden Pass LNG Terminal LP and Golden Pass Pipeline LP construction and operation of an LNG receiving and transportation facility northeast of Sabine Pass, Texas, adjacent to the Port Arthur Canal in Jefferson County, Texas (FERC, 2005). The project was designed to import, store, and deliver foreign-source LNG to natural gas markets and includes a marine ship berthing area, LNG storage tanks and vaporization facilities, and a natural gas pipeline. The 122.4-mile natural gas pipeline was completed in April 2009, 1 year ahead of schedule (FERC, 2006b). The pipeline would cross Jefferson, Orange, and Newton counties, Texas, and Calcasieu Parish, Louisiana. Although the facility was expected to open in mid 2009, damage caused by Hurricane Ike pushed the anticipated opening into 2010 (*Wall Street Journal*, 2008).

Measures would be taken to minimize impacts to soil and geological resources. Approximately 2.8 acres of prime farmland would be permanently affected. No impacts are anticipated to groundwater resources. Primary impacts to surface waters would be from construction, including dredging 6.3 mcy for the LNG terminal; this action would create approximately 63.9 acres of open water and convert 43 acres of shallow water to deep water. Maintenance dredging is expected to occur every 2 years and would result in an average of 410,000 cy per year. Dredged material would be pumped to PA 8 or PA 9, and approximately 1.2 mcy would be beneficially used for wetland restoration in the J.D. Murphree WMA. The proposed pipeline would cross the J.D. Murphree WMA. Approximately 0.5 acre of eroded shoreline would be reclaimed by filling the shallow-water area adjacent to the canal. Pipeline construction would minimize impacts to surface waters in 19 crossings using 31 horizontal directional drills.

It is anticipated that clearing and construction would affect approximately 2,007 acres of palustrine wetlands, estuarine emergent marsh, upland prairie, forest, agriculture and pastureland, and open-water/channel shoreline habitat. Approximately 239 acres of forested uplands and wetlands would be converted to herbaceous cover. Permanent vegetation effects would be approximately 227 acres for the LNG terminal and access road and 712 acres for the pipeline easement, aboveground facilities, and access roads (FERC, 2006b).

Golden Pass would affect approximately 399 wetland acres: 109 acres lost to LNG terminal facility development; 64 acres converted from forested to herbaceous or lost for aboveground facilities and access roads; and 226 acres affected by pipeline construction. Approximately 83 acres of forested wetlands would be cleared for pipeline right-of-way (ROW); of this, 40 acres would be maintained as herbaceous wetland within the ROW and the remaining 43 acres would eventually return to forested wetland areas. Pipeline construction would cross 14.9 miles of the J.D. Murphree WMA and nearly 1 mile of the Sabine Island WMA. The impacts to the forested wetland areas are considered permanent because of the time required for those wetlands to naturally recover to preproject conditions. Three years of invasive species control would be performed along the pipeline route to facilitate native species' success. Routing would minimize wetlands impacts on J.D. Murphree WMA, and directional drilling would minimize impacts to the Sabine Island WMA. Permanent impacts to wetlands would be mitigated through the following actions:

- creation of approximately 244 acres of vegetated wetland within the J.D. Murphree WMA;
- purchase of an 829-acre tract (195.5 acres forested wetlands, 7.6 acres emergent and scrub shrub wetlands, 18.8 acres forested riparian corridor, and 603.2 acres upland mixed-age pine stands) adjacent to the Big Thicket National Preserve; and
- purchase of 50 acres from The Nature Conservancy's Southwest Louisiana Pine Wetland Mitigation Bank to compensate for the forested wetland impacts within the Calcasieu River watershed.

The Golden Pass projects would affect just over six marshland acres designated as EFH for several life stages of red drum, Spanish mackerel, and white and brown shrimp. Deep, open-water EFH may be created by berth and marine basin dredging, providing habitat for some lifestages of some species. Of 15 potentially occurring federally and State-listed threatened and endangered species, the projects may affect only the red-cockaded woodpecker.

Thirty-three residences are within 1 mile of the proposed LNG terminal. Visual and land use impacts would occur in limited areas; however, Golden Pass would implement special construction techniques to minimize land use impacts to affected residences. The Texas State Historic Preservation Officer (SHPO) has concurred that no historic properties would be affected by the LNG terminal; however, the pipeline system consultation is not complete. Investigations and consultation indicate that buried cultural resources and the viewshed and cultural landscape of historic structures may be affected by the pipeline system.

The following plans would be implemented to minimize impacts to potentially affected resources:

- Spill Prevention, Containment, and Countermeasures Plans;
- Storm Water Pollution Prevention Plan;
- Upland Erosion Control Plan;
- Revegetation and Maintenance Plan;
- Wetland and Waterbody Construction and Mitigation Procedures; and
- Aquatic Resources Mitigation Plan.

The Golden Pass LNG and Pipeline impacts summary is presented in Table 4.16-1, in comparison to the SNWW CIP and other past, present, and reasonably foreseeable projects.

4.16.3.11 Kinder Morgan Louisiana Pipeline

Kinder Morgan Louisiana Pipeline LLC has obtained authorization to construct and operate a 140-mile pipeline system in Cameron, Calcasieu, Jefferson Davis, Acadia, and Evangeline parishes, Louisiana (FERC, 2006a; 2007). The proposed Kinder Morgan Louisiana Pipeline is designed to transport regasified natural gas from the Sabine Pass LNG Terminal to various intrastate and interstate natural gas pipeline systems, delivering a peak day capacity of not less than 3,395,000 decatherms.

The pipeline system would consist of three pipelines and associated pipeline support facilities, including pig launchers and receivers and metering equipment. Leg 1 of the pipeline consists of approximately 130 miles of 42-inch-diameter pipeline originating at a receipt point within the Sabine Pass LNG Terminal and terminating at an interconnection with an existing Columbia Gulf Transmission interstate pipeline in Evangeline Parish, Louisiana. Leg 2 is an approximately 0.4 mile of 36-inch-diameter pipeline originating at a receipt point in the Sabine Pass LNG Terminal and terminating at an interconnection with the existing Natural Gas Pipeline Company of America north of the LNG terminal. The third pipeline originates at the termination point of Leg 1 and would not have impacts within the SNWW study area. Fifteen new lateral pipelines from the proposed pipeline interconnecting sites to existing interstate pipelines are expected to be constructed by separate entities.

The FEIS was issued in April 2007 (FERC, 2007). Specific resource impact information for the Kinder Morgan Louisiana Pipeline is included in Table 4.16-1. The corridor for Leg 1 is located in the SNWW study area; it commences from the Sabine Pass LNG terminal, proceeds north across Sabine Lake, up the Sabine River, and then turns eastward along the GIWW. The corridor in Sabine Lake was designed to avoid impacts to the extensive oyster reefs near Blue Buck Point and does not impact other oyster reef or habitat. Pipeline construction was expected to result in permanent impacts to 0.8 acre of brackish marsh in the SNWW study area. Compensatory mitigation for these wetland impacts consisted of marsh restoration and preservation through the creation of 5,511 linear feet (2.53 acres) of wave-dampening terraces.

4.16.3.12 Jefferson County Drainage District No. 6 Taylor Bayou Flood Reduction Project

The Jefferson County Drainage District No. 6 (JCDD6) received a Department of Army permit in 2007 to construct flood control improvements to Green Pond Gully, Willow Slough, and Taylor Bayou, southwest of the city of Beaumont, in Jefferson County, Texas (USACE, 2006e, 2007c). Actions will include regional detention and levee construction, channel improvements, and the construction of a diversion channel (known as the Needmore Diversion Channel) from near the confluence of the North and South Forks of Taylor Bayou south to the GIWW. The Green Pond Detention Basin, levee construction, channel modifications, and Needmore Diversion Channel will be undertaken as part of flood reduction measures for the Taylor Bayou watershed. The Green Pond Detention Basin will be a 9,000-acre, aboveground detention facility located between Lawhorn Road, Farm-to-Market Road 365, South China Road, and Gallier Canal, with a maximum storage capacity of 15,000 acre-feet. The Needmore Diversion Channel is a 63,000-foot-long, 14-foot-deep, 200-foot-wide bottom channel within a 1,000-foot-wide ROW extending from near the confluence of the North and South forks of Taylor Bayou to the GIWW. Rectification of several man-made channel restrictions are included along portions of the North Fork of Taylor Bayou at Craigen Road, SH 124, IH 10, between Crystal Lakes, and between IH 10 and Green Pond Gully to restore and improve the flood flow characteristics of the waterway. The project will result in the direct impact to 692.4 acres of jurisdictional wetlands and 337.2 acres of nonjurisdictional low-to-high-quality forested and medium-to-high-quality herbaceous wetlands.

To offset impacts for the project, the JCDD6 has agreed to preserve 538 acres of wetlands adjacent to Spindletop Bayou and an additional 1,926 acres of forested wetlands and uplands within the Green Pond facility. An additional 7,000 acres will have restricted land use to preserve the area from development. A total of 44 acres of wetlands and riparian forest within or adjacent to the Needmore Diversion (40 acres of wetland shelf within the channel and 4 acres of riparian wooded corridor along the east border of the channel from Taylor Bayou south to Willow Slough) will also be created. In total, mitigation will consist of the preservation of approximately 2,464 acres of wetlands and wetland forests and the creation of 44 acres of wetlands and riparian forest to compensate for impacts to approximately 692 acres of jurisdictional waters and wetlands. To ensure that impacts to water quality in Taylor Bayou are minimized, the project design includes a flap gate structure at the Needmore Diversion Channel's south end to eliminate the possibility of saltwater intrusion in periods of reduced freshwater inflows and during storm surge events. In addition, the diversion channel's input from the South Fork of Taylor Bayou will be controlled to take only floodwaters above elevation 5.2 feet mean sea level ensuring that normal flows of Taylor Bayou are not impacted and only severe flood events are reduced in size and duration by the proposed diversion channel. At issuance, all required Federal, State, and/or local authorization or certifications had been obtained except for water quality certification and coastal zone consistency certification. JCDD6 stated that the project is consistent with the Texas CMP goals and policies and would be conducted in a manner consistent with that program and that water quality certification would be obtained from TCEQ.

A historic properties investigation has been conducted within the permit area, and no sites determined eligible for or listed on the NRHP are within the permit area or affected area. No known threatened and/or endangered species or their critical habitats are likely to be adversely affected by the proposed work. The action is not anticipated to have a substantial adverse impact on EFH or federally managed fisheries in the Gulf. Specific resource impact information for the Taylor Bayou Flood Reduction Project is included in Table 4.16-1.

4.16.4 Reasonably Foreseeable Future Actions

4.16.4.1 Port Arthur LNG and Pipeline

Port Arthur LNG, L.P., and Port Arthur Pipeline, L.P., proposed construction of a new LNG import terminal and pipeline system in Jefferson County, Texas (FERC, 2006c). The facility includes LNG ship unloading berths, LNG storage and vaporization, and a new 73-mile, 36-inch-diameter natural gas pipeline system to deliver the natural gas to existing interstate and intrastate pipeline systems. The project was authorized by FERC in 2006 and would be constructed in two phases over approximately 10 years.

Geological resources would be minimally affected. Erosion control devices and plans would reduce shoreline erosion and flooding effects from storm events. Adverse effects to groundwater and water supplies are not anticipated. Impacts to surface waters would be primarily from the 6.7 mcy of material dredged for the LNG ship berths and turning basin, pumped to an existing DMPA onsite for beneficial reuse. Approximately 82 acres of land would be converted to open water. Fourteen areas would be horizontally directionally drilled to minimize potential adverse water quality effects from the pipeline crossing several major waterbodies.

Clearing and construction would impact 1,497 acres of palustrine, scrub-shrub, and forested wetlands; estuarine emergent marsh; coastal prairie/grasslands; coastal woodlands/upland forests; agriculture and pastureland; disturbed lands; and, open-water/channel shoreline habitats. Operational (permanent) vegetation impacts would include approximately 198 acres for the LNG terminal and 87 acres (forest to herbaceous conversion) for the pipeline. Construction of the proposed LNG facility and pipeline would result in impacts to approximately 391 acres of wetlands, of which 96 acres would be permanent (83 acres for LNG terminal facility and 13 acres for the pipeline). Approximately 13 acres of the pipeline system permanently impacted wetlands would be converted from forested to herbaceous cover. The remaining 295 acres of impacted wetlands would be restored and allowed to revegetate to preconstruction conditions.

The Port Arthur LNG terminal and pipeline projects would affect a total of 456 acres of estuarine and deep-water habitats designated as EFH for several life stages of red drum, Spanish mackerel, white and brown shrimp, and bonnethead shark (*Sphyrna tiburo*). Eighty-two acres of deep, open-water EFH may be created by berth and marine basin dredging, providing habitat for some lifestages of some species. Of 22 potentially occurring Federal- and State-listed threatened and endangered species, the projects are not likely to adversely affect any of these species or their designated critical habitats.

No residences occur within 1 mile of the proposed LNG terminal and three residences occur within 50 feet of the proposed pipeline work area. Land use and visual impacts are likely. Site-specific construction plans would be implemented to minimize effects to these residences during construction. No direct effects are anticipated to the private, State, and Federal recreation and conservation areas in the Louisiana or Texas. CZMP consistency determinations have been issued by Louisiana and Texas. Two cultural sites within the terrestrial portion of the proposed construction area have been assessed as potentially eligible for listing in the NRHP. Additionally, seven magnetic and/or acoustic anomalies have been detected where the pipeline would cross Sabine Lake. Studies and avoidance/mitigation measure planning efforts are in progress.

If unmitigated, direct and indirect emissions during the LNG terminal operation would exceed de minimis air quality conformity thresholds. Mitigation measures would be implemented, preventing increase of emissions with respect to future baseline emissions. Operational risks to public health and safety would be none to minimal, depending on the location and activity. The moving safety zone, moored vessel security zone at the terminal, and one-way traffic areas would affect other commercial and recreational traffic using the SNWW.

The following minimization and protection plans would be implemented to address unavoidable impacts:

- Spill Prevention, Containment, and Countermeasures Plans;
- Storm Water Pollution Prevention Plan;
- Upland Erosion Control Plan;
- Revegetation and Maintenance Plan;
- Wetland and Waterbody Construction and Mitigation Procedures;
- Aquatic Resources Mitigation Plan (primarily for wetlands); and
- LNG Vessel Management and Emergency Plan.

The Port Arthur LNG and Pipeline impacts summary is presented in Table 4.16-1, in comparison to the SNWW CIP and other past, present, and reasonably foreseeable projects.

4.16.4.2 East Texas Regional Water Plan

The 2007 Texas State Water Plan is the eighth water plan developed by TWDB as a part of its core mission to ensure that sufficient, clean, and affordable water supplies are available for the citizens of the State of Texas and that those water supplies foster a healthy economy and environment (TWDB, 2007). The plan was developed from May 2005 to August 2006 and approved in November 2006. The state plan includes participation from 16 regional groups (TWDB, 2007).

The ETRW Planning area includes all or part of 20 counties, from Beaumont, Port Arthur, and Orange counties north to Tyler County, spanning from the Texas-Louisiana border east to the Trinity River Basin boundary. Three surface water river basins (Sabine, Trinity, and Neches) and four aquifers (Gulf Coast, Carrizo-Wilcox, Sparta, and Queen City) serve the water uses in the region. The Neches-Trinity Coastal Basin and approximately 1 square mile of the Cypress Creek Basin are also partially encompassed in the planning area. The 2006 ETRW Plan that was adopted as part of the 2007 Texas State Water Plan seeks to address a projected 41 percent increase in water demand from 2010 to 2060 through several strategies (TWDB, 2007):

- construction of a new reservoir, Lake Columbia (Eastex) on Mud Creek (tributary of the Angelina River) in Cherokee County, Texas (approximately 187,839 acre-feet);
- negotiated use of adjacent Region C surface water supplies, Toledo Bend Reservoir (existing), and Lake Fastrill (not yet constructed on the Neches River);
- expanded groundwater use based on long-term sustainability;
- municipal conservation through plumbing code implementation and public education to save over 20,600 acre-feet of water annually by 2060;
- City of Athens indirect reuse of wastewater discharge, returning a portion of treated wastewater to Lake Athens, the city's primary water supply; and
- policy recommendations.

The ETRW Plan is consistent with protection of agricultural, public, park, oil, gas, and coal production resources. The development of Lake Columbia and Lake Fastrill may affect several resource classes, including timber, State- and Federal-threatened and/or endangered species, water resources, and others; however, these reservoirs would not be within the SNWW project area. Lake Columbia is anticipated to inundate approximately 10,000 acres. Lake Fastrill would inundate approximately 24,950 acres, including a portion of the proposed USFWS North Neches NWR. Site-specific information to identify wetlands, bottomland hardwoods, ecologically significant stream segments, Sabine-Neches estuary freshwater inflow needs, cultural resources, and prime farmland sites is currently not available. Because specific resource impact information is not available at this time, strategies discussed in the ETRW Plan are not included in Table 4.16-1.

4.16.4.3 Port of Beaumont Intermodal Improvement Projects

Both the Southside and Northside intermodal improvements projects have received funding from the H.R. 3 Transportation Bill. The Southside Project would provide infrastructure modifications and facilities expansion for direct intermodal interchange, transfer, and access for the Port of Beaumont to improve access and operation capabilities. The project would include rail holding tracks and loading ramps, and would increase the port's railcar storage capacity by about 75 percent. Operational efficiency and security would be enhanced by relocating the interchange tracks to expanded facilities at the terminal (Port of Beaumont, 2005a).

The Northside Intermodal Improvements Project would fund development and construction of an access road to connect IH 10 to port-owned property on the north bank of the Neches River. Additional funding was received for a rail infrastructure improvement project under a Federal program designed to promote air quality and congestion reduction (Port of Beaumont, 2005b).

These projects, combined, are expected to:

- Enhance the port’s capacity for railcars
- Improve the port’s ability to handle military cargo
- Enhance security for military and other cargo
- Increase the efficiency of port operations
- Make downtown riverfront property available for commercial development
- Provide significant growth opportunities for development of the port’s northbank property in Orange County, Texas

In addition to projects outlined above, additional Port of Beaumont improvements include:

- A general cargo wharf
- A new dock office
- A new building for the port’s military customers
- Repairs of bulkheads and upgrades of lots
- New double layberth for military vessels and new 90,000-square-foot transit shed on the Orange County, Texas, side
- Extend main Harbor Island east wharf with new transit shed on Beaumont side – new 680-foot extension to Harbor Island wharf, and linking railroad tracks on the new wharf to existing tracks. Project is meant to relieve berth congestion at the terminal.

Specific resource impact information is not available at this time; therefore, the Port of Beaumont intermodal improvement projects’ potential impacts are not included in Table 4.16-1.

4.16.4.4 Keith Lake Fish Pass Ecosystem Restoration Section 1135 CAP

Keith Lake Fish Pass is located in Jefferson County, Texas, approximately 15 miles south of Port Arthur and intersects SH 87. The pass is approximately 0.3 mile south of the GIWW and on the west bank of the Sabine-Neches Ship Channel south of Port Arthur. The pass connects Keith Lake to the Port Arthur Canal and is part of a drainage system that impacts about 60,000 acres of wetlands (10,000 acres of coastal marsh habitat) in McFaddin NWR, Sea Rim State Park, and J.D. Murphree WMA in the Neches River delta. At 10,000 acres, the Keith Lake watershed contains approximately 8 percent of existing Texas coastal estuarine marshes. Assuming no increase in the rate of marsh loss from the most recent estimates, approximately 3,460 acres (or 35 percent) of brackish marsh in the Keith Lake watershed would be lost during the next 50 years (USACE, 2002).

Area marsh has been adversely affected by saltwater intrusion and high-energy inflows resulting from an obsolete and unrefurbishable 1933 USACE structure and the impacts of the 1974 USDA “water exchange pass” project, now known as the Keith Lake Fish Pass. The pass was created to improve water circulation into the Salt Bayou Drainage system and was a 3,600-foot straight-line canal, 155 feet wide and 5 feet deep with 2:1 side slopes. Higher-than-expected water volume and velocity have eroded the pass to 240 feet wide and 7 feet deep since 1977. The cut has improved the amount and variety of marine species in the area; however, the marsh system has been degraded by high salinity levels and hydraulic energy impacts from the ship channel.

Emergent coastal wetland habitats and wetland soils loss has been accelerated in Jefferson County, Texas. Open water is formed when salt-intolerant vegetation dies and the underlying organic topsoil material erodes away before the succession of salt-tolerant vegetation can take place. The area is vital nesting and brooding habitat for mottled ducks, with an increasing amount of nesting by fulvous whistling duck (*Dendrocygna bicolor*) and black-bellied whistling ducks (*D. autumnalis*). Several species of migratory birds traveling the Central Flyway use the area as a rest stop or staging area.

Jefferson County, Texas, and USACE, Galveston District, with support from the TPWD, GLO, and TWDB, are studying ways to reduce the amount of saltwater intrusion and decrease high-energy inflows entering the marsh, thus slowing marsh habitat loss. The goal of the study and any recommended conservation measure is to sustain and protect over 60,000 acres of brackish coastal marshes within the Saltwater Bayou Watershed, including approximately 2,600 acres in the Keith Lake system. As yet, undetermined measures must assist in achieving the objective presented in the Salt Bayou Project Joint Management Concept Plan for Sea Rim State Park, McFaddin NWR, and J.D. Murphree WMA (August 1990). The TPWD is developing alternatives and potential impact information for the Keith Lake Fish Pass project is not currently available to include in Table 4.16-1.

4.16.4.5 Sabine Pass to Galveston Bay Shoreline Erosion Project

The purpose of the Sabine Pass to Galveston Bay Shoreline Erosion Feasibility Study is to address the severe shoreline erosion occurring along the upper Gulf Coast of Texas between the SNWW (Sabine Pass) and the Galveston Entrance Channel (Galveston Bay) and the entire Gulf shoreline of Galveston Island (USACE, 2004b). The study area consists of approximately 90 miles of Gulf shoreline in Jefferson, Chambers, and Galveston counties along the upper Texas coast from Sabine Pass to San Luis Pass at the western end of Galveston Island. The major problems identified in the reach to the north of Galveston Bay result from shoreline erosion and include the potential destruction of nationally significant wetlands, loss of land and damage to homes and commercial properties, and significant damage to SH 87. The Sabine Pass to Galveston Bay Shoreline Erosion Project is in the planning stages, and no information regarding potential impacts is available for Table 4.16-1.

4.16.4.6 Toledo Bend Reservoir Relicensing

Toledo Bend Reservoir is located on the Sabine River in Texas and Louisiana and forms a portion of the boundary between the two states. The reservoir is approximately 65 miles long and inundates land in Newton, Sabine, Shelby, and Panola counties, Texas, and Sabine and DeSoto parishes, Louisiana. Toledo Bend Reservoir has 1,200 shoreline miles, normally covers an area of 185,000 acres, and has a controlled storage capacity of 4,477,000 acre-feet. The reservoir was constructed by SRA-TX and Sabine River Authority of Louisiana (SRA-LA) for water supply with secondary uses of hydroelectric power generation and recreation. On December 12, 2002, the SRA-TX approved an application to TCEQ to amend Certificate of Adjudication No. 05-4658 to include the right to divert 293,300 acre-feet per year of the available portion of the stored Texas water from Toledo Bend Reservoir for multiple use (municipal, industrial, agricultural) (SRA-TX and LNVA, 2006). TCEQ is mandated to consider environmental flows (instream and freshwater needs) during permit evaluations for new reservoirs or amended water rights.

The SRA-TX and SRA-LA have initiated the process to renew the FERC license that allows the generation of hydroelectric power. The current FERC license expires October 14. 2013. The intention of SRA-TX and SRA-LA is to continue current operations as a hydropower peaking unit during the summer months. However, as water supply sales increase, hydropower generation may be reduced.

The Authorities submitted a Notice of Intent to file an application for a new license and request designation as non-Federal representatives in September 2008, and a Proposed Study Plan in July 2009 to FERC (SRA, 2009), but specific resource impact information is not available at this time; therefore, the Toledo Bend Reservoir Operating Plan and potential FERC relicensing potential impacts are not included in Table 4.16-1.

4.16.4.7 Cameron Parish Dredge Project

Cameron Parish Gravity Drainage District #7 proposes to dredge 6,970 feet of Johnson’s Bayou to remove debris and sediments deposited during Hurricane Ike. Material would be placed into an upland confined PA. No wetland impacts would occur. Also, preliminary coordination determined no substantial effects, and no effects to EFH and threatened or endangered species, respectively. Information available is minimal, and this project is not included in Table 4.16-1.

4.16.4.8 Taylor Bayou Canal Seven Gate Saltwater Barrier

Located at the existing Taylor Bayou Canal Seven Gate Saltwater Barrier at the intersections of the Taylor Bayou Canal and Taylor Bayou, the SNND proposes to construct four additional saltwater gates. This effort would include 137-x-40-foot pile-supported slap and gate walls, 98 feet of concrete wing wall, 3,000 cy of riprap, 6,500 feet of 8-inch conduit, replacement of the control building (which was destroyed by Hurricane Ike), and 50,000 cy of material acquired from dredging. Impacts would involve 2.3 acres of wetland. Information available is minimal, and this project is not included in Table 4.16-1.

4.16.4.9 Study Area Habitat Protection and Restoration Actions

Four projects are currently planned in the study area that target protection and restoration of wetlands and include the Star Bayou/Rose City Mitigation Bank, and three restoration and enhancement projects at McFaddin NWR.

The Star Bayou/Rose City Mitigation Bank would require dredging of Star Bayou (400-x-200-foot area) to acquire 26,000 cy of material. This material would be used to construct, restore, and enhance wetland areas at part of another ongoing mitigation effort in the Rose City Marsh Complex Habitat Restoration

Area. Although temporary impacts may occur from dredging, the project would result in long-term beneficial effects to wetlands in the study area.

The USFWS proposes to rehabilitate earthen levees and install water control structures at two locations on McFaddin NWR. The first project, Big Hill Unit Restoration, would involve acquisition of 534,000 cy of dredged material for 8,900 feet of levee rehabilitation along Lost Bayou. Also, 400 feet of new levee would be created. Water control structures would be used to manipulate freshwater inflows from Willow Slough, and general aquatic habitat management. Although 0.18 acre of wetlands would be filled through these actions, the overall long-term effect of the project would result in net benefits to the study area wetland complexes.

The second project, Clam Lake Restoration Project, would create a 625-square-foot levee with control structures within wetlands. Material for levees would come from immediately adjacent areas. Although the project would fill 2.94 acres of marsh and excavate another 3.67 acres, project goals include saltwater intrusion protection for 1,500 acres of wetlands within the Wild Cow Bayou Unit, restoration of 248 acres of marsh, and enhancement of 730 acres of wetlands adjacent to 10-mile Cut.

The third project on McFaddin NWR would involve the placement of 12,132 linear feet of graded rock serving as a breakwater structure for protection along an eroded shoreline along the north side of the GIWW. The breakwater would be approximately 25 feet wide at the base, 3.5 feet high in the center, 20 to 40 feet from the existing eroded bank, resulting in 43,570 cy of fill below the mean high tide line. No direct wetland impacts would occur, and the breakwater may have beneficial effects to adjacent wetlands.

Information on these four protection and restoration projects was limited and only included wetland impacts (or indirect effects) that would all be beneficial to study area wetland complexes. No other information regarding potential project effects associated with the cumulative impacts analysis was available, and thus these projects are not included in Table 4.16-1.

4.16.4.10 Sabine Lake Oil and Gas Projects

Eight oil and gas projects are planned for Sabine Lake that would impact regulated waters and include four exploration wells (El Paso E&P Co.), three flowlines (El Paso E&P Co.), and one oil and gas drilling, production, and transportation facility (Shoreline Southeast LLC).

Four exploration wells occurring in Sabine Lake would involve minimal discharge of materials into regulated waters. All four projects combined are anticipated to impact a total of 0.14 acre of bay bottom, and no mitigation is proposed. These projects would not cause long-term detriment to the study area’s aquatic resources.

The three proposed flowlines in Sabine Lake are 6-inch diameter and would be jetted into place about 3 feet below mudline. All of these projects combine for a total of 0.43 acre of impacts to bay bottom, and no mitigation is proposed. These projects would not cause long-term detriment to the study areas aquatic resources.

Information on these Sabine Lake oil and gas projects was limited and only included regulated waters impacts. No other information regarding potential project effects associated with the cumulative impacts analysis was available, and thus these projects are not included in Table 4.16-1.

4.16.5 Cumulative Impacts Results

The following sections provide discussion of the potential cumulative impacts summarized in Table 4.16-1, which may result from the Preferred Alternative combined with past, present, and reasonably foreseeable actions within the Study Area.

4.16.5.1 Ecological and Biological Resources

Ecological and biological resources are expected to experience short-term temporary adverse effects resulting from increased turbidity, disturbed bottom, and placement of dredged material during construction and maintenance operations. Some permanent impacts are expected to wetlands; however, these are to be offset by the benefits of BU features and compensatory mitigation for each project considered in this assessment.

4.16.5.1.1 Wetlands

All projects considered in this analysis have compensatory measures and/or minimization or mitigation plans to address wetland loss and/or impacts. In total, the restoration activities, purchased-and-protected areas, and created wetlands offset impacts within and adjacent to the project area, resulting in a net gain of wetland acres (approximately 10:1). This net gain is not always type-for-type; conversion of forested wetlands is considered permanent loss given the time it takes to recover mature forested wetlands and the high potential for invasive species colonization. Overall, cumulative impacts to wetlands are not expected to be significant with implementation of the Preferred Alternative's Mitigation Plan.

4.16.5.1.2 Bottomland Forest

The Preferred Alternative causes no loss of forested wetland acreage (either swamp or bottomland hardwood) throughout the study area. Salinity impacts to the forested wetlands on the Neches River are avoided by DMMP hydrologic and marsh restoration on the river. Salinity impacts to swamps on the Sabine River are related to a minor decrease in the function of the ecological system, as conservatively estimated in the WVA model (Appendix C) by comparison to maximum growth under optimal conditions. The loss in function is considered to be negligible since projected salinity levels are within the tolerance levels of the swamps.

4.16.5.1.3 Terrestrial Vegetation

Terrestrial vegetation impacts occur on most projects considered in this cumulative impacts assessment. Clearing for construction, ROW maintenance (trimming and mowing), prescribed burning, conversion to open water, and dredged material placement may affect terrestrial vegetation. The conversion of forested areas to herbaceous cover or open land or water is the most significant impact as the time to recover forest vegetation communities is significantly longer than that to recover herbaceous habitats, without active intervention. Additional impacts stem from the invasion of non-native fast-colonizing species in disturbed areas.

Upland vegetation on any PA would be covered by dredged material deposition; however, this vegetation consists of mostly opportunistic species, which would recolonize easily once the site has been dewatered. Herbaceous cover impacted typically recovers in a reasonable timeframe with the implementation of erosion control measures. Several of the projects considered in this assessment have invasive species monitoring and control measures, forest land impact minimization actions, or net beneficial actions (such as native prairie restoration and prescribed burning or replanting disturbed areas), which can reduce the loss of native terrestrial vegetation.

In the Preferred Alternative, a total of 86 acres of marsh would be converted to upland confined PAs. The loss of biological function and acreage is fully compensated by DMMP restoration plans resulting in a net increase in coastal marsh acreage in the project area. Cumulatively, the SNWW does not contribute to terrestrial vegetation loss or impacts.

4.16.5.1.4 Submerged Aquatic Vegetation

Physical impacts to SAV may result from projects augmenting marshlands, protecting shoreline, and affecting wetlands. Additionally, increased salinity resulting from the Preferred Alternative and other projects included in this analysis could affect submerged vegetation and related habitats. Marsh restoration and DMMP restorations and nourishment measures offset adverse effects associated with the Preferred Alternative. Additionally, the Preferred Alternative would increase the amount of shallow-water areas and reduce wave action in certain areas, making conditions more conducive to SAV recruitment and growth, effectively resulting in a net increase of SAV in the study area.

4.16.5.1.5 Plankton and Benthos

Placement of dredged material in offshore placement sites would bury benthic organisms incapable of escaping or burrowing up through the dredged material. Only the dredge projects considered in this document would affect benthic organisms in the study area through this method. Recolonization is expected; however, benthic community structure and abundance may be altered as early successional recovery stages are not necessarily the same as those buried by excavated materials. Additionally, repeated localized dredging in one place may prevent full benthic community development and shift community structure since overall benthic impacts affect a very small percentage of water bottom in the study area. It is possible that the new community would still provide adequate food source for the aquatic community. Excavation would increase turbidity levels and may provide cover benefits to certain organisms. In general, all projects considered in this cumulative impacts assessment have the potential for short-term negative impacts; none of the coverage or turbidity impacts are expected to adversely affect benthic organisms or plankton. Minimization and mitigation measures to restore, enhance, and augment estuarine environments and shorelines would likely provide a net benefit to these organisms.

4.16.5.1.6 Essential Fish Habitat

The Sabine Pass LNG and Pipeline, Golden Pass LNG and Pipeline, and the Preferred Alternative have the potential to affect EFH through excavation and dredged material placement in open-water PAs. These activities could affect food sources in EFH and increase turbidity. Dredged material associated with these projects that would be placed in open-water sites would not contain contaminants, as determined by the EPA and USACE review and permitting. Additionally, loss of shallow-water habitats from some of the projects' activities considered in this analysis may adversely affect EFH for lifestages of several species; however, the Preferred Alternative's proposed actions would result in a net benefit to EFH through marsh creation and reduced impacts to SAV.

4.16.5.1.7 Threatened and Endangered Species

Most of the projects included in this assessment are not expected to or did not significantly impact federally listed threatened or endangered species. In general, the species potentially most affected are sea turtles during hopper dredging activities and piping plover during dredged material placement. While turtle mortality is a possibility, the USACE-NMFS sea turtle avoidance and documentation procedures established for hopper dredging activities and applied during all projects using hopper dredges significantly reduce the likelihood of adversely affecting protected sea turtles. In relevant projects' assessment documents, piping plover populations and designated Critical Habitat were determined to not be affected. Food species potential impacts are short term and recoverable, based on all assessments.

4.16.5.2 Physical and Chemical Resources

4.16.5.2.1 Air Quality

Objectionable odors (mercaptan, hydrogen sulfide) may result from construction and maintenance excavation and/or dredging of sediments containing high concentrations of organic matter. Several of the projects in this assessment document that NO_x and CO emissions would occur during dredging and/or excavation equipment activities. These activities are considered temporary and intermittent. Most of the projects considered in this analysis lie within or adjacent to the BPA Ozone 8-hour Nonattainment Zone, which includes Jefferson and Orange counties. All projects within the study area with the potential to affect air quality must conform to the TCEQ SIP. Coordination and compliance with the TCEQ and EPA would result in no significant cumulative impacts to air quality within the study area.

4.16.5.2.2 Noise

Temporary noise impacts would result from construction and maintenance dredging activities, which would change with location, depending on the section being dredged. It is unlikely that dredging would occur for more than one of the reviewed projects at one time.

4.16.5.2.3 Topography, Bathymetry, Soils, Sediment Quality

Terrestrial and marine contours would be permanently changed in construction and maintenance dredging projects, but not by most of the LNG and pipeline projects (which state that temporarily impacted project areas would be returned to preconstruction contours). Topography and bathymetry would be cumulatively changed (increased) in upland and offshore PAs as a result of dredged material deposition. Most soil impacts in all projects are considered temporary and/or recoverable given best construction and erosion control practices, including protection measures implemented as a result of stormwater permitting and water quality certification. No significant impacts to sediments or from sediments are expected, except that there may be an increased risk of spill during construction of the reasonably foreseeable projects included in this analysis.

4.16.5.2.4 Water Quality

For those projects that include dredging activities, dredging and placement operations are expected to temporarily degrade water quality in the project vicinity through increased turbidity and nutrient releases from the sediment. Dredging placement is not expected to affect water quality as much of the construction and maintenance material would be used beneficially and the rest would go into PAs. For the most part, salinity increases for the projects considered in this analysis were negligible, within natural fluctuation ranges, or offset by mitigation or protective measures. Increased ship traffic in the study area could increase the risk of a toxic spill; however, that risk is offset by the increased safety in the channel expected from the widening and deepening of the SNWW. LNG and pipeline projects presented in this analysis would implement water quality control measures (soil erosion prevention and control, spill prevention and response plans, and runoff containment).

4.16.5.2.5 Sediment Quality

None of the projects reviewed for this assessment are expected to impact sediment quality. For projects where contaminant spills or leaks are a potential adverse effect, prevention and response plans would be implemented. None of the sediment analyses conducted for this project identified cause for concern.

4.16.5.2.6 Shoreline/Bank Erosion

Shoreline fluctuations along the Gulf, natural waterways, and constructed navigation channels within the study area are ongoing. While some of the erosion and change can be attributed to natural causes, these can be exacerbated by unmitigated wave action, destabilized shoreline, loss of vegetation, and other factors. Such factors are generally a result of increased frequency and size of ship traffic (enhancing wave action), conversion of shallow gradual water – shoreline transition areas to deeper, open water, and upland activities and development, which can increase runoff and erosion. The Preferred Alternative is expected to reduce the number of vessel trips when compared to the number of trips expected with the No-Action Alternative, thus reducing the potential for increased wave action. Some of the habitat restoration projects reviewed are expected to decrease shoreline erosion in small, localized areas.

Additionally, beach and shoreline nourishment as part of projects' mitigation measures, slow the rate of erosion and shoreline loss in specific areas.

4.16.5.3 Cultural and Socioeconomic Resources

4.16.5.3.1 Economy

All of the channel enhancement, maintenance, LNG, and pipeline projects are expected to have a net benefit to the regional economy.

4.16.5.3.2 Recreational Facilities/Areas

Although some of the projects considered in this analysis create conditions that contribute to shoreline erosion, vegetation loss, and land use impacts throughout their project areas, many public recreation lands owned by the USFWS (Texas Point NWR, McFaddin NWR), TPWD (Tony Houseman WMA, J.D. Murphree WMA, units of the Lower Neches River WMA), TxDOT, and LDWF (Sabine Island WMA) benefit from many of the mitigation and minimization measures. Cumulative and coordinated wetland enhancement and restoration efforts on public lands, increased access to public waters, and habitat creation contribute to habitats, which support recreational activities (bird watching, hunting, fishing). The Preferred Alternative's DMMP restoration measures and marsh mitigation would result in a net benefit to those recreational areas by creating substantial marsh acreage.

4.16.5.3.3 Commercial and Recreational Fisheries

None of the projects reviewed would adversely impact commercial or recreational fisheries (see also subsection 4.16.5.1.6, Essential Fish Habitat). The Preferred Alternative DMMP and marsh mitigation measures would provide a long-term net benefit to fisheries by the creation of new nursery areas.

4.16.5.3.4 Ship Accidents/Spills

The LNG and pipeline projects, in combination with this project's Preferred Alternative, are expected to increase the number of large vessels using the area's navigable waterways (i.e., SNWW, GIWW, Neches River). It is anticipated that the deepening of the SNWW under the Preferred Alternative, in combination with the other dredging and port projects reviewed in this analysis, would have a net benefit on shipping safety; therefore, the potential for accidents and spills is likely to decrease.

4.16.5.3.5 Public Health and Safety

Most of the LNG and pipeline projects, in addition to this project, increase the potential for large ship traffic in inhabited areas along project area waterways. No adverse impacts are anticipated for these projects, although, small recreational craft traffic and other channel users may experience delays and reduced mobility with increases in ship traffic throughout the project area.

4.16.5.3.6 Cultural Resources

Activities associated with any of the reviewed projects have the potential to adversely affect unknown cultural resources by altering the integrity of the location, design, setting, materials, construction, or association contributing to a resource's significance (related to National Register eligibility criteria). No known sites on the NRHP would be impacted by projects reviewed in this analysis; however, projects that are eligible under NRHP criteria have been identified and could be affected. Discovery of potentially protected features/sites during construction and maintenance activities would require verification and further coordination with the SHPO.

4.16.6 Conclusions

Cumulative impacts from past, existing, and reasonably foreseeable future projects, along with the Preferred Alternative, are not expected to have significant adverse effects within the study area. Many of the projects within the study area are part of the continued port and shipping industry development. Some projects considered in this assessment are beneficial to certain natural resources (predominantly wetlands and the species dependent on them) and add to the diversity and health of publicly held recreation and conservation areas, migratory bird habitats, EFH, and other sensitive coastal resources. Impacts associated with the Preferred Alternative have been fully offset by compensatory mitigation measures. In addition, the Preferred Alternative would have net beneficial effects on wetlands, water quality, and SAV with the construction of extensive BU features on the Neches River and the Gulf shoreline.

5.0 MITIGATION PLAN

This chapter discusses the evaluation of mitigation measures for the Preferred Alternative, and presents the Recommended Mitigation Plan that has been developed in consultation with the appropriate resource agencies. Mitigation is necessary because unavoidable impacts to nationally significant intertidal wetlands remain after efforts to minimize impacts were exhausted. Net project impacts and benefits after application of DMMP BU feature benefits, are summarized in Table 5.1-1.

Table 5.1-1
Net Project Impacts and Benefits by Average Annual Habitat Units

	Bottomland Hardwood	Swamp	Fresh Marsh	Intermediate Marsh	Brackish Marsh	Saline Marsh	Totals
Preferred Alternative Impacts (negative AAHUs)							
Texas	0	–2	–6	–8	–31	–	–12
Louisiana	0	0	–8	–571	–3	–7	–709
Total Project Impacts	0	–2	–96	–619	–54	–2	–121
Preferred Alternative Benefits (positive AAHUs)							
Texas	0	0	284	433	235	222	1,068
Louisiana	0	0	0	0	0	210	210
Total Project Benefits	0	0	178	433	235	432	1,278
Net Project Benefits or Impacts (AAHUs)	0	–2	–6	–186	81	390	–43

This chapter is divided into six sections: Section 5.1 summarizes Federal policy and regulatory requirements for mitigation plans, and mitigation objectives that were followed in the plan's development. Section 5.2 provides a brief history of the development and coordination of the Recommended Mitigation Plan, including application of the HS and WVA models. Section 5.3 summarizes FWP impacts of the Preferred Alternative after benefits of the DMMP BU features have been applied. Section 5.4 discusses the evaluation of alternatives for compensatory mitigation, and presents the cost effective/incremental cost analysis (CE/ICA) of mitigation alternatives. Section 5.5 describes the Recommended Mitigation Plan that compensates for unavoidable salinity impacts.

5.1 SUMMARY OF PROJECT IMPACTS

Unavoidable indirect impacts of the Preferred Alternative in Louisiana remain after all benefits of the DMMP BU features have been applied. Although the SNWW channel is located primarily in Texas, large indirect impacts may occur due to small increases in salinity levels causing an increase in wetland loss and a decrease in biological productivity in aquatic habitats of both Texas and Louisiana. Remaining impacts in Louisiana may affect approximately 182,000 acres (284 square miles) of tidal, emergent marsh habitats, resulting in a total loss of 1,709 AAHUs (a 1.8 percent loss from the FWOP condition). The important ecological functions of the wetlands in the affected area would decline as increases in salinity levels affect marsh communities, and the fish and wildlife that depend upon this habitat. The slightly higher salinities may lead to the loss of 691 acres of marsh, associated SAV and shallow-water habitat, as stressed emergent marsh converts to open water. Some direct effects of the Preferred Alternative's navigation improvements were not captured and quantified by the WVA modeling. However, a full impact analysis has been performed for these effects, and they have been determined to be minor and temporary. These impacts include (1) impacts to water quality and benthic organisms and their Gulf, estuarine, and riverine water-bottom habitats resulting from dredging to construct the navigation improvements, the creation of new offshore ODMDSs, the borrow area trench for Willow Bayou mitigation areas, and marsh restoration in shallow, open-water areas; (2) potential dredging impacts to bottom-feeding and pelagic organisms such as sea turtles; and (3) potential impacts to shoreline birds and their habitat from the placement of maintenance material on the Gulf shoreline.

Potential adverse affects to threatened and endangered sea turtles during hopper dredging to construct the Entrance Channel would be addressed by the adoption of reasonable and prudent measures to avoid impacts that are established in the BO for the CIP. No other adverse effects to threatened and endangered species have been identified.

5.2 MITIGATION PLANNING

In the evaluation of alternatives for the SNWW CIP, ecological impacts of the Preferred Alternative have been avoided and minimized to the greatest extent practicable, as required by national policy (Section 906(d), WRDA 86), national environmental laws and executive orders, and the USACE regulations (ER 1105-2-100). The results of proposed actions to minimize impacts are presented in detail in Chapter 2. Unavoidable impacts to significant resources that remain are compensated to the extent justified as described below.

5.2.1 Compliance with Federal Requirements

Implementation guidance for Section 2036(a) of WRDA 07 (Mitigation for Fish and Wildlife and Wetlands Losses), issued August 31, 2009, requires that the Preferred Alternative contain a specific plan to mitigate fish and wildlife losses since it has been determined that the Preferred Alternative would have unavoidable impacts after benefits of the DMMP BU features are applied. Adverse impacts to ecological resources that are caused by a proposed project must be avoided or minimized to the extent practicable, and remaining unavoidable impacts must be compensated to the extent justified. The Preferred Alternative must contain sufficient mitigation to ensure that the CIP would not have more than a negligible adverse impact on significant ecological resources.

Central to this requirement is the determination of significance, as mitigation is required only for impacts to significant resources. Significance must be based upon the contribution of the resource to the Nation's economy and technical, institutional, and/or public recognition of the value of the resource. Criteria for determining significance include, but are not limited to, scarcity or uniqueness of the resource from a national, regional, State, or local perspective. The USFWS Habitat Stewardship Program has identified estuarine intertidal emergent wetlands as one of three nationally recognized "scarce and vulnerable" wetland habitats. These are the same sensitive wetland habitats (saline, brackish, intermediate, and fresh marsh) addressed by the Mitigation Plan.

These habitats are also considered significant and vulnerable by the CWPPRA, Public Law 101-646 (Title III) and the North American Waterfowl Management Plan (2004). The Texas Land and Water Resources Conservation Plan (TPWD, 2005e) recognizes the Gulf coastal marshes in Tier One of high priority ecoregions and considers these habitats to be the most threatened of the State's two high diversity ecoregions. Significant marsh habitat on the Lower Neches River and along the Texas Point shoreline have been declared "critical erosion areas" by the Texas Coastwide Erosion Response Plan. Furthermore, coastal marshes in the Louisiana portion of the study area are recognized as threatened and vulnerable by the Louisiana Coast 2050 Plan (LCWCR/WCRA, 1998), the LCA Ecosystem Restoration Study (USACE, 2004a), and the Louisiana Comprehensive Master Plan (LCPRA, 2007; USACE, 2008a).

Although mitigation technically includes avoiding and minimizing project impacts to ecological resources, this chapter focuses on actions that are typically considered compensatory mitigation, i.e., rectifying impacts by restoration, preservation, or maintenance activities during the life of the project, or replacing fish and wildlife resources that have been adversely affected. Replacements are generally made "in-kind," but substitutions, or replacements "out-of-kind," are also acceptable mitigation if they are at least equal in value and significance to the resources lost. The purchase of credits from mitigation banks established by others was considered as an option in providing compensatory mitigation for the Preferred Alternative. Only two existing mitigation banks were identified in the lower Sabine and Neches watersheds. Neither was available for use as the credits from one were sold out and the other was developed for the exclusive use of a State agency.

The WVA model (Appendix C) quantifies impacts to all habitats in the study area and provides a means to establish the appropriate amount of compensating mitigation. Recommended mitigation measures must be justified by CE/ICA, which identifies the least-cost mitigation plan by demonstrating that the value of the last increment of losses prevented, reduced, or replaced is at least equal to the costs of the last added increment.

The USACE regulations (ER 1105-2-100) recognize wetland resources for special consideration in mitigation planning, and these are the type of resources that could suffer long-term impacts from the Preferred Alternative. Impacts to wetlands must be fully mitigated, and projects must meet the goal of no net loss of wetlands. The Mitigation Plan described below fulfills the special requirements for wetlands. These plans also contribute to multiagency regional plans (Louisiana Coast 2050; a TPWD regional management plan for J.D. Murphree WMA, Sea Rim State Park, Texas Point, and McFaddin NWR; and the North American Waterfowl Plan) by restoring and preserving scarce and vulnerable wetlands and wildlife habitat, and using dredged material beneficially to the greatest extent possible.

5.2.2 Compensatory Mitigation Objectives and Target

The following objectives were established to evaluate mitigation measures considered for the SNWW CIP. The objectives were developed by the USACE in consultation with the ICT.

- Minimize salinity impacts to the SNWW affected area
- Maximize the use of dredged material in marsh restoration measures
- Meet goal of no net loss of wetlands
- Replace lost habitat quality on a one-to-one basis as measured by AAHUs
- Replace habitats in-kind to the extent practicable
- Mitigate losses in the state where they occur
- Share dredged material from Sabine Pass equally between Louisiana and Texas

These objectives reflected the most significant expected impacts of the CIP, widespread interest in potential beneficial uses of dredged material, the national policy objective to prevent wetland loss, and the USACE requirements to fully compensate for unavoidable project adverse effects. The last objective is related to the fact that the CIP affects resources from two states. While this FEIS evaluates impacts on the SNWW coastal and estuarine system without regard to state boundaries, the mitigation plan complies, to the greatest extent practicable, with the CZMP for each state. Under the Coastal Zone Management Act (CZMA), states with approved coastal management programs have jurisdiction within their coastal boundaries to ensure compliance with their programs. The CZMA and its implementing regulations require that Federal activities comply to the maximum extent practicable with these programs. In Louisiana, the Louisiana State and Local Coastal Resources Management Act functions as the state coastal management program for CZMA purposes. Compensatory mitigation is used to offset any net loss of wetland ecological value after efforts have been made to avoid or minimize impacts. Furthermore, the CWPPRA requires Federal agencies to ensure that maintenance or modification of navigation projects be consistent with the purposes of the restoration plan submitted under CWPPRA. Louisiana has adopted a Coastal Wetlands Conservation Plan under this authority with a goal of no net loss of wetlands in coastal areas of Louisiana as a result of development activities. The proposed SNWW mitigation plan would provide additional compensatory mitigation beyond the total project loss of 843 AAHUs so that impacts in Louisiana would be compensated in that state. There is, however, a significant exception to this requirement. Federal lands are excluded from coverage under the CZMA, and this means that compensatory mitigation for impacts to Federal lands may be developed without regard to state boundaries.

Since the CZMA does not apply to Federal lands, excess Texas BU benefits could be used to compensate for impacts to Federal lands in Louisiana. The only lands affected by this exclusion are located in the Sabine NWR. While the Texas Point and McFaddin NWRs in Texas would also be affected by salinity increases associated with the project, two DMMP BU features (the Neches River and the Gulf Shore BU features) provide benefits that offset all project impacts in Texas (including impacts to both NWRs) and provide excess benefits of 656 AAHUs. The DMMP BU features fulfill Texas's CZMP requirements to avoid and minimize impacts to the coastal zone, such that no compensatory mitigation for Texas state resources is needed.

Total SNWW project impacts to the Sabine NWR are –340 AAHUs. When these are removed from the total project impacts in Louisiana (–1,499 AAHUs), the mitigation target proposed for compliance with Louisiana's CZMP is –1,159 AAHUs. Table 5.1-2 illustrates this calculation. Since all mitigation measures for the SNWW would be located in Louisiana, the new mitigation target would compensate for total project losses of –843 AAHUs by providing 1,159 AAHUs of compensatory mitigation.

Table 5.1-2
FWP Compensatory Mitigation Target for Louisiana

Units (AAHUs)	Texas	Louisiana	Project
Net FWP Benefits/Impacts			
Total Impacts (negative)	–12	–709	–121
Total BU Benefits (positive)	1,068	210	1,278
Net FWP Benefits (positive) or Impacts (negative)	656	–499	–43
Excess Texas Benefits Applied to Federal Lands (Louisiana)			
Excess Texas Benefits	656		
Sabine National Wildlife Refuge Impacts	–40		
Net Excess Texas Benefits	316		
Compensatory Mitigation Target			
Net Impacts by State and Project		–499	–43
Federal Impacts Compensated with Texas Excess Benefits		340	
FWP Compensatory Mitigation Target		–159	–43

5.3 RESOURCE AGENCY COORDINATION OF THE RECOMMENDED MITIGATION PLAN

Since the primary environmental concerns are the interrelated issues of saltwater intrusion, marsh loss, and destruction of wildlife habitat and fishery nursery areas, the ICT formed two workgroups to oversee the development and application of models used to evaluate salinity changes and ecological effects of the CIP. The MW participated in the development and review of the HS model, and the HW participated in the selection and application of the ecological model. Both models played an integral role in the development of FWOP and FWP conditions and were used to compare the effectiveness of restoration and mitigation measures.

Any ICT agency interested in participating was invited to attend these workshop meetings. Representatives from the following agencies participated in one or both of the workgroups:

- USFWS Clear Lake (Texas) Field Office
- USFWS – Louisiana Field Office
- USFWS – Chenier Plain NWR complex
- USFWS – Sabine NWR

- NMFS – Galveston, Texas
- NMFS – Baton Rouge, Louisiana
- EPA Region 6
- GLO
- TWDB
- TPWD
- TPWD – J.D. Murphree WMA
- LDNR
- LDWF
- SRA-TX
- USACE (Galveston District and ERDC-CHL)

Concerns that a deeper navigation channel would bring higher salinity in the Sabine Lake estuarine system were addressed with a 3-dimensional HS model that predicts changes in salinity, circulation, and water elevation due to proposed channel improvements. The modeling was performed by the ERDC's CHL worked closely with the MW to calibrate and verify the base model for initial modeling. The modeling was revised in 2009 to incorporate changes resulting from external and USACE reviews. The MW reviewed the ERDC's model calibration and verification process, and the revised modeling results.

The SNWW ICT established the HW to apply the WVA model; representatives from 14 agencies regularly attended and agreed upon data used as inputs for the model. Over 30 ICT and workgroup meetings were conducted from 2001 to 2006, and one meeting was held in 2009. The USFWS-Louisiana Ecological Field Office provided assistance to ensure that WVA methodology (USFWS, 2002b) was followed properly and that WVA model Excel worksheets were being used appropriately. The USACE conducted an in-house quality check for worksheet accuracy. In 2009, changes in the proposed project and HS modeling necessitated that the WVA modeling be revised. Due to schedule constraints, the USACE performed the modeling without ICT involvement, basing it as closely as possible on methods and assumptions used by the ICT in the original modeling. The results of this remodeling were coordinated with the ICT. A quality check was also performed for the revised worksheets.

5.4 EVALUATION OF ECOLOGICAL MITIGATION MEASURES

5.4.1 Preliminary Screening of Alternatives

A large number of potential mitigation measures were evaluated, but the majority were eliminated during preliminary screening. Measures were generally of two types: measures to reduce or avoid salinity intrusion and measures to restore or protect habitat. Salinity effects for large-scale measures affecting the estuary as a whole were evaluated with the HS model; a desktop model was developed for alternatives affecting smaller, localized drainages (Brown and Stokes, 2009). Ecological benefits were evaluated for most of the measures using the WVA model; some were eliminated early in the process because they were not feasible or implementable. Screening-level costs were based upon conceptual designs and costs for similar structures that had been constructed recently by the USFWS. Final costs were only developed for mitigation measures ultimately included in the Mitigation Plan.

5.4.1.1 Measures to Reduce Salinity Intrusion

Since impacts of the Preferred Alternative would be related primarily to salinity increases associated with a deeper SNWW navigation channel, extensive efforts were made to identify mitigation measures that could minimize or eliminate the projected increase in salinity intrusion. Measures were formulated that affected the estuary as a whole, or smaller, localized areas within specific wetlands.

Sabine Pass Lock and Dam

The construction of a lock and dam at Sabine Pass was considered to address increases in saltwater intrusion from the proposed deepening and widening of the SNWW. The lock and dam were not considered to be a project alternative because the structures would not improve navigation efficiency, but it was believed they could minimize salinity impacts. The existing SNWW navigation channel through Sabine Pass is 40 feet deep and 500 feet wide. Large ocean-going petroleum and chemical product tankers regularly transit the waterway. Placing a lock in the channel would create new transit delays as discussed below.

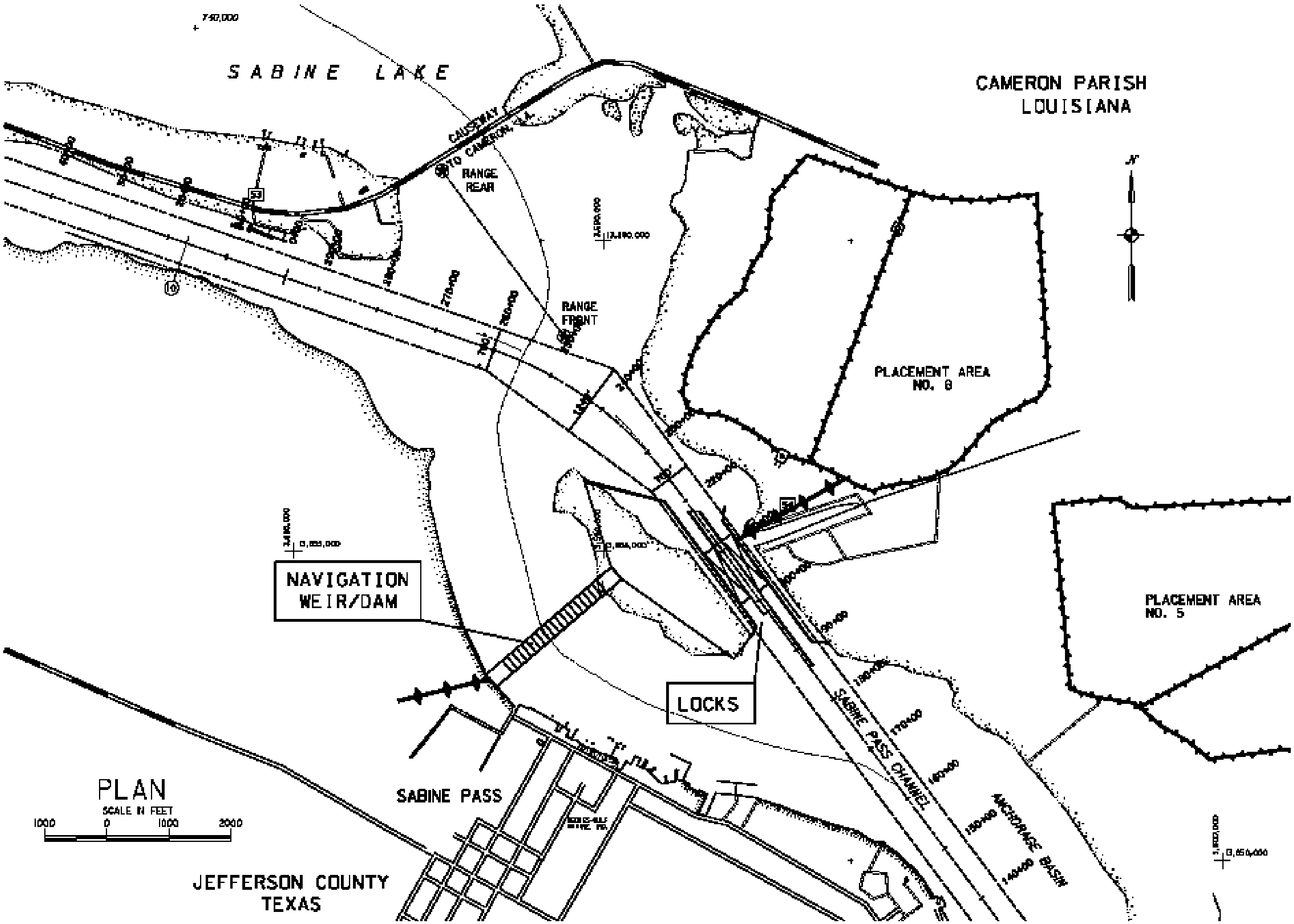
The structures anticipated for salinity control would consist of two navigation locks within the current SNWW navigation channel. Figure 5.4-1 presents a conceptual drawing of the lock and dam alternative. A connecting levee would be required from the east lock wall to the Louisiana side of the pass, and a dam would be required to close the old river channel on the Texas side. This dam would be constructed from the cutoff island to the Texas shoreline immediately upstream of the City of Sabine Pass. It would consist of a reinforced concrete sill positioned at elevation –25 feet mean low tide (MLT), with a set of tainter gates. The tainter gates would be closed under normal conditions, but would open to allow the discharge of upstream floodwaters. A levee would also be required to connect the west end of the dam to higher ground.

The lock and dam would prevent continuous saltwater intrusion from the Gulf by blocking the deeper navigation channel and old river channel, while allowing two-way ship traffic and periodic discharges of upstream floodwaters. The lock and dam structure would create a pool behind the structures with a 3- to 5-foot increase in water elevations over current conditions. The pool is necessary to create the hydraulic head pressures required for the lock to function properly.

There are significant engineering challenges to be met in designing the large locks required to accommodate the large ships, which would use the proposed CIP. The width and depth of the lock chamber would be larger than any other known lock constructed in the U.S., and therefore additional research and data would be needed in order to design and construct the large lock gates and machinery.

FIGURE 5.4-1

CONCEPTUAL DESIGN OF LOCK-DAM STRUCTURE



With respect to impacts on navigation, the locks would not have a direct effect on the deepening benefits of the proposed project, but would significantly reduce the navigational efficiency of the existing or proposed channel. A preliminary economic analysis estimated that annual delay costs for both inbound and outbound trips would be approximately $7 million. This estimate did not include queuing effects. In reality, slowdowns due to the locks would generate additional delays and queues would form. The vessel delay and personnel cost would need to be treated as added costs for the lock feature. The delays associated with a lock would lead to additional cost and result in a loss of business for the ports of Port Arthur and Beaumont.

From an environmental standpoint, the proposed lock and dam would have both positive and negative environmental impacts on the region. On the positive side, the lock would significantly reduce saltwater intrusion through Sabine Pass into the upriver wetlands systems. Such reduction in saltwater intrusion would ameliorate degradation caused by current saltwater intrusion and permit slow reestablishment of some of the former fluvial freshwater wetlands that existed prior to initial channelization of the river. These freshwater wetlands would likely support increased freshwater sports fishing opportunities, waterfowl, and perhaps some cypress-tupelo swamp acreage.

However, the proposed lock and dam would produce negative environmental impacts as well. Reducing saltwater inputs upstream and flooding existing marshes would significantly decrease productivity of the existing saline and brackish marshes, as the obligate higher-salinity marsh plants are gradually lost in the freshwater conditions. In addition, even before significant loss of marshes upstream of the lock, many largely marine species would be physically precluded from reaching the nursery marsh areas by the lock. Therefore, many commercial, sportfish, and shellfish species would likely decrease in abundance.

The lock alternative was eliminated from further consideration on the basis of navigation economics, environmental, and cost factors. The lock alternative would reduce navigation benefits and result in higher vessel transportation costs. Environmental benefits associated with control salinity intrusion would be partially offset by significant impacts associated with restricting ingress/egress of marine organisms. Finally, significant engineering challenges associated with construction of such a large structure would result in high costs, estimated in excess of $2 billion.

Sabine Lake Sill

Three versions of a sill or weir at the mouth of Sabine Lake were modeled with the HS model (Brown and Stokes, 2009): a submerged sill at –10 feet MLT; a stepped, submerged sill ranging from –2.5 feet MLT at the shore to a –10-foot MLT boat bay in the center; and an emergent sill with a –10-foot MLT boat bay in the center of the channel. This alternative was eliminated from further consideration when modeling determined that a sill provided little, if any, salinity mitigation, except for some reduction in salinity at the southwest end of Sabine Lake. This is likely because the principal pathway for salinity transport into the system is via the Sabine-Neches Canal at the northwest corner of Sabine Lake. In addition, the more restrictive versions created unacceptably high velocities through the mouth of Sabine Lake and unacceptably high water elevations in the southern part of Sabine Lake during flood events.

Structural Water Control

Nineteen various water-control structures were proposed to control salinity intrusion into the marshes east of Sabine Lake and west of Sabine Pass (see Appendix C). The ERDC developed desktop models to evaluate changes in salinity achieved by these structures (Brown and Stokes, 2009), and the WVA model was applied to evaluate their ecological benefits. Various combinations of a sheet pile wall, a large rock weir, earthen plugs, and channel fill were evaluated for Texas Bayou in the Texas Point NWR. Large, adjustable salinity control structures and large rock weirs were evaluated for Willow Bayou, Three Bayou, Black Bayou, Greens Bayou, and the Right Prong of Black Bayou. Smaller rock weirs and low rock liners were assessed for numerous smaller channels in the Willow Bayou and Black Bayou hydro-units. Earthen plugs in logging canals and submerged pipeline ROWs were suggested as a means of reducing salinities within swamps at Blue Elbow and the Sabine Island WMA. NMFS was concerned that proposed water control structures could adversely affect EFH and other aquatic resources by blocking or reducing marine fishery access to the Louisiana marshes east of Sabine Lake. It is possible that structures could cause salinities to be higher in managed areas during droughts or after storm surges. Ultimately, all of the proposed water control structures were eliminated from further consideration when WVA modeling yielded net negative benefits (i.e., impacts). Salinity reductions were generally modest and could not overcome the adverse effects of restrictions to marine organism access.

Ensuring Freshwater Inflow

Purchasing freshwater flows from both the SRA-TX and LNVA was investigated as a potential mitigation measure. Contracts could be negotiated for the 50-year period of analysis that require annual payments for a specific volume of flow, which was determined with the HS model. The alternative was eliminated from further consideration because there is no guarantee that the mitigation flow would be available when it is needed most—during periods of low flows or drought, when the incremental salinity increase associated with the deeper navigation channel would have its greatest adverse effect. The new allocation would be subordinate to preexisting water rights and subject to changes in priorities by State water plans. Ultimately, there is no guarantee that sufficient flows, although contracted and paid for annually, would be provided at the expense of human needs.

Marsh Creation

Several measures were considered in which marshes would be used to constrict flows and thereby reduce salinity intrusion from the navigation channel. Marsh creation was evaluated for the following locations: (1) upstream and downstream of the mouth of Sabine Lake, (2) a specific shoreline reach of the Port Arthur Canal, (3) an eroded area at the head of the west jetty, (4) eroding islands between the Sabine-Neches Canal and the northwest corner of Sabine Lake, and (5) the mouths of channels draining Rose City and Bessie Heights. Some of these alternatives were eliminated from further consideration when HS modeling determined they were not effective at reducing salinities. Others were eliminated because they would block access to private property, cause backwater flooding, or create safety problems with navigation.

5.4.1.2 Measures to Restore or Protect Habitat

The HW also evaluated a wide array of measures, which utilized marsh restoration, inshore shoreline protection, and Gulf shore nourishment to compensate for wetland loss or protect from increased erosion. The most effective of these in terms of costs and ecosystem benefits were ultimately selected for inclusion in the Recommended Mitigation Plan; those described below were eliminated during preliminary screening.

Marsh Restoration Measures

Thirty-nine combinations of measures and scales of marsh restoration were evaluated. Screening was based upon an informal analysis of benefits determined by the WVA model and costs developed by the USACE. All possible sources of material for marsh restoration were considered (submerged in situ soils, new work and maintenance material from the nearest SNWW channel reaches, sediments from Sabine Lake, Sabine River Channel maintenance material, and accumulated material in the Lake Charles Deepwater Channel/Louisiana GIWW). Locations evaluated for restoration were (1) a degraded marsh area near the head of the West Jetty in the Texas Point NWR; (2) Old River Cove east of the power plant intake canal; (3) the eastern shores of PAs 8 and 11 on Pleasure Island; (4) an old logging canal north of Texas Bayou; (5) a large open-water area south of the Louisiana GIWW and east of Black Bayou Cutoff; and (6) a small, confined open-water area at the northeast corner of the Louisiana GIWW and Black Bayou Cutoff. The large open-water area on the GIWW east of the Black Bayou Cutoff was eliminated because the area was approved for an in situ marsh-terracing project under CWPPRA Project CS-27. Different scales of marsh fill and source material were used within the same footprints in Willow and Black bayous to create different alternatives. Most of the alternatives were eliminated because they produced unacceptably low benefits when compared to costs. Small scales of in situ marsh terracing and marsh creation using dredged material located in the Willow and Black bayou hydro-units were eliminated because of low benefits. Twelve larger scales of the same alternatives were advanced for further screening due to their higher benefits and improved cost effectiveness.

Inshore Shoreline Protection

Twenty-one combinations of shoreline protection measures and scales were evaluated in the preliminary screening. Measures were developed for two locations: the eastern shore of Sabine Lake and the north shore of the GIWW in Texas.

For the GIWW shoreline, two separate reaches of rock breakwater (2.4 miles long and 1.5 miles long) were proposed to stabilize areas where low banklines allow higher-salinity waters from the GIWW to enter the large expanse of fresh and intermediate marsh north of the GIWW. Benefits were assessed using the WVA model, based upon an assumed salinity reduction in the marshes protected by the breakwater. The alternative was eliminated because of low benefits in relation to cost. IWR-PLAN comparison revealed it was less cost effective than other alternatives.

For the Sabine Lake shoreline, a foreshore dike was proposed for the Sabine Lake shore between Willow Bayou and the mouth of Black Bayou. This alternative was evaluated in three scales of 3, 4.4, and 8.6 miles in length. Two material types were evaluated for the breakwater: barged-in rock and earthen material obtained from Sabine Lake sediments adjacent to the breakwater. Each of these alternatives was also evaluated at three distances from the Sabine Lake shore: 150, 250, and 500 feet. Finally, marsh restoration behind the dikes was also proposed. Marsh would be created behind the earthen and rock alternatives, 150 feet from the shore using Sabine Lake sediments from the access channel required for construction, and new work material from the SNWW channel was evaluated for the 250- and 500-foot scales. Benefits determined by the WVA were based on the creation of new marsh and the elimination of shoreline retreat. Initially, the rate of shoreline retreat was determined by a GIS analysis of satellite images by the USFWS (Greco and Clark, 2005). However, the rate of shoreline retreat was later revised to incorporate the most likely rate of RSLR, and a forecasted 1.1-foot rise in water surface elevation. Costs of the different measures were estimated by the USACE, including additional costs to raise the dike to accommodate RSLR. All of these alternatives were eliminated because costs were high when compared to benefits.

Gulf Shore Nourishment

Eleven measures and scales of Gulf shoreline nourishment were evaluated for Texas and Louisiana Points. The measures were developed in an effort to find the most-cost-effective combination of pumping distance, material type, and length of shoreline nourishment. All of the alternatives were constrained by the requirement that both new work and maintenance material be split evenly between Texas and Louisiana. All but one assumed unconfined placement of dredged material along the current shoreline using a hydraulic pipeline dredge. One alternative envisioned construction of a confined cell along the Texas Point shoreline using new work and maintenance materials. This alternative was eliminated early in the screening because of excessively high costs. Alternatives relying upon unconfined placement of either new work or maintenance material from Sabine Pass sections 5 or 5 and 6 were evaluated for ½-, 2-, and 3-mile-long shoreline reaches. All would begin ½ mile from each jetty, avoiding areas near the jetties where the accretion rate is high. Cost effectiveness analysis determined that the 3-mile-long scale of the maintenance material alternative was the least-cost alternative for the placement of dredged material, and therefore it was adopted as part of the DMMP. One alternative that uses new work material to nourish shoreline at Louisiana Point was advanced for further screening as a potential mitigation alternative.

5.4.2 Final Screening of Ecological Mitigation Measures

The Mitigation Plan was selected using the USACE certified version of IWR-PLAN software. IWR-PLAN uses the tools of CE/ICA to weigh the costs of mitigation plans against their nonmonetary output. A mitigation plan is defined as a group of mitigation measures. Cost-effectiveness analysis is used to identify least-cost plans, and incremental cost analysis identifies the subset of cost-effective plans that are superior financial investments, called “best buys plans.” Best buys plans are the most efficient plans at producing the output variable (in this case, AAHUs); they provide the greatest increase in the value of the output variable for the least increase in cost.

Mitigation measures advanced for final screening with IWR-PLAN are listed in Table 5.4-1. For the CE/ICA, the measures were expressed as Solutions A through M, and each solution was evaluated at different scales (Table 5.4-2). Two categories of solutions were evaluated:

1) Marsh restoration in the Willow and Black bayou areas; and
2) Gulf shore nourishment.

The footprint of several marsh restoration solutions is identical; they propose marsh restoration in the same physical area using different sources of sediment (i.e., in situ material, SNWW new work material, and dedicated dredging from Sabine Lake). Solutions with identical footprints are not combinable with other solutions and were identified as such in IWR-PLAN. Other solutions reflect different placement sequences and combinations for the various open-water locales within Willow Bayou or Black Bayou. These were developed in an effort to identify combinations that have more-cost-effective pumping distances. One alternative (LA 2-18C) was duplicated in the IWR-PLAN solutions, with the cost for dredging varied by the size of dredge (i.e., an average size dredge versus the largest, most powerful dredge that could access the area, the *California*). Scales are defined by adding increments of acreage restored, varying the amount of sediment used in the restoration, or the length of shoreline protected or nourished.

Table 5.4-2 contains incremental costs and output for all solutions and scales included in the analysis. The IWR-PLAN code for each solution and the scales of that solution are indicated in the first column, and a brief description of each solution is provided in the second column. For example, the first solution is Willow Bayou in situ terracing (Solution A). This solution has four scales (A_1-A_4), which increase in acres incrementally through the four scales. Scale A_1 restores 38 acres of emergent marsh; Scale A_2 creates an additional 26 acres for a cumulative total of 47 acres for both scales A_1 and A_2. The third column provides a unique identification number for each solution and scale that was used for mapping and tracking through cost estimating and ecological modeling. The fourth column provides the cumulative AAHU output associated with the cumulative acres being restored, and the fifth provides the cumulative average annualized cost.

Variables used in the analysis were nonmonetary ecological benefits established by WVA modeling (expressed in AAHUs) and average annualized costs. These costs include the first cost of construction, costs for marsh plantings, postconstruction monitoring, and 50-year annualized O&M costs. The costs of alternatives that involve the use of maintenance material over one or multiple dredging cycles were amortized over the 50-year period of analysis, using dredging-cycle projections based on historical dredging data and the discount rate in effect at that time.

Table 5.4-1
Mitigation Alternatives Evaluated in Final Screening

Marsh Restoration - In Situ Terracing			
Description of Alternative			
"Duck-wing"-shaped earthen terraces built with in situ material using amphibious excavator. Each terrace is 1,000 feet long; 100-foot gap between terraces; approximately 500 feet between each row of terraces. Terraces should have 15-foot-wide tops at +2.0 feet NAVD88 and 4:1 side slopes.			
Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Willow Bayou	LA 2-16(A)	Influence area – 1,831 acres in north part of Greens Lake; located within the same footprint as LA 2-16(B) and LA 2-16(C)	38 acres
	LA 2-17(A)	Influence area – 2,297 acres in southern part of Greens Lake; located within the same footprint as LA 2-17(B) and LA 2-17(C)	45 acres
	LA 2-18(A)	Influence area – 680 acres in area north of Willow Bayou canal; located within the same footprint as LA 2-18(B) and LA 2-18(C)	11 acres
	LA 2-19(A)	Influence area – 1,809 acres in area west of Deep Bayou; located within the same footprint as LA 2-19(B) and LA 2-19(C)	28 acres
Marsh Restoration – Sabine Lake Dedicated Dredging			
Description of Alternative			
Hydraulically dredged material from Sabine Lake (dedicated dredging) to restore marsh and shallow-water habitat in open-water areas of marsh. Borrow trench located 500 feet from shore, excavated approximately 7.5 feet deep; width and length vary for each scale. Assume unconfined flow of maintenance material, frequent movement of pipe, and few training or containment structures.			
Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Willow Bayou	LA 2-16(B)	Influence area – 1,831 acres in north part of Greens Lake; borrow trench approximately 1,000 feet wide x 2 miles long	822 acres
	LA 2-17(B)	Influence area – 2,297 acres in southern part of Greens Lake area; borrow trench approximately 1,250 feet wide x 2 miles long	1,035 acres
	LA 2-18(B)	Influence area – 680 acres in area north of Willow Bayou Canal; borrow trench approximately 700 feet wide x 0.8 mile long	251 acres
	LA 2-19(B)	Influence area – 1,809 acres in area west of Deep Bayou; borrow trench approximately 1,200 feet wide x 1.8 miles long	719 acres
	LA 2 ADD B	Influence area – 1,285 acres in area north of Willow Bayou Canal; borrow trench approximately 1,000 feet wide x 1.25 miles long	436 acres

Table 5.4-1, cont'd

Marsh Restoration – SNWW New Work Material			
Description of Alternative			
Use new work material from SNWW Section 10 to restore emergent marsh and shallow-water habitat in open water in north part of Greens Lake area. Assume unconfined flow of new work material, frequent movement of pipe, and few training or containment structures.			
Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Willow Bayou	LA 2-16(C)	Influence area – 1,831 acres in north part of Greens Lake area; located within the same footprint as LA 2-16(A) and LA 2-16(B)	822 acres
	LA 2-17(C)	Influence area – 2,297 acres in southern part of Greens Lake area; located within the same footprint as LA 2-17(A) and LA 2-17(B)	1,035 acres
	LA 2-18(C)	Influence area – 680 acres in area north of Willow Bayou Canal; located within the same footprint as LA 2-18(A) and LA 2-18(B)	251 acres
	LA 2-19(C)	Influence area – 1,809 acres in area west of Deep Bayou; located within the same footprint as LA 2-19(A) and LA 2-19(B)	719 acres
	LA 2-ADD C	Influence area – 1,285 acres in area north of Willow Bayou Canal; located within the same footprint as LA 2-ADD B	436 acres
Marsh Restoration – Channel to Orange Maintenance Material			
Description of Alternative			
Hydraulically pump maintenance material from the Channel to Orange (Sabine River) between East Pass and the GIWW into areas north of Black Bayou to restore emergent marsh in degraded marsh and open-water areas. Assume unconfined flow of maintenance material, frequent movement of pipe, and few training or containment structures. Material would come from maintenance dredging of the Sabine River Channel.			
Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Black Bayou	LA 3-10R	Influence area – 2,465 acres; restoring 132 acres every 5 years, TY 5 thru TY 30 (total of 6 cycles, ending TY 30)	792 acres

Table 5.4-1, cont'd

Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Marsh Restoration - GIWW Dedicated Dredging			
Description of Alternative			
Dedicated dredging of adjacent GIWW to restore emergent marsh and shallow-water habitat; percent of open water restored to emergent marsh is different in A and B scales. Assume unconfined flow of hydraulically pumped material that has accumulated in GIWW (formerly the 30-foot Deepwater Channel to Lake Charles), frequent movement of pipe, and few training or containment structures.			
Hydro-Unit	No.	Size of Influence Area	Emergent Marsh Created
Black Bayou	LA 3-15(A)	Influence area – 1,788 acres in area west of Black Bayou Cutoff Canal; assume 60 percent of open water restored to emergent marsh	546 acres
	LA 3-18(A)	Influence area – 1,877 acres in large area of open water south of LA 3-15; assume 60 percent of open water restored to emergent marsh	497 acres
	LA 3-15(B)	Influence area – 1,788 acres area west of Black Bayou Cutoff Canal; assume 75 percent of open water restored to emergent marsh	683 acres
	LA 3-18(B)	Influence area – 1,877 acres in large area of open water south of LA 3-15; assume 75 percent of open water restored to emergent marsh	621 acres
Gulf Shoreline Nourishment			
Description of Alternative			
Nourish Gulf shoreline at Louisiana Point; length of nourished shore and number of placement cycles vary. Material pumped along shoreline using hydraulic pipeline dredge. Assume 50:50 split of material between Texas and Louisiana. Assume 60 percent retention of material after initial placement; 50 percent of newly added acres remain at end of 6 years.			
Hydro-Unit	No.	Size of Influence Area	Length of Shoreline
Sabine Lake Ridges	LA 5-3	Nourish 0.5 to 1.0 mile from east jetty; assume one-time unconfined placement of new work material from SNWW Section 5; all added acres eroded away by TY 51	0.5 mile
	LA 5-1 and 6-1	Nourish 0.5 to 3.5 miles from east jetty; assume one-time unconfined placement of new work material from SNWW Section 5; all added acres eroded away by TY 51	3.0 miles
	LA 5-5	Nourish 0.5 to 3.5 miles from east jetty; assume one-time unconfined placement of new work material from SNWW sections 5 and 6; all added acres eroded away by TY 51	3.0 miles

Table 5.4-2
Solutions and Scales for Cost Effectiveness/Incremental Cost Analysis

	Solutions	ID#	Cumulative AAHUs per Solution and Increment	Cumulative Average Annual Cost ($) per Solution and Increment
Marsh Restoration				
A_1	Willow Bayou In Situ Terracing (38 acres)	LA 2-16A	18	145,413
A_2	Willow Bayou In Situ Terracing (83 acres)	LA 2-16A LA 2-17A	40	316,720
A_3	Willow Bayou In Situ Terracing (111 acres)	LA 2-16A LA 2-17A LA 2-19A	54	426,845
A_4	Willow Bayou In Situ Terracing (122 acres)	LA 2-16A LA 2-17A LA 2-19A LA 2-18A	59	472,395
B_1	Willow Bayou Sabine Lake Dedicated Dredging (822 acres)	LA 2-16B	446	2,794,551
B_2	Willow Bayou Sabine Lake Dedicated Dredging (1,857 acres)	LA 2-16B LA 2-17B	940	5,980,573
B_3	Willow Bayou Sabine Lake Dedicated Dredging (2,576 acres)	LA 2-16B LA 2-17B LA 2-19B	1,360	8,183,098
B_4	Willow Bayou Sabine Lake Dedicated Dredging (2,827 acres)	LA 2-16B LA 2-17B LA 2-19B LA 2-18B	1,512	8,806,642
C_1	Willow Bayou Sabine Lake Dedicated Dredging (822 acres)	LA 2-16B	446	2,794,551
C_2	Willow Bayou Sabine Lake Dedicated Dredging (1,857 acres)	LA 2-16B LA 2-17B	940	5,980,573
D_1	Willow Bayou Sabine Lake Dedicated Dredging (251 acres)	LA 2-18B	152	620,877
$\mathbf{D_2}$	**Willow Bayou Sabine Lake Dedicated Dredging (687 acres)**	**LA 2-18B** **LA 2-ADD B**	**365**	**1,632,476**
D_3	Willow Bayou Sabine Lake Dedicated Dredging (1,406 acres)	LA 2-18B LA 2-ADD B LA 2-19B	785	3,945,394
E_1	Willow Bayou SNWW New Work using the Dredge *California* (2,827 acres)	LA 2-16C LA 2-17C LA 2-19C LA 2-18C	1,552	9,205,547
F_1	Willow Bayou SNWW New Work (822 acres)	LA 2-16C	446	3,692,959
F_2	Willow Bayou SNWW New Work (1,857 acres)	LA 2-16C LA 2-17C	940	7,399,625

Table 5.4-2, cont'd

	Solutions	ID#	Cumulative AAHUs per Solution and Increment	Cumulative Average Annual Cost ($) per Solution and Increment ($1,000)
G_1	Willow Bayou SNWW New Work (251 acres)	LA 2-18C	152	1,391,853
G_2	Willow Bayou SNWW New Work (687 acres)	LA 2-18C LA 2-ADD C	365	3,010,940
G_3	Willow Bayou SNWW New Work (1,406 acres)	LA 2-18C LA 2-ADD C LA 2-19C	785	6,336,854
H_1	**Black Bayou Sabine River Maintenance Dredging (792 acres)**	**LA 3-10R**	**198**	**753,717**
I_1	Black Bayou GIWW Dedicated Dredging (546 acres)	LA 3-15A	231	685,753
I_2	Black Bayou GIWW Dedicated Dredging (1,043 acres)	LA 3-15A LA 3-18A	470	1,695,472
J_1	Black Bayou GIWW Dedicated Dredging (497 acres)	LA 3-18A	239	1,009,720
K_1	Black Bayou GIWW Dedicated Dredging (683 acres)	LA 3-15B	307	833,787
K_2	**Black Bayou GIWW Dedicated Dredging (1,304 acres)**	**LA 3-15B LA 3-18B**	**617**	**2,079,427**
L_1	Black Bayou GIWW Dedicated Dredging (621 acres)	LA 3-18B	310	1,245,640
Gulf Shoreline Nourishment				
M_1	Louisiana Point Gulf Shoreline Nourishment – SNWW new work material – 0.5 mile	LA 5-3	5	97,144
M_2	Louisiana Point Gulf Shoreline Nourishment – SNWW new work material (Section 5 only) – 3 miles	LA 5-1 LA 6-1	54	370,062
M_3	Louisiana Point Gulf Shoreline Nourishment - SNWW new work material (sections 5 and 6) – 3 miles	LA 5-5	90	1,087,715

5.4.3 Selection of the Best Buy Mitigation Plan

The result of the incremental analysis is illustrated on Figure 5.4-2 and in Table 5.4-3. Ten best buy plans were identified, with incremental costs ranging from $2,716 to $19,935 per AAHU. Line 1 is the No-Action Plan, with no cost and no output. The first column numbers the plans in order of cost effectiveness, with the most cost-effective plan (Plan 2) shown on the second line. Column 2 in Table 5.4-3 lists the codes for all solutions included in each best buy plan, as determined by the incremental cost analysis. The mitigation alternatives advanced for final screening (discussed previously) are the solutions evaluated by IWR-PLAN. Refer to Table 5.4-2 for a description of the mitigation measure represented by the codes shown in column 2. Column 3 shows the incremental output (in AAHUs) of the solution, which is added with each new best buy plan. Column 4 shows the average annual cost associated with the incremental output (the last solution added) of each best buy plan.

Figure 5.4-2. Results of CE/ICA Analysis

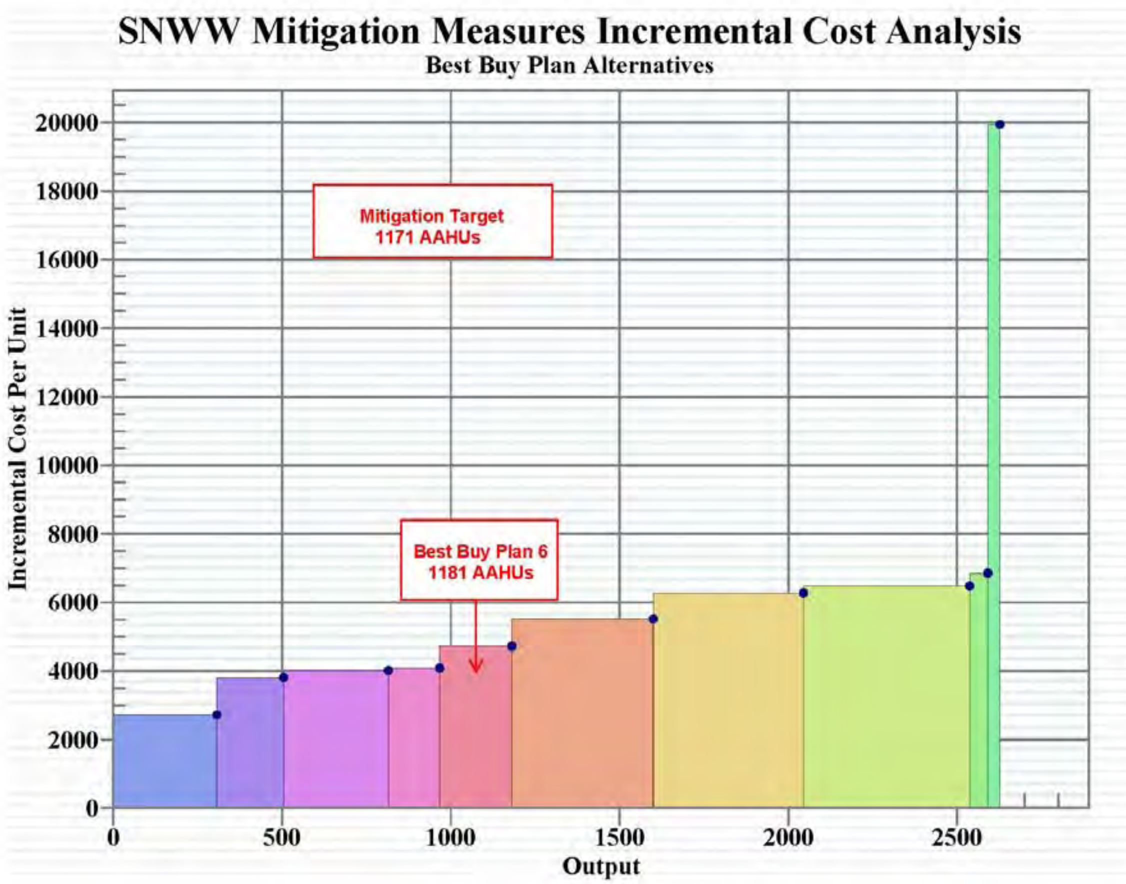


Table 5.4-3
Incremental Cost of Best Buy Plan Combinations (Ordered by Output)

Counter	Plan Alternative	Output (AAHUs)	Cost ($1.00)	Average Cost ($1.00/AAHU)	Incremental Cost ($1.00/AAHU)	Inc. Output ($1.00)	Inc. Cost Per AAHU
1	No-Action Plan	0.00	0.00				
2	A0B0C0D0E0F0G0H0I0J0K1L0M0	307.00	833,787.00	2,715.9186	833,787.0000	307.0000	2,715.9186
3	A0B0C0D0E0F0G0H1I0J0K1L0M0	505.00	1,587,504.00	3,143.5723	753,717.0000	198.0000	3,806.6515
4	A0B0C0D0E0F0G0H1I0J0K2L0M0	815.00	2,833,144.00	3,476.2503	1,245,640.0000	310.0000	4,018.1935
5	A0B0C0D1E0F0G0H1I0J0K2L0M0	967.00	3,454,021.00	3,571.8935	620,877.0000	152.0000	4,084.7171
6	**A0B0C0D2E0F0G0H1I0J0K2L0M0**	**1,181.00**	**4,465,620.00**	**3,781.2193**	**1,011,599.0000**	**214.0000**	**4,727.0981**
7	A0B0C0D3E0F0G0H1I0J0K2L0M0	1,600.00	6,778,538.00	4,236.5863	2,312,918.0000	419.0000	5,520.0907
8	A0B0C1D3E0F0G0H1I0J0K2L0M0	2,045.00	9,573,089.00	4,681.2171	2,794,551.0000	445.0000	6,279.8899
9	A0B0C2D3E0F0G0H1I0J0K2L0M0	2,537.00	12,759,111.00	5,029.2121	3,186,022.0000	492.0000	6,475.6545
10	A0B0C2D3E0F0G0H1I0J0K2L0M2	2,591.00	13,129,173.00	5,067.2223	370,062.0000	54.0000	6,853.0000
11	A0B0C2D3E0F0G0H1I0J0K2L0M3	2,627.00	13,846,826.00	5,270.9654	717,653.0000	36.0000	19,934.8056

Best Buy Plan 2, shown on line 2, consists of Solution $K_{1;}$ it has the lowest cost per AAHU ($2,716) of all the best buy plans and consists of only the first scale of that solution, with an output of 307 AAHUs. Best Buy Plan 3 adds Solution H_1 to Solution K_1, with an incremental output of 198 AAHUs for Solution $H_{1,}$ and a total output of 505 AAHUs for the plan. Best Buy Plan 4 consists of Solutions H_1 and K_2; in this case, the difference between total output for this plan and Best Buy Plan 3 (H_1 and K_1) is the incremental output between K_2 and K_1 (815 – -505 = 310 AAHUs). The cumulative output for each successive group of plans is shown in Column 3. The first plan with the cumulative total that exceeds the mitigation target is generally selected as the Best Buy Mitigation Plan.

The incremental annualized cost per unit of output (Column 5) is calculated by dividing total average annual cost for each incremental solution by the output from that solution. For Best Buy Plan 4, the total annualized cost of K_2 (in this case, $1,245,640) is divided by the incremental output (310 AAHUs) to obtain $4,018. Average annual costs were developed for all solutions that were analyzed with IWR-PLAN. These costs include the first cost of construction, marsh plantings, monitoring, and 50-year annualized O&M costs. They are not provided in this document, except as incremental costs per habitat unit, but are available upon request.

Best Buy Plan 6 (Solutions D_2, H_1, and K_2 – shown in bold in tables 5.4-2 and 5.4-3) appears to be an efficient mitigation plan since it reaches the mitigation target of 1,159 AAHUs (Table 5.4-4) by providing a total of 1,181 AAHUs. Best Buy Plan 6 consists of emergent marsh restoration in two Willow Bayou areas (totaling 607 acres) and three areas in the Black Bayou area (totaling 2,096 acres). Best Buy Plan 7 was also evaluated to determine whether its considerable additional benefits were worth the comparatively small incremental cost. Best Buy Plan 7 provides 420 additional AAHUs (719 more acres restored in Willow Bayou) by adding Solution D_3 for an additional average annual cost per unit of output of $4,237 (total average annual cost of $2,312,918). Since the estimated total first cost of this increment is $39,275,000 (screening-level cost) and Best Buy Plan 6 meets the mitigation target, Best Buy Plan 7 was deemed not worth the additional investment.

Table 5.4-4
Recommended Mitigation Plan

Recommended Mitigation Plan	Mitigation AAHUs
Willow Bayou	
LA 2-18 B Marsh Restoration (Sabine Lake dredging)	152
LA 2-ADD B Marsh Restoration (Sabine Lake dredging)	214
Black Bayou West	
LA 3-10R Marsh Restoration (Sabine River Channel maintenance material)	198
Black Bayou East	
LA 3-15 B Marsh Restoration (GIWW dredging)	307
LA 3-18 B Marsh Restoration (GIWW dredging)	310
Total Compensation	1,181
FWP Mitigation Target	–1,159
Net Benefits After Compensation	**22**

5.5 RECOMMENDED MITIGATION PLAN

The CE/ICA selected Best Buy Plan 6 as the most efficient combination of mitigation measures to compensate for the indirect impacts of the Preferred Alternative. It provides 1,181 AAHUs, which is 10 AAHUs more than the mitigation target. It is important to remember that additional compensatory mitigation would be provided in Louisiana beyond the total 843 AAHUs impacts of the Preferred Alternative. The mitigation plan would result in a net gain of 338 AAHUs for the project as a whole.

Unavoidable impacts of the SNWW CIP remain only in Louisiana; all CIP impacts in Texas are minimized and offset by the DMMP, and no mitigation is required. Therefore, all of the mitigation measures in Best Buy Plan 6 would be located in Louisiana. The mitigation plan consists of restoring five degraded marsh areas east of Sabine Lake near Willow and Black bayous, Louisiana (Table 5.5-1, Figure 5.5-1). Each of these alternatives is described in detail below. The recommended Mitigation Plan compensates for the Preferred Alternative's salinity increase and associated losses in marsh and productivity by marsh creation activities that would influence a total of 8,095 acres of Louisiana marshes in the Willow and Black Bayou watersheds. The plan would restore 2,783 acres of emergent marsh in existing open-water areas within the marsh, improve 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh, and stabilize and nourish 4,355 acres of existing marsh located in and around the marsh restoration zone. The amount of recommended mitigation is based upon the amount of marsh acreage that could be lost as a result of the project, and the additional amount that would need to be restored in order to fully compensate for adverse changes to biological function of the remaining marsh throughout the affected area over the 50-year period of analysis. More than a one-to-one ratio of created marsh to natural marsh is needed to fully compensate for the loss of marsh productivity caused by the CIP. Studies by NMFS (Minello, 2000; Minello and Webb, 1997) have shown that created marshes are not functionally equivalent to natural marshes for all estuarine species for as much as 15 years after the marshes are planted. In total, these measures would produce 1,159 AAHUs and provide full compensation for all impacts of the CIP. The USACE and the ICT would monitor all of the mitigation areas as described by the monitoring plan presented in Appendix I.

Table 5.5-1
Recommended Mitigation Plan – Acreage Analysis

Mitigation Measure	AAHUs	Total Influence Area (acres)	Nourished Existing Marsh (acres)	Restored Open Water (acres)	Restored Emergent Marsh (acres)
Willow Bayou					
LA 2-18B	152	681	367	63	251
LA 2-ADD B	214	1,285	745	104	436
Subtotal	366	1,966	1,112	167	687
Black Bayou West					
LA 3-10R	198	2,465	1,317	356	792
Black Bayou East					
LA 3-15B	307	1,788	878	227	683
LA 3-18B	310	1,876	1,048	207	621
Subtotal	617	3,664	1,926	434	1,304
Total Mitigation	1,181	8,095	4,355	957	2,783

Specific performance criteria for the marsh restoration areas were established in consultation with the ICT: (1) placed material would be 60 to 80 percent vegetated with native, typical, emergent marsh 5 years after each placement of material; (2) marsh would remain intact and 60 to 80 percent vegetated with native, typical, emergent marsh through the 50-year period of analysis; and (3) invasive, noxious, and/or exotic plants would compose less than 4 percent of marsh cover at year 2 and year 5.

5.5.1 Willow Bayou Mitigation

Recommended Willow Bayou mitigation measures (LA 2-18B and LA 2-ADD B) are located within the boundaries of the Sabine NWR (see Figure 5.5-1). The USACE has requested that the USFWS prepare a compatibility determination for the proposed activity. See correspondence dated January 24, 2007, in Appendix A1. Material dredged from a borrow trench in Sabine Lake would be used to restore 687 acres of emergent marsh within open-water areas, improve 167 acres of shallow-water habitat, and nourish 1,112 acres of existing marsh within the total influence area of 1,966 acres (see Table 5.5-1). Small ponds and sinuous, interconnected channels would be created to maintain tidal connectivity, increase marsh edge, and create protected areas for SAV. Approximately 1,966 acres of existing marsh in the influence area would also be renourished by winnowing fine-grained suspended solids during placement events. Marsh would be constructed by the unconfined flow of dredged material from a hydraulic pipeline. Frequent pipe movement and careful elevation control would be necessary to obtain the appropriate marsh elevations. In order to maximize edge in the marsh, topographic relief would be created by varying the final elevation of material placement, and planting with appropriate native flora at each elevation. The varied topography would allow for differences in duration of tidal inundation, create different floral communities, and maximize biodiversity. Tidal creek channels would be constructed in the marsh creation area after the dredged material has settled. These would be needed to return the area to normal tidal regime, facilitate marine organism access, and allow water and nutrients to flow into the area.

The dedicated dredging would take approximately 3.1 mcy of material from a 1.8-mile-long borrow trench in Sabine Lake. The borrow trench would be located at least 1,000 feet from the Sabine NWR shore and would average 1,030 feet wide by 7.5 feet deep. The borrow trench would be continuous and parallel to the current shoreline, in line with the common longshore circulation pattern in Sabine Lake. The circulation is expected to prevent the development of hypoxic conditions that would be detrimental to aquatic organisms, and would eventually fill the trench with Sabine River sediments. An access channel, approximately 8 miles long, from the GIWW near the mouth of the Sabine River would be needed for the dredge to reach the proposed borrow area. The exact locations of the borrow trench and access channel would be determined in consultation with the ICT after PED bottom surveys of potential locations. The USACE and ICT would monitor these mitigation areas in accordance with the specific success criteria and monitoring plan presented in Appendix J.

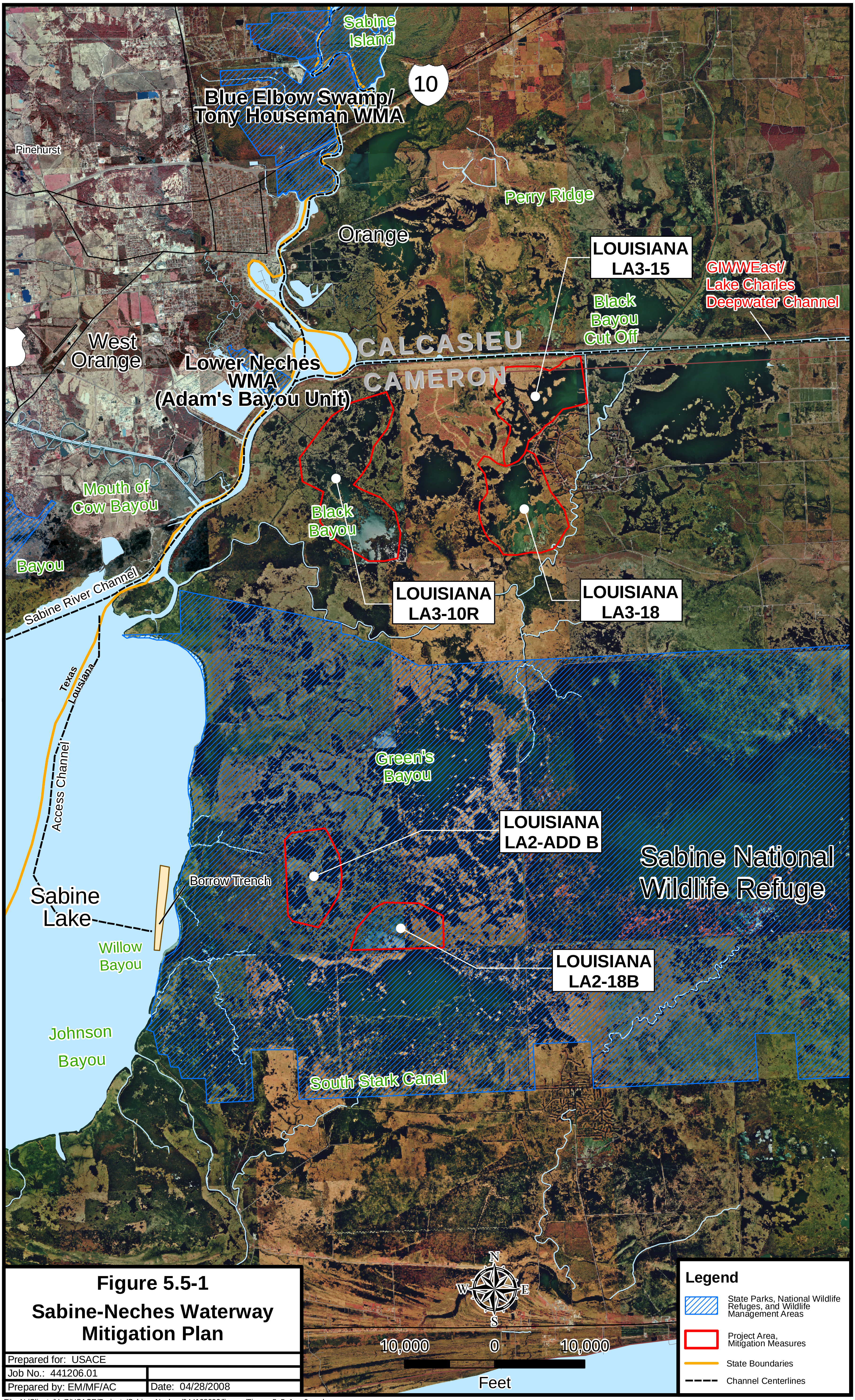


Figure 5.5-1

Sabine-Neches Waterway Mitigation Plan

Prepared for: USACE	
Job No.: 441206.01	
Prepared by: EM/MF/AC	Date: 04/28/2008

File: N:/Clients/U_Z/USACE/Projects/Sabine_Neches/044198000/figures/Figure_5_5_1_vr6.mxd

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One-time impacts of the borrow trench and access channel dredging would include an increase in water column turbidity during dredging activities; such effects are temporary and local to nekton, phytoplankton, and water quality. A hydraulic pipeline dredge would be used to minimize turbidity. For further information, see subsection 4.11.2.1. No further effects to water quality and related organisms would be expected. Benthic fauna would be removed due to excavation of sediment during dredging activities; however, benthic organisms can rapidly recolonize and no long-term effects are anticipated. Due to low salinity (1 to 6 ppt) in this area of Sabine Lake, live oyster reefs are not likely (Fagerberg, 2003). A study by T. Baker Smith, Inc. (2006) found no live oyster reefs in this area. SAV cover is not likely to be found in this area due to the prevalence of shallow, turbulent, and turbid water.

5.5.2 Black Bayou Mitigation

For the Black Bayou West (LA 3-10R) mitigation measure, material from maintenance dredging of the Sabine River Channel between East Pass and the GIWW would be used to restore a large area of marsh north of Black Bayou and west of Rusty Vincent Lake (see Figure 5.5-1 and Table 5.5-1). Maintenance dredging of the Sabine River Channel is considered a separate project within the SNWW system, with a different non-Federal sponsor. It is a without-project condition for the SNWW CIP, and therefore only the incremental cost associated with placing the material in the marsh is included in the cost estimate for the Preferred Alternative. Material removed during regularly scheduled maintenance dredging of this channel would be hydraulically pumped into a large degraded marsh area west of Rusty Vincent Lake. This area is close to the navigation channel, minimizing pumping distance and cost. Marsh restoration in LA 3-10R would be accomplished in six 5-year dredging cycles beginning by the first year of the completion of CIP construction. Each dredging cycle would pump approximately 526,000 cy of material to create 132 acres; a total of 792 acres of emergent marsh would be created over 30 years; 356 acres of shallow-water habitat would be improved, and 1,317 acres of existing marsh would be nourished within the total 2,465 acres influenced by the unconfined flow of dredged material.

For the Black Bayou East (LA 3-15B and LA 3-18B) mitigation measures, marsh restoration would be accomplished in two areas just west of the Black Bayou Cutoff Canal using dedicated dredging of accumulated material in the Lake Charles Deepwater Channel/GIWW (see Figure 5.5-1 and Table 5.5-1). The Lake Charles Deepwater Channel was constructed in 1926 and coincides along its entire 24.9-mile length with the GIWW between the Sabine River and Lake Charles (USACE, 1998c). Communications with the New Orleans District indicate the depth of the 30-foot channel has been reduced to approximately 12 feet due to sedimentation.

Dedicated dredging of the Lake Charles Deepwater Channel for the Black Bayou mitigation efforts would remove and kill benthic organisms; however, constant ship traffic in the shallow channel is an ongoing disturbance to these organisms. Recovery of benthic organisms would be rapid (Sheridan, 1999). No impacts to salinity would be expected because the dredged section would not connect with the Sabine River Channel or the Calcasieu Ship Channel; therefore, there would be no connection with the saltwater wedge in the Calcasieu Ship Channel (there is no Sabine River wedge; Brown and Stokes, 2009) It is expected that sediment would accumulate over time, refilling the channel to its current depth of approximately –12 feet.

Approximately 10.5 mcy of material would be pumped from a 13-mile stretch of the GIWW approximately 125 feet wide (the width of the GIWW/Deepwater Channel) into the two areas. The first (LA 3-15B) would be located adjacent to the GIWW and would have the shortest pumping distance; the second would be located south of LA 3-15B, and pumping would move to it after the first is complete. A total of 1,304 acres of emergent marsh would be restored, 434 acres of shallow-water habitat would be improved, and 1,926 acres of existing marsh would be nourished within the total 3,664 acres influenced by the unconfined flow of dredged material.

Marsh would be constructed by the unconfined flow of dredged material from a hydraulic pipeline. Frequent pipe movement and careful elevation control would be necessary to obtain the appropriate marsh elevations. In order to maximize edge in the marsh, topographic relief would be created by varying the final elevation of material placement, and planting with appropriate native flora at each elevation. The varied topography would allow for differences in duration of tidal inundation, create different floral communities, and maximize biodiversity. Tidal creek channels would be constructed in the marsh creation area after the dredged material has settled. These would be needed to return the area to the normal tidal regime, facilitate marine organism access, and allow water and nutrients to flow into the area. The USACE and ICT would monitor these mitigation areas in accordance with the specific success criteria and monitoring plan presented in Appendix J.

5.5.3 Comparison of Recommended Mitigation Plan to Mitigation Planning Objectives

The net benefits of the Mitigation Plan are shown in tables 5.4-4 and 5.5-1. Compensatory mitigation was considered only after impacts were minimized and offset by DMMP BU features. The DMMP features maximize, to the greatest degree possible, the use of dredged material as a beneficial resource, and share the material from Sabine Pass equally between the states. The mitigation plan (+1,181 AAHUs) fully compensates for AAHU losses to state resources in Louisiana and results in a net gain of 338 AAHUs for the project as a whole. Impacts to East Sabine Lake marshes are replaced in-kind by the marsh mitigation plans in Willow and Black bayous. Minor productivity impacts to cypress-tupelo swamp on the Sabine River near the GIWW are not matched in-kind. The ICT considered this to be acceptable since the loss in function is negligible. Projected FWP salinity levels are within the tolerance levels of these swamps, and the CIP causes no loss of swamp acreage.

5.5.4 Performance Criteria for DMMP Restoration/Nourishment and Mitigation Areas

5.5.4.1 Design and Construction

General performance criteria for marsh design and construction for DMMP BU features and Louisiana mitigation measures are presented below. Reference marshes would be located near to mitigation sites so that vegetation, salinity regime, and hydrology would be directly comparable. Specific criteria would be developed during the PED phase.

Goals and Objectives

- To create intertidal marshes compatible with the surrounding natural environment using dredged material.
- To reach consistent and similar intertidal fluctuations that mimic existing nearby marshes to provide habitat suitable for local species to survive and grow.
- To create a sustainable habitat that would withstand environmental conditions and anthropogenic impacts for the period of analysis.

Methods

- Build or reinforce existing containment levees adjacent to large canals with mechanically dredged, in situ material. Keep containment levees to the minimum necessary to prevent filling of adjacent navigable canals.
- Place hydraulically dredged material within degraded marsh areas and allow unconfined flow over larger influence areas.
- Frequently move pipe to prevent the accumulation of unsuitably high elevations of material.
- Allow fine-grained sediments to winnow through fringing marsh while material settles at discharge locations.
- Shape the material where required and plant vegetation to sustain the intertidal habitat over time.

Standards

- A sustainable marsh habitat maintained.
- Marsh elevations and geotechnical factors shall fall within certain parameters set in the design.
- Marsh water depths, water quality, water temperatures, DO levels, and salinity of the created marsh shall be favorable to expected flora and comparable to those in reference marshes.
- Water displacement over the tidal cycle shall be similar to reference marshes.

Monitoring and Contingency Plans

Monitoring and contingency plans for the mitigation measures and DMMP BU features are presented in Appendix J. The monitoring and contingency plans for mitigation measures and BU features have been developed in accordance with recent implementing guidance for sections 2036 (a) and 2039, respectively, of WRDA 07, and the monitoring plans for beneficial use of dredged material in Texas and Louisiana as required by the Section 2039 guidance.

The monitoring plans identify specific ecological success criteria to be used in determining whether the mitigation and BU DMMP features have been successful. Details of the monitoring plan for all of the mitigation sites in Louisiana and the BU features are presented in tables 3 and 4, respectively, of Appendix J. These tables present the key monitoring parameters, periodicity, costs, and responsible parties.

Periodic monitoring to determine the success of marsh mitigation measures and DMMP BU features would continue until the Division Commander determines that the ecological success criteria of the mitigation and DMMP BU features have been met. This determination would be based upon monitoring results and ICT consultation reports provided by the District Engineer. The ICT would be consulted annually to determine progress in the planning, construction, and postconstruction evaluation of the ecological success of these features.

5.5.4.2 Implementation

Upon authorization of the CIP, the USACE would use its Navigational Servitude to obtain access for construction of the Texas and Louisiana DMMP BU features and the Louisiana mitigation measures, for the purposes of planning, construction, and postconstruction monitoring. Landowners would be advised of the need for access. All restored areas would remain jurisdictional wetlands and continue to be subject to the Servitude; therefore, conservation easements would not be required. Agencies on the ICT have requested the opportunity to provide input to the future engineering, design, construction, and monitoring of the project. The ICT would participate in the detailed planning of the marsh creation areas during the PED phase, monitor construction of the mitigation areas, and participate in planning and conducting postconstruction monitoring.

6.0 CONSISTENCY WITH TEXAS AND LOUISIANA COASTAL MANAGEMENT PROGRAMS

In an effort to encourage states to better manage coastal areas, Congress enacted the CZMA in 1972. Texas and Louisiana both have developed and continue to implement federally approved coastal zone management programs and plans (TCMP and LCMP, respectively). States with approved plans have the right to review Federal activities (including private activities that require Federal permits) to determine whether they are consistent to “the maximum extent practicable” with the policies of the state’s coastal zone management program. Appendix I addresses the compliance of the Preferred Alternative in this FEIS with the TCMP and LCMP in full detail.

In summary, coastal natural resource areas (CNRAs), would be affected by the Preferred Alternative. The Preferred Alternative is a result of evaluating six project designs, several mitigation approaches, and beneficial uses of dredged material. Evaluations were made by an ICT and involved extensive modeling of ecological functions based on potential impacts, RSLR, and mitigative measures. The alternatives evaluations included attempts to minimize and avoid CNRAs to the maximum extent practicable and provide overall benefits to the ecosystem functions.

No net loss of coastal wetlands was a specific goal of the SNWW CIP ICT and alternatives evaluation. Several components of the DMMP and mitigation plan involve restoration, protection, and enhancement of coastal wetlands. The Neches River BU Feature would restore 2,853 acres of emergent marsh, nourish 1,234 acres of existing marsh, and improve 871 acres of shallow-water habitat. Additionally, the mitigation plan consists of restoring five degraded marsh areas east of Sabine Lake near Willow and Black bayous, Louisiana. This mitigation measure would restore 2,783 acres of emergent marsh in existing open-water areas within the marsh, improve 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh, and stabilize and nourish 4,355 acres of existing adjacent marsh.

USACE has evaluated the proposed SNWW CIP for consistency with the Texas and Louisiana coastal management programs, and concluded that the Recommended Plan is fully consistent to the maximum extent practicable with the enforceable policies of both state programs. An ICT comprised of Federal and State resource agency representatives from Texas and Louisiana assisted USACE over a nearly 10-year period to perform appropriate scientific studies and modeling needed to ensure that the proposed project avoids and minimizes environmental impacts to the greatest extent practicable. USACE in particular notes that State and Federal agencies including USFWS, NMFS, TPWD, TCEQ, LDEQ, and the EPA have expressed no outstanding concerns with the project. By letter dated March 30, 2010, the Texas Coastal Coordination Council concurred with the USACE consistency determination. By letter dated March 31, 2010, the LDNR Office of Coastal Management (OCM) found that the SNWW CIP is conditionally consistent with their state program. The finding requires that USACE submit an additional consistency determination no later than the time at which draft contract plans and specifications are circulated for internal review. A requirement of the conditional consistency is the submission of additional detailed information on topics that "would include, but not be limited to, the topics of storm surge, bar channel deepening, salinity, borrow from Sabine Lake, mitigation plans and adequacy, and pipeline relocation." The letter also notes that the USACE letter to LDNR-OCM, dated March 19, 2010, does not constitute an adequate resolution to the issues described. USACE consulted with LDNR (as a member of the ICT) concerning technical issues raised in this letter, and issues originally approved by LDNR as a member of the ICT are now being reopened. USACE maintains that the issues, as summarized below, have been adequately addressed. Since USACE finds that the Recommended Plan is consistent to the maximum extent practicable with the enforceable policies of the LCMP, USACE does not accept conditional consistency as proposed by LDNR-OCM. By letter dated April 26, 2010, USACE notified LDNR of its finding and that it will proceed with the project.

Storm Surge

LDNR asserts that the effects of the deeper shipping channel and the borrow of material from the GIWW and Sabine Lake may be significant and have not been modeled thoroughly enough to identify all potential impacts. ERDC-CHL was consulted about the need to model the salinity effect of borrowing material from the GIWW and Sabine Lake relative to salinity impacts. Neither feature was expected to increase salinity impacts, and so they were not included in the HS modeling.

ERDC was also consulted on the potential for ODMDSs to increase wave set-up and erosion on Louisiana shores. ODMDS sites are located too far from shore and in water too deep to affect the Louisiana shore. Waves of any consequence present within a thousand feet of the shoreline are generally depth limited because of the mild nearshore slope and the presence of a soft mud (PIE, 2003). The closest ODMDS (#4) is located between 3.8 and 6 miles from Louisiana in 34 to 43 feet of water. Appendix B discusses previous monitoring of this ODMDS and studies of bottom ocean currents in the region that have determined the dredged material would disperse between placement cycles and not accumulate, and thus would not affect wave set-up or erosion.

ERDC has just completed a sensitivity analysis of potential storm surge impacts from the deeper shipping channel and placement areas (Wamsley, Cialone, and McAlpin, 2010). The analysis is discussed in more detail in subsection 4.6.2.1. The analysis clearly and unequivocally identifies no impact to Louisiana from the deflection of storm surges by the higher PA levees or from the deeper navigation channel. Therefore, further modeling to identify impacts is not necessary.

Bar Channel Deepening

Modeling of potential impacts on wave climate has been performed by ERDC-CHL as reported by Gravens and King (2003). The report has been presented on the USACE, Galveston District's SNWW webpage since 2003, and it is reported in here in subsection 4.6.2.2. The modeling addressed the changes in the wave climate that would be produced by a deeper and longer offshore channel, including the Outer Bar Channel. In the first 2 miles east of Sabine Pass, the net eastward transport would be slightly reduced (by a maximum of about 1,400 cy/year), and farther east there would be essentially no change. For a

50-foot project, between ½ mile and 3–4 miles of the east jetty, the accretion would decrease by less than 0.5 foot/year, and farther from the jetties than that, the change in the shoreline would decrease to zero. This small impact would be more than offset by the proposed Gulf Shore BU feature's regular shoreline nourishment at Louisiana Point.

Salinity

LDNR asserts that the SNWW salinity modeling used questionable assumptions and boundary conditions, and data collected over a short and nonrepresentative time period. Boundary conditions and assumptions were developed by ERDC and coordinated with the ICT in numerous meetings of the ICT and its MW from 2000 to 2004, and the revised HS modeling presented at the last ICT meeting on August 27, 2009. While LDNR participated in most of the MW meetings, and all prior ICT meetings, no representatives from LDNR attended the last ICT meeting. The ICT presented no objections to the revised modeling at this meeting. The HS modeling for the Preferred Alternative has been subjected to extensive agency technical review (ATR) and independent external peer review (IEPR). ATR identified no significant concerns. The primary IEPR concern related to the need to include the effects of relative sea level rise. This was included as demonstrated in the latest the HS modeling report (Brown and Stokes, 2009). As part of the ICT, LDNR participated in the development of modeling assumptions and reviewed the modeling results. No negative comments were received prior to the consistency determination coordination.

Borrow Site in Sabine Lake

LDNR has requested more information on design details regarding the proposed Sabine Lake borrow trench for the Willow Bayou mitigation areas. USACE has agreed to provide all of the information (i.e., geotechnical information on borrow quality, analysis of potential access channels, and disposal plans) needed to develop detailed engineering plans during the PED phase. Designs would minimize impacts to the maximum extent practicable. This FEIS (subsection 5.5.1) fully evaluates potential impacts of the access channels and borrow area and has determined that impacts would be minimal and temporary.

LDNR also requires that mitigation of oyster seed ground impacts must be accomplished to the satisfaction of LDWF. The exact locations of the borrow trench and access channel would be determined in consultation with the ICT after PED bottom surveys of potential locations. The proposed route of the access channel was chosen to keep dredging impacts to a minimum; it takes advantage of deeper water in the center of the lake, thereby minimizing dredging and bottom impacts. Due to low salinity in this area of Sabine Lake, live oyster reefs are not likely (Fagerberg, 2003; T. Baker Smith, 2006). Nevertheless, as stated in subsection 5.5.1 and in the USACE letter dated March 4, 2010, to LDWF, USACE has proposed that a water-bottom survey of the borrow and access channel areas be conducted during the PED phase of the project. In the unlikely event that oyster reef is encountered, plans will be revised to avoid impacts.

LDNR-OCM asserts that royalty payments and license issues over sediment resources must be resolved with LDWF before LDNR-OCM can concur that the final design is consistent, to the maximum extent practicable, with Louisiana Coastal Resources Program. USACE maintains that the United States is not bound by Louisiana statute (R.S. 56:2011) pursuant to the Supremacy Clause of the United States Constitution, and that Louisiana is not entitled to compensation under the Fifth Amendment, pursuant to the doctrine of Navigation Servitude. This servitude gives the Federal Government the right to use the "Navigable Waters" of the United States without compensation for navigation projects. In a letter dated March 19, 2010, on the issue of payment of royalties, the USACE provided a detailed legal and policy analysis to support the conclusion that no royalty payments are proper or allowable under current Federal law.

Mitigation Plans and Adequacy

LDNR asserts that details of the proposed mitigation are insufficient to determine whether all potential losses will be adequately compensated. USACE disagrees—mitigation site locations have been finalized, and conceptual designs are sufficient to support ecological modeling of the compensatory mitigation. USACE has agreed to work with the ICT (which includes LDNR) to obtain all of the information needed to develop detailed engineering plans, including geotechnical data relevant to site design, during PED.

LDNR asserts that the proposed mitigation plan falls at least 318 AAHUs short of replacing the anticipated habitat losses to Louisiana, and that additional mitigation will have to be performed in Louisiana to offset this deficit. USACE maintains that the proposed mitigation plan would more than compensate for all impacts of the proposed SNWW CIP. LDNR has questioned the use of benefits from BU features in Texas to offset impacts in Louisiana (see Table 5.1-2). In Louisiana, the benefits of BU measures offset the loss of 210 AAHUs to private lands along the coast at Louisiana Point, and the loss of 340 AAHUs to Federal land in the SNWR. Exclusion of the Federal SNWR is based upon the definition of “coastal zone” in the Coastal Zone Management Act of 1972, as amended. “Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents (16 USC §1453).” The net impact of the project to non-Federal lands in Louisiana after application of BU benefits is the loss of 1,159 AAHUs, and the proposed mitigation plan would provide 1,181 AAHUs in order to fully and separately compensate losses to these lands. Furthermore, the Louisiana marsh mitigation measures would compensate for the predicted loss of 691 acres in Louisiana over 50 years by the restoration of 2,783 acres of emergent marsh, the improvement of 957 acres of shallow-water habitat, and the nourishment of 4,355 acres of existing marsh. Since the marsh restoration is several times greater than the predicted marsh loss, there would be no net loss of wetlands.

LDNR has also questioned the benefits of the Gulf Shore BU feature at Louisiana Point, and asserts that additional mitigation in Louisiana will be required unless acceptable technical justification of the projected benefits is provided. The benefits of the BU feature in Louisiana were established by WVA modeling accomplished by the ICT, of which LDNR was a part. The technical justification presented in Appendix C, subsection 8.3.1.2 and WVA modeling were reviewed and accepted by the ICT. The monitoring plan (Appendix J) would determine whether benefits are being reached as predicted.

Pipeline Relocation

A total of 104 pipelines have been identified crossing the SNWW navigation channels. Of the 104 pipelines, 46 require adjustment to meet the minimum required vertical and horizontal clearances for the SNWW CIP. The individual circumstances of each pipeline will be evaluated by USACE in consultation with the non-Federal sponsor and the pipeline owner during the PED and Construction phases, and decisions regarding necessary actions will be made individually for each pipeline at that time. Costs of pipeline relocations have been included in the economic analysis of potential project benefits. Direct and indirect economic benefits of the proposed deepening will accrue to all users of the SNWW, including the energy industries, and to the regional economy in Louisiana as established by an independent economic analysis (Martin Associates, 2006). The economic analysis presented in FFR Section V.F establishes that there would be a net economic benefit to the country from the proposed project. Minimal impacts to Louisiana industries are anticipated because construction would work around pipeline relocations as needed to accommodate all parties for a safe, effective, and minimally disruptive working plan.

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7.0 CONSISTENCY WITH OTHER STATE AND FEDERAL PLANS AND REGULATIONS

This FEIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations and has been prepared using the CEQ NEPA regulations (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 (*Environmental Quality: Policy and Procedures for Implementing NEPA*, 33 CFR 230). The USACE will follow provisions of all applicable laws, regulations, and policies related to the proposed actions, including those for which applicability, review, and enforcement are their responsibility. Additionally, the local sponsor may be required to secure local municipal permits as a "Land, Easements, Rights-of-Way, Relocation, and Disposal Areas" requirement. The following sections present brief summaries of Federal environmental laws, regulations, plans, and coordination requirements applicable to this FEIS.

7.1 NATIONAL ENVIRONMENTAL POLICY ACT

This FEIS has been prepared in accordance with CEQ regulations in compliance with NEPA provisions. All impacts on terrestrial and aquatic resources have been identified, significant adverse impacts requiring mitigation have been identified, and mitigation has been proposed.

7.2 RIVER AND HARBOR ACT OF 1899

Sections 9 (33 USC 401) and 10 (33 USC 403) are related to structural construction and dredge-and/or-fill activities, respectively, within U.S. navigable waterways. The USACE authorizes permits under this statute. While the agency would not issue a permit for its own actions, the USACE would meet and be consistent with all applicable elements of the statute. Additionally, the USACE and ICT determined that dredged material testing was required under the related Regulatory Guidance Letter 06-02 (*Guidance on Dredged Material Testing for Purposes of Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbors Act, and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972,* July 6, 2002). Results are presented in sections 3.3 and 3.4.

7.3 CLEAN WATER ACT

USACE has received §401 State Water Quality Certification from Texas and Louisiana for this action. Both states have determined that the requirements for water quality certification have been met and have concluded that the placement of fill material will not violate water quality standards of each state. The Preferred Alternative is the least environmentally damaging practicable alternative. A CWA §404(b)(1) evaluation of the proposed action, provided in Appendix E of this FEIS, describes the effects of the proposed discharges. Short-term increases in turbidity may be caused by the unconfined flow of dredged material during construction of BU features and mitigation measures. Proposed channel improvements should decrease the number of vessel trips, thus decreasing the probability of a spill.

Appendix E of this FEIS contains the §401(b)(1) evaluation needed for state water quality certification. All relevant sediment and water quality data for both new work and maintenance dredging material were reviewed by a team of State and Federal resource agencies (the CW of the ICT), including the TCEQ and LDEQ, and they found no cause for concern over water or sediment quality in any channel reach. New work sediments were deemed suitable for use in constructing BU or mitigation sites and upland confined PAs, although excess new work material would have to be placed in upland confined PAs. Maintenance material would be handled according to the DMMP. The DMMP measures maximize, to the greatest degree possible, the use of dredged material as a beneficial resource, and share the material from Sabine Pass equally between the states.

7.4 CLEAN AIR ACT of 1970

The CAA is the comprehensive Federal law that regulates air emissions from area, stationary, and mobile sources. An analysis of estimated air contaminant emissions from equipment (including dredges and support equipment such as tugboats, runabouts, and tenders, as well as land based equipment such as bulldozers and employee vehicles) associated with the proposed CIP is expected to result in short-term impacts on air quality in the immediate vicinity of the project area, but no long-term impacts are expected. Emissions of VOC for the project are exempt from a General Conformity Determination because they are below the general conformity threshold of 100 tons per year. However, estimated NO_x emissions for the Preferred Alternative exceed the general conformity threshold; i.e., greater than 100 tpy, for all years of construction.

Pursuant to Section 176 of the CAA Amendments of 1990, the USACE prepared a document entitled, “Draft General Conformity Determination, Sabine-Neches Channel Improvement Project.” This document was noticed for public comment and was submitted by the USACE to the TCEQ, the EPA, and other air pollution control agencies, as appropriate, concurrently with this DEIS. As part of the General Conformity process, the USACE made this document available to the public for review and comment for a period of 30 days. The TCEQ has provided written concurrence that emissions from the Preferred Alternative are conformant with the Texas SIP for the BPA (Appendix A1). Based on TCEQ’s comments, the USACE has prepared a Final General Conformity Determination for the proposed SNWW CIP (Appendix F).

7.5 NATIONAL HISTORIC PRESERVATION ACT OF 1966

Compliance with the NHPA of 1966, as amended, requires identification of all NRHP-listed or NRHP-eligible properties in the project area and development of mitigation measures for those adversely affected in coordination with the Texas and Louisiana SHPOs and the Advisory Council on Historic Preservation. As indicated in Section 3.13, this project would not impact NRHP-listed properties or SALs; however, it may potentially adversely impact terrestrial and marine historic properties eligible for listing in the NRHP. This FEIS has been coordinated with the Texas and Louisiana SHPOs. An HPPA (Appendix H) has been executed among the Texas and Louisiana SHPOs, the SNND and USACE to address subsequent investigations, coordinate surveys of impact areas, test potentially eligible sites, and manage data recovery or avoidance measures as necessary. Tribal coordination, required by the NHPA, has been conducted. Tribes with historical or cultural ties to the region were contacted early in the study to identify their interests and concerns. The draft Programmatic Agreement has also been coordinated with the Tribes. No Tribes have requested to become consulting parties, and no impacts to Tribal land or traditional cultural properties have been identified.

7.6 ENDANGERED SPECIES ACT

Potential impacts to federally listed threatened and endangered species have been assessed by the USACE in a BA. The BA determined that several federally listed species of sea turtles and wintering populations of the piping plover and its Critical Habitat could potentially be affected by project construction or operation. The BA concluded that the Preferred Alternative would not jeopardize the continued existence of piping plovers or result in the adverse modification of its designated Critical Habitat. Potential impacts to sea turtles from hopper dredging were identified, and interagency consultation under Section 7 of the ESA was initiated. NOAA/NMFS responded with a BO as outlined under Section 7(c) of the ESA of 1973, as amended. The BA and BO are presented in Appendix G of this FEIS; other related correspondence is present in Appendix A2. While the project alternative changed, project-related impacts remained the same and therefore the BO conclusions would remain the same.

Potential impacts to the wintering piping plover would be associated with implementation of the Gulf Shore BU Feature. The recurring placement of dredged material for shoreline nourishment would affect areas of designated Critical Habitat. The USFWS has designated the entire shoreline between Constance Beach and Sabine Pass (Unit LA 1, in part) as Critical Habitat for wintering piping plover. Proposed beach nourishment activities at Louisiana Point would occur along approximately 3 miles of this unit, beginning approximately 0.5 mile east of Sabine Pass. No designated Critical Habitat, or even suitable habitat, is present along the Texas portion of the Gulf Shore BU Feature. The USFWS, in letters dated March 20 and March 22, 2007 (Appendix A2), concurred that the Preferred Alternative is not likely to adversely affect the piping plover or its Critical Habitat and the brown pelican. The USFWS Louisiana Field Office stated that no further ESA consultation would be required with its office unless changes are made to the scope or location of the project. The USFWS Clear Lake Field Office letter was silent on the need for further consultation. However, the USACE staff confirmed by telephone that no further ESA consultation would be required unless changes are made to the scope or location of the project. The Clear Lake Field Office did recommend that steps be taken to determine whether bald eagles are nesting within or near the project area since the number of bald eagles in Texas is increasing. Prior to project construction, the USACE would check with the TPWD and local landowners to determine whether there have been recent bald eagle sightings and determine the need for surveys and further coordination at that time.

The USFWS provided further guidance in a letter dated February 5, 2010, and recommended that all activity in Louisiana occurring within 2,000 feet of a brown pelican rookery be restricted to the non-nesting period (i.e., September 15 through March 31). However, because nesting periods vary considerably among Louisiana's colonies, it is possible that this activity window could be altered based upon the dynamics of the individual colony. Prior to project construction, the LDWF Fur and Refuge

Division will be contacted to obtain the most current information about the nesting chronology of individual brown pelican colonies. In Texas, the USFWS recommended all activity occurring within 1,000 feet of a rookery be restricted to the non-nesting season.

Loggerhead, Kemp’s ridley, hawksbill, leatherback, and green sea turtles may be present in the study area waters during certain times of the year. Construction and postconstruction maintenance activities involving the use of hopper dredges could result in impacts to sea turtles. No critical habitat for sea turtles is present in the study area, and there have been no reports of sea turtles nesting in the study area, as most of the shoreline is an eroding, muddy marsh. The NMFS has concluded that hopper dredging during construction and maintenance is likely to adversely affect but is not likely to jeopardize the continued existence of loggerhead, Kemp’s ridley, hawksbill, leatherback, or green sea turtles. The Opinion authorizes incidental lethal take of four turtles (three Kemp’s ridley sea turtles and one loggerhead or green sea turtle) during the course of the proposed project’s hopper dredging. Only incidental takes that occur while the specified reasonable and prudent measures are in full implementation are authorized. These measures specify that (1) dredging should be completed, whenever possible, within specified temperature and date-based dredging windows; (2) NMFS-approved protected species observers must provide 100 percent monitoring during certain date and temperature-determined periods; (3) rigid deflector dragheads must be used on hopper dredges at all times; and (4) relocation trawling is required after the take of one sea turtle during the project. The Opinion authorizes the per-fiscal-year nonlethal noninjurious take, external flipper-tagging, and taking of tissue samples of 32 sea turtles in any combination in association with any relocation trawling conducted during hopper dredging. Maintenance-dredging activities for the proposed project are covered by an existing agreement between the NMFS and USACE regarding the taking of sea turtles with hopper dredges to ensure that significant impacts do not occur (NOAA, 2003).

7.7 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

The Migratory Bird Treaty Act of 1918 (as amended) extends Federal protection to migratory bird species; among other activities, nonregulated “take” of migratory birds is prohibited under this Act in a manner similar to the ESA prohibition of “take” of threatened and endangered species. Additionally, EO 13186, “Responsibility of Federal Agencies to Protect Migratory Birds,” requires Federal activities to assess and consider potential effects of their actions on migratory birds (including, but not limited to, cranes, ducks, geese, shorebirds, hawks, and songbirds). The effect of the Preferred Alternative on migratory bird species has been assessed. The USFWS has concurred that the Preferred Alternative is not likely to affect designated piping plover habitat at Louisiana Point. DMMP marsh restoration and Louisiana marsh mitigation areas would result in a net increase in migratory bird habitat in the project area. Construction contracts would include instructions to avoid impacts to migratory birds and their nests from construction-related activities. The Migratory Bird Conservation Act (16 USC 715–715d, 715e, 715f–715r; 45 Stat. 1222) establishes a Migratory Bird Conservation Commission to approve areas of land or water for acquisition as reservations for migratory birds and is not applicable to the project.

7.8 FISH AND WILDLIFE COORDINATION ACT OF 1958

The Fish and Wildlife Coordination Act directs Federal agencies to consult with the USFWS and relevant state wildlife resource agencies regarding potential impacts to wildlife from proposed improvements like the proposed SNWW CIP. The intent of this consultation is to help prevent the loss of and damage to wildlife resources from water development projects. USACE has consulted with the USFWS throughout the ICT process, and as a result, USFWS recommendations have been incorporated into the final impact assessment and the BU and compensatory mitigation plans for the Preferred Alternative. The USFWS submitted a Coordination Act Report (CAR) that affirms the USACE impact assessment and approves the proposed BU and mitigation plans. The CAR, dated March 16, 2010, is presented in Appendix A3.

7.9 NATIONAL WILDLIFE REFUGE SYSTEM IMPROVEMENT ACT OF 1997

The National Wildlife Refuge System Improvement Act of 1997 amended the National Wildlife Refuge System Administration Act of 1966 to improve management of the NWR System. An amendment to the 1966 Act requires that each refuge administrator review any proposed new use of a refuge to determine whether its use is compatible with the purposes of the refuge and consistent with public safety. Since the proposed Willow Bayou mitigation measures LA 2-18 and LA 2-ADD B are located in the Sabine NWR, and the proposed Gulf Shore BU Feature at Texas Point is located in the Texas Point NWR, the USACE has requested compatibility determinations from each refuge manager. Each refuge must identify the effects of the proposed use on refuge resources and provide an opportunity for public review and comment.

7.10 MARINE MAMMAL PROTECTION ACT OF 1972

The Marine Mammal Protection Act was passed in 1972 and amended through 1997. It is intended to conserve and protect marine mammals and establish the Marine Mammal Commission, the International Dolphin Conservation Program, and a Marine Mammal Health and Stranding Response Program. The Preferred Alternative is in compliance with this Act. No impacts to marine mammals are expected.

7.11 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1996

Congress enacted amendments to the MSFCMA (PL 94-265) in 1996 that established procedures for identifying EFH and required interagency coordination to further the conservation of federally managed fisheries. EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans. Rules published by the NMFS (50 CFR sections 600.805–600.930) specify that any Federal agency that authorizes, funds, or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above-mentioned Act and identifies consultation requirements. Sections 3.10 and 4.11 of this FEIS were prepared to address EFH in the project area and to initiate consultation under the Act. Any detrimental impacts of the Preferred

Alternative on EFH are minor and temporary, but the project would provide indirect benefits since the project, including the DMMP restoration sites, would lead to an overall net gain in marsh habitat. The NMFS, by letter dated March 8, 2010, has concurred with the FEIS assessment of EFH impacts, and concurs that the proposed BU features and mitigation will offset the adverse impacts to EFH and provide a net-benefit to federally managed fisheries. No further consultation under the MSFCMA with NOAA or NMFS is required.

7.12 FEDERAL WATER PROJECT RECREATION ACT

The Federal Water Project Recreation Act of 1995 requires consideration of opportunities for outdoor recreation and fish and wildlife enhancement in planning water resource projects. The beneficial uses included in the project for the construction and maintenance material include uses requested by various recreational groups, environmental groups, and State and Federal regulatory agencies. All would benefit one or more of the items listed above.

7.13 MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT OF 1972

This Act requires a determination that dredged material placement in the ocean would not reasonably degrade or endanger human health, welfare, or amenities or the marine environment, ecological systems, or economic potential (shellfish beds, fisheries, or recreational areas). Maintenance and construction dredged material proposed for placement at the existing and new ODMDSs, designated by the EPA under Section 102 of Marine Protection, Research, and Sanctuaries Act (MPRSA), is subject to evaluation using the ocean dumping environmental criteria. The proposed new ODMDSs are outlined in Appendix B. The conclusion of the ODMDS Designation FEIS (Appendix B) was that the Preferred ODMDSs met all of the 5 general and 11 specific criteria listed in 40 CFR 228.5 and 228.6 and are therefore acceptable under the MPRSA. All material transported for ocean disposal would be evaluated pursuant to the EPA Ocean Dumping Regulations and Criteria (Section 103). Use of the ODMDSs would be in accordance with an approved Site Monitoring and Management Plan (SMMP).

7.14 COASTAL ZONE MANAGEMENT ACT

In an effort to encourage states to better manage coastal areas, Congress enacted the CZMA in 1972. Texas and Louisiana both have developed and continue to implement federally approved coastal zone management programs and plans (TCMP and LCMP, respectively). States with approved plans have the right to review Federal activities (including private activities that require Federal permits) to determine whether they are consistent to “the maximum extent practicable” with the policies of the state’s coastal zone management program. Appendix I addresses the compliance of the Preferred Alternative in this FEIS with the TCMP and LCMP in full detail.

In summary, CNRAs would be affected by the Preferred Alternative. The Preferred Alternative is a result of evaluating six project designs, several mitigation approaches, and beneficial uses of dredged material. Evaluations were made by the ICT and involved extensive modeling of ecological functions based on potential impacts, RSLR, and mitigative measures. The alternatives evaluations included attempts to minimize and avoid CNRAs to the maximum extent practicable and provide overall benefits to the ecosystems functions.

No net loss of coastal wetlands was a specific goal of the ICT and alternatives evaluation. Several components of the DMMP and mitigation plan involve restoration, protection, and enhancement of coastal wetlands. The Neches River BU Feature would restore 2,853 acres of emergent marsh, nourish 1,234 acres of existing marsh, and improve 871 acres of shallow-water habitat. Additionally, the mitigation plan consists of restoring five degraded marsh areas east of Sabine Lake near Willow and Black bayous, Louisiana. This mitigation measure would restore 2,783 acres of emergent marsh in existing open-water areas within the marsh, improve 957 acres of shallow-water habitat by creating shallower, smaller ponds and channels within the restored marsh, and stabilize and nourish 4,355 acres of existing adjacent marsh.

USACE has evaluated the proposed SNWW CIP for consistency with the Texas and Louisiana coastal management programs, and concluded that the Recommended Plan is fully consistent to the maximum extent practicable with the enforceable policies of both state programs. The Texas Coastal Coordination Council has concurred with the USACE consistency determination. The LDNR-OCM found that the SNWW CIP is conditionally consistent with their state program. Since conditional consistency as proposed by LDNR-OCM is not acceptable, LDNR-OCM has been notified that USACE will proceed with the project. This issue is discussed in further detail in Section 6.0.

7.15 COASTAL BARRIER IMPROVEMENT ACT OF 1990

This act is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The Coastal Barrier Improvement Act of 1990 was enacted to reauthorize the Coastal Barrier Resources Act (CBRA) of 1982. The Gulf shoreline at the Texas Point NWR is designated as an “otherwise protected area” (unit T01P). The Gulf shoreline in the Louisiana portion of the study area contains no CBRA-designated units. Exceptions to the Federal expenditure restrictions also include maintenance or constructed improvement(s) to existing Federal navigational channels and related structures (e.g., jetties), including the disposal of dredged materials related to maintenance and construction (The Center for Regulatory Effectiveness, n.d.); therefore, the Preferred Alternative is exempt from the prohibitions identified in the act.

7.16 FARMLAND PROTECTION POLICY ACT OF 1981 AND THE CEQ MEMORANDUM PRIME AND UNIQUE FARMLANDS

In 1980, the CEQ issued an Environmental Statement Memorandum “Prime and Unique Agricultural Lands” as a supplement to the NEPA procedures. Additionally, the Farmland Protection Policy Act was passed in 1981, requiring consideration of those soils, which the USDA defines as best suited for food, forage, fiber, and oilseed production, with the highest yield relative to the lowest expenditure of energy and economic resources. The NRCS concurred that the “prime farmland if drained” soil mapped in PA 24A is not Important Farmland, and provided the Farmland Conversion Impact Rating Form indicating an exemption.

7.17 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

The Preferred Alternative includes the development of two new PAs (PA18A and PA24) and the Neches River BU Feature within the floodplain of the Neches River. Alternatives to avoid the adverse effects of developing the two new PAs in the floodplain were evaluated, and it has been determined that this is the only practicable alternative. The Neches River BU Feature would construct marsh in areas of open water within the floodplain that formerly were emergent marsh; they would remain jurisdictional wetlands after construction. Development in the BU areas would be controlled by Section 404 regulations, and their construction would not be expected to induce growth in the floodplain. BU alternatives were evaluated in consideration of existing drainages to ensure that restored wetland areas would not induce flooding. This FEIS fulfills public notification requirements as it provides an explanation of why these project features are proposed to be located in the floodplain and provides an opportunity for the public to comment on these plans.

7.18 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

This EO directs Federal Agencies to avoid undertaking or assisting in new construction in wetlands, unless no practical alternative is available. One of the two new PAs proposed for development (PA 24A) would result in the conversion of 86 acres of wetlands to a confined PA. Alternatives to avoid the loss of 86 acres of wetlands were evaluated, and it has been determined that this is the only practicable alternative. The Preferred Alternative’s Neches River BU Feature would result in a net gain in wetlands along the lower Neches River, and the ecological benefits of this feature would more than offset the loss of 86 wetland acres due to the construction of PA 24A. The Neches River BU Feature would construct marsh in areas of open water within the floodplain that formerly were emergent marsh; they would remain jurisdictional wetlands after construction. The Neches River BU Feature would improve water quality, inhibit erosion and sediment loss, and restore habitat for fish and wildlife species, improving the long-term productivity of the lower Neches River ecosystem.

7.19 EXECUTIVE ORDER 13112, INVASIVE SPECIES

Under EO 13112, Federal agencies may not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species unless the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species. Related to project development and implementation, Federal agencies whose action(s) may affect the status of invasive species are required to use relevant programs, information, and authorities to do the following:

- prevent the introduction and/or spread of invasive species;
- accurately monitor invasive species populations related to their area of effects;

- provide restoration for natural vegetation communities adversely affected by invasive species;
- provide environmentally sound control of invasive species; and
- consult with the Invasive Species Council and ensure their actions are consistent with the Invasive Species Management Plan.

Although ship traffic would increase with the Preferred Alternative, the increase would be less than the predicted growth of ship traffic under the No-Action Alternative, and therefore, no additional impacts with respect to ballast water are expected. Furthermore, no changes in foreign ports of call are predicted.

7.20 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

This EO directs Federal agencies to determine whether the Preferred Alternative would have a disproportionate adverse impact on minority or low-income population groups within the project area. The Preferred Alternative would not significantly affect any low-income or minority population (Section 4.12).

7.21 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT AND RESOURCE CONSERVATION AND RECOVERY ACT

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (as amended) was designed to help clean up the nation's inactive hazardous waste sites. There are a variety of different requirements included in this sweeping legislation. CERCLA also requires industries to disclose to their communities what hazardous substances they use and store. CERCLA authorized the EPA to remediate polluted sites; for this purpose it created Superfund to pay for site cleanups when there is no clear-cut responsible party. The EPA can also pursue potentially responsible parties to make them pay for response and remediation activities. Superfund, 40 CFR 302–310, authorized the EPA to respond to and remedy polluted sites and created Superfund to pay for site cleanups when a responsible party could not be identified.

The RCRA of 1976 (as amended) provides for comprehensive cradle-to-grave regulation of hazardous waste and authorizes environmental agencies to order the cleanup of contaminated sites. Since 1984, it has also called for the extensive regulation of underground storage tanks and the cleanup of contamination caused by leaking tanks. In addition, RCRA addresses the environmental problems associated with nonhazardous solid waste and encourages states to develop solid waste management programs, regulate solid waste landfills, and eliminate open dumps. Federal facilities are required to comply with Federal, State, and local regulations and requirements on solid and hazardous waste and underground storage tanks to the same extent as private parties. RCRA contains provisions on a number of other topics, such as resource recovery, used oil management and recycling, small town environmental planning, and plastic ring carriers. While most RCRA provisions focus on the protection of human health, its wide-ranging attempts to prevent, reduce and eliminate pollution have an obvious, if largely unstated, effect on wildlife protection as well.

These acts require the reporting of hazardous, toxic, and radioactive waste and prescribe specific handling and remediation requirements. A records search was performed to identify possible RCRA and CERCLA sites in or near the project area, and these are described in the FEIS. An evaluation of the potential for these sites to impact the proposed project was conducted, and yielded the following concern. Contaminant issues affecting PA 17 must be resolved by the non-Federal sponsor before the PA can be used as part of the preferred alternative. Alternative placement areas are available should this not be resolved in time for use.

7.22 FEDERAL AVIATION ADMINISTRATION – HAZARDOUS WILDLIFE ATTRACTANTS ON OR NEAR AIRPORTS

In accordance with FAA AC 150/5200-33 and the Memorandum of Agreement among the FAA, the USACE, and other Federal agencies (July 2003), the Preferred Alternative was evaluated to determine if proposed land uses could increase wildlife hazards to aircraft using public use airports in the study area. Potential attractants (four existing PAs) were found to be located between the 10,000-foot and 5-mile perimeters of the Southeast Texas Regional Airport in Beaumont, Texas. No new PAs would be constructed within the separation perimeters, and no change in land use is proposed in conjunction with the Preferred Alternative. USACE provided this information to the FAA, and concluded that continued use of the four existing PAs does not constitute a change in land-use and is compatible with airport operations.

7.23 TEXAS CHENIER PLAIN NATIONAL WILDLIFE REFUGE COMPLEX COMPREHENSIVE CONSERVATION PLAN

The Texas Chenier Plain NWR Complex is four units administered by the USFWS: Anahuac NWR, McFaddin NWR, Texas Point NWR, and Moody NWR. These units are located along the upper Texas Gulf Coast in Chambers, Jefferson, and Galveston counties. Only the Texas Point NWR is located within the SNWW study area. The Refuge Complex's aquatic habitats (open-water and near-shore Gulf habitats), freshwater to saline marshes, riparian habitats, coastal woodlots, rice fields, native prairies, cheniers and coastal beach, and dune habitats harbor over 300 bird species, 75 species of freshwater fish, and 400 species of salt and brackish water finfish and shellfish.

Long-term, large-scale alterations to the region—over 100,000 acres of coastal wetland loss in 25 years; loss and conversion of more than 99 percent of the historic tallgrass prairie along the Louisiana and Texas Gulf Coasts for agriculture, residential, and commercial uses; increases in nonnative plant and animal species; loss or severe restriction of freshwater and sediment inflows and increased saltwater intrusion; and ongoing threats from sea level rise and land subsidence—have prompted the USFWS to act to facilitate the long-term protection of natural resources in the region.

The Texas Chenier Plain National Wildlife Refuge Complex Comprehensive Conservation Plan (CCP) provides a 15-year vision to identify and propose solutions to significant problems that may adversely affect the populations and habitats of fish, wildlife, and plants and the actions necessary to correct or mitigate such problems (USFWS, 2008a). The CCP has four goals: (1) conserve, enhance and restore the refuge's coastal wetlands to provide habitat for native fish and wildlife; (2) conserve, enhance and restore the refuge's coastal prairies and coastal woodlands to provide habitat for native fish and wildlife; (3) implement a comprehensive biological program to guide and support conservation effort for all native fish, wildlife, and plant species; and (4) work with others on a landscape level to address threats to natural biological diversity, ecological integrity, and environmental health on the Refuge Complex. Specific strategies will include habitat restoration, protection, and land acquisition from willing sellers.

The Preferred Alternative would impact the goals of the CCP by causing small increases in salinity and land loss, and related decreases in productivity within the intermediate, brackish, and saline marshes of the Texas Point NWR. However, losses quantified by the WVA model would be more than offset by gains from the regular beneficial use of dredged material for shoreline nourishment at Texas Point. This BU feature complies with another goal of the CCP—the restoration of sediment supply to the Gulf's nearshore littoral zone at Texas Point NWR through the beneficial use of dredged material. Other CCP goals (restoration of hydrology by reducing saltwater intrusion with rock weirs or earthen plugs in Texas Bayou, and using dredged material to restore mineral sediment to interior marsh) were thoroughly evaluated in the screening of BU and mitigation measures. Construction of rock weirs or earthen plugs at Texas Bayou were determined to be ineffective in reducing saltwater intrusion. The beneficial use of dredged material to restore interior marsh would be feasible, but the cost would exceed the Traditional Placement Plan. The latter goal could be pursued if a non-Federal sponsor offers to pay the incremental cost of construction. The SNWW CIP does not conflict with any of the refuge expansion goals of the Texas Point NWR.

7.24 SABINE NATIONAL WILDLIFE REFUGE COMPLEX COMPREHENSIVE CONSERVATION PLAN

The Sabine NWR is part of the Southwest Louisiana National Wildlife Refuge Complex, which also includes Cameron Prairie and Lacassine NWRs to the east within Cameron Parish, and Shell Keys NWR in Iberia Parish. Only the western portion of the Sabine NWR (portions of Unit 5, excluding Pool 3, Unit 6, and Unit 7) is located within the SNWW study area. The refuge contains a diversity of habitat including extensive coastal marshes and open water, wooded ridges and levees, canals, ponds, and bayous. The refuge provides habitat for many species of wildlife, including ducks, geese, alligators, muskrats, nutria, raptors, wading birds, shorebirds, blue crabs, shrimp, and finfish. It is one of the primary overwintering refuges for waterfowl in the Mississippi Flyway.

Overall, the greatest risk to fish, wildlife, plants, and their habitats in the Chenier Plain ecosystem is from extensive wetland habitat degradation and loss that has occurred over the past century. Wetlands in the Chenier Plain declined 16 percent from the mid-1960s to 1990. These habitat losses have led to commensurate impacts on wildlife populations, especially those dependent on wetlands. These losses have prompted the USFWS to implement a 15-year protection plan to facilitate wetland preservation and restoration, a most important wildlife conservation priority of the Gulf Coast ecosystem.

The CCP provides a 15-year vision to identify and propose solutions to significant problems that may adversely affect the populations and habitats of fish, wildlife, and plants and the actions necessary to correct or mitigate such problems (USFWS, 2008b). CCP primary goals include (1) maintaining, restoring, and enhancing unique coastal wetland habitats on the refuge to provide favorable conditions to improve species diversity and richness of migratory birds and native terrestrial and aquatic species; and (2) maintaining healthy and viable wildlife and fish populations on the refuge to contribute to the purpose for which it was established.

The Preferred Alternative would impact the first goal of the CCP by causing small increases in salinity and land loss, and related decreases in productivity within the intermediate, brackish, and saline marshes of the refuge. However, losses as quantified by the WVA model would be more than offset by gains from the regular beneficial use of dredged material for shoreline nourishment at Louisiana Point and other BU features associated with the project in Texas. In addition, it is proposed that two of the compensatory mitigation measures proposed for the SNWW CIP be located within the Sabine NWR. These measures would employ one of the management strategies recommended by the CCP—using dredged material to restore mineral sediment to emergent marsh in degraded areas of the refuge. In the long term, these mitigation areas would contribute to the restoration of habitat and maintenance of healthy fish and wildlife populations in the refuge.

7.25 TEXAS COASTWIDE EROSION RESPONSE PLAN

The Texas Coastwide Erosion Response Plan has identified several parts of the study area as “critical erosion areas” because of impacts to habitats and traffic safety from ongoing erosion, and has called for an increase in the beneficial use of dredged material from the SNWW project to help address these issues. The plan was developed as part of the CEPRA (GLO, 2004, 2005). The program has identified the Gulf shoreline between Texas Point and Sea Rim State Park as a critical erosion area. It attributes the erosion, in part, to a lack of sediment coming down the Sabine and Neches rivers, and the interruption of longshore sediment transport by the SNWW jetties. The CEPRA Plan recommends that long-term regional sediment management be utilized, along with highway realignment and beach dune restoration, to protect the important coastal evacuation route of SH 87 in Jefferson County. In Orange County, the CEPRA Plan calls for restoration of 9,400 acres of marsh in the Lower Neches River using dredged material to raise soil elevations in the former marsh areas that have become open water. The Preferred Alternative would address some of the ongoing problems by using maintenance material for shoreline nourishment at Texas Point and by restoring and nourishing approximately 5,000 acres of marsh in the Lower Neches River floodplain.

7.26 LOUISIANA COAST 2050

In Louisiana, the Coast 2050 is a comprehensive, ecosystem-based restoration plan, completed in 1998 to address coastal wetland loss throughout southern Louisiana. Planning involved Federal, State, and local entities, landowners, environmentalists, wetland scientists, and others in the development of an integrated, multiple-use approach to ecosystem management. A major funding source for these projects comes from the Federal CWPPRA. The SNWW is located in Region 4 of this plan.

The goals of Coast 2050 are to:

- Sustain coastal ecosystem with the essential functions and values of the natural ecosystem
- Restore the ecosystem to the highest practicable acreage of productive and diverse wetlands
- Accomplish this restoration through an integrated program that has multiple use benefits

In the Sabine Lake area, Coast 2050 strategies include:

- Maintain Sabine River inflow
- Beneficial use of dredged material for marsh creation
- Seasonally operated locks at the mouths of navigation channels to relieve salinity stress on marshes

Detailed strategies for specific areas are described in the Coast 2050: Toward a Sustainable Coastal Louisiana (LCWCR/WCRA, 1998). The USACE, New Orleans District, and LDNR prepared the *Louisiana Coastal Area Feasibility Study* to provide the necessary technical data required to implement the conceptual plan of the Coast 2050 document (USACE, 2004a). The Preferred Alternative would impact the first goal of the Coast 2050 Plan by causing small increases in salinity and land loss, and small decreases in productivity. However, these losses would be fully compensated by marsh restoration mitigation measures in the Willow and Black bayou watersheds.

7.27 LOUISIANA COASTAL AREAS ECOSYSTEM RESTORATION STUDY AND PLAN

The LCA Ecosystem Restoration Study (USACE, 2004a) documented the most critical human and natural needs of the endangered Louisiana coastal area, identified short- and long-term critical priorities, and recommended large-scale, long-term studies that were beyond the scope of that study. The eastern half of the SNWW study area is located in the western part of Region 4, the Chenier Plain. Without any preservation or restoration actions, the report predicted that Sabine Lake wetlands would continue to experience severe wetland deterioration and land loss due to increased salinity levels and marine influences from the SNWW and the GIWW, relative sea level change, tropical storms, oil and gas infrastructure, sediment reduction/vertical accretion deficit, and saltwater intrusion resulting from diminished freshwater inflow.

For Region 4 as a whole, existing rates of habitat loss are predicted to continue, resulting in the loss by 2050 of 9.8 percent of existing fresh marsh, 16.3 percent of intermediate marsh, 100 percent of saline marsh, and 33.3 percent of swamp habitat. Brackish marsh and open water are predicted to increase by 46.5 and 11.4 percent, respectively. This would reduce habitat diversity and result in a long-term loss of an estimated 37 square miles of land loss.

The LCA report did not recommend any near-term critical restoration features for congressional authorization or additional study in Region 4. While beneficial use of dredged material from the Calcasieu Channel is recommended for wetlands adjacent to that channel, no beneficial use projects are identified for the marshes along the eastern shore of Sabine Lake. A long-term, large-scale study of freshwater and sediment management in the Chenier Plain was recommended and this would include the portion of the SNWW study area east of Sabine Lake and the Sabine River. The Preferred Alternative does not include any features that would conflict with future restoration features. Impacts of the proposed project would be fully compensated by the marsh mitigation measures.

7.28 LOUISIANA’S COMPREHENSIVE MASTER PLAN

Louisiana has developed a coastal master plan that integrates planning for ecosystem restoration and hurricane protection in planning for a sustainable coast (LCPRA, 2007). The master plan establishes a clear set of priorities for comprehensive coastal protection in Louisiana. In the Chenier Plain, the plan notes that navigation channels and canals have allowed salt water to penetrate inland, destroying fringe marsh and impinging on freshwater lakes. The plan recommends the development of a new plan to develop appropriate measures to address these impacts. Portions of the plan that affect the SNWW study area are as follows. The Chenier Plain Freshwater and Sediment Management and Reallocation Plan suggests managing river and surface fresh water supplies to ensure availability of fresh water throughout the year. This management would also permit the delivery of fresh water to areas exposed to saltwater stress. It is suggested that the GIWW could be used as a conduit to distribute fresh water from the Atchafalaya River toward marshes to the west. The plan also seeks to maintain the integrity of freshwater resources by raising and fortifying selected portions of SH 82, installing segmented offshore breakwaters to protect the barrier shoreline, fortifying dredged material banks along the GIWW, and placing saltwater barriers on the SNWW to manage salinity levels. The plan recognizes that safe and efficient navigation must be maintained when implementing such a project. It suggests that a barrier could be operated periodically to manage saltwater intrusion events. Marsh restoration using dredged material from maintenance dredging of navigation channels is also recommended. In planning hurricane protection structures, the plan emphasizes nonstructural solutions such as flood insurance, elevating and retrofitting structures, and revising building codes. No structural solutions for hurricane protection are recommended for the study area. The State’s Annual Plan would be the vehicle for presenting yearly scheduling and cost information about proposed projects. The Preferred Alternative does not include any features that would conflict with restoration priorities of this plan. Impacts of the proposed project would be fully compensated by marsh mitigation measures.

7.29 LOUISIANA COASTAL PROTECTION AND RESTORATION

In February 2008, the Louisiana Coastal Protection and Restoration Draft Technical Report was released for public review and comment (USACE, 2008a). The study was conducted as a joint effort of the Federal government and the State of Louisiana to investigate and integrate hurricane risk reduction and coastal restoration for south Louisiana. The purpose of the report is to describe the progress that the USACE has made in this effort, which is mandated by the Energy and Water Development Appropriation Act of 2006 and the Department of Defense, Emergency Supplemental Appropriations to Address Hurricanes in the Gulf of Mexico, and Pandemic and Influenza Act, 2006. Additional time would be needed for the USACE to complete the comprehensive hurricane analysis and design for south Louisiana due to engineering, environmental, and economic complexities. The Louisiana Coastal Protection and Restoration effort is closely tied to Louisiana's Comprehensive Master Plan discussed above. The report does not make recommendations for project authorizations, appropriations, or nongovernmental decisions. It describes methodologies used to perform the technical evaluation and the process used to engage stakeholders.

One of the most significant accomplishments is the development and application of numerical models that replicate hurricane surges and determine the statistical frequency of events along the entire Louisiana coast. This effort has vastly improved the ability of the USACE to evaluate hurricane threats along the northern Gulf coast, including storm surge and wave effects. The Louisiana Coastal Protection and Restoration effort also quantified the risk reduction benefits provided by wetlands. The Louisiana coast is divided into planning units that generally correspond to previously defined subregions. Planning Unit 4 corresponds to Region 4, the Chenier Plain.

Hurricane modeling determined that certain areas of the Gulf are more likely to experience higher-intensity storms. Southeastern Louisiana, Mississippi, and western Alabama were shown to have a higher probability of severe-storm occurrence than elsewhere along the Gulf. The probability of a hurricane greater than Category 2 on the Saffer-Simpson Scale hitting the Gulf coastline in the SNWW study area is 2 percent in any 1 year, half that of the highest probability zone (4 percent in any 1 year). Hurricane Rita is a close comparison to a 100-year storm based on size, intensity, and track. It produced a peak storm surge with an approximately 90-year return interval, compared to the 400-year storm surge of Hurricane Katrina. The Louisiana Coastal Protection and Restoration storm surge modeling projects that a water surface height in the SNWW study area (east of Sabine Lake) with a 100-year storm would range from 15 feet near the coast to 11 feet north of the GIWW near Orange, Texas. Storm surge effects would be felt in the Sabine River valley far north of the current study area. For a 400-year storm, water elevations would range from 19 feet near the coast to 12 feet north of the GIWW near Orange, Texas.

Planning Unit 4 Alternatives located within the SNWW study area are limited to two types: (1) construction of a 12-foot-high levee along the entire GIWW alignment, ending at the Sabine River: and (2) marsh restoration in the marshes east of Sabine Lake. The coastal restoration alternative includes marsh restoration in two areas that are proposed as compensatory mitigation measures for the SNWW CIP (LA 3-10R and LA 3-15). Coastal restoration scored relatively highly in minimizing environmental impacts but did not appear to be a cost-effective measure. The potential for channel deepening proposed in the Preferred Alternative was evaluated with HS modeling conducted for this study. The results of this analysis indicated there would be no significant increase in storm surge effects.

7.30 NORTH AMERICAN WATERFOWL MANAGEMENT PLAN

The purpose of the North American Waterfowl Management Plan (NAWMP, Plan Committee, 2004) is to sustain abundant waterfowl populations by conserving landscapes through partnerships that are guided by sound science. The 2004 Plan establishes a new 15-year horizon for waterfowl conservation in North America by assessing and defining needs, priorities, and strategies needed to promote waterfowl conservation in the twenty-first century. The SNWW study area is located in the Gulf Coastal Prairie, an area of continental significance to North American ducks, geese, and swans as it lies within the Central Flyway. The plan focuses on habitat conservation at a continental scale and identifies general objectives for habitat conservation in five key priority regions, including the Gulf Coast Prairie Region. The beneficial use of dredged material to restore degraded marshes is specifically identified as a habitat conservation strategy in this plan. The Preferred Alternative would contribute to plan goals with the restoration and nourishment of approximately 5,000 acres of emergent marsh in the Lower Neches River floodplain and regular shoreline nourishment at Texas and Louisiana Points.

8.0 ANY ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PREFERRED ALTERNATIVE BE IMPLEMENTED

The Preferred Alternative would result in minor adverse impacts to benthos and fish from dredging and placement of dredged material but these impacts are temporary. Although the SNWW channel is located primarily in Texas, large indirect impacts may occur due to small increases in salinity levels causing an increase in wetland loss and a decrease in biological productivity in aquatic habitats of both Texas and Louisiana. In Texas, 33,500 acres of intertidal marsh and swamp are expected to be indirectly impacted due to the slight salinity increase as a result of the proposed action. Biological productivity may be reduced over approximately 39,000 acres of tidal marsh and swamp in Texas, with the potential loss of 247 acres of emergent marsh, including 86 acres of fresh marsh that would be converted to an upland PA. Impacts in Louisiana may affect approximately 182,000 acres of tidal, emergent marsh, and potentially result in the loss of about 691 additional acres of marsh within the area of tidal influence. This includes 86 acres of wetland habitat that would be converted to an upland PA. The BU features and compensatory mitigation address wetland loss by restoring a total of 5,636 acres of emergent marsh, 1,828 acres of improved shallow-water habitat, and nourishing 5,589 acres of existing marsh, which more than compensates for wetland losses resulting from a small increase in salinity and enhances the long-term productivity of the study area's ecosystem.

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9.0 ANY IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE IMPLEMENTATION OF THE RECOMMENDED PLAN

The primary impact of the Preferred Alternative is an indirect impact associated with a small increase in salinity and an associated reduction in biological productivity over approximately 211,500 acres of intertidal marsh and swamps in Texas and Louisiana, and the potential resultant loss of about 691 acres of marsh within the area of tidal influence of the SNWW. Benefits of the Neches River BU Feature more than offset the direct impact of conversion of 86 acres of fresh marsh to a confined PA (PA 24A) and the indirect impact of the increase in salinity over 39,000 wetland acres in Texas. The Neches River BU Feature restores 2,853 acres of emergent marsh, improves 871 acres of shallow-water habitat, and nourishes 1,234 acres of existing marsh, providing benefits that offset all project impacts in Texas and all but the loss of 843 AAHUs in Louisiana. The indirect effect of a small increase in Gulf shoreline erosion in both states (totaling approximately 15 acres over the period of analysis) is minimized by the Gulf Shore BU Feature. Compensatory mitigation for unavoidable impacts in Louisiana restores 2,783 acres of emergent marsh, improves 957 acres of shallow-water habitat, and nourishes 4,355 acres of existing marsh in the Willow and Black bayou areas. The BU features and compensatory mitigation address wetland loss by restoring 5,636 acres of emergent marsh, 1,828 acres of shallow-water habitat, and nourishing 5,589 acres of existing marsh, which more than compensates for worst-case wetland losses resulting from a small increase in salinity and enhances the long-term sustainability of the study area ecosystem. Since there would be a time lag before the restored marshes become established and ecologically functional, there would be a temporary loss of productivity during the interim period. Benthic organisms in the Gulf that are buried during initial and subsequent use of the ODMDSs would recover quickly after each use. The productivity of expanded PAs on the Neches River and the Sabine Lake bottom taken for borrow material would be temporarily disrupted, but would shortly be transformed into different habitats that would contribute to the long-term productivity of the SNWW estuary.

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10.0 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

BU features and compensatory mitigation provided under the Preferred Alternative address wetland loss by restoring 5,636 acres of emergent marsh, 1,828 acres of shallow-water habitat, and nourishing 5,589 acres of existing marsh, which more than compensates for worst-case wetland losses resulting from a small increase in salinity and enhances the long-term productivity of the study area ecosystem. Since there would be a time lag before the restored marshes become established and ecologically functional, there would be a temporary loss of productivity during the interim period. Benthic organisms in the Gulf that are buried during initial and subsequent use of the ODMDSs would recover quickly after each use. The productivity of expanded PAs on the Neches River and the Sabine Lake bottom taken for borrow material would be temporarily disrupted, but would shortly be transformed into different habitats that would contribute to the long-term productivity of the SNWW estuary.

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11.0 ENERGY AND NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

NEPA regulations in 40 CFR 1502.16(e) and (f) require a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS.

Under the No-Action Alternative, the energy requirements for maintaining the channel would continue as before. However, the navigation requirements for energy (fuel) to transport commercial products is likely to increase in the future as commerce increases and more traffic increases congestion and navigation time into and out of regional ports. Air quality impacts are likely to increase with an increase in navigation traffic congestion and travel time along the SNWW.

The Preferred Alternative is expected to reduce energy (fuel) requirements for transporting products on a ton/mile basis by deepening the channel and providing bend easings:

- ships can be more heavily loaded with cargo; and
- fewer vessel trips would be required in lightering of crude oil from large ships offshore.

Energy (fuel) would be required to deepen the channel, but this is a short-term impact. Energy to maintain the deeper channel is expected to increase by roughly a factor of two, with the increase in shoal material expected for the larger channel. This increase in fuel requirement is expected to be more than offset by fuel savings in ship traffic in the larger channel and should help reduce air quality impacts slightly over the No-Action Alternative, especially since the largest increase in shoaling is offshore. Increased efficiency in moving petroleum and other petroleum-based commodities to the local refineries is expected to help conserve natural or depletable resources in the future. The reduced energy requirements of the more-efficient channel would result in a smaller increase in transportation costs in the future, which reduces overall production costs for the consumer.

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12.0 LIST OF AGENCIES AND ORGANIZATIONS TO WHOM COPIES OF THE FINAL STATEMENT ARE SENT

12.1 PUBLIC INVOLVEMENT PROGRAM

The USACE and SNND involved the public through public meetings and other outreach throughout the history of this project. A proactive approach was taken to inform and involve the public, resource agencies, industry, local government, and other interested parties about the project and to identify any public concerns.

The first public scoping meeting was held on May 24, 2000, at the John Gray Center Auditorium, Lamar University, Beaumont, Texas. The purpose of this meeting was to inform the public about the initiation of the feasibility study and to solicit comments on navigation concerns, alternatives to be addressed, and environmental issues and concerns.

The second public scoping meetings were held on May 28, 2002, at the Best Western Hotel, Lake Charles, Louisiana, and May 29, 2002, at the John Gray Center Auditorium, Lamar University, Beaumont, Texas. The purpose of these meeting were to inform the public about study progress and to solicit comments on environmental issues such as changes in salinity and circulation, changes in fresh- and saltwater marshes, water and sediment quality, erosion along the channel, threatened and endangered species impacts, and beneficial use of dredged materials.

Other various forms of outreach utilized during this project included early regulatory agency coordination, ICT, RW, MW, CW, OW, and HW meetings, public workshop to obtain ideas for BU of dredged material, media trips down the waterway, presentations at the GMFMC Texas Habitat Protection Advisory Panel, meetings with the Sabine Pilots Association, presentation at the 2007 Southeast Texas Leaders meeting, meetings with SNWW industries, individual contacts, press releases, and comment forms.

DEIS Public Hearings were conducted on January 26, 2010, at the Beaumont Civic Center in Beaumont, Texas, and on January 27, 2010, at the Lake Charles Civic Center in Lake Charles, Louisiana, to solicit comments and information from the public. Approximately 51 people attended the meeting in Beaumont, and 19 in Lake Charles. An open house was conducted prior to the Public Meetings, which included table-top poster presentations and discussions among the USACE, the SNND, USACE consultants, and the public. Formal presentations were made by SNND and USACE during the public meetings, and then oral comments were taken from the public. These comments were considered when finalizing the FEIS. Transcripts of the DEIS public meetings are presented in Appendix K.

12.2 REQUIRED COORDINATION

The FEIS is being circulated to all known Federal, State, and local agencies. Interested organizations and individuals are also being sent notice of availability. A list of those who are being sent a copy of this document, along with a request to review and provide comments on the documents, is provided in Section 12.3.

12.2.1 PUBLIC VIEWS AND RESPONSES

Public views and concerns expressed during this study have been considered during the preparation of this FEIS. The views and concerns were used to develop planning objectives, identify significant resources, evaluate impacts of various alternatives, identify potential PAs, and identify a plan that is socially and environmentally acceptable. Important concerns expressed included the beneficial use of dredged material and recreational opportunities.

Development of alternatives is explained in Section 2. The recommended plan takes into consideration the expressed objectives, views, and concerns of the resource agencies and public. Public comments received are addressed Appendix A5.

12.3 STATEMENT RECIPIENTS

The following list includes agencies, organizations, and public that were sent a copy of these documents and/or the Notice of Availability with a request to review and provide comments.

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Richard Medina, Chief, Planning and Environmental Branch	35 years, Environmental Impact Assessment and Impact Analysis, Planning and Environmental Resources	Document review
Rob Hauch, Physical Scientist	26 years, Environmental Impact Assessment and Impact Analysis; Dredged Material, Water, and Sediment Quality Analyses	Appendix B preparation assistance, project review
Kristy Morten, HTRW Specialist	28 years, HTRW and Biological Analysis	HTRW, document review
Nicole Minnichbach, Staff Archeologist	7 years, Archeology	Archeology section preparation and review
Nancy Young, Civil Engineer	10 years, Civil Engineer	Engineering design of BU features and mitigation measures
John Damm, Geotechnical Engineer	20 years, Geotechnical Engineer	Engineering design of BU features
Ryan Brown, Geotechnical Engineer	3 years, Geotechnical Engineer	Engineering design of BU features
U.S. Environmental Protection Agency		
Barbara Keeler	30 years of coastal environmental science and NEPA experience for EPA, currently serving as the Region 6 Coastal & Wetlands Planning Coordinator.	Served as the EPA Regional lead for technical and policy EIS review. Participated in this effort as the EPA representative on the Habitat Workgroup and the Sabine-Neches Interagency Coordination Team.
Stephen Bainter	30 years environmental related activities experience, to include experiences in positions as the Municipal Whole Effluent Coordinator, Water Quality Permitting Specialist, and Water Quality Standards Coordinator for EPA Region 6. Currently assigned as EPA Region 6's Ocean Dumping Coordinator.	ODMDS EIS and SMMP technical review.

Name/Title	Experience	FEIS Area of Responsibility
U.S. Environmental Protection Agency, concluded		
Renee Bellew	9 years environmental related activities experience, currently serving as a Water Quality Standards Coordinator for EPA Region 6. Participated in this effort while as the EPA Region 6's Ocean Dumping Coordinator.	ODMDS EIS technical and policy review.
PBS&J		
Martin Arhelger, Vice President, Project Director	30 years, Environmental Assessment and Impact Analysis	Project Manager, water and sediment quality
Angela Bulger	8 years, NEPA Compliance and Coordination	Assistant Project Manager, document coordination
Tony Risko	18 years, Coastal Engineering	Assistant Project Manager
Lisa Vitale, Marine Biologist	15 years, Marine Biology	Assistant Project Manager, Marine Fisheries/EFH, document coordination and production, quality control
Tomas Dixon, Senior Scientist	8 years, Wildlife and Protected Species	Wildlife and threatened & endangered species, BA and CMP preparation
Derek Green, Biologist, Wildlife Specialist	24 years, Environmental Assessment and Analysis	Wildlife and habitat, threatened and endangered species, sea turtle analysis
Erik Huebner, Senior Scientist	10 years, Wildlife and Protected Species	Wildlife and threatened & endangered species
Tommy Ademski, Senior Environmental Planner	10 years, Planning	Noise analysis
Wendy Connally, Ecologist	4 years, Environmental Assessment and Analysis	Cumulative Impacts and QA/QC
Kathy Calnan, Ecology, Botany	16 years, Vegetation Analysis and Impacts	Vegetation Analysis
Dave Buzan, Aquatic Biologist	30 years, Aquatic Biology, Vegetation Analysis and Impacts	Freshwater Fisheries, Vegetation Analysis
Ruben Velasquez, Senior Engineer	30 years, Air Quality	Air Quality, General Conformity
Bob Gearhart, Archeologist, Magnetometer and Side-Scan Sonar Specialist	22 years, Marine Archeology	Marine archeology
Steve McVey, Geologist, HazMat Specialist	12 years, Environmental Geology	HTRW Analysis
Tricia LaRue, Environmental Planner	5 years, Planning and Socioeconomics	Socioeconomics
Michael Hettenhausen, Environmental Planner	2 years, Planning and Document Review	General ecology, document review
Eric Monshaugen, GIS Specialist	4 years, GIS	GIS data/figures
Chris Vidrick, Senior Word Processor	30 years, Word Processing	Word processing, document formatting and review
Bob Bryant, Lead Word Processor	18 years, Word Processing	Word processing, document formatting and review
Linda Nance, Technical Editor	35 years, Editing	Technical document editing

Name/Title	Experience	FEIS Area of Responsibility
Independent Technical Review		
Philip M. Payonk, Chief, Environmental Resources Section, CESAW-TS-PE	27 years Environmental Impact Assessment and Impact Analysis; Dredged Material, Water, and Sediment Quality Analyses; Ocean Disposal Coordinator	Environmental Impact Review; compliance with environmental laws and regulations
Bernard E. Moseby, Economist, CESAM-PD-FE	21 years Economic Analysis, Deep Draft Navigation	Review of Mitigation Measures CE/ICA
Carl E. Dyess, Dredging Project Manager, CESAM-OP	18 years, Dredging Operations Manager	Review of operations and maintenance plans
Wade A. Ross, Supervisory Hydraulic Engineer, CESAM-EN-HH	16 years, Hydraulic Engineer, Deep Draft Navigation	Review of hydrology and hydraulics issues
Dennis E. Mekkers, Hydraulic Engineer, CESAM-EN-HH	12 years, Structural Hydraulic Design, Tidally Influenced Wetlands Modeling and Restoration	Review of HS models
Naomi R. Fraenkel, Civil Engineer, CENAN-PL-F	5 years, Deep Draft Navigation Planning	Review of plan formulation
James A. Wagoner III, Assistance District Counsel, CESAM-OC	18 years, Real Estate Attorney	Real estate issues review
Wallace W. Brassfield, Cost Engineer, CENWW-EC-X	40 years, Construction Cost Estimating	Project costs review

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14.0 LITERATURE CITED

Adair, S.E., J.L. Moore, and C.P. Onuf. 1994. Distribution and status of submerged vegetation in estuaries of the upper Texas coast wetlands 14(2):110–121.

Allen, J. 2002. United States Coast Guard. Port Author, Texas. Personal communication with Lisa Vitale, PBS&J, Austin, Texas. December 11, 2002.

Alperin, L.M. 1977. Custodians of the Coast: History of the United States Army Engineers at Galveston. Published by Galveston District, U.S. Corps of Engineers, Galveston, Texas.

American Anthropological Association Style Guide. 2009. 2009 Style Guide. http://www.aaanet.org/publications/style_guide.pdf.

American Ornithologists' Union (AOU). 1998. Check-list of North American birds. 7th edition. Allen Press, Inc., Lawrence, Kansas.

———. 2000. 42nd supplement to the check-list of North American birds. Auk 117:847–858.

———. 2002. 43rd supplement to the check-list of North American birds. Auk 119:897–906.

———. 2003. 44th supplement to the check-list of North American birds. Auk 120:923–931.

———. 2004. 45th supplement to the check-list of North American birds. Auk 121:985–995.

———. 2005. 46th supplement to the check-list of North American birds. Auk 122:1026–1031.

———. 2006. 47th supplement to the check-list of North American birds. Auk 123:926–936.

———. 2007. 48th supplement to the check-list of North American birds. Auk 124:1109–1115.

Anderson, J., and J.S. Wellner. 2002. Evaluation of Beach Nourishment Sand Resources along the East Texas Coast, June 28, 2002. Report of the Texas General Land Office, Department of Earth Sciences, Rice University, Houston, Texas.

Anderson, J.B. 2007. The Formation and Future of the Upper Texas Coast. Texas A&M University Press.

Armstrong, N.E., M. Brody, and N. Funicelli. 1987. The ecology of open-bay bottoms of Texas: a community profile. U.S. Fish and Wildlife Service Biological Report 85(7.12):104. U.S. Department of the Interior, Washington, D.C.

Aten, L.E. 1983. Indians of the Upper Texas Coast. Academic Press, New York.

Aten, L.E., and C.N. Bollich. 1969. A Preliminary Report on the Development of a Ceramic Chronology for the Sabine Lake Areas of Texas and Louisiana. Bulletin of the Texas Archaeological Society 40:241–258.

———. 2002. Late Holocene Settlement in the Taylor Bayou Drainage Basin, Test Excavations at the Gaulding Site, 41JF27, Jefferson County, Texas. Texas Archeological Research Laboratory Studies in Archeology 40. Texas Archeological Society Special Publications 4. Texas Archeological Research Laboratory, Austin.

Auil-Marshalleck, S., P. Campbell, L. Butler, and L. Robinson. 2001. Trends in Texas commercial fishery landings, 1972–1999. Texas Parks and Wildlife Department, Austin. Management Data Series No. 194:180.

Baker, R.J., L.C. Bradley, R.D. Bradley, J.W. Dragoo, M.D. Engstrom, R.S. Hoffmann, C.A. Jones, F. Reid, D.W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Museum of Texas Tech University, Lubbock. Occasional Papers, Number 229. December 1, 2003.

Baldwin, A.H., and I.A. Mendelssohn. 1998. Effects of salinity and water level on coastal marshes: an experimental test of disturbance as a catalyst for vegetation change. Aquatic Botany 61:255–268.

Banks Information Solutions. 2002. Regulatory Agency Database Report. Banks Information Solutions, Austin, Texas.

Barras, J., S. Beville, D. Britsch, S. Hartley, S. Hawes, J. Johnston, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2004. Historical and Projected Coastal Louisiana Land Changes: 1978–2050. USGS Open File Report 03-334 (Revised January 2004). U.S. Department of the Interior, U.S. Geological Survey.

Barras, J., P.E. Bourgeois, and L.R. Handley. 1994. Land loss in coastal Louisiana 1956–1990. National Biological Survey, National Wetlands Research Center, Lafayette, Louisiana.

Bartlett, R.D., and P.P. Bartlett. 1999. A field guide to Texas reptiles and amphibians. Gulf Publishing Company, Houston.

Beaumont Chamber of Commerce. 2008. Comprehensive Annual Financial Report for Year Ended August 31, 2008.

Beaumont Independent School District. 2008. Comprehensive Annual Financial Report for Year Ended August 31, 2008.

Beavers, R.C. 1978. An archaeological reconnaissance and assessment of the Sabine River, north shore of Sabine Lake to the Gulf Intracoastal Waterway: Cameron, Calcasieu parishes, Louisiana and Orange County Texas. Research Report No. 1. University of New Orleans Archaeological and Cultural Research Program, New Orleans.

Bellard, S. 2002. City of Port Arthur. Personal communication to Chris Moore, PBS&J, Austin, Texas. January 17, 2002.

Berman, A.E. 2005. The debate over subsidence in coastal Louisiana and Texas. Houston Geological Society Publications Bulletin, November 24.

Bertness, M.D., L. Gough, and S.W. Shumway. 1992. Salt tolerances and the distribution of fugitive salt marsh plants. Ecology 73:1842–1851.

Bezanson, D. 2001. Natural vegetation types of Texas and their representation in conservation areas. The Nature Conservancy of Texas, San Antonio. http://tconr.home.texas.net/Vegetation.

Blackburn, J., C. Johnson, and M. Berryhill. 2001. The value of the Texas bays and adjacent wetlands. CLE International Wetlands Conference, February. Austin, Texas.

Blair, W.F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.

Blankinship, R. 2005. Texas Parks and Wildlife Department, Coastal Fisheries Division. Personal communication to Erik Huebner, PBS&J, May 12.

Block, W.T. 1976. A History of Jefferson County, Texas, from Wilderness to Reconstruction. Master's thesis, Lamar University, Nederland Publishing Company, Nederland, Texas.

———. 1984. Sabine Pass' Famed "Oil Pond," It Saved Ships, but Snared Whales. Beaumont Enterprise, February, 1984. http://www.wtblock.com/wtblockjr/oilpond.htm (accessed March 23, 2008).

Blum, M.D., A.E. Carter, T. Zayac, and R. Goble. 2002. Middle Holocene Sea-Level and Evolution of the Gulf of Mexico Coast (USA), Journal of Coastal Research, Special Issue 36.

Bohnsack, J.A. 1989. Are high densities of fishes at artificial reefs the result of habitat limitation or behavioral preferences? Bulletin of Marine Science 44(2):631–645.

Bolton, H.E. 1970. Texas in the middle eighteenth century. The University of Texas Press, Austin.

Bond, C.L., and E. Foster. 1993. Magnetometer Survey of Salt Water Barrier Locations, Pine Island Bayou and Neches River, Jefferson, Hardin and Orange Counties, Texas. Document No. 930076. Espey, Huston & Associates, Inc., Austin, Texas.

Bouillon, J. 2002. Port of Orange. Personal communication to Chris Moore, PBS&J, Austin, Texas. April 30, 2002.

Bradley, P. 2002. Insurance Services Office (ISO). Personal communication to Kathie Martel, PBS&J, Austin, Texas. January 16, 2002.

Bradley, P.M., and J.T. Morris. 1992. Effect of salinity on the critical nitrogen concentration of *Spartina alterniflora* Loisel. Aquatic Botany 43(2):149–161.

Brannon, J.M., R.H. Plumb, and I. Smith. 1978. Long-term release of contaminants from dredged material. DMRP. USAEWES. Technical Report D-78-49.

Britton, J.C., and B. Morton. 1989. Shore ecology of the Gulf of Mexico. The University of Texas Press, Austin.

Brongersma, L.D. 1972. European Atlantic turtles. Zool. Verhl. 121.

Broome, S.W., I.A. Mendelssohn, and K.L. McKee. 1995. Relative growth of *Spartina patens* (Alt.) Muhl. and *Scirpus olneyi* Gray occurring in a mixed stand as affected by salinity and flooding depth. Wetlands 15:20–30.

Brown, G.L., and J. Stokes. 2009. Numerical Model Study of Potential Salinity Impacts Due to Proposed Navigation Improvements to the Sabine-Neches Waterway, Texas (August 2009 draft report). U.S. Army Engineer Research Development Center – Coastal and Hydraulics Laboratory (ERDC-CHL), Vicksburg, Mississippi.

Brown, Jr., L.F., W.L. Fisher, J.H. McGowen, and C.G. Groat. 1973. Environmental geologic atlas of the Texas coastal zone-Beaumont-Port Arthur area. The University of Texas, Bureau of Economic Geology, Austin.

Bruce, K.A., G.N. Cameron, and P.A. Harcombe. 1995. Initiation of a new woodland type on the Texas coastal prairie by the Chinese tallow tree (*Sapium sebiferum* (L.) Roxb.). Bulletin of the Torrey Botanical Club 122(3):215–225.

Buchman, M. 1999. National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables. HAZMAT Report 99-1.

Bureau of Economic Geology (BEG). Revised 1982. Geologic Atlas of Texas. Houston Sheet. The University of Texas at Austin.

———. 2009. The Texas Shoreline Change Project. BEG Coastal Studies Group, The University of Texas at Austin. http://www.beg.utexas.edu/ coastal/intro.htm/ (accessed February 10, 2009).

Byrnes, M.R., and R.A. McBride. 1995. Preliminary Assessment of Beach Response to a Segmented Breakwater System: Constance Beach and Vicinity, 1990–1994. Coastal Studies Institute, Louisiana State University, Baton Rouge, Louisiana. 26 p.

Calcasieu Parish School Board. 2008. Comprehensive Annual Financial Report July 1, 2007–June 30, 2008.

Calcasieu Parish School System Sales and Use Tax Department. 2008. Tax Rate. http://www.calcasieu salestax.org/ (accessed July 30, 2009).

Cameron Parish Police Jury. 2002. Welcome to Cameron Parish: Other Services (Transportation Infrastructure). http://user.camtel.net/cameron/public/other.html (accessed 2005).

Campbell, L. 1995. Endangered and threatened animals of Texas, their life history and management. Texas Parks and Wildlife Department, Resource Protection Division, Austin. 130 pp.

———. 2001. Texas Parks and Wildlife Department, Rockport Marine Lab. Personal communication to Lisa Vitale, PBS&J, Austin, Texas. May 21, 2001.

Carlson, A.E., A.N. LeGrande, D.W. Oppo, R.E.Came, G.A. Schmidt, F.S. Anslow, J.M. Licciardi, and E.A. Obbink. 2008. Rapid early Holocene deglaciation of the Laurentide ice sheet. Nature Geoscience 1:620–624.

Carothers, H.P., and H.C. Innis. 1960. Design of inlets for Texas and coastal fisheries. Journal of Waterways and Harbors Division, Vol. 86.

Cendercast, P. 2002. City of Groves. Personal communication to Chris Moore, PBS&J, Austin, Texas. January 17, 2002.

Center for Regulatory Effectiveness, The. n.d. Coastal Barrier Resources Act. Washington, D.C. http://www.thecre.com/fedlaw/legal14coast/coastal_barrier_resources_act_lm.htm (accessed February 2007).

Chabreck, R.H., and G. Linscombe. 1978. Vegetation type map of the Louisiana coastal marshes. Louisiana Wildlife and Fisheries Commission, Baton Rouge.

Chambers, G.V., and A.K. Sparks. 1959. An ecological survey of the Houston ship channel and adjacent bay waters. The University of Texas Institute of Marine Science Publication 6:215–250, Austin.

Chick, N.H. 1988. Down A Winding River: The Steamboat Era Comes to Orange. In Gateway to Texas: The History of Orange and Orange County, Dr. Howard C. Williams, editor, pp. 41–48. The Heritage House Museum of Orange, Texas.

City of Beaumont. 2002. Beaumont Chamber of Commerce. www.bmtcoc.org.

———. 2009. Fire and Rescue. http://www.cityofbeaumont.com/fire.htm (accessed July 30, 2009).

City of Bridge City. 2002. Official City of Bridge City website. www. bridgecitytex.com.

City of Groves. 2009. Fire Department. http://cigrovestx.com/firehome.php (accessed July 30, 2009).

City of Nederland. 2005. Official City of Nederland website. http://www.nederlandtx.com/ cityned.htm (accessed November 21, 2005).

———. 2009. Fire and Rescue Services. http://www.ci.nederland.tx.us/fire/ (accessed July 30, 2009).

City of Port Arthur Fire Department. 2009. http://pafd.portarthur.com/about.asp (accessed July 30, 2009).

City of Port Neches. 2002. Official Ports of Neches website. http://www.portarthur.net/city_profile.cfm.

Clark, D. 2009. U.S. fish and Wildlife (USFWS), Louisiana. Personal communication with Jan Stokes, U.S. Army Corps of Engineers, Galveston District – September 24.

Clark, D., J. Mazourek, K. Roy, and M. Floyd. 2000. East Sabine Lake hydrologic restoration project, candidate project information sheet for wetland value assessment. USFWS, Lafayette, Louisiana and NRCS, Alexandria, Louisiana.

Clarke, D.G., and D.H. Wilber. 2000. Assessment of potential impacts of dredging operations due to sediment resuspension. DOER Technical Notes Collection. ERDCTN-DOER-E9. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Coalition to Restore Coastal Louisiana. 2002. Coast Wise Publication. www.crcl.org/pubs/ wise/sabine.htm.

Conner, W.H., K.W. McKleod, and J.K. McCarron. 1997. Flooding and salinity effects on growth and survival of four common forested wetland species. Wetlands Ecology and Management 5:99–109.

Coulter, M.C., J.A. Rodgers, and J.C. Depkin. 1999. Wood stork (*Mycteria Americana*). A. Poole and F. Gill editors. The birds of North America, No. 409. Birds of North America, Inc., Philadelphia, Pennsylvania.

Cowardin, L.M., V. Carter, F. Golet, and E. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Crawley, R., and R.T. Sanchez. 1999. A Case Study of the Unemployment Rate in the Beaumont-Port Arthur MSA. http://www.twc.state.tx.us/lmi/publications/tlmr/tlmrhome.html (accessed December 4, 2002).

Crother, B.I., J. Boundy, J.A. Campbell, K. De Quieroz, D.R. Frost, D.M Green, R. Highton, J.B. Iverson, R.W. McDiarmid, P.A. Meylan, T.W. Reeder, M.E. Seidel, J.W. Sites, Jr., S.G. Tilley, and D.B. Wake. 2003. Scientific and standard English names of amphibians and reptiles of North America north of Mexico: update. Herpetological Review 34(3):196–203.

Crother, B.I., J. Boundy, J.A. Campbell, K. De Quieroz, D.R. Frost, R. Highton, J.B. Iverson, P.A. Meylan, T.W. Reeder, M.E. Seidel, J.W. Sites, Jr., T.W. Taggart, S.G. Tilley, and D.B. Wake. 2000. Scientific and standard English names of amphibians and reptiles of North America north of Mexico, with comments regarding confidence in our understanding. Society for the Study of Amphibians and Reptiles, Herpetological Circular No. 29. November 2000.

Crother, B.I., J. Boundy, K. De Quieroz, and D. Frost. 2001. Scientific and standard English names of amphibians and reptiles of North America north of Mexico: errata. Herpetological Review 32(3):152–153.

Culbertson, J., L. Robinson, P. Campbell, and L. Butler. 2004. Trends in Texas Commercial Fishery Landings, 1981–2001. Management Data Series No. 224. Coastal Fisheries Division, Texas Parks and Wildlife Department, Austin.

Daigle, J.J., G.E. Griffith, J.M. Omernik, P.O. Faulkner, R.P. McCulloh, L.R. Handley, L.M. Smith, and S.S. Chapman. 2006. Ecoregions of Louisiana (color poster with map, descriptive text, summary tables and photographs). U.S. Geological Survey, Reston, Virginia (map scale 1:1,000,000).

Davis, D.W. 1996. The Sabine Lake area: a region in transition. Proceedings, Sabine Lake Conference, September 13–14, Beaumont, Texas (TAMU-SG-97-101):8–12.

Davis, P. 2002. Port of Port Arthur. Personal communication to Chris Moore, PBS&J, Austin, Texas. April 30, 2002.

Day, J.W. Jr., D. Pont, P.F. Hensel, and C. Ibanez. 1995. Impacts of sea-level rise on deltas in the Gulf of Mexico and the Mediterranean: The importance of pulsing events to sustainability. Estuaries 18:636–647.

Day, J.W. Jr., and P.H. Templet. 1989. Consequences of sea level rise: Implications from the Mississippi Delta. Coastal Management 17:241–257.

DeLaune, R.D., J.A. Nyman, and W.H. Patrick, Jr. 1994. Peat collapse, ponding and wetland loss in a rapidly submerging coastal marsh. Journal of Coastal Research 10:1021–1030.

Department of Health and Human Services (HHS). 2006. The 2006 HHS Poverty Guidelines. http://gov/poverty/06poverty.shtml (accessed February 13, 2006).

Ditton, R.B., and J.M. Falk. 1981. Obsolete petroleum platform as artificial reef material. D.Y. Aska, editor. Artificial Reefs: Conference Proceedings. Florida Sea Grant Report Number 41:96–105.

Dixon, J.R. 2000. Amphibians and reptiles of Texas. Texas A&M University Press, College Station.

Dokken, Q.R. 1997. Platform reef ecological and biological productivity: fact or fiction? Proceedings: Sixteenth Annual Gulf of Mexico Information Transfer Meeting. OCS Study MMS 97–0038:12–19. New Orleans: Minerals Management Service, Gulf of Mexico OCS Regional Office. U.S. Department of the Interior, Washington, D.C.

Drees, B.M., and J.A. Jackman. 1998. A field guide to common Texas insects. Gulf Publishing Company, Houston.

Driscoll, T. 2001. Texas Parks and Wildlife Department, Inland Fisheries Division. Personal Communication to Andrew Labay, PBS&J, Austin, Texas. October 4, 2001.

Duedall, E.W., and M.A. Champ. 1991. Artificial reefs: emerging science and technology. Oceanus 34(1):94–101.

Eckert, S.A. 1992. Bound for deepwater. Natural History, March, pp. 28–35.

Eleuterius, L.N. 1989. Natural selection and genetic adaptation to hypersalinity in *Juncus roemerianus* Scheele. Aquatic Botany 36(1):45–53.

Enright, J.M., and R.L Gearhart. 2005. Historic properties identification, oyster reef identification, and pipeline and obstruction identification for the Sabine-Neches waterway widening and deepening, Jefferson and Orange counties, Texas, and Cameron Parish, Louisiana. Texas Historical Commission, Austin.

Entergy Louisiana. 2002. Calcasieu Parish Profile. http://www.entergy-louisiana.com/Economic_Development/ssrc_display.asp?parish=Calcasieu (accessed December 1, 2005).

Environmental Protection Agency (EPA). 1974. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety. EPA 550/9-74-004. March. NNA19870406.0098.

———. 1978. A water quality success story: the Neches River. EPA Office of Water Planning and Standards special publication provided by Texas Natural Resource Conservation Commission, Austin. Publication No. USEPA M W297N C.2.

———. 1982. Environmental Impact Statement (EIS) for the Galveston, Texas Dredged Material Disposal Site Designation. 152 pp + Appendices.

———. 1986. Quality criteria for water, 1986. EPA 440/5 86 0001, as revised.

———. 2001. An initial survey of aquatic invasive species issues in the Gulf of Mexico Region, Version 4. Prepared by Battelle for the Gulf of Mexico Program U.S. Environmental Protection Agency. EPA/OCPD Contract No. 68-C-00-121. Work Assignment 1-07.

———. 2002a. AIRData net tier report. EPA AIRData. http://www.epa.gov/air/data/nettier.html.

———. 2002b. AIRData monitor values report. EPA AIRData. http://www.epa.gov/air/data/monvals.html.

———. 2003. Potential Environmental Justice Index Pilot. EPA Region 6. March 11.

———. 2006. Star Lake Canal Superfund Site, Port Neches, Jefferson County, Texas, EPA ID#TX0001414341, Site ID: 0605043, Updated February 2006 (EPA publication date 3/6/2006). Region 6 Superfund Program, Information Bulletins/Fact Sheets/Site Updates. http://epa.gov/region6/6sf/pdffiles/0605043.pdf.

Environmental Protection Agency (EPA), and U.S. Army Corps of Engineers (USACE). 1998. Evaluation of Dredged material Proposed for Discharge in Waters of the U.S. – Testing Manual (Inland Testing Manual). EPA 823-B-98-004. February.

———. 2003. Regional Implementation Agreement (RIA) for Testing and Reporting Requirements for Ocean Disposal of Dredged Material off the Louisiana and Texas Coasts under Section 103 of the Marine Protection, Research, and Sanctuaries Act. July 2003. EPA Region 6, USACE New Orleans District and USACE Galveston District. http://www.epa.gov/earth1r6/6wq/ecopro/em/ocean/ria.pdf (accessed 2007).

Epsilon Associates Inc. 2006. Hudson River PCBs Superfund Site. Phase 1 Final Design Report (Attachment J-Noise Impact Assessment).

Espey, Huston & Associates, Inc. (EH&A). 1976. Biological studies in Sabine Lake 1974–1975. Document No. 7644. Espey, Huston & Associates, Inc., Austin, Texas.

———. 1979. Sabine-Neches Waterway, solid phase bioassay. Document No. 79208. Espey, Huston & Associates, Inc., Austin, Texas.

———. 1983a. Contract DACW64-83-C-0026 Sabine-Neches Waterway, Texas, Sabine Bank Channel biological services. Document No. 83687. Espey, Huston & Associates, Inc., Austin, Texas.

———. 1983b. Contract DACW64-83-C-0026 Sabine-Neches Waterway, Texas, Sabine Pass Jetty Channel biological services. Document No. 83583. Espey, Huston & Associates, Inc., Austin, Texas.

Ewing, K., K. McKee, I. Mendelssohn, and M. Hester. 1995. A comparison of indicators of sublethal salinity stress in the salt marsh grass, *Spartina patens* (Ait.) Muhl. Aquatic Botany 52:59–74.

Fagerburg, T. 2003. Field Data Collection Summary Report for the Sabine-Neches Waterway Study. U.S. Army Engineer Research and Development Center, Waterways Experiment Station (ERDC-WES). Vicksburg, Mississippi.

Farris, G.S., G.J. Smith, M.P. Crane, C.R. Demas, L.L. Robbins, and D.L. Lavoie (editors). 2007. Science and the Storms: the USGS Response to the Hurricanes of 2005. USGS Circular 1306, 283 p.

Fearn, M.L. 1995. Louisiana’s Cajun Prairie: Holocene History of a Southern Grassland. Ph.D. dissertation. Louisiana State University, Baton Rouge.

Federal Emergency Management Agency. 2008. Hurricane Ike Impact Report. Emergency Support Function #14, Long-Term Community Recovery Interagency Analysis.

Federal Energy Regulatory Commission (FERC). 2004. Final Environmental Impact Statement: Sabine Pass LNG and Pipeline Project. Docket Nos. CP04-47-0000, CP04-38-0000, CP04-39-0000, CP04-40-0000. Office of Energy Projects, Washington, D.C. 20426.

———. 2005. Order Granting Authorization under Section 3 of the Natural Gas Act and Issuing Certificates: Golden Pass LNG Terminal LP (Docket No. CP04-386-000) and Golden Pass Pipeline LP (Docket Nos. CP04-400-000, CP04-401-000, and CP04-402-000) (issued July 6, 2005). http://www.ferc.gov/market-oversight/st-mkt-ovr/som-rpt-2004.pdf (accessed January 2007). Office of Energy Projects, Washington, D.C. 20426.

———. 2006a. Pre-filed Projects FY 2006. Office of Energy Projects, Washington, D.C. http://www.ferc.gov/industries/gas/indus-act/pre-filing/fy-2006.pdf (accessed January 2007).

———. 2006b. Golden Pass LNG Terminal and Pipeline Project Final Environmental Impact Statement. Office of Energy Projects, Washington, D.C. http://elibrary.ferc.gov/idmws/File_list.asp?document_id4309499 (accessed January 2007).

———. 2006c. Final Environmental Impact Statement for Port Arthur LNG, LP and Port Arthur Pipeline, LP's Port Arthur LNG Project http://elibrary.ferc.gov/idmws/Doc_Family.asp?document_id=4399659 (accessed January 2007).

———. 2007. Kinder Morgan Louisiana Pipeline Project Final Environmental Impact Statement (FERC/EIS-0205). Office of Energy Projects, Washington, D.C.

Federal Highway Administration (FHWA). 2006. U.S. Department of Transportation. Roadway Construction Noise Model User’s Guide. FHWA-HEP-05-054. January 2006.

Firmin, B. 2006. Email from Brigette Firmin, NMFS, to Martin Arhelger, PBS&J, July 6.

Fleming, K.M. 1980. Texas bear hunting. In: Texas Parks and Wildlife 38(5):12–15.

Floyd, J. 2009. Personal communication with Manger of Human Resources and Executive Assistant Port of Beaumont on July 29.

Francavigilia, R.V. 1998. From Sail to Steam: Four Centuries of Texas Maritime History, 1500–1900. The University of Texas Press, Austin.

Frazier, D.E. 1974. Depositional episodes: Their relationship to the quaternary framework in the northwestern portion of the Gulf Basin, Geological Circular 74-1. Bureau of Economic Geology, The University of Texas at Austin.

Gabrysch, R.K., and G.D. McAdoo. 1972. Development of ground-water resources in the Orange County area, Texas and Louisiana, 1963–1971. Report No. 156, Texas Water Development Board, Austin.

Gardner, L.R., and D.E. Porter. 2001. Stratigraphy and geologic history of a southeastern salt marsh basin. North Inlet, South Carolina, USA. Wetlands Ecology and Management 9:371–382.

Gardner, L.R., B.R. Smith, and W.K. Michener. 1992. Soil evolution along a forest-marsh transect under a regime of slowly rising sea level, North Inlet, South Carolina, USA. Geoderma 55:141-157.

Garner, N.P. 1995. Performance Report, Federal Aid Project No. W-125-R-6, Job No. 85: suitability of habitats in east Texas for black bears. Texas Parks and Wildlife Department, Austin. December 29.

Gammill, S., K. Balkum, K. Duffy, E. Meselhe, J. Porthouse, E. Ramsey, and R. Walters. 2002. Hydrologic Investigation of the Louisiana Chenier Plain. Report prepared for the Louisiana Coastal Wetlands Conservation and Restoration Task Force by the Louisiana Department of Natural Resources, Baton Rouge.

Garrett, J.M., and D.G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Press, Inc., Austin.

Geier & Geier Consulting. 1997. Noise Measurements taken on September 23, 1997, to support the Oakland Harbor Navigation Improvement Project EIS.

General Land Office (GLO). 1996. Oil spill planning and response atlas – upper Texas coast. Texas General Land Office, Austin.

———. 1997. State Parks and Wildlife Management Areas.

———. 2004. Texas Coastwide Erosion Response Plan, 2004 Update. Texas General Land Office, Austin, Texas. http://www.glo.state.tx.us/coastalerosion/CEPRA-LegReport2005/pdf/.

———. 2005. Coastal Erosion Planning and Response Program (CEPRA) Report to the 79th Legislature. Texas General Land Office, Austin, Texas. http://www.glo.state.tx.us/coastalerosion/ CEPRA-LegReport2005/index.html.

Gibson, J. 1978. An archaeological reconnaissance of the lower Sabine River Valley, Toledo Bend dam to Gulf Intracoastal Waterway, Louisiana and Texas. Report No. 2. The University of Southwestern Louisiana Center for Archaeological Studies, Lafayette.

Gibson, J.L., R.B. Gramling, C. Ray Brassieur, S.J. Brazda, and S.G. Lark. 1978. An archaeological reconnaissance of the Lower Sabine River Valley, Toledo Bend dam to Gulf Intracoastal Waterway, Louisiana and Texas. Center for Archaeological Studies, University of Southwestern Louisiana, Report No. 4.

Global Ballast Water Management Programme. 2002. The problem. http://globallast.imo.org/index.asp?page=problem.htm?menu=true.

Gonzalez, J.L., and T.E. Törnqvist. 2006. Coastal Louisiana in Crisis: Subsidence or Sea Level Rise? EOS, Transactions, American Geophysical Union 87(45):493–508.

Gosselink, J.G. 1970. Growth of *Spartina patens* and *Spartina alterniflora* as influenced by salinity and source of nitrogen. Coastal Studies Bulletin No. 5, Special Sea Grant Issue, Louisiana State University. Pp 97–110.

Gough, L., and J.B. Grace. 1999. Effects of environmental change on plant species density: Comparing predictions with experiments. Ecology 80:882–890.

Gould, H.R., and E. McFarlan, Jr. 1959. Geologic history of the Chenier Plain, southwestern Louisiana. Gulf Coast Association of Geological Societies Transactions 9:261–270.

Gravens, M., and D.B. King. 2003. Shoreline impacts study for Sabine-Neches Project. U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal Hydraulics Laboratory (ERDC-CHL), Vicksburg, Mississippi.

Greater Orange Area Chamber of Commerce. 2002. Official website. http://www.org-tx.com/chamber.

Greco, R., and D. Clark. 2005. GIS analysis of East Sabine Lake shoreline retreat, 1978–2004. U.S. Fish and Wildlife Service, Ecological Services Field Office, Lafayette, Louisiana.

Green. A., M. Osborn, P. Chai, J. Lin, C. Loeffler, A. Morgan, P. Rubec, S. Spanyers, A. Walton, R.D. Slack, D. Gawlik, D. Harpole, J. Thomas, E. Buskey, K. Schmidt, R. Zimmerman, D. Harper, D. Hinkley, T. Sager, and A. Walton. 1992. Status and trends of selected living resources in the Galveston Bay system. Galveston Bay National Estuary Program Publication GBNEP-19, Webster, Texas.

Green, D. 1984. Long-distance movements of Galapagos green turtles. Journal of Herpetology 18:121–130.

Greiner LaPeyre, M.K., J.B. Grace, E. Hahn, and I.A. Mendelssohn. 2001. The importance of competition in regulating-plant species-abundance along a salinity gradient. Ecology 82(1):62–69.

Griffith, G.E., S.A. Bryce, J.M. Omernik, J.A. Comstock, A.C. Rogers, B. Harrison, S.L. Hatch, and D. Bezanson. 2004. Ecoregions of Texas (color poster with map, descriptive text, and photographs). U.S. Geological Survey, Reston, Virginia (map scale: 1:2,500,000).

Guidroz, W.S., G.W. Stone, and D. Dartez. 2006. Hurricane Rita, 2005: Assessment of a storm-induced geological event along the southwestern Louisiana coast and adjacent interior marsh: Gulf Coast Association of Geological Societies Transactions 56:229–239.

Gulf Engineers and Consultants, Inc. (GEC). 2002. Sabine-Neches Waterway Feasibility Study, Environmental Restoration /Beneficial Use Workshops. Prepared for the U.S. Army Corps of Engineers, Galveston District, Baton Rouge, Louisiana.

Gulf of Mexico Fisheries Management Council (GMFMC). 2004. Final Environmental Impact Statement for the Generic Amendment to the following fishery management plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Stone Crab Fishery of the Gulf of Mexico, Coral and Coral Reef Fishery of the Gulf of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic; Coastal Migratory Pelagic Resources of the Gulf of Mexico and South Atlantic. Gulf of Mexico Fishery Management Council. Gulf of Mexico Fishery Management Council, Tampa, Florida.

Haggard, J.V. 1945. The neutral ground between Louisiana and Texas, 1806–1821. The Louisiana Historical Quarterly 28:(4).

Haig, S.M., and E. Elliott-Smith. 2004. Piping plover. The birds of North America Online. (A. Poole, editor) Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Piping_Plover/.

Harcombe, P.A., and J.E. Neaville. 1977. Vegetation types of Chambers County, Texas. Texas Journal of Science 29:209–234.

Hardin County Tax Appraisal District. 2008. Tax Rates. http://www.hardincad.org/taxrates.htm (accessed July 30 2009).

Hardison, K.A. 1998. The Time of Thunder: Orange County and the War for Southern Independence. In Gateway to Texas: The History of Orange and Orange County, Dr. Howard C. Williams, editor, pp. 79–89. The Heritage House Museum of Orange, Texas.

Harrel, R.C. 1975. Water quality and saltwater intrusion in the lower Neches River. Texas Journal of Science 26(1–2):107–117.

———. 1993. Origin and decline of the estuarine clam *Rangia cuneata* in the Neches River, Texas. American Malacological Bulletin 10(2):153–159.

Harrel, R.C., J. Ashcraft, R. Howard, and L. Patterson. 1976. Stress and community structure of macrobenthos in a Gulf Coast riverine estuary. Contributions in Marine Science 20:69–81.

Harrel, R.C., and M.A. Hall, III. 1991. Macrobenthic community structure before and after pollution abatement in the Neches River estuary (Texas). Hydrobiologia 211:241–252.

Hatch, S.L., K.N. Ghandi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. The Texas Agricultural Experiment Station MP-1655. The Texas A&M University System, College Station.

Heideman, G. 2002. Texas Department of State Health Services, Seafood Safety Division. Personal communication to Lisa Vitale, PBS&J, Austin, Texas. May 16, 2002.

Helen, F. 2002. Personal communication with Chris Moore of PBS&J and Fred Helen, Director of Regional Development and Services, Southeast Texas Regional Planning Commission. November 18.

Henke, S.E., and W.S. Fair. 1998. Management of Texas horned lizards. Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville. Management Bulletin No. 2.

Hester, M.W., I.A. Mendelssohn, and K.L. McKee. 1996. Intraspecific variation in salt tolerance and morphology in the coastal grass *Spartina patens*. American Journal of Botany 83:1521–1527.

———. 2001. Species and population variation to salinity V stress in *Panicum hemitomon*, *Spartina patens*, and *Spartina alterniflora*: morphological and physiological constraints. Environmental and Experimental Botany 46:277–297.

HFP Acoustical Consultants, Inc. 2002. Environmental Noise Survey. Cheniere Energy, Inc. Freeport LNG Terminal in Quintana Beach, Texas. October.

Hildebrand, H. 1982. A historical review of the status of sea turtle populations in the western Gulf of Mexico. In K. Bjorndal (editor), Biology and Conservation of Sea Turtles. Pp. 447–453. Smithsonian Institution Press, Washington, D.C. 583 pp.

———. 1983. Random notes on sea turtles in the western Gulf of Mexico. D. Owens et al., eds. Proceedings Western Gulf of Mexico Sea Turtle Workshop TAMU-SG-84-105. Texas A&M University, College Station. Pp. 34–40.

———. 1986. Personal communication to Derek Green, EH&A, Corpus Christi, Texas. January 16.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). Biological Report 97 (1). U.S. Fish and Wildlife Service, Washington, D.C.

Hooper, R.G., A.F. Robinson, Jr., and J.A. Jackson. 1980. The red-cockaded woodpecker: notes on life history and management. U.S. Forest Service General Report SA-GR9, Atlanta, Georgia.

Hopkinson, C.S., J.G. Gosselink, and R.T. Parrondo. 1978. Aboveground production of seven marsh plant species in coastal Louisiana. Ecology 59(4):760–769.

Howard, R.J., and I.A. Mendelssohn. 1999. Salinity as a constraint on growth of oligohaline marsh macrophytes. II. Salt pulses and recovery potential. American Journal of Botany 86(6):795–806.

———. 2000. Structure and composition of oligohaline marsh plant communities exposed to salinity pulses. Aquatic Botany 68:143–164.

Hoyt, S.D., and J.S. Schmidt. 1997. Diving Assessments for Twenty-six Localities, Sabine Pass Channel, Jefferson County, Texas, Cameron Parish, Louisiana. Document No. 960983. Espey, Huston & Associates, Inc., Austin, Texas.

Hoyt, S.D., E. Foster, J.S. Schmidt, M. Nash, S. Aronow, and R. Rogers. 1998. Initial investigations, archival research, remote sensing, and terrestrial survey, Neches River saltwater barrier, Beaumont, Texas, Orange and Hardin counties. Document No. 980006. Espey, Huston & Associates, Inc., Austin. Texas.

Hoyt, S.D., J.S. Schmidt, and Robert Gearhart. 1994. Magnetometer survey of Sabine Pass Channel and assessment of the *Clifton*, 41JF65, Jefferson County, Texas, Cameron Parish, Louisiana. Document No. 940510. Espey, Huston & Associates, Inc., Austin, Texas.

Hsiao, S.V., and O.H. Shemdin. 1980. Bottom dissipation in finite-depth water waves. Proceedings of the 16th Coastal Engineering Conference. Hamburg, Germany.

Hubbs, C. 1982. A checklist of Texas freshwater fishes. Technical Series No. 11. Texas Parks and Wildlife Department, Austin.

Hubbs, C., R.J. Edwards, and G.P. Garrett. 2008. An annotated checklist of freshwater fishes of Texas, with key to identification of species. Texas Academy of Science. http://www.texasacademy ofscience.org/.

Huh, O.K., H. Roberts, L.J. Rouse, and D.A. Rickman. 1991. Fine grain sediment transport and deposition in the Atchafalaya and Chenier Plain sedimentary system. Coastal Sediments ’91. American Society of Civil Engineers, New York. Pp 817–830.

Im, H. 1975. An analysis of the G.E. Arnold Survey of east Texas. Unpublished Master of Arts Thesis, The University of Texas at Austin.

Institute of Water Resources-Waterborne Commerce of the U.S. (IWR-WCUS). 2007. Waterborne Commerce of the United States, Parts II and V. IWR-WCUS-06-5. http://www.iwr.usace.army.mil/ wcsc.htm/.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team R.K. Pachauri and A. Reisinger (editors)]. IPCC, Geneva, Switzerland, 104 p.

Isphording, W.C., F.D. Imsand, and G.C. Flowers. 1989. Physical characteristics and aging of gulf coast estuaries. Transactions – Gulf Coast Association of Geological Societies, Vol 39.

Iverson, J.B. 1986. A checklist with distribution maps of the turtles of the world. Paust Printing, Richmond, Indiana.

Jackson, J.A. 1994. Red-cockaded woodpecker (*Picoides borealis*). In The birds of North America, No. 85 (A. Poole and F. Gill, editors). The Academy of Natural Sciences, Philadelphia, and the American Ornithologist’s Union, Washington, D.C.

Jackson, W. 2004. Coast Guard vessel ID system enters critical phase. Government Computer News 23:25 (August 9).

Jefferson County Navigation District (JCND). 2002. Phone interview with Tom Jackson of the Jefferson County Navigation District regarding saltwater barriers and lock structures in Jefferson County. September 5.

Jefferson County Tax Appraisal District. 2008. 2008 tax rates, homestead exemptions granted, and taxing entity codes. http://www.jcad.org/reports/reports_entitycode.aspx (accessed July 30, 2009).

Kane, H.E. 1959. Lake Quaternary geology of Sabine Lake and vicinity, Texas and Louisiana. Gulf Coast Association of Geological Societies Transactions 9:225–235.

Kasprzak, M. 2007. Louisiana Department of Wildlife and Fisheries. Personal communication to Lisa Vitale, PBS&J, March 8.

Keeland, B.D., and R.R. Sharitz. 1995. Seasonal growth patterns of *Nyssa sylvatica* var. *biflora*, *Nyssa aquatica*, and T*axodium distichum* as affected by hydrologic regime. Canadian Journal of Forestry Research 25:1084–1096.

Kemp, P.R., and G.L. Cunningham. 1981. Light, temperature and salinity effects on growth, leaf anatomy and photosynthesis of *Distichlis spicata* (L.). American Journal of Botany 68(4):507–516.

King, D.B., Jr. 2007. Wave and Beach Processes Modeling for Sabine Pass to Galveston Bay, Texas, Shoreline Erosion Feasibility Study. Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center. ERDC/CHL TR-07-6. Vicksburg, Mississippi.

Kozlowski, T.T. 1997. Responses of woody plants to flooding and salinity. Tree Physiology Monograph No. 1. Herron Publishing, Victoria, Canada.

Kuhn, N.L., and G. Chen. 2005. Freshwater Inflow Recommendation for the Sabine Lake Estuary of Texas and Louisiana. March 15, 2005. Texas Parks and Wildlife Department, Coastal Fisheries Division, Coastal Studies Program, Austin.

Langley, J.A., K.L. McKee, D.R. Cahoon, J.A. Cherry, and J.P. Megonigal. 2009. Elevated CO_2 stimulates marsh elevation gain, counterbalancing sea-level rise. Proceedings of the National Academy of Sciences, published on-line before printing of March, 26, 2009. http://www.pnas.org/content/early/2009/03/25/0807695106.full.pdf+html?sid=110db994-42a9-4ab 1-899e-c3dfb 7e78680.

Leary, T. 1957. A schooling of leatherback turtles, *Dermochelys coriacea coriacea*, on the Texas coast. Copeia 3:232.

Lee, H.I. 2003. Shoreline Assessment of Jefferson County, Texas. Thesis submitted to Texas A&M University, College Station.

Lester, J., and L. Gonzales (editors.). 2001. Ebb and flow: Galveston Bay characterization highlights. State of the Bay Symposium V, January 31–February 2, 2001. Galveston Bay Estuary Program, Galveston, Texas.

Lewis, R.J. 1987. Hawley's condensed chemical dictionary, 11th Edition. Reinhold Company, New York.

Linscombe, G. 2001. Vegetation type map of the Louisiana coastal marshes (scale 1:62,500). Louisiana Department of Wildlife and Fisheries, New Orleans.

Linthurst, R.A., and E.D. Seneca. 1981. Aeration, nitrogen and salinity as determinants of *Spartina alterniflora* Loisel. growth response. Estuaries 4(1):53–63.

Lockwood, M.W., and B. Freeman. 2004. The TOS handbook of Texas birds. Texas A&M University Press, College Station.

Long, E.R. 1999. Survey of sediment quality in Sabine Lake, Texas and vicinity. National Oceanic and Atmospheric Administration, Center for Coastal Monitoring and Assessment, Technical Memorandum NOS NCCOS CCMA 137. U.S. Department of Commerce, Washington, D.C.

Louis Berger Group and Toxicological and Environmental Associates (LBG and TEA). 2008. Wetland Value Assessment Model Application in the Sabine-Neches Waterway Channel Improvement Project: Model Assessment Report. The Louis Berger Group and Toxicological & Environmental Associates.

Louisiana Association of Tax Administration. 2008. Uniform Local Sales Tax Code. http://www.laota.com/ (accessed July 30, 2009).

Louisiana Coastal Protection and Restoration Authority (LCPRA). 2007. Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast. LCPRA, Baton Rouge.

Louisiana Coastal Wetlands Conservation and Restoration Task Force (LCWCR). 1998. Caring for Coastal Wetlands, a summary of the 1997 Evaluation Report to the U.S. Congress on the effectiveness of Louisiana Coastal Wetland Restoration Projects. http://www.lacoast.gov/reports/program/CaringBrochure/index.htm (accessed February 2007). U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana.

———. 2002a. Black Bayou Hydrologic Restoration (CS-27). http://www.lacoast.gov/reports/display.asp?projectNumber=CS-27&reportType=general (accessed January 2007) and http://www.lacoast.gov/projects/overview.asp?statenumber=CS-27 (accessed February 6, 2007). U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana.

———. 2002b. Perry Ridge Shore Protection (CS-24). http://www.lacoast.gov/reports/display.asp?projectNumber=CS-24&reportType=general (accessed January 2007) and http://www.lacoast.gov/projects/overview.asp?statenumber=CS-24 (accessed February 2007). U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana.

———. 2002c. GIWW – Perry Ridge West Bank Stabilization (CS-30). http://www.lacoast.gov/reports/display.asp?projectNumber=CS-30&reportType=general and http://www.lacoast.gov/reports/managers.asp?projectNumber=CS%2D30 (accessed February 2007). U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana.

———. 2003. East Sabine Lake Hydrologic Restoration (CS-32). http://www.lacoast.gov/reports/display.asp?projectNumber=CS-32&reportType=general and http://www.lacoast.gov/projects/ (accessed January 2007). U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana.

———. 2006. Black Bayou Hydrologic Restoration (CS-27) Project Managers' Technical Fact Sheet (update December 19, 2006). http://www.lacoast.gov/reports/managers.asp?projectNumber=CS%2D27 (accessed February 6, 2007).

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority (LCWCR/WCRA). 1998. Coast 2050: Toward a Sustainable Coastal Louisiana, Louisiana Department of Natural Resources, Baton Rouge. http://www.coast2050.gov/reports/.

———. 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices. Appendix F-Region 4 Supplemental Information. Louisiana Department of Natural Resources, Baton Rouge.

Louisiana Department of Labor (LDOL). 2005. Labor Market Publications and Reports. http://www.ldol.state.la.us/qm_lmi.asp (accessed November 14, 2005).

———. 2009. Labor Market Publications and Reports. http://www.ldol.state.la.us/qm_lmi.asp (accessed August 10, 2009).

Louisiana Department of Natural Resources (LDNR). 1993. Bottomland Hardwoods Model, modified from Habitat Assessment Models for Fresh Swamp and Bottomland Hardwoods within the Louisiana Coastal Zone.

———.1997. Holly Beach to Constance Beach Shore Protection Preliminary Feasibility Report. LDNR, Coastal Restoration Division, Open File Report 97-01. Baton Rouge, Louisiana.

———. 2002a. Brown Marsh data information management system. http://www.brownmarsh.net/contact.htm.

———. 2002b. Sabine National Wildlife Refuge. http://www.dnr.state.la.us/crm/coastmgt/gems/sabinena.htm.

———. 2003a. Monitoring Plan for Black Bayou Hydrologic Restoration (State Project Number CS-27, Priority Project List 6), Calcasieu and Cameron Parishes. 13 p. Coastal Resources Division, Monitoring Section, Coastal Restoration and Management, Louisiana.

———. 2003b. Monitoring Plan for Perry Ridge Shore Protection (State Project Number CS-24, Priority Project List 4), Calcasieu Parish. 8 p. Coastal Resources Division, Monitoring Section, Coastal Restoration and Management, Louisiana.

———. 2005a. 2005/2006 Annual Inspection Report for Black Bayou Hydrologic Restoration Project (CS-27). Calcasieu and Cameron Parishes. 6 p. Coastal Restoration and Management, Louisiana.

———. 2005b. 2005 Operations, Maintenance, and Monitoring Report for Perry Ridge Shore Protection (CS-24). Calcasieu Parish. 12 p. Coastal Restoration and Management, Louisiana.

———. 2007. 2004 Operations, Maintenance, and Monitoring Report for Black Bayou Hydrologic Restoration (CS-27). Calcasieu and Cameron Parishes. 22 p. Coastal Restoration and Management, Louisiana.

Louisiana Department of Revenue. 2005. Parish tax agencies. www.laota.com/pta.htm.

Louisiana Department of Wildlife and Fisheries (LDWF). Var. Lower Sabine River fisheries data. Louisiana Department of Fisheries and Wildlife, Inland Fisheries Division, Baton Rouge.

Louisiana Department of Wildlife and Fisheries District Biologist. 2001. Pers. comm. to PBS&J Senior Scientist (fisheries) re: Sabine River fisheries data and angling (phone and email November 19, 2001).

Louisiana Economic Development. 2005. Louisiana Parish Profiles. www.lded.state.la.us/overview/profile.aspx (accessed November 17, 2005).

Louisiana State Census Data Center. 2007. Louisiana Population Projections. http://louisiana.gov/Explore/Population_Projections/ (accessed July 29, 2009).

Louisiana State University. 2009. LIDAR data provided by Louisiana Oil Spill Coordinator's Office, compiled by Louisiana State University CADGIS Research Laboratory. http://atlas.lsu.edu/central/ (accessed on February 6, 2009).

Louisiana Workforce Commission. 2007. Employment and Wages 4th Quarter 2006. http://www.laworks.net/LaborMarketInfo/LMI_WageData2002toPresent.asp?year=2008&qtr=4 (accessed July 29, 2009).

———. 2009. Employment and Wages 4th Quarter 2008. http://www.laworks.net/LaborMarketInfo/LMI_WageData2002toPresent.asp?year=2008&qtr=4 (accessed July 29, 2009).

Lower Neches Valley Authority (LNVA). 2002. 2002 Basin highlights report. Lower Neches Valley Authority, Beaumont, Texas.

Lytle, W.M., and F.R. Holdcamper. 1975. Merchant Steam Vessels of the United States, 1790–1868. Reprint of 1952 edition. The Steamship Historical Society of America, Inc. Staten Island, New York.

Mantz, P.A., and A. Dong. 1996. Tidal circulation in Sabine Lake. Proceedings, Sabine Lake Conference, September 13–14, 1996, Beaumont, Texas (TAMU-SG-97-101):16–23.

Marcantel, R.J. 1996. Existing ecosystem management systems protecting the coastal wetlands in the Calcasieu/Sabine River Basin. Proceedings, Sabine Lake Conference, September 13–14, 1996. Beaumont, Texas (TAMU-SG-97-101):24–26. http://nsgl.gso.uri.edu/tamu/tamuw9600.pdf. Publication by Texas A&M University, College Station (TAMU-SG-97-101).

Martin Associates. 2006. Economic Impacts of the Sabine-Neches Waterway and Economic Benefits of Maintenance Dredging of the Waterway. Martin Associates, Lancaster, Pennsylvania.

Martin, L. 2002. Regional Sediment Management: Background and Overview of Initial Implementation. IWR Report 02-PS-2. U.S. Army Corps of Engineers, Institute for Water Resources, Belvoir, Virginia. http://www.wes.army.mil/rsm/pubs/pdfs/rsm-tn-8.pdf (accessed March 20, 2008).

Mason, C. 1981. Hydraulics and stability of five Texas inlets. Miscellaneous Paper CERC-81-1. U.S. Army Engineer Coastal Engineering Research Center. Fort Belvoir, Virginia.

Mathewson, C.C. 1987. Factors influencing coastal processes and engineering design along the Texas coast. Bulletin of the Association of Engineering Geologists XXIV(3).

Maurer, D., R.T. Keck, J.C. Tinsman, W. A. Leathem, C. Wethe, C. Lord, and T.M. Church. 1986. Vertical migration and mortality of marine benthos in dredged material: a synthesis. International revue gestam Hydrobiologia 71:49–63.

May, E.B. 1973. Environmental effects of hydraulic dredging in estuaries. Alabama Marine Resources Bulletin 9:1–85.

Maynord, S. 2005. Ship effects before and after deepening of Sabine-Neches Waterway, Port Arthur, Texas. ERDC/CHL TR-03-15. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

McFarlane, R.W. 1996. A conceptual ecosystem model for Sabine Lake. Proceedings, Sabine Lake Conference, September 13–14, 1996, Beaumont, Texas (TAMU-SG-97-101):27–31.

McGuff, P.R., and W. Roberson. 1974. Lower Sabine and Neches Rivers, Texas and Louisiana: a study of the prehistoric and historic resources in areas under investigation for navigation improvement. Texas Archaeological Survey, Research Report No. 46. The University of Texas at Austin.

McIntire, W.G. 1958. Prehistoric Indian settlements of the changing Mississippi River Delta. Coastal Studies Series No. 1. Louisiana State University, Baton Rouge.

McKee, K.L., and I.A. Mendelssohn. 1989. Response of a freshwater marsh plant community to increased salinity and increased water level. Aquatic Botany 34:301–316.

McKee, K.L., I.A. Mendelssohn, and M.D. Materne. 2006. Salt marsh dieback in coastal Louisiana: Survey of plant and soil conditions in Barataria and Terrebonne Basins, June 2000–September 2001. U.S. Geological Survey Open File Report 2006-1167. 71 pp. http://pubs.usgs.gov/of/2006/1167/pdf/of06-1167_508.pdf.

McKee, J.E., and H.W. Wolf. 1973. Water quality criteria. Publication No. 3-A. California State Water Resources Control Board, Sacramento.

McNab, W.H., and P.E. Avers. 1994. Ecological subregions of the United States: section descriptions. U.S. Forest Service WO-WA-5. Washington, D.C. 267 pp.

Megonigal, J.P., W.H. Conner, S. Kroeger, and R.R. Sharitz. 1997. Aboveground production in southeastern floodplain forests: a test of the subsidy-stress hypothesis. Ecology 78(2):370–384.

Meier, M.H. 1989. A debate on responsible artificial reef development. Bulletin of Marine Science 44(2):1051–1057.

Meyer, K.D. 1995. Swallow-tailed kite (*Elanoides forficatus*). A. Poole and F. Gill editors. The Birds of North America, No. 138. The Academy of Natural Sciences, Philadelphia, Pennsylvania.

Meylan, A. 1982. Sea turtle migration – evidence from tag returns. In: Biology and conservation of sea Turtles (K. Bjorndal, editor), 91–100. Smithsonian Institution Press, Washington, D.C.

Military Surface Deployment and Distribution Command. 2004. “The History Channel captures operations at Beaumont, Texas,” TRANSLOG Summer 2004. The Transportation Engineering Agency, the 597th Transportation Group, Alexandria, Virginia.

———. 2006. “Port of Beaumont reaches mile-stone handling military cargo,” TRANSLOG Summer 2006. The Transportation Engineering Agency, the 597th Transportation Group, Alexandria, Virginia.

Milliken K.T., J.B. Andersen, and A.B. Rodriguez. 2008a. Tracking the Holocene evolution of Sabine Lake through the interplay of eustasy, antecedent topography, and sediment supply variations, Texas and Louisiana, USA. The Geological Society of America, Special Paper 443-05.

———. 2008b. A new composite Holocene sea-level curve for the northern Gulf of Mexico, in J.B. Anderson and A.B. Rodriguez, editors, Response of Upper Gulf Coast Estuaries to Holocene Climate Change and Sea-Level Rise: Geological Society of America Special Paper 443, p. 1–11.

Minello, T.J. 2000. Temporal development of salt marsh value for nekton and epifauna: Utilization of dredged material marshes in Galveston Bay, Texas. Wetlands Ecol. and Manag. 8:327–341.

Minello, T.J., and L.P. Rozas. 2002. Nekton populations in Gulf Coast wetlands: fine scale distributions, landscape patterns, and restoration implication. Ecol Appl 12:441–445.

Minello, T.J., and J.W. Webb, Jr. 1997. Use of natural and created *Spartina alterniflora* salt marshes by fishery species and other aquatic fauna in Galveston Bay, Texas, USA. Mar. Ecol. Prog. Ser. 151:165–179.

Minerals Management Service (MMS). 1997. Gulf of Mexico OCS lease sales 169, 172, 175, 178, and 182, central planning area, final environmental impact statement. Gulf of Mexico OCS Regional Office, U.S. Department of the Interior, New Orleans.

Mitsch, W.J., J.R. Taylor, and K.B. Benson. 1991. Estimating primary productivity of forested wetland communities in different hydrologic landscapes. Landscape Ecology 5(2):75–92.

Moherek, A.J. 1978. Flume Experiments on sand, silt and clay mixtures from the Offshore Dredged Material Disposal Site, Galveston, Texas. U.S. Army Engineer Waterways Experiment Station, Technical Report D-78-34.

Morang, A. 2006. North Texas Sediment Budget, Sabine Pass to San Luis Pass. Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center. ERDC/CHL TR-06-17. Vicksburg, Mississippi.

Morgan, J.P., L.G. Nichols, and M. Wright. 1958. Morphological effect of Hurricane Aubrey. Technical Report No. 10, Coastal Studies Institute, Louisiana State University, Baton Rouge.

Moore, W.E., and S. Aronow. 1993. An Archaeological Survey of the Proposed Colliers Ferry Wetlands Recreational Area and Nature Preserve, Jefferson County, Texas. Brazos Valley Research Associates Contract Reports, No. 25.

Morris, J.T., P.V. Sundareshwar, C.T. Nietch, B. Kjerfve, and D.R. Cahoon. 2002. Responses of coastal wetlands to rising sea level: Ecology 83(10):2869–2877.

Morton, R.A. 1975. Shoreline Changes Between Sabine Pass and Bolivar Roads, An Analysis of Historical Changes of the Texas Gulf Shoreline. Bureau of Economic Geology, The University of Texas at Austin.

———. 1977. Historical Shoreline Changes and Their Causes, Texas Gulf Coast. Bureau of Economic Geology, The University of Texas at Austin.

———. 1996. Geological and historical development of Sabine Lake – an overview. Proceedings, Sabine Lake Conference, September 13–14, Beaumont, Texas, (TAMU SG 97-101). http://nsgl.gso.uri.edu/tamu/tamuw9600.pdf Publication by Texas A&M University, College Station (TAMU-SG-97-101).

———. 2003. An Overview of Coastal Land Loss: With Emphasis on the Southeastern United States: USGS OFR 03-337.

Morton, R.A., J.C. Bernier, and J.A. Barras. 2006. Evidence of regional subsidence and associated interior wetland loss induced by hydrocarbon production, Gulf Coast region, USA, in Environmental Geology 50:261-274.

Morton, R.A., Julie C. Bernier, John A. Barras, and Nicholas F. Ferina. 2005. Rapid Subsidence and Historical Wetland Loss in the Mississippi Delta Plain: Likely Causes and Future Implications: Open-File Report 2005–1216, U.S. Department of the Interior, U.S. Geological Survey.

Morton, R.A., J.C. Gibeaut, and R. Gutierrez. 1995. Pre-project surveys of beach and nearshore conditions, Galveston beach nourishment project. Bureau of Economic Geology, The University of Texas at Austin.

Morton, R.A., and J.G. Paine. 1990. Coastal land loss in Texas – an overview. Transactions – Gulf Coast Association of Geological Societies 40:625–634.

Mosier, D. 2002. Lower Neches Valley Authority, TWC §11.121 Application to Appropriate State Water 06-5743, Neches River Saltwater Barrier, Neches River, Neches River Basin, Jefferson County, Texas. Memo to David Koinm. Texas Natural Resources Conservation Commission. January 2.

Musick, J. 1979. The marine turtles of Virginia with notes on identification and natural history. Educational Series No. 24. Sea Grant Program, Virginia Institute of Marine Science, Gloucester Point, Virginia.

Myers, S. 2009. Personal communication with Human Resources Manager and Executive Assistant Port of Port Arthur on July 30.

Nairn, R.B. 1992. Designing for cohesive shores. Proceedings Coastal Engineering in Canada. J.W. Kamphuis, editor, Department of Civil Engineering, Queen’s University, Kingston, Canada.

Nairn, R.B., and D.H. Willis. 2002. Erosion, transport, and deposition of cohesive sediments. Coastal Engineering Manual, Part III, Coastal Sediment Processes, Chapter 5, T. Walton, editor, Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

National Ballast Information Clearinghouse (NBIC). 2007. NBIC Online Database. Electronic publication, Smithsonian Environmental Research Center and United States Coast Guard. http://invasions.si.edu/nbic/search.html (accessed March 8, 2007).

National Fish and Wildlife Laboratory (NFWL). 1980. Selected vertebrate endangered species of the seacoast of the United States. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-80/01.

National Marine Fisheries Service (NMFS). 2003. Endangered Species Act, Section 7 Consultation, Biological Opinion for Dredging of Gulf of Mexico Navigation Channels and Sand Mining (Borrow) Areas Using Hopper Dredges by COE Galveston. Issued November 19, 2003.

———. 2005. Annual Commercial Landing Statistics for Texas and Louisiana, 2002 and 2003. http://www.st.nmfs.gov/st1/commercial/landings/annual_landings.html (accessed 2005).

———. 2006a. Information on sea turtles. http://www.nmfs. noaa.gov/pr/species/turtles.html.

———. 2006b. Gulf sturgeon (*Acipenser oxyrhinchus desotoi*). http://www.nmfs.noaa.gov/pr/species/fish/Gulf_ sturgeon.html (accessed March 14).

———. n.d. Office of Protected Resources Species Information. http://www.nmfs.noaa.gov/pr/species/esa/ (accessed 2001).

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 1991a. Recovery plan for U.S. population of loggerhead turtle. National Marine Fisheries Service, U.S. Department of the Interior, Washington, D.C.

———. 1991b. Recovery plan for U.S. population of Atlantic green turtle. National Marine Fisheries Service, Washington, D.C.

———. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

National Oceanic and Atmospheric Administration (NOAA). 2003. Biological Opinion regarding Dredging of Gulf of Mexico Navigation Channels and Sand Mining ("BoITOW") Areas Using Hopper Dredges by COE Galveston, New Orleans, Mobile, and Jacksonville Districts (Consultation Number F/SER/2000/01287) (November 19, 2003). http://el.erdc.usace.army.mil/tessp/pdfs/2003GulfBO.pdf (accessed February 2007). National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida.

National Park Service (NPS). 2006. Information on sea turtles. http://www.nps.gov/pais/myweb2a/.

National Research Council (NRC). 1987. Responding to changes in sea level: engineering implications. Commission of Engineering and Technical Systems, National Research Council, National Academy Press, Washington, D.C.

Natural Diversity Database (NDD), Texas Parks and Wildlife Department (TPWD). 2005a. Annotated county lists of rare species, Jefferson County. Texas Parks and Wildlife Department, Wildlife Diversity Branch, Austin. Revised April 6.

———. 2005b. Annotated county lists of rare species, Orange County. Texas Parks and Wildlife Department, Wildlife Diversity Branch, Austin. Revised June 2.

———. 2006. Special species and natural community data files and NDD data on USGS topographic maps.

Nederland Economic Development Corporation. 2008. Major employers. http://www.nededc.com/stats.htm.

Nelson, D.A., and E.J. Pullen. 1988. Environmental considerations using beach nourishment for dredged material placement. In R.L. Lazor and R. Medina (editors), 1990. Beneficial uses of dredged material: Proceedings of the Gulf coast regional workshop. USACE, Washington, D.C. Technical Report D-90-3.

Nelson, H.F., and E.E. Bray. 1970. Stratigraphy and history of the Holocene sediments in the Sabine-High Island area, Gulf of Mexico. Special Publication 15, Deltaic sedimentation, modern and Ancient, Society of Economic Paleontologists and Mineralogists, J.P. Morgan and R.H. Shaver, editors, 48–77.

Nielsen-Gammon, J.W. 2009. The Changing Climate of Texas in "The Impact of Global Warming on Texas" edited by Gerald North, Jurgen Schmandt, and Judith Clarkson, University of Texas Press, Austin.

North American Waterfowl Management Plan (NAWMP), Plan Committee. 2004. North American Waterfowl Management Plan 2004. Gulf Coast Joint Venture: Initiative Plans. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secreteria de Medio Ambiente y Recursos Naturales.

Nyman, J.A., R.D. DeLaune, H.H. Roberts, and W. H. Patrick, Jr. 1993. Relationship between vegetation and soil formation in a rapidly submerging coastal marsh. Marine Ecology Progress Series 96:269–279.

Oberholser, H.C. 1974. The Bird Life of Texas. 2 vol. University of Texas Press, Austin. 1,069 pp.

Odum, H.T., and R.F. Wilson. 1962. Further studies on reaeration and metabolism of Texas Bays, 1958–1960. Publ. Inst. Mar. Sci., (8):23–25. The University of Texas at Austin.

Onuf, C.P. 1995. Seagrass meadows of the Laguna Madre of Texas. In: Our Living Resources, A report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals and Ecosystems (editors, E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac). U.S. Dept. of the Interior, National Biological Service, Washington, D.C., pp. 275–277.

Orange County Tax Appraisal District. 2008. Tax Rates. http://www.orangecad.net/Appraisal/PublicAccess/ (accessed July 30, 2009).

Pacific International Engineering (PIE). 2003. Coastal geomorphology of a non-barrier Gulf of Mexico beach: Analysis for protection of Highway 87 and McFaddin NWR in Jefferson County, Texas. Austin, Texas.

Paille, R. 1996. Water exchange patterns and salinity in marshes between Calcasieu and Sabine Lakes. Proceedings, Sabine Lake Conference, September 13–14, 1996, Beaumont, Texas, (TAMU-SG-97-101):36–43. http://nsgl.gso.uri.edu/tamu/tamuw96001.pdf. Publication by Texas A&M University, College Station (TAMU-SG-97-101). Author, R. Paille, U.S. Fish and Wildlife Service, Ecological Services Division, Lafayette, Louisiana.

Parchure, T.M., S. Maynord, and S. Sarruff. 2005. Desktop Study for Sediment-Related Problems at Sabine-Neches Project. U.S. Army Corps of Engineers, Engineer Research and Development Center, Coastal Hydraulics Laboratory, Vicksburg, Mississippi.

Parker, J.C. 1965. Ecology of western gulf estuaries. Pages 63–67 in Fish. Res. Rep Contrib. No. 207, pp. 63–67. Bur. Comm. Fish. Biol. Lab., Galveston, Texas.

Parrondo, R.T., J.G. Gosselink, and C.S. Hopkinson. 1978. Effects of salinity and drainage on the growth of three salt marsh grasses. Botanical Gazette 139(1):102–107.

Pattillo, M.E., T.E. Czapla, D.M. Nelson, and M.E. Monaco. 1997. Distribution and abundance of fishes and invertebrates in Gulf of Mexico estuaries. Vol. II: Species life history summaries. ELMR Rep. No. 11. NOAA/NOS Strategic Environmental Assessment Div., Silver Spring, Maryland. 377 pp.

PBS&J. 1999. Sabine-Neches Waterway Entrance Channel, Contaminant Assessment. Document No. 991247. PBS&J, Austin, Texas.

———. 2002. Hazardous, toxic, and radioactive waste survey of the Sabine-Neches Waterway. Document No. 020157. PBS&J, Austin, Texas.

———. 2004a. Sabine-Neches Waterway Entrance Channel 2004 Contaminant Assessment. Document No. 040338. PBS&J, Austin, Texas.

———. 2004b. Sediment Transport Modeling of Dredged Disposal Material, Cheniere Sabine Pass Liquefied Natural Gas Terminal, Cameron Parish, Louisiana. PBS&J, Houston, Texas.

———. 2005. Historic Properties Identification, Oyster Reef Identification, and Pipeline and Obstruction Identification for the Sabine/Neches Waterway Widening and Deepening, Jefferson and Orange Counties, Texas, and Cameron Parish, Louisiana. PBS&J, Austin, Texas.

———. 2006. Biological Assessment for Impacts to Endangered and Threatened Species Relative to the Sabine-Neches Waterway Channel Improvement Project, Texas and Louisiana. PBS&J, Austin, Texas.

Pearson, C.E., D.B. Kelley, R.E. Weinstein, S.M. Gagliano with contributions by Baron K. Sen Gupta, M.A. Egar, F.M. Wiseman, and P.H. Templet. 1986. Archaeological Investigations of the Outer Continental Shelf: A Study Within the Sabine River Valley. Offshore Louisiana and Texas. Coastal Environments, Inc., Baton Rouge, Louisiana.

Penland, S., and K. Ramsey. 1990. Relative sea-level rise in Louisiana and the Gulf of Mexico: 1908–1988. Journal of Coastal Research 6:323–342.

Pezeshki, S.R., and R.D. DeLaune 1995. Variations in the response of two U.S. Gulf coast populations of *Spartina alterniflora* to hypersalinity. Journal of Coastal Research 11(1):89–95.

Pezeshki, S.R., R.D. DeLaune, and W.H. Patrick Jr. 1987a. Response of Baldcypress (*Taxodiuin distichum* L. var. *distichum*) to increases in flooding salinity in Louisiana’s Mississippi River Deltaic Plain. Wetlands 7:1–10.

———. 1987b. Effects of flooding and salinity on photosynthesis of *Sagittaria lancifolia*. Marine Ecology Progress Series 41:87–91.

———. 1987c. Response of the freshwater marsh species, *Panicum hemitomon* Schult, to increased salinity. Freshwater Biology 17:195–200.

———. 1990. Flooding and saltwater intrusion: potential effects on survival and productivity of wetland forests along the U.S. Gulf Coast. Forest Ecology and Management 33/34:287–301.

Port of Beaumont. 2005a. “New Vessel Traffic System Safeguards Port,” Welcome Aboard, Fall 2005. http://www.portofbeaumont.com/news/wa0805.pdf.

———. 2005b. New Release: Port Receives Grant for Infrastructure Projects (August 4, 2005). http://portofbeaumont.com/news/tealu.htm (accessed January 2007).

———. 2008. Did you know? http://www.portofbeaumont.com/index.htm (accessed May 2008).

Powel, E.N., E.E. Hoffmann, J.M. Klinck, and S.M Ray. 1992. Modeling oyster populations. I. A commentary on filtration rate. Is faster always better? Journal of Shellfish Research 11(2):387–398.

Pulich W.M., Jr., C. Blair, and W.A. White. 1997. Current status and historical trends of seagrass in the Corpus Christi Bay National Estuary Program Study Area. Report CCBNEP-20. Corpus Christi Bay National Estuary Program, National Resources Center, TAMU-GG, Corpus Christi, Texas. 131 pp.

Quammen, M.L., and C.P. Onuf. 1993. Laguna Madre: seagrass changes continue decades after salinity reduction: Estuaries 16(2):302–310.

Raab, L.M., and H.A. Smith. 1983. Archeological Site-Testing on Taylor Bayou, Jefferson County, Texas, Toward a Regional Settlement-Subsistence Model. Rio Grande Associates, Houston.

Rabinow, R.A. 2004. The Liquid Pipeline Industry in the United States, “Where It’s Been, Where It’s Going, a report for the Association of Oil Pipe Lines, April 2004, p. 14.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea-level rise. Science 315:368–370.

Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida, and the Gulf of Mexico. Rev. Ed. University of Miami Press, Coral Gables, Florida.

Reid, G.K., Jr. 1957. Biologic and hydrographic adjustment in a disturbed Gulf coast estuary. Limnol. Oceanogr. 2:198–212.

Richard, A. 2002. Port of Beaumont. Personal communication to Chris Moore, PBS&J, Austin, Texas. April 30.

Richardson, D., E. Rozenburg, and D. Sarkozi. 1998. A birder's checklist of the upper Texas coast: Brazoria, Chambers, Fort Bend, Galveston, Harris, and Jefferson counties. Houston Outdoor Nature Club, Ornithology Group, Houston, Texas.

Ricklis, R.A., and M.D. Blum. 1997. The Geoarchaeological Record of Holocene Sea Level Change and Human Occupation of the Texas Gulf Coast. Geoarchaeology 12(4):287–314.

Rogers, R. 1991. National Register Testing at site 41OR58: Sabine River, Orange County, Texas. Espey, Huston and Associates, Inc., Austin, Texas.

Rohling, E.J., K. Grant, CH. Hemleben, M. Siddall, B.A.A. Hoogakker, M. Bolshaw, and M. Kucera. 2008. High rates of sea-level rise during the last interglacial period. Nature Geoscience 1:38–42.

Rosman, I. 1987. Underwater sightings of sea turtles in the northern Gulf of Mexico. OCS study. [New Orleans, Louisiana.] U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office.

Ross, J.P. 1982. Historical decline of loggerhead, ridley, and leatherback sea turtles. In: K. Bjorndal (editor), Biology and Conservation of Sea Turtles. Pp. 189–195. Smithsonian Institution Press, Washington, D.C.

Rouse, L.J., Jr., W.J. Wiseman, Jr., L.C. Bender, N.L. Guinasso, Jr., F.J. Kelly, D.A. Brooks, Y-T Lo, J. She, and A. Valle-Levinson. 2004. Observational and Predictive Study of Inner Shelf Currents over the Louisiana-Texas Shelf. Coastal Marine Institute, Louisiana State University. Published by U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS Study, MMS 2004-036.

Ryder, R.A., and D.E. Manry. 1994. White-faced Ibis (*Plegadis chihi*). A. Poole and F. Gill, editors. The birds of North America. The Academy of Natural Sciences, Washington, D.C.

Sabine Pilots Association. 2007. Guidelines: Ship Traffic Control for the Sabine-Neches Waterway. Sabine Pilots Association, Groves, Texas. http://www.sabinepilots.com/guidelines.htm (accessed March 9, 2008).

Sabine River Authority (Texas and Louisiana). 2009. Toledo Bend Project Joint Operation website: www.tbpjo.org (accessed August 8, 2009).

Sabine River Authority of Texas (SRA-TX). 2002. Monthly Water Quality Reports. www.sra.dst.tx.us/.

Sabine River Authority of Texas (SRA) and Lower Neches Valley Authority (LNVA). 2006. Ecological Condition of the Sabine-Neches Estuary. First published December 2004, updated March 2005 and April 2006.

Salinas, L.M., R.D. DeLaune, and W.H. Patrick, Jr. 1986. Changes occurring along a rapidly submerging coastal area: Louisiana, USA. Journal of Coastal Research 2:269–284.

Saloman, C.H., and S.P. Naughton. 1977. Effects of Hurricane Eloise on the benthic fauna of Panama City Beach, Florida. Marine Biology, Vol 42.

Sasser, C.E., and J.G. Gosselink. 1984. Vegetation and primary production in a floating freshwater marsh in Louisiana. Aquatic Botany 20:245–255.

Scarborough-Bull, A., and J.J. Kendall, Jr. 1992. Preliminary investigation: platform removal and associated biota. L.B. Cahoon (editor), Proceedings of the American Academy of Underwater Sciences Twelfth Annual Scientific Diving Symposium, September 24–27, 1992. University of North Carolina Sea Grant College Program, Chapel Hill. Pp 31–37.

Schmidly, D.J. 1991. The bats of Texas. Texas A&M University Press, College Station.

———. 2004. The mammals of Texas, revised edition. University of Texas Press, Austin.

Schreiber, E.A., C.J. Feare, B.A. Harrington, B.G. Murray, Jr., W.B. Robertson, Jr., M.J. Robertson, and G.E. Woolfenden. 2002. Sooty tern (*Sterna fuscata*). In: The birds of North America, No. 665 (A. Poole and F. Gill, editors). The Birds of North America, Inc., Philadelphia, Pennsylvania.

Schwartz, F. 1976. Status of sea turtles, Cheloniidae and Dermochelidae, in North Carolina. Abstr. in Proceedings and abstracts from the 73rd meeting of the North Carolina Academy of Science, Inc., April 2–3, 1976, at the University of North Carolina, Wilmington. J. Elisha Mitchell Sci. Soc. 92(2):76–77.

Scroggs, S. 2002. Great Texas Birding Classic Tournament Coordinator. Texas Parks and Wildlife Department. Telephone conversation with K. Martel Goldsmith, PBS&J, Austin, Texas. December 5.

Servello, F., and C.E. Blanchard 1992. Cultural resources evaluation of Dreary Island (16CM141). C.H. Fenstermaker and Associates, Inc., Lafayette, Louisiana.

Shackelford, C.E., and G.G. Simons. 2000. A two-year report of the swallow-tailed kite in Texas: a survey and monitoring project for 1998 and 1999. Texas Parks and Wildlife Department, PWD BK W7000-496 (6/00). Austin.

Shannon, M.C., C.M. Grieve, and L.E. Francois. 1994. Whole-plant response to salinity. In Plant-Environment Interactions. Edited by R.E. Wilkinson. Marcel Dekker, New York.

Shaver, D.J. 2000. Padre Island National Seashore, field station leader. Personal communication to Derek Green, PBS&J, Austin, Texas. November 20.

———. 2006. Padre Island National Seashore, field station leader. Personal communication to Derek Green, PBS&J, April 3.

Sheridan, P. 1999. Temporal and spatial effects of open water dredged material disposal on habitat utilization by fishery and forage organisms in Laguna Madre, Texas. Final Report to the Laguna Madre Interagency Coordination Team, March.

Sheridan, P.F., R.D. Slack, S.M. Ray, L.W. McKinney, E.F. Kilma, and T.R. Cainan. 1989. Biological components of Galveston Bay. Galveston Bay: Issues, Resources, Status and Management. National Oceanic and Atmospheric Administration Estuary-of-the-Month Seminar Series No. 13, U.S. Department of the Interior, Washington, D.C. Pp. 23–51.

Shields, M. 2002. Brown pelican (*Pelecanus occidentalis*). In: The birds of North America, No. 609 (A. Poole and F. Gill, editors). The Birds of North America, Inc., Philadelphia, Pennsylvania.

Shinkle, K.D., and R.K. Dokka. 2004. Rates of vertical displacement at benchmarks in the lower Mississippi valley and the northern Gulf Coast. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. NOAA Technical Report NOS/NGS 50.

Simon, J.L., and D.M. Dauer. 1977. Reestablishment of a benthic community following natural defaunation. In Belle W. Barauch Institute for Marine Biology and Coastal Research. Ecology of Marine Benthos, 1st ed. University of South Carolina Press, Columbia.

Smeins, F.E., D.D. Diamond, and C.W. Hanselka. 1991. Coastal prairie. Pages 269–290 in R.T. Coupland (editor), Ecosystems of the world: Natural grasslands–introduction and western hemisphere. Elsevier, New York.

Spalding, E.A., and M.W. Hester. 2007. Interactive Effects of Hydrology and Salinity on Oligohaline Plant Species Productivity: Implications of Relative Sea-level Rise. Estuaries and Coasts, 30(2):214–225.

Soil Conservation Service. 1965. Soil survey of Jefferson County, Texas. U.S. Department of Agriculture, Washington, D.C.

Southeast Texas Waterways Advisory Council (SETWAC). 2007. Meeting Minutes, Meeting of July 12, 2007. http://www.uscg.mil/d8/vts/portarthur/setwac.htm.

Southwest Louisiana – The Chamber. 2008. Top 10 employers – Cameron and Calcasieu parishes, Louisiana. http://www.chamberswla.org/foundation/toptenemployers.html.

Stanley, D.R., and C.A. Wilson. 1990. A fishery-dependent based study of fish species composition and associated catch rates around oil and gas structures off Louisiana. Fisheries Bulletin 88:719–730.

Stern, E.M., and W.B. Stickle. 1978. Effects of turbidity and suspended material in aquatic environments. Literature Review. Tech. Rpt. D-78-21. USACE, Waterways Experiment Station, Vicksburg, Mississippi.

Story, D.A., J.A. Guy, B.A. Burnett, M.D. Freeman, J.C. Rose, D.G. Steele, B.W. Olive, and K.J. Reinhard. 1990. The archeology and bioarcheology of the Gulf Coastal Plain: Volume 1. Report prepared by the Arkansas Archeological Survey for the U.S. Army Engineers, Southwestern Division.

Stright, M.J. 1990. Archaeological sites on the North American Continental Shelf. Paper submitted to The Archaeological Geology of North America, edited by N.P. Lasca and J. Donahue, Geological Society of America, Centennial Special Volume 4, Boulder, Colorado.

Sutherlin, J. 1997. Historical development of the marsh system on the west side of Sabine Lake. Sabine Lake Conference: Where Texas and Louisiana Come Together (conference proceedings). Sabine Lake Conference, Beaumont, Texas. http://nsgl.gso.uri.edu/tamu/tamuw96001.pds. Publication by Texas A&M University, College Station (TAMU-SG-97-101).

Taylor, R.B. 2000. Performance Report, Federal Aid Project No. W-125-R-11, Job No. 91: black.

T. Baker Smith, Inc. 2006. Oyster Assessment for Proposed Locations, Flow Lines and Facilities to Serve the Ballard Well SL 17131 No. 1 and the MF 102080 Well No. 1, Sabine Lake, Cameron Parish, Louisiana, and Jefferson County, Texas. Lafayette, Louisiana.

Teeter, A.M., G.L. Brown, M.P. Alexandret, C.J. Callegan, M.S. Sarruff, and D.C. McVan. 2003. Wind-wave resuspension and circulation of sediment and dredged material in Laguna Madre, Texas. ERDC/CHL TR-02-XX. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Tennant, A. 1998. A field guide to Texas snakes. Second edition. Gulf Coast Publishing, Houston, Texas.

Texas A&M University. 2000. Beaumont-Port Arthur – real estate market overview – 2000. Texas A&M – Real Estate Center, College Station.

Texas Commission on Environmental Quality (TCEQ, formerly Texas Natural Resource Conservation Commission [TNRCC]). 2002. Draft 2002 Texas Water Quality Inventory and 303(d) List. Surface Water Quality Monitoring Team, Monitoring Operations Division, Lab and Mobile Monitoring Section, Office of Enforcement. TCEQ, Austin. September 2002.

———. 2008. Revisions to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution: Eight-Hour Ozone Redesignation Request and Maintenance Plan for the Beaumont-Port Arthur Ozone Nonattainment Areas; TCEQ Adopted December 10, 2008.

Texas Comptroller of Public Accounts. 2005a. Local sales and use tax information – sales tax. http://www.cpa.state.tx/taxinfo/salestax.html#localtax (accessed November 17, 2005).

———. 2005b. Local sales and use tax information – property tax. http://www.cpa.state.tx/taxinfo/proptax/riremedy1.html#1.

———. 2009. Sales and Use Tax. http://www.window.state.tx.us/ taxinfo/sales/ (accessed July 30, 2009).

Texas Department of State Health Services (TDSHS). 2008. Classification of shellfish harvesting areas of Sabine Lake. http://www.dshs.state.tx.us/seafood/mapspdf/shellfishclassificationmaps/sabine08.pdf.

Texas Department of Transportation (TxDOT). 1999a. TxDOT urban files for Hardin, Jefferson, and Orange counties, Texas. Texas Department of Transportation, Austin.

———. 1999b. Parks coverage for Hardin, Jefferson, and Orange counties, Texas. Texas Department of Transportation, Austin.

Texas Legislature Online (TLO). 2007. Texas Legislature Online actions. http://www.capitol.state.tx.us/BillLookup/BillNumber.aspx.

Texas Natural Heritage Program (TNHP). 1993. Plant communities of Texas. Texas Parks and Wildlife Department, Austin.

Texas Parks and Wildlife Department (TPWD). 1980. Statewide freshwater fisheries monitoring and management program, Federal aid in sport fish restoration act project F-30-19: existing reservoir and stream management recommendations for Sabine River. Austin.

———. 1985. Statewide freshwater fisheries monitoring and management program, Federal aid in sport fish restoration act project F-30-19: Existing Reservoir and Stream Management Recommendations for Taylor Bayou, Hildebrand Bayou, Cow Bayou, Little Cypress Bayou, Adams Bayou, 1984. Austin.

———. 1992. Coastal Wetlands Habitat (CWH) – Lower Neches River. TPWD Resource Protection, Aquatic Studies Branch.

———. 1994. Performance Reports for Sabine and Neches Rivers, as required for the Federal Aid in Fisheries Restoration Act (report and datasheets). Jasper Inland Fisheries Officer, Jasper, Texas.

———. 1995a. Statewide freshwater fisheries monitoring and management program, Federal aid in sport fish restoration act project F-30-19: Survey Report for the Neches River, 1994. Austin.

———. 1995b. Statewide freshwater fisheries monitoring and management program, Federal aid in sport fish restoration act project F-30-19: Survey Report for Taylor Bayou, 1995. Austin.

———. 1997. Texas wetlands conservation plan. Texas Parks and Wildlife Department, Austin.

———. 1999. Seagrass conservation plan for Texas. Texas Parks and Wildlife Department, Austin.

———. 2003. Salt Bayou Open Water Trend Analysis, 2003 and 2004 Revision. GIS Department, Austin, Texas.

———. 2004. Wetland Habitat Map of J. D. Murphree WMA. Texas Parks and Wildlife, Port Arthur, Texas.

———. 2005a. J.D. Murphree Wildlife Management Area. http://www.tpwd.state.tx.us/huntwild/hunt/wma/find_a_wma/list/?id=40.

———. 2005b. Lower Neches Wildlife Management Area. http://www.tpwd.state.tx.us/huntwild/hunt/wma/find_a_wma/list/?id=58.

———. 2005c. Tony Houseman Wildlife Management Area. http://ww.tpwd.state.tx.us/huntwild/hunt/wma/find_a_wma/list/?id=38.

———. 2005d. 2004 Texas Commercial Landings. http://www.tpwd.state.tx.us/fishboat/fish/commercial/comland.phtml (accessed July 28, 2009).

———. 2005e. Land and water resources conservation and recreation plan. Texas Parks and Wildlife Department.

———. 2006. Information on the leatherback sea turtle. http://www.tpwd.state.tx.us/huntwild/wild/species/endang/animals/reptiles_amphibians/leathback.html.

———. 2010. Annotated county lists of rare species, Jefferson and Orange counties. Texas Parks and Wildlife Department, Wildlife Diversity Branch, Austin.

Texas Water Commission. 1963. Reconnaissance investigation of the ground water resources of the Gulf Coast region. Bulletin 6305. Texas Water Commission, Austin.

Texas Water Development Board (TWDB). 2007. The 2007 State Water Plan. http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm, Chapters 1 (Highlights), 2 (Region I Planning Document), and 3 (Fifty Years of Water Planning in Texas). Adopted November 14, 2006 (accessed January 2007). Austin, Texas.

Texas Workforce Commission (TWC). 2009. Quarterly Employment and Wages. http://www.tracer2.com/cgi/dataanalysis/industryselection1.asp?menuchoice=industry (accessed July 29, 2009).

Tirpak, A. 2002. Texas Parks and Wildlife Department, Coastal Fisheries. Personal communication with Andrew Labay, PBS&J (via Amanda Schneider, USACE). October 8.

Titus, J.G., and V. Narayanan. 1995. The probability of sea level rise. U.S. Environmental Protection Agency (EPA), EPA-230-R-95-008.

Törnqvist, T.E., S.J. Bick, K. van der Borg, and A.F.M. de Jong. 2006. How stable is the Mississippi Delta? Geology 34:697–700, doi: 10.1130/G22624.1.

Tubman, M.W., and J.N. Suhayda. 1976. Wave action and bottom movements in fine sediments. Proceedings of the 15th Coastal Engineering Conference, Honolulu. ASCE, New York.

Turner Collie & Braden. 2003. Sabine-Neches Waterway Feasibility Site Concept, Beneficial Use Development, Prepared for the U.S. Army Corps of Engineers by Turner Collie & Braden, Inc. July 14.

Turner, E.S., and T.R. Hester. 1985. A Field Guide to Stone Artifacts of Texas Indians. Texas Monthly Press, Austin.

University of Texas. 2001. Handbook of Texas – Sabine Lake. http://www.tsha.utexas.edu/handbook/online/articles/view/SS/ros1.html.

U.S. Army Corps of Engineers (USACE). 1961. Calcasieu River and Pass, Louisiana. New Orleans District, New Orleans, Louisiana.

———. 1971a. Survey of Holly Beach and Vicinity, Louisiana, Series No. 95. USACE, New Orleans District, Louisiana. 19 p.

———. 1971b. Texas coast shores regional inventory report.: U.S. Army Corps of Engineers, Galveston District. Galveston, Texas.

———. 1975a (reprinted 1984). Final Environmental Impact Statement: Maintenance Dredging Gulf Intracoastal Waterway Texas Section, Main Channel and Tributary Channels. Volumes 1, 2, and 3. Galveston, Texas.

———. 1975b. Environmental inventory and impact evaluation of maintenance dredging of the Sabine-Neches Waterway, Appendix A: biological inventory. U.S. Army Engineer District, Galveston, Texas.

———. 1980. Survey of Sabine River, Texas from its mouth to east Hamilton: Annual Report of the Chief of Engineers, pp. 1195–1204. U.S. Army Engineer District, Galveston, Texas.

———. 1982. Sabine-Neches Waterway, Texas: feasibility report and environmental impact statement for channel improvements for navigation. U.S. Army Engineer District, Galveston, Texas.

———. 1992. Final Project Modification Report and Environmental Assessment: Salt Bayou, McFaddin Ranch Wetlands, Texas. Galveston District, Southwestern Division.

———. 1997a. Neches River and Tributaries, Texas, and Saltwater Barrier at Beaumont, Texas: General Reevaluation Report and Environmental Assessment. Galveston District, Southwestern Division, Texas.

———. 1997b. Environmental Assessment Sabine-Neches Waterway, Texas: Marine Organism Access between Placement Area No. 11 and Sabine Lake. Galveston District, Southwestern Division, Texas.

———. 1998a. Environmental assessment for a change in location of the Neches River and tributaries, saltwater barrier at Beaumont, Texas. U.S. Army Engineer District, Galveston, Texas.

———. 1998b. Use of Sediment Quality Guidelines (SQGs) in Dredged Material Management. Waterways Experiment Station. Dredging Research Technical Note EEDP-04-29.

———. 1998c. Lake Charles Deep Water Channel, Louisiana, Condition of Improvement, June 30, 1989. New Orleans District Civil Works Project Maps. http://www.mvn.usace.army.mil/eng2/edsd/proj_maps/1-5A.htm.

———. 2000. Environmental Assessment: Alternate Maintenance Dredging Placement Area for Sabine-Neches Waterway, Texas Point National Wildlife Refuge, Jefferson County, Texas. Galveston District, Southwestern Division, Texas.

———. 2002. Keith Lake Fish Pass Ecosystem Restoration Section 1135 CAP (October 10, 2002). Galveston District, Southwestern Division, Texas.

———. 2003a. Civil Works Program Congressional Submission, Fiscal Year 2004: Southwestern Division (February 2003). http://www.usace.army.mil/cw/cecwb/just_state/just_2004/swd.pdf (accessed January 2007).

———. 2003b. Waterborne Commerce of the United States - Part 2 - Waterways and Harbors, Gulf Coast, Mississippi River Systems and Antilles. Institute for Water Resources, Alexandria Virginia. http://www.iwr.usace.army.mil/ ndc/wcsc/wcsc.htm (accessed November 17, 2005).

———. 2003c. Authorities and Policies Supporting Implementation of Regional Sediment Management. Regional Sediment Management (RMS) Demonstration Program Technical Note. Engineer Research and Development Center (ERDC). ERDC/RSM-TN-8, June 2003.

———. 2003d. Draft Environmental Assessment: Beneficial Uses of Dredged Material for Marsh Preservation, Gulf Intracoastal Waterway Port Arthur to High Island, Texas (May). Galveston District, Southwestern Division, Texas.

———. 2004a. Louisiana Coastal Areas Ecosystem Restoration Study and Plan, and Final Environmental Impact Statement. New Orleans District, Corps of Engineers, New Orleans, Louisiana.

———. 2004b. Notice of Studies and Initial Public Scoping Meetings for Sabine Pass to Galveston Bay, Texas, Shoreline Erosion Project (August 9, 2004). http://www.swg.usace.army.mil/pao/newsrel/SPtoGBStudy.asp (accessed January 2007).

———.2004c. Laguna Madre Project. http://www.swg.usace.army.mil/items/Laguna/history/ (accessed January 2007). Galveston, Texas.

———.2005a. Neches River Cypress Swamp Preserve. http://www.swg.usace.army.mil/reg/mitigation/bank/neches_rivers/neches_river.asp.

———. 2005b. Blue Elbow Swamp Mitigation Bank. http://www.swg.usace.army.mil/reg/mitigation/bank/blue_elbow/blue_elbow.asp.

———. 2005c. Breaux Act (Coastal Wetlands Planning, Protection, and Restoration Act), as presented by Col. Peter J. Rowan. http://www.lacoast.gov/cwppra/slideshow/cwppra-TIcommittee-18feb05.pdf (accessed February 2007). New Orleans District, Mississippi Valley Division, Louisiana.

———. 2006a. "12 Points for Change," USACE Headquarters, Washington, D.C., released August 24, 2006.

———. 2006b. 10 Frequently Asked Questions about Regional Sediment Management. USACE. http://www.iwr.usace.army.mil/inside/products/proj/docs_proj/RSMFAQs-3.doc (accessed March 25, 2008).

———. 2006c. USACE sea turtle data warehouse. http://el.erdc.usace.army.mil/seaturtles/index.cfm (accessed August 30).

———. 2006d. Public Notice: Permit Application 22643, Jefferson County Drainage District No. 6 Flood Control Improvements (February 16, 2006). Galveston District, Southwestern Division, Texas.

———. 2006e. Public Notice: Permit Application 23426(02), Sabine Pass LNG, L.P. Galveston District, Southwestern Division, Texas.

———. 2007a. Waterborne Commerce of the United States – Part 2 (1970–2004) – Waterways and Harbors, Gulf Coast, Mississippi River Systems and Antilles. Institute for Water Resources, Alexandria, Virginia. http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm.

———. 2007c. Department of Army Permit 22643, Jefferson County Drainage District No. 6 Flood Control Improvements (August 24, 2007). Galveston District, Southwestern Division, Texas.

———. 2008a. Louisiana Coastal Protection and Restoration Draft Technical Report. U.S. Army Corps of Engineers, New Orleans District.

———. 2008b. Unpublished update of Economic Guidance Memo #08-04, Deep-Draft Vessel Operating Cost FY 2008, December 2007.

———. 2009a. Circular No. 1165-2-211. Water Resource Policies and Authorities Incorporating Sea-level Change Considerations in Civil Works Programs. Expires July 1, 2011. EC 1165-2-211. 3 pp. and appendices.

———. 2009b. Memorandum from Michael D. Gonzalez to Michael C. Sterling, P.E. regarding saltwater intrusion in coastal areas due to a relative rise in sea-level.

U.S. Census Bureau. 1990. P001. Persons. Data Set: 1990 Summary Tape File 3.

———. 2000a. P8. Hispanic or Latino by Race. Data Set: Census 2000 Summary File 1.

———. 2000b. P88. Ratio of Income in 1990 to Poverty Level. Data Set: Census 2000 Summary File 3.

———. 2000c. P53. Median Household Income in 1999 (Dollars). Data Set: Census 2000 Summary file 3.

———. 2000d. P30. Means of Transportation to Work. Data Set: Census 2000 Summary File 3.

———. 2000e. H4. Household Tenure. Quick Tables: Summary File 1.

———. 2000f. P1. Profile of General Demographic Characteristics. Quick Tables: Summary File 1.

———. 2000g. Census 2000, Summary File 3 (SF 3); American Factfinder; http://factfinder.census.gov/ (accessed November 25, 2005).

U.S. Climate Change Science Program (USCCSP). 2009. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. Synthesis and Assessment Product 4.1. 298 pp.

U.S. Coast Guard (USCG). 2006. Ballast water management program. http://www.uscg.mil/hq/g-m/mso/bwm.htm.

———. 2008a. Vessel Traffic Management, Navigation Center, U.S. Department of Homeland Security, United State Coast Guard. http://www.navcen.uscg.gov/mwv/vts/vts_home.htm (accessed March 9, 2008).

———. 2008b. VTS Port Arthur Operating Procedures Guide. http://www.uscg.mil/d8/VTSPortArthur/Documents/VTS%20Port%20Arthur_Opertating-Guide.pdf (accessed March 9, 2008).

U.S. Department of Commerce (USDC), National Oceanic and Atmospheric Administration (NOAA). 2006. NOAA Tides and Currents, Sea Levels Online: Mean Sea Level Trends for Stations in Texas. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.

———. 2009. NOAA Tides and Currents, Sea Levels Online: Mean Sea Level Trends for Stations in Texas. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat Evaluation Procedure (HEP) Manual (102 ESM). U.S. Fish and Wildlife Service, Washington, D.C.

———. 1992. Threatened status of the Louisiana black bear and related rules. Federal Register. Vol. 57, No. 4.

———. 1995. Threatened and endangered species of Texas. U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C.

———. 1998. Final habitat stewardship program, Texas Chenier Plain. U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C.

———. 2001. National wildlife refuges in Texas owned by the U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C.

———. 2002a. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Introduction. Prepared by Environmental Work Group, CWPPRA Technical Committee, USFWS, Lafayette, Louisiana.

———. 2002b. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Procedural Manual. Prepared by Environmental Work Group, CWPPRA Technical Committee, USFWS, Lafayette, Louisiana.

———. 2002c. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Emergent Marsh Community Models. Prepared by Environmental Work Group, CWPPRA Technical Committee. USFWS, Lafayette, Louisiana.

———. 2002d. Coastal Wetlands Planning, Protection and Restoration Act, Wetland Value Assessment Methodology, Swamp Marsh Community Model. Prepared by Environmental Work Group, CWPPRA Technical Committee. USFWS, Lafayette, Louisiana.

———. 2002e. The 2001 National Survey of Fishing, Hunting and Wildlife Associated Recreation. http://fa.r9.fws.gov/surveys/surveys.html. Last revised October 1, 2002.

———. 2003. "2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Texas"; revised March 2003. http://www.census.gov/prod/2003pubs/01fhw/fhw01-tx.pdf (accessed November 18, 2005).

———. 2004. Final Environmental Assessment: East Sabine Lake Hydrologic Restoration, Project Construction Unit 1 (CS-32), Cameron Parish, Louisiana. 32 p. plus appendices. U.S. Fish and Wildlife Service, Ecological Services, Lafayette, Louisiana.

———. 2005a. "McFaddin and Texas Point National Wildlife Refuges." http://www.fws.gov/southwest/refuges/texas/mcfaddin/index. html.

———. 2005b. Sabine National Wildlife Refuge. http:// www.fws.gov/sabine/.

———. 2005c. Threatened and endangered species of Louisiana, parish list. U.S. Fish and Wildlife Service, Louisiana Ecological Services Office, Lafayette. July 14.

———. 2006. 2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. http://wsfrprograms.fws.gov/Subpages/NationalSurvey/National_Survey.htm (accessed July 28, 2009).

———. 2007. Texas colonial waterbird census database. http://www.fws.gov/texascoastalprogram/TCWC.htm (accessed January 14).

———. 2008a. Texas Chenier Plain National Wildlife Refuge Complex Final Environmental Impact Statement/Comprehensive Conservation Plan/Land Protection Plan (May). http://www.fws.gov/southwest/refuges/Plan/LINKS.pdf (accessed July 2009). Southwest Region, Albuquerque, New Mexico.

———. 2008b. Sabine National Wildlife Refuge Complex, Final Environmental Impact Statement/Final Comprehensive Conservation Plan.

———. 2008c. Sabine National Wildlife Refuge Complex, Cameron Parish, Louisiana: Final Comprehensive Conservation Plan. FR 73: 115 (June 13, 2008).

———. 2009. Endangered species list: list of species by county for Texas. http://www.fws.gov/ifw2es/EndangeredSpecies/lists/ListSpecies.cfm (accessed March 9).

U.S. Fish and Wildlife Service and Gulf States Marine Fisheries Commission (USFWS and GSMFC). 1995. Gulf sturgeon recovery plan. Atlanta, Georgia.

U.S. Fish and Wildlife Service (USFWS) and Louisiana Department of Natural Resources (LDNR). 2008a. East Sabine Lake Hydrologic Restoration, Project Status Report as of April 25, 2008. http://www.lacoast.gov/reports/managers.asp?projectNumber=CS%2D32.

———. 2008b. Black Bayou Hydrologic Restoration, Project Status Report as of April 25, 2008. http://www.lacoast.gov/reports/managers.asp?projectNumber= CS%2D27.

U.S. Fish and Wildlife Service (USFWS) and Natural Resources Conservation Service (NRCS). 2003. Revised Project Information Sheet for Wetland Value Assessment. East Sabine Lake hydrologic restoration project (CS-32): Construction Unit 1. USFWS Ecological Services Office, Lafayette, Louisiana.

U.S. Fish and Wildlife Service (USFWS) and Texas General Land Office (GLO). 1992. National Wetland Inventory (NWI).

U.S. Geological Survey (USGS). 1990. Land use and land cover (LULC) data. U.S. Geological Survey, Department of the Interior, Washington, D.C.

———. 1997. Global Change and Submerged Aquatic Vegetation Research. Prepared by National Wetlands Research Center, Lafayette, Louisiana. USGS FS-090-97.

U.S. Geological Survey-National Wetlands Research Center (USGS-NWRC). 2002a. Perry Ridge Shore Protection Project No CS-24, General Fact Sheet. http://www.lacoast.gov/reports.

———. 2002b. GIWW-Perry Ridge West Bank Stabilization Project No CS-30, General Fact Sheet. http://www.lacoast.gov/reports.

———. 2002c. Black Bayou Hydrologic Restoration Project No CS-27, General Fact Sheet. http://www.lacoast.gov/reports.

———. 2004. Louisiana Coastal Areas Mapping Units for the Calcasieu-Sabine Basin. U.S. Department of the Interior, U.S. Geological Survey, National Wetlands Research Center, Lafayette, Louisiana and Coastal Restoration Field Station, Baton Rouge, Louisiana.

Van Siclen, D.C. 1975. Guidebook for coastal geology field trip. University of Houston, Department of Geology.

Visser, J.M., and C.E. Sasser. 1998. 1997 Coastal Vegetation Analysis. Report to Greg Steyer of Louisiana Department of Natural Resources, Baton Rouge.

Visser, J.M., C.E. Sasser, R.H. Chabreck, and R.G. Linscombe. 1999. Long-term vegetation change in Louisiana tidal marshes: 1968–1992. Wetlands 19:168–175.

Visser, J.M., G.D. Steyer, G.P. Shaffer, S.S. Höppner, M.W. Hester, E. Reyes, P. Keddy, I.A. Mendelssohn, C.E. Sasser, and C. Swarzenski. 2004. Chapter 9, Habitat Switching Module in Appendix C, Hydrodynamic and Ecological Modeling, Louisiana Coastal Area Ecosystem Restoration Study. U.S. Army Corps of Engineers, New Orleans District, Louisiana, pp C143–157.

Vitale, L.D., and Q.R. Dokken. 2000. Preliminary observations of fish assemblages associated with a partially removed platform off the Texas coast. Proceedings: eighteenth annual Gulf of Mexico information transfer meeting. New Orleans.

Vittor & Associates, Inc. 1997. Sabine Lake, Texas: benthic community assessment. Barry A Vittor & Associates, Inc., Mobile, Alabama.

Voellinger, L.R. 1990. Prehistoric adaptations along Clear Lake Site 41GV22, Galveston County, Texas prepared by Espey, Huston & Associates, Inc. for USACE, Galveston District, Texas.

Wall Street Journal. 2008. Exxon to Delay Texas LNG Plant: Hurricane Ike Damaged Terminal and Assessment has Taken Months. By Russell Gold. December 20, 2008. http://online.wsj.com/article/SB122970422712121943.html (accessed July 31, 2009).

Walther, P. 2005. Personal communication to Janelle Stokes from Pat Walther, USFWS, Texas Point National Wildlife Refuge.

Wamsley, T.V. 2008. Memorandum from CEERD-HR-C to CESWG, Subject: CHL Response to Galveston District Information Request Related to Sabine-Neches Waterway Channel Improvement Project, Draft Feasibility Report, External Peer Review Comments.

Wamsley, T.V., M.A. Cialone, J.M. Smith, J.H. Atkinson, and J.D. Rosati. 2009a. The potential of wetlands in reducing storm surge. Ocean Engineering. DOI 10.1016/j.oceaneng.2009.07.018.

Wamsley, T.V., M.A. Cialone, J.M. Smith, and B.A. Ebersole. 2009b. Influence of landscape restoration and degradation on storm surge and waves in southern Louisiana. Journal of Natural Hazards 51(1):207–224.

Wamsley, T.V., M.A. Cialone, and T.O. McAlpin. 2010. Sensitivity analysis for Sabine-Neches Waterway Navigation Project. USACE, ERDC-CHL, Vicksburg, Mississippi.

Warren, R.S., and P.M. Brockelman. 1989. Photosynthesis, respiration, and salt gland activity of *Distichlis spicata* in relation to soil salinity. Botanical Gazette 150(4):346–350.

Warren, T.A., L.M. Green, and K.W. Spiller. 1994. Trends in finfish landings of sport-boat anglers in Texas marine waters, May 1974–May 1992. Data Series No. 109. Texas Parks and Wildlife Department, Austin.

Webb, D. 2003. Ship Simulation Study for Sabine-Neches Improvement Project (Revised March 2007). Coastal and Hydraulics Laboratory, ERDC. Vicksburg, Mississippi.

Webb, E.C., and I.A. Mendelssohn. 1996. Factors affecting vegetation dieback of an oligohaline marsh in coastal Louisiana: field manipulation of salinity and submergence. American Journal of Botany 83:1429–1434.

Weddle, R.S. 1985. The Spanish Sea: the Gulf of Mexico in North American discovery, 1500–1685. Texas A&M University Press, College Station.

Wells, J.T., and G. P. Kemp. 1982. Mudflat marsh progradation along Louisiana's Chenier Plain: a natural reversal of coastal erosion. In: D.F. Boesch, editor, Proceedings of the Conference on Coastal Erosion and Wetlands Modification in Louisiana: Causes, Consequences, and Options. U.S. Fish and Wildlife Service.

———. 1986. Interaction of surface waves and cohesive sediments: Field observations and geological significance. Estuarine Cohesive Sediment Dynamics, A. J. Mehta, editor. Springer-Verlag, New York. Pp 43–65.

Werler, J.E., and J. Dixon. 2000. Texas snakes, identification, distribution, and natural history. The University of Texas Press, Austin.

Wesselman, J.B. 1971. Ground-water resources of Chambers and Jefferson Counties, Texas. Report No. 190, Texas Water Development Board, Austin.

White, W.A., T.R. Calnan, R.A. Morton, R.S. Kimble, T.G. Littleton, J.H. McGowen, and H.S. Nance. 1987. Submerged lands of Texas, Beaumont-Port Arthur area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands. Geology Special Publication, Bureau of Economic Geology, The University of Texas at Austin.

White, W.A., and T.A. Tremblay. 1995. Submergence of wetlands as a result of human-induced subsidence and faulting along the upper Texas Gulf Coast. Journal of Coastal Research 11(3):788–807.

Willis, J.M., and M.W. Hester. 2004. Interactive Effects of Salinity, Flooding, and Soil Type on *Panicum Hemitomon*. Wetlands 24(1):43–50. March.

Wilson, C.A., and M.A. Allison. 2008. An equilibrium profile model for retreating marsh shorelines in southeast Louisiana. Estuarine, Coastal and Shelf Science 80:483–494.

Witzell, W.N. 1983. Synopsis of biological data on the hawksbill turtle *Eretmochelys imbricata* (Linnaeus, 1766). FAO Fisheries Synopsis No. 137. FIR/S137, SAST – Hawksbill Turtle – 5.31

Young, L. 2001. Texas Parks and Wildlife Department, Law Enforcement Division. Personal Communication to Andrew Labay, PBS&J, Austin, Texas. October 31.

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