TAYLOR ENGINEERING, INC.

Economic and Natural Resource Benefits Study of Coastal Erosion Planning and Response Act (CEPRA) Cycle 5 and 6 Projects

Texas

February 2011

Economic and Natural Resource Benefits Study of Coastal Erosion Planning and Response Act (CEPRA) Cycle 5 and 6 Projects

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by

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EXECUTIVE SUMMARY

Texas' coastal assets, including beaches, dunes, bluffs, estuaries, wildlife preserves, and parks, provide significant economic value for the Texas citizenry. Natural (e.g., storms) and man-made (e.g., some inlets) changes and their subsequent result, erosion, adversely affect these coastal assets. The Texas Legislature requires the General Land Office (GLO) report the economic and natural resource benefits derived from Coastal Erosion Planning and Response Act (CEPRA) construction projects funded every biennium. As such, the GLO contracted Taylor Engineering, Inc. — under GLO Contract No. 10-103-010 and Work Order No. 4176 — to perform the benefit-cost analyses for selected Cycle 5 and 6 projects. This report analyzed the following eight CEPRA Cycle 5 and 6 projects:

- #1355 South Padre Island Beach Nourishment with Truck Haul
- #1356 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material
- #1379 Surfside Revetment Project
- #1404 Sylvan Beach Shoreline Protection and Beach Nourishment
- #1447 Galveston Seawall Emergency Beach Nourishment
- #1453 Isla Blanca Park Beach Nourishment with Beneficial Use of Dredged Material
- #1456 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material
- #1483 West Galveston Island Estuarine Restoration

This study classified and estimated economic and financial benefits associated with commercial and recreational fishing, tourism and ecotourism (wildlife viewing), improved water quality, carbon sequestration, beach recreation, out-of-state visitor spending, and storm protection. The stream of economic benefits over time varied from project to project depending on a project's durability. The period of analysis for the various projects varied from 1 to 20 years. For each project, this study compared benefits with costs.

This study adopts a Texas accounting perspective or stance. Funding from outside Texas and spending by visitors from outside the state represent financial benefits to the state. A Texas accounting stance views project contributions normally considered a cost when viewed from a national or world perspective as a financial benefit. Costs funded by non-Texas dollars represent a financial benefit because money flows into the Texas economy. As appropriate, the finding reported here shows this adjustment to reflect the Texas accounting perspective for the estimates of benefits and costs. This report serves to estimate the cost effectiveness of the eight projects listed above via benefit to cost ratios and net benefits on an individual project basis, and as a group, or "portfolio."

Table E.1 presents a summary of the assessed projects. In total, for every Texas dollar invested in these projects, the state of Texas receives $2.65 in economic and financial benefits.

Table E.1 Summary of CEPRA Cycle 5 and 6 Projects, Costs, and Benefits

Project Number	Project Name	County	Total Discounted Cost*	CEPRA Cost	Total Discounted Benefits	Benefit-to-Cost (B/C) Ratio
1355	South Padre Island Beach Nourishment with Truck Haul	Cameron	$720,801	$551,544	$1,330,538	1.85
1356	South Padre Island Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$610,248	$457,686	$356,931	0.58
1379	Surfside Revetment Project	Brazoria	$1,373,395	$1,287,558	$11,302,986	8.23
1404	Sylvan Beach Shoreline Protection and Beach Nourishment	Harris	$3,660,822	$2,196,493	$6,467,363	1.77
1447	Galveston Seawall Emergency Beach Nourishment	Galveston	$7,226,249	$5,419,686	$8,428,234	1.17
1453	Isla Blanca Park Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$12,661	$9,496	$547,337	43.23
1456	South Padre Island Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$593,258	$444,943	$3,470,022	5.85
1483	West Galveston Island Estuarine Restoration	Galveston	$1,117,725	$622,689	$8,694,158	7.78
		Totals	$15,315,159	$10,990,096	$40,597,567	2.65

Notes: *Texas portion only
Dollar values reflect present worth equivalents at the beginning of 2010 with a 4% discount rate

The direct and positive net benefits (B/C ratios greater than one) from the eight evaluated projects indicate that these coastal erosion control projects yield high returns on investment for the state of Texas. Preserving Texas' coastal assets proves a worthy public investment strategy for the Texas taxpayers and citizens.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the following individuals and agencies for their efforts. Mr. Thomas Durnin and Mr. Dennis Rocha of the GLO offered valuable insight into the projects and provided much data and contacts needed to perform the benefit analysis. The City of LaPorte (Mr. Stephen Barr), Galveston Island State Park, Galveston Park Board of Trustees (Mr. Mario Rabago), Galveston Island Visitors Center, Village of Surfside (Mr. Larry Davison), Town of South Padre Island (Mr. Ruben Trevino and Mr. Scott Fry), The University of Texas, and Harris, Galveston, Brazoria, and Cameron (Mr. Javier Mendez) counties provided site-specific project information.

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1.0 INTRODUCTION

1.1 Purpose

Texas' coastal assets, including beaches, dunes, bluffs, estuaries, wildlife preserves, and parks, provide significant economic value for the Texas citizenry. Natural (e.g., storms) and man-made (e.g., some inlets) changes and their subsequent result, erosion, adversely affect these coastal assets. To address the significant erosive threat to Texas coastal areas, the 76th Texas Legislature passed the Texas Coastal Erosion Planning and Response Act (CEPRA) in 1999. The CEPRA program, in concert with local project partners, invests significant state resources to control coastal erosion. The Texas General Land Office (GLO) created project partnerships between federal, state and local entities to implement a series of erosion response projects in Cycles 1 (state fiscal years 2000 – 2001), 2 (state fiscal years 2002 – 2003), 3 (state fiscal years 2004 – 2005), and 4 (state fiscal years 2006 – 2007). The CEPRA program allocated a combined $45 million for Cycle 1, 2, 3, and 4 projects. The GLO applies CEPRA funds for estuary programs, beach nourishment projects, dune restoration projects, shoreline protection projects, habitat restoration/protection, and coastal research and studies. Funding for erosion control projects continued in Cycles 5 (state fiscal years 2008-2009) and 6 (state fiscal years 2010-2011) by allocating over $31 million to fund about 50 erosion response projects and studies.

Notably, the Texas Legislature requires the GLO report the economic and natural resource benefits derived from CEPRA construction projects funded every biennium. As such, the GLO contracted Taylor Engineering, Inc. — under GLO Contract No. 10-103-010 and Work Order No. 4176 — to perform the benefit-cost analyses for selected Cycle 5 and 6 construction projects. This report analyzed the following eight CEPRA Cycle 5 and 6 projects:

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These projects represented \$10.9 million out of a collective \$31.5 million (\$17.5 million for Cycle 5 and \$14 million for Cycle 6) allocated for funding coastal erosion projects and studies during the Cycle 5 and 6 biennia. Figure 1.1 presents a map of the projects' locations along the Texas coast. These projects include seven beach restoration and shoreline protection projects and one natural resource project. This report serves to estimate the cost effectiveness of the eight projects listed above via benefit to cost ratios.

1.2 Report Scope

This report discusses the methodology and results of the natural resource and economic benefit analyses for select projects constructed during Cycles 5 and 6. Following this introduction, Chapter 2 describes the natural resource and economic benefit methodologies applied in the present study. Chapter 3 discusses economic benefits and costs associated with the seven beach restoration and shoreline protection projects. Chapter 4 discusses benefits and costs associated with the natural resource project. Chapter 5 summarizes and concludes the report.

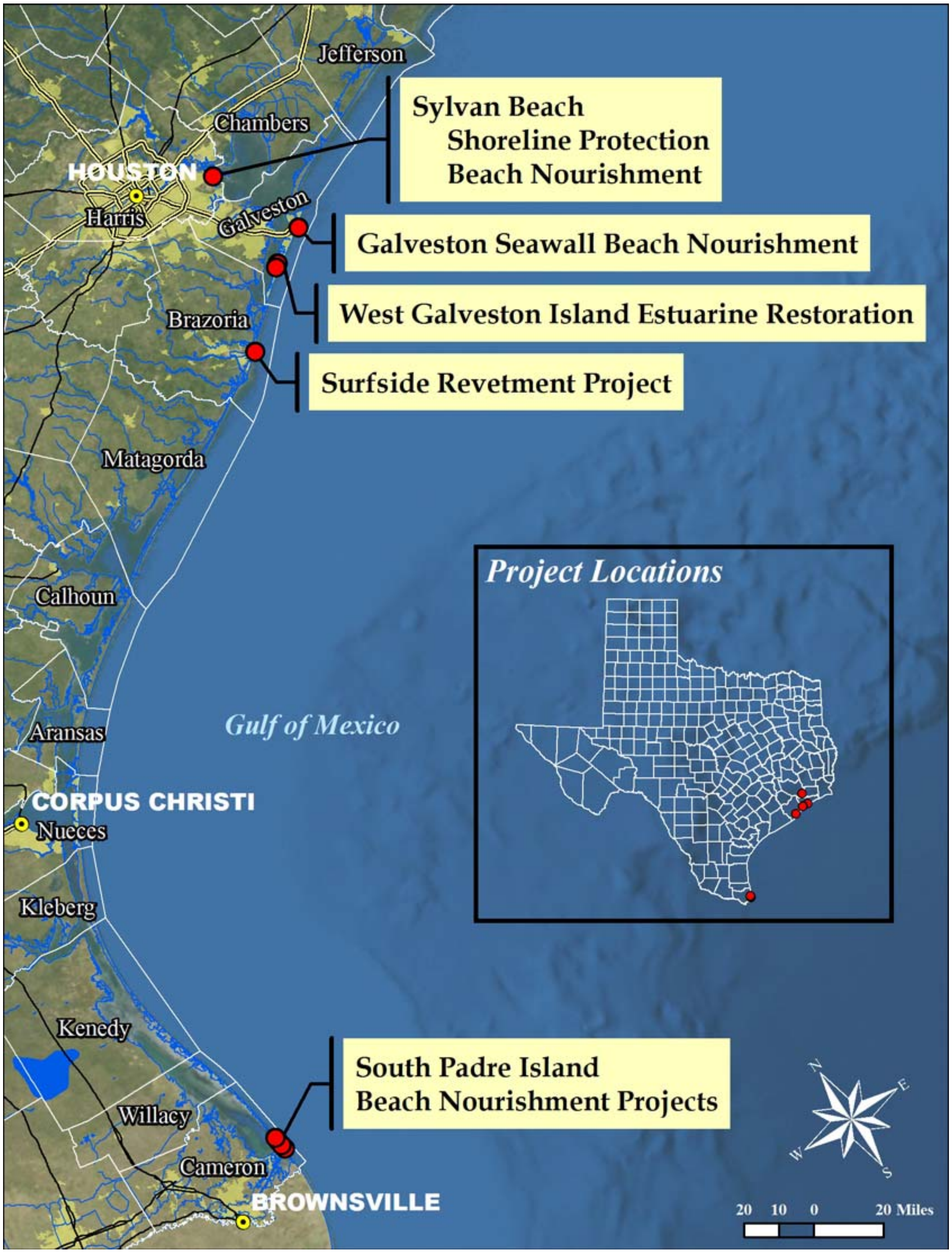

Figure 1.1 Location Map of Cycle 5 and 6 Subject Projects

2.0 ECONOMIC AND NATURAL RESOURCE BENEFIT METHODOLOGY

2.1 General Concepts

Beach and shoreline protection projects accrue economic benefits when CEPRA projects mitigate for erosion and degradation of beaches and dunes and protect upland property. Natural resource projects accrue economic benefits when the projects protect, restore, or create wetlands and other habitats. Beach/dune and natural resource projects' economic benefit methodologies differ in many respects as detailed in Sections 2.2 and 2.3. Each project type requires following different methodological steps and procedures, but some over-arching concepts apply to all of these projects. The present study adopts similar methodologies to those applied in the previous Cycle 4 economic benefit study (Stites et al., 2008) and 2009 update to the Texas erosion response plan (Krecic et al., 2009).

Overall, benefits and costs represent the estimated difference, over the period of analysis, between conditions with the project and conditions without the project. Adjusting each year's benefit reflects then-current price levels with an assumed annual inflation rate derived from the consumer price index (CPI) (http://www.bls.gov/cpi/: consumer price index) for historical years and long-term forecasts by the Federal Open Market Committee of the U.S. Federal Reserve and the Congressional Budget Office for years beyond 2010. Table 2.1 summarizes these rates. An annual discount rate of 4% converts values occurring at different points in time to comparable equivalent values, adjusting for the time value function. The reference point in time for this discounting, or present worth adjustment calculation, represents the beginning of the period of analysis.

Table 2.1 Price Level Adjustment Information

Year	Annual Average Consumer Price Index	Annual Inflation from Previous Year (%)
2007	207.3	2.8%
2008	215.2	3.8%
2009	214.5	-0.3%
2010	219.7	2.4%
2011	--	1.1%
2012 – 2014	--	1.2%
2015 –	--	1.8%

Present value factors, based on the 4% discount rate, convert values at different points in time to comparable values at the same point in time. In these evaluations, the beginning of the period of analysis represents the point in time used for these discounting calculations. The key to this discounting process, or present value conversion, is equivalence. For example, a benefit accruing in year five is equivalent to its discounted value at the beginning of year one. Discounting reflects that values received or spent in the future are worth less than those received or spent now because of interest. Interest reflects a combination of two effects: (1) changes in prices (inflation), and (2) the time value preference function (i.e., even without any inflation an interest rate still exists because a dollar now is preferable to a dollar later). These analyses include inflation in the estimates of benefits accruing over time. The discount rate also includes inflation.

This study assumes most benefits accrue throughout the year. Therefore, the present value calculations apply mid-year discounting (instead of the conventional end-of-period convention) for all benefit calculations.

For convenience and consistency, this study estimates benefit values initially in 2010 price levels. It then adjusts (based on historical and forecast inflation estimates previously discussed) benefits to represent price levels existing in the year of benefit accrual. Benefit accrual begins in 2008, 2009, 2010, and 2011 for the different projects analyzed in this study. For some projects, construction took place early in the year, and even though benefits did not begin to accrue until later in that year, this study treats benefits as though they accrue throughout the same year. For these projects, the authors recognize that this method reflects, if not what really happens then something very close. The small effect of this calculation method on the outcome is insignificant.

This study treats costs as single point-in-time values at the beginning of the period of analysis. The analyses exclude determining a time value adjustment to reflect the actual pattern of project implementation spending that occurred over time because of the relatively short project implementation period (less than a year). Therefore, the effect of doing that adjustment would prove insignificant.

The stream of economic benefits over time varies from project to project depending on the durability of the project. The period of analysis for the various projects varied from 1 to 20 years.

This study adopted a Texas accounting perspective or stance. Texas taxpayers and citizens likely have the most interest in Texas costs and benefits. Funding from outside Texas and spending by visitors from outside the state represent financial benefits to the state. From a national or world perspective, many would view funding sourced from outside Texas as a cost. A “Texas” accounting stance, however, views project contributions that originate from outside Texas a financial benefit to Texas. Costs funded by non-Texas dollars represent a financial benefit because money flows into the Texas economy, including the multiplier effect described below. Along with this effect, one may properly subtract this non-Texas part of the project cost from the total implementation cost because it does not represent a state-incurred expense. As appropriate, the finding reported here reflects this adjustment to reflect the Texas accounting perspective for the estimates of benefits and costs.

With respect to out-of-state spending, one can apply multipliers to estimate the secondary effects of spending by non-Texans visiting projects within the state. These multiplier factors, when multiplied by out-of-state visitor spending, capture the effects of changes in sales, income, and employment brought about by the initial spending amounts. Two types of such effects exist. One type of multiplier effect takes place within backward-linked industries located within the state. These industries would include businesses that supply goods and services to the business operations (e.g., food, gas, and lodging) where visitors/tourists spend their money. The other type of multiplier effect results from the spending by employees in the businesses where visitors spend their money and by employees in the backward-linked businesses and industries involved. The part of this spending that takes place within Texas creates additional sales and economic activity.

Detailed analysis could yield this multiplier effect by applying the results of input-output tables (representing the complex web of economic relationships in the economic system) that exist for states and regions and a myriad of economic sectors of the economy. Conducting such an analysis exceeds the scope of this present study. This study adopts a more general approach to determine the multiplier effect for out-of-state visitors to the assessed CEPRA projects. For purposes of this evaluation, an overall average multiplier of 1.75 serves as a general average effect representative of conditions in the Texas economy. (Multipliers often range from 1.5 to 2.0.)

The authors judge a value of 1.75 reasonable in light of the following observations. In the Cycle 3 CEPRA report, Oden and Butler (2006) acknowledge that this multiplier effect is “typically in the range of two times the direct effects.” This multiplier effect is larger for large regions, such as the state of Texas and smaller for small areas, such as cities and counties. This tendency relates to the higher population, greater number of industries, and overall higher level of economic integration for a large, diverse, and vigorous economy such as exists in Texas, than for small inner state areas. Some (e.g., Horwath Tourism & Leisure Consulting, 1981) have estimated tourism multipliers to range from 1.56 to 2.17 for select counties and regions in Pennsylvania, Wisconsin, Wyoming, and Colorado. In addition, Wiersma et al.

(2004) have estimated tourism output multipliers to range from 1.33 to 1.45 for various regions in New Hampshire and 1.51 for the state of New Hampshire. Horváth and Frechtling (1999) report multiplier values of 2.40 for the United States, 2.08 for Puerto Rico, 1.76 for Miami, Florida, 1.63 for Washington, DC, 1.21 for Oregon, and 1.44 for Maryland.

Reducing this multiplier effect reflects that only the retail margins and, in some cases, the wholesale and transportation margins of goods and services purchased by visitors remain in the Texas economy. These margins vary across the economy. For lodging, the margins are very large. Most lodging and related service spending likely remain within Texas. For most items made outside of Texas, the margins likely approach about 50%. One may express the average combined effect of this margining as a “capture rate,” representing on average the portion of visitor spending that the Texas economy captures. This study adopts a capture rate of 80% (0.8). Combining the capture rate of 0.8 with an overall average multiplier effect of 1.75 results in a net multiplier effect of 1.4 (i.e., 0.8 * 1.75 = 1.4). For example, if non-Texans visiting Texas projects represent 10% of total visitors who spend, on average, $100/day, then the estimated overall financial economic beneficial impact for Texas of this spending equals total visitation days times 0.1 times $100/visit-day times 1.4.

One may also estimate a similar effect to account for any federal spending that may occur as part of initial project construction or recurring annual operations (e.g., maintenance and inspection), because a major portion of federal spending taking place within Texas represents a net increase inflow of spending for the state economy. However, one must reduce the amount of initial federal spending to account for contributions to federal tax revenues from individuals and businesses in Texas. Applying the ratio of the state of Texas population to the U.S. population total as a proxy for this effect (approaching 10%), an estimated net multiplier effect to apply to any such spending would equal federal spending times 0.9 times 1.4 or federal spending times 1.26. This federal spending would represent an estimated net economic financial benefit to the Texas economy.

Many argue that "outside money subsidies," as described in the preceding paragraph, do not really constitute a part of project’s intrinsic economic performance. However, this study’s purpose is to show the net economic and financial benefit-cost accounting for Texas' citizens, taxpayers, and their representatives. Meeting this objective requires making these net adjustments. Although not "project benefits" in a traditional sense, these outside monies play an integral part in the net economic and financial benefit-cost story.

Comparing the estimated benefits to the project costs shows the net benefits of the assessed projects. Dividing the estimated benefits by the cost produces the benefit-to-cost (B/C) ratio for each project. B/C ratios greater than one indicate the cost effectiveness of a particular project.

As a final note, hand calculations may yield different results from those tabulated in this report because of number rounding versus spreadsheet calculations.

2.2 Beach Restoration and Shoreline Protection Projects

The recently constructed beach restoration and shoreline protection projects intend to provide immediate protection to the upland property owners against high frequency storms. Beach restoration generally adds large quantities of sand to the beach; most sand placement occurs on the dry portion of the beach. This process results in a seaward movement of beach elevation contours, typically from the beach berm to the shallow nearshore. Beach nourishment represents a means to turn back time. Because the erosion mechanisms still exist, erosion will return the beach to its original state and continue to erode further. Beach restoration design includes specifications of berm elevations to mimic those of the natural beach, berm extensions to obtain desired beach widths, and beach foreshore slopes, typically steeper than the natural beach, to transition the beach fill to the existing beach. Wave action subsequently reshapes the beach profile to a more natural profile.

“Hard” shoreline protection projects, such as the Surfside revetment, typically limit the landward extent of erosion. These rock or concrete structures, typically sloped, induce wave breaking and loss of wave energy during the wave runup process and therefore, limit reflection of wave energy from shore. Rock revetments typically consist of two or more layers of rock with the upper, larger rock providing stability against wave attack. A properly-designed revetment must ensure that the lower, smaller rock does not wash out through the upper layers. Should this occur, the revetment may lose elevation and therefore, its protective capabilities, through settlement.

Another purpose of beach restoration projects includes restoring and maintaining public recreational beaches. Beach erosion has detrimentally affected public recreational use of the sandy beaches by narrowing the dry beach width along the shoreline. Absent sand placement, the recreational beach would continue to narrow and become less suitable for many types of public recreation. As such, this study identified storm damage reduction and visitation benefits as pertinent to the project areas. Chapter 3 describes the seven examined beach restoration and shoreline protection projects. The paragraphs below discuss each of these benefits and the associated methodologies to calculate the benefits.

2.2.1 Storm Damage Reduction Benefits

Beach restoration and shoreline protection projects protect land and structures on their landward side against both the ongoing background shoreline erosion and episodic, storm-related erosion. The prevention of land loss and damage to structures form the basis of storm protection benefits to upland properties. Storm damage reduction benefits require estimates of background erosion, storm-related erosion, location of properties and structures with respect to the shoreline, and value of land and structures near the shoreline. Similar to the Cycle 4 economic benefit study, the present study adopts a rigorous engineering approach to develop storm damage reduction benefits.

Background erosion estimates obtained from the University of Texas, Bureau of Economic Geology (UTBEG) (www.beg.utexas.edu) provide the long-term erosion expected to occur at a beach.

Computing storm-induced beach erosion requires applying a numerical model such as Storm-Induced Beach Change (SBEACH) (Larson and Kraus, 1989). This storm erosion model, developed to simulate beach profile change due to cross-shore transport of sediment under changing water levels and breaking waves, provides short-term erosion and recovery predictions on straight beaches. The model assumes that a beach profile evolves to a new equilibrium profile in response to the elevated water levels associated with the storm surge and increased breaking wave heights associated with the storm wave height. Model application requires information on beach profiles, beach sand size, and wave height and period, and water level time series (hydrographs) for the duration of the storm.

The GLO provided site-specific beach profile survey data along the project shorelines. The survey data include both pre- and post-construction information. Engineering reports (Lockwood, Andrews, and Newnam, Inc., 2006; HDR| Shiner Moseley and Associates, Inc., 2007; HDR, 2009c) supplied representative sand size information in the project areas.

The USACE Wave Information Study (WIS) hindcast provides offshore wave conditions (wave height, period, and direction) for the SBEACH model. Other numerical models (e.g., WISWAVE, WAM) driven by climatological wind fields overlaid on grids of the estimated bathymetry generate the WIS hindcast data. The WIS numerical hindcasts supply long-term wave climate information at nearshore locations (stations) of U.S. coastal waters. In some instances, measurements from National Data Buoy Center (NDBC) offshore buoys provided wave information.

Water level (storm surge) information originates from sources such as site-specific Federal Emergency Management Agency (FEMA) Flood Insurance Studies. These studies report peak water level elevations for various return period storms. These reported elevations include astronomical tide in addition to storm effects. In some instances, measured water levels originated from the Texas Coastal Ocean Observation Network (TCOON) stations.

A joint University of Notre Dame/University of Florida team developed water levels and wave heights and periods for Hurricane Ike (2008). This study applied these data for determining the benefits associated with the Surfside revetment (CEPRA Project #1379).

Computation of storm-induced erosion requires selection of representative beach profiles along the various project areas. Delineation of the project shoreline into reaches minimizes the amount of these computations. SBEACH application with the above information and with select model tuning parameters provided beach recession-frequency curves for each examined beach profile in this study.

Analyses necessitated computing damages due to background erosion and storms for each project year. For years 2008 – 2010, this study applied known (measured) storm characteristics to determine storm damages. Storms that occurred during this period included Hurricanes Dolly and Ike in 2008 and Hurricane Alex and Tropical Storm Hermine in 2010. For 2011 and beyond, this study modeled the effects of 1-, 2-, 5-, 10-, 20-, and 50-, and 100-year return period storms for each future year’s shoreline position.

Damage calculations considered the values of land and structures on the affected properties. For undeveloped properties, this analysis considered the location of the seaward edge of the property from the shoreline, the land area lost due to the corresponding storm-related recession, and the unit land price for the particular property as obtained from the appropriate property appraisal district. For developed properties, this analysis considered the location of the seaward edge of the property from the shoreline, the distance of the seaward and landward sides of structures from the shoreline, the values of structures for the particular property as obtained from the appropriate county appraisal district, the land area lost due to corresponding storm-related recession, and the unit land price for the particular property as obtained from the appropriate appraisal district.

Following similar USACE methods, this analysis distinguishes between slab-on-grade and pile-supported structures. It assumes damage to slab-on-grade structures occurs when the shoreline recedes landward of the seaward edge of the structure and that total damage occurs when the shoreline recedes halfway through the structure. Note that many post-storm observations (e.g., GEC, 2005) revealed that mid- and high-rise residential buildings with robust structural systems and on deep foundations tend to sustain inundation and wave damage only to the lowest floors, with upper floors remaining intact and undamaged by flood. As such, this study assumes damage occurs to pile-supported structures (with two or more stories that likely have deep foundations) when the shoreline recedes landward of the seaward edge of the structure and that total damage (damage to the lowest two stories only) occurs when the shoreline recedes to the landward edge of the structure. Figure 2.1 presents a typical damage function curve for these two structure types. For example, given erosion extends 35% into a slab-on-grade structure's footprint and a structure appraises at $200,000, this structure sustains 70% damage or $140,000 worth of damage with the above assumptions applied.

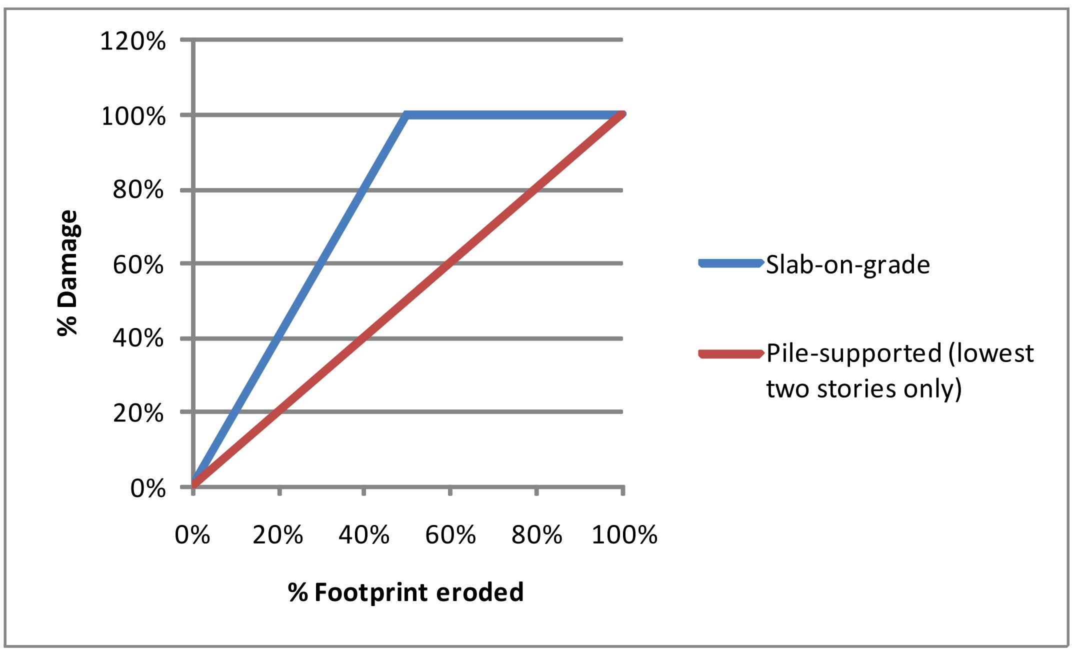

Figure 2.1 Structure Damage Functions

Notably, property appraisers usually do not disaggregate structure values by story. Therefore, the present analysis assumes the values divide equally across the number of stories. For example, a five-story, pile-supported structure appraised at $500,000 has a $100,000 per-story value. Therefore, the lowest two stories values equal $200,000, the value eligible for damage.

The functional relationship between return period and cumulative probability relates damage to cumulative probability. That is, return period relates to the cumulative probability distribution by

$$T_r = \frac{1}{1 - P(X)} \qquad (2.1)$$

where T_r is the return period and *P(X)* is the cumulative probability of *X*, a storm event. As noted above, this study modeled the effects of 1-, 2-, 5-, 10-, 20-, 50-, and 100-year return period storms. Substituting 1 for T_r in Eq. 2.1 and solving for *P(X)* yields 0 or 0%. Therefore, storms will exceed the 1-year storm, on average, 100% of the time. Similarly, substituting 20 for T_r in Eq. 2.1 and solving for *P(X)* yields 0.95 or 95%. Therefore, storms will exceed the 20-year storm, on average, 5% of the time.

After modeling the effects of 1-, 2-, 5-, 10-, 20-, and 50-, and 100-year return period storms for a particular year's shoreline position, one may develop a damage-cumulative probability curve similar to Figure 2.2. The area under the damage-cumulative probability curve then establishes the expected annual damage for the year. Calculating the area under the curve requires averaging the total damage between adjacent damage points and multiplying by the probability interval between cumulative probabilities corresponding to the damage points (i.e., the trapezoidal integration method). By way of an example, Figure 2.2 shows two labeled points on the damage-cumulative probability curve. The area (valued at $792,000) under the portion of the curve bound by the two points equals the average of $4,900,000 and $380,000 ($2,640,000) times the difference of 0.8 minus 0.5 (0.3). Following this procedure and summing the individual results produces the total area under the curve (i.e., expected annual damage for that year).

Note the expected annual damage will not necessarily occur in a particular year. Rather, over a long time period, the average damage will approach this expected value. The damage-cumulative probability relationship changes every year because background erosion moves the shoreline landward every year. Accounting for this erosive beach behavior requires calculating damage-cumulative probability curves for each project year throughout the period of analysis. Furthermore, the present analysis, consistent with USACE practice, assumes the repair of the preceding year's structural damage before each subsequent year. For example, say a total expected annual damage equals $2,000,000 including $1,250,000 in structural damage and $750,000 in land loss in 2011. Before 2012, this analysis assumes repair of the $1,250,000 structural damage such that the damage could occur again in 2012. Only the land loss ($750,000) becomes ineligible for future years' damage (or benefit). The total project benefit for a given year represents the difference in storm damage between without- and with-project conditions.

Table 2.2 presents an example damage-cumulative probability distribution for a given year without-project conditions. Calculating the expected average interval damage requires three steps. First, average two adjacent total damage estimates of different return period storms. For example, the total damage for one- and two-year return period storms equals $160,500 and $380,000 based on model simulations. The average of these two values equals $270,250. Next, determine the interval probability (0.5) by subtracting the cumulative probability value for the one-year (0.0) from the two-year (0.5) return period storm. Third, multiply the average interval damage ($270,250) by the interval probability (0.5) to yield the expected value interval damage ($135,125). Repeating these calculations for each expected value interval damage calculation and summing produces the expected average annual damage for a given year and project condition. Doing this procedure for each year in the period of evaluation for conditions with and without the project results in expected value annual damages for each year with and without the project. Table 2.3 presents an example storm damage reduction benefit calculation, which shows the cumulative present worth of the storm damage reduction benefit for all years in the period of analysis.

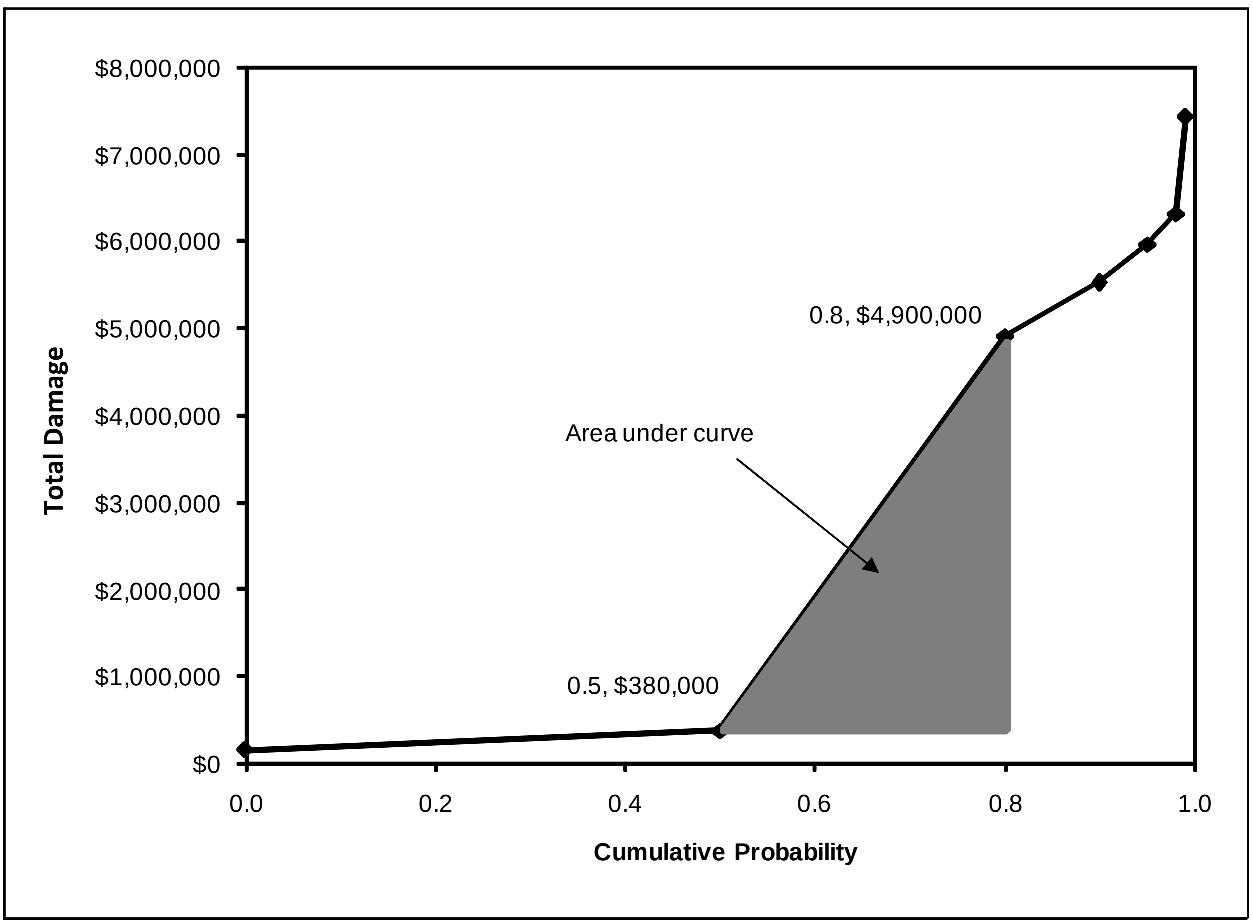

Figure 2.2 Example Damage-Cumulative Probability Curve for a Given Year

Table 2.2 Example of Total Damage-Cumulative Probability (Year 1, without Project)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage
1	1	0.0	$150,000	$10,500	$160,500			
2	0.5	0.5	$290,000	$90,000	$380,000	$270,250	0.5	$135,125
5	0.2	0.8	$1,700,000	$3,200,000	$4,900,000	$2,640,000	0.3	$792,000
10	0.1	0.9	$2,025,000	$3,500,000	$5,525,000	$5,212,500	0.1	$521,250
20	0.05	0.95	$2,260,000	$3,690,000	$5,950,000	$5,737,500	0.05	$286,875
50	0.02	0.98	$2,300,000	$4,000,000	$6,300,000	$6,125,000	0.03	$183,750
100	0.01	0.99	$2,500,000	$4,930,000	$7,430,000	$6,865,000	0.01	$68,650
>100	0.01	0.99	$2,500,000	$4,930,000	$7,430,000	$7,430,000	0.01	$74,300
					Expected Average Annual Damage			$2,061,950

Table 2.3 Example of Storm Damage Reduction Benefit Calculation

Year	Without Project (2010 Prices)	With Project (2010 Prices)	Difference (Benefit)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
2010	$2,061,950	$860,000	$1,201,950	$1,201,950	$1,178,609	$1,178,609
2011	$1,470,000	$520,000	$950,000	$960,450	$941,799	$2,120,408
2012	$1,081,000	$700,000	$381,000	$389,813	$382,243	$2,502,651
2013	$1,980,000	$1,100,000	$880,000	$911,160	$893,466	$3,396,117
2014	$2,000,000	$1,090,000	$910,000	$953,529	$935,012	***$4,331,130***

2.2.2 Beach Visitation Benefits

For beach visitation benefits, this study adopted two categories — spending by out-of-state visitors and recreational enjoyment by all visitors. To develop with- and without-project out-of-state visitor spending requires knowing annual out-of-state visitation, out-of-state visitor spending, and how the with- and without-project conditions affect beach width for each year in the period of analysis. Oden and Butler report out-of-state visitation by percentage of the total beachgoer population, total number of peak day visitors, and spending for various beach sites throughout Texas, including the Galveston seawall area and South Padre Island, based on site-specific beachgoer surveys. Based on these same surveys, Oden and Butler note that people will visit out-of-state beaches instead of Texas beaches if the Texas beaches become increasingly narrower. Note that Oden et al. (2003) report the number of peak visitor days during the year for South Padre Island. Other project analyses assume a number of peak visitor days based on the traditional Memorial Day to Labor Day period or no peak period. All analyses, except for Sylvan Beach, assume beach visitation increases at the same rate as general population increases, namely

1.5%/year (reflecting a weighted average of Texas and U.S. forecast growth, based on the observation that visitors from outside the state generally approach 10% of all visitors).

The present analysis assumes that out-of-state visitor spending per person remains invariant between with- and without-project conditions. Increasing the beach visitation each year by the general population growth rate (1.5%/year) produced estimates of beach population assuming the beach has the capability to accommodate this beach population growth. Because erosion usually reduces beach width, adjustments in beach visitation growth must occur to reflect the effect of narrowing beaches. This visitation reduction then reduces the beach visitation growth that would otherwise take place as a result of general population growth. Calculating the beachgoer population each year (adjusted for beach narrowing) and multiplying by the out-of-state spending times the 1.4 multiplier effect produces the value for any given year. Adjusting these values for inflation and discounting, and summing yields the total benefit (Table 2.4, in bold italic) over the period of analysis.

Table 2.4 Example of Out-of-State Beach Visitor Benefit Calculation

Year	Total Visitation		Out of State				Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
			Visitation		Visitor Spending					
	With Project	Without Project	With Project	Without Project	With Project	Without Project				
2010	102,241	97,438	19,324	18,416	$2,578,891	$2,457,743	$121,148	$121,148	$118,795	$118,795
2011	102,871	97,996	19,443	18,521	$2,594,771	$2,471,806	$122,965	$124,318	$117,215	$236,010
2012	103,496	98,548	19,561	18,626	$2,610,547	$2,485,738	$124,809	$127,696	$115,770	$351,780
2013	104,118	99,095	19,678	18,729	$2,626,213	$2,499,531	$126,682	$131,167	$114,343	$466,122
2014	104,734	99,636	19,795	18,831	$2,641,761	$2,513,179	$128,582	$134,732	$112,933	***$579,056***

Based on 2004 and 2005 site-specific beachgoer surveys, Oden and Butler estimate beach visitation with respect to beach width “elasticity,” which measures the percentage change in annual visitation given a percentage change in beach width, at South Padre Island and Galveston and Surfside beaches. These surveys revealed that the elasticity coefficient of visitation with respect to beach width equals -0.22 at South Padre Island and -0.28 at Galveston and Surfside area beaches. These elasticities mean that should the beach become one-half as wide (50% reduction in beach width), people will reduce their annual beach visits by 11% (i.e., 50% * 0.22) at South Padre Island and 14% (i.e., 50% * 0.28) at Galveston and Surfside area beaches. In short, a 0.22% visitor reduction at South Padre Island and a 0.28% visitor reduction at Galveston and Surfside area beaches occur for every 1% loss of beach width.

Notably, the elasticity relationships described above may differ from today’s condition. New beachgoer surveys might reveal different visitor preferences. No credible method, however, exists to adjust these relationships to reflect today's visitors and conditions. As such, the present study applied established (although possibly dated) relationships.

Regarding reduced visitation as a beach narrows, some minimal low level of visitation would likely still occur even if erosion reduced the beach width to near zero. For example, people may, even with no beach, come to the shore to surf, fish, swim, or view wildlife. Acknowledging this concept requires prescribing a minimal level of visitation at 100% beach width loss. This study adopts 20 – 30% beach visitation (or 70 – 80% reduction in beach visitation) at 100% beach loss. Without this assumption, application of only the Oden and Butler relationship between beach loss and visitation reduction would result in unrealistically and unlikely high beach visitation with complete beach loss. This unrealistically high visitation occurs because Oden and Butler based their evaluation on a survey question as to how beach visitation would change with a 50% loss in beach width. It did not focus on complete beach loss. This study elected to use the Oden and Butler relationship for up to 80% beach width loss, then apply an assumed linear relationship between that level of visitation reduction (for 80% loss of beach width) and 70 – 80% reduction in visitation at 100% beach loss. This assumption likely results in a more realistic relationship than would have been the case with a large discontinuity at the assumed 70 – 80% visitation reduction at 100% beach loss.

In addition, ensuring the projected beachgoer population would not exceed the beach's capacity in any given year required estimating the maximum number of visitors per day the beach could accommodate. Studies by the USACE and Florida Department of Environmental Protection have determined that the average person needs 100 square feet (sf) of dry beach for normal beach activity. The available dry beach surface area divided by 100 sf and multiplied by 2 (for daily turnover rate) yielded this number. Multiplying this result by 365 days produced a supposed maximum annual number of beach visitors for each area. For each year, the analysis adopts the lesser of the projected beachgoer population and capacity. Projections of beach visitation in this study did not exceed maximum capacity for any of the evaluated areas.

The other category of visitation benefits includes recreation for all visitors. Estimating this category of benefits requires knowing the total annual beach visitation with and without the project and the unit day value (UDV). The UDV method (USACE, 2010) relies on expert or informed opinion and judgment to approximate the average "willingness to pay" of users (per person per visit) of recreational projects. The UDV method assigns points to general recreation based on five criteria: (1) recreation experience, (2) availability of opportunity, (3) carrying capacity, (4) accessibility, and (5) environmental.

One rates an individual site based on a total of 100 points. Table 2.5 presents the guidelines for assigning points. Table 2.6 facilitates converting points to dollar values for general recreation.

Assessing both with- and without-project conditions generates the points for each general recreation category in Table 2.5. Summing these points and interpolating that point value against the values shown in Table 2.6 yields with- and without-project UDVs. Applying the beachgoer population difference for with- and without-project conditions each year, multiplying by the appropriate UDV, and then taking the difference produces the benefit for any given year. Adjusting these values for inflation and discounting, and summing yields the total benefit (Table 2.7, in bold italic) over the period of analysis.

This paragraph presents an example of how to assign points to a typical beach area common to the Texas coast. In this example, the beach can accommodate a variety of activities including swimming, surfing, snorkeling, fishing, picnicking, sunbathing, and other active and passive activities. Further, no high quality value activities, defined as activities not common to the region, exist. As such, one could assign a recreation experience value of 10 points to the beach area. Availability of opportunity assigns points based on travel times to the recreational activity. Given visitors have many beaches in the area to choose, one could assign a value of 3 points for availability of opportunity. A typical beach area usually possesses adequate facilities, such as relatively wide dry beach, to allow beachgoers to enjoy their recreational experience. Therefore, this judgment warrants assigning 8 points for carrying capacity. Accessibility measures the ability of visitors to reach the site. Given people can access the beach via good roads, one may assign 14 points for accessibility. Finally, the environmental category judges the site’s aesthetics, such as topography, air and water quality, vegetation, climate, adjacent areas, and pests. In this example, the beach may appear average compared to other area beaches. As such, the beach may warrant 6 points. Summing these assigned points over the five categories yields 41 points. Interpolating between 40 and 50 points on Table 2.6 produces a UDV of about $6.81.

2.2.3 Period of Analysis

Note that the period of analysis varies between the examined projects. Reasons for these variations include differences in project scale, presence of hard structures, expected life of the project, and observations of project performance.

Table 2.5 Guidelines for Assigning Points to General Recreation Projects (USACE, 2010)

Criteria	**Judgment Factors**				
Recreation Experience	Two general activities	Several general activities	Several general activities; one high quality value activity	Several general activities; more than one high quality value activity	Numerous high quality value activities; some general activities
Total Points: 30 Point Value:	0 – 4	5 – 10	11 – 16	17 – 23	24 – 30
Availability of Opportunity	Several within 1 hr travel time; a few within 30 min travel time	Several within 1 hr travel time; none within 30 min travel time	One or two within 1 hr travel time; none within 45 min travel time	None within 1 hr travel time	None within 2 hr travel time
Total Points: 18 Point Value:	0 – 3	4 – 6	7 – 10	11 – 14	15 – 18
Carrying Capacity	Minimum facility for development for public health and safety	Basic facility to conduct activities	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total Points: 14 Point Value:	0 – 2	3 – 5	6 – 8	9 – 11	12 – 14
Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site; fair access, good roads within site	Good access, good road to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Total Points: 18 Point Value:	0 – 3	4 – 6	7 – 10	11 – 14	15 – 18
Environmental	Low aesthetic factors that significantly lower quality	Average aesthetic quality; factors exist that lower quality to minor degree	Above average aesthetic quality; any limiting factors can be reasonably rectified	High aesthetic quality; no factors exist that lower quality	Outstanding aesthetic quality; no factors exist that lower quality
Total Points: 20 Point Value:	0 – 2	3 – 6	7 – 10	11 – 15	16 – 20

Table 2.6 Conversion of Points to Dollar Values for Fiscal Year 2011 (USACE, 2010)

Point Values	General Recreation Values UDV (per person per visit)
0	$3.58
10	$4.26
20	$4.70
30	$5.38
40	$6.72
50	$7.62
60	$8.29
70	$8.74
80	$9.63
90	$10.31
100	$10.75

Table 2.7 Example of Recreation Benefit for All Beach Visitors

Year	Total Visitation		Recreation Value		Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project	With Project	Without Project				
2010	102,241	97,438	$856,783	$663,556	$193,227	$193,227	$189,475	$189,475
2011	102,871	97,996	$862,059	$667,353	$194,706	$196,848	$185,601	$375,076
2012	103,496	98,548	$867,300	$671,114	$196,186	$200,724	$181,977	$557,053
2013	104,118	99,095	$872,505	$674,838	$197,667	$204,666	$178,414	$735,467
2014	104,734	99,636	$877,670	$678,523	$199,148	$208,674	$174,911	***$910,378***

2.3 Natural Resource Restoration Projects

Natural resource restoration projects generally create or enhance an area's natural resources. Examples of previous GLO natural resource restoration projects include those that created beach and wetland habitat, protected estuarine habitats, and other projects that directly or indirectly created, enhanced, or provided protection for the development and sustainability of natural habitats and the plant and animal communities themselves.

This study assesses the economic benefits of marsh restoration in West Galveston Bay. Cost-effective construction of new marsh habitat benefits the ecosystem by increasing area for the life cycle activities of a wide variety of species with commercial and recreational value as well as the many other species that create a self-sustaining community. The marshes also function to capture, filter, and improve the quality of rainfall runoff from adjacent residential areas, and as part of the larger ecosystem, restore some of the carbon-sequestering capacity of the original marsh extent. The larger ecosystem to which this

Galveston Bay restoration contributes also provides storm protection, and each small addition to the system, such as this restoration, provides additional functionality to the human ecosystem.

Similar to the Cycle 4 economic benefits study, the present study quantified natural resource benefits. Estimating these benefits required obtaining the following information:

- Published information on economic benefits of coastal ecosystems, particularly those associated with Texas and adjacent Gulf of Mexico states (particularly Louisiana)
- Information from Galveston Island State Park (GISP) staff and local real estate sales professionals

Site visits and interviews with real estate agencies provided support for the literature values of economic benefit estimates. Interviews with the GISP staff and real estate professionals provided an additional understanding of the expected and already realized benefits of the project.

In addition to those over-arching concepts presented in Section 2.1, the economic benefit estimates developed in this study for the natural resource project rests on two assumptions. First, the project sites provide economic benefits in a manner similar to those described in the literature. This assumption served as a surrogate for the extensive on-site interviews and natural resource evaluations described in the literature pertinent to this study. Second, the West Galveston Bay project has a 20-year period of analysis for benefit accrual based on existing information for similar projects and the performance of the mounded marsh already constructed on the site.

The benefit calculations recognized several categories of accumulating benefits:

- Benefits from recreational and commercial fishing, recreation (fishing, ecotourism, aesthetics), and storm/flood protection functions (to the City of Jamaica Beach, GISP, and other area infrastructure) provided by habitat whose erosion the project prevents. As mentioned above, benefits represent the estimated difference, over the period of analysis, between conditions with and without the project
- Benefits to the area’s water quality provided by newly created marsh area
- Carbon sequestration benefits provided by the additional marsh area

Calculations assumed benefits accrued over the entire project benefit period of analysis for natural resource functions.

In spite of the local real estate business optimism regarding an increase in property values due to the project, this analysis excludes a onetime value increase of the properties immediately bordering the project. While such an effect on real estate values may initially exist, the effect could possibly reverse itself over the life of the project as the created marsh erodes. However, a short discussion of this benefit proves useful to understand what benefit might accrue as a result of the project in a different economic climate.

Project benefits to real estate (residential lots and residences immediately adjacent to the project) often occur as a onetime increase in the property value. Average property values for the local area around a wetland or natural habitat enhancement project, and in particular those properties immediately adjacent to such a project, will often increase due to the perceived increase in aesthetic value. Fausold and Lilieholm (1999) and Kroger and Manalo (2006) provide examples of estimating such benefits. The increased value would benefit the present owners. Any subsequent value reassessment or sale would pass along the property amenity; the presence of the West Galveston Bay project would not result in a further project-related increase in value.

Taylor Engineering grouped the reported natural resource benefit estimates identified in the literature search into the following general categories.

- Commercial fishing
- Recreational fishing
- Recreation
- Storm/flood protection
- Water quality improvement
- Carbon sequestration

Unlike the previous Cycle 4 study, this study included carbon sequestration as one of the ecosystem service functions. Wetlands can provide terrestrial carbon sequestration by removing carbon dioxide from the atmosphere during plant growth. Living growth stores carbon and dead plant material deposits it in the soil. Similar to the previous Cycle 4 study, the present analyses applied the individual values included in many authors' meta-analysis (rather than the data they compiled from literature). Estimates of wetland/aquatic ecosystem service values identified in the literature and used in this analysis (Table 2.8) came primarily from reports that compile and summarize many literature estimates. Considerable overlap in the literature reviewed exists, and much of the data comes from inapplicable studies (e.g. urban wetlands, freshwater wetlands) or estimated values not germane to this study (e.g. hunting benefits).

Table 2.8 Literature Review Summary: Maximum and Minimum Ecosystem Service Values (Adjusted to 2010 Prices)

Environmental Service	Literature Source	Valuation Method	2010 Prices	
			Minimum	Maximum
Commercial fishing	Farber and Constanza (1987)	Net factor income	$86.10	$86.10
	Farber (1996)	Production functions	$62.07	$83.76
	Barbier et al. (1997)	Net factor income	$728.60	$1,944.46
	Woodward and Wui (2000)	Meta-analysis	$1,362.67	$1,362.67
	Bell (2002)	Contingent value	$64.47	$2,387.52
	Xu (2004)	Hedonic	$588.77	$588.77
Recreational fishing	Gosselink et al. (1973)	Net factor income	$374.96	$374.96
	Bell (1997)	Net factor income	$2,161.42	$2,161.42
	Woodward and Wui (2000)	Meta-analysis	$625.29	$625.29
	Xu (2004)	Hedonic	$1,842.69	$2,092.41
Recreation	Bergstrom et al. (1990)	Market value per acre visitor spending recreation	$156.36	$156.36
	Ko (2007)	Travel cost and contingent value	$746.72	$746.72
Storm/flood protection	Farber (1996)	Avoided cost	$1,621.97	$1,621.97
	Woodward and Wui (2000)	Contingent value	$415.10	$688.34
	Boyer and Polasky (2004)	Hedonic and travel cost	$115.88	$115.88
Water quality	Chmura et al. (2003)	Per acre per year if wetlands used over waste facilities	$150.22	$150.22
	Ko (2007)	Avoided cost	$119.63	$119.63
Carbon sequestration	Pearce (2001), Chmura et al. (2003), Tol (2005)	Marginal product estimation	$34.23	$137.93

Benefit calculations excluded environmental service values, which depicted replacement costs of wetlands or replacement of wetlands with infrastructure, because the authors deemed these inappropriate for this restoration project. Table 2.9 summarizes the minimum and maximum per acre dollar value reported for each ecosystem service function. Median values shown represent the medians of the minimum and maximum values shown in Table 2.9.

Benefit calculations assume a fixed annual amount of benefit per acre of a benefit-providing habitat created by the project. Table 2.10 provides an example calculation of the total value of increased recreational fishing over a 10-year period resulting from the creation of 20 acres of an ecologically significant wetland that erodes at a rate of 2 acres per year, with an annual service value (e.g., recreational fishing) of $1,000 per acre. In this example, the difference between a newly created project eroding versus no project results in a total present value benefit of $101,255.

Table 2.9 Ecosystem Service Functions and Values (2010 Prices)

Service Function	Value per Acre		
	Minimum	**Median**	**Maximum**
Recreational fishing	$374.96	$1,179.84	$2,161.42
Commercial fishing	$62.07	$588.77	$2,387.52
Recreation	$156.36	$451.54	$746.72
Storm/flood protection	$115.88	$551.72	$1,621.97
Water quality	$119.63	$134.93	$150.22
Carbon sequestration	$34.23	$86.08	$137.93
Total	$863.13	$2,992.88	$7,205.78

Table 2.10 Example of Benefit Calculation for Erosion of Newly Created Acreage

Year	Relevant Acres		Acres With vs. Without	Benefit Value (2010 Prices)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project					
2011	20	0	20	$20,000	$20,220	$19,827	$19,827
2012	18	0	18	$18,000	$18,416	$17,364	$37,192
2013	16	0	16	$16,000	$16,567	$15,019	$52,211
2014	14	0	14	$14,000	$14,670	$12,788	$64,999
2015	12	0	12	$12,000	$12,800	$10,729	$75,728
2016	10	0	10	$10,000	$10,859	$8,752	$84,480
2017	8	0	8	$8,000	$8,844	$6,853	$91,334
2018	6	0	6	$6,000	$6,752	$5,031	$96,365
2019	4	0	4	$4,000	$4,582	$3,283	$99,648
2020	2	0	2	$2,000	$2,332	$1,607	***$101,255***

3.0 BEACH RESTORATION AND SHORELINE PROTECTION BENEFIT ANALYSIS

3.1 Town of South Padre Island Projects

3.1.1 Background

The Town of South Padre Island lies on a barrier island along the Gulf of Mexico in Cameron County, Texas. It also lies one to four miles north of Brazos Santiago Pass. During Cycles 5 and 6, the GLO and the town nourished its beaches under three separate projects: #1355 South Padre Island Beach Nourishment with Truck Haul (2008), #1356 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material (2009), and #1456 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material (2010). Figure 3.1 shows the extents of each project.

Chronic long-term erosion, storm-related episodic erosion, and upland development characterize the area's beaches. Protecting upland structures and infrastructure from potential storm damage constitutes the major purpose of these projects. Upland development in the project area comprises single-family homes, multifamily homes, and commercial properties. Shorefront structures generally encroach on the shoreline. Based on the maximum predicted erosive shoreline condition, the present analysis includes all Gulf-front properties located about 200 to 300 ft landward of the shoreline. Given the 2010 Cameron Central Appraisal District information, these property values (including structures) approach $100 million.

Economic benefits from the beach projects in the town include storm damage reduction and visitation. Storm damage reduction benefits derived from comparisons of pre- and post-storm conditions with and without the project. Known and probabilistic tropical events served as input.

This analysis adopted two visitation benefit categories — spending by out-of-state visitors and recreational enjoyment by all visitors. Both require estimates of the beachgoer population over the two-year period of analysis. Oden and Butler report about 639 peak day visitors to the Neptune Circle area based on a 2005 survey. According to Oden et al., 104 peak visitor days occur in the South Padre Island area. One-fifth (assumed) of the peak day visitors (128) visit the beach during off peak days and 261 (i.e., 365 – 104) off peak days occur during a 365-day year. Given the above visitor information, approximately 99,864 visits (66,456 [639 * 104] + 33,408 [128 * 261]) occurred in 2005 in the project area.

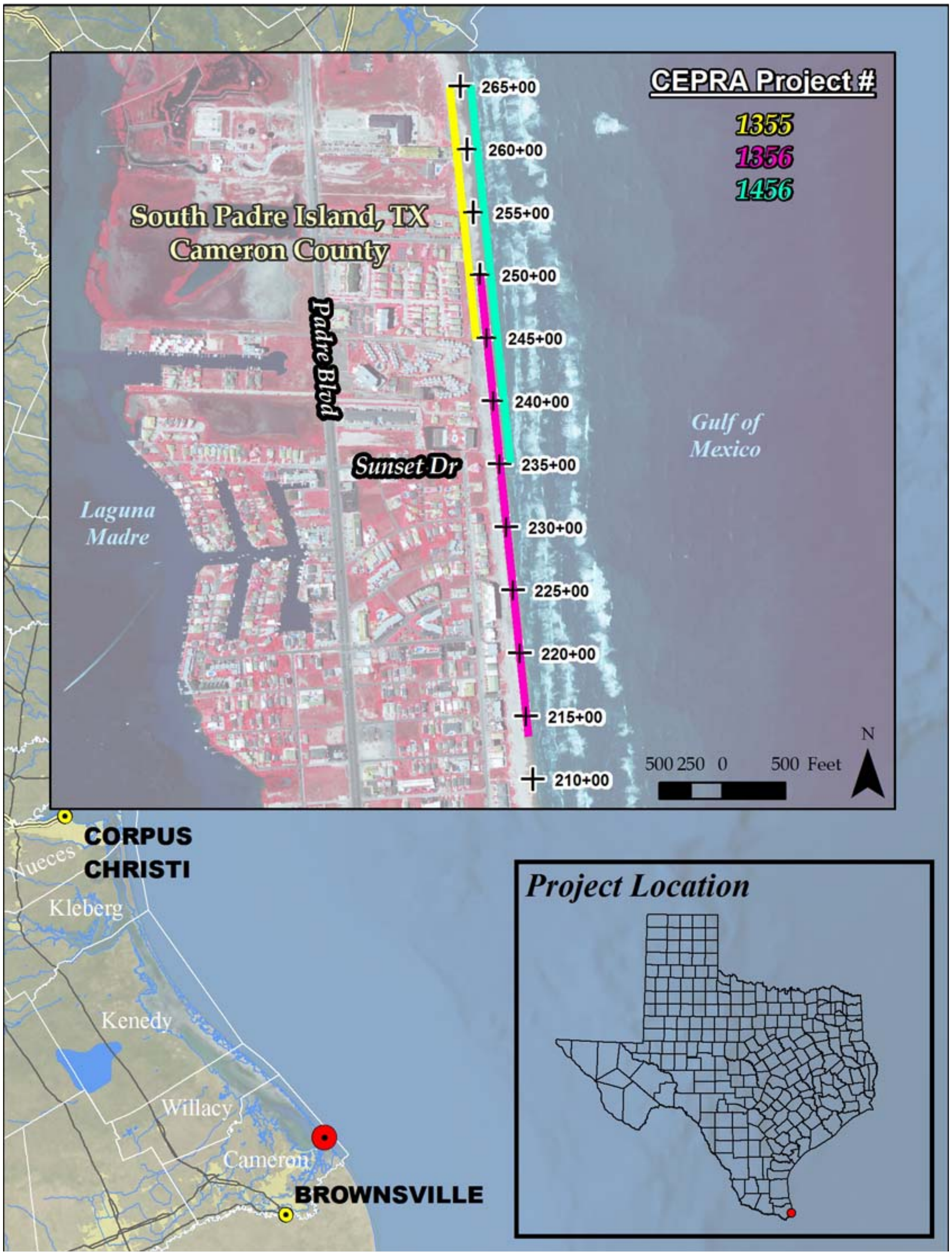

Figure 3.1 Town of South Padre Island Projects Location Map

Pre- and post-construction surveys produced initial with- and without-project beach widths for years 2008, 2009, and 2010. Incorporating the above information yields without- (Table 3.1) and with-project (Table 3.2) visitation estimates. In the tables, the first beach visitation column represents beach visitation given no beach width constraint on visitation (i.e., beach visitation grows at an estimated 1.5% annually). One must calculate this beach visitation number as a starting point in order to apply the beach width elasticity relationship (Oden and Butler, 2006) to determine estimated beach visitation with- and without-the project. Given site-specific data, this analysis adopts the elasticity relationship for South Padre Island where a 0.22% visitor reduction occurs for every 1% loss of beach width. Application of the elasticity relationship to estimated visitation growth and to estimated beach width in relevant years since the time of the survey accounts for beachgoers' beach width preferences. Note that this analysis adopted 30% visitation (or 70% reduction in beach visitation) at 100% beach loss.

Table 3.1 South Padre Island without Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey beach width (ft)	Without project beach width (ft)	Without project % change in beach width	Without project % reduction in visitation	Without project constrained annual visitation
2005	99,864	123	--	--	--	--
2006	101,362	--	--	--	--	--
2007	102,882	--	--	--	--	--
2008	104,426	--	18	-85%	30%	73,098
2009	105,992	--	91	-26%	6%	99,996
2010	107,582	--	70	-43%	9%	97,438
2011	109,196	--	65	-47%	10%	97,996

Notes: Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.22%
Erosion rate = -4.4 ft/yr

Oden and Butler report that 18.9% of the visitors to the Neptune Circle area originate from outside Texas. These out-of-state visitors spend $84.74 (2005 dollars) per person per visit in the area. Inflating this value to 2010 dollars yields $95.33.

The following sections discuss each of the town's three Cycle 5 and 6 projects. Given the overlapping nature of the three projects, the benefit-cost analyses assumed a period of analysis of one year each for projects #1355 and #1356. This study estimated benefits over a two-year period for project #1456 because of its relative size and emergency nature.

Table 3.2 South Padre Island with Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey beach width (ft)	With project beach width (ft)	With project % change in beach width	With project % reduction in visitation	With project constrained annual visitation
2005	99,864	123	--	--	--	--
2006	101,362	--	--	--	--	--
2007	102,882	--	--	--	--	--
2008	104,426	--	84	-31%	7%	97,239
2009	105,992	--	126	3%	0%	105,992
2010	107,582	--	95	-23%	5%	102,241
2011	109,196	--	90	-26%	6%	102,871

Notes: Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.22%
Erosion rate = -4.4 ft/yr

3.1.2 #1355 South Padre Island Beach Nourishment with Truck Haul

Project Description

The project area (Figure 3.1) extended from approximately Stations 245+00 to 265+00. Based on information obtained from the UTBEG, the project area’s shoreline erodes about -3.3 to -5.6 feet per year (ft/yr) with a distance-weighted average of -4.4 ft/yr. Project objectives included nourishing the beach with sand cleared and transported from Park Road 100, the major north-south road on South Padre Island, and clearing this road right-of-way of wind-blown sand. Once constructed, this Cycle 5 project restored approximately 2,000 ft of the most critical eroding segments of the beach with approximately 101,178 cubic yards (cy) of sand removed from Park Road 100’s right-of-way. Construction began March 3, 2008 and ended March 27, 2008. Figure 3.2 presents representative pre- and post-construction photographs. Table 3.3 presents the funding breakdown for the project.

Analysis

Economic benefits from this beach project include storm damage reduction and visitation. Storm damage reduction benefits accounted for known storms. The GLO provided pre- and post-construction beach profile data along the project area. Figure 3.3 presents typical pre- and post-construction profiles. One pre-construction profile and one post-construction profile represents initial without- and with-project conditions for SBEACH modeling.

PRE-NOURISHMENT

POST-NOURISHMENT

Figure 3.2 Town of South Padre Island Beach Pre-and Post-Construction Conditions (February 27, 2008; March 27, 2008; HDR|Shiner Moseley and Associates, 2008b)

Table 3.3 Funding for South Padre Island Project #1355 (2008 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$509,933
Town of South Padre Island	$156,489
Total	$666,421

This study applied model parameters (Table 3.4) presented in Stites et al. for the South Padre Island area.

Table 3.4 SBEACH Model Parameters

Parameter	Value
Transport Rate Coefficient (K)	2.5×10^{-6} m^4/N
Eps Parameter (ε)	0.002 m^2/s
Transport Rate Decay Factor (λ)	0.5 m^{-1}
Avalanching Angle (φ)	35°
Landward surf zone depth	1.0 ft
Median grain size	0.18 – 0.19 mm[†]

[†] HDR|Shiner Moseley and Associates (2007)

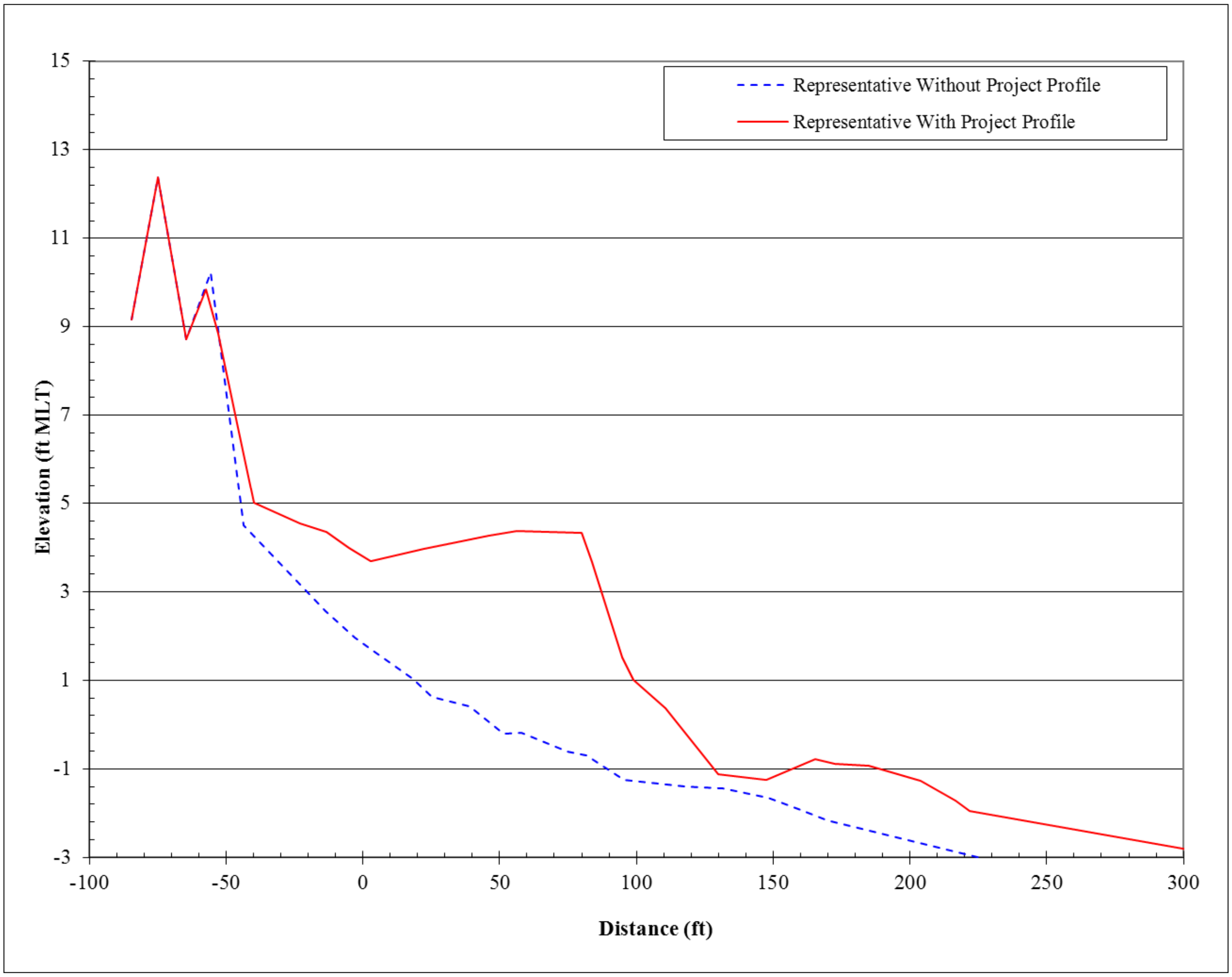

Figure 3.3 Town of South Padre Project #1355 Typical Pre- and Post-Construction Representative Profiles

One storm — Hurricane Dolly (July 20 – 25) — occurred in 2008 after project construction. Estimating project benefits required modeling the without-project condition in SBEACH. Notably, HDR|Shiner Moseley and Associates (2008a) provided a post-Hurricane Dolly profile to represent post-Hurricane Dolly with-project conditions. Figure 3.4 shows the water level elevation, wave height, and wave period for Hurricane Dolly, with water level and wave data derived from TCOON Station 018 (Port Isabel) and NDBC Station 42020 (50 nautical miles southeast of Corpus Christi) measurements.

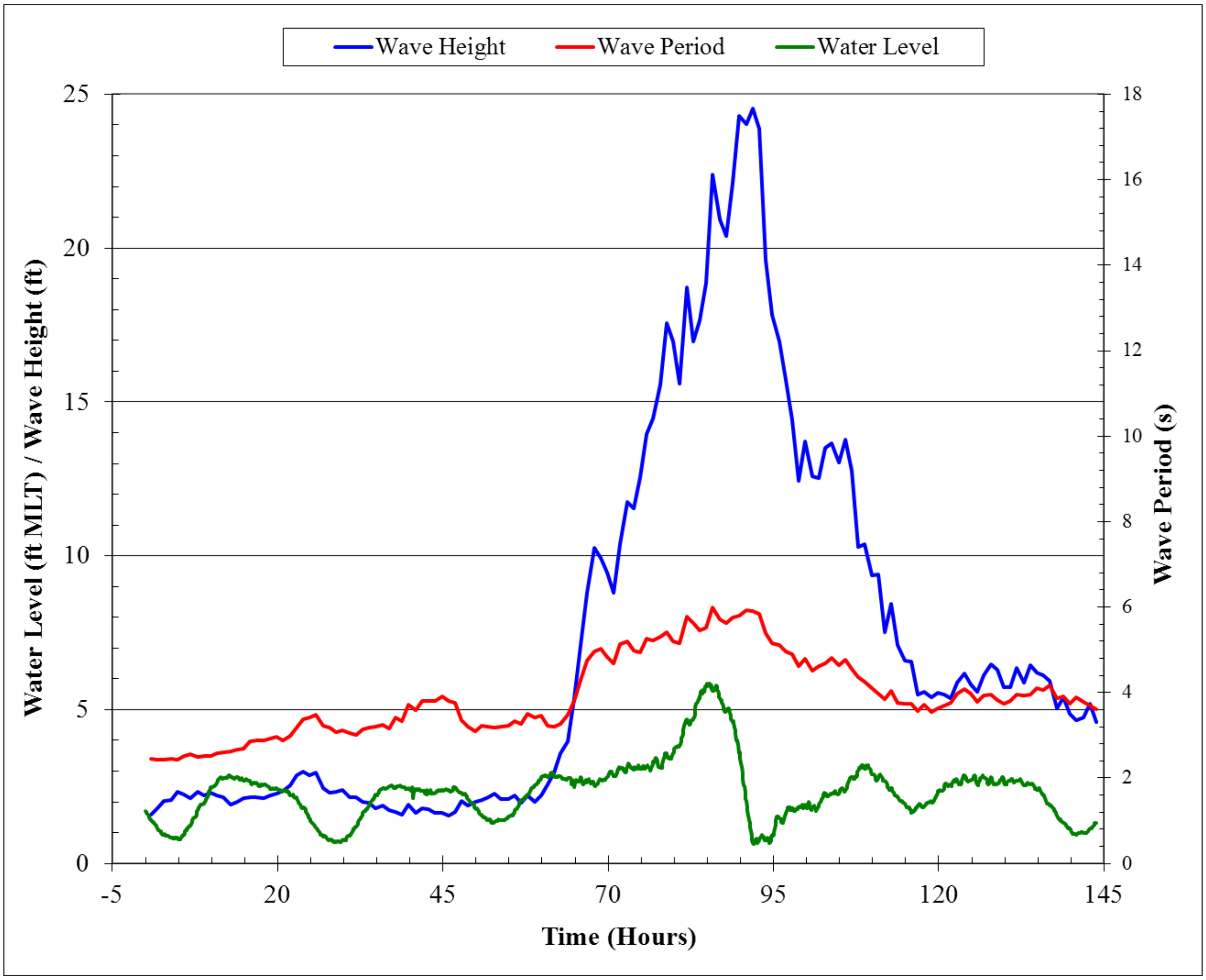

Figure 3.4 Time-Varying Storm Characteristics during Hurricane Dolly

Figure 3.5 presents the post-Dolly profile for without- and with-project conditions. Table 3.5 presents a summary of the recorded and expected storm damage reduction benefits for the beach nourishment project #1355. From the table, the 2008 storm damage reduction benefit equals $361,608. Note that damages with and without the project generally consist of land loss with the without-project condition losing marginally more land.

Table 3.5 South Padre Island Project #1355 Storm Damage Reduction Benefit

Year	Damages Without Project (2010 Prices)	Damages With Project (2010 Prices)	Difference (Benefit)	Benefit (2008 Prices)	Discounted Present Worth
2008	$2,356,943	$1,980,462	$376,481	$368,769	$361,608

Notes: Benefit adjusted from 2010 prices to 2008 prices with the CPI; CPI for 2008 = 215.2 and for 2010 = 219.7; conversion factor = 215.2/219.7 = 0.9795
Discount rate = 4.0% (mid-year discounting)

In addition to storm damage reduction benefits, the project also provided beach visitation benefits. The with- and without-project visitation estimates (Tables 3.1 and 3.2) serve as input for estimating the benefits from spending by out-of-state visitors and the value of recreation benefits for all visitors. Table 3.6 summarizes the benefit to Texas from spending by out-of-state visitors (including the multiplier effect). The present value of this benefit (present value, beginning in 2008) is $584,868.

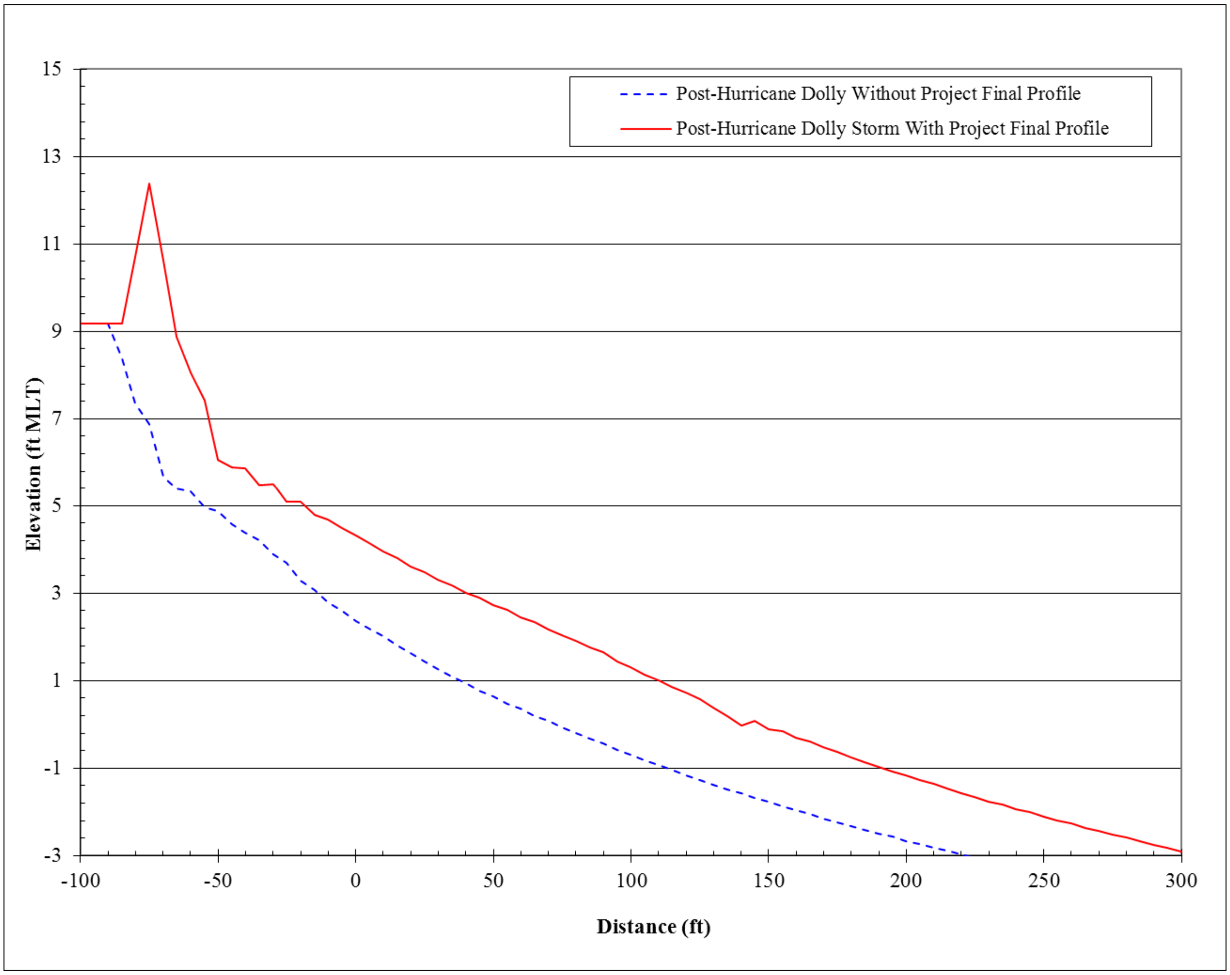

Figure 3.5 South Padre Island Project #1355 with- (Post-Con) and without- (Pre-Con) Project Post-Hurricane Dolly Profile

Calculating recreation enjoyment benefits for all visitors involved applying the visitation numbers derived in Tables 3.1 and 3.2 to the UDV developed (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.7 presents a summary of the points assigned for with- and without-project conditions in the project area. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) results in with- and without-project UDVs of about $8.09 and $6.72 per person per visit. Taking the difference between the estimated recreation value for all visitors with- and without-project estimates yields the benefit for the year. Table 3.8 presents the recreation value benefit for this South Padre Island project. In total, the benefit equals $283,681 (present value, beginning in 2008).

Table 3.6 South Padre Island Project #1355 Out-of-State Visitor Spending Benefit

Year	Total Visitation		Out of State				Difference (2010 Prices)	Benefit (2008 Prices)	Discounted Present Worth
			Visitation		Visitor Spending				
	With Project	Without Project	With Project	Without Project	With Project	Without Project			
2008	97,239	73,098	18,378	13,816	$2,452,712	$1,843,789	$608,923	$596,451	$584,868

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
Out-of-state visitation = 18.9% of total visitation
Out-of-state visitor spending = $95.33 per person (2010 prices)
Multiplier effect = 1.4
Benefit adjusted from 2010 prices to 2008 prices with the CPI; CPI for 2008 = 215.2 and for 2010 = 219.7; conversion factor = 215.2/219.7 = 0.9795
Discount rate = 4.0% (mid-year discounting)

Table 3.7 UDV Points Assigned for South Padre Island Project #1355

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	10	6	30
Availability of Opportunity	3	3	18
Carrying Capacity	11	5	14
Accessibility	18	18	18
Environmental	15	8	20
Total	57	40	100

Table 3.8 South Padre Island Recreation Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference (2010 Prices)	Benefit (2008 Prices)	Discounted Present Worth
	With Project	Without Project	With Project	Without Project			
2008	97,239	73,098	$786,566	$491,218	$295,348	$289,299	$283,681

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
UDV (with project) = $8.09
UDV (without project) = $6.72
Benefit adjusted from 2010 prices to 2008 prices with the CPI; CPI for 2008 = 215.2 and for 2010 = 219.7; conversion factor = 215.2/219.7 = 0.9795
Discount rate = 4.0% (mid-year discounting)

Table 3.9 summarizes the benefit and cost information for this project. The B/C ratio equals 1.85 with a total estimated benefit of about $1.23 million and a cost of about $0.67 million.

Table 3.9 Benefit-Cost Summary for South Padre Island Project #1355 (2008)

Benefit Type	**Discounted Present Worth**
Storm Damage Reduction	$361,608
Visitation	
Out-of-State Spending	$584,868
Recreation	$283,681
Subtotal	$868,549
Total	$1,230,157
Total Cost	$666,421
B/C Ratio	1.85

Note: Dollar values represent present worth equivalents at the beginning of 2008 with a 4% discount rate

As with benefits, the project cost represents the difference between conditions with and without the project. Without the project, the Texas Department of Transportation (TxDOT) would have cleared the sand used for the project from Park Road 100. Only the incremental costs for transporting this sand (extra mileage, additional placement costs) constitute the costs attributable to the project. This study excluded making this adjustment. The total cost of moving the sand from Park Road 100 to the project nourishment site (without subtracting the costs that one would have incurred without the project) represented the estimated project cost. The effect of this on the project's estimated economic performance is likely insignificant.

3.1.3 #1356 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material

Project Description

The project area (Figure 3.1) extended from approximately Station 208+40 (near East Verna Jean Dr.) to Station 255+00 (near White Sands St.). Based on information obtained from the UTBEG, the project area's shoreline erodes about -3.0 to -5.3 ft/yr with a distance-weighted average of -4.1 ft/yr. This constructed Cycle 5 project nourished approximately 4,660 ft of eroding Gulf-front beach with approximately 406,00 cy of material from the Brazos Santiago Pass. Construction began January 8, 2009 and ended February 28, 2009. Figure 3.6 presents representative pre- and post-construction photographs. Figure 3.7 presents typical pre- and post-construction profiles. Table 3.10 presents the funding breakdown for the project. These costs represent the incremental costs for placing the dredged material on the beach.

PRE-NOURISHMENT

POST-NOURISHMENT

Figure 3.6 Town of South Padre Island Beach Pre-and Post-Construction Conditions (January 9, 2009; February 24, 2009; HDR, 2009b)

Table 3.10 Funding for the South Padre Island Nourishment Project #1356 (2009 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$440,083
Town of South Padre Island	$146,694
Total	$586,777

<u>Analysis</u>

In 2009, the Town of South Padre Beach experienced no major storms. Therefore, this project did not provide storm damage reduction benefits in 2009. The project, however, likely provided beach visitation benefits. With- and without-project visitation estimates (Tables 3.1 and 3.2) serve as input for estimating the benefits from spending by out-of-state visitors and the value of recreation benefits for all visitors. Table 3.11 summarizes the benefit to Texas from spending by out-of-state visitors (including the multiplier effect). The present value of this benefit (present value, beginning in 2009) is $144,796.

Calculating recreation enjoyment benefits for all visitors involved applying the visitation numbers derived in Tables 3.1 and 3.2 and to the UDV developed (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.12 presents a summary of the points assigned for with- and without-project conditions in the project area. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) results in with- and without-project UDVs of about $8.38 and $6.81 per person per visit. Taking the difference between the estimated recreation value for all visitors with- and without-project estimates yields the benefit for the year. Table 3.13 presents the recreation value benefit for this South Padre Island project. In total, the benefit equals $198,407 (present value, beginning in 2009).

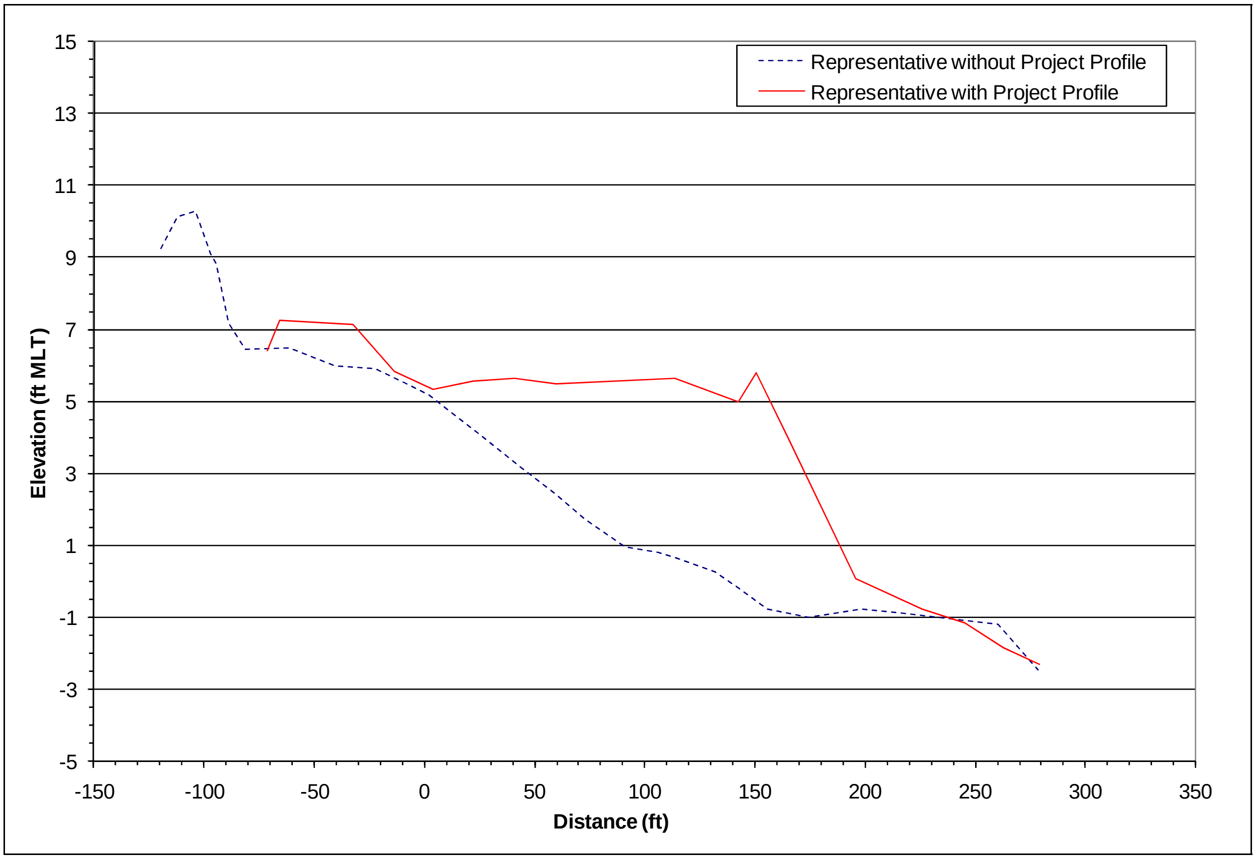

Figure 3.7 Town of South Padre Project #1356 Typical Pre- and Post-Construction Representative Profiles

Table 3.11 South Padre Island Project #1356 Out-of-State Visitor Spending Benefit

Year	Total Visitation		Out of State				Difference	Benefit	Discounted Present Worth
			Visitation		Visitor Spending				
	With Project	Without Project	With Project	Without Project	With Project	Without Project	(2010 Prices)	(2009 Prices)	
2009	105,992	99,996	20,032	18,899	$2,673,494	$2,522,251	$151,243	$147,664	$144,796

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
Out-of-state visitation = 18.9% of total visitation
Out-of-state visitor spending = $95.33 per person (2010 prices)
Multiplier effect = 1.4
Benefit adjusted from 2010 prices to 2009 prices with the CPI; CPI for 2009 = 214.5 and for 2010 = 219.7; conversion factor = 214.5/219.7 = 0.9763
Discount rate = 4.0% (mid-year discounting)

Table 3.12 UDV Points Assigned for South Padre Island Project #1356

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	12	7	30
Availability of Opportunity	3	3	18
Carrying Capacity	12	5	14
Accessibility	18	18	18
Environmental	17	8	20
Total	62	41	100

Table 3.13 South Padre Island Project #1356 Recreation Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference (2010 Prices)	Benefit (2009 Prices)	Discounted Present Worth
	With Project	Without Project	With Project	Without Project			
2009	105,992	99,996	$888,213	$680,972	$207,241	$202,336	$198,407

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
UDV (with project) = $8.38
UDV (without project) = $6.81
Benefit adjusted from 2010 prices to 2009 prices with the CPI; CPI for 2009 = 214.5 and for 2010 = 219.7; conversion factor = 214.5/219.7 = 0.9763
Discount rate = 4.0% (mid-year discounting)

Table 3.14 summarizes the benefit and cost information for this project. The B/C ratio equals 0.58 with a total estimated benefit of about $343,203 and a cost of about $586,777. Even though the estimated B/C ratio falls below one, the project would have provided storm damage protection to upland property should a storm have occurred in 2009. As such, the project would have likely realized storm damage reduction benefits.

Table 3.14 Benefit-Cost Summary for South Padre Island Project #1356 (2009)

Benefit Type	**Discounted Present Worth**
Visitation	
Out-of-State Spending	$144,796
Recreation	$198,407
Subtotal	$343,203
Total	$343,203
Total Cost	$586,777
B/C Ratio	0.58

Note: Dollar values represent present worth equivalents at the beginning of 2009 with a 4% discount rate

3.1.4 #1456 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material

<u>Project Description</u>

The project area (Figure 3.1) extended from approximately Stations 235+00 to 265+00. Based on information obtained from the UTBEG, the project area's shoreline erodes about -3.3 to -5.6 ft/yr with a distance-weighted average of -4.6 ft/yr. This constructed Cycle 6 project nourished approximately 3,000 ft of eroding Gulf beach with approximately 130,000 cy of dredged material from the Brazos Santiago Pass. Construction began February 25, 2010 and ended March 12, 2010. Figure 3.8 presents representative pre- and post-construction photographs. Table 3.15 presents the funding breakdown for the project.

PRE–NOURISHMENT

POST–NOURISHMENT

Figure 3.8 Town of South Padre Island Beach Pre-and Post-Construction Conditions (January 28, 2010; March 15, 2010; HDR, 2010b)

Table 3.15 Funding for the South Padre Island Project #1456 (2010 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$444,494
Town of South Padre Island	$148,314
Total	$593,258

Note: The GLO shared project costs with project #1453.

Analysis

Economic benefits from this beach project include storm damage reduction and visitation. Storm damage reduction benefits accounted for known storms. The GLO provided pre- and post-construction beach profile data along the project area. Figure 3.9 presents typical pre- and post-construction profiles. One pre-construction profile and one post-construction profile represents initial without- and with-project conditions for SBEACH modeling. This study applied the model parameters shown in Table 3.4.

Two storms — Hurricane Alex (June 25 – July 2, 2010) and Tropical Storm Hermine (September 4 – 10, 2010) — occurred in 2010 after project construction. Figures 3.10 and 3.11 show the water level elevation, wave height, and wave period for both storms. Water level and wave data originated from TCOON Station 051 (South Padre Island) and NDBC Station 42020 (50 nautical miles southeast of Corpus Christi) measurements.

Estimating project benefits required modeling with- and without-project conditions in SBEACH. Taylor Engineering first modeled the effects of Hurricane Alex and Tropical Storm Hermine for the year 2010. Then the study applied synthetic storms for the year 2011 on the resulting post-storm 2010 with- and without-project profiles.

To simulate 1-, 2-, 5-, 10-, 20-, 50-, and 100-year storm events, this study applied a synthetic storm with characteristics corresponding to the return period under consideration. Each synthetic storm consisted of an associated storm tide, wave height, and wave period. This analysis applied storm characteristics (Table 3.16) as previously described in Stites et al.

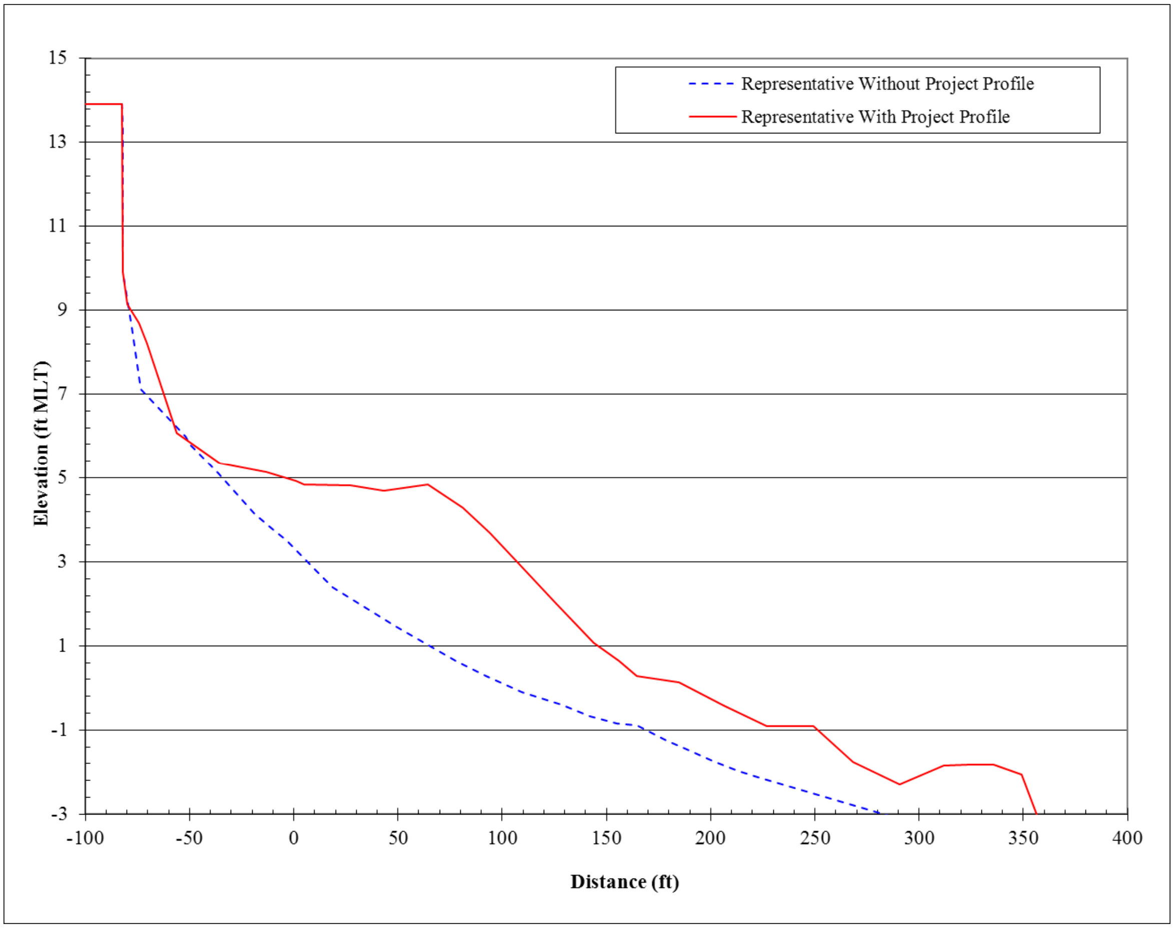

Figure 3.9 Town of South Padre Project #1456 Typical Pre- and Post-Construction Representative Profiles

With a typical storm event lasting about 36 hours, distributing the peak storm characteristics over a 36-hour period simulates the passage of a storm and provides a realistic storm model. Before the storm period, three normal tide cycles initialized the model. For a diurnal tide typical of this area, three tidal cycles last about 72 hours. Therefore, each simulation covers a 108-hour time period.

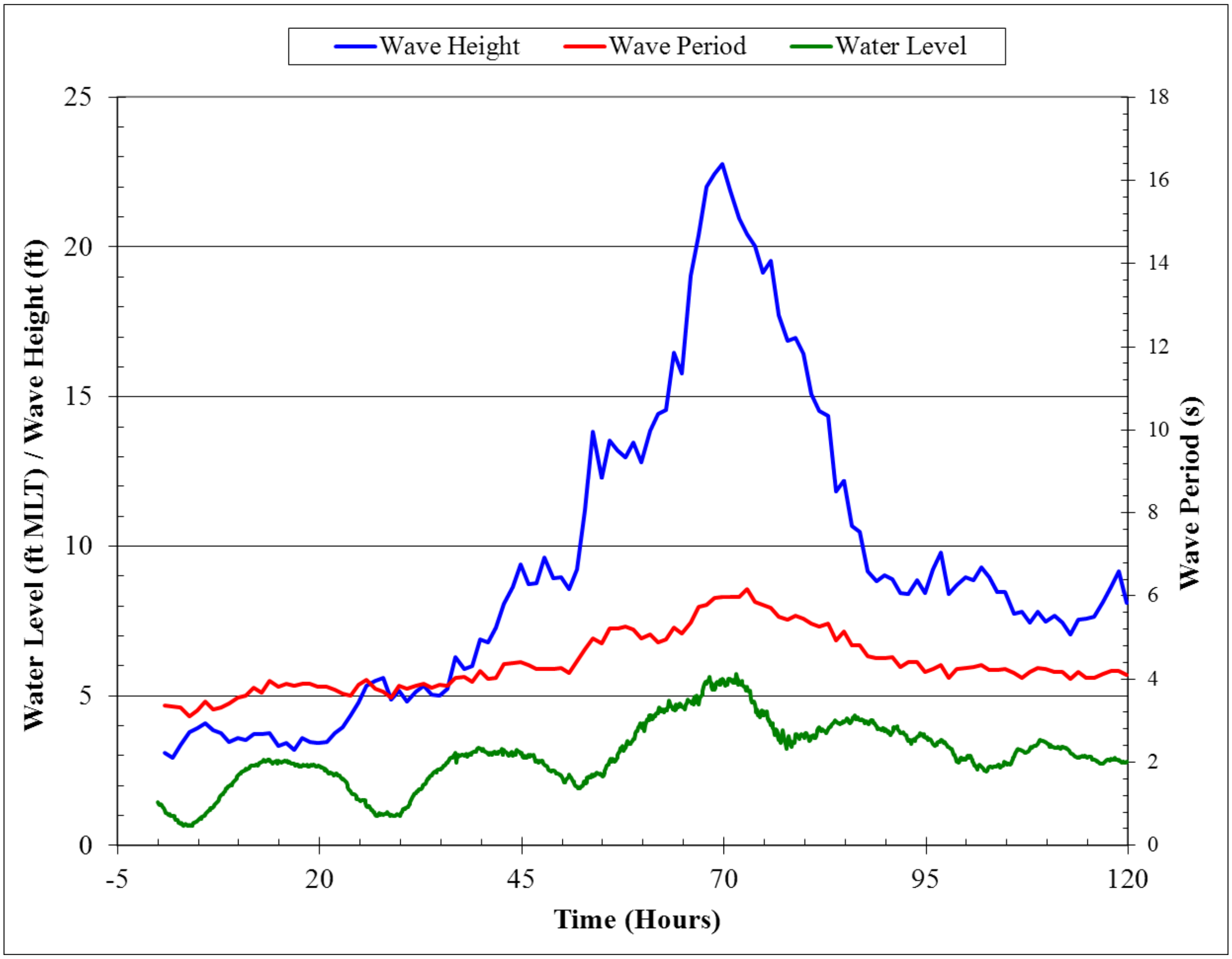

Figure 3.10 Time-Varying Storm Characteristics during Hurricane Alex (2010)

Table 3.16 South Padre Island Peak Storm Characteristics for Various Return Periods (Derived from Stites et al., 2008)

Return Period (yr)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
Storm Tide (ft MLT)[1]	5.3	6.2	7.5	8.4	9.4	10.9	11.5
Nearshore Wave Height (ft)	3.1	5.6	9.0	11.4	14.2	17.3	19.9
Nearshore Wave Period (s)	7.2	8.1	9.2	10	11	12	12.9

[1]MLT = -0.9 ft National Geodetic Vertical Datum

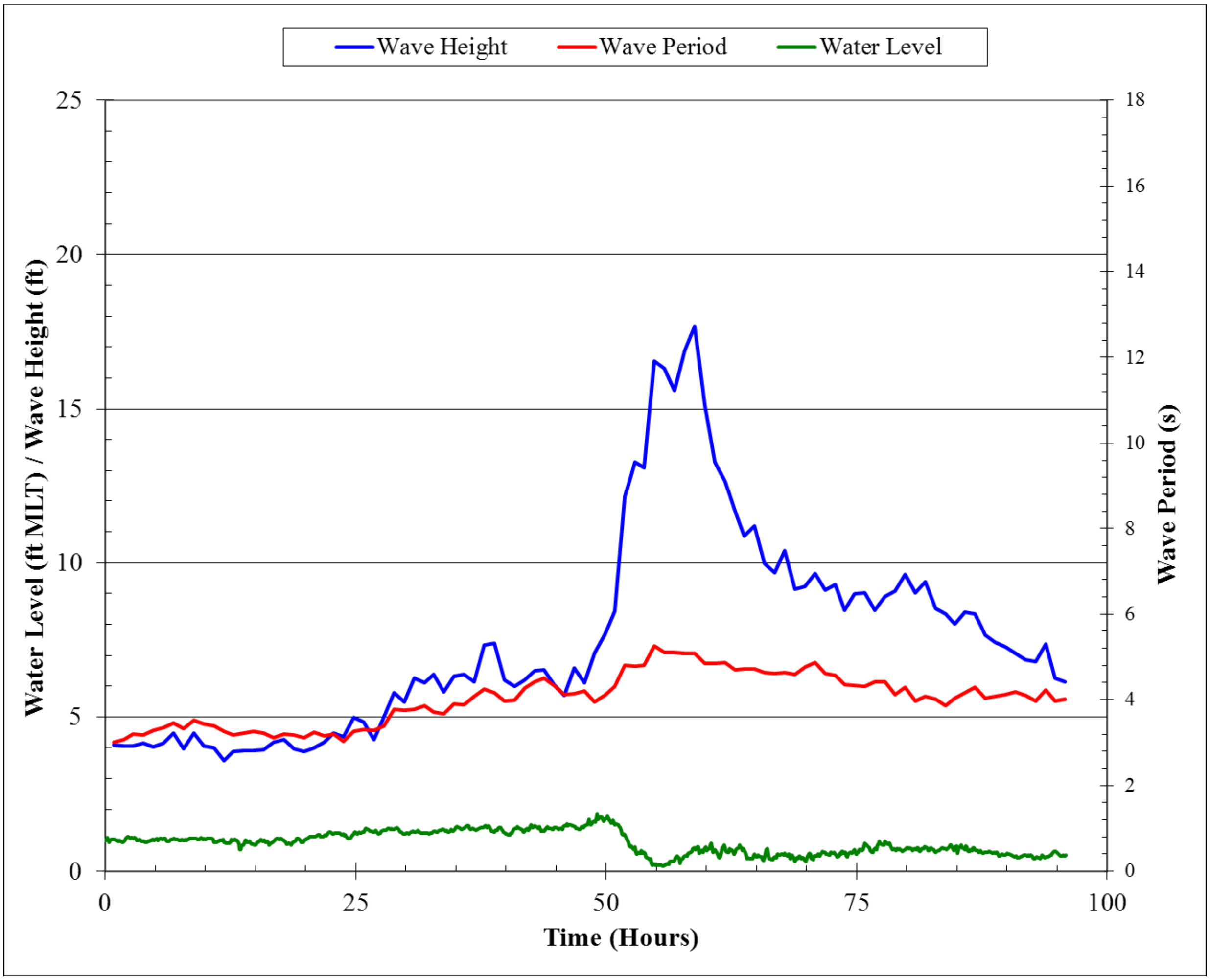

Figure 3.11 Time-Varying Storm Characteristics during Tropical Storm Hermine (2010)

To develop synthetic time-varying storm surge hydrographs, many authors (e.g., Kriebel, 1989) have applied sine squared distributions such as

$$S(t) = S_p \sin^2(\pi \frac{t-36}{36}) \tag{3.1}$$

where S is the storm tide (ft MLT), t is time (hours), and S_p is the peak storm tide elevation (ft MLT). The final water surface elevation time series consists of three standard tidal cycles (about 72 hours) developed from a normally varying tide from mean high water (1.48 ft MLT) to mean low water (0.36 ft MLT), followed by the return period specific storm surge hydrograph. Generating the normal tidal cycles requires applying the following equation:

$$S(t) = 1.12\cos^2(\pi \frac{t - 24.8}{24.8}) + (0.36) \tag{3.2}$$

Minor smoothing at the transition prevented abrupt changes in the water surface elevation. Figure 3.12 shows the final 1-, 2-, 5-, 10-, 20-, 50-, and 100-year hydrographs.

As with the storm surge, the temporal wave height variation consisted of two parts. A cosine squared distribution (Eq. 3.3) approximated the wave heights during normal conditions over the first 72 hours (3 tidal cycles), followed by a sine squared distribution (Eq. 3.4) which approximated the storm wave heights over 36 hours.

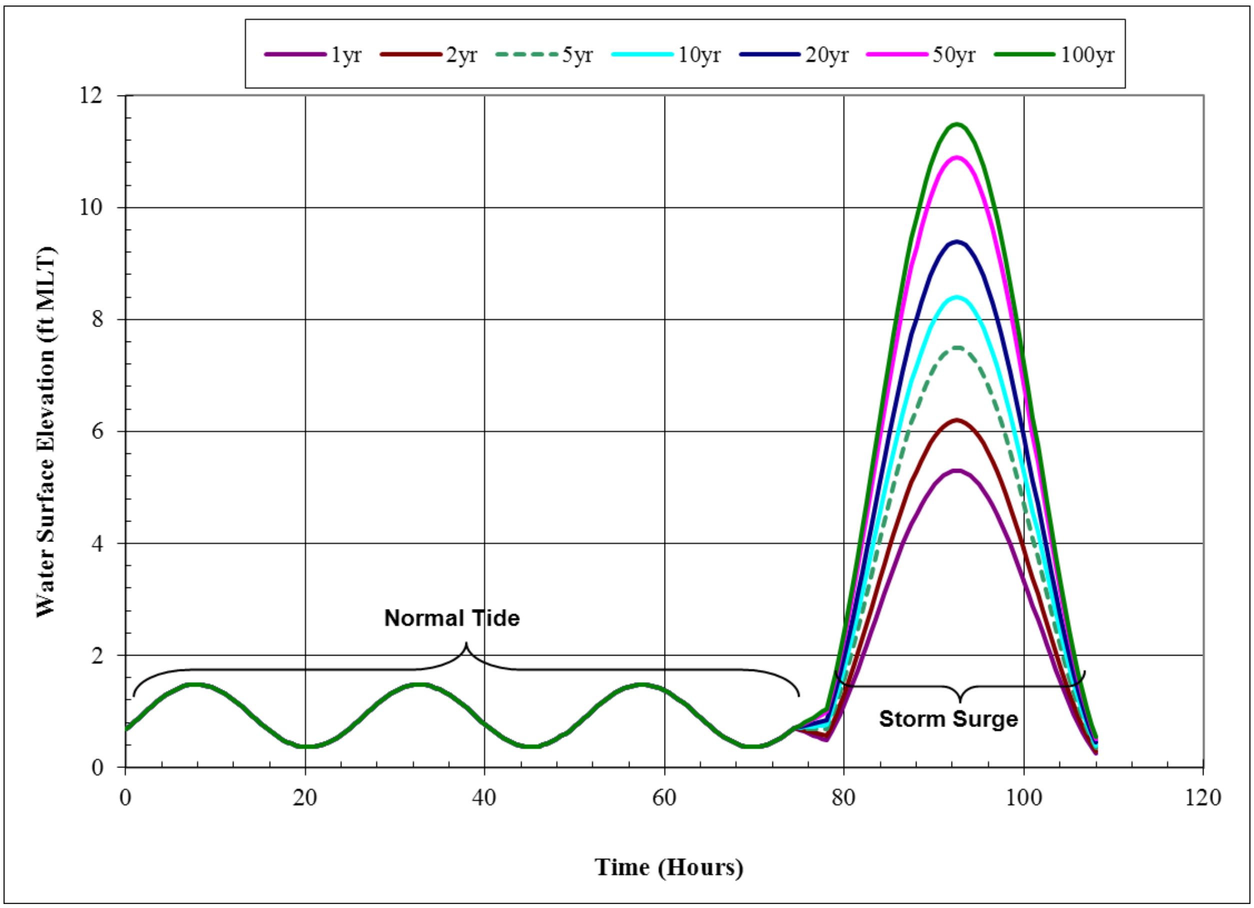

Figure 3.12 South Padre Island Synthetic, Time-Varying Water Surface Elevations

$$H(t) = 1.5\cos^2(\pi \frac{t - 24.8}{24.8}) + 1.5 \tag{3.3}$$

and

$$H(t) = (H_p - H_{\min})\sin^2(\pi \frac{t-36}{36}) + H_{\min} \tag{3.4}$$

where H is the wave height (ft), H_p is the peak wave height (ft), and H_{min} is the minimum wave height following a storm.

Each tidal cycle averaged 24.8 hours, and the wave heights varied from 1.0 to 2.0 ft for 1- and 2-year hydrographs and 1.5 to 3.0 ft for all other return period hydrographs. These conditions represent the relatively calm conditions frequently observed in the Gulf of Mexico. Storm wave heights varied from 2 to 5 ft to the peak wave height (Table 3.16) and abate to 2 to 5 ft after storm passage. The 2-to-5-ft values for H_{min} (minimum wave height following storm) simulate the agitated sea conditions typically found after a storm passes an area. Figure 3.13 shows the resulting wave height distributions the model requires.

During the first 72 hours of normal conditions, the wave period varies from three to four seconds for 1-, 2-, and 5-year return period storms according to a cosine-squared distribution with a tidal cycle of 24.8 hours. The wave period varies from four to five seconds for 10-, 20-, 50-, and 100-year return period storms according to a cosine-squared distribution with a tidal cycle of 24.8 hours. Similarly, a sine squared distribution approximated the storm wave periods over the final 36 hours with a minimum final wave period of five (1-, 2-, and 5-year return period storms) and six (10-, 20-, 50-, and 100-year storms) seconds. Figure 3.14 shows the resulting wave period distributions the model requires.

SBEACH produced post-storm profiles for Hurricane Alex, Tropical Storm Hermine, and 1-, 2-, 5-, 10-, 20-, 50-, and 100-year storms for with- and without-project profiles for 2010 and 2011. Figure 3.15 presents a typical post-storm profile for without- and with-project conditions for the 5-year storm.

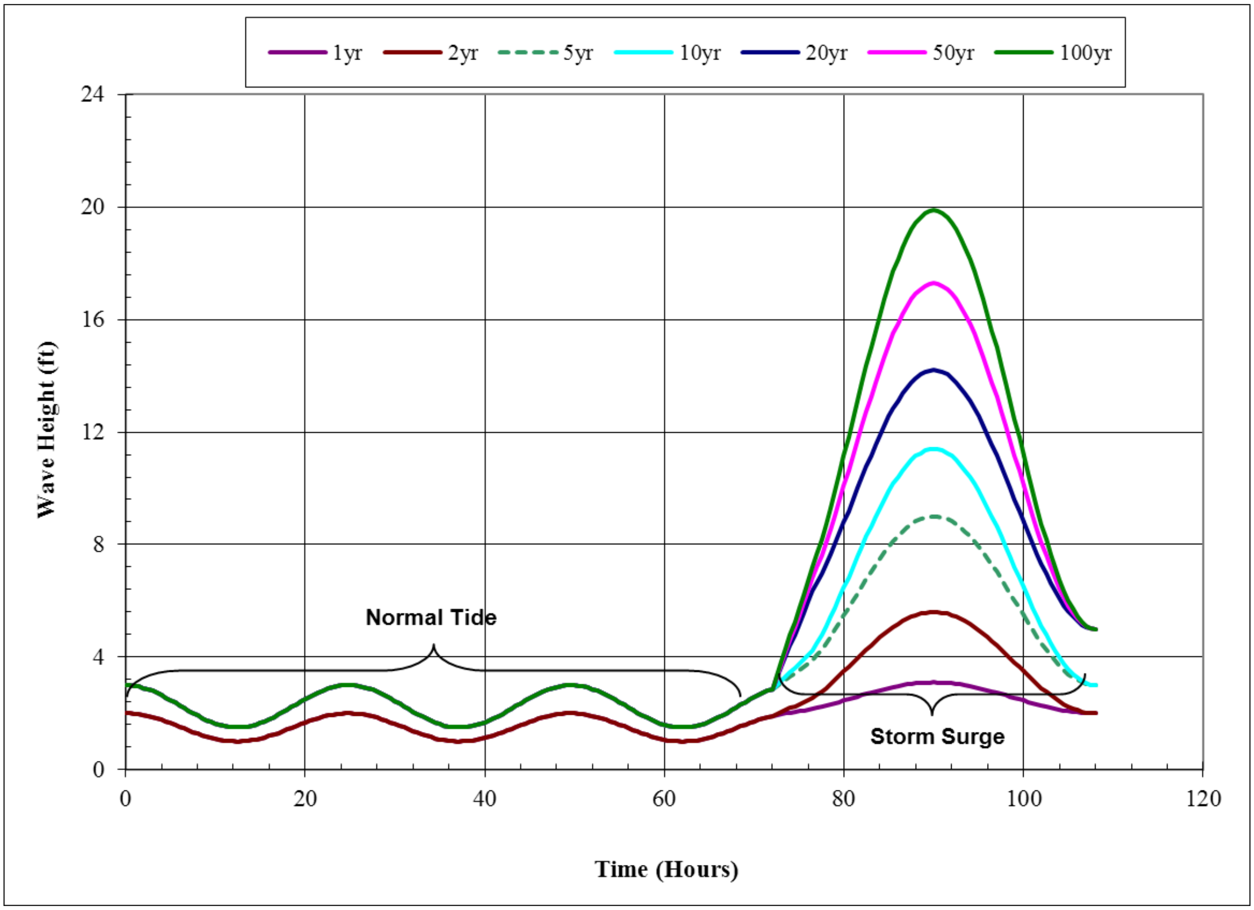

Figure 3.13 South Padre Island Synthetic, Time-Varying Wave Heights

The methodology outlined in Section 2.2 and the site-specific information described above produces the damage-cumulative probability distribution for the year 2011 with and without the project. Table 3.17 presents the damage-cumulative probability distribution for 2011 without-project conditions. From the table, the expected annual total damage for this condition averages approximately $7.7 million. Appendix A presents these distributions for 2011 with- and without-project conditions.

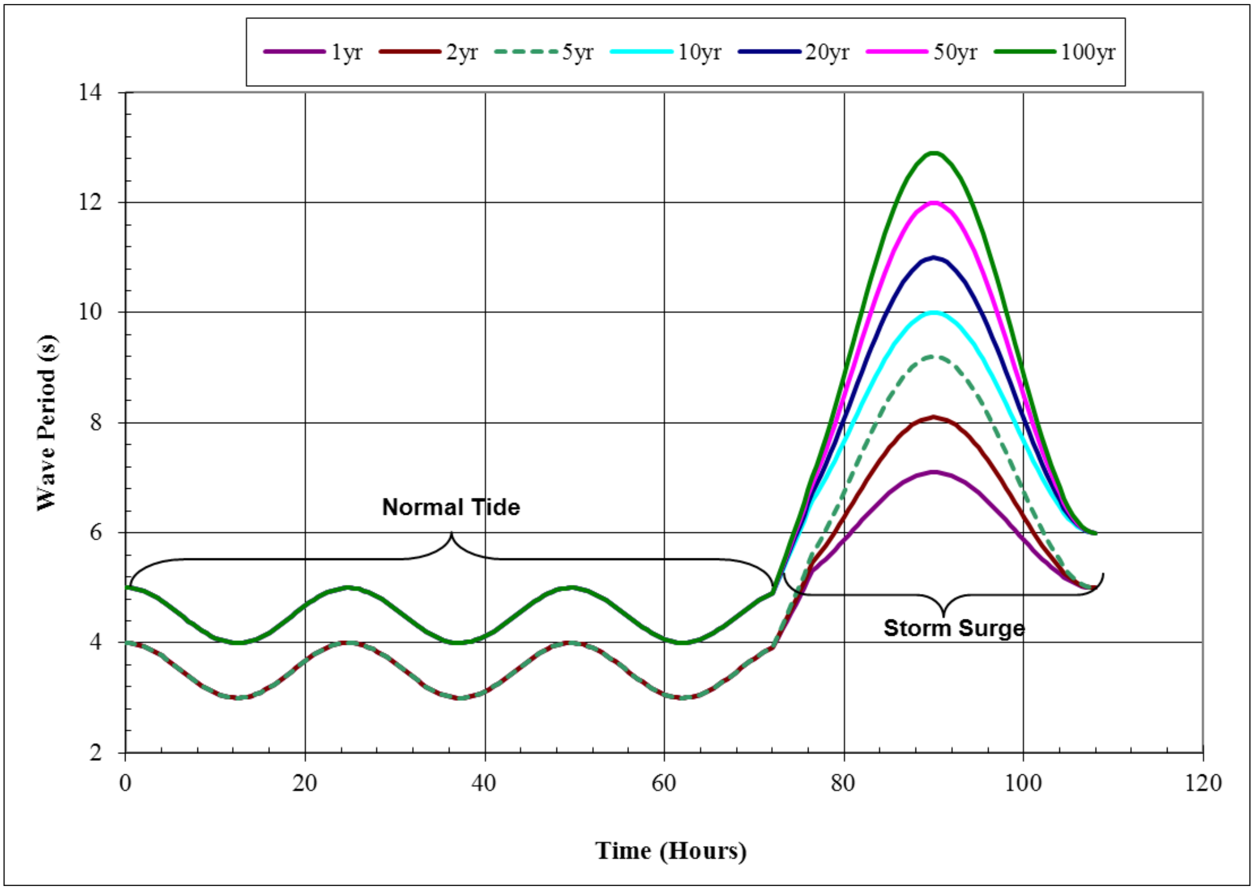

Figure 3.14 South Padre Island Synthetic, Time-Varying Wave Periods

Table 3.18 presents a summary of the recorded and expected storm damage reduction benefits for the beach nourishment project #1456. From the table, the storm damage reduction benefit equals $2,858,936 over the two-year period of analysis.

In addition to storm damage reduction benefits, the project also provided beach visitation benefits. The with- and without-project visitation estimates serve as input for estimating the benefits from spending by out-of-state visitors and the value of recreation benefits for all visitors. Table 3.19 summarizes the benefit to Texas from spending by out-of-state visitors (including the multiplier effect). The present value of this benefit for the two-year period of analysis is $236,010.

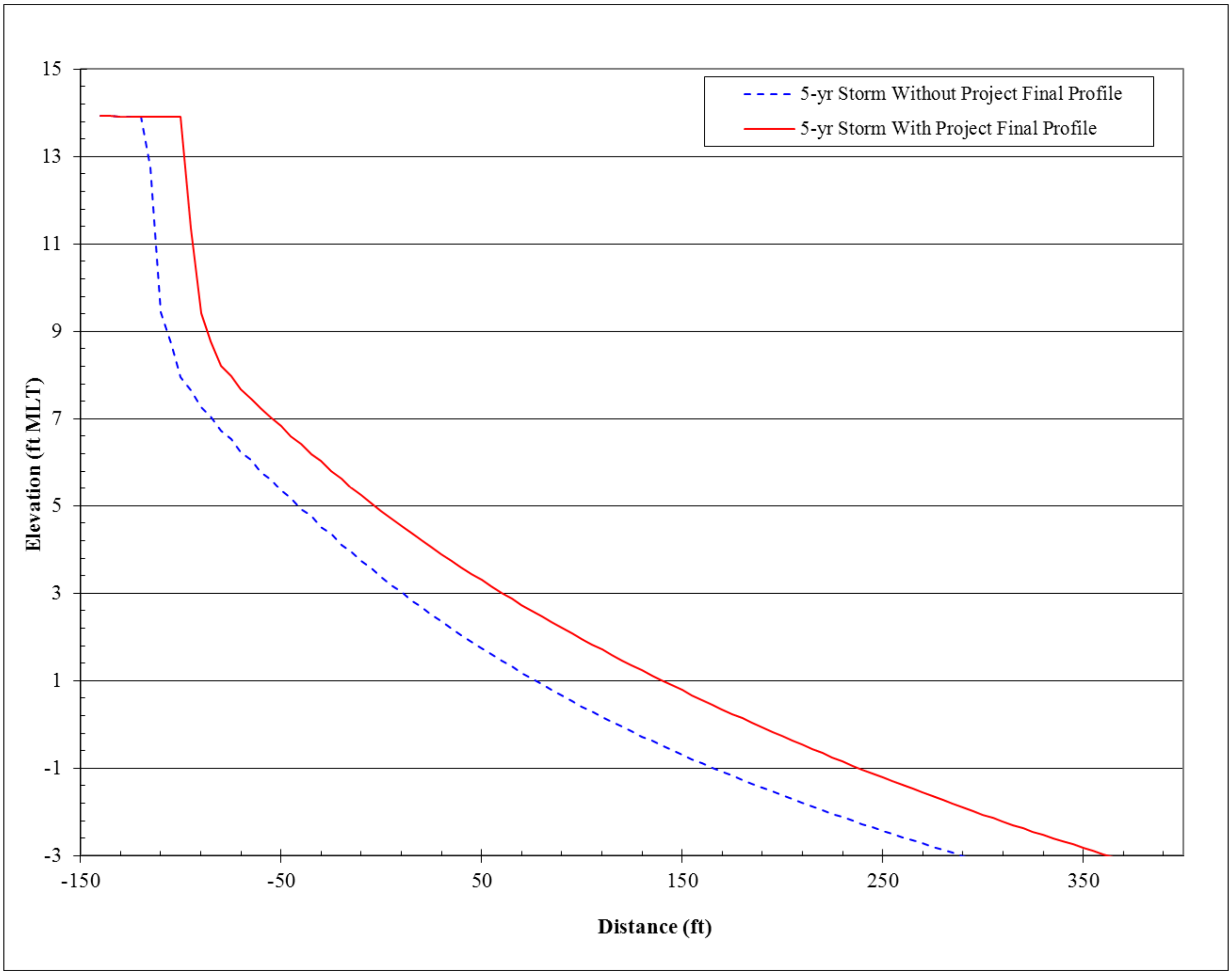

Figure 3.15 South Padre Island Project #1456 with- (Post-Con) and without- (Pre-Con) Project Typical Five-Year Post-Storm Profile

Calculating recreation enjoyment benefits for all visitors involved applying the visitation numbers derived in Tables 3.1 and 3.2 to the UDV developed (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.20 presents a summary of the points assigned for with- and without-project conditions in the project area. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) results in with- and without-project UDVs of about $8.38 and $6.81 per person per visit. Taking the difference between the estimated recreation value for all visitors with- and without-project estimates yields the benefit for the year. Table 3.21 presents the recreation value benefit for this South Padre Island project. In total, the benefit equals $375,076 over the two-year period of analysis.

Table 3.17 South Padre Island Project #1456 Total Damage-Cumulative Probability (2011, without Project)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage
1	1.00	0.00	$3,749,609	$0	$3,749,609			
2	0.50	0.50	$4,393,833	$246,708	$4,640,541	$4,195,075	0.50	$2,097,538
5	0.20	0.80	$4,941,621	$1,068,732	$6,010,352	$5,325,447	0.30	$1,597,634
10	0.10	0.90	$8,481,650	$4,939,335	$13,420,985	$9,715,669	0.10	$971,567
20	0.05	0.95	$13,133,372	$14,182,060	$27,315,433	$20,368,209	0.05	$1,018,410
50	0.02	0.98	$19,968,863	$25,420,127	$45,388,990	$36,352,211	0.03	$1,090,566
100	0.01	0.99	$21,541,994	$27,557,998	$49,099,992	$47,244,491	0.01	$472,445
>100	<0.01	>0.99	$21,541,994	$27,557,998	$49,099,992	$49,099,992	0.01	$491,000
			Expected Average Annual Damage in 2010 Prices:					$7,739,160

Table 3.18 South Padre Island Project #1456 Storm Damage Reduction Benefit

Year	Without Project (2010 Prices)	With Project (2010 Prices)	Difference (Benefit)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
2010	$4,170,251	$3,477,168	$693,083	$693,083	$679,624	$679,624
2011	$7,739,160	$5,452,939	$2,286,221	$2,311,370	$2,179,312	***$2,858,936***

Notes: Inflation rate = 1.1% for 2011
Discount rate = 4.0% (mid-year discounting)

Table 3.19 South Padre Island Project #1456 Out-of-State Visitor Spending Benefit

Year	Total Visitation		Out of State				Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
			Visitation		Visitor Spending					
	With Project	Without Project	With Project	Without Project	With Project	Without Project				
2010	102,241	97,438	19,324	18,416	$2,578,891	$2,457,743	$121,148	$121,148	$118,795	$118,795
2011	102,871	97,996	19,443	18,521	$2,594,771	$2,471,806	$122,965	$124,318	$117,215	***$236,010***

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
Out-of-state visitation = 18.9% of total visitation
Out-of-state visitor spending = $95.33 per person (2010 prices)
Multiplier effect = 1.4
Inflation factor = 1.1% for 2011
Discount rate = 4.0% (mid-year discounting)

Table 3.20 UDV Points Assigned for South Padre Island Project #1456

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	12	7	30
Availability of Opportunity	3	3	18
Carrying Capacity	12	5	14
Accessibility	18	18	18
Environmental	17	8	20
Total	62	41	100

Table 3.21 South Padre Island Project #1456 Recreation Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project	With Project	Without Project				
2010	102,241	97,438	$856,783	$663,556	$193,227	$193,227	$189,475	$189,475
2011	102,871	97,996	$862,059	$667,353	$194,706	$196,848	$185,601	***$375,076***

Notes: Total visitation estimates derive from Tables 3.1 and 3.2
UDV (with project) = $8.38
UDV (without project) = $6.81
Inflation factor = 1.1% for 2011
Discount rate = 4.0% (mid-year discounting)

Table 3.22 summarizes the benefit and cost information for this project. The B/C ratio equals 5.85 with a total estimated benefit of about $3.47 million and a cost of about $0.59 million. Cost-sharing with project #1453 and taking advantage of relatively small incremental costs (because of large federal cost share on these projects) to place dredged material on the beach appears a worthy strategy.

Table 3.22 Benefit-Cost Summary for South Padre Island Project #1456 (2010 – 2011)

Benefit Type	**Discounted Present Worth**
Storm Damage Reduction	$2,858,936
Visitation	
Out-of-State Spending	$236,010
Recreation	$375,076
Subtotal	$611,086
Total	$3,470,022
Total Cost	$593,258
B/C Ratio	5.85

Note: Dollar values represent present worth equivalents at the beginning of 2010 with a 4% discount rate

3.1.5 Summary

While individually some of these projects may appear economically unjustified, all of these projects, taken together, show that placing sand on the Town of South Padre Island's beaches appears economically justified. Converting all project benefits and costs to equivalent present value amounts at a common time point and dividing the summed benefits by the summed costs yields a B/C ratio of 2.68 for this group of Cycle 5 and 6 projects.

Table 3.23 Benefit-Cost Summary for South Padre Island Projects #1355, #1356, and #1456

Project #	Total Discounted Benefits	Total Discounted Costs
1355	$1,330,538	$720,801
1356	$356,931	$610,248
1456	$3,470,022	$593,258
Total	$5,157,491	$1,924,307
B/C Ratio	2.68	

Note: Dollar values represent present worth equivalents at the beginning of 2010 with a 4% discount rate

3.2 #1379 Surfside Revetment Project

3.2.1 Project Description

The Village of Surfside Beach lies immediately north of the Freeport Ship Channel Entrance along the Gulf of Mexico in Brazoria County, Texas. The project area (Figure 3.16) extends from the channel's north jetty northeast to State Road 332. Chronic long-term erosion, storm-related episodic erosion, and upland development characterize the area's beaches. Based on information obtained from UTBEG, the project area's shoreline erodes about -3.2 ft/yr on average. Upland development in the project area generally comprises single-family homes. Shorefront structures generally lie close to the shoreline.

In summer (June through August) 2008, the GLO constructed the revetment along Beach Drive between Texas Street and Whelk Street to protect upland property from erosion and storm damage. Immediately after construction, Hurricane Ike made landfall in Galveston and decimated Galveston Island. Compared to the local statistical distribution of storms, Hurricane Ike had a 30-year return period (Coast and Harbor Engineering [CHE], 2008). The GLO designed the Surfside Beach revetment for a two-year return period storm. The revetment and road suffered damage costing approximately $919,050 to repair (CHE, 2008).

Figures 3.17 and 3.18 present pre-construction and post-construction photographs. Table 3.24 presents the funding breakdown for the project. Notably, any costs that originate from national agencies or organizations decrease by 90% (see Section 2.1) to account for the fact that some entity other than the state of Texas incurs those costs. Federal dollars fund the Federal Emergency Management Agency (FEMA) and Texas contributes, roughly in proportion to Texas' share of the national population, about 10% of the federal dollars through individual and corporate taxes. Given 90% of FEMA's $793,613 originates from non-Texas sources, one may reduce the cost to Texas by $714,251 (i.e., 0.9 * $793,613). Therefore, the project cost to Texas revises downward for this benefit-cost analysis from $1,984,033 to $1,269,781 (i.e., $1,984,033 - $714,251).

Table 3.24 Funding for the Surfside Revetment Project (2008 Prices)

Funding Source	**Amount**
Texas General Land Office, Coastal Erosion Planning and Response Act	$1,190,420
Federal Emergency Management Agency (via Village of Surfside) (Texas only)	$793,613 ($79,361)
Total (Texas only)	$1,984,033 ($1,269,781)

3.2.2 Analysis

Economic benefits from the revetment in Surfside Beach include only storm damage reduction. Anecdotal evidence suggested beach visitation remained unaffected by the presence of the revetment. This study performed benefit calculations over a five-year period given the large probability of storms greater than the two-year return period storm that could occur over a five-year period.

Storm damage reduction benefits accounted for known storms and probabilistic future storms. The GLO provided pre- and post-construction beach profile data along the project area. One pre-construction and one post-construction profile represent the initial without- and with-project conditions for the SBEACH modeling (Figure 3.19). Unfortunately the present study failed to identify any previous SBEACH model calibration parameters specific to the project area. Therefore, this analysis adopted model parameters specified in HDR (2009c) for West Galveston Island. Table 3.25 shows the applied SBEACH model parameters.

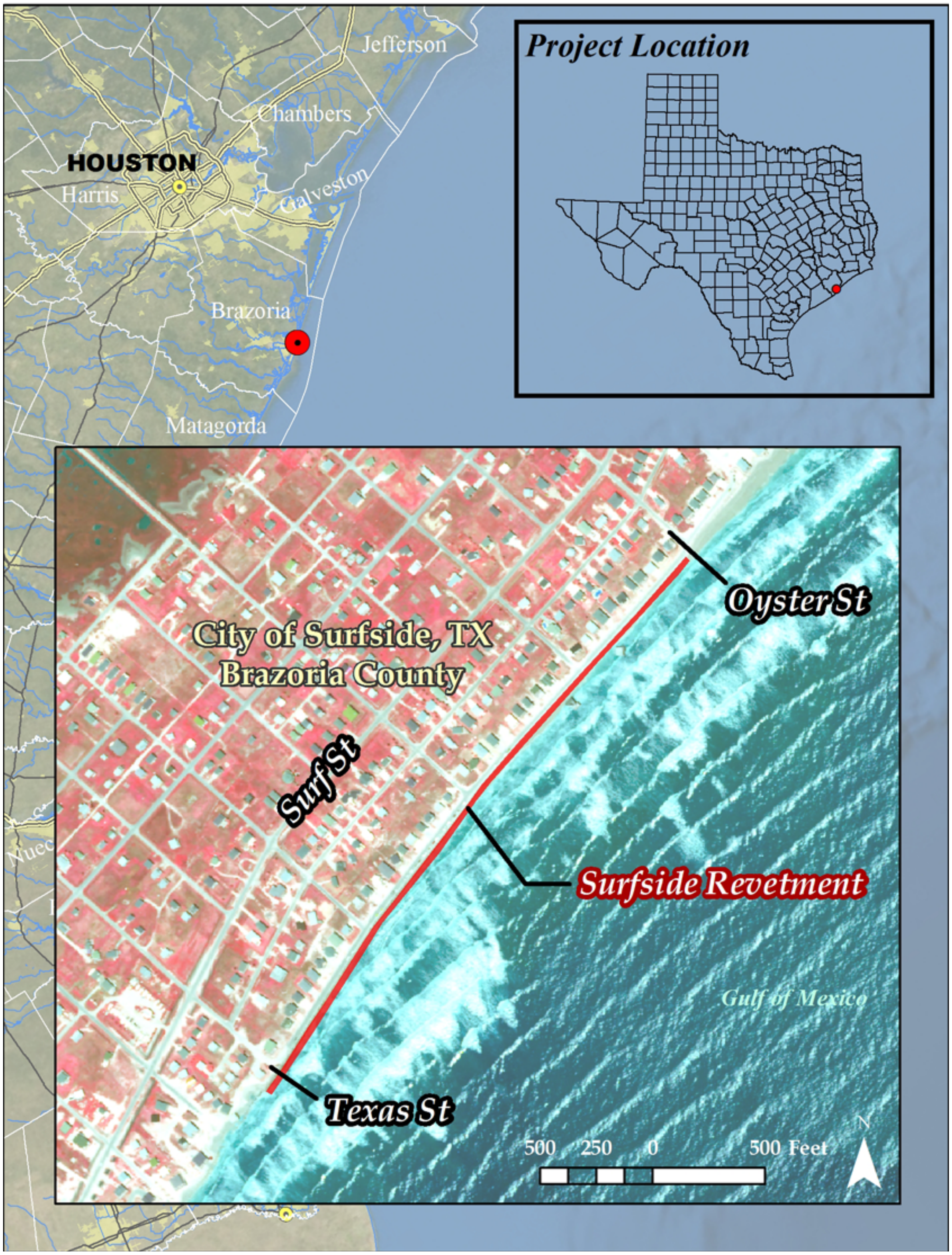

Figure 3.16 Surfside Revetment Location Map

Figure 3.17 Surfside Beach before Revetment (provided by GLO)

Figure 3.18 Surfside Beach after Revetment (provided by GLO)

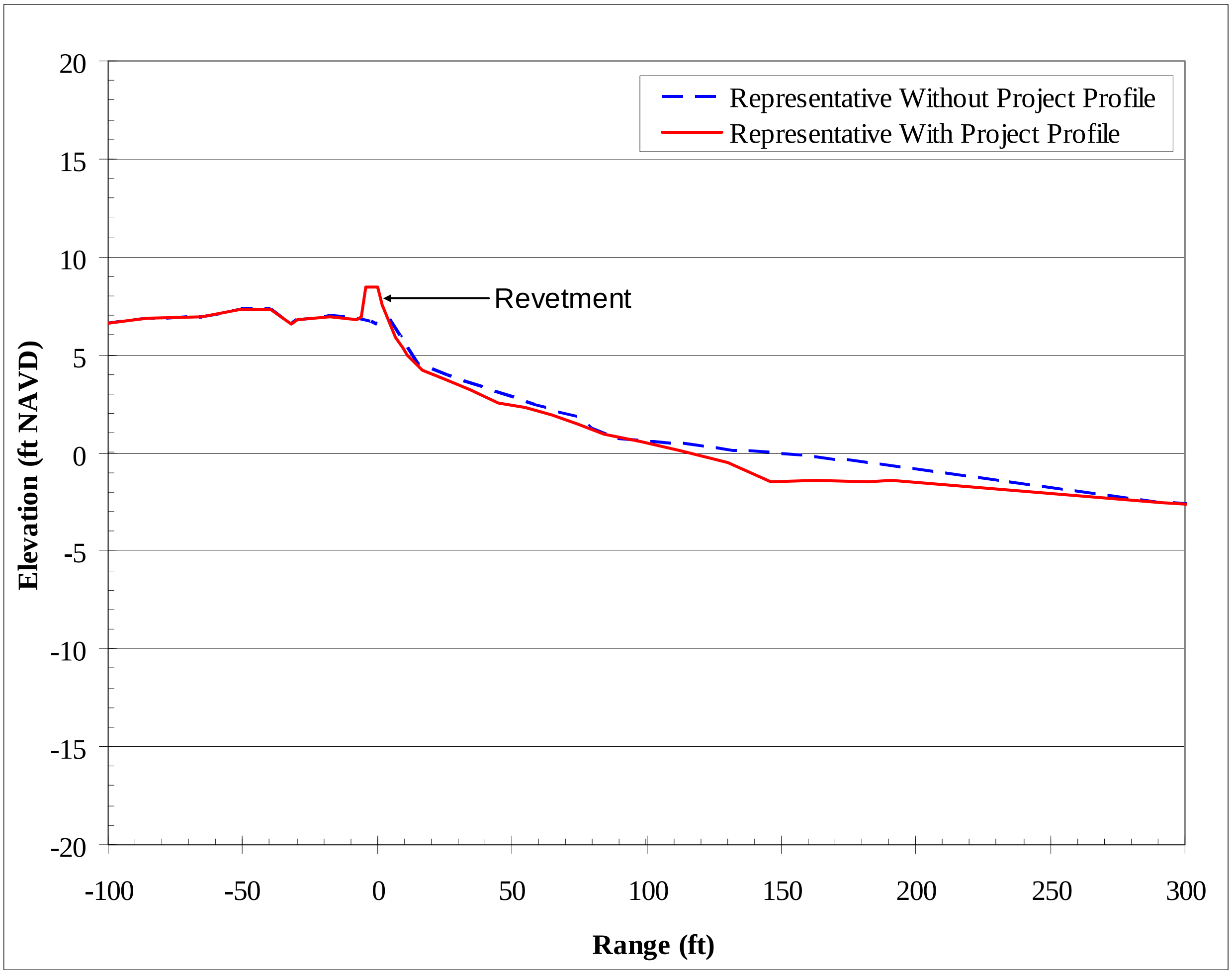

Figure 3.19 Surfside Beach Representative Pre- and Post-Construction Profiles

Table 3.25 SBEACH Model Parameters (HDR, 2009c)

Parameter	**Value**
Transport Rate Coefficient (K)	2.25×10^{-6} m^4/N
Eps Parameter (ε)	0.002 m^2/s
Transport Rate Decay Factor (λ)	0.5 m^{-1}
Avalanching Angle (ω)	35°
Landward Surf Zone Depth	1.6 ft
Median Grain Size	0.14 mm

As stated above, Hurricane Ike occurred in 2008 immediately after project construction. A joint University of Notre Dame/University of Florida team developed water level elevations, wave heights, and wave periods for Hurricane Ike. Before the hurricane, the team deployed nine instruments in 10-meter water depths along the Texas coast from Corpus Christi to the Texas/Louisiana border. Figure 3.20 shows the resultant hurricane water level and wave data near Surfside Beach.

Estimating project benefits required modeling with- and without-project conditions in SBEACH. Taylor Engineering first modeled the effects of Hurricane Ike for the year 2008. No tropical storms significantly affecting Surfside Beach occurred in 2009 and 2010. Then the study applied synthetic storms for the years 2011 and 2012.

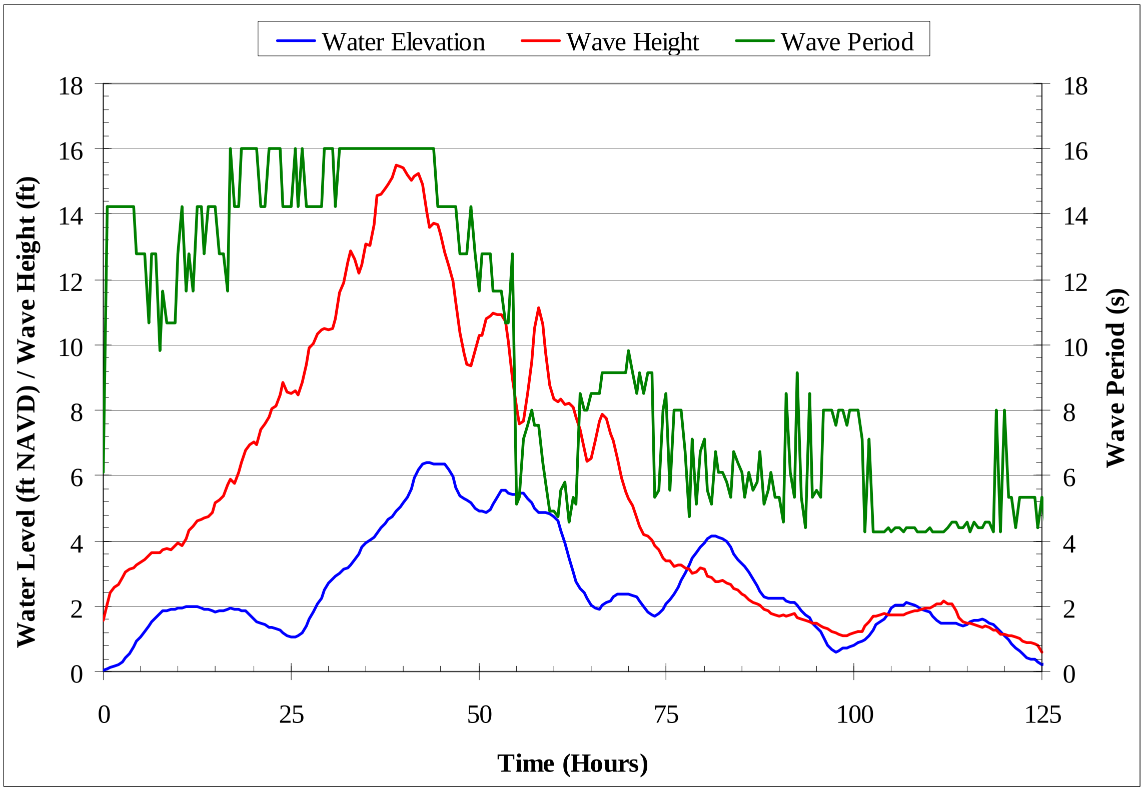

Figure 3.20 Hurricane Ike Water Level Elevation, Wave Height, and Wave Period

Figure 3.21 shows the SBEACH results for the effect of Hurricane Ike on Surfside Beach without the revetment. Without the revetment, SBEACH predicts that Ike would have caused 113 ft of erosion, equivalent to $4,350,000 of land loss and $4,020,000 of structure damage. According to this result, the construction of the revetment in 2008 spared Surfside Beach over $8 million in storm damages within a month of its completion.

In 2009 and 2010, Surfside Beach experienced no major storms. Taylor Engineering eroded the with- and without-revetment profiles by -3.2 ft (one year's background erosion, since Hurricane Ike arrived late in 2008) and then applied synthetic storms to these profiles, beginning in 2011.

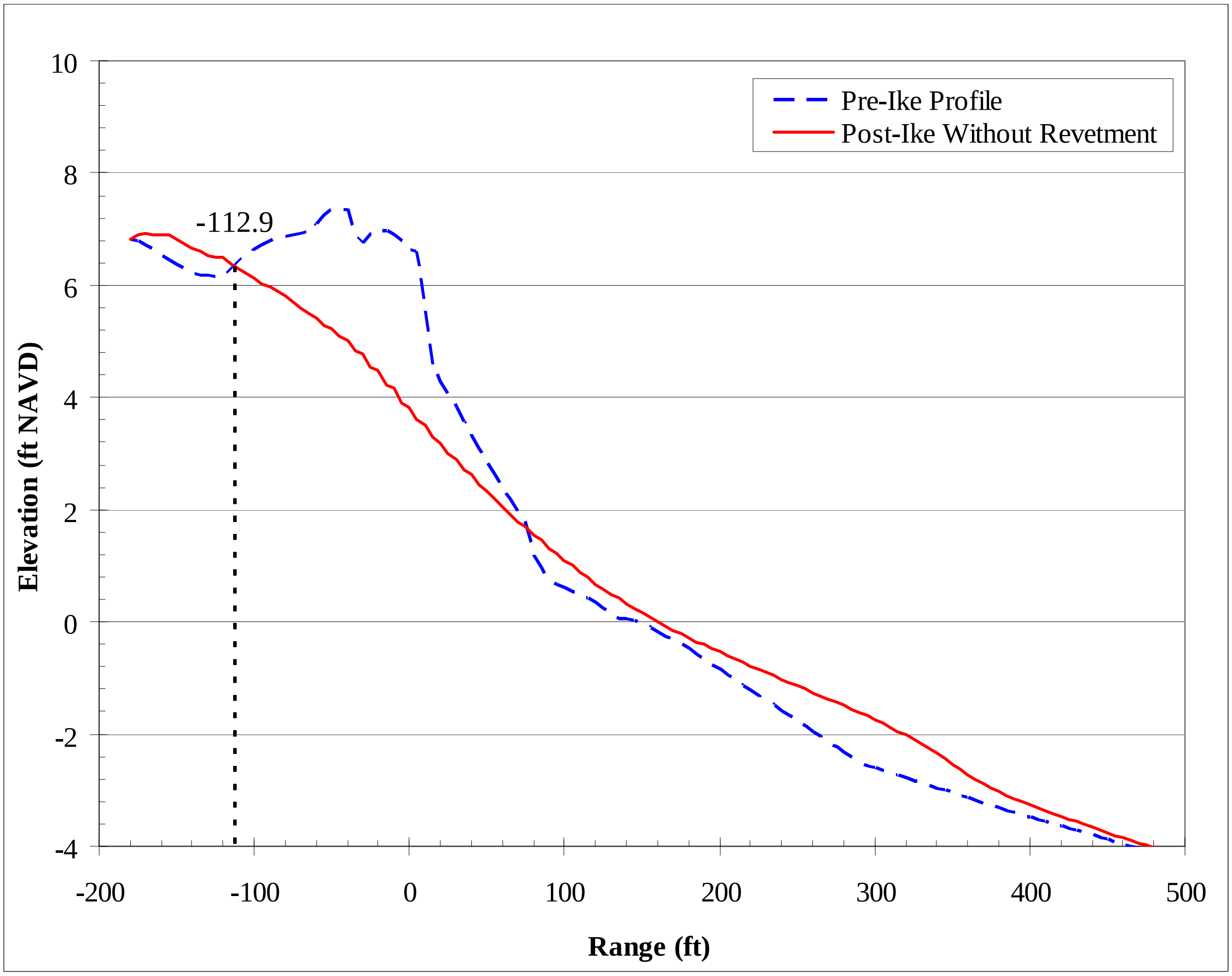

Figure 3.21 SBEACH Model Results for Hurricane Ike

To simulate 1-, 2-, 5-, 10-, 20-, 50-, and 100-year storm events, this study applied a synthetic storm with characteristics (Table 3.26) corresponding to the return period under consideration. Developing synthetic time-varying storm surge hydrographs required applying Eq. 3.1 (page 41). The final water surface elevation time series consists of three standard tidal cycles (about 72 hours) developed from a normally varying tide from mean high water (1.23 feet NAVD) to mean low water (-0.22 feet NAVD), generated by Eq. 3.2 (page 42), followed by the return period specific storm surge hydrograph. Note that substituting 1.45 for 1.12 and -0.22 for 0.36 in Eq. 3.2 produces the desired normal tide hydrograph. Minor smoothing at the transition prevented abrupt changes in the water surface elevation. Figure 3.22 shows the final 1-, 2-, 5-, 10-, 20-, 50-, and 100-year hydrographs.

Table 3.26 Peak Storm Characteristics for Various Return Periods

Return Period (yr)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
Storm Tide[†] (feet NAVD)	2.1 [a]	2.4 [a]	3.2	4.4	6.6[*]	9.4	10.9
Offshore Wave Height[‡] (feet)	11.6	13.3	15.8	17.3	19.2	21.5	23.2
Offshore Wave Period[‡] (seconds)	10.1	10.7	11.0	11.8	12.3	12.9	13.4

[†]Data from HDR (2009c)
[‡]Data from Lockwood, Andrews, and Newman, Inc. (2006)
[a]Assumed value
[*]Interpolated

As with the storm surge, the temporal wave height variation consisted of two parts. A cosine squared distribution (Eq. 3.3, page 42) approximated the wave heights during normal conditions over the first 72 hours (3 tidal cycles), followed by a sine squared distribution (Eq. 3.4, page 43) which approximated the storm wave heights over 36 hours. Each tidal cycle averaged 24.8 hours, and the wave heights varied from 1.5 to 3.0 ft, representing the relatively calm conditions frequently observed in the Gulf of Mexico. Storm wave heights varied from 5 ft to the peak wave height (Table 3.26) and abate to 5 ft after storm passage. The 5-ft value for H_{min} simulates the agitated sea conditions typically found after a storm passes an area. Figure 3.23 shows the resulting wave height distributions the model requires.

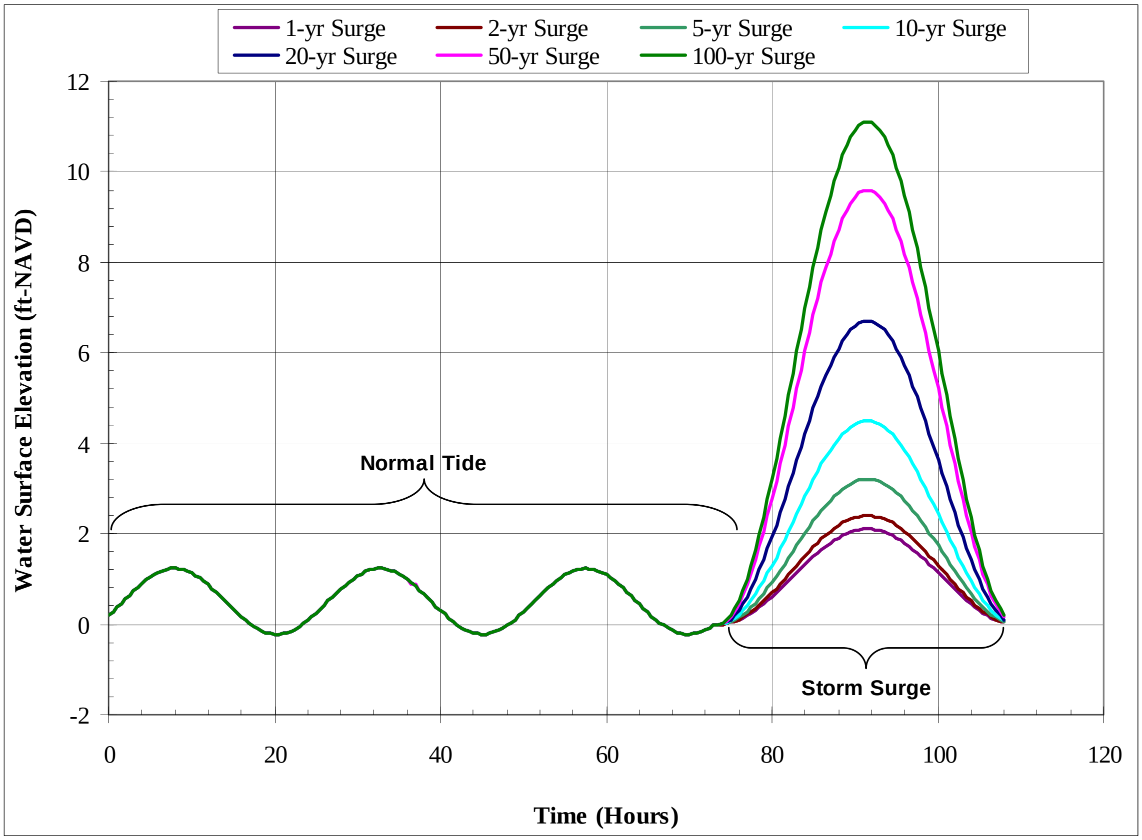

Figure 3.22 Surfside Beach Time-Varying Water Surface Elevations

During the first 72 hours of normal conditions, the wave period varies from five to six seconds for 1-, 2-, and 5-year return period storms according to a cosine-squared distribution with a tidal cycle of 24.8 hours. The wave period varies from seven to eight seconds for 10-, 20-, 50-, and 100-year return period storms according to a cosine-squared distribution with a tidal cycle of 24.8 hours. Similarly, a sine squared distribution approximated the storm wave periods over the final 36 hours with a minimum final wave period of seven (1-, 2-, and 5-year return period storms) and nine (10-, 20-, 50-, and 100-year storms) seconds. Figure 3.24 shows the resulting wave period distributions the model requires.

SBEACH produced post-storm profiles for 1-, 2-, 5-, 10-, 20-, 50-, and 100-year storms on eroded with- and without-project profiles between 2011 and 2012. Figure 3.25 presents a typical post-storm profile for without- and with-project conditions for the 5-year storm.

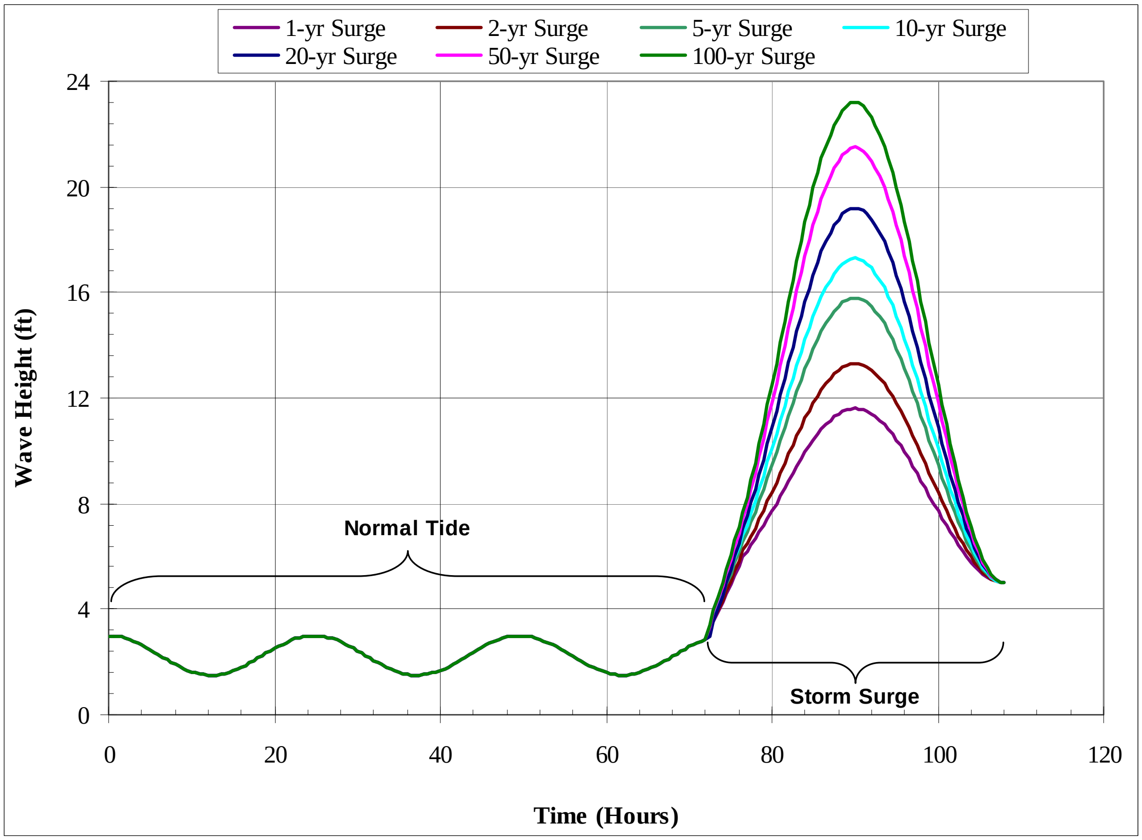

Figure 3.23 Surfside Beach Synthetic, Time-Varying Wave Heights

The methodology outlined in Section 2.2 and the site-specific information described above produces the damage-cumulative probability distribution between 2011 and 2012 on the with- and without-project representative profiles. Note that this analysis translated each with- and without-project representative profile 3.2 feet landward between 2011 and 2012 to account for the historical long-term erosion at the site.

The analysis also took into account the potential damage to the revetment. An assignment of appropriate damage levels pivots on two assumptions. First, typically revetment damage occurs when the water level lies near its crest elevation. Second, larger storms than the design storm usually reach a structures' crest elevation before exceeding it. After Hurricane Ike (approximately a 30-year storm whose water level approached that of the revetment), the revetment suffered approximately $919,050 of damage (CHE, 2008). This value equals approximately $937,431 ($919,050 * 1.02) in 2010 prices. This study assumed damage to the revetment and road (un-modeled in SBEACH) would equal $0 for 1-, and 2-year return period storms, linearly increase from 2- to 30-year return period storms, and become constant thereafter.

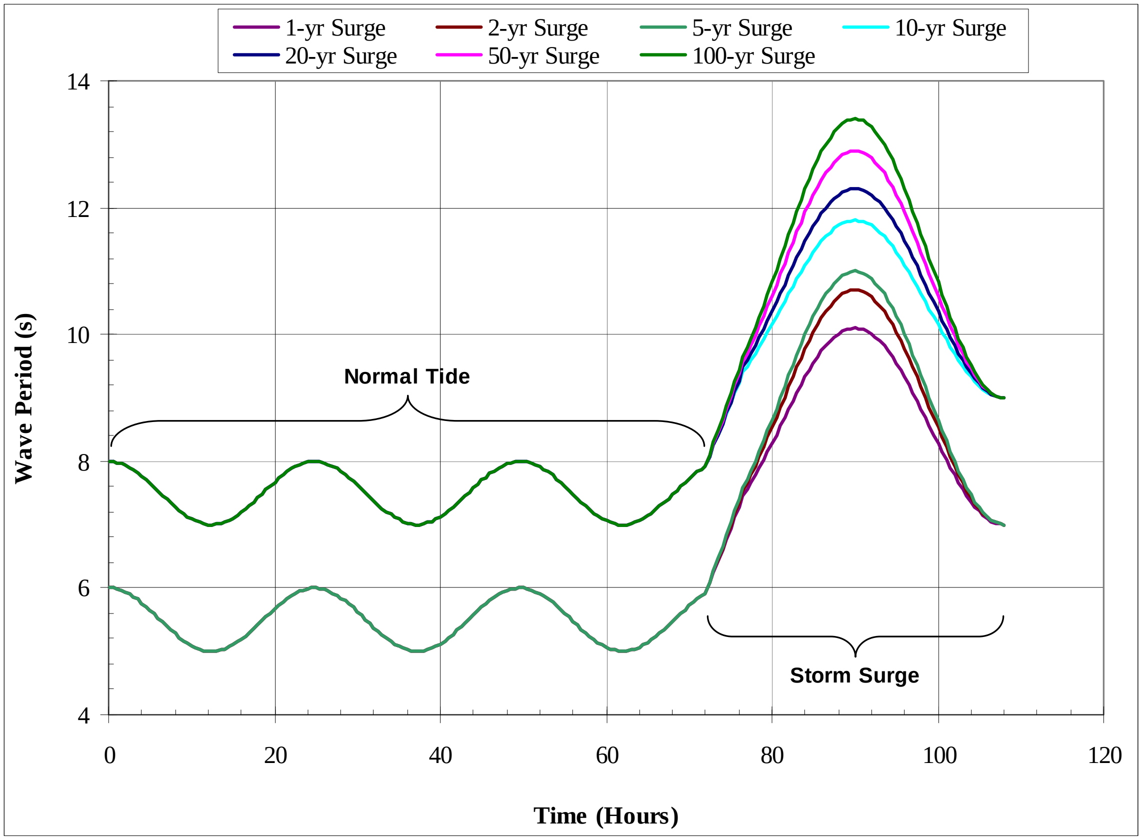

Figure 3.24 Surfside Beach Synthetic, Time-Varying Wave Period

Based on the maximum predicted erosive shoreline condition, the present analysis includes all Gulf front properties located about 400 feet landward of the shoreline. Given the 2010 Brazoria County Central Appraisal District information, these property values (including structures) approach $13.5 million.

Table 3.27 presents the damage-cumulative probability distribution for 2011 with-project conditions. From the table, the expected annual total damage for this condition averages $310,950 (2010 prices). Appendix A presents these distributions for the 2011 and 2012 with- and without-project conditions.

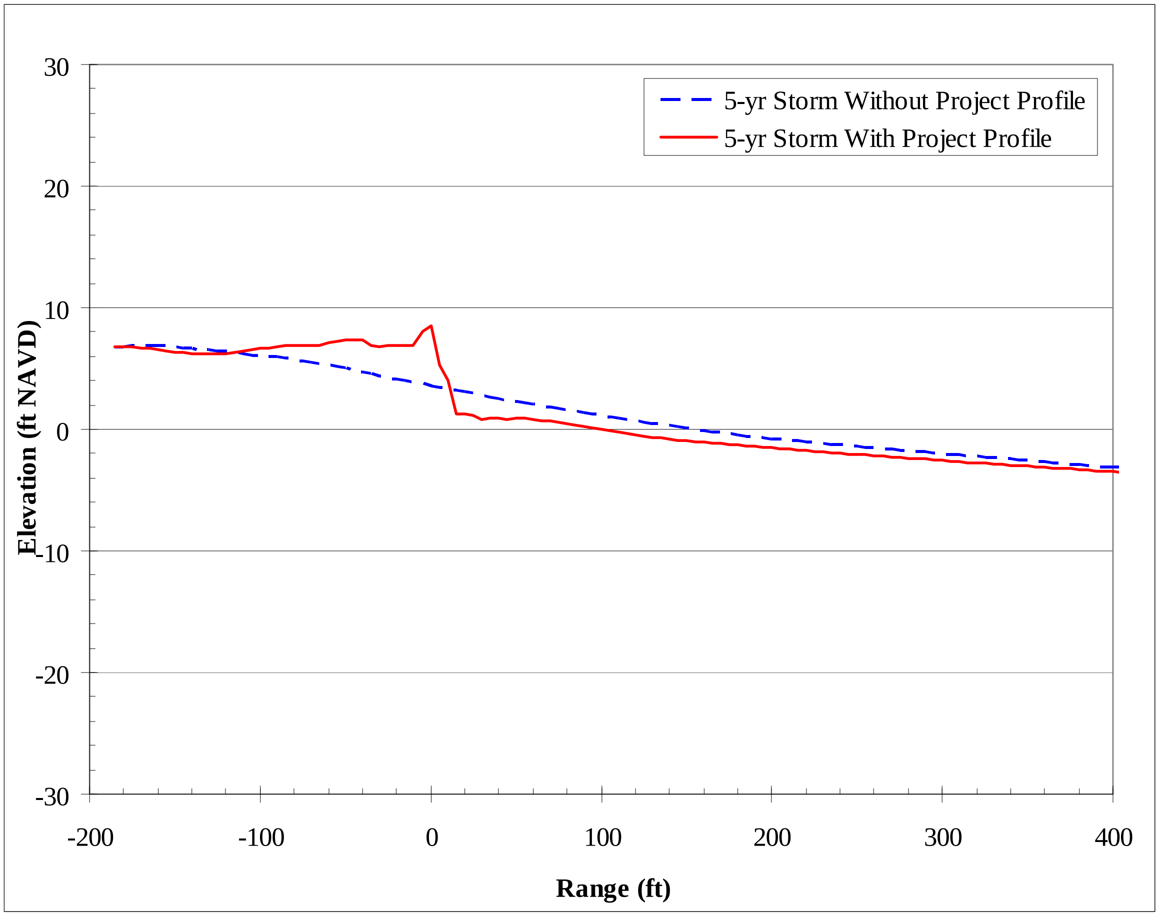

Figure 3.25 Surfside Beach with- and without-Project Five-Year Post-Storm Profile

Table 3.27 Surfside Beach Total Damage-Cumulative Probability (2011, with Project)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Revetment /Road Damage (included in Structure Damage)
1	1.00	0.00	$0	$0	$0				$0
2	0.50	0.50	$0	$0	$0	$0	0.50	$0	$0
5	0.20	0.80	$0	$100,439	$100,439	$50,220	0.30	$15,066	$100,439
10	0.10	0.90	$0	$267,837	$267,837	$184,138	0.10	$18,414	$267,837
20	0.05	0.95	$53,866	$602,634	$656,500	$462,169	0.05	$23,108	$602,634
50	0.02	0.98	$2,451,601	$4,024,933	$6,476,534	$3,566,517	0.03	$106,996	$937,431
100	0.01	0.99	$2,897,261	$4,768,287	$7,665,547	$7,071,041	0.01	$70,710	$937,431
>100	<0.01	>0.99	$2,897,261	$4,768,287	$7,665,547	$7,665,547	0.01	$76,655	$937,431
			Expected Average Annual Damage in 2010 Prices:					$310,950	

Table 3.28 presents a summary of the recorded and expected storm damage reduction benefits for the revetment project at Surfside Beach. From the table, the total benefit over the period of analysis exceeds $9,450,000.

Table 3.28 Surfside Beach Storm Damage Reduction Benefit

Year	Without Project (2010 Prices)	With Project (2010 Prices)	Difference (Benefit)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
2008	$8,369,457	$937,431	$7,432,026	$7,279,800	$7,138,431	$7,138,431
2009	$0	$0	$0	$0	$0	$7,138,431
2010	$0	$0	$0	$0	$0	$7,138,431
2011	$1,610,073	$310,950	$1,299,124	$1,313,414	$1,144,946	$8,283,377
2012	$1,673,550	$312,864	$1,360,686	$1,392,162	$1,166,916	$9,450,293

Notes: Benefit adjusted from 2010 prices to 2008 prices with the CPI; CPI for 2008 = 215.2 and for 2010 = 219.7; conversion factor = 215.2/219.7 = 0.9795
Inflation rate = 1.1% for 2011 and 1.2% for 2012
Discount rate = 4.0% (mid-year discounting)

Note that an additional benefit $999,953 ($714,251 * 1.4 [multiplier effect]) exists to account for federal spending (a net increase inflow of spending for the state economy) that occurs as part of the initial construction. This benefit adds to the benefits calculated above.

Adding the federal spending benefit, $999,953 to the storm damage reduction benefit derived in Table 3.28, $9,450,293, results in a total estimated benefit for this project of $10,450,246, the total benefit calculated in this study. With a total project cost of $1,269,781, the resulting B/C ratio for the Surfside revetment project equals 8.23. Table 3.29 summarizes the costs and benefits.

Table 3.29 Benefit-Cost Summary for Surfside Revetment Project (2008 – 2012)

Benefit Type	**Discounted Present Worth**
Storm Damage Reduction	$9,450,293
Federal Spending	$999,953
Total	$10,450,246
Total Cost	$1,269,781
B/C Ratio	8.23

Note: Dollar values represent present worth equivalents at the beginning of 2008 with a 4% discount rate

3.3 #1404 Sylvan Beach Shoreline Protection and Beach Nourishment

3.3.1 Project Description

Sylvan Beach, a public park, lies along the western shore of Galveston Bay in the City of LaPorte in Harris County, Texas (Figure 3.26). During the early 1900's, the beach attracted huge crowds. In recent years, the park has lost its beach because of wave action generated by wind and boat wake from the Houston Ship Channel. The city attempted to protect the shoreline with a wooden bulkhead and concrete rubble to little avail.

The constructed project included removal of the existing bulkhead and rubble and installation of 1,700 ft of rock revetment and groins, about 34,000 cy of beach sand, a concrete boardwalk, articulated concrete mattresses, a bollard-rope fence, benches, and themed lighting. Construction began in April 2009 and ended in January 2010. Two pocket beaches enclosed by four rock groins (two per pocket beach) represents a major element of the project. Recreational enjoyment constitutes the major purpose of the project. Figures 3.27 and 3.28 present pre- and post-construction photographs of the area. Table 3.30 presents the funding breakdown for the project.

Table 3.30 Project Funding for Sylvan Beach Shoreline Protection Project (2010 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$2,196,493
City of LaPorte	$901,743
Harris County	$562,586
Total	$3,660,822

3.3.2 Analysis

Recreation benefits — recreational enjoyment by all visitors — represent the project benefit calculated in this study. This benefit requires estimates of the beachgoer population over the period of analysis. Estimates relied on pre- and post-construction Google Earth aerials. Notably, site observations and interviews revealed that locals generally visit the beach after work and on the weekend with little change throughout the year. A March 2010 aerial, representing post-construction conditions, shows about 105 cars parked near the beach. Assuming two people per car, a turnover rate of 1.5, and no seasonal difference in visitation, approximately 114,975 visits (105 * 2 * 1.5 * 365) occurred in 2010 at Sylvan Beach with the project. An April 2006 aerial, representing pre-construction conditions, shows

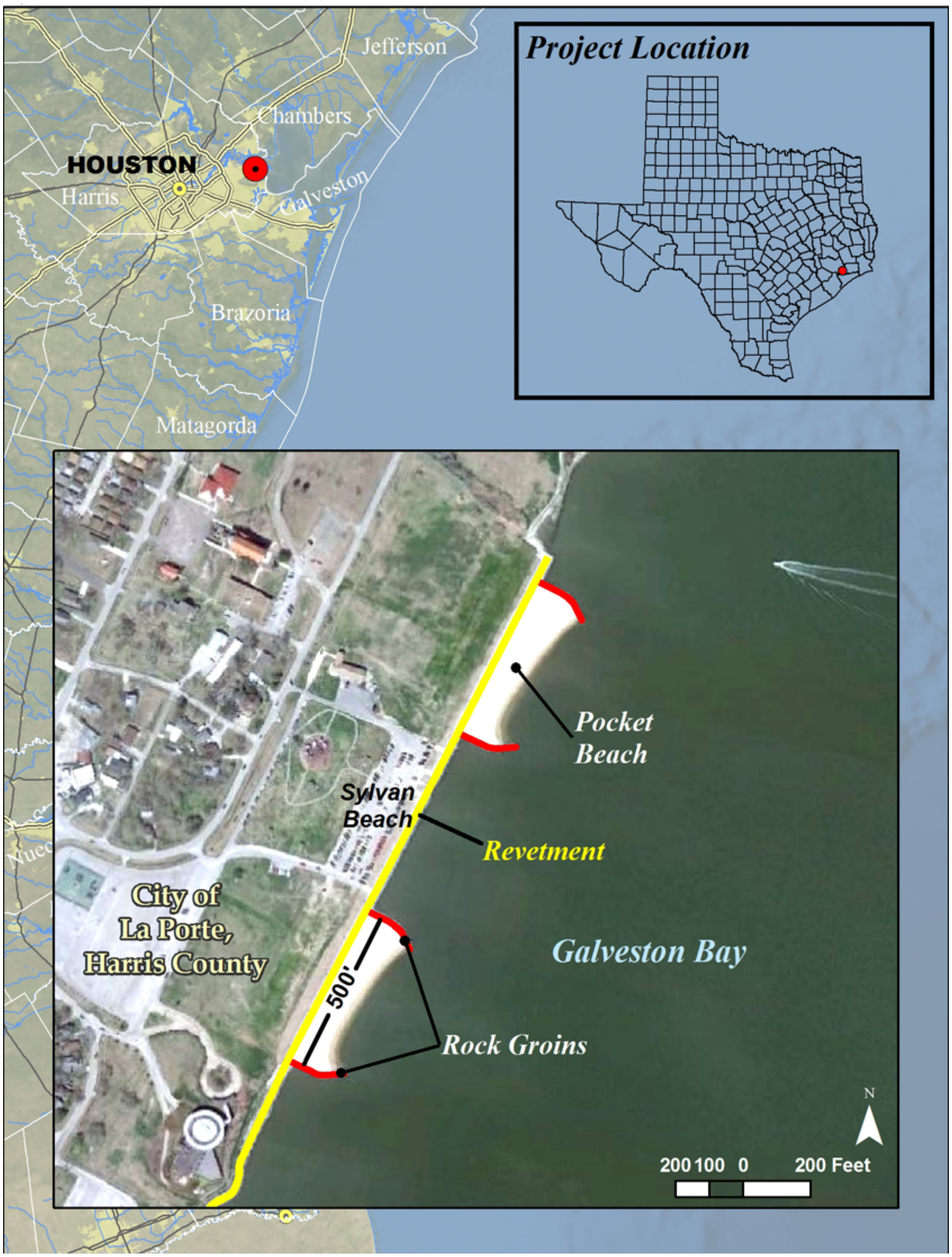

Figure 3.26 Sylvan Beach Location Map

Figure 3.27 Pre-Construction Photograph, Sylvan Beach (provided by the GLO)

Figure 3.28 Post-Construction Photograph, Sylvan Beach (provided by the GLO)

about 18 cars parked near the waterfront (no beach present). Assuming two people per car, a turnover rate of 1.5, and no seasonal difference in visitation, approximately 19,710 visits (18 * 2 * 1.5 * 365) occurred in 2006 at Sylvan Beach without the project. Increasing the latter number to a 2010 number by a small growth rate (0.5%/year) yields 20,107. This study applies a smaller annual growth rate in visitation (0.5%/year) than the weighted population growth (1.5%/year) used for the coastal project sites because the area is heavily developed and highly urbanized.

Post-construction surveys produced an initial beach width of 75 ft. This beach width served as initial input for the with-project condition. Without-project conditions assumed no beach present. Incorporating the above information yields without- (Table 3.31) and with-project (Table 3.32) visitation estimates. In the tables, the first beach visitation column represents beach visitation given no beach width constraint on visitation (i.e., beach visitation grows at 0.5% annually). One must calculate this beach visitation number as a starting point in order to apply the beach width elasticity relationship (Oden and Butler, 2006) and determine estimated beach visitation with- and without-the project. Absent other site-specific data, this analysis adopts the elasticity relationship for Galveston and Surfside area beaches where a 0.28% visitor reduction occurs for every 1% loss of beach width. Note that this analysis adopted 20% visitation (or 80% reduction in beach visitation) at 100% beach loss.

This study performed benefit calculations over a 10-year period given the presence of the groins to help retain the beach.

Table 3.31 Sylvan Beach without Project, Total Beach Visitation

Year	Unconstrained annual visitation
2010	20,107
2011	20,208
2012	20,309
2013	20,410
2014	20,512
2015	20,615
2016	20,718
2017	20,822
2018	20,926
2019	21,030

Notes: Beach visitation growth rate = 0.5%/year

Calculating recreation benefits for all visitors involved applying the visitation numbers shown in Tables 3.31 and 3.32 and developing the UDV (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.33 presents a summary of the points assigned for with- and without-project conditions at Sylvan Beach. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) and interpolating yields with- and without-project UDVs of about $8.52 and $4.61 per person per visit. Taking the difference between with- and without-project recreational values yields the benefit for each year. Inflating, discounting and summing the values produce the total visitor recreation benefit. Table 3.34 presents the recreation benefit for Sylvan Beach. In total, the benefit equals $5,593,493 over the period of analysis.

Table 3.32 Sylvan Beach with Project, Total Beach Visitation

Year	Unconstrained annual visitation	With project Beach width (ft)	With project % change in beach width	With project % reduction in visitation	With project Beach visitation
2010	114,975	75	0%	0%	114,975
2011	115,550	68	-10%	3%	112,314
2012	116,128	60	-20%	6%	109,624
2013	116,708	53	-30%	8%	106,905
2014	117,292	45	-40%	11%	104,155
2015	117,878	38	-50%	14%	101,375
2016	118,468	30	-60%	17%	98,565
2017	119,060	23	-70%	20%	95,724
2018	119,655	15	-80%	22%	92,853
2019	120,254	8	-90%	51%	58,684

Notes: Beach visitation growth rate = 0.5%/year
Reduction in visitation per 1% change in beach width = 0.28%
Erosion rate (assumed) = 7.5 ft/yr

Table 3.33 UDV Points Assigned for Sylvan Beach

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	16	2	30
Availability of Opportunity	14	3	18
Carrying Capacity	12	5	14
Accessibility	15	6	18
Environmental	8	2	20
Total	65	18	100

Recall the total project cost equals $3,660,822. Therefore, the calculated B/C ratio for the Sylvan Beach project equals 1.77. Table 3.35 summarizes the costs and benefits.

Table 3.34 Sylvan Beach Shoreline Protection and Beach Nourishment Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project	With Project	Without Project				
2010	114,975	20,107	$979,012	$92,734	$886,278	$886,278	$869,067	$869,067
2011	112,314	20,208	$956,358	$93,198	$863,160	$872,655	$822,796	$1,691,863
2012	109,624	20,309	$933,452	$93,664	$839,789	$859,215	$778,966	$2,470,829
2013	106,905	20,410	$910,294	$94,132	$816,162	$845,062	$736,668	$3,207,497
2014	104,155	20,512	$886,881	$94,603	$792,278	$830,176	$695,857	$3,903,354
2015	101,375	20,615	$863,211	$95,076	$768,135	$819,366	$660,381	$4,563,735
2016	98,565	20,718	$839,282	$95,551	$743,730	$807,614	$625,874	$5,189,610
2017	95,724	20,822	$815,092	$96,029	$719,063	$794,882	$592,315	$5,781,925
2018	82,125	20,926	$699,294	$96,509	$602,785	$678,338	$486,030	$6,267,955
2019	41,063	21,030	$349,647	$96,992	$252,655	$289,441	$199,408	***$6,467,363***

Notes: UDV (with project) = $8.52
UDV (without project) = $4.61
Inflation rate = 1.1% for 2011, 1.2% for 2012 – 2014, and 1.8% for 2015 and beyond
Discount rate = 4.0%

Table 3.35 Benefit-Cost Summary for Sylvan Beach (2010 – 2019)

Benefit Type	Discounted Present Worth
Visitation	$6,467,363
Total Cost	$3,660,822
B/C Ratio	1.77

Note: Dollar values represent present worth equivalents at the beginning of 2010 with a 4% discount rate

3.4 #1447 Galveston Seawall Emergency Beach Nourishment

3.4.1 Project Description

The City of Galveston lies on Galveston Island along the Gulf of Mexico coast in Galveston County, Texas (Figure 3.29). Based on information obtained from UTBEG, the project area's shoreline erodes about -3.7 ft/yr on average In response to erosion from Hurricane Ike, this emergency project included placing approximately 470,000 cy of beach-quality sand on the Gulf beach in front of the seawall from 17th to 61st streets in the City of Galveston. The project utilized sand dredged from an area located adjacent to the south jetty of the Galveston-Houston ship channel, pumped to a containment area at Apffel Park on the east end of the island, and transported by truck to the beach. The total length of beach nourished equaled 12,650 ft. Beach placement began December 17, 2008 and ended January 2,

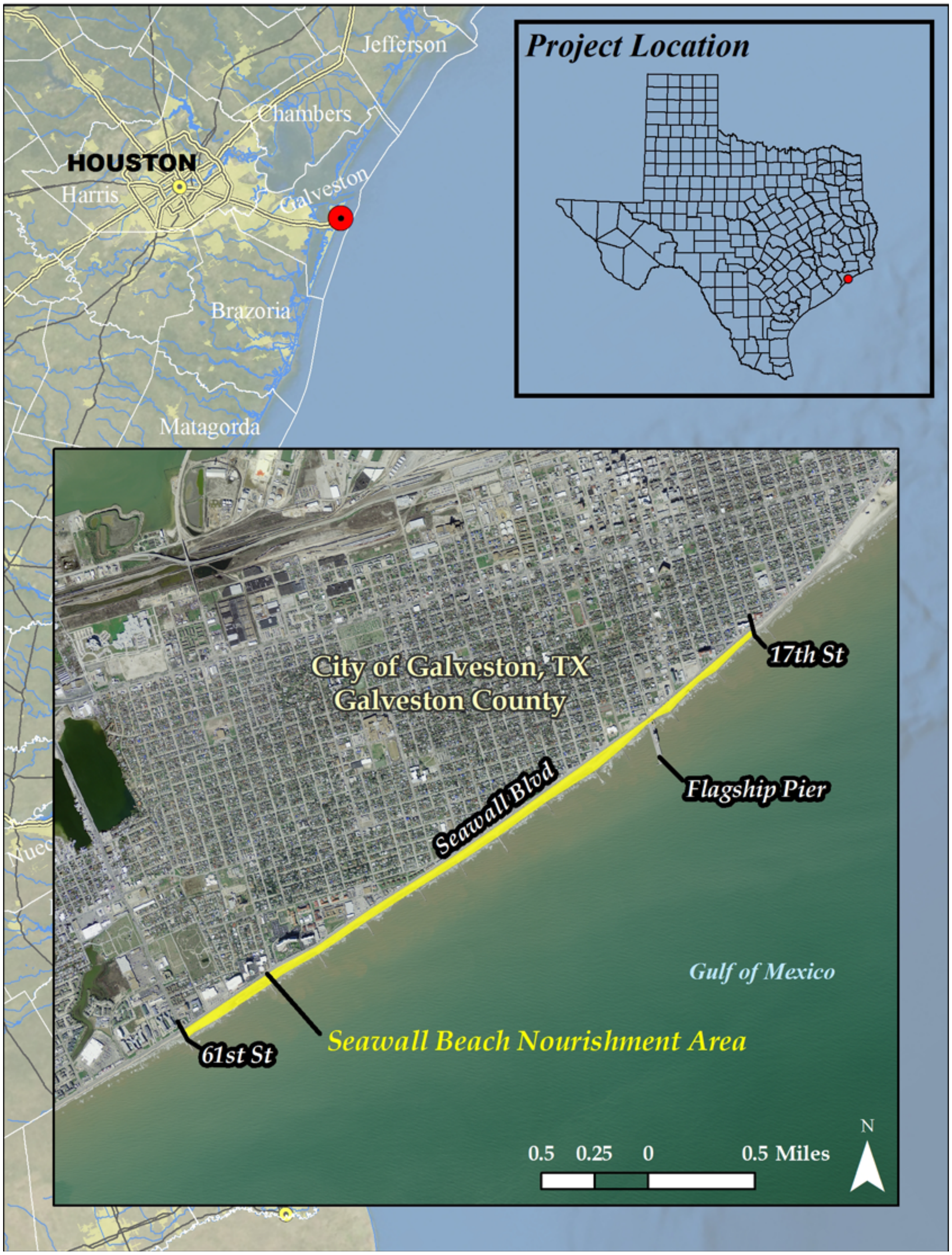

Figure 3.29 Galveston Seawall Emergency Beach Nourishment Location Map

2009. Figures 3.30 and 3.31 present pre- and post-construction photographs of the project area. Table 3.36 presents the funding breakdown for this project.

Table 3.36 Project Funding for Galveston Seawall Beach Project (2009 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$5,211,237
Galveston Park Board of Trustees	$1,737,079
Total	$6,948,316

3.4.2 Analysis

Economic benefits derive from preventing seawall failure and beach visitation over a 20-year period of analysis. Given the lack of detailed design information of the wall, this study could not apply the previously used techniques to estimate storm damage reduction benefits. However, it did examine benefits as the measured difference between conditions with and without the project

Original construction of the seawall began in 1902 following the worst natural disaster in U.S. history — the 1900 hurricane that struck the city, killed nearly 9% of the city's population, destroyed over 2,500 houses, and washed away 300 ft of land. Then later, the storm of 1915 and erosion in succeeding years endangered exposure of the piling under the seawall. Groins, built in 1934, helped reduce erosion and protect the seawall by retaining beach sand. Most recently, erosion from Hurricane Ike threatened exposure of the pilings.

In the case of the seawall, one could argue that conditions without the project would entail no effort to protect the seawall. Two main problems exist with this approach. First, saying, with an acceptable level of certainty, when complete project failure would take place due to undermining, leading to exposure of the untreated wooden piling, proves difficult. With a failed seawall, a repeat of a major event, such as what happened in 1900, would prove catastrophic. Second, this situation likely represents a completely unrealistic scenario. The seawall is part of the city's infrastructure, as evidenced by the history of its original construction and efforts undertaken over the years to ensure its continued structural integrity. Abandonment of the project would lead to complete loss of structural integrity and ultimately failure. This would leave Galveston arguably in worse shape, and perhaps even more vulnerable than before the 1900 disaster. This situation is unlikely to occur. No one questions keeping the seawall. Rather, many have focused on properly maintaining and continuing its protective function.

Figure 3.30 Pre-Construction Photograph Facing East (provided by the GLO)

Figure 3.31 Post-Construction Photograph Facing East (provided by the GLO)

In light of these observations, this study bases its benefit evaluation on the following conditions:

- Without the project – periodic replacement of lost riprap armor in the absence of periodic nourishment
- With the project – nourishment, eliminating the need for the more costly riprap replacement measure

Table 3.37 summarizes the benefits associated with protecting the seawall. It assumes that 20% of the existing riprap at a cost of nearly $800,000 (2010 dollars) needs replacing every five years because of storm damage to the riprap. From the table, placing sand in front of the seawall instead of riprap saves the city and the GLO over $2.3 million over 20 years.

This analysis adopted two visitation benefit categories — spending by out-of-state visitors and recreational enjoyment by all visitors. Both require estimates of the beachgoer population over the two-year period of analysis. Oden and Butler report about 162 peak day visitors to the Galveston seawall area based on a 2004 survey. Similar to methods adopted in Stites et al., this study assumed the peak season runs from Memorial Day to three weeks before Labor Day (approximately 80 days). Given 32 people (assumed) visit the beach during off peak days, 285 (i.e., 365 – 80) off peak days exist during a 365-day year, and the above peak visitor information, approximately 22,080 visits (32 * 285 + 162 * 80) occurred in 2004 in the project vicinity.

Pre- and post-construction surveys produced initial with- and without-project beach widths. Incorporating the above information yields without- (Table 3.38) and with-project (Table 3.39) visitation estimates. In the tables, the first beach visitation column represents beach visitation given no beach width constraint on visitation (i.e., beach visitation grows at an estimated 1.5% annually). One must calculate this beach visitation number as a starting point in order to apply the beach width elasticity relationship (Oden and Butler, 2006) to determine estimated beach visitation with- and without-the project. Given site-specific data, this analysis adopts the elasticity relationship for Galveston where a 0.28% visitor reduction occurs for every 1% loss of beach width. Application of the elasticity relationship to estimated visitation growth and to estimated beach width in relevant years since the time of the survey accounts for beachgoers' beach width preferences. Note that this analysis adopted 25% visitation (or 75% reduction in beach visitation) at 100% beach loss.

Table 3.37 Replacement of Seawall Riprap Benefit

With project	Without project	Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$797,263	$797,263	$825,493	$691,932	$691,932
$0	$0	$0	$0	$0	$691,932
$0	$0	$0	$0	$0	$691,932
$0	$0	$0	$0	$0	$691,932
$0	$0	$0	$0	$0	$691,932
$0	$797,263	$797,263	$897,192	$618,114	$1,310,046
$0	$0	$0	$0	$0	$1,310,046
$0	$0	$0	$0	$0	$1,310,046
$0	$0	$0	$0	$0	$1,310,046
$0	$0	$0	$0	$0	$1,310,046
$0	$797,263	$797,263	$980,898	$555,444	$1,865,490
$0	$0	$0	$0	$0	$1,865,490
$0	$0	$0	$0	$0	$1,865,490
$0	$0	$0	$0	$0	$1,865,490
$0	$0	$0	$0	$0	$1,865,490
$0	$797,263	$797,263	$1,072,415	$499,129	***$2,364,619***

Notes: Without project condition assumes replacing a portion of the seawall's existing riprap every five years

Inflation rate = 1.2% for 2012 – 2014 and 1.8% for 2015 and beyond

Discount rate = 4% (mid-year discounting)

Oden and Butler report that 6.9% of the visitors to the Galveston seawall area originate from outside Texas. These out-of-state visitors spend $103.52 (2004 dollars) per person per visit in the seawall area. Inflating this value to 2010 dollars yields $120.40.

Table 3.38 Galveston Area without Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey beach width (ft)	Without project beach width (ft)	Without project % change in beach width	Without project % reduction visitation	Without project constrained annual visitation
2004	22,080	100	--	--	--	--
2005	22,411	--	--	--	--	--
2006	22,747	--	--	--	--	--
2007	23,089	--	--	--	--	--
2008	23,435	--	--	--	--	--
2009	23,786	--	0	-100%	75%	5,947
2010	24,143	--	-4	-104%	75%	6,036
2011	24,505	--	-7	-107%	75%	6,126
2012	24,873	--	-11	-111%	75%	6,218
2013	25,246	--	-15	-115%	75%	6,312
2014	25,625	--	-19	-119%	75%	6,406
2015	26,009	--	-22	-122%	75%	6,502
2016	26,399	--	-26	-126%	75%	6,600
2017	26,795	--	-30	-130%	75%	6,699
2018	27,197	--	-33	-133%	75%	6,799
2019	27,605	--	-37	-137%	75%	6,901
2020	28,019	--	-41	-141%	75%	7,005
2021	28,439	--	-44	-144%	75%	7,110
2022	28,866	--	-48	-148%	75%	7,217
2023	29,299	--	-52	-152%	75%	7,325
2024	29,739	--	-56	-156%	75%	7,435
2025	30,185	--	-59	-159%	75%	7,546
2026	30,637	--	-63	-163%	75%	7,659
2027	31,097	--	-67	-167%	75%	7,774
2028	31,563	--	-70	-170%	75%	7,891

Notes: Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.28%
Erosion rate = -3.7 ft/yr

The with- and without-project visitation estimates serve as input for estimating the benefits from spending by out-of-state visitors and the value of recreation benefits for all visitors. Table 3.40 summarizes the benefit to Texas from spending by out-of-state visitors (including the multiplier effect). The present value of this benefit for the 20-year period of analysis is $3,441,463.

Table 3.39 Galveston Area with Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey beach width (ft)	With project beach width (ft)	With project % change in beach width	With project % reduction visitation	With project constrained annual visitation
2004	22,080	100	--	--	--	--
2005	22,411	--	--	--	--	--
2006	22,747	--	--	--	--	--
2007	23,089	--	--	--	--	--
2008	23,435	--	--	--	--	--
2009	23,786	--	120	20%	0%	23,786
2010	24,143	--	116	16%	0%	24,143
2011	24,505	--	113	13%	0%	24,505
2012	24,873	--	109	9%	0%	24,873
2013	25,246	--	105	5%	0%	25,246
2014	25,625	--	102	1%	0%	25,625
2015	26,009	--	98	-2%	1%	25,849
2016	26,399	--	94	-6%	2%	25,963
2017	26,795	--	90	-10%	3%	26,075
2018	27,197	--	87	-13%	4%	26,184
2019	27,605	--	83	-17%	5%	26,291
2020	28,019	--	79	-21%	6%	26,395
2021	28,439	--	76	-24%	7%	26,497
2022	28,866	--	72	-28%	8%	26,595
2023	29,299	--	68	-32%	9%	26,690
2024	29,739	--	65	-36%	10%	26,783
2025	30,185	--	61	-39%	11%	26,872
2026	30,637	--	57	-43%	12%	26,957
2027	31,097	--	53	-47%	13%	27,039
2028	31,563	--	50	-50%	14%	27,118

Notes: Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.28%
Erosion rate = -3.7 ft/yr

Calculating recreation enjoyment benefits for all visitors involved applying the visitation numbers derived in Tables 3.38 and 3.39 to the UDV developed (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.41 presents a summary of the points assigned for with- and without-project conditions in the project area. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) results in with- and without-project UDVs of about $7.35 and $6.18 per person per visit. Taking the difference between the estimated recreation value for all visitors with- and without-project estimates yields the benefit for the year. Table 3.42 presents the recreation value benefit for this project. In total, the benefit equals $2,297,988 (present value, beginning of 2009).

Table 3.40 Galveston Seawall Beach Nourishment Out-of-State Visitor Spending Benefit

Year	Total Visitation		Out of State				Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
			Visitation		Visitor Spending					
	With Project	Without Project	With Project	Without Project	With Project	Without Project				
2009	23,786	5,947	1,641	410	$276,649	$69,162	$207,487	$202,576	$198,642	$198,642
2010	24,143	6,036	1,666	416	$280,799	$70,200	$210,599	$210,599	$198,567	$397,208
2011	24,505	6,126	1,691	423	$285,010	$71,253	$213,758	$216,109	$195,925	$593,133
2012	24,873	6,218	1,716	429	$289,286	$72,321	$216,964	$221,983	$193,510	$786,643
2013	25,246	6,312	1,742	435	$293,625	$73,406	$220,219	$228,017	$191,124	$977,768
2014	25,625	6,406	1,768	442	$298,029	$74,507	$223,522	$234,214	$188,769	$1,166,536
2015	25,849	6,502	1,784	449	$300,636	$75,625	$225,011	$240,019	$186,007	$1,352,543
2016	25,963	6,600	1,791	455	$301,965	$76,759	$225,206	$244,550	$182,229	$1,534,772
2017	26,075	6,699	1,799	462	$303,266	$77,911	$225,355	$249,117	$178,493	$1,713,264
2018	26,184	6,799	1,807	469	$304,538	$79,079	$225,458	$253,717	$174,797	$1,888,061
2019	26,291	6,901	1,814	476	$305,780	$80,266	$225,514	$258,348	$171,141	$2,059,203
2020	26,395	7,005	1,821	483	$306,990	$81,470	$225,521	$263,006	$167,526	$2,226,729
2021	26,497	7,110	1,828	491	$308,168	$82,692	$225,477	$267,688	$163,950	$2,390,679
2022	26,595	7,217	1,835	498	$309,313	$83,932	$225,381	$272,390	$160,414	$2,551,093
2023	26,690	7,325	1,842	505	$310,422	$85,191	$225,231	$277,109	$156,916	$2,708,009
2024	26,783	7,435	1,848	513	$311,495	$86,469	$225,026	$281,841	$153,457	$2,861,466
2025	26,872	7,546	1,854	521	$312,531	$87,766	$224,765	$286,580	$150,036	$3,011,503
2026	26,957	7,659	1,860	528	$313,527	$89,082	$224,445	$291,323	$146,653	$3,158,156
2027	27,039	7,774	1,866	536	$314,483	$90,419	$224,064	$296,065	$143,308	$3,301,464
2028	27,118	7,891	1,871	544	$315,397	$91,775	$223,622	$300,799	$139,999	***$3,441,463***

Notes: Total visitation estimates derive from Tables 3.38 and 3.39
Out-of-state visitation = 6.9% of total visitation
Out-of-state visitor spending = $120.40 per person (2010 prices)
Multiplier effect = 1.4
Benefit adjusted from 2010 prices to 2009 prices with the CPI; CPI for 2009 = 214.5 and for 2010 = 219.7; conversion factor = 214.5/219.7 = 0.9763
Inflation factors = 1.1% for 2011, 1.2% for 2012 – 2014, and 1.8% for 2015 and beyond
Discount rate = 4.0% (mid-year discounting)

Table 3.41 UDV Points Assigned for Galveston Seawall Beach Project

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	10	7	30
Availability of Opportunity	3	3	18
Carrying Capacity	10	6	14
Accessibility	14	14	18
Environmental	10	6	20
Total	47	36	100

Table 3.42 Galveston Seawall Project Recreation Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project	With Project	Without Project				
2009	23,786	5,947	$174,830	$36,774	$138,056	$134,789	$132,171	$132,171
2010	24,143	6,036	$177,453	$37,325	$140,127	$140,127	$132,121	$264,293
2011	24,505	6,126	$180,115	$37,885	$142,229	$143,794	$130,364	$394,656
2012	24,873	6,218	$182,816	$38,454	$144,363	$147,702	$128,757	$523,413
2013	25,246	6,312	$185,558	$39,030	$146,528	$151,717	$127,170	$650,582
2014	25,625	6,406	$188,342	$39,616	$148,726	$155,840	$125,602	$776,184
2015	25,849	6,502	$189,989	$40,210	$149,779	$159,769	$123,816	$900,000
2016	25,963	6,600	$190,829	$40,813	$150,016	$162,902	$121,388	$1,021,388
2017	26,075	6,699	$191,651	$41,425	$150,226	$166,066	$118,986	$1,140,374
2018	26,184	6,799	$192,455	$42,047	$150,408	$169,260	$116,611	$1,256,985
2019	26,291	6,901	$193,240	$42,678	$150,562	$172,484	$114,261	$1,371,246
2020	26,395	7,005	$194,005	$43,318	$150,687	$175,734	$111,937	$1,483,182
2021	26,497	7,110	$194,749	$43,967	$150,782	$179,010	$109,638	$1,592,820
2022	26,595	7,217	$195,473	$44,627	$150,846	$182,309	$107,364	$1,700,183
2023	26,690	7,325	$196,174	$45,296	$150,877	$185,629	$105,115	$1,805,298
2024	26,783	7,435	$196,852	$45,976	$150,876	$188,969	$102,890	$1,908,188
2025	26,872	7,546	$197,506	$46,665	$150,841	$192,325	$100,690	$2,008,878
2026	26,957	7,659	$198,136	$47,365	$150,770	$195,696	$98,514	$2,107,392
2027	27,039	7,774	$198,740	$48,076	$150,664	$199,078	$96,362	$2,203,754
2028	27,118	7,891	$199,318	$48,797	$150,520	$202,468	$94,234	***$2,297,988***

Notes: Total visitation estimates derive from Tables 3.38 and 3.39
UDV (with project) = $7.35
UDV (without project) = $6.18
Benefit adjusted from 2010 prices to 2009 prices with the CPI; CPI for 2009 = 214.5 and for 2010 = 219.7; conversion factor = 214.5/219.7 = 0.9763
Inflation factors = 1.1% for 2011, 1.2% for 2012 – 2014, and 1.8% for 2015 and beyond
Discount rate = 4.0% (mid-year discounting)

Table 3.43 summarizes the benefit and cost information for this project. The B/C ratio equals 1.17 with a total estimated benefit of about $8.1 million and a cost of about $6.9 million.

Table 3.43 Benefit-Cost Summary for Galveston Seawall Beach Project (2009 – 2028)

Benefit Type	Discounted Present Worth
Riprap	$2,364,619
Visitation	
Out-of-State Spending	$3,441,463
Recreation	$2,297,988
Subtotal	$5,739,451
Total	$8,104,071
Total Cost	$6,948,316
B/C Ratio	1.17

Note: Dollar value represent present worth equivalents at the beginning of 2009 with a 4% discount rate

3.5 #1453 Isla Blanca Park Beach Nourishment with Beneficial Use of Dredged Material Project

3.5.1 Project Description

Isla Blanca Park is located just north of the Brazos-Santiago Pass on the southern end of South Padre Island. The project area (Figure 3.32) extends from Station 7+00 (700 ft north of the jetty at Brazos-Santiago Pass) to Station 34+00 in Isla Blanca Park. Based on information obtained from the UTBEG, the project area shoreline erodes about -0.2 to -5.5 ft/yr with a distance-weighted average of -2.7 ft/yr. Structures in the project area include two pavilions and a walkover. This constructed Cycle 6 project, in conjunction with Project #1456, included nourishing the beach with approximately 90,000 cy of dredged material from the Brazos Santiago Pass. Construction began March 2, 2010 and ended March 12, 2010. Figure 3.33 presents representative pre- and post-construction photographs. Table 3.44 presents the funding breakdown for the project.

Table 3.44 Funding for the Isla Blanca Park Nourishment Project (2010 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$9,496
Cameron County	$3,165
Total	$12,661

Note: The GLO shared project costs with project #1456. The above costs represent approximate cost shares for engineering only.

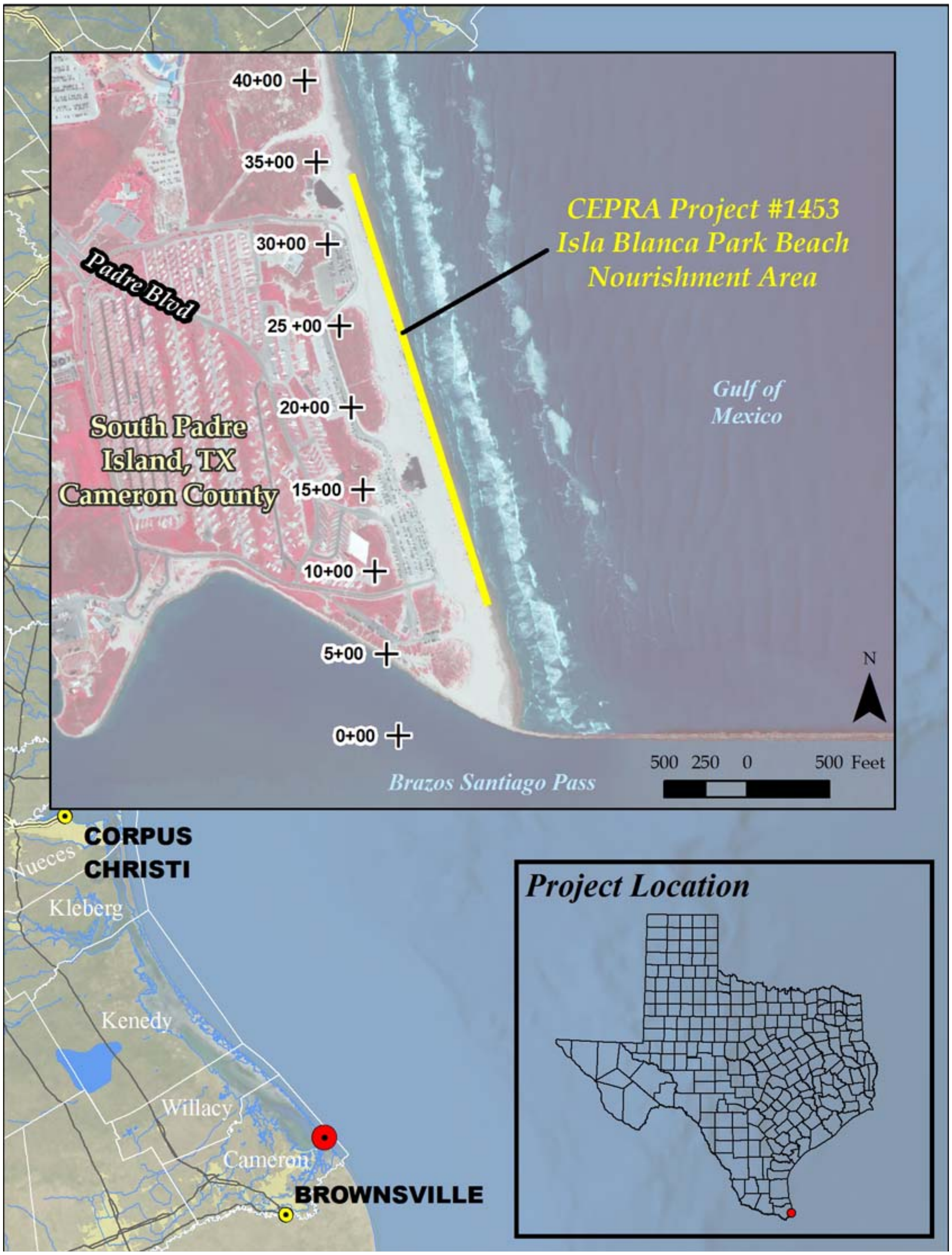

Figure 3.32 Isla Blanca Park Project Location Map

Figure 3.33 Isla Blanca Park Pre-and Post-Construction Conditions
(January 29, 2010; March 16, 2010; HDR, 2010a)

3.5.2 Analysis

Economic benefits from this beach project include storm damage reduction and visitation. To estimate storm damage reduction benefits, this study applied the same methodology and storms as applied for Project #1456 (Section 3.1.4). The GLO provided pre- and post-construction beach profile data along the project area. Figure 3.34 presents typical pre- and post-construction profiles. One pre-construction profile and one post-construction profile represents initial without- and with-project conditions for the SBEACH modeling. SBEACH produced post-storm profiles for Hurricane Alex, Tropical Storm Hermine, and 1-, 2-, 5-, 10-, 20-, 50-, and 100-year storms on eroded with- and without-project profiles between 2010 and 2014. Figure 3.35 presents a typical post-storm profile for without- and with-project conditions for the 5-year storm.

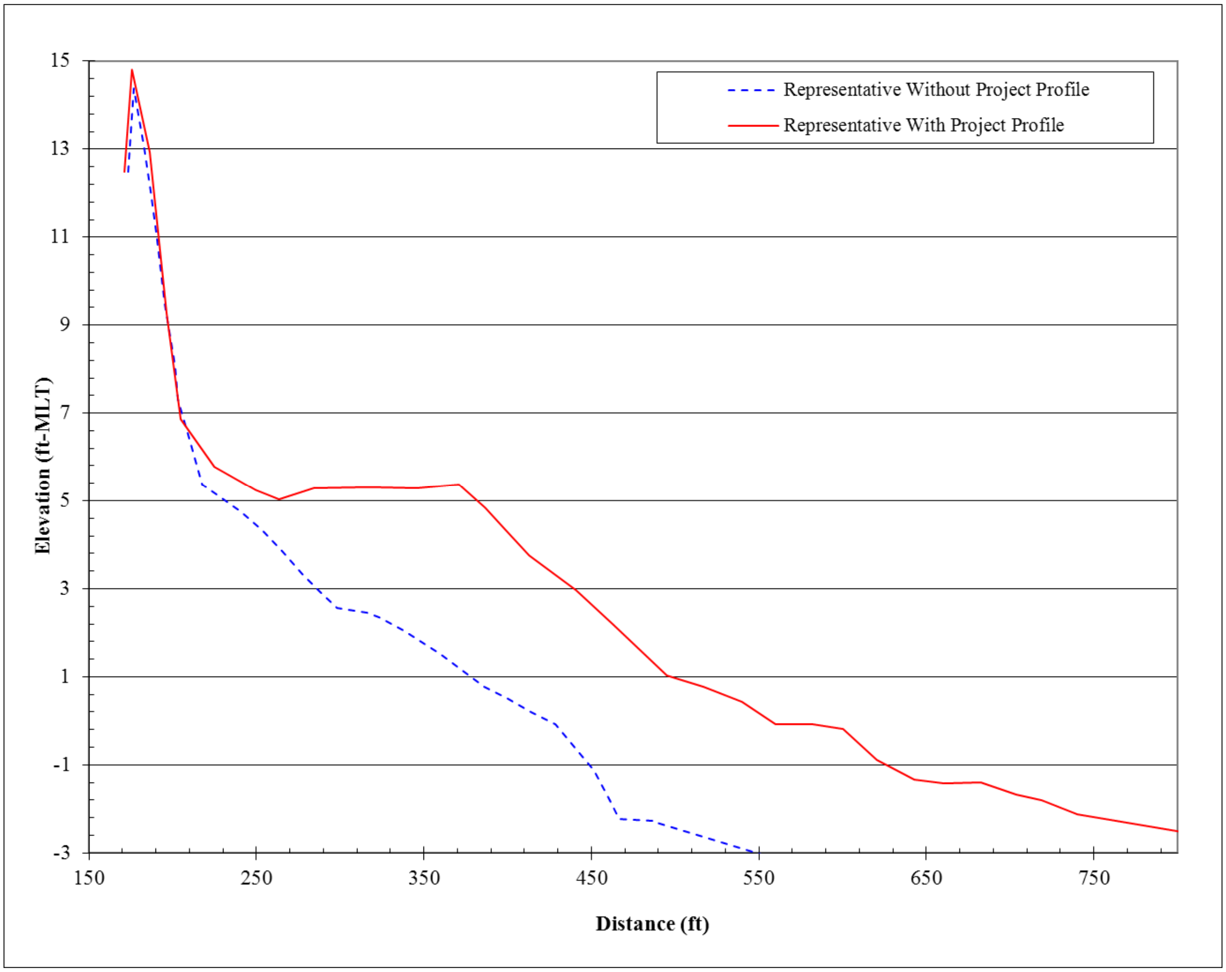

Figure 3.34 Isla Blanca Typical Pre- and Post-Construction Representative Profiles

The methodology outlined in Section 2.2 and the site-specific information described above produces the damage-cumulative probability distribution for each year between 2011 and 2014 on the with- and without-project representative profiles. Note that this analysis translated each with- and without-project representative profile 2.7 ft landward every year to account for the historical long-term erosion at the site. Given the lower background erosion rate compared to other South Padre Island projects, this study estimated benefits over a five-year period. Table 3.45 presents the damage-cumulative probability distribution for 2011 without-project conditions. From the table, the expected annual total damage for this condition averages approximately $185,000. Appendix A presents these distributions for 2011 – 2014 for both with- and without-project conditions.

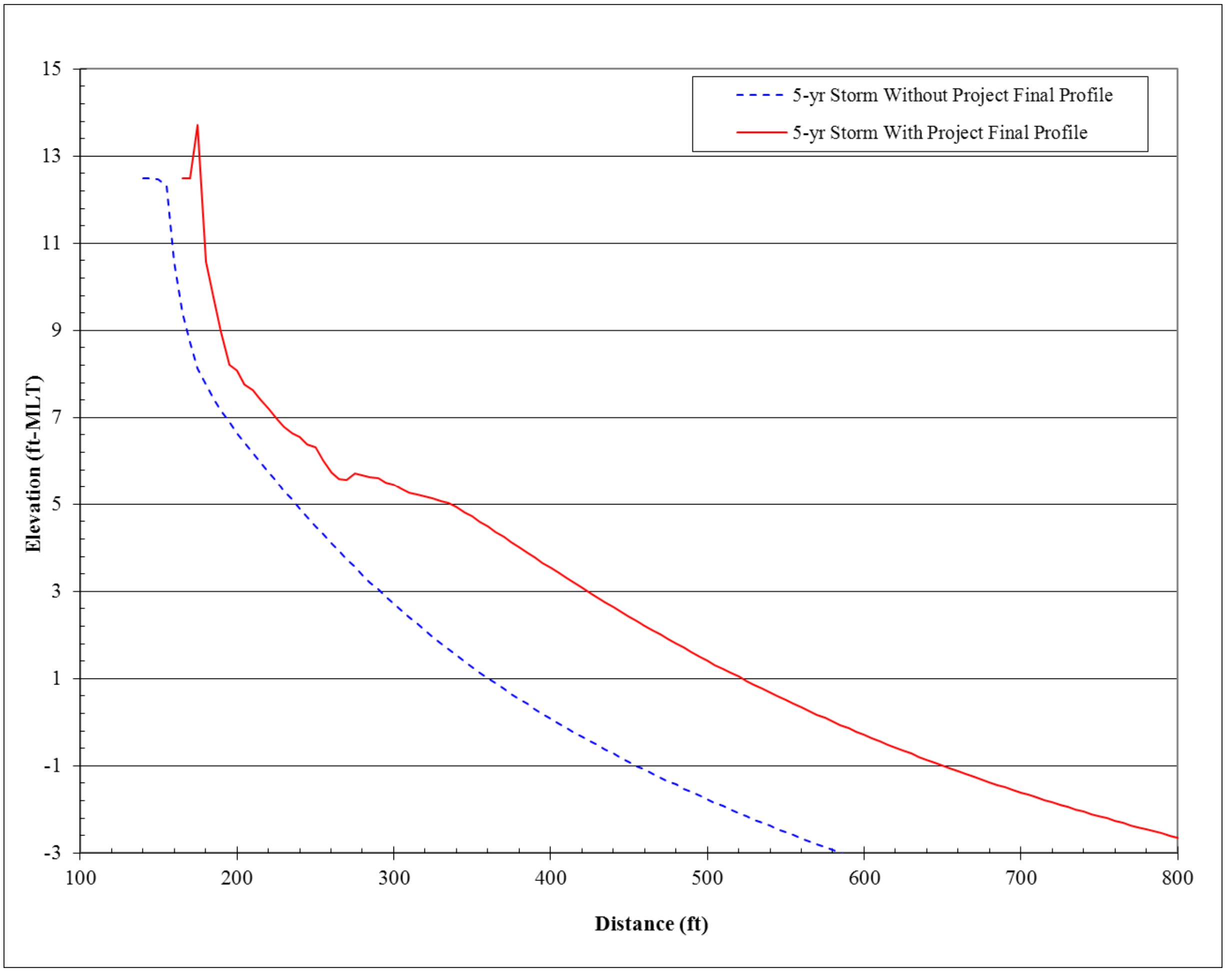

Figure 3.35 Isla Blanca Park with- (Post-Con) and without- (Pre-Con) Project Typical Five-Year Post-Storm Profile

Table 3.46 presents a summary of the recorded and expected storm damage reduction benefits for the beach restoration project at Isla Blanca Park. From the table, the total benefit over the analysis equals $171,469 over the five-year period of analysis.

Table 3.45 Isla Blanca Park Total Damage-Cumulative Probability (Year 2011, without Project)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage
1	1.00	0.00	$149,132	$0	$149,132			
2	0.50	0.50	$149,132	$0	$149,132	$149,132	0.50	$74,566
5	0.20	0.80	$223,698	$0	$223,698	$186,415	0.30	$55,924
10	0.10	0.90	$223,698	$0	$223,698	$223,698	0.10	$22,370
20	0.05	0.95	$298,264	$0	$298,264	$260,981	0.05	$13,049
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066
100	0.01	0.99	$447,396	$0	$447,396	$410,113	0.01	$4,101
>100	<0.01	>0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474
			Expected Average Annual Damage in 2010 Prices:					$184,551

Table 3.46 Isla Blanca Park Storm Damage Reduction Benefit

Year	Without Project (2010 Prices)	With Project (2010 Prices)	Difference (Benefit)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
2010	$149,132	$149,132	$0	$0	$0	$0
2011	$184,551	$125,644	$58,907	$59,555	$56,152	$56,152
2012	$184,551	$144,285	$40,266	$41,197	$37,349	$93,502
2013	$186,042	$144,285	$41,757	$43,236	$37,690	$131,192
2014	$191,635	$145,777	$45,858	$48,052	$40,277	***$171,469***

Notes: Inflation rate = 1.1% for 2011 and 1.2% for 2012 – 2014
Discount rate = 4.0% (mid-year discounting)

In addition to storm damage reduction benefits, the project also provided beach visitation benefits. Similar to other South Padre Island projects, this analysis adopted two visitation benefit categories — spending by out-of-state visitors and recreational enjoyment by all visitors. Both require estimates of the beachgoer population over the two-year period of analysis. Oden and Butler report about 920 peak day visitors to the Isla Blanca Park area based on a 2005 survey. According to Oden et al., 104 peak visitor days occur in the South Padre Island area. One-fifth (assumed) of the peak day visitors (184) visit the beach during off peak days and 261 (i.e., 365 – 104) off peak days exist during a 365-day year. Given the above visitor information, approximately 143,704 visits (920 * 104 + 184 * 261) occurred in 2005 in the project area.

Pre- and post-construction surveys produced initial with- and without-project beach width for 2010. Incorporating the above information yields without- (Table 3.47) and with- (Table 3.48) project visitation estimates. In the tables, the first beach visitation column represents beach visitation given no beach width constraint on visitation (i.e., beach visitation grows at an estimated 1.5% annually). One must calculate this beach visitation number as a starting point in order to apply the beach width elasticity relationship (Oden and Butler, 2006) to determine estimated beach visitation with- and without-the project. Given site-specific data, this analysis adopts the elasticity relationship for South Padre Island where a 0.22% visitor reduction occurs for every 1% loss of beach width. Application of the elasticity relationship to estimated visitation growth and to estimated beach width in relevant years since the time of the survey accounts for beachgoers' beach width preferences.

Table 3.47 Isla Blanca Park without Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey* beach width (ft)	Without project beach width (ft)	Without project % change in beach width	Without project % reduction in visitation	Without project constrained annual visitation
2005	143,704	47	--	--	--	--
2006	145,860	--	--	--	--	--
2007	148,047	--	--	--	--	--
2008	150,268	--	--	--	--	--
2009	152,522	--	--	--	--	--
2010	154,810	--	53	12%	0%	154,810
2011	157,132	--	50	7%	0%	157,132
2012	159,489	--	48	1%	0%	159,489
2013	161,881	--	45	-4%	1%	160,298
2014	164,310	--	42	-10%	2%	160,661

Notes: *Beach width estimated from 2005 beach placement project
Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.22%
Erosion rate = -2.7 ft/yr

Oden and Butler report that 18.3% of the visitors to the Isla Blanca Park area originate from outside Texas. These out-of-state visitors spend $68.69 (2005 dollars) per person per visit in the Isla Blanca Park area. Inflating this value to 2010 dollars yields $77.27.

The with- and without-project visitation estimates (Tables 3.47 and 3.48) serve as input for estimating the benefits from spending by out-of-state visitors and the value of recreation benefits for all visitors. Table 3.49 summarizes the benefit to Texas from spending by out-of-state visitors (including the multiplier effect). The present value of this benefit (present value, beginning in 2010) is $91,740.

Calculating recreation enjoyment benefits for all visitors involved applying the visitation numbers derived in Tables 3.47 and 3.48 to the UDV developed (see Section 2.2, Table 2.5) for with- and without-project conditions. Table 3.50 presents a summary of the points assigned for with- and without-project conditions in the project area. Converting the points to dollar values with the help of Table 2.6 (Section 2.2) results in with- and without-project UDVs of about $8.16 and $7.82 per person per visit. Taking the difference between the estimated recreation value for all visitors with- and without-project estimates yields the benefit for the year. Table 3.51 presents the recreation value benefit for this project. In total, the benefit equals $284,127 (present value, beginning in 2010).

Table 3.48 Isla Blanca Park with Project, Total Beach Visitation

Year	Unconstrained annual visitation	Survey* beach width (ft)	With project beach width (ft)	With project % change in beach width	With project % reduction in visitation	With project constrained annual visitation
2005	143,704	47	--	--	--	--
2006	145,860	--	--	--	--	--
2007	148,047	--	--	--	--	--
2008	150,268	--	--	--	--	--
2009	152,522	--	--	--	--	--
2010	154,810	--	127	169%	0%	154,810
2011	157,132	--	124	164%	0%	157,132
2012	159,489	--	122	158%	0%	159,489
2013	161,881	--	119	152%	0%	161,881
2014	164,310	--	116	147%	0%	164,310

Notes: *Beach width estimated from 2005 beach placement project
Weighted population growth rate (proxy for unconstrained visitation growth) = 1.5%/year
Reduction in visitation per 1% change in beach width = 0.22%
Erosion rate = -2.7 ft/yr

Table 3.49 Isla Blanca Park Out-of-State Visitor Spending Benefit

Year	Total Visitation		Out of State				Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
			Visitation		Visitor Spending					
	With Project	Without Project	With Project	Without Project	With Project	Without Project				
2010	154,810	154,810	28,330	28,330	$3,064,782	$3,064,782	$0	$0	$0	$0
2011	157,132	157,132	28,755	28,755	$3,110,753	$3,110,753	$0	$0	$0	$0
2012	159,489	159,489	29,187	29,187	$3,157,415	$3,157,415	$0	$0	$0	$0
2013	161,881	160,298	29,624	29,334	$3,204,776	$3,173,420	$31,356	$32,466	$28,302	$28,302
2014	164,310	160,661	30,069	29,401	$3,252,847	$3,180,619	$72,229	$75,684	$63,438	***$91,740***

Notes: Total visitation estimates derive from Tables 3.47 and 3.48
Out-of-state visitation = 18.3% of total visitation
Out-of-state visitor spending = $77.27 per person (2010 prices)
Multiplier effect = 1.4
Inflation rate = 1.1% for 2011 and 1.2% for 2012 – 2014
Discount rate = 4.0% (mid-year discounting)

Table 3.50 UDV Points Assigned for Isla Blanca Park Project

Criteria	Points Assigned (With Project)	Points Assigned (Without Project)	Total Possible Points
Recreation Experience	12	10	30
Availability of Opportunity	3	3	18
Carrying Capacity	10	9	14
Accessibility	18	18	18
Environmental	15	13	20
Total	58	53	100

Table 3.51 South Padre Island Recreation Benefit for All Visitors

Year	Total Visitation		Recreation Value		Difference	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With Project	Without Project	With Project	Without Project				
2010	154,810	154,810	$1,262,631	$1,210,769	$51,861	$51,861	$50,854	$50,854
2011	157,132	157,132	$1,281,570	$1,228,931	$52,639	$53,218	$50,178	$101,032
2012	159,489	159,489	$1,300,794	$1,247,365	$53,429	$54,665	$49,559	$150,591
2013	161,881	160,298	$1,320,305	$1,253,688	$66,618	$68,977	$60,129	$210,720
2014	164,310	160,661	$1,340,110	$1,256,532	$83,578	$87,576	$73,407	***$284,127***

Notes: Total visitation estimates derive from Tables 3.47 and 3.48
UDV (with project) = $8.16
UDV (without project) = $7.82
Inflation rate = 1.1% for 2011 and 1.2% for 2012 – 2014
Discount rate = 4.0% (mid-year discounting)

Table 3.52 summarizes the benefit and cost information for this project. The B/C ratio equals 43.23 with a total estimated benefit of about $547,000 and a cost of about $12,700.

Table 3.52 Benefit-Cost Summary for Isla Blanca Park (2010 – 2014)

Benefit Type	**Discounted Present Worth**
Storm Damage Reduction	$171,469
Visitation	
Out-of-State Spending	$91,740
Recreation	$284,127
Subtotal	$375,868
Total	$547,337
Total Cost	$12,661
B/C Ratio	43.23

Note: Dollar values represent present worth equivalents at the beginning of 2010 with a 4% discount rate

4.0 NATURAL RESOURCE RESTORATION BENEFIT ANALYSIS

4.1 #1483 West Galveston Island Estuarine Restoration

4.1.1 Project Description

The West Galveston Island Estuarine Restoration project consisted of constructing 328.5 acres of estuarine marsh complex between February and November 2010 on the west side of Galveston Island near Galveston Island State Park (GISP) (Figures 4.1 and 4.2). The project included dredging 810,300 cy of sandy sediment from the adjacent open bay to create the marshes (Figure 4.2). The resulting marsh consists of emergent habitat planted with approximately 177,333 Spartina alterniflora (smooth cordgrasss) transplants. Of the 328.5 acres, 130 acres of mound-design marsh lies in Jumbile Cove (Figure 4.3) and 198.5 acres of terrace/mound design marshes in the Carancahua Cove (Figure 4.4) portion of Galveston Island State Park (GISP) (Figure 4.2).

A combination of regional land subsidence and sea level rise has eroded the marshes in the project area (HDR, 2009a). Land subsidence rates have decreased since the 1970s due to termination of groundwater pumping. Recent data suggest minimal land subsidence (0.01 ft since 2002) near the project area (HGCSD, 2009). Ravens et al. (2009) report a sedimentation rate at GISP of 0.08 inches per year. In contrast, NOAA (2009) reports a mean sea level rise in the area of 0.25 inches per year — three times higher than the subsidence rate. Previous marsh restoration efforts have occurred within or adjacent to GISP (in 2000) and Jumbile Cove (in 2001 and 2004). The project replaced the GISP terrace marshes, which by 2009 had eroded to the point that they maintained predominantly subtidal elevation (HDR, 2009a). The project also supplemented the existing marsh mounds at Jumbile Cove. Table 4.1 presents the funding breakdown for the project.

Table 4.1 Funding for West Galveston Island Estuarine Restoration Project (2010 Prices)

Funding Source	Amount
Texas General Land Office, Coastal Erosion Planning and Response Act	$647,597
National Oceanographic and Atmospheric Administration (American Recovery & Reinvestment Act) (Texas only)	$5,148,369 ($514,837)
Total Total (Texas only)	$5,795,966 ($1,162,434)

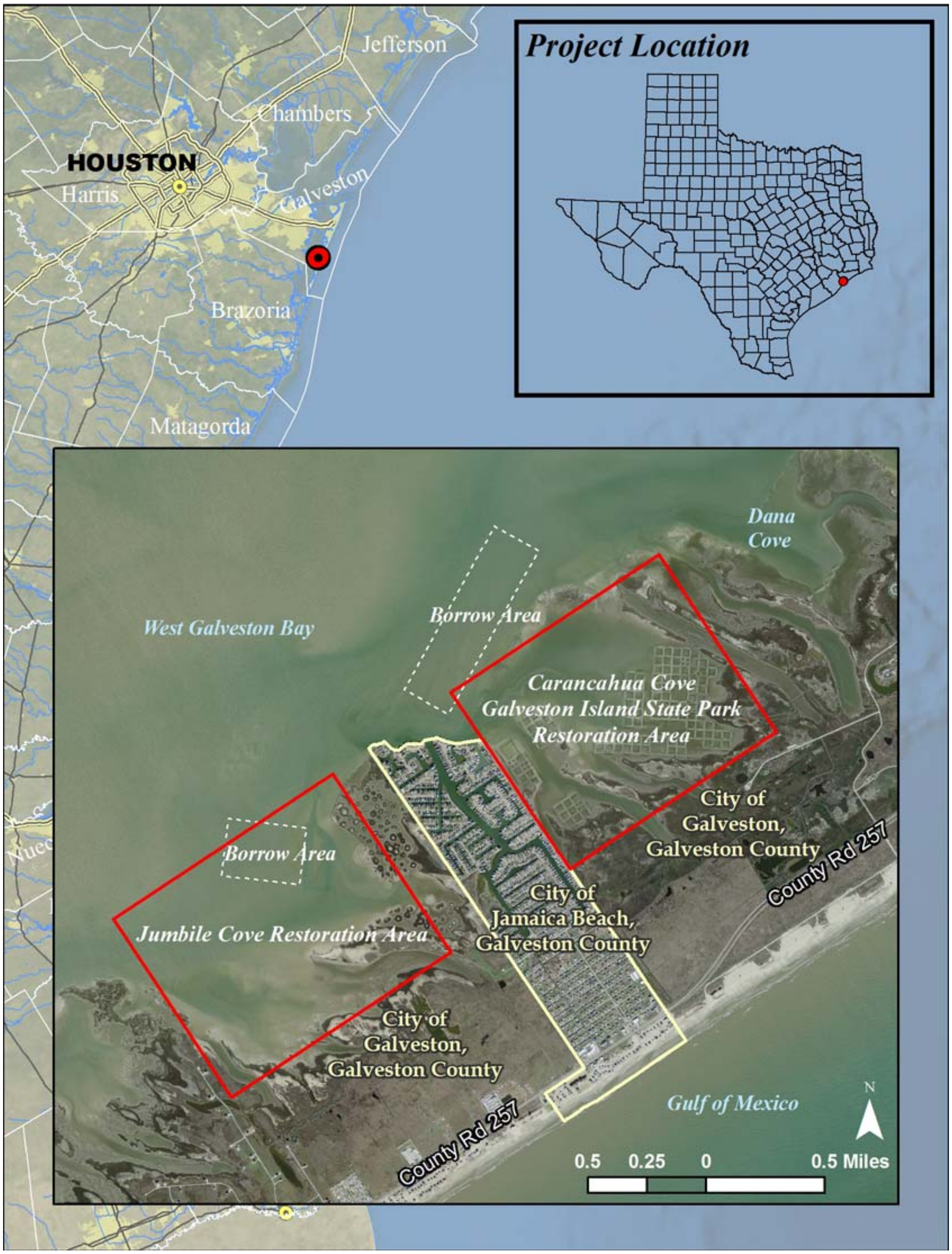

Figure 4.1 West Galveston Island Estuarine Restoration Project Location Map

Figure 4.2 West Galveston Island Estuarine Restoration Project Overview

Figure 4.3 Jumbile Cove Project Layout

Figure 4.4 GISP Project Layout

Notably, any costs that originate from national agencies or organizations decrease by 90% (see Section 2.1) because some entity other than the state of Texas incurs those costs. Federal dollars fund the American Recovery & Reinvestment Act (ARRA) and Texas contributes, roughly in proportion to Texas' share of the national population, about 10% of the federal dollars through individual and corporate taxes. Given 90% of the ARRA's $5,148,369 originates from non-Texas sources, one may reduce the cost to Texas by $4,633,532 (i.e., 0.9 * $5,148,369). Therefore, the project cost to Texas revises downward for this benefit-cost analysis from $5,795,966 to $1,162,434 (i.e., $5,795,966 - $4,633,532).

4.1.2 Analysis

Natural resource function benefits equal the estimated difference between conditions with and without the project. Although the marsh will mature over a several year period, benefit calculations assume a steady decrease in the source of the benefit due to marsh erosion and settlement. With the project, 328.5 acres of marsh initially exist. Each subsequent year, the marsh area declines by 5% of the initial 328.5-acre area. Without the project, zero acres exist in each of the years of the evaluation period.

This evaluation chose a 20-year period of analysis for this project based on existing information for similar projects and the performance of the mounded marsh already constructed on the site.

Table 4.2 presents the dollar values assigned for each service function identified for this project. Conservatively, this study assigned low (minimum) dollar values to these functions. Table 4.3 presents the service functions' benefits estimated as the difference between with-project and without-project conditions and expressed as a present value amount at the beginning of the period of analysis, 2011.

Table 4.2 Selected Habitat Service Functions and Values for West Galveston Island Estuarine Restoration

Service Function	Annual Service Values per Acre (2010 Prices)
Recreational fishing	$374.96
Commercial fishing	$62.07
Recreation	$156.36
Storm/flood protection	$115.88
Water quality	$119.63
Carbon sequestration	$34.23
Total	$863.13

Note that an additional benefit $6,486,945 ($4,633,532 * 1.4 [multiplier effect]) exists to account for federal spending (a net increase inflow of spending for the state economy) that occurs as part of the initial construction. This benefit adds to the benefits calculated above.

Adding the federal spending benefit ($6,486,945) to the ecosystem service benefit derived in Table 4.3 ($2,554,979) results in a total estimated benefit for this project of $9,041,924. With a total project cost of $1,162,434, the resulting B/C ratio for the West Galveston Island Estuarine Restoration project equals 7.78. Table 4.4 summarizes the costs and benefits.

Table 4.3 West Galveston Island Estuarine Restoration Benefits

Year	Acres		Difference (acres)	Benefit Value (2010 Prices)	With Inflation	Discounted Present Worth	Cumulative Discounted Present Worth
	With project	Without project					
2011	328.5	0	328.5	$283,539	$286,658	$281,091	$281,091
2012	312.1	0	312.1	$269,362	$275,593	$259,847	$540,939
2013	295.7	0	295.7	$255,185	$264,221	$239,543	$780,482
2014	279.2	0	279.2	$241,008	$252,537	$220,144	$1,000,626
2015	262.8	0	262.8	$226,831	$241,960	$202,812	$1,203,438
2016	246.4	0	246.4	$212,654	$230,920	$186,114	$1,389,552
2017	230.0	0	230.0	$198,477	$219,405	$170,032	$1,559,584
2018	213.5	0	213.5	$184,300	$207,401	$154,547	$1,714,131
2019	197.1	0	197.1	$170,123	$194,893	$139,641	$1,853,772
2020	180.7	0	180.7	$155,946	$181,867	$125,296	$1,979,068
2021	164.3	0	164.3	$141,770	$168,310	$111,496	$2,090,564
2022	147.8	0	147.8	$127,593	$154,206	$98,224	$2,188,788
2023	131.4	0	131.4	$113,416	$139,539	$85,463	$2,274,251
2024	115.0	0	115.0	$99,239	$124,294	$73,198	$2,347,449
2025	98.5	0	98.5	$85,062	$108,456	$61,414	$2,408,864
2026	82.1	0	82.1	$70,885	$92,007	$50,096	$2,458,960
2027	65.7	0	65.7	$56,708	$74,930	$39,229	$2,498,189
2028	49.3	0	49.3	$42,531	$57,209	$28,799	$2,526,988
2029	32.8	0	32.8	$28,354	$38,826	$18,793	$2,545,781
2030	16.4	0	16.4	$14,177	$19,762	$9,198	***$2,554,979***

Notes: Inflation rate = 1.1% for 2011, 1.2% for 2012 – 2014, and 1.8% for 2015 and beyond
Discount rate = 4.0% (mid-year discounting)
Annual erosion rate = 5% of initial acreage

Table 4.4 Benefit-Cost Summary for West Galveston Island Estuarine Restoration (2011 – 2030)

Benefit Type	**Discounted Present Worth**
Ecosystem services	$2,554,979
Federal spending	$6,486,945
Total	$9,041,924
Total Cost	$1,162,434
B/C Ratio	7.78

Note: Dollar values represent present worth equivalents at the beginning of 2011 with a 4% discount rate

5.0 SUMMARY AND CONCLUSIONS

5.1 Summary

To address the significant erosive threat to Texas coastal areas, the 76th Texas Legislature passed the CEPRA in 1999. The CEPRA invests significant state resources to control coastal erosion in partnership with local, state, and federal entities. The Texas GLO created project partnerships between these entities to implement a series of erosion response projects and studies in Cycles 1 (state fiscal years 2000-2001), 2 (state fiscal years 2002-2003), 3 (state fiscal years 2004-2005), and 4 (state fiscal years 2006-2007). They continued these partnerships through an allocation of more than $31 million to 50 erosion response projects and studies for Cycles 5 ($17.5 million in state fiscal years 2008-2009) and 6 ($14 million in state fiscal years 2010-2011).

The Texas Legislature requires the GLO report the economic and natural resource benefits derived from CEPRA funding every biennium. As such, the GLO contracted Taylor Engineering, Inc. under GLO Contract No. 10-103-010 and Work Order No. 4176 to perform the benefit analyses for Cycle 5 and 6 construction projects. This report analyzed a subset of eight CEPRA Cycle 5 and 6 projects:

- #1355 South Padre Island Beach Nourishment with Truck Haul
- #1356 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material
- #1379 Surfside Revetment Project
- #1404 Sylvan Beach Shoreline Protection and Beach Nourishment
- #1447 Galveston Seawall Emergency Beach Nourishment
- #1453 Isla Blanca Park Beach Nourishment with Beneficial Use of Dredged Material
- #1456 South Padre Island Beach Nourishment with Beneficial Use of Dredged Material
- #1483 West Galveston Island Estuarine Restoration

This study classified and estimated economic and financial benefits associated with commercial and recreational fishing, tourism and ecotourism (wildlife viewing), improved water quality, carbon sequestration, beach recreation, out-of-state visitor spending, and storm protection. The stream of economic benefits over time varies from project to project depending on the durability of the project. The period of analysis for the various projects varied from 1 to 20 years.

This study adopts a Texas accounting perspective or stance. Funding from outside Texas and out-of-state spending represent financial benefits to the state. A Texas accounting stance views project contributions normally considered a cost when viewed from a national or world perspective as a financial benefit. Costs funded by non-Texas dollars represent a financial benefit because money flows into the Texas economy. This adjustment has occurred where appropriate to reflect the Texas accounting perspective of the estimates of benefits and costs. Table 5.1 presents a summary of the assessed projects. In total, for every Texas dollar invested in these projects, the state of Texas receives $2.65 in economic and financial benefits.

Table 5.1 Summary of CEPRA Cycle 5 and 6 Projects, Costs, and Benefits

Project Number	Project Name	County	Total Discounted Cost*	CEPRA Cost	Total Discounted Benefits	Benefit-to-Cost (B/C) Ratio
1355	South Padre Island Beach Nourishment with Truck Haul	Cameron	$720,801	$551,544	$1,330,538	1.85
1356	South Padre Island Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$610,248	$457,686	$356,931	0.58
1379	Surfside Revetment Project	Brazoria	$1,373,395	$1,287,558	$11,302,986	8.23
1404	Sylvan Beach Shoreline Protection and Beach Nourishment	Harris	$3,660,822	$2,196,493	$6,467,363	1.77
1447	Galveston Seawall Emergency Beach Nourishment	Galveston	$7,226,249	$5,419,686	$8,428,234	1.17
1453	Isla Blanca Park Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$12,661	$9,496	$547,337	43.23
1456	South Padre Island Beach Nourishment with Beneficial Use of Dredged Material	Cameron	$593,258	$444,943	$3,470,022	5.85
1483	West Galveston Island Estuarine Restoration	Galveston	$1,117,725	$622,689	$8,694,158	7.78
		Totals	$15,315,159	$10,990,096	$40,597,567	2.65

Notes: *Texas portion only
Dollar values reflect present worth equivalents at the beginning of 2010 with a 4% discount rate

5.2 Conclusions

The data and evaluations presented in this report support the following conclusions:

- The direct and positive net benefits (B/C ratios greater than one) accruing from construction of the eight subject projects indicate that these coastal erosion control projects yield high returns on investment for the state of Texas; and
- Preserving Texas' coastal assets proves a worthy public investment strategy for the taxpayers and citizenry of Texas.

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APPENDIX A

Storm Damage Reduction Benefits—Damage-Cumulative Probabilities

Surfside Beach

Without Project Conditions, Year 3 (2011)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$0	$0	$0							
2	0.50	0.50	$74,452	$0	$74,452	$37,226	0.50	$18,613	$37,226	$18,613	$0	$0
5	0.20	0.80	$1,045,962	$4,433	$1,050,395	$562,424	0.30	$168,727	$560,207	$168,062	$2,217	$665
10	0.10	0.90	$4,135,741	$4,020,170	$8,155,911	$4,603,153	0.10	$460,315	$2,590,852	$259,085	$2,012,302	$201,230
20	0.05	0.95	$5,163,619	$5,400,145	$10,563,764	$9,359,838	0.05	$467,992	$4,649,680	$232,484	$4,710,158	$235,508
50	0.02	0.98	$4,860,996	$4,466,405	$9,327,401	$9,945,583	0.03	$298,367	$5,012,308	$150,369	$4,933,275	$147,998
100	0.01	0.99	$5,023,579	$4,937,838	$9,961,418	$9,644,409	0.01	$96,444	$4,942,288	$49,423	$4,702,122	$47,021
>100	<0.01	>0.99	$5,023,579	$4,937,838	$9,961,418	$9,961,418	0.01	$99,614	$5,023,579	$50,236	$4,937,838	$49,378
			Expected Average Annual Damage in 2010 Prices:					$1,610,073		$928,272		$681,801

With Project Conditions, Year 3 (2011)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$0	$0	$0							
2	0.50	0.50	$0	$0	$0	$0	0.50	$0	$0	$0	$0	$0
5	0.20	0.80	$0	$100,439	$100,439	$50,220	0.30	$15,066	$0	$0	$50,220	$15,066
10	0.10	0.90	$0	$267,837	$267,837	$184,138	0.10	$18,414	$0	$0	$184,138	$18,414
20	0.05	0.95	$53,866	$602,634	$656,500	$462,169	0.05	$23,108	$26,933	$1,347	$435,236	$21,762
50	0.02	0.98	$2,451,601	$4,024,933	$6,476,534	$3,566,517	0.03	$106,996	$1,252,733	$37,582	$2,313,784	$69,414
100	0.01	0.99	$2,897,261	$4,768,287	$7,665,547	$7,071,041	0.01	$70,710	$2,674,431	$26,744	$4,396,610	$43,966
>100	<0.01	>0.99	$2,897,261	$4,768,287	$7,665,547	$7,665,547	0.01	$76,655	$2,897,261	$28,973	$4,768,287	$47,683
			Expected Average Annual Damage in 2010 Prices:					$310,950		$94,646		$216,304

Surfside Beach

Without Project Conditions, Year 4 (2012)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$0	$0	$0							
2	0.50	0.50	$131,181	$0	$131,181	$65,590	0.50	$32,795	$65,590	$32,795	$0	$0
5	0.20	0.80	$1,139,531	$12,808	$1,152,339	$641,760	0.30	$192,528	$635,356	$190,607	$6,404	$1,921
10	0.10	0.90	$4,182,492	$4,020,170	$8,202,662	$4,677,501	0.10	$467,750	$2,661,012	$266,101	$2,016,489	$201,649
20	0.05	0.95	$5,197,308	$5,512,234	$10,709,542	$9,456,102	0.05	$472,805	$4,689,900	$234,495	$4,766,202	$238,310
50	0.02	0.98	$4,958,074	$4,728,744	$9,686,818	$10,198,180	0.03	$305,945	$5,077,691	$152,331	$5,120,489	$153,615
100	0.01	0.99	$5,083,455	$5,136,049	$10,219,504	$9,953,161	0.01	$99,532	$5,020,765	$50,208	$4,932,396	$49,324
>100	<0.01	>0.99	$5,083,455	$5,136,049	$10,219,504	$10,219,504	0.01	$102,195	$5,083,455	$50,835	$5,136,049	$51,360
			Expected Average Annual Damage in 2010 Prices:					$1,673,550		$977,371		$696,179

With Project Conditions, Year 4 (2012)

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$0	$0	$0							
2	0.50	0.50	$0	$0	$0	$0	0.50	$0	$0	$0	$0	$0
5	0.20	0.80	$0	$100,439	$100,439	$50,220	0.30	$15,066	$0	$0	$50,220	$15,066
10	0.10	0.90	$0	$267,837	$267,837	$184,138	0.10	$18,414	$0	$0	$184,138	$18,414
20	0.05	0.95	$53,866	$602,634	$656,500	$462,169	0.05	$23,108	$26,933	$1,347	$435,236	$21,762
50	0.02	0.98	$2,469,895	$4,081,228	$6,551,123	$3,603,812	0.03	$108,114	$1,261,881	$37,856	$2,341,931	$70,258
100	0.01	0.99	$2,910,839	$4,782,888	$7,693,727	$7,122,425	0.01	$71,224	$2,690,367	$26,904	$4,432,058	$44,321
>100	<0.01	>0.99	$2,910,839	$4,782,888	$7,693,727	$7,693,727	0.01	$76,937	$2,910,839	$29,108	$4,782,888	$47,829
			Expected Average Annual Damage in 2010 Prices:					$312,864		$95,215		$217,649

Isla Blanca Park Project #1453

2011, Without Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$149,132	$0	$149,132							
2	0.50	0.50	$149,132	$0	$149,132	$149,132	0.50	$74,566	$149,132	$74,566	$0	$0
5	0.20	0.80	$223,698	$0	$223,698	$186,415	0.30	$55,924	$186,415	$55,924	$0	$0
10	0.10	0.90	$223,698	$0	$223,698	$223,698	0.10	$22,370	$223,698	$22,370	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$260,981	0.05	$13,049	$260,981	$13,049	$0	$0
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066	$335,547	$10,066	$0	$0
100	0.01	0.99	$447,396	$0	$447,396	$410,113	0.01	$4,101	$410,113	$4,101	$0	$0
>100	<0.01	>0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$184,551		$184,551		$0

2011, With Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$0	$0	$0							
2	0.50	0.50	$149,132	$0	$149,132	$74,566	0.50	$37,283	$74,566	$37,283	$0	$0
5	0.20	0.80	$149,132	$0	$149,132	$149,132	0.30	$44,740	$149,132	$44,740	$0	$0
10	0.10	0.90	$149,132	$0	$149,132	$149,132	0.10	$14,913	$149,132	$14,913	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$223,698	0.05	$11,185	$223,698	$11,185	$0	$0
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066	$335,547	$10,066	$0	$0
100	0.01	0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
>100	<0.01	>0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$125,644		$125,644		$0

Isla Blanca Park Project #1453

2012, Without Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$149,132	$0	$149,132							
2	0.50	0.50	$149,132	$0	$149,132	$149,132	0.50	$74,566	$149,132	$74,566	$0	$0
5	0.20	0.80	$223,698	$0	$223,698	$186,415	0.30	$55,924	$186,415	$55,924	$0	$0
10	0.10	0.90	$223,698	$0	$223,698	$223,698	0.10	$22,370	$223,698	$22,370	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$260,981	0.05	$13,049	$260,981	$13,049	$0	$0
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066	$335,547	$10,066	$0	$0
100	0.01	0.99	$447,396	$0	$447,396	$410,113	0.01	$4,101	$410,113	$4,101	$0	$0
>100	<0.01	>0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$184,551		$184,551		$0

2012, With Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$74,566	$0	$74,566							
2	0.50	0.50	$149,132	$0	$149,132	$111,849	0.50	$55,924	$111,849	$55,924	$0	$0
5	0.20	0.80	$149,132	$0	$149,132	$149,132	0.30	$44,740	$149,132	$44,740	$0	$0
10	0.10	0.90	$149,132	$0	$149,132	$149,132	0.10	$14,913	$149,132	$14,913	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$223,698	0.05	$11,185	$223,698	$11,185	$0	$0
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066	$335,547	$10,066	$0	$0
100	0.01	0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
>100	<0.01	>0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$144,285		$144,285		$0

Isla Blanca Park Project #1453

2013, Without Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$149,132	$0	$149,132							
2	0.50	0.50	$149,132	$0	$149,132	$149,132	0.50	$74,566	$149,132	$74,566	$0	$0
5	0.20	0.80	$223,698	$0	$223,698	$186,415	0.30	$55,924	$186,415	$55,924	$0	$0
10	0.10	0.90	$223,698	$0	$223,698	$223,698	0.10	$22,370	$223,698	$22,370	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$260,981	0.05	$13,049	$260,981	$13,049	$0	$0
50	0.02	0.98	$447,396	$0	$447,396	$372,830	0.03	$11,185	$372,830	$11,185	$0	$0
100	0.01	0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
>100	<0.01	>0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$186,042		$186,042		$0

2013, With Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$74,566	$0	$74,566							
2	0.50	0.50	$149,132	$0	$149,132	$111,849	0.50	$55,924	$111,849	$55,924	$0	$0
5	0.20	0.80	$149,132	$0	$149,132	$149,132	0.30	$44,740	$149,132	$44,740	$0	$0
10	0.10	0.90	$149,132	$0	$149,132	$149,132	0.10	$14,913	$149,132	$14,913	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$223,698	0.05	$11,185	$223,698	$11,185	$0	$0
50	0.02	0.98	$372,830	$0	$372,830	$335,547	0.03	$10,066	$335,547	$10,066	$0	$0
100	0.01	0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
>100	<0.01	>0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$144,285		$144,285		$0

Isla Blanca Park Project #1453

2014, Without Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$149,132	$0	$149,132							
2	0.50	0.50	$149,132	$0	$149,132	$149,132	0.50	$74,566	$149,132	$74,566	$0	$0
5	0.20	0.80	$223,698	$0	$223,698	$186,415	0.30	$55,924	$186,415	$55,924	$0	$0
10	0.10	0.90	$298,264	$0	$298,264	$260,981	0.10	$26,098	$260,981	$26,098	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$298,264	0.05	$14,913	$298,264	$14,913	$0	$0
50	0.02	0.98	$447,396	$0	$447,396	$372,830	0.03	$11,185	$372,830	$11,185	$0	$0
100	0.01	0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
>100	<0.01	>0.99	$447,396	$0	$447,396	$447,396	0.01	$4,474	$447,396	$4,474	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$191,635		$191,635		$0

2014, With Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$74,566	$0	$74,566							
2	0.50	0.50	$149,132	$0	$149,132	$111,849	0.50	$55,924	$111,849	$55,924	$0	$0
5	0.20	0.80	$149,132	$0	$149,132	$149,132	0.30	$44,740	$149,132	$44,740	$0	$0
10	0.10	0.90	$149,132	$0	$149,132	$149,132	0.10	$14,913	$149,132	$14,913	$0	$0
20	0.05	0.95	$298,264	$0	$298,264	$223,698	0.05	$11,185	$223,698	$11,185	$0	$0
50	0.02	0.98	$447,396	$0	$447,396	$372,830	0.03	$11,185	$372,830	$11,185	$0	$0
100	0.01	0.99	$372,830	$0	$372,830	$410,113	0.01	$4,101	$410,113	$4,101	$0	$0
>100	<0.01	>0.99	$372,830	$0	$372,830	$372,830	0.01	$3,728	$372,830	$3,728	$0	$0
			Expected Average Annual Damage in 2010 Prices:					$145,777		$145,777		$0

South Padre Island Project #1456

2011, Without Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$3,749,609	$0	$3,749,609							
2	0.50	0.50	$4,393,833	$246,708	$4,640,541	$4,195,075	0.50	$2,097,538	$4,071,721	$2,035,861	$123,354	$61,677
5	0.20	0.80	$4,941,621	$1,068,732	$6,010,352	$5,325,447	0.30	$1,597,634	$4,667,727	$1,400,318	$657,720	$197,316
10	0.10	0.90	$8,481,650	$4,939,335	$13,420,985	$9,715,669	0.10	$971,567	$6,711,635	$671,164	$3,004,034	$300,403
20	0.05	0.95	$13,133,372	$14,182,060	$27,315,433	$20,368,209	0.05	$1,018,410	$10,807,511	$540,376	$9,560,698	$478,035
50	0.02	0.98	$19,968,863	$25,420,127	$45,388,990	$36,352,211	0.03	$1,090,566	$16,551,117	$496,534	$19,801,094	$594,033
100	0.01	0.99	$21,541,994	$27,557,998	$49,099,992	$47,244,491	0.01	$472,445	$20,755,428	$207,554	$26,489,062	$264,891
>100	<0.01	>0.99	$21,541,994	$27,557,998	$49,099,992	$49,099,992	0.01	$491,000	$21,541,994	$215,420	$27,557,998	$275,580
			Expected Average Annual Damage in 2010 Prices:					$7,739,160		$5,567,225		$2,171,935

2011, With Project Conditions

Tr (yrs)	Probability	Cumulative Probability	Lot Damage	Structure Damage	Total Damage	Average Interval Damage	Interval Probability	Expected Value Interval Damage	Average Interval Land Loss	Expected Value Interval Land Loss	Average Interval Structural Damage	Expected Value Interval Structural Damage
1	1.00	0.00	$1,622,768	$0	$1,622,768							
2	0.50	0.50	$3,322,863	$0	$3,322,863	$2,472,816	0.50	$1,236,408	$2,472,816	$1,236,408	$0	$0
5	0.20	0.80	$4,258,053	$136,726	$4,394,780	$3,858,821	0.30	$1,157,646	$3,790,458	$1,137,137	$68,363	$20,509
10	0.10	0.90	$4,798,355	$804,825	$5,603,180	$4,998,980	0.10	$499,898	$4,528,204	$452,820	$470,776	$47,078
20	0.05	0.95	$11,327,428	$10,452,243	$21,779,671	$13,691,426	0.05	$684,571	$8,062,891	$403,145	$5,628,534	$281,427
50	0.02	0.98	$18,139,387	$24,052,410	$42,191,797	$31,985,734	0.03	$959,572	$14,733,408	$442,002	$17,252,327	$517,570
100	0.01	0.99	$20,635,847	$26,289,774	$46,925,621	$44,558,709	0.01	$445,587	$19,387,617	$193,876	$25,171,092	$251,711
>100	<0.01	>0.99	$20,635,847	$26,289,774	$46,925,621	$46,925,621	0.01	$469,256	$20,635,847	$206,358	$26,289,774	$262,898
			Expected Average Annual Damage in 2010 Prices:					$5,452,939		$4,071,747		$1,381,192