Preserving Texas Coastal Assets: Economic and Natural Resource Evaluation of Erosion Control Projects under the Coastal Erosion Planning and Response Act

Technical Report

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Executive Summary

The Gulf coastline is a natural treasure that defines Texas as a special place. Abutting the coastline and its beaches, dunes, and bluffs are hundreds of square miles of wetlands and other natural areas: critical habitats that support and generate the fish, birds and countless other fauna and flora that characterize the Texas coastal zone. These coastal environments have an intrinsic value that can be appreciated by all citizens, yet they also generate tangible economic wealth, year in and year out, for governments, households and businesses. The valuable features of the Texas coastal zone are, however, being affected by natural and man-made damage. A fundamental problem is the gradual process of erosion that endangers beaches, dunes, bluffs and other coastal features and causes intrusion and transformation of fresh and saltwater wetlands.

To address this significant threat to coastal areas, the Texas State Legislature passed the Texas Coastal Erosion Planning and Response Act (CEPRA) in 1999. The Act allocated $15 million in State resources during the biennium covering fiscal years 2000-2001 for erosion control and required local partnerships and participation in the funding of erosion control projects. Under the Act, the Texas General Land Office (GLO) created partnerships between the state and local jurisdictions to implement a series of erosion response projects in Cycle 1 for fiscal years 2000 and 2001.

Erosion along the Texas coast is a significant, long-term problem while public resources available to tackle this challenge are limited. Erosion control efforts must seek to preserve the maximum value of natural coastal assets for a given commitment of public resources.

Erosion control efforts must seek to preserve the maximum value of natural coastal assets for a given commitment of public resources

The objective of this evaluation was to assess the economic costs and economic and natural resource benefits of 23 CEPRA projects funded in Cycle 1. This report provides detailed information on how the cost effectiveness of individual erosion control projects was estimated. The report also reviews, on a project by project basis, estimates of net economic and natural resource benefits of 23 Cycle 1 projects.

Two major classes of benefits generated from CEPRA projects are analyzed in this report. Economic benefits of CEPRA actions are generated when projects mitigate or reverse erosion and degradation of beaches, shorelines and park areas in, or close to, coastal communities. The natural resource benefits of CEPRA accrue when projects protect, restore or create wetland areas and other habitats including bay margins that are typically outside developed areas.

Economic Benefits of CEPRA Projects

Preserving coastal assets from erosion damage generates tangible economic wealth through a five basic channels:

- Reduced losses to public property from storm damage and erosion
- Preserved value of private properties in proximity to the project areas
- Generation of additional property tax revenue
- Sustained visitation and related tourist spending in the affected area
- Generation of additional user fees from recreational use of the coastal asset

Surfside Beach (#1015)

Through an intensive analysis of 13 erosion control projects in parklands or developed areas, estimates of the total economic benefits ere developed (sums of the above five elements). The stream of economic benefits over time varied based on the probable durability of specific projects. It was assumed that erosion response projects that involved hard structures or other durable structural elements would have a 20-year project life. In cases where there are no structural elements to sustain project effects (as in a basic re-nourishment project for a beach), it is assumed that benefits would accrue over a 10-year period.

To account for the time value or opportunity cost of benefits and costs over the life of each project, a discount rate was selected and annual costs and benefits were adjusted. Discounting allows both costs and benefits that occur over time to be brought into comparable present value equivalents.

The evaluation of the 13 CEPRA projects showed that the direct net economic benefits of these projects were impressive.

Total Discounted Benefits of the Projects	=	***$136,255,000***
Total Discounted Costs of the Projects	=	***$8,484,000***
Total Net Benefits of the Projects	=	***$127,771,000***

These estimates indicate that for every dollar invested in CEPRA projects by Texas state government and local partners, over $16 dollars will be generated in economic benefits over the life of the projects. This 16-to-1 benefit-cost ratio is based on a conservative set of assumptions used to derive benefit estimates.

Natural Resource Benefits of CEPRA Projects

For certain types of erosion control projects, especially projects that protect or restore wetland areas, the losses that are avoided with erosion protection are much harder to specify with precision. We employ a qualitative assessment method to evaluate wetland and other ecological protection projects under the CEPRA Program. The Army Corps of Engineers' Wetlands Evaluation Technique, called "WET," is explained in this report and is used as a means to analyze the values and functions that might accrue from the 2000-2001 CEPRA coastal natural resource projects. The basic outcome is an evaluation that links hydrogeomorphic properties of specific wetland areas with functions that yield natural resource and environmental benefits.

Wetland projects are evaluated based upon the degree to which the wetland area affected by a project can be shown to provide the following wetland functions and values:

- Ground Water Recharge
- Ground Water Discharge
- Flood Flow Alteration
- Sediment Stabilization
- Sediment / Toxicant Retention
- Nutrient Removal / Transformation
- Wildlife Diversity / Abundance
- Aquatic Diversity / Abundance
- Uniqueness / Heritage
- Recreation

The CEPRA natural resource projects analyzed scored high in virtually all cases on the following functions:

- Sediment Stabilization (or shoreline stabilization)
- Aquatic Diversity / Abundance
- Wildlife Diversity / Abundance
- Uniqueness and Heritage

Almost all of the CEPRA projects studied will have substantial natural resource payoffs. Most are located in waterfowl use regions of major concern; have commercial or shell fishing within or near the project area; are affiliated in some way with an organized conservation group, public agency or other entity for the purpose of preservation; involve ecological enhancement or low-intensity recreation; provide buffers to features of social or economic value that are situated in erosion-prone or wave vulnerable areas; and lie within the habitat range of multiple aquatic and terrestrial species that are listed as endangered, threatened, candidates or "of concern." All of these variables tend to lead to higher probability ratings for wetland values and functions under WET.

Almost all of the CEPRA projects studied will have substantial natural resource payoffs

Most of the 10 CEPRA natural resource projects evaluated were found to provide other wetland values and functions such as toxicant retention, nutrient removal, or flood flow alteration. The least noteworthy wetland values and functions, on average, were ground water recharge and discharge which is not unexpected in estuarine settings.

Even though concise estimates of the economic benefits flowing from these environmental preservation and restoration projects could not be derived, positive economic impacts are clearly associated with these projects. Coastal wetlands are the primary ecological foundation supporting much commercial and recreational activity on the Texas coast from commercial and recreational fishing, to waterfowl hunting, to bird watching. In aggregate terms, Texas' wetland systems are the source and support environment of flora and fauna that generate billions of dollars from commercial and recreational use. Because the 10 CEPRA projects score high in preserving aquatic and wildlife diversity, the indirect economic benefits of these projects are likely quite significant.

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Section I. Introduction

The GLO contracted with a research team at the University of Texas at Austin to evaluate the economic costs and economic and natural resource benefits of 23 projects funded in the first cycle of the CEPRA initiative (see Table 1, below). The objective of this evaluation was to provide specific information on the cost effectiveness of individual erosion control projects as well as important indicators of the net benefits of the overall CEPRA program to citizens of Texas.

Table 1: CEPRA Projects for Fiscal Year 2001

	Project #	Project Title	Type of Evaluation
1.	#1003	McFaddin Dune	Natural Resource Impact
2.	#1007	Key Allegro #1	Economic Impact
3.	#1008	Pleasure Island	Economic Impact
4.	#1010	South Padre Beach	Economic Impact
5.	#1015	Surfside Beach	Economic Impact
6.	#1019	Bessie Heights	Natural Resource Impact
7.	#1020	Halls Lake	Natural Resource Impact
8.	#1031	Mesquite Point	Economic Impact
9.	#1032	Little Cedar Bayou	Economic Impact
10.	#1036	Kaufer-Hubert Park	Economic Impact
11.	#1037	Gilchrist/Caplen Beach	Economic Impact
12.	#1039	Rollover Pass 1 & 2	Economic Impact
13.	#1041	Nueces Bay	Natural Resource Impact
14.	#1044	North Deer Island	Natural Resource Impact
15.	#1047	Omega Bay	Natural Resource Impact
16.	#1048	Delehide Cove	Natural Resource Impact
17.	#1050	Moses Lake	Natural Resource Impact
18.	#1052	GIWW McFaddin	Natural Resource Impact
19.	#1053	Park Road 100	Economic Impact
20.	#1059	Port Lavaca, Bay Front	Economic Impact
21.	#1060	Port Lavaca, Marina	Economic Impact
22.	#1062	Cove Harbor	Economic Impact
23.	#1065	Jumbile Cove	Natural Resource Impact

The scale of the erosion problem along the Texas coast is large and long-term, while the public resources available to tackle this challenge are limited. Therefore, erosion control efforts should seek to preserve the maximum value of natural coastal assets for a given commitment of public and private resources. The objective of this report is to assess the economic costs and economic and environmental benefits of a large subset of 23 CEPRA projects funded in the 2001 fiscal cycle (see Table 1, above).

Two major classes of benefits generated from CEPRA projects are analyzed in this report: 1) the economic benefits that derive when CEPRA projects mitigate or reverse erosion and degradation of beaches, shorelines and park areas; and 2) the natural resource benefits that accrue when projects protect, restore or create wetland areas and other habitats including bay margins (see below).

The first major section of this report details the estimating procedures used to derive economic costs and benefits of 13 CEPRA projects in, or close to, coastal communities or recreational areas where economic effects can be explicitly estimated. When erosion of coastal assets such as beaches, bay shores and park areas is mitigated by a CEPRA project, the size and quality of the asset is preserved (e.g., a beach is wider over time compared to its condition without a project intervention). This in turn influences the coastal environment and leads to specific outcomes measurable as economic benefits. Preserving coastal assets yields tangible economic gains that include:

- **Protection of public property from direct storm or erosion damage**
- **Protection of the value of residential properties proximate to project areas**
- **Increased property tax revenues for local jurisdictions**
- **Sustained recreational activity by users of beaches, parks and bayside area**
- **Generation of additional user fees from recreational use of the coastal asset**

To develop a useful economic evaluation model, the research team first conducted a comprehensive survey of research and literature on the economic aspects of erosion response programs (Oden, Butler and Paterson, 2000). Drawing upon the best available research in Texas and in other states, where economic impacts were evident, the project team collaborated with GLO project managers to delineate a workable cost-benefit estimating framework and to identify and secure the data needed to generate the estimates for the 13 study projects. The methodological approach, assumptions and data elements used to derive costs and benefits are detailed and applied to each project.

To derive estimates of economic costs and benefits of these projects, we first classified and estimated economic benefits associated with public and private property protection (land and infrastructure), enhanced valuation of proximate residential and other privately owned properties, and revenue benefits from recreational visitation. The estimated benefits of the study projects were compared to project costs to derive the net benefits for the 13 erosion control projects.

The second main section of the report qualitatively analyzes the natural resource benefits of 10 CEPRA wetland protection and environmental enhancement projects. For certain types of erosion control projects, especially projects that protect or restore wetland areas, the losses that are avoided with erosion protection are much harder to specify with precision. In the case of wetland projects, certain avoided losses (i.e., benefits) such as fauna retained by protecting habitat from erosion and inundation may be relatively traceable. However, many resource protection and environmental functions of wetland areas may be hard to translate into concise economic benefit estimates due to severe data limitations and major variations between wetland sites or zones. The literature on wetland valuation offers a wide array of estimating methodologies that yield highly diverse benefit estimates for different categories and qualities of wetland areas (e.g., freshwater, tidal, etc.) (Barbier et al., 1997).

Our literature review revealed one source that offered a partial estimate of the economic benefits of Texas wetlands (Whittington et al., 1994). This study estimated the marginal value of wetlands on recreational fishing in Galveston Bay. The study demonstrates that wetland acreage is positively associated with recreational fish landings, which, in turn, are positively associated with recreational fishing days. Based on the effect of wetlands on recreational fishing, the value of wetlands for recreational fishing is $8,500 per acre (in 1993 dollars). They note that the full value of wetlands is likely to be considerably higher because in addition to recreational fishing, these areas have numerous other functions that have indirect economic value.

Because this sole estimate of wetland value is partial, and could not be applied to other Texas wetland areas with significantly different characteristics, the university research team used a qualitative assessment method to evaluate wetland and other ecological protection projects under the CEPRA program. The Army Corps of Engineers' Wetlands Evaluation Technique, called "WET," was used as a means to analyze the values and functions that might accrue from the 2000-2001 CEPRA coastal wetland projects. Wetland projects are evaluated under WET based upon the degree to which the wetland area affected by a project can be shown to provide the following wetland functions and values (Barbier et al., 1997; Dennison et al., 1997):

1. **Ground Water Recharge**
2. **Ground Water Discharge**
3. **Flood flow Alteration**
4. **Sediment Stabilization**
5. **Sediment/Toxicant Retention**
6. **Nutrient Removal / Transformation**
7. **Wildlife Diversity / Abundance**
8. **Aquatic Diversity / Abundance**
9. **Uniqueness / Heritage**
10. **Recreation**

The basic outcomes of the WET method for the projects studied are delineated in the third section of the report. The systematic qualitative evaluation provided by the application of the WET methodology clearly indicates that the environmental benefits of the 10 CEPRA projects studied are substantial. All of the CEPRA projects analyzed scored high in sediment stabilization (or shoreline stabilization), supporting aquatic and wildlife diversity and abundance, and protecting unique or historically significant sites. Most of the 10 CEPRA environmental projects were also found to provide other wetland values and functions such as toxicant retention, nutrient removal, or flood flow alteration.

Section II. Economic Costs and Benefits of 13 CEPRA Cycle 1 Projects

A. Theoretical and Conceptual Issues in Evaluating Erosion Control Projects

This report directly addresses the question of whether the benefits of reducing erosion in 13 CEPRA projects exceeded the costs of the project. When estimating the economic value (the benefits side) of a project, likely economic outcomes are compared for two scenarios: a baseline scenario of what would happen if no action was taken; and an alternative scenario of what would happen when a project is implemented. The estimated monetary value of what would be lost if a project were not implemented constitutes the project-related economic benefits. These benefits can then be compared to the costs of a proposed project to determine net economic benefits or benefit-cost ratios. This estimate addresses the question of whether a particular erosion control project is worth undertaking.

Generating meaningful benefit-cost evaluations of project proposals is quite challenging on a number of levels. First, the coastal zone is an extremely complex natural system. Second, defining with precision the area and duration of project impacts and hence the associated benefits and costs, can be difficult. Third, for useful cost benefit evaluations to be made, a reasonable chain of cause and effect must be established between specific project interventions, their tangible physical effects on the impact area and the different types of economic benefit that directly result from specific projects.

1. Defining the area and duration of physical impacts

Projects that reduce erosion will directly preserve a particular upland area, gulf beach, or bay-shore area over some period of time. All economic benefit estimates are driven by the impacts of the project, over time, on the natural assets of a particular area. The quality of any economic assessment is contingent upon how accurately the physical impacts of a project over time are specified.

The physical impact of proposed projects must be carefully specified along two coordinates - area and time. The impact area of a project must be carefully delineated, but also must consider neighboring areas where erosion rates and shore environments will be changed due to the project. For example, the construction of a bulkhead can stabilize a specific shoreline and preserve a park or recreation area, but it may also ensure that a channel remains navigable because eroded soils do not continue to spill into an adjacent waterway. The time period over which a coastal area is widened and/or erosion rates are changed must also be estimated for both the immediate project area and neighboring areas that are affected.

A related challenge in specifying the area and duration of impact occurs in cases where damage to critical infrastructure due to erosion might affect a large area if a proposed erosion control project is not undertaken. If it can be established that key roads, power lines or water lines might be severed unless an erosion control project were implemented, then the impact area could be much more extensive than the immediate project area.

In projects where critical infrastructure will be preserved, we worked with GLO project managers and local partners to evaluate if erosion damage would indeed cut off a specific area from access or services, whether and for how long a project would preserve the infrastructure, and whether alternative measures might also preserve access. For example, if a major access road would be undermined without a proposed project it must be determined if, and for how long, a bypass or alternative route could secure access to the neighboring area. In this case, the cost of the alternative access could constitute a benefit due to the proposed erosion control project, but the economic benefits of the project would not be based on securing access to the entire area past the erosion damaged segment. In all cases reasonable estimates of the direct and indirect physical impacts are essential to derive the scale and duration of economic benefits of erosion control projects.

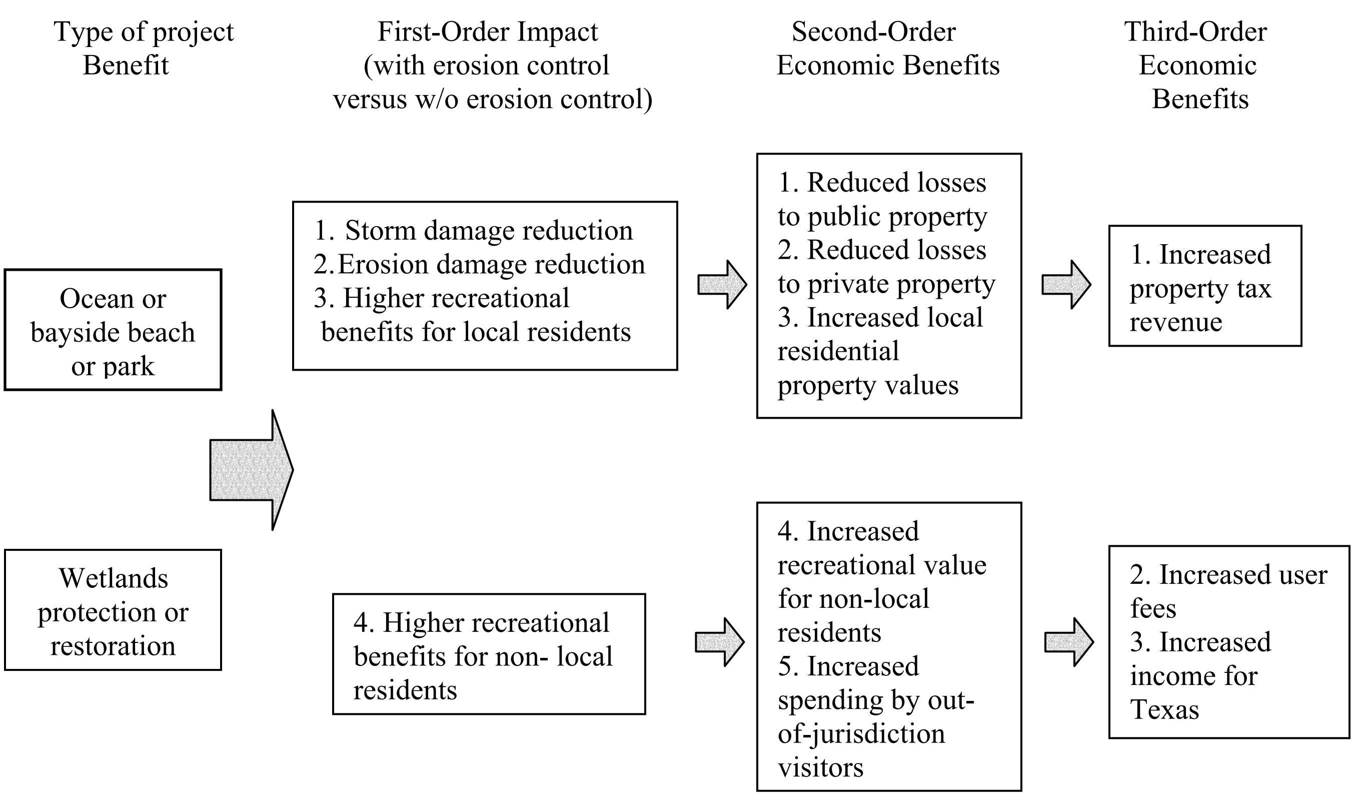
2. Categories of economic benefit from erosion control projects

Erosion of beaches, bay sides and wetlands represents a depreciation of natural assets that generate economic value for households, businesses and governments. However, because these natural assets are by and large publicly owned, economic values are not expressed directly in market prices. The economic value of coastal features must, therefore, be estimated indirectly by imputing the influence of natural assets on property values or on the behavior of consumers. A substantial literature has identified links between ocean or bay-side beach protection and economic gains to private and public actors (among others, Black et al., 1990; Cordes and Yezer, 1995; Edwards and Gable, 1991; Jack Faucett Associates, 1998; Kerns et al., 1980; Pompe and Rinehart, 1995; Stronge and Schultz, 1997a).

There is a reasonable consensus among existing studies that beaches have three first order impacts that can yield economic benefits: they protect public and private property from storm damage; they protect public and private property from sea or fresh water incursion (erosion damage); and they provide recreational benefits to users of beach or bay-side areas. These first order benefits, in turn, influence the values of other economic assets, providing consumers with greater utility or enjoyment, thereby leading to changes in consumer behavior.

In the case of gulf or bay-side erosion control, a project could directly protect public or private property by reducing the risk of damage during major storms or by saving property from being undermined or inundated by seawater. If specific property damage losses would likely occur without a project, then the value of losses avoided over time would constitute a direct economic benefit. Because of the typically low and flat topography of the Texas coast, beaches often do not provide substantial protection from major storms. During major hurricanes, many barrier island regions suffer some temporary inundation and sustaining beach widths does not significantly change this process. Dune development and restoration can, however, yield measurable storm protection benefits for some storm events. While certain CEPRA projects may yield storm damage protection benefits, the projects funded in 1999-2001 are primarily targeted to mitigate damage in areas where high erosion rates directly threaten private and public land, structures and recreational beaches and parklands.

Figure 1: Economic Benefit Linkages from Erosion Control Projects



To the extent that erosion control reduces the risk of storm or erosion damage it will also have a positive influence on the value of residential property. Properties fronting the gulf or bay in the project area will enjoy the greatest benefit because the risks of property damage or loss are higher. However, if erosion threatens critical infrastructure links impacting a broader area, an erosion control project may preserve property values over a larger area. In addition, property values are determined by a host of factors that influence consumers' willingness to pay for property in a particular place including school quality, safety, and the quality and proximity of natural amenities such as beaches, parks and open water. Those who choose to buy properties in coastal communities enjoy better and easier access to beach related recreational opportunities and other amenities such as attractive views, opportunities to enjoy nature, boating and fishing, and access to unique settings. The stream of recreational benefits and other amenities enjoyed by beach community residents are capitalized in local property values (Edwards and Gable, 1991, Stronge and Schultz, 1997a). Therefore, the recreational and other amenity benefits enjoyed by local residents (versus non-resident visitors) are embodied in land and housing prices. If an erosion control project maintains or increases the size and quality of beaches or parks, it will add to recreational benefits and stimulate net increases in property values in both waterside properties and properties over a broader area of the community (compared to the situation without the project).

Recreation on Texas Beach

Additional property tax revenue will be generated, if property values are higher as a result of damage reduction and added recreational value. In Texas, property tax revenue flows primarily to local school districts and city and county governments.

Another second order economic benefit that might accrue from erosion control is increased visitation and spending in beach, bay-shore or proximate recreation areas. As erosion reduces beach space or parkland, visitors will choose other locales due to congestion or the diminishment in quality of the natural asset. The spending by tourists who choose alternate locations because of erosion will be lost to the locale, and in some cases, the state economy. When an erosion control project retains visitors who would go elsewhere without the project, the spending of these visitors can be viewed as a benefit resulting from the project.

One potential benefit of erosion control projects that was not estimated in this report due to information and data limitations is recreational benefits for non-local residents (depicted in Figure 1 as first order benefit number 4). Individuals visit coastal areas because they value (or get utility from) the use of the recreation amenities available. A portion of this value will be captured by market prices day trippers and tourists pay on-site such as parking and access fees and costs of overnight accommodations (Bell and Leeworthy, 1990). But individuals will value the recreational benefits they receive in excess of what they pay on-site to obtain access to the beach or park. This excess, or consumer surplus is not directly expressed in market transactions and must be estimated indirectly through contingent valuation or travel cost methods (Bell, 1986; Bell and Leeworthy, 1990; Walsh et al., 1990). These methods estimate the recreational benefits as the difference between what consumers would be willing to pay for access to a beach or park area and what they actually pay. If erosion control projects sustain wider and/or less crowded beaches or park areas, the recreational benefits enjoyed by consumers will be greater.

If an erosion control project maintains or increases the size and quality of beaches or parks, it will add to recreational benefits and stimulate net increases in proximate property values

However, because our research failed to uncover any Texas studies on the consumer surplus of coastal visitors that could be generalized to our various project areas, we decided that no estimate of these benefits would be included. It is important to note that some level of consumer surplus or recreational benefits would derive from the 13 study projects. For instance, a review of nine studies that estimated the recreational value that consumers put on beaches, placed the value of a beach visit-day between $46.26 and $7.02 with a mean value of $33.70 (in 1998 dollars) (Bell and Leeworthy,1990; Jack Faucett Associates, 1998; King and Potepan, 1997; Walsh et al. 1990). Hence, our inability to include an estimate of recreational value specific to the projects studied implies the total benefits that might be yielded for this set of initiatives is underestimated.

B. Estimating Project-Related Costs and Benefits

In deriving cost benefit estimates for individual projects, the various second and third order benefits associated with erosion control were delineated. It is important to ensure that the estimated benefits are due to the projects and are not the result of other exogenous factors. This explains why it is crucial to tie benefits to the specific changes in the natural asset that result from a project intervention.

Table 2: CEPRA Cycle 1 Projects with Economic Benefit-Cost Estimates

Project Number	Project Name	Project Characteristics	County	Total Cost ($)	State Cost Share ($)
1007	Key Allegro #1	Construction of vertical bulkhead to stabilize shoreline and preserve access road endangered by erosion	Aransas	169,437	129,078
1008	Pleasure Island	Construction of sheet pile bulkheads in three places to secure shoreline and preserve access road to island	Jefferson	1,251,851	719,498
1010	South Padre Beach	Nourishment of 2,000 linear ft. of South Padre Island Beach	Cameron	* 2,277,800	435,207
1015	Surfside Beach	Nourishment of beach area, extending beach length by 3,000 ft. and expanding average beach width by 27 ft.	Brazoria	304,108	228,081
1031	Little Cedar Bayou	Construction of rock rubble breakwater to stabilize shore and preserve wetlands along a 450-ft. stretch of public park	Harris	225,509	175,161
1032	Mesquite Point	Construction of 1,200 linear ft. of sheet pile bulkhead to stabilize shoreline at Walter Umphrey Park	Jefferson	442,601	331,935
1036	Kaufer-Hubert Park	Construction of steel sheet pile and concrete bulkhead to stabilize shoreline and protect access road in Kaufer-Hubert Memorial Park	Kleberg	548,955	459,164
1037	Gilchrist/ Caplan Beach	Beach nourishment along 5,280 ft. of public beach, widening beach by an average of 56 ft.	Galveston	1,549,115	1,163,587
1039	Rollover Pass 1&2	Beach re-nourishment along 5,280 ft. stretch of public beach, widening beach by an average of 50 ft.	Galveston	* 717,699	130,107
1053	Park Road 100	Removal of 90,000 cubic yards of sand blocking State access road, then transported and used to re-nourish South Padre Island Beach	Cameron	104,000	52,000
1059	Port Lavaca, Bay Front	Construction of concrete bulkhead to protect park area from erosion damage	Calhoun	572,400	328,000
1060	Port Lavaca, Marina	Construction of 270-ft. metal bulkhead to protect park access road and marina from erosion and related sedimentation	Calhoun	158,710	119,032
1062	Cove Harbor	Construction of 360-ft. concrete bulkhead to protect marina and recreational area from erosion and channel sedimentation	Aransas	162,000	110,480

*Includes contributions from U.S. Army Corps of Engineers.

Source: Texas General Land Office, *Project Goal Summaries*, November 2001 and discussions with GLO CEPRA project managers.

The Coastal Erosion Planning and Response Act is designed to support a wide variety of projects to stem erosion on Gulf beaches, bayside shorelines and coastal wetlands. Different types of erosion management can require different approaches to estimating economic benefits. To understand the basic characteristics and typologies of the 13 erosion control projects funded in Cycle 1 where discrete economic effects could be estimated, the basic characteristics of the projects are presented above (see Table 2, above).

The set of erosion control projects that were studied varied widely in terms of areas covered (beach, bay shore bluff, infrastructure), project scale, cost, and type of loss anticipated without project implementation. These projects are for ocean or bayside erosion control, with one project having a minor effect on wetland restoration. Nine of these projects are near urban or developed areas, while four are state or local parks with significant visitation in rural or less developed settings. Eight of the projects involve shoreline protection with some structural element, while five projects involve some form of beach re-nourishment. Eight of the projects protect some type of public infrastructure (roads, access points, buildings, parkland).

Estimating of the costs of each project was relatively straightforward. We simply used the cost estimates provided by the GLO and the project partners in each project contract. It is noteworthy that in two projects there was a significant "in-kind" federal contribution that was included to calculate total costs.

The benefits from erosion control projects are, as previously noted, losses that are avoided by preserving or improving natural assets. Estimating the total benefits associated with a particular project involves estimating and summing the set of discrete benefits outlined in Figure 1 above. To estimate benefits in various categories we gathered an array of data from secondary sources, aerial photographs of the project areas, field visitations and interviews with project participants and individuals involved in local recreation, real estate and tourism. In the case of property values, we relied on current information from local tax appraisal districts as well as a set of studies in Texas and other states that estimate the effects of beach width or area on proximate property values.

1. Specifying the impact area and project costs

As noted, physical differences in the project area drive the benefit estimates. Beach width and area, parkland area, recreational areas or access points that would be lost if projects were not implemented shape the changes in behaviors and asset values that constitute the various projects' economic benefits. To carefully estimate the physical extent and duration of project impacts we relied on three sources: the GLO project goal summaries submitted by project partners under CEPRA guidelines; discussions with GLO project managers; and aerial photographs of the project areas taken in May 2001. For every project the following information was developed and verified with project partners.

1. ***The area that will be directly affected by the erosion control project (linear feet as well as depth and area of beach, bay shore or wetland where erosion will be controlled)***

2. ***Historic annual erosion rates in the area directly affected by the project***

3. ***The time period over which erosion control will occur (net erosion or accretion over time with the project compared to without the project)***

4. ***Cross sectional profile of existing beach, bay-shore or wetland in project area (including dunes, vegetation line or other barrier, and tide lines)***

5. ***Public access points and access to contiguous beach or bay-shore areas directly affected by the project***.

In determining the duration of benefits a number of conceptual issues arise. These projects are one-time interventions that affect the size and quality of the impact area over time. The stream of benefits from the initial intervention continues over future years and depends upon the natural forces affecting each area and the time over which the initial construction or beach re-nourishment effort will last. In most of the projects studied, a design life for the project is designated. However, the physical change to the area due to the project may outlast the projects designated design life.

An example of a beach re-nourishment project helps to illustrate the above point. In the case depicted in Table 3, below, there is a one-time extension of the beach width by 50 feet and no other improvements are made. With information on the beach length in the direct project area (5,280 feet), the historic erosion rate and the area effected by the project, the net physical effects can be determined (Table 3). Without the project, the beach width would be completely eroded away by the 14th year. If the re-nourishment led to a 50-foot extension over the length of the beach in year one, and no other measures were implemented to reduce the historic erosion rate, the change in beach width would be only a positive 4.5 feet by year 8. The beach would actually be narrower in year 9 than when the project was first implemented. Hence, the design life of the project would be slightly less than 9 years. However, the net change in beach width due to the project would be the entire 50 feet, since the beach in year 9 would still be 50 ft. narrower without the project (28 feet w/o the project versus 78 feet with the project). Indeed, through a 20- year time horizon, the project would contribute to the preservation of the beach asset. In this example, we are assuming that erosion would not absolutely eliminate the beach, only roll it landward from its current location.

This illustrative scenario puts into relief another conceptual challenge. The above changes to the beach area assume that the historic erosion rate will affect the area evenly over a given time horizon. Obviously beach erosion is an uneven process, greater in some years than in others. Because we cannot predict future annual erosion rates, there is little choice but to choose the historic rate to delineate project effects. However, there is some probability that a major storm event could suddenly "wash out" the net addition to the beach from re-nourishment. Based upon extensive discussions with project managers and engineers, it was decided that in cases where there are no structural elements to sustain project effects in cases of storm damage, and where the design life of projects is less than 20 years, that benefits would be estimated only over a shorter 10-year time frame.

Table 3: Example: Estimating the Physical Impacts of Erosion Control Projects

Assumptions:

Beach width in direct project area, year 1 = 80 feet
Historic annual erosion rate = 6.5 feet per year
Length of beach front directly affected by projects = 5,280 feet
Reduction in erosion rate in area effected by projects = 0

Project Example #1
Re-nourish – Extend width by 50 feet

Direct project area:

	Beach Width with Project	Beach Width W/O project	Difference
Year 1	130	80	50
2	123.5	73.5	50
3	117	67	50
4	110.5	60.5	50
5	104	54	50
6	97.5	47.5	50
7	91	41	50
8	84.5	34.5	50
9	78	28	50
10	71.5	21.5	50
11	65	15	50
12	58.5	8.5	50
13	52	2.0	50
14	45.5	- 4.5	50
15	39	-11	50
16	32.5	-17.5	50
17	26	-24.0	50
18	19.5	-30.5	50
19	13	-37	50
20	6.5	-43.5	50

A second case can be used to highlight the conceptual issues associated with a different type of project. There are several projects where hard structures are constructed to prevent erosion of parkland or recreational areas. In many of these cases, the project not only preserves parkland but also maintains access to marinas or channels to the gulf or bay for recreational users. In these cases, the physical change due to the project must include both land preservation and access.

Table 4: Example: Estimating the Physical Impacts of Structural Erosion Control Projects

Assumptions:

Recreational Area in direct project area, year 1 = 200,000 sq. feet
Historic annual erosion rate = 5 feet per year
Length of shoreline directly affected by project = 360 feet
Reduction in erosion rate in area effected by projects = 5
Sedimentation from erosion

Project # 2
Reduce erosion rate from 5 ft. per year to 0 ft. per year
5 ft. length X 360 ft. width = 1,800 sq. ft./yr.

Direct project area:

Year	Recreational Area with Project (Sq. ft.)	Recreational Area W/O Project	Difference	Access Limitation W/O Project
1	200,000	200,000	0	
2	200,000	198,200	1,800	
3	200,000	196,400	3,600	
4	200,000	194,600	5,400	
5	200,000	192,800	7,200	
6	200,000	191,000	9,000	
7	200,000	189,200	10,800	
8	200,000	187,400	12,600	
9	200,000	185,600	14,400	
10	200,000	183,800	16,200	
11	200,000	182,000	18,000	Access Limited
12	200,000	180,200	19,800	
13	200,000	178,400	21,600	
14	200,000	176,600	23,400	
15	200,000	174,800	25,200	
16	200,000	173,000	27,000	
17	200,000	171,200	28,800	
18	200,000	169,400	30,600	
19	200,000	167,600	32,400	
20	200,000	165,800	34,200	

In this case, a 360-foot concrete bulkhead is constructed to protect recreational area from erosion and a channel that allows access to the bay from related sedimentation. If the project were not constructed, there would be some loss in recreational area due to erosion along the 360-foot stretch. The loss of space would, over time, squeeze out some users of the recreational park area. But in this case, the more important impacts stemming from project affects on physical features is keeping shoreline erosion from filling-up the single channel providing access to the bay and gulf. Without the project access would be cut off for fishing and recreational boating, severely reducing recreational activity by year 11. In this case, the 20-year time horizon is appropriate because the design life of the project is in far in excess of 20 years.

These are simply two illustrations of how the physical impacts of projects are determined and how the physical impacts in turn shape the economic benefit analysis. As it will be shown below in the individual project descriptions, the projects considered are quite heterogeneous and the details of specifying the extent and duration of the physical impacts must be tailored to each specific case.

2. Estimating public infrastructure and property benefits

In certain cases, beachfront or bayshore erosion can directly threaten public property and critical public infrastructure that links communities along significant stretches of shoreline. A clear benefit related to erosion control is the avoidance of losses to public property. This element is estimated by calculating the replacement costs of roads, lands, buildings, utilities or other property that would suffer complete or partial damage without the project. The time period over which property is protected due to the project is also estimated. To carefully estimate the physical extent and duration of project impacts, we relied on several sources: the GLO project summaries submitted by project partners under CEPRA guidelines; discussions with GLO project managers and local and county officials; Texas Department of Transportation (TxDOT) regional unit estimates for maintenance and replacement costs acquired from TxDOT district managers; and aerial photographs of the project areas taken in May of 2001. For every project the following information was developed and verified with project partners.

1. ***Value of state, local or county streets or highways lost or damaged without the erosion control project***

2. ***Value of state, local or county lands, buildings or structures lost or damaged without the erosion control project***

3. ***Cost or feasibility of bypass or alternative route for erosion damaged infrastructure***

4. ***Time period over which erosion control project will prevent damage to critical infrastructure***

In the case of these public property and infrastructure impacts, the main conceptual issue that had to be addressed was how infrastructure links affected access to a broader area. If erosion damage cut a critical infrastructure link without the proposed project, the economic impacts of the project might extend from the point of interruption to the next access point. If a single highway that serves a narrow barrier island is undermined by erosion, the entire area from the place the highway is cut to the end of the island could in theory be affected.

To determine the extent of the area affected by a project that mitigates erosion of critical infrastructure, information was gathered from a number of sources about how erosion affects the larger system of roads or other infrastructure. If a road is expected to be cut, in some cases we estimated the cost of a bypass around or elevation over the damaged highway. In some cases, no alternative bypass was feasible. With the former type, we included the cost of the bypass or alternative access (developed with TxDOT experts) to the benefits of limiting erosion and saving the existing road over a certain period of time. In the latter case the value of all property, recreation benefit, and other public infrastructure from the point where access was severed to the rest of the project area was included as a benefit attributable to the project

3. Estimating property value and property tax benefits

Beach or shoreline erosion can cause direct damage to structures or render land and structures worthless if shoreline erosion results in property located on a public beach. The most direct property value benefit is damage avoidance to shoreline properties that would result from a project. Estimates of direct damage avoidance were made on a project by project basis based on discussions with GLO project managers, local and county officials, and the review of county property appraisal data for the affected area. There were a few cases where significant commercial and residential property losses would occur without the proposed project.

The more complicated benefit estimates involved the effects of projects on residential property values proximate to the project areas. Considerable research shows that shoreline erosion affects property values in beach and shorefront communities. (Black et al, 1990; Edwards and Gable, 1991; Jack Faucett Associates, 1998; Hillyer et al., 1997; Kerns et al. 1980; Pompe and Rinehart, 1995; Stronge and Schultz, 1997a, 1997b). Beaches and shorelines add to nearby property values because they protect property and access to property and provide unique recreational and amenity benefits. In a series of studies of Florida beach communities, Stronge and Schultz estimate that the price per square foot of residential property was 20 to 22 percent higher on barrier island properties when compared to similar properties just off the islands. Since other locational attributes were similar for on and off island properties, the authors argue that the difference reflects a premium for proximity to a beach (Stronge and Schultz, 1997a, 1997b). They found, however, that the differential or premium for commercial properties was much lower (8 percent in one case, 0 in another). Existing research suggests that beach proximity premiums are, unsurprisingly, highest for shoreline properties. But studies also show that premiums extend through entire coastal towns or communities and up to ten miles from the beach or shoreline, declining with distance from the feature (Pompe and Rinehardt, 1995; Edwards and Gable, 1991).

While there is little debate that proximity to shores and beachfronts increases residential property values, the challenge in evaluating erosion control impacts is to link changes in property values to changes in beach or shoreline conditions. Developing rigorous estimates of how erosion affects property values along the

Texas coast would require an econometric study using a hedonic price model for a set of Texas shoreline communities. This was beyond the scope of this study. For this stage of the project our goal was to develop a procedure to provide a useful approximation of property value impacts associated with projects near residential areas

Hence, we used estimates of property value effects from a set of studies using hedonic price models completed in Texas and other states to derive a proxy estimate for erosion-related effects on property values in Texas.

Table 5: Estimated or Derived Values from Major Studies on the Effects of Beach Size on Proximate Residential Property Values

Study	Locale	Method	Estimated or derived property value effect per foot of beach width
Kerns, Waldon R. and Carl H. Hobbs. 1980. "An Economic Analysis Strategy for Management of Shoreline Erosion," *Coastal Zone Management Journal* 8(2): 165-184	Virginia Coast	Hedonic pricing model	.001235
Faucett, Jack and Associates. 1998. *The Economic Effects of a Five Year Nourishment Program for the Ocean Beaches of Delaware.* Submitted to Delaware Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation, Shoreline Management Branch, February 1998.	Delaware Coast	Hedonic pricing model	.000981
Pompe, Jeffrey J. and James R. Rinehart. 1995. "The Value of Beach Nourishment to Property Owners: Storm Damage Reduction Benefits," *The Review of Regional Studies* 25(3): 271-285.	South Carolina Coast	Hedonic Pricing Model	.002
Kreisel, Warren, Craig Landry and Andy Keeler, : Coastal Erosion Hazards: The University of Georgia's Results - Appendix D".2000 in Evaluation of Erosion Hazards, The John Heintz Center, Washington, DC: FEMA, pp D-1, 31-33	Select Texas and Florida Gulf Coast Communities	Hedonic Pricing Model	.00034
Mean Coefficient Value, Four Studies			**.00114**

These hedonic pricing models assume that residential property values are determined by a number of attributes such as house size, number of bedrooms, local climate, proximity to a central city, safety, and proximity to natural amenities. The models use regression techniques to determine the marginal value of each component, and the overall value of a residential property is an aggregation of the value of each attribute (Rosen, 1974). The use of multiple regression methodologies isolates the effect of one attribute on residential prices, while controlling for all the other attributes that influence price. This approach is crucial to isolate the effect of say, beach width or quality, on property prices.

An extensive literature search uncovered four studies that used hedonic pricing models to directly or indirectly estimate the effect of beach width on housing prices in beach communities (Kerns et al., 1980, Jack Faucett Associates, 1995; Pompe and Rinehart, 1995; and Kreisel, Landry and Keeler, 2000). The studies were for beach communities in Virginia, Delaware and South Carolina and select communities on the Florida and Texas Gulf Coasts respectively. It was found that the effect of beach width on residential property values ranged between .034 and .2 percent per foot of beach width (see Table 5). The mean effect from the four studies was that each foot of beach width added .114 percent to the value of residential property in communities close to the beach. So, for example, if a value of a house in a coastal community was $100,000 and the local beach was extended by 30 feet, this would add $3,420 to the value of the property (.00114*30*$100,000). Three studies report the average effect for properties up to one mile from the beachfront. The higher (.2%) value derived from the Pompe and Rinehart study was for properties on or very near the beach.

To derive property related benefits, the next challenge is to determine the area over which an erosion control project will influence property values. The various studies that relate changes in property values to changes in shorelines provide no consistent guidance about the spatial range of property value impacts. The range of impacts estimated in existing studies varies from only shoreline properties, to property 10 miles from a beachfront. In real settings, the effect of beach width on property values would depend on a number of factors including access, topography of the communities, and profile of the area. On a barrier island that is one-quarter mile wide, the impacts of beach width and quality would likely influence property values throughout the community. Extending a bayshore near an urban area would likely effect only property close to the improvement.

Without specific studies of Texas coastal communities, we employed a simple rule to define the property value impact area. Based on a small set of studies indicating that beach improvements definitely have effects on property values within one mile of the beach front, we established a one-mile impact range. Property value impacts were then estimated in an area defined by one mile along the coast from endpoints of areas directly affected by the project, and then one mile inland from this coastal span. With projects on barrier islands, the depth of the impact area was limited to the distance from the ocean shoreline to the bayside shoreline. We finally proposed that estimates of property value benefits be confined to residential property. There is very little information on the effects of erosion control on commercial properties. Existing evidence suggests that commercial property benefits are only marginal (Stronge and Schultz, 1997a, 1997b).

We obtained the following information from secondary data sources including county appraisal districts and checked their validity with project managers, local officials and in some cases, members of the local real estate industry.

1. ***The value of real residential property that will be lost or damaged without the erosion control project***

2. ***The value of taxable residential property in proximity to the erosion control project (an area within one mile along the coast from endpoints of the area directly affected by the project or inland from the coastal impact area to the bay-side of a barrier island)***

3. ***The average annual property appreciation rate for coastal residential properties***

4. ***The combined residential property tax rates for all local jurisdictions, including special districts in each relevant project area***

In some projects, there was not any residential property within one mile (or equivalent area). In cases where there was residential property within the designated impact zone, we used year 1999 or 2000 county appraisal data to estimate current values. We inflated all 1999 values to 2000 base year and then inflated future property values throughout the 20- (or 10-) year study period based upon a national estimate of coastal property appreciation. The appreciation number that was used was seven percent per annum. This figure was derived from a Heinz Center study which found that over the past 50 years the value of coastal properties nationwide appreciated at an average annual seven percent rate, compared to the national housing price index which has risen by 6.6 percent (Kreisel et al., 2000).

In order to calculate the effect of projects on residential property values, we first estimated the effect of the project on property values relative to value changes without the project. We treated the properties as assets, that is, we looked at the appreciation of the asset over the study period. If for example, a beach is widened in year one and the underlying erosion rate is unchanged, this will cause the value of residential property to increase significantly in year one and only add marginal value in subsequent years (only adding each year, in real terms, the difference between the property appreciation rate and the inflation rate). If on the other hand a structure is put in place that reduces the erosion rate over time, a project will add extra value to proximate properties in each year of the study period.

If property values are positively affected by erosion control projects, they will generate additional local property tax revenues. We obtained and summed the property tax rates for all local jurisdictions and applied this rate to the annual difference between residential property values in the impact zone with the project and without the project. So as not to double count property related benefits, we deducted the property tax revenues from the asset appreciation on the household side.

4. Estimating economic revenue benefits from increased visitation

Most of the 13 CEPRA projects generate benefits by expanding the opportunities for visitation to the coastal area and related recreational spending. The behavior of visitors residing elsewhere in Texas and visitors from outside the state would be affected by erosion of natural amenities. As erosion reduces beach space or parkland, visitors will choose other locales due to congestion or the decline in the quality of the natural asset. From the point of view of the jurisdiction, all spending from visitors outside the local area that is retained due to the project constitutes an economic benefit. However, for the State of Texas, it would be spending by out-of-state tourists retained due to the project that would constitute a net economic benefit. It is reasonable to assume that in-state tourists would be more likely to spend their travel and leisure money elsewhere in the state if they chose not to go to a particular park or beach that is experiencing erosion.

Estimating the recreational benefits associated with each project involved a four-step process. As a first step, we had to obtain estimates of visitation and seasonal variations in visitation for each site. Second, we had to estimate how the project would affect visitation patterns over the year and study period. Third, we had to develop estimates of the origin of visitors by season. Finally, we estimated daily visitor spending associated with typical visitors to each site. Developing estimates required assembling the following information.

1. ***Number of visitors to area directly affected by the erosion control project during peak season***
2. ***Number of visitors by season (peak, medium and low) to area affected by the erosion control projects***
3. ***Visitor density in area directly affected by erosion control project by season***
4. ***Share of visitors from other jurisdictions within Texas by season in project area***
5. ***Share of visitors from outside Texas by season to project area***
6. ***Parking, entry or other user fees paid by visitors to area from outside the local jurisdiction directly affected by the erosion control project to city or county jurisdictions***
7. ***Visitor spending by visitors from outside the local jurisdiction in the area directly affected by erosion control project.***

We drew on numerous sources to develop these estimates. For visitation we used aerial observations of the sites on Memorial Day 2001 and used procedures to count visitors and space (visitor density on this peak day). We then verified these estimates with local officials and asked local experts to delineate the number of days in a peak season, a medium season, and a low season. These varied somewhat across sites. We then assumed that visitation would grow at a constant annual rate over the study period (20 or 10 years). The growth in visitation for each site was derived from the growth in hotel and motel occupancy during the period 1985-2000 in developed areas or from the growth rate in tourism for the county where the site is located in areas that are not near a major settlement. These growth rates were derived from two Texas Department of Economic Development sources (Texas Department of Economic Development, 2001; Texas Department of Economic Development, 2000). We then used hotel occupancy rates and estimates by local officials to estimate the percentage of peak day visitors who visited on medium and low season days.

Erosion will reduce beach or parkland size, reducing the capacity of the coastal amenity to accommodate visitors. Typically, beach or park use was constrained by overcrowding primarily during peak season days. Low utilization of a beach or bayside park in off-peak seasons would suggest that visitation would not be constrained in off-seasons by beaches or recreational areas made smaller by erosion, unless erosion reduced or eliminated access altogether. To ascertain the effects of the project on visitation we analyzed the effect of each project on recreational space (ex. beach or park area) and developed visitor density estimates by season with and without the project. For this we used the visitor estimates above, visitor growth rates, and space available in the project area with and without the project. We then used a conservative rule of thumb estimate developed by the U.S. Army Corps of Engineers that indicates that congestion or overcrowding occurs when visitor density exceeds 100 square feet per person. That is, when density increases to less than 100 square feet per person, people move somewhere else. Hence, the impact of a project on visitation is a function of initial visitation, growth in visitation, visitor density by season, and the available recreational space with and without the project. Projects only lead to increased visitation on days when there would be crowding-out as the result of erosion, reducing the recreation space without the project.

The third step was determining the origin of visitors for each site and for each season. We generally relied on local officials, chambers of commerce, and informants from the local travel industry (ex. motel operators, bait shops etc.) to derive these estimates. To estimate the benefit incidence of visitor spending we distinguished between visitors from the local area, visitors from Texas but outside the local area, and visitors from out-of-state.

The final step was estimating visitor spending for each site. For this we relied upon Texas Department of Economic Development estimates of average daily visitor spending by county and metropolitan Area (Texas Department of Economic Development, 2000). The number of net visitor days across the course of the year that would be generated due to the project was multiplied by average visitor spending in the county or metro area to estimate visitor spending benefits related to each project. These spending totals were then broken out for visitors from outside the local jurisdiction to calculate the incidence of benefits. As noted above, recreational benefits for local residents are not net to the area and are in large measure captured in local property values

Once these data elements are assembled, it is relatively straightforward to estimate the recreational benefits of specific projects. For example, if we assumed that by year 10, 100 visitors would be crowded out during a peak day without the project and there were 40 peak days per year at that site, there would be a loss of 4,000 visitor days in that year. Assuming 60 percent of the visitors were from outside the jurisdiction and average spending for out of town visitors was $100 per day, the annual loss (or benefit due to the project) would equal $240,000 (4,000 visitor days * 60% out of jurisdiction visitors * $100 per visitor day spending). It should be noted that total expenditures were not broken out in terms of purchase prices and sales taxes. Clearly the largest portion of visitor spending would go to local proprietors, while a fraction associated with sales taxes or user fees would go to local or state government jurisdictions.

For all categories, the estimated benefits only included direct asset savings (property damage and property value appreciation effects) and direct revenue effects (from increased visitation). The indirect or induced effects of net spending increases associated with increased visitor spending were not estimated. Indirect and induced effects, or multiplier, from additional visitor spending are typically in the neighborhood of 2 times the direct effects. While it is common and legitimate to include these benefits, this report concentrated only on direct project effects.

C. Summary Cost-Benefit Estimates of 13 CEPRA Cycle 1 Projects

The estimate of a total cost-benefit ratio involves consideration of contributions by all government entities to pay for project costs, as well as consideration of public and private economic benefits and local impacts delineated above. Stated differently, the assessment of total benefits blends benefits accruing to local and state levels and the private sector, as well as the costs to all levels. To derive estimates of the economic costs and benefits of these projects, estimated economic benefits were classified as discussed above: public property protection (land and infrastructure); private property protection and enhanced valuation; local property tax benefits; and revenue from increased recreational visitation. These benefit categories (B+C+D+E, as in Figure 2 below) are added up to determine total benefits flowing from each project over the project's life (10 or 20 years).

These benefit streams are then compared to the total costs of the projects to derive net benefits, or benefit-cost ratios. To account for the time value or opportunity costs of the monetary benefits over the life of each project, a discount rate was selected and annual costs and benefits were adjusted by this rate. Discounting allows costs and benefits that occur over time to be brought into comparable present-value equivalents.

Figure 2: Cost-Benefit Elements 13 Cycle 1 Projects

Estimate of Total Cost-Benefit Ratio

A. Total Project Costs

B. Value of Public Property Damage Avoided Due to the Project

C. Increase in Property Values in the Impact Area Due to the Project

D. Additional Spending from Increased Visitation by Non- Local Residents (in state and out-of state) Due to the Project

E. Additional User Fees from Increased Visitation by Non- Local Residents (in state and out-of state) Due to the Project

Cost = A
Total Benefits = B+C+D+E
Total Benefit/Cost Ratio = (B+C+D+E) / A

Employing the scenario that benefits from erosion control projects would be generated for 20 years if projects involved structural elements and 10 years if they did not, the total net benefits and benefit cost ratios for the 13 study projects are impressive. When the present value of project costs is subtracted from the present value of net benefits, every project yields positive net benefits.

Table 6: Total Net Economic Benefits for 13 CEPRA Cycle 1 Projects

Project Number	Project Title	Total Benefits $	Present Value of Total Costs $	Present Value of Total Benefits $	Total Net Benefits $	Total Benefit - Cost Ratio $
1007	Key Allegro #1	493,819	169,437	285,766	116,329	1.69
1008	Pleasure Island	11,919,712	1,251,851	4,720,770	3,468,919	3.77
1010	South Padre Beach	27,387,336	2,277,800	19,525,279	17,247,479	8.57
1015	Surfside Beach	10,048,292	304,108	5,737,444	5,433,336	18.87
1031	Little Cedar Bayou	1,326,084	225,509	681,469	455,960	3.02
1032	Mesquite Point	48,861,578	442,601	21,153,426	20,710,825	47.79
1036	Kaufer-Hubert Park	12,882,917	548,955	5,207,369	4,658,414	9.49
1037	Gilchrist Beach	5,226,912	1,549,115	3,519,125	1,970,010	2.27
1039	Rollover Pass 1&2	3,204,234	717,699	2,001,427	1,283,728	2.79
1053	Park Road 100	18,263,892	104,000	10,329,953	10,225,953	99.33
1059	Port Lavaca, Bayfront	11,648,334	572,400	5,032,154	4,459,754	8.79
1060	Port Lavaca, Marina	1,120,338	158,710	547,173	388,463	3.45
1062	Cove Harbor	132,301,152	162,000	57,513,601	57,351,601	355.02
Total for 13 Projects		284,684,600	8,484,185	136,254,956	127,770,771	16.06

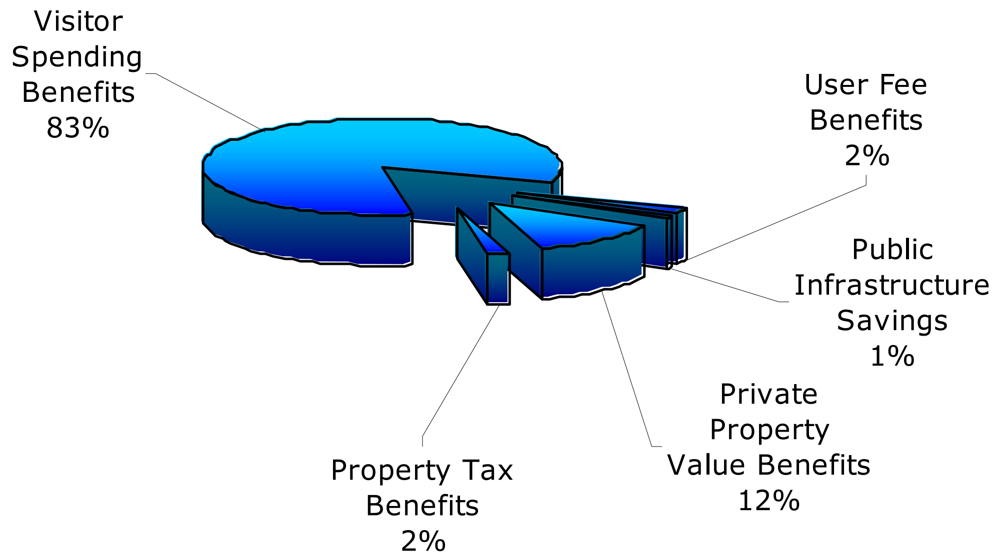
Total Benefit Cost Ratio = $16.06

This finding suggests that in every case there is a net gain in social welfare due to the public investment in erosion control. The benefit-cost ratio provides a basic measure of the social rate of return from public investment. By this measure all 13 projects yield strongly positive returns for the taxpayer investment, from $1.69 for every dollar invested in the Key Allegro project to $355 for every dollar invested in the Cove Harbor project.

In aggregate terms, the 13 projects will generate substantial net benefits. Nearly $128 million in net benefits will be generated over the next 20 years from this set of erosion control initiatives. For every dollar invested in these projects by the CEPRA Cycle 1 state program and federal and local project partners, over $16 dollars in economic benefits will be generated over the next 20 years.

It should once again be emphasized that these cost-benefit estimates were made under a set of relatively conservative assumptions. No values for consumer surpluses were estimated and no values for the indirect effects of re-spending recreation related revenues were added. As noted above, if a calculation were made of the multiplier effects on the local and state economies from the re-spending of recreation related revenues, the returns from these projects would be significantly higher. Nonetheless, the direct and positive net benefits from these 13 projects suggest that the preservation of coastal assets has very high economic returns for Texas.

Figure 3: Types of Benefits from Erosion Control



The lion's share of project benefits is attributable to the net gains in recreational visitation that stem from preserving the quality and size of beaches, parks and bayshore areas. More visitors would be attracted to recreational sites because of the erosion control projects, and the spending of these additional visitors will boost the economies of surrounding communities. Roughly 83 percent of project benefits come from project related gains in visitor spending (see Figure 3 above).

The positive effect of erosion control on private property values constitutes the other significant benefit category. Most of the private property gains associated with the projects came from improving access to property and preserving unique recreational and amenity benefits of nearby privately owned coastal properties. Only a modest amount of direct property damage avoidance was attributable to the projects studied. Damage avoidance to public properties and infrastructure and property tax and user fee gains related to the projects were minor contributors to overall benefits.

Project related benefits will be shared by the state through increased out-of state visitation, avoidance of losses to state properties, and increased user fees. The projects will allow local jurisdictions to retain revenues from recreational activity and enjoy higher property values and property taxes. These results again suggest that public investments in these erosion control initiatives are a wise investment for the State of Texas as well as the local partners.

D. Cost Benefit Estimates for the 13 FY 2001 CEPRA Projects

Developing the data elements outlined in this report and deriving cost and benefit estimates for each individual project allows for an estimate and comparison of project-related economic costs and benefits. To complete the cost benefit model used to derive the estimates of each project, the nominal values of estimated annual benefits and costs must be discounted over the duration of the project because individual projects incur costs and benefits at different rates over their life. Discounting allows costs and benefits that occur over time to be brought into comparable present value equivalents. Discounting reduces the present value of costs or benefits by greater amounts the further into the future that they occur. The rationale for discounting is that benefits or costs in future years are less valuable because they represent resources that are not available for alternative uses where they might receive a rate of return over time. If $100 was available today it could invested (at 6% rate of return) and would be worth $106 by the end of the year. Hence, the $100 dollars is worth more today than $100 a year from now.

To account for the time value or opportunity cost of the future flows of costs and benefits, a discount rate must be selected and annual costs and benefits must be adjusted over the life of each project. There is some controversy over the selection of the appropriate discount rate for public projects. Some argue that the discount rate on public project should equal the yield on government backed securities. This would in effect represent an opportunity cost of investing in one public project versus another. The Office of Management and Budget argues that the appropriate discount rate should reflect the opportunity cost of private capital (Economic Analysis of Federal Regulations under Executive Order 1866, 1996). Hence the discount rate should be based on the returns available on common private instruments such as corporate bonds. Opportunity costs, in this context, are defined as the return that taxpayers could receive if their taxes did not go to a public project. For the purposes of the following illustrative ranking models, the 2001 rate on Aaa corporate bonds, 7.08%, will be used as the operative discount rate (Economic Report of the President, 2001).

Discounting allows costs and benefits that occur over time to be brought into comparable present value equivalents

KEY ALLEGRO (#1007)

Key Allegro Island is located in Aransas Bay. What was a swampy bay island thirty-five years ago is now a major residential subdivision of the City of Rockport in Aransas County, accounting for one-third of the city's tax base. Chronic erosion of the island's shoreline has continued to the extent that and Bay Shore Drive, the only access and evacuation route off the Island was in danger of being breached or damaged. The result of ongoing shore erosion is that the present-mean water line was within 15 feet of the primary access road at several locations. During light and moderate storms, tides and waves often reached, and sometimes covered, the road.

The shoreline has been retreating at an average rate of one to three feet per year. According to Coastal Technologies Corporation, the surface soils found at the site primarily consist of fine-grained sand, shell, and concrete riprap. While the site is characterized by a small tidal range with infrequent storm surges from tropical storms, and limited wave heights due to the protective barrier islands, the type of surface soils present are easily transported by even the smallest movements. Thus, the chronic retreat of the shoreline is primarily caused by wind- and vessel-generated waves from the bay.

The Key Allegro Canal and Property Owner's Association applied for and received approval for a CEPRA project from the Texas General Land Office (GLO). Two specified project areas were identified: (1) an area where Bay Shore Drive connects the island to the mainland, and (2) a 2,400-foot area of shoreline along the bay side of the Key Allegro Subdivision where several residential properties are threatened from shoreline erosion. The project as originally proposed addressed both areas by including the construction of a bulkhead to protect Bay Shore Drive (project area 1) and breakwaters to protect property on the southern shoreline (project area 2). Project area 2 was not funded under Cycle 1. However, project area 1 has been completed. A 224 linear foot vertical bulkhead was constructed on the bay side of the mean high water line in order to stabilize the shoreline.

Various materials and locations were considered for constructing the bulkhead. Materials considered included aluminum, steel, vinyl, and reinforced concrete sheet piles. Coastal Technologies Corporation recommended aluminum sheet piles because of theirs strength and corrosion resistance. Two alternatives were considered for the location for the bulkhead, placement of the bulkhead either landward or on the water side of the mean high water line.

The water side location was recommended because the placement allowed a larger buffer zone between the road and the shoreline and was more aesthetically pleasing. In total, the project cost $169,437, 25% of which was paid for by the homeowners association.

The benefits to the project are clearly defined from the problems caused by the erosion. The homeowners on the island saw this project as a necessary measure to protect their sole access and evacuation route. County government supported the project to protect properties that were important to support the local tax base.

Key Assumptions and Data Elements

Estimating the costs and benefits of this project involved a unique procedure. In estimating project benefits, the key issues were how the infrastructure link threatened by erosion related to access to the broader area and the extent to which alternatives to securing access were available. This relatively modest project ensured that erosion damage would not undermine a small section of the only access and evacuation route for homeowners. The endangered section is near the entrance of the island from the mainland. If this link was cut due to erosion damage, and nothing else was done, all of the homes and other properties on the island would severely depreciate. There would be no loss of recreational value for citizens of the state, since the Island is a private subdivision with no recreational areas or activities accessible to the public.

After discussions with project managers and Texas Department of Transportation (TxDOT personnel), it was decided that if the small section of the access road were undermined by erosion (the condition that would exist without the project), it would be necessary to build an alternative bridge and change slightly the orientation of the road up to, and past the threatened segment. To estimate benefits in this case, we included the cost of the alternative access bypass as the major cost avoided (or benefit of this project). It was thought that this was a more realistic scenario than counting the value of all property and infrastructure for the entire Island as benefits from this small bulkhead project.

To estimate costs and benefits we first estimated that with an erosion rate of 1.3 feet per year in the immediate project area (from the Engineer's Report), by year nine the road would be severed and an alternative would have to be in place. We then obtained a cost estimate for the alternative from TxDOT which include costs of labor and materials in this TxDOT region. This estimate in 2001 dollars ($403,200) was then inflated to 2009 dollars ($493,819). This total was then discounted and compared to the cost of the project ($169,436) to estimate the benefit cost ratio. The difference between the discounted cost of the project and the cost of the alternative constitutes the net benefit of the Key Allegro project.

Key Allegro – Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Construction and Labor Costs Bridge and Road Alternative	Net Infrastructure Benefits (Cost Avoided)	Total Benefits	Present Value of Total Benefits
2009	$493,819	$493,819	$493,819	$285,766
Time Period 2001-2020	**Present Value of Benefits**	**Present Value of Cost**	**Net Benefits**	**Benefit Cost Ratio**
Total	$285,766	$169,437	$116,329	1.69

In this case, there are no recreation-related benefits or other benefits that flow to non-local consumers or jurisdictions.

PLEASURE ISLAND (#1008)

Pleasure Island is a 21-mile long island located between Port Arthur and Sabine Lake in Jefferson County. The island is separated from the mainland by the Sabine-Neches Channel, which is part of the Gulf Intercoast Waterway (GIWW). Due primarily to significant vessel traffic through the channel and the highly erodible unconsolidated soil of the island, six miles of the western shoreline (from one mile south to five miles north of the Martin Luther King Bridge access point) have experienced acute erosion. The average erosion rate was one to three feet per year; however, some areas had eroded with more intensity than others resulting in large masses of land sliding into the channel.

The primary objective of this project was to stabilize key segments of the shoreline and protect them from further erosion. Specifically, the project addresses erosion of the shoreline at three locations. First, erosion of an 18-foot high bluff just north of Martin Luther King Bridge was threatening the T.B. Ellison Parkway, the sole access road to and main artery through the island. Some of the shoreline had been stabilized temporarily with concrete slabs; however, a section of approximately 300 feet was undermined. The proposed shoreline stabilization measure placed 300 feet of bulkhead onto the shoreline at a total cost of $410,812. The expected design life of the project is 25 years. The project was completed August 31, 2001 and took a total of 18 weeks.

The second project area included the shoreline of the Pleasure Island Golf Course. A 10 to 15 foot bluff was eroding, resulting in the loss of 1,400 feet of valuable course land. Further loss of land would alter the character of the golf course as planned and would increase the costs associated with the existing design. The proposed measure included the placement of vinyl sheet pile bulkhead in critical areas at a total cost of $409,088. The expected design life of the project is 25 years.

The third project area involved 300 feet of shoreline along an unprotected 30-foot high bluff. The bluff is adjacent to city-owned property that is leased by Cajun Cabins and gas station. The cost of this project was $431,950.

The broad benefit of the above stabilization measures is the sustained viability of the island's economy. The measures for the site along the T.B. Ellison Parkway are expected to reduce infrastructure and/or relocation costs while measures at the other two sites are expected to reduce property damage and insurance losses and preserving property values and recreational spaces. The total cost of all project elements was $1,251,851.

Key Assumptions and Data Elements

Deriving benefit estimates for this project was relatively complex since each of the three sites classified under this project had unique features and uses characteristics. For the first component, erosion control along a 300 foot stretch of shoreline threatening the T.B. Ellison Parkway, we estimated the cost of an access alternative that would bypass the existing parkway along the endangered stretch.

The alternative bypass segment for the existing parkway was developed and based upon discussions with Texas Department of Transportation (TxDOT) personnel. To estimate costs and benefits for this component, we first estimated that with an erosion rate of 2.9 feet per year in the immediate project area, by year 13 the parkway would be unusable and an alternative would have to be in place. We then obtained a cost estimate for the alternative from TxDOT which included costs of minor land acquisition, and labor and materials valid for this TxDOT region. This estimate in 2001 dollars ($261,407) was then inflated to 2013 dollars ($411,213). The fact that this component of the project allowed this cost to be avoided permitted us to classify the cost of the alternative as public infrastructure benefit.

For the second component, stabilization of the shoreline along the Pleasure Island Golf Course site, the main benefit was the effect of retaining this recreational asset on nearby residential properties. In this case, it was assumed that the planned golf course erosion was similar to a beach or shore area erosion, by diminishing the size and quality of this amenity, would have a minor effect on nearby property values. To estimate this effect we took the annual erosion rate at this site and estimated the appraised value of property adjacent to the golf area. The only residential properties within the one mile impact zone were clustered near the golf facility, so it seems reasonable to assume that delays in making improvements to the golf course due to erosion reducing available land would suppress the value of these properties.

The third component, stabilizing a 300 feet of shoreline adjacent to city-owned property that is leased by a proprietor of tourist cabins (Cajuns cabins), and an RV park and a gas station, yields primarily recreation spending benefits. If no measures were taken to mitigate erosion in this area, historic erosion rates would lead to inundation of the recreational site by 2010 and it would be lost to recreation and tourist visitors. To calculate reduced visitor spending we consulted with the proprietor to estimate the number of visitors to this site in high, medium, and low seasons. We also obtained an estimate of the origin of visitors to this site, with 50 percent non-local Texans and 50 percent out-of-state residents. We then calculated average visitor days lost, spending per visitor day, and lease fees paid by the proprietor to the Pleasure Island Commission. These losses were then summed and classified as benefits associated with the erosion control project.

Pleasure Island – Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction (Including User Fees)
Total Benefits	$411,213	$0	$1,341,803	$475,254	$9,691,442

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$11,919,712	$4,720,770	$1,251,851	$3,468,919	3.77

SOUTH PADRE ISLAND (#1010)

This CEPRA project is on the Gulf shoreline of South Padre Island, located in Cameron County and the corporate limits of the town of South Padre Island. The project addresses the chronic retreat of the Gulf shoreline on a section the island. The shoreline area most affected is a four-mile strip located from one to five miles north of the Brazos Santiago Pass north jetty. On average, this four-mile shoreline had been retreating at a rate of five feet per year resulting in narrowing of the public beach, loss of beach tourism revenue, and loss of taxable property. Erosion to this shoreline area is due to several factors affecting a coastal sediment budget deficit including sand trapped by the Brazos Santiago jetties, storm damage, landward wind drifts, beach maintenance, and beachfront development practices.

The object of the South Padre Island project is to re-nourish a portion of the beach using sand dredged from the Brazos Santiago Pass. As a result of coordination with the U.S. Army Corps of Engineers in the maintenance dredging of Brazos Santiago Pass, approximately 3,200 linear feet of South Padre Island Beach was re-nourished, with 200 feet of width added to the beach. The expected design life of the project is eight years and the total costs, including those incurred by the Army Corps of Engineers, equaled $2,277,800.

Nourishment of this beach helps maintain the city's most important economic asset, the public beach. The expected result is increased economic activity and associated tax revenues for tourist businesses. Additionally, the project is expected to reduce infrastructure maintenance and/or relocation costs, boost private property values and associated tax revenues, and improve beach access.

Key Assumptions and Data Elements

This project involves a one-time re-nourishment of a 3,200 ft. stretch of beach adding approximately 105 feet to the width along this stretch. The historic erosion rate is 5 feet per year with beach width in 2001, prior to the re-nourishment project at 100 feet. So given the historic erosion rate beach width would be reduced to 55 feet by year 10 and 5 feet by year 20 without the project. The erosion of this beach would diminish local property values, reduce property tax revenues and begin to reduce visitation during peak season days due to overcrowding from reduced beach size starting in year 2009. One notable feature of this project is that the cost of dredging the sand was borne by the U.S. Army Corps of Engineers. Hence, the federal government shared much of this project's costs.

To estimate the effects of beach widening on proximate residential properties we used maps to designate an impact zone where houses fronted or were oriented toward this beach area. We then used current property valuation data from the Cameron County Appraisal District to calculate the value of residential property in the impact zone. Since there was a large and significant widening of the beach in 2001, property values would increase significantly in this year due to the wider, higher quality beach resulting from the project. Property would retain value through the study period (10 years) relative to what would occur without the project. We then calculated the additional property tax revenue that would be generated each year by the higher appraised value and counted the additional revenue as a local benefit (deducting it from the appreciated value to the homeowners (taxpayers) to avoid double counting).

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the area, and seasonal variations. We obtained this information from aerial photographs taken on Memorial Day, 2001 and from county and local visitor's bureau personnel. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Hotel Performance Database.* We used the average annual growth rate in tourism 1985-2000 to project visitor growth over the 10-year study period. We also obtained estimates from the local visitor bureau regarding of the origin of visitors to this site. Using visitation estimates, and estimates of beach area without the project, it was found that by year 8 density would exceed 1 person per 100 square feet during 104 peak season days, and that visitors would begin to be crowded out. We then estimated the number of visitors crowded out in subsequent years. These visitors (visitor days) crowded out will all be accommodated with the larger beach area resulting from this re-nourishment project. The spending of the additional visitors from out of state and other parts of Texas that result from retaining a wider beach are counted as a benefit from this project.

Because this is a re-nourishment project the duration of the project's effects are somewhat uncertain. Given historic erosion rates, the beach area without the project would fall from 320,000 sq. feet (100 ft. width) in 2001, to 16,000 sq. feet (5 ft. width) by 2020. With the project, the beach area will grow to 640,000 sq. ft. in 2001(200 ft. width) and remain at 352,000 sq. ft. (110 ft. width) by 2020. However, there is a reasonable probability that a major storm event could more rapidly diminish the beach area created by re-nourishment. We therefore present cost-benefit evaluations for a 10-year study or project life period.

South Padre Island – Net Benefit Estimate (10 Year Project Life)

Time Period 2001-2011	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	0	$15,554,226	$2,877,855	$8,955,255

Time Period 2001-2011	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$27,387,336	$19,525,279	$2,277,800	$17,247,479	8.57

This is an extremely popular beach area with a large share of visitors from out of state. The high visitor spending benefits from the project are substantial in the 10-year scenario. However, since visitor crowding out due to reduced beach area does not take hold until 2009, visitor-spending benefits are limited to the last two years of the project. On the other hand, the benefits to property values are concentrated in earlier years as the beach improvement leads to a large initial appreciation in values that is sustained through the 10 year project period.

SURFSIDE BEACH (#1015)

The Village of Surfside is located on the Gulf of Mexico in Brazoria County, south of Galveston. The project area extends along the pedestrian beach from Jetty View Street near the Freeport Harbor Ship Channel Jetty to near Oyster Street, specifically targeting the area just north of the jetty that has suffered the most severe erosion rates.

Erosion rates for this area range from two to ten feet per year, with an average of 4.6 feet per year. The narrowing of the beach has been so drastic that it had caused the prohibition of vehicles and the removal of beach houses on the public beach area. The beach was only 46 feet wide in 2001 when the project commenced. Additionally, rock riprap was exposed at several points along the shoreline creating an eyesore and safety hazard for visitors. Aluminum sheet pile bulkheads could also be found along the shoreline protecting a dozen private properties.

In general, the erosion was the result of the sand-starved environment similar to the entire Texas Gulf coast. However, this specific project area was experiencing higher erosion rates than other areas. This phenomenon had occurred despite the expected accretion due to littoral drift toward the jetty. The Corps of Engineers and University of Texas, Bureau of Economic Geology pointed toward four possible causative factors: (1) increased scouring due to wave amplification by the jetty structure, (2) a sediment budget deficit due to dredging and displacement of the Brazos River mouth, (3) subsidence from historical industrial ground water pumping, and (4) sediment loss due to the porosity of the jetty and/or inability to migrate across the cut. Additionally, Tropical Storm Frances in 1998 significantly aggravated erosion in this area.

The project undertaken by the Texas General Land Office (GLO) was a nourishment project. This included transferring 49,000 cubic yards of sand from an upland source to the affected area. The total project cost was $304,108.

There are both public and private benefits associated with this project. For the general public, the project lengthened the beach and improved beach access. The effect of this effort is expected to provide an economic stimulus for the area, protect public infrastructure, mitigate storm damage and thus reduce the public costs of post-storm response, and protect the dune system. Private benefits include protecting and possibly increasing private property values along the shoreline area.

Key Assumptions and Data Elements

This project involves a one-time nourishment of a 3,700 ft. stretch of beach adding approximately 27 feet to the width of this stretch. The historic erosion rate is 4.6 feet per year and beach width in 2001, prior to the nourishment project, was only 46 feet. So given the historic erosion rate, beach width would be reduced to 5 feet by year 10 without the project or other mitigating action. The continued erosion of this beach would diminish local property values, reduce property tax revenues, and limit visitation during peak and off peak season days due to overcrowding from reduced beach size starting in year 2008.
To estimate the effects of beach widening on proximate residential properties we again used maps to designate an impact zone where houses fronted or were oriented toward this beach area. We then used current property valuation data from the Brazoria County Appraisal District to calculate the value of residential property in the impact zone. Since there was a large and significant widening of the beach in 2001, property values would increase significantly in this year due to the wider higher quality beach resulting from the project.

Surfside Beach – Net Benefit Estimate (10 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	0	$1,208,293	$265,771	$8,574,228

Time Period 2001-2011	Total Benefits	Present Value of Benefits	Present value of Cost	Net Benefits	Benefit Cost Ratio
Total	$10,048,292	$5,737,444	$304,108	$5,433,336	18.87

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the area, and seasonal variations. We obtained this information on peak visitation from aerial photographs and derived seasonal estimates based on information provided by local officials. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Texas Destinations 1999.* We used the average annual growth rate in tourism 1985-2000 in Brazoria County to project visitor growth over the 10-year study period. We also obtained estimates from local officials and hotel owners of the origin of visitors to this site. Ninety percent were non-local Texas residents. Using visitation estimates, and estimates of beach area without the project, it was found that by year 8 density would exceed 1 person per 100 square feet during peak season days, and that visitors would begin to be crowded out. By year 10, non-peak day visitors would begin to be crowded out as well. These visitors (visitor days) crowded out would be accommodated with the larger beach area resulting from nourishment from years 2008-2011. Because this is a nourishment project the duration of the project's effects are somewhat uncertain. There is a reasonable probability that a major storm event could more rapidly diminish the beach area created by re-nourishment. We therefore present cost-benefit evaluations for a 10-year study or project life period.

LITTLE CEDAR BAYOU (#1031)

Aerial photo of Little Cedar Bayou

Little Cedar Bayou is located on the northwestern side of Galveston Bay in the City of La Porte in Harris County. The south shoreline of this bayou, located within the Little Cedar Bayou Public Park, was eroding at an average rate of one and a half to two feet per year, resulting in the loss of 33,000 square feet of city owned land. The park is a nature preserve for migratory songbirds, upland wildlife, and mature hardwood trees. It is also becoming a popular location for fishing, bird watching, and educational field trips for nearby schools.

The erosion of this 450-foot stretch of shoreline was primarily the result of wind driven waves and ship wakes from vessels passing through the Houston-Galveston Navigation Channel. Additionally, the Harris County Coastal Subsidence District estimates that the bayou and surrounding area have subsided six to seven feet since 1906. Despite the minimization of subsidence in the last 25 years, the effects of this trend have aggravated erosion in the area.

A shoreline stabilization project was implemented several years ago in which wetland grasses were planted along the shoreline. However, the project was unsuccessful because several of the existing hardwood trees fell into the bayou, which both destroyed the planting area and caused further erosion. These fallen trees were partially or fully submerged in the bayou's waters since this time making impossible the establishment of wetland grasses.

The Houston-Galveston Area Council and the City of La Porte applied and received approval for a CEPRA project grant in order to stabilize the shoreline. A nearshore breakwater was designed to mitigate the impact of waves. This breakwater was constructed of rock rubble at the height of the mean high tide in order to allow water to pass through the breakwater for the establishment of wetlands. In addition to mitigating the impact of the waves, the project also reestablished the shoreline through the removal of the fallen debris, repairing and grading the slope, and replanting native grasses. In total, the project cost $225,509, 25% of which was funded by local sources.

The primary benefit of the project is the protection of plant and wildlife habitat within the park through the creation of wetlands. In addition to wildlife preservation benefits, the project is expected to enhance the public park for the visiting public through educational kiosks and additional benches and tables overlooking the wetlands. It is also the hope of the local group that this project will serve as a demonstration project, which can be adapted to other sites with similar erosion problems.

Key Assumptions and Data Elements:

This was a somewhat unusual project in terms of physical and potential economic impacts. This erosion control effort repairs an erosion-damaged area and will create new wetlands along the park's shoreline. The new wetlands area and nearby parkland will further serve as an educational site on wetland environments and wildlife habitat. This project will not significantly affect parkland area over the project period and is not proximate to a residential settlement. The procedures used to estimate residential and recreational benefits in the other projects couldn't be directly applied to the Little Cedar Bayou initiative.

In this case, it seemed likely that the restored parkland shoreline and new wetlands area would attract new visitors to the park. The construction of educational kiosks and observation areas would contribute to a more attractive park that attracted more visitations. While this construction and related improvements were not part of the project, they would not occur without first improving the area, limiting continued erosion damage, and creating the wetland environment.

It seemed reasonable to assume that the project and related improvements would stimulate additional visitation to the park. To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the area, and consulted with Harris County park officials to estimate additional annual visitors who would likely be drawn to the park due to the project. A conservative estimate of 1,000 additional visitors (visitor days) per year was used to derive the additional visitor spending due to the project. We also obtained estimates from park officials of the origin of visitors to this site. It was estimated that this County park drew 50 percent of its visitors from other jurisdictions in Texas, while the other 50 percent were local residents. The spending of the additional visitors from other parts of Texas that result the park and wetlands improvements are counted as a benefit from this project.

Little Cedar Bayou - Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	0	0	0	$1,236,084

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present value of Cost	Net Benefits	Benefit Cost Ratio
Total	$1,326,084	$681,469	$225,509	$455,960	3.02

Because this project creates recreational and educational value in an area that attracts only local and in-state visitors, benefits flow to the local level. However there may be benefits, not accounted for here, to Texas residents who are able to enjoy and learn from this restored park site and to the State of Texas for the maintenance and restoration of submerged lands and wetlands in this inlet to upper Galveston Bay.

MESQUITE POINT (#1032)

Mesquite Point is located in Port Arthur, Jefferson County next to the Texas-Louisiana border. The 1,200-foot project area, which borders the Sabine-Nueces Ship Channel, is located in the Walter Umphrey State Park, a popular site for local fishermen and visitors from Texas and nearby Louisiana. There is also a RV parking area and playground within the project area.

The shoreline of Mesquite Point has been eroding at an average rate of one to three feet per year. The erosion was thought to be caused primarily by wakes generated from vessels in the Sabine-Nueces Ship Channel. Other erosion factors include wind-generated waves and storm surges, unstable substrate along the shoreline, and natural and human-induced subsidence.

A total of two acres of land had been eroded over the years, resulting in a loss of property and a growing threat to access to and use of a portion of the park. Additionally, park officials hesitated to implement planned improvements (such as additional camping areas and boat parking) because of the threat caused by the persistent erosion.

The project undertaken by the Texas General Land Office (GLO) included the construction of a vinyl sheetpile bulkhead to stabilize the shoreline. The 1,200 linear foot bulkhead was lined with a six-foot wide sidewalk to make the area more attractive for fishermen and visitors. These stabilization measures are expected to have a life span of 50 years and cost a total of $442,601. The costs were shared by the GLO (75%) and local jurisdictions in Jefferson County (25%).

These stabilization measures will allow for various park enhancements such as additional camping areas, bird watching areas, a boat ramp, and more RV parking and hookups. These enhancements are expected to result in increased economic activity and associated revenues. Additionally, the project is expected to mitigate storm damage and thus reduce the public costs of post-storm response measures as well as reduce any infrastructure maintenance and/or relocation costs due to land erosion. Nearby residents are expected incur an indirect benefit from the project in the form of higher property values.

Key Assumptions and Data Elements:

This project involves the construction of a bulkhead with a sidewalk and fishing area extension to protect a major section of the park from erosion damage. Without the project, park and recreation areas would be lost including a RV area, some parking areas and a section that draws numerous fishermen. This park area is a major recreational asset for some residential properties along the access highway. The benefits of this include the effects of the park revitalization on proximate property values, but more significantly maintaining this heavily used State Park as a site for visitation and recreational activity.

To estimate the effects of retaining park and recreation areas on proximate residential properties we used maps to designate an impact zone as a group of properties within one mile of the park along the major access road. We then used assessed valuation data from the Jefferson County Appraisal District to calculate the value of residential property in the impact zone. Since there would be steady and significant erosion of park and recreation area without the project it was assumed that this would diminish the recreational value of the park for nearby residents and diminish marginally property values through time. There would be an additional marginal decline in property values in each year of the study period as parkland was lost without the project. With the project, parkland loss is avoided and property values would continue to appreciate at their historic rates. The difference is the property value benefit due to the project. We then calculated the additional property tax revenue that would be generated each year by the higher appraised value and counted the additional revenue as a local benefit (deducting it from the appreciated value to the homeowners (taxpayers) to avoid double counting). In this case, we had to account for the fact that several affected properties enjoyed an agricultural exemption on a share property taxes.

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the park, and seasonal variations. We obtained this information on peak visitation from local officials and park mangers. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Hotel Performance Data Base 2000.* We used the average annual growth rate in tourism 1985-2000 in the Beaumont Port Arthur MSA to project visitor growth over the 20-year study period. However, in this case, we made an adjustment to the historic growth rate estimate. Since the fishing area of the park would be doubled due to the project, and the majority of current park visitors come to fish, we adjusted growth rates up for the first 10 years. It was estimated that by year ten, the fishing area utilization (fishermen per sq. ft.) would grow to the current level and additional growth from this source would be constrained in the last ten years of the project's life. We also obtained estimates from local officials about the origin of visitors to this site. In this case, there were two types of user fees linked to visitation that would generate revenue of local and state jurisdictions. Additional state fishing license fees and R.V. hookup fees from increased visitation by out-of state visitors were estimated. Also additional marina and docking fees going to a local proprietor were estimated as a local benefit.

Using estimates of visitation with and without the project, and access and size of specific recreation areas endangered by erosion (such as the RV Park and fishing area), we calculated an average annual visitation and visitor spending. The spending of the additional visitors from out of state and other parts of Texas, and spending related to user fees that result from maintaining the park area are counted as a benefit from this project.

Mesquite Point - Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction (including User Fees)
Total Benefits	0	0	$726,699	$144,982	$47,989,897

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present value of Cost	Net Benefits	Benefit Cost Ratio
Total	$48,861,578	$21,153,426	$442,601	$20,710,825	47.79

This project yields a high benefit cost ratio for all jurisdictions. This stems from the fact that a relatively small project intervention preserves a recreational area heavily used by many out-of-area Texans and out-of-state residents.

Kaufer-Hubert Memorial Park (#1036)

The Kaufer-Hubert Memorial Park is a county park located on the shoreline of Baffin Bay in Kleberg County. The park has various recreational facilities, including a fishing pier, boat ramp, bay overlook observation tower, birding overlook, soccer fields, several picnic areas, etc. and is located directly in front of an RV resort.

Erosion of the shoreline had cut away at a half-mile long section parallel to the access road of the park. The erosion was caused by three factors: the natural impact of tidal and wave action, damage from tropical and other severe storms, and the wakes of vessels traveling in the bay. Given the current average erosion rate of up to three feet per year, it was expected that the road would have incurred major damage within a 10-year time period.

The project undertaken through the CEPRA program was meant to stabilize the shoreline along a 675 ft. reach. A steel sheetpile bulkhead was constructed and capped with concrete. Also, a second phase to the project is being considered. The second phase would include extending the bulkhead further along the access road.

The first phase of the project was completed in January 2001 and is expected to have a 50-year life span. In total the project cost $548,200; roughly $90,000 of the cost was funded through local sources while the remaining funds were provided by the GLO.

The stabilization measures are expected to result in various benefits for the public. The park is an economic asset for the county as it generates tourism revenues. The project is expected to improve the recreational value and safety of the park and increase tourism activity. It is also expected to reduce the probability of property and infrastructure damage, especially for the access road.

Key Assumptions and Data Elements:

This project involves the construction of a bulkhead to protect a stretch of shoreline, the main access road and access to a pier area in this county park. The main economic benefits associated with the project are related to preserving access and park quality for a major R.V. park and smaller tenting area. Without the project, continued erosion would undermine the access road by 2009. An alternative access road could be built, but given the configuration of the park, any alternative would provide much more limited access from the R.V. area to the shoreline and pier. In addition, any feasible alternative would significantly alter the character of the park. We constructed a scenario (with and without the project) based on estimates about how an alternative road (necessary without the project) would reduce the attractiveness of the park and suppress visitation. The benefits of the project equal the cost of the alternative access road and the additional visitation activity and spending that would result from preserving the old road and access characteristics versus the new, more limited access from an alternative road.

Given historic erosion rates, by 2009 the existing access road would be undermined by erosion damage. Discussion with project managers and local proprietors revealed that there were a limited number of options for a bypass or alternative road. Taking the best and most likely alternative, we estimated the cost of building it. We then obtained a cost estimate for the alternative from TxDOT which includes costs of labor and materials in this TxDOT region. This estimate in 2001 dollars ($517,440) was then inflated to 2009 dollars ($633,735). This cost would be avoided due to the project and was counted as a benefit.

To estimate the effects of retaining superior access from the R.V. Park and tenting area, we asked park personnel to estimate the effect of inferior access (the case without the project) on visitation to this area. It was estimated that poor access to the shore and fishing area would suppress visitation by 25 percent beginning in 2009.

Kaufer-Hubert Memorial Park - Net Benefit Estimates (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction (including User Fees)
Total Benefits	$633,735	0	0	0	$12,249,182

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present value of Cost	Net Benefits	Benefit Cost Ratio
Total	$12,882,917	$5,207,369	$548,955	$4,658,414	9.49

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the park, and seasonal variations. We obtained information on peak visitation from park personnel. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Texas Destinations 1999.* We used the average annual growth rate in tourism 1985-2000 to project visitor growth over the 20-year study period. We also obtained estimates from park personnel about the origin of visitors to this site. The R.V. Park was a popular resting place for "snowbirds' who drive their R.V.s to south Texas during winter months. It was estimated that out of state visitors accounted for 75 percent of R.V. park users, while 25 percent were non-local Texans. Using visitation estimates, we assumed that beginning in year nine (2009) the park would be less attractive due to reduced access and diminished quality and there would be 25 percent fewer visitors through the 2009-2020 period. The spending of the additional visitors from out of state and other parts of Texas that result from maintaining current park access and quality is counted as a benefit from this project. We further counted the reduced R.V. hook up and other park access fees that would be lost due to diminished visitation under the alternative as project benefits

This project yields a high benefit cost ratio for all jurisdictions. This is the result of a large number of out of state and non-local Texans who use the R.V. facility and tent areas. Preserving visitation to these areas yields substantial benefits for the State and the local jurisdiction.

GILCHRIST BEACH (#1037)

Located on the Bolivar Peninsula in Galveston County, the Gilchrist area has incurred a constant rate of erosion of its shoreline. This is especially true for the shoreline two and a half miles immediately west and east of the Rollover Fish Pass, a man-made cut across the peninsula that connects the Gulf of Mexico with the Galveston Bay system, allowing the fish to pass freely from one water system to the other. While the pass has allowed improved circulation of salt water in the bay, it has also resulted in increased transport of sand through the pass. This project involves the dredging of approximately 297,474 cubic feet of sand from Rollover Bay and placement along a 5,280-foot segment of Gulf beach.

The erosion of the Gilchrist shoreline is caused by various factors. Not only had the area been affected by a general sediment budget deficit incurred along the entire Gulf coast, but it also had been affected by a regional coastal sediment budget deficit due to sand lost into the bay via Rollover Pass, sand trapped by the Sabine jetties, winds transporting sand landward, a reduced river sand supply from which the coastal supply is drawn, and specific beach maintenance and beachfront development practices

With an average erosion rate of five feet per year (and eight feet per year in the area one half mile immediately west of the pass), the county was concerned with loss of various properties along the shoreline, associated revenues, and public infrastructure. Specifically, private properties located in the project area were concerned with either total loss of property or reduced property values if the erosion continued at the current rate. Similarly, the county was concerned with the continual narrowing of its public beach, with which a significant percentage of its economy is associated, as well as threats to public infrastructures such as Highway 87.

Key Assumptions and Data Elements:

This project involves a one-time nourishment of a 5,300 ft. stretch of beach adding approximately 56 feet in width along this stretch. Total costs of this project equaled $1,549,115, with local partners contributing roughly $386 thousand. The historic erosion rate is very high, averaging as much as 8 feet per year in some areas. Beach width in 2001 prior to the nourishment project averaged 80 feet, but it was very uneven across this stretch varying from 15 feet in some places to 100 in others. Given the historic erosion rate, without the project or other mitigating measures, beach width would be reduced to 8 ft. by year 10. The continued erosion of this beach would undermine and damage beachfront properties, diminish local property values, reduce property tax revenues and reduce visitation during peak and off peak season days due to overcrowding from reduced beach size starting in year 2011. There are a number of beach properties that are threatened and would be lost. The number and value of properties lost by year varies depending on beach width directly in front of the various houses.

To estimate the effects of beach widening on properties directly threatened by erosion, we used maps to designate beach front properties at risk. Since we could not determine the exact year when each individual property would fall past the mean high tide line without the project, we assumed that one-half of at risk properties would be affected under a ten-year life cycle. We then obtained information on the assessed valuations of these properties in 2001 from the Galveston County Appraisal District. These values were inflated to 2011 to estimate the cost of these lost properties in the ten year project life scenario. These totals were then counted as benefits (costs avoided) due to the project.

To estimate the effect of the project on residential properties we again used maps to designate an impact zone of houses proximate to the beach area. We then used assessed valuations from the County Appraisal District to calculate the value of residential property in the impact zone. Since there was a significant widening of the beach in 2001, property values would increase significantly in this year due to the wider, higher quality beach resulting from the project. We calculated the additional property tax revenue that would be generated each year by the higher appraised value and by avoiding damage to beachfront properties and counted the additional revenue as a local benefit. We then deducted these additional annual taxes from the appreciated value enjoyed by the homeowners (taxpayers) to avoid double counting.

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the area and seasonal variations. We obtained this information on peak visitation from aerial photographs and derived seasonal estimates based on information provided by local officials. We then estimated growth rates in visitation based on the Texas Department of Economic Development, Hotel Performance Data Base. We used the average annual growth rate in tourism the Texas Destination Reports 1999 for the Galveston-Brazoria MSA, to project visitor growth over the 10-year study period. We also obtained estimates from local officials of the origin of visitors to this site. It was estimated that 52 percent of visitors were non-local Texans and 20 percent were out of state residents.

This stretch of beach is not heavily used. Using visitation estimates, growth rates and estimates of beach area without the project, it was found that only by 2011 as beach width fell toward zero, would visitors be crowded out. Because this is a nourishment project, the duration of the project's effects are somewhat uncertain. There is a reasonable probability that a major storm event could more rapidly diminish the beach area created by nourishment. We therefore present cost-benefit evaluations for a 10-year study or project life period.

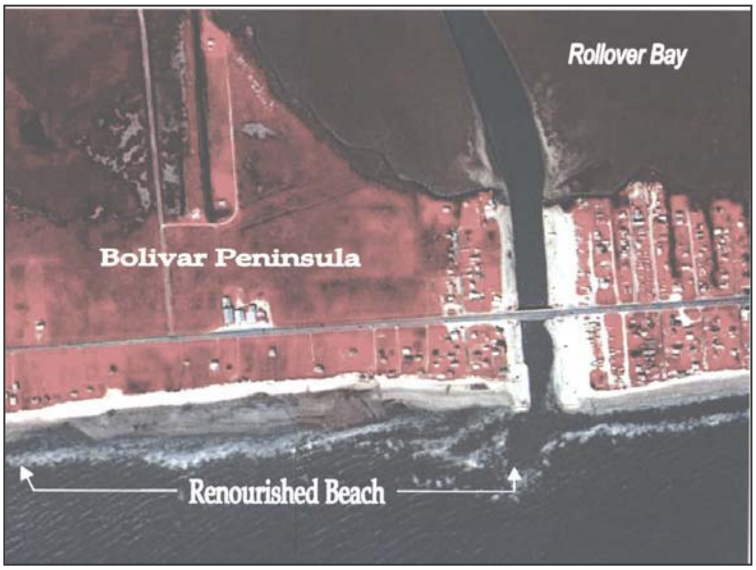
Gilchrist Beach - Net Benefit Estimates (10 Year Project Life):

Time Period 2001-2011	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	$1,393,815	$2,399,923	$524,111	$909,063

Time Period 2001-2011	Total Benefits	Present Value of Benefits	Present value of Cost	Net Benefits	Benefit Cost Ratio
Total	$5,226,912	$3,519,125	$1,549,115	$1,970,010	2.27

GIWW ROLLOVER BAY REACH #1039 #1&2

This project is also on the Bolivar Peninsula in Galveston County, just to the west of the above Gilchrist beach project. This initiative involves beach nourishment on the west side of Rollover Fish Pass. The same general features and causes for erosion as described above apply to this case. However, historic erosion rates are slightly lower along this stretch--6.5 feet per year versus 8 feet along the Gilchrist stretch.



Working with the U.S. Army Corp of Engineers, the Texas General Land Office (GLO) used approximately 266,430 cubic yards of sand dredged from the GIWW by the Corps and placed it onto the beach adjacent to Rollover Pass. The sand was initially deposited along a one-mile (5,280 ft.) stretch of beach on the west side of the pass and long shore currents redistributed the sand westward. The placement of this dredged material led to an expansion of beach width averaging 50 feet. The project costs were estimated to equal $717,699, with the GLO paying only about $130,107 directly toward the project. The relatively low costs of this project to the state are due to the fact that the U.S. Army Corps of Engineers dredged and transported the material to the project area as a part of its maintenance dredging program expense.

There are various benefits associated with the project. For the general public, the widening of the public beach is expected to increase economic activity and associated tax revenues of area establishments. Additionally, nourishment of the beach is expected to better protect the land from storm damage and thus reduce public costs of post-storm response as well as reduce any infrastructure maintenance/relocation costs due to land erosion. Private benefits include protecting and possibly raising property vales and associated tax revenues of private property along the shoreline.

Key Assumptions and Data Elements:

The assumptions and estimating procedures in this case are also similar to the above Gilchrist case. Beach width in 2001, prior to the re-nourishment project, averaged 80 feet, but was also very uneven across this stretch. Given the historic average erosion rate of 6.5 feet per year, without the project or other mitigating measures, beach width would be reduced to 22 ft. by year 10 and to 44 feet by year 20. The continued erosion and ultimate disappearance of the beach in its current location would undermine and damage beachfront properties, diminish local property values, and reduce property tax revenues. Visitation during peak and off peak season days due to overcrowding from reduced beach size would start only in year 2014, so was not added as a benefit of this project over the 10 year estimating period.

To estimate the effects of beach widening on properties directly threatened by erosion, we used maps to designate beach front properties at risk. Since we could not determine the exact year when each individual property would fall past the mean high tide line without the project, we assumed that one-half of at risk properties would be affected under a 10-year life cycle. We then obtained information on the assessed valuation of these properties in 2001 from the Galveston County Appraisal District. These values were inflated to 2011 to estimate the cost of these lost properties in the ten year project life scenarios. These totals were then counted as benefits (costs avoided) due to the project.

To estimate the effect of the project on residential properties we again used maps to designate an impact zone of houses proximate to the beach area. We then used assessed valuation data from the Galveston Appraisal District to calculate the value of residential property in the impact zone. Since there was a significant widening of the beach in 2001, property values would increase significantly in this year due to the wider higher quality beach resulting from the project. We calculated the additional property tax revenue that would be generated each year by the higher appraised value and by avoiding damage to beachfront properties and counted the additional revenue as a local benefit. We then deducted these additional annual taxes from the appreciated value enjoyed by the homeowners (taxpayers).

Because this is a nourishment project the duration of the project's effects are somewhat uncertain. There is a reasonable probability that a major storm event could significantly diminish the beach area created by nourishment. We therefore present cost-benefit evaluations both a 10-year study or project life period.

GIWW Rollover Pass Net Benefits Estimate (10 Year Project Life):

Time Period 2001-2011	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	$1,929,132	$1,006,915	$258,187	0

Time Period 2001-2011	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$3,204,234	$2,001,427	$717,699	$1,283,728	2.79

As in the previous case, most benefits for this project go to the local jurisdiction. Under the 10-year project life scenario, there would be no visitor spending benefits generated for this project.

PARK ROAD 100 (#1053)

This project is on southern Padre Island, located in Cameron County and just north of the corporate limits of the Town of South Padre Island. It deals with two concurrent issues: chronic retreat of his gulf-side shoreline and sand migration onto a northern access road, Park Road 100. The shoreline area most affected by erosion is a four-mile strip located from one to five miles north of the north jetty at Brazos Santiago Pass. On average, this four-mile shoreline had been retreating at a rate of five feet per year resulting in narrowing of the public beach, loss of beach tourism revenue, and loss of taxable property. This project is in the same general area as the Padre Island project (#1010 above).

The object of this shoreline project was two-fold: to nourish another portion of the beach and dune system using sand cleared and transported from Park Road 100;

and to clear the access road of piled-up blowing sand. Blowing sand and small dunes gradually covers the Park Road 100 access road. The Park Road 100 project handled 90,000 cubic yards of sand removed from the access road and transported it to the beach/dune system. The cost of transporting the sand was $104,000, which was shared equally by the Texas Department of Transportation and the GLO, with a small contribution of $3,500 from the local jurisdiction.

The transport of sand and nourishment of the beach area helps to maintain the town's most important economic asset, the public beach. The expected result is increased economic activity and associated tax revenues for tourist businesses. Additionally, the project is expected to improve access by the clearing of Park Road 100 and provide greater habitat value in a healthy beach/dune system.

Key Assumptions and Data Elements:

This project involves a one-time nourishment of a 1,300 ft. stretch of beach adding to dunes and approximately 50 feet to the width along this stretch. The historic erosion rate is 5 feet per year and beach width in 2001 prior to the re-nourishment project was 100 feet. So given the historic erosion rate beach width would be reduced to 55 feet by year without the project. The erosion of this beach would begin to reduce visitation during peak season days due to overcrowding from reduced beach size starting in year 2006. It was assumed that there would be no separable effects on property values beyond those calculated in the other nearby project (#1010 above). We therefore focused on estimating the visitor spending benefits associated with the beach area added due to the project.

To estimate the benefits associated with visitation and recreation spending we estimated current visitation to the area, and seasonal variations. We obtained this information from aerial photographs and from county and local visitor's bureau personnel. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Hotel Performance Data Base.* We used the average annual growth rate in tourism 1985-2000 to project visitor growth over the 10-year study period. We also obtained estimates of the origin of visitors to this site, from the local visitor bureau. Sixty-four percent of visitors to this beach were estimated to be residents of other states, and 30 percent were Texas residents from outside the local area. Using visitation estimates, and estimates of beach area without the project, it was found that by year 6 (2006) density would exceed 1 person per 100 square feet during 104 peak season days, and that visitors would begin to be crowded out. We then estimated the number of visitors crowded out in subsequent years. These visitors (visitor days) crowded out will all be accommodated with the larger beach area resulting from nourishment. The spending of the additional visitors from out of state and other parts of Texas that result from retaining a wider beach are counted as a benefit from this project.

Because this is a nourishment project the duration of the project's effects are somewhat uncertain. Given historic erosion rates, the beach area without the project would fall from 120,000 sq. ft. (100 ft. width) in 2001, to 66,000 sq. ft. (50 ft. width) by 2010. With the project, the beach area will grow to over 191,000 sq. ft. in 2001(145 ft. width) and remain at 132,000 sq. feet (100 ft. width) by 2010.

Park Road 100 - Net Benefit Estimate (10 Year Project Life)

Time Period 2001-2011	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	0	0	0	$18,263,892

Time Period 2001-2011	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$18,263,892	$10,329,953	$104,000	$10,225,953	99.33

This is an extremely popular beach area with a large share of visitors from out of state. The high visitor spending benefits from the project are substantial in the 10-year scenario.

PORT LAVACA - BAYFRONT PENINSULA (#1059)

Located on Lavaca Bay at the end of State Highway 87, the City of Port Lavaca maintains a city park on the Bayfront Peninsula. The park is part of the old downtown area, which is currently being redeveloped. The area is also known as a bird watching site. In fact, there are 15 designated bird watching sites in the city that attract annual visitors to the area. Access to the park was threatened by the failure of an existing bulkhead to prevent erosion.

The shoreline was eroding at an average rate of five to seven feet per year. The erosion was thought to be caused by wind- and vessel-generated waves impacting a bulkhead constructed of improper material for saltwater. Failure to strengthen the existing bulkhead had resulted in subsequent erosion allowing large amounts of the shoreline to erode into and cause further siltation of the marina basin, as well as reducing considerably the city park area.

This project included the construction of a concrete bulkhead on the north side of the peninsula on which fishermen and park visitors congregate and enjoy the bay. The project cost was $572,400, 75% of which was funded by the GLO with 25%

funded locally. The life expectancy of the project is 30 years with minimal maintenance costs.

In 1996, the city commissioned a master plan. The committee determined that the peninsula area was one of the city's primary assets and recommended that it be revived as a tourist destination to anchor the redevelopment efforts. Protecting public land of high recreation and tourist value was seen as an important part of this effort. In addition to these economic benefits, the expectation is that the project will also lead to a reduction in the need for and cost of dredging the marina basin and improved safety conditions associated with walking on the shoreline.

Key Assumptions and Data Elements:

This project involves the construction of a bulkhead and park extension to protect the major bay front park in Port Lavaca from severe erosion damage. Without the project, this park and recreation area would be seriously undermined by erosion and in future years would have been all but eliminated. The project also protects the major access road to the area. This park area, furthermore, ties the downtown residential neighborhood to the bay front. As a result of the project, downtown residents have a view of the park and bay. Without the project, residents would instead have a vision of an eroded shoreline. The benefits of this project therefore flow from the positive effects of the park restoration on proximate property values in the downtown area and maintaining the park as a site for visitation and recreational activity.

To estimate the effects of retaining the park and recreation area and access to the area on proximate residential properties we used maps to designate an impact zone as the neighborhood that was linked to and oriented toward the park area. We then used assessed valuation data from the Calhoun County Appraisal District to calculate the value of residential property in the impact zone. Since there would be steady and significant erosion of the park and recreation area without the project, it was assumed that this would degrade the park and have a negative effect on property values through time. There would be an additional marginal decline in property values in each year of the study period as parkland was lost without the project. With the project, parkland loss is avoided and property values would continue to appreciate at their historic rates. The difference is the property value benefit due to the project. We then calculated the additional property tax revenue that would be generated each year by the higher appraised value and counted the additional revenue as a local benefit, deducting it from the appreciated value to the homeowners (taxpayers) to avoid double counting.

To estimate the benefits associated with visitation and recreation spending, we estimated current visitation to the park and seasonal variations. We obtained this information on peak visitation from local officials and park mangers. We then estimated growth rates in visitation based on the Texas Department of Economic Development, *Texas Destinations 1999.* We used the average annual growth rate in tourism 1985-2000 in the Victoria MSA to project visitor growth over the 20-year study period. We also obtained estimates from local officials about the origin of visitors to this site. Twenty percent of visitors were estimated to be non-local Texans, 15 percent out-of-state visitors. Using visitation estimates, and the total park area we calculated an average annual density per foot of park area. We simply assumed that as the park area diminished due to erosion that visitor days would be lost corresponding to square feet per park visitor in a given year. For example in the second year, average annual park visitors per square foot were 37.7 and there would have been 5,125 square feet of park space lost due to erosion. This would lead to a loss of 139 visitor days in this year without the project. In subsequent years, loss of park space crowds out still more visitors (or visitor days). The spending of the additional visitors from out of state and other parts of Texas that result from maintaining the park area are counted as a benefit from this project.

Port Lavaca - Bayfront Peninsula - Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction
Total Benefits	0	0	$8,586,042	$1,647,169	$1,415,123

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$11,648,334	$5,032,154	$572,400	$4,459,754	8.79

This Port Lavaca project results primarily in local benefits versus statewide benefits. The primary benefit is to residential property owners who would benefit from retaining the bayside park. The aesthetic and recreational amenities due to keeping and improving the park add to local property values and taxes. Preserving the park also adds modestly to visitor and recreational spending, but most out-of jurisdiction visitors are non-local Texans, not out of state visitors.

PORT LAVACA - MARINA (#1060)

Located on Lavaca Bay, the City of Port Lavaca maintains a marina adjacent to the City Park described above (#1059). The marina was threatened by erosion damage as was the park. This shoreline was eroding at an average rate of five to seven feet per year, which was thought to be caused by wind- and vessel-generated waves impacting a bulkhead constructed of improper material for saltwater. Failure to strengthen the existing bulkhead had resulted in erosion of large amounts of the shoreline causing further siltation of the marina basin. Without action, access to the marina from the land and the bay was in jeopardy.

This project included the construction of a 270-foot metal sheetpile bulkhead on the south side of the peninsula to protect the access road and adjacent marina. The project cost $158,710, 75% of which was funded by the GLO and 25% of which was funded locally. The life expectancy of the project is 30 years with minimal maintenance costs.

Protecting access to and continued use of the marina increases out-of area visitors who use the Marina to access the bay and Gulf. The marina is an important asset that attracts tourists for day use and more extended stays. In addition to these economic benefits, the expectation is that the two projects will also lead to a reduction in the need for and cost of dredging the marina basin and improved safety conditions associated with walking on the shoreline.

Key Assumptions and Data Elements:

This project involves the construction of a bulkhead to protect frontage access to the marina and the channel that boats traverse from the marina to Lavaca Bay. Without the project, access would begin to be cut off in the second year and by year four one-third of the marina would be lost (2004). In subsequent years, 22 boat docking slots would be lost due to erosion and siltation of the channel. The benefits of this project therefore flow from maintaining the marina as a site for visitation and recreational activity.

To estimate the benefits associated with visitation and recreation spending we estimated current use of the marina and seasonal variations. We obtained this information on marina use from local officials, as well as the place of origin of marina users. Local authorities estimated that 63 percent of docked boats are owned by non-local Texans and about four percent by non-Texas residents. We then estimated the annual loss in visitors due to the loss of the 22 marina docking slots. This would lead to a loss of 156 visitor days in year two without the project, climbing to 624 visitor days in the 2005-2020 period. The spending of the additional visitors from out-of-state and other parts of Texas that result from maintaining marina access is counted as a benefit from this project. In addition, the loss of marina slots would reduce docking fees collected by the local port authority from marina users.

Port Lavaca - Marina - Net Benefit Estimate (20 Year Project Life):

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction (Including User fees)
Total Benefits	0	0	0	0	$1,120,338

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$1,120,338	$547,173	$158,710	$388,463	3.45

The Port Lavaca marina project results primarily in local benefits. The primary benefit is from increased visitation of non-local Texas from retaining marina access. Since few marina users are from out-of-state, most visitor spending attributable to the project is a transfer to the local jurisdiction.

COVE HARBOR (#1062)

Cove Harbor is located two miles south of the City of Rockport, just east of State Highway 35. In 1996, a harbor improvement project was completed which included dredging the harbor as well as constructing a four-lane concrete boat launch and 500-foot long bulkhead. Due to lack of funds, the bulkhead was not completed, leaving approximately 360-feet of shoreline unprotected. The goal of this CEPRA project was to extend the current bulkhead the remaining 360 ft. length of the shoreline in order to prevent further erosion.

The shoreline within the project area was found to be eroding at an average rate of four-and-a half-feet per year. The erosion caused drainage ditches to form, which allowed large amounts of surface soils (consisting mainly of white sand) to wash into the harbor basin during even moderate rainfall. Additionally, 75 to 80 boats using the boat launch on a daily basis caused wave reflection-related erosion. The project was expected to preserve the shoreline and reduce the future need for harbor dredging.

The 360-foot concrete bulkhead was expected to protect the parking area for the boat launch, the access road to the launch, various infrastructures and the channel allowing access from the marina to the bay. The protected shoreline allowed additional parking spaces, which allowed for 48 additional boats to utilize the launch per day, as well as better protection of natural resources. The Aransas County Navigation District provided $50,000 (or 30%) of $162,000 project costs, and the GLO provided $112,000.

Key Assumptions and Data Elements:

In this case a 360-foot concrete bulkhead is constructed to protect a heavily used boat launch, marina and recreational area from erosion damage. This site is one of the few in the area offering parking, bait and fishing guide services, and boat launch and marina access. Cove Harbor is a major recreational fishing center and guided fishing touring in the Rockport area. If the bulkhead project were not constructed, there would be a continual loss of parking and the recreational area each year. By year 11 (2011), a part of the area would be unusable due to erosion and silting of the channel. Loss of access would cut off for fishing and recreational boating, severely reducing recreational activity at this site.

To estimate the benefits associated with visitation and recreation spending, we estimated current use of the boat dock and marina, and seasonal variations. We obtained this information on marina use from local officials and the owner of the local bait shop and restaurant. We also got estimates of the origins of visitors. It was estimated that 62 percent of boats launched and using the marina are typically owned by non-local Texans, and about 11 percent are owned by non-Texas residents. We then estimated the visitor growth rate in the area from the Texas Department of Economic Development, *Hotel Performance Data Base* for 1985-2000. We then estimated the annual loss in visitors due to the loss of parking, marina slots and eventually the boat launch. By year 11 there would be a loss of nearly 87,000 visitor days per year due to the loss of key parts of the facility. There would be an even greater loss in subsequent years as growth in visitation (above the 87,000 visitor day level) could not be accommodated. The spending of the additional visitors from out-of-state and other parts of Texas that result from this project maintaining access are counted as benefits from this project. In addition, the loss of marina slots would reduce docking fees collected by the local proprietor from marina users.

Cove Harbor - Net Benefit Estimate (20 Year Project Life)

Time Period 2001-2020	Public Infra-structure Benefits	Private Property Damage Benefits	Private Property Value Benefits	Property Tax Benefits	Additional Visitor Spending Out of Jurisdiction (Including User fees)
Total Benefits	0	0	0	0	$132,301,152

Time Period 2001-2020	Total Benefits	Present Value of Benefits	Present Value of Cost	Net Benefits	Benefit Cost Ratio
Total	$132,301,152	$57,513,601	$162,000	$57,351,601	355.02

This relatively small-scale project generates substantial benefits because it preserves a very busy recreational area and marina from erosion damage. This is a major staging site for boating, fishing and other tourism in the area. Preserving access therefore affects a large number of visitors to the area across the project's life span. Despite the fact that most visitors are out of area Texans, the volume of out of state visitors is significant, yielding considerable benefits for the State.

Section III. Natural Resource Benefits of 10 CEPRA Natural Resource Projects

A. A Cost Effectiveness Framework

The natural resource benefits were estimated for 10 CEPRA natural resource projects that were far enough along in planning and construction detail to allow for a careful qualitative analysis. The analysis in this section discusses the costs and the likely environmental and social functions and values associated with each project. The natural resource projects reviewed involved the protection, creation and/or the restoration of coastal wetlands. While it is possible to evaluate wetlands shoreline stabilization and erosion control projects within a classic benefit-cost framework, this task was not undertaken primarily because there are insufficient data, at present, on the monetary value of Texas coastal wetlands.

The natural resource projects reviewed involved the protection, creation and/or the restoration of coastal wetlands

A full benefit-cost analysis of coastal wetlands projects would require consideration of all salient use and non-use values. Use values are the direct extractive benefits such as fish and shellfish harvests, eco-tourism activity such as birding and nature programs, and indirect use benefits such as flood attenuation, ground water recharge, and habitat functions (see Table 4, below). Non-use values include the value Texas citizens place upon protecting a natural resource for its pure existence, the value of protecting a resource so it can be bequeathed to future generations, and the value of conserving a resource to preserve future use options. While the benefit assessment techniques used on the beach nourishment projects in this report could be applied, in theory, to the wetlands projects, the benefits accounted for under that approach would be woefully incomplete because they would not capture much of the indirect use and non-use values discussed above.

The extraordinary value of wetland areas in environmental terms, and indirectly in economic terms is well documented in the literature. Wetland systems provide a crucial foundation for an array of environmental functions and further support a host of other functions and activities that have clear economic value (see Table 7, below). The qualitative evaluation of CEPRA environmental projects focuses on three essential elements: cost of the projects; wetland acreage restored, created, or protected; and the environmental functions and values associated with each project site. Estimates of project cost and impact areas were obtained from GLO CEPRA project descriptions, discussions with CEPRA project managers and local partners, and site visits.

Determination of environmental and socioeconomic functions supported by each project area involved the application of the WET evaluation methodology developed by the Army Corps of Engineers. Use of this method required compilation and analysis of a variety of data sources as they related to the CEPRA project. This included USGS 7.5 minute topographic maps, county soil survey maps, aerial photographs, national wetland classification inventory maps, endangered and threatened species listings and habitat designations, statewide comprehensive outdoor recreation plans, floodplain maps of the federal emergency management agency, flood hazard boundary maps, flood insurance rate maps, and a variety of data on drinking water systems, water quality, land holdings, recreational usage, and dredging locations (among other sources).

Table 7: Wetland Functions and Values

Environmental & Ecological Functions	Socio-Economic Values
• Water Quality Maintenance	• Products
• Sediment Trapping & Stabilization	• Finfish & Shellfish
• Chemical & Toxicant Trapping	• Forage & Hay
• Nutrient Absorption & Cycling	• Timber
• Hydrologic Functions	• Food Products
• Ground Water Recharge/Discharge	• Fur & Other Wildlife Products
• Saltwater Intrusion Prevention	• Aquaculture/Mariculture
• Flow Stabilization	• Recreation & Eco-Tourism
• Primary Production/Energy Transfer	• Fishing & Crabbing
• Ecosystem Stabilization	• Hunting & Trapping
• Biological Diversity	• Nonconsumptive Fish & Wildlife Uses
• Biogeochemical Cycling	• Boating & Swimming
• Fish & Wildlife Habitat	• Camping & Picnicking
• Invertebrates	• Hiking, Trail Walking/Jogging
• Fish & Shellfish	• Visual Aesthetics & Photography
• Reptiles & Amphibians	• Water Supply
• Waterfowl	• Wastewater Treatment
• Wading Birds, Shorebirds & Other Birds	• Flood Control/Attenuation
• Furbearers & Other Mammals	• Erosion Control
• Endangered & Threatened Species	• Storm Buffering
	• Education & Scientific Research,
	• Cultural/Archaeological Value

Source: D. W. Moulton, T. E. Dahl, D. M. Dall, 1997; and Tiner, R.W., Jr. 1984.

B. WET Evaluation Methodology for CEPRA Natural Resource Projects

Today, there are over 80 wetland evaluation techniques in use in the United States that apply to variety of situations, and which were created for a variety of purposes ranging from planning, management, regulatory review, and education (Kusler, 1997; WWF, 1992 Lonard et al., 1981). Based on a selective review of the available techniques, the investigators selected the Army Corps of Engineers' (COE's) Wetlands Evaluation Technique, called "WET," as a means to analyze the values and functions that might accrue from the 2000-2001 CEPRA coastal wetland projects) (Adamus et al., 1987). WET was selected for several reasons: (1) it assesses most of the widely recognized wetland functions and values; (2) it is applicable to a wide variety of wetland types, including freshwater and coastal wetlands; (3) it is reproducible and can be completed relatively quickly without a multidisciplinary research team, and (4) it is premised on a sound technical review of the scientific literature.

WET is a broad-based approach to wetland evaluation based on correlative predictors of wetland functions. It is a general model designed to alert planners, regulators and others to the probability that a particular wetland performs a specific function, and also to provide insight to the likely local regional, state and national significance of those functions. The technique was originally intended to be adapted by states and regions to make it more geographically sensitive to unique climatic and physiographic conditions. However, that development has lagged, and is now unlikely given the increased attention being given to the development and refinement of the Hydrogeomorphic Approach (HGM) wetland evaluation methods by the COE and Texas agencies (Shafer and Yozzo, 1998). When the HGM assessment technique is fully refined for coastal wetland conditions, it will be desirable to adapt it for a CEPRA rapid assessment purpose.

In the present study, WET was used to assess each CEPRA wetlands project for its likely social significance due to its special designation, potential economic value, environmental function and strategic location. WET assesses functions and values by characterizing a wetland in terms of its physical, chemical, and biological processes and attributes. This characterization is accomplished by identifying threshold values for "predictors." Predictors are simple or integrated variables that directly or indirectly suggest that a physical, chemical or biological process is likely to be present. Threshold values for predictors are established by investigators who complete a series of questions concerning each predictor. Responses to the questions are analyzed in a series of interpretation keys that define the relationship between predictors and wetland functions and values as defined in the scientific literature. This interpretation results in an assignment of a qualitative probability rating of high, moderate or low for some 10 environmentally and socially significant wetlands functions and values--Ground Water Recharge, Ground Water Discharge, Floodflow Alteration, Sediment Stabilization, Sediment Toxicant Retention, Nutrient Removal/Transformation, Production Export, Wildlife Diversity/Abundance, Aquatic Diversity/Abundance, Recreation, and Uniqueness/Heritage (Adamus et al., 1987).

A brief description of the functions and values as detailed by Adamus et. al., (1987) and C.B. Schneider and S.W. Sprecher (2000) is provided below.

In this framework**,** wetland projects are evaluated based upon the degree to which the wetland area affected by a project can be shown to provide 10 essential wetland functions and values (Barbier et al., 1997; Dennison et al., 1997):

1. **Ground Water Recharge**
2. **Ground Water Discharge**
3. **Flood Flow Alteration**
4. **Sediment Stabilization**
5. **Sediment/Toxicant Retention**
6. **Nutrient Removal / Transformation**
7. **Wildlife Diversity / Abundance**
8. **Aquatic Diversity / Abundance**
9. **Uniqueness / Heritage**
10. **Recreation**

To delineate the extent to which each area supported these functions, extensive data was compiled for each CEPRA environmental project. The assembled database and map information were used to answer 31 interpretative questions defined by the WET model. Among the 31 questions, there are six "red flag" questions that nearly automatically trigger "high" ratings for many of the wetland values and functions. For example, if the project area has any known federal or state listed endangered or threatened species (including officially designated candidate species) known to regularly use the area, it automatically will obtain a "high" rating on the uniqueness/heritage scale. Likewise, projects that represent most or all of a wetland system (estuarine, palustrine, lacustrine etc.,) in a given locality/watershed will jump in importance across many values and functions (scarcity and uniqueness are drivers of importance).

Once all 31 questions were answered, the social significance of each value/function was assigned using Boolean logic and decision trees. For example, a project that acts as a physical buffer to features of social or economic value that are situated in an erosion-prone or wave vulnerable location will receive a "high" rating, while those projects that are simply located in an urban setting would get a "moderate" rating, and those projects that do not meet either of those conditions would obtain a "low" rating on the likely social significance of the wetland for sediment stabilization. For more information on the WET technique interpretative keys, please refer to the technical documentation (Adamus et al., 1987).

C. CEPRA Environmental Projects Summaries Costs and Environmental Functions and Values

The first qualitative dimension of the evaluation of CEPRA natural resource projects involves a basic assessment of the total costs of each project and the acreage of the area restored, created or protected by the project. A variety of comparisons are provided in Table 5 below, showing project costs, type of wetland impact and total costs per acre of net wetland created. It is important to consider the different environmental effects typically associated with restoring or creating wetlands, versus protecting existing wetlands. Existing wetland systems that remain intact tend to be significantly more productive than restored or newly created wetlands. Hence, the environmental and indirect economic and social benefits are likely to be greater in cases where existing wetlands are protected from erosion related damage.

Table 8: Summary Cost Data for 10 CEPRA Environmental Projects

Project Name	Total CEPRA Project Costs $	Acreage Restored	Acreage Created	Acreage Protected	Total Acreage	Cost Per Acre $
#1003 McFaddin Dune	325,000			500	500	650
#1019-Bessie Heights	750,000	222			222	3,378
#1020-Halls Lake	880,000		5	475	480	1,833
#1041 Nueces Bay	1,303,436		3.2	3.2	6.4	482,754
#1044 North Deer Island	800,000			103	103	7,767
#1047 Omega Bay	333,625	21.5			21.5	15,517
#1048 Delehide Cove	1,344,000	50		710	760	1,768
#1050 Moses Lake	330,000		1.8	50	51.8	6,370
#1052 GIWW-McFaddin	1,500,000			45,000	45,000	33
#1065 Jumbile Cove	567,000	136		48	184	3,082

It is not possible to make confident judgments about the cost effectiveness of this set of projects solely from the preceding cost data. However some sense of the value of preserving wetland environments in the state can be gleaned from the one study that did offer a partial estimate of the economic benefits of Texas wetlands (Whittington et al., 1994). Based on an analysis of marginal value of wetlands on recreational fishing in Galveston Bay, the authors of the study estimate that the capitalized value of wetlands for recreational fishing is $8,500 per acre (in 1993 dollars). Given modest inflation since 1993, the costs per acre estimates of all except one of these 10 projects is in range, suggesting that positive net economic benefits are likely in light of this study's findings. Moreover, the full value of wetland restoration is likely to be considerably higher because these areas have numerous other functions, in addition to recreational fishing, that have economic value.

Table 9: Wetland Evaluation of 10 CEPRA Projects Using the WET System

Project:	**#1005 McFaddin Dune**	**#1019 Bessie Heights**	**#1020 Halls Lake**	**#1041 Nueces Bay**	**#1044 North Deer Island**
Wetlands Functions and Values:					
Ground Water Recharge	Low	Mod	Mod	Low	Low
Ground Water Discharge	Low	Mod	Mod	Low	Low
Flood Flow Alteration	Mod	Mod	Mod	Mod	Mod
Sediment Stabilization	High	High	High	High	High
Sediment/Toxicant Retention	Low	Mod	Mod	Mod	Mod
Nutrient Removal / Transform	Mod	Mod	Mod	Mod	Mod
Wildlife Diversity / Abundance	High	High	High	High	High
Aquatic Diversity / Abundance	High	High	High	High	High
Uniqueness / Heritage	High	High	High	High	High
Recreation	Low	High	High	Mod	Low

Project:	**#1047 Omega Bay**	**#1048 Delehide Cove**	**#1050 Moses Lake**	**#1052 GIWW McFaddin**	**#1065 Jumbile Cove**
Wetlands Functions and Values:					
Ground Water Recharge	Low	Low	Low	Mod	Low
Ground Water Discharge	Low	Low	Low	Mod	Low
Flood Flow Alteration	Mod	Mod	Mod	Mod	Mod
Sediment Stabilization	High	High	High	High	High
Sediment/Toxicant Retention	High	Mod	Mod	Mod	Mod
Nutrient Removal / Transform	High	Mod	High	High	High
Wildlife Diversity / Abundance	High	High	High	High	High
Aquatic Diversity / Abundance	High	Mod	Mod	High	High
Uniqueness / Heritage	High	High	High	High	High
Recreation	High	Mod	Mod	Mod	Low

Table 9, above, provides a summary of all CEPRA environmental project functions and values as assessed using the WET technique. The CEPRA projects scored high in virtually all cases on the significance of shoreline stabilization, aquatic diversity/abundance, wildlife diversity/abundance and uniqueness and heritage functions and values. This is not surprising as most CEPRA projects are located in waterfowl use regions of major concern; have commercial fishing or shell fishing within or near the project area; are affiliated in some way with an organized conservation group, public agency or other entity for the purpose of preservation; offer ecological enhancement or low-intensity recreation; provide a buffer to features of social or economic value that are situated in erosion-prone or wave vulnerable areas; and lie within the habitat range of multiple aquatic and terrestrial species that are listed as endangered, threatened, candidates or "of concern." All of these variables tend to lead to higher probability ratings for wetland values and functions under WET.

Most CEPRA projects were likely to provide other wetland values and functions such as toxicant retention, nutrient removal, or flood flow alteration. The least noteworthy wetland values and functions, on average, were ground water recharge and discharge which is to be expected in estuarine settings.

D. Cost Benefit Estimates for the 10 CEPRA Environmental Projects

MCFADDIN DUNE (#1003)

McFaddin National Wildlife Refuge (NWR), managed by the U.S. Fish and Wildlife Service (USFWS), is located in the south central part of Jefferson County, approximately 12 miles west of Sabine Pass and 16 miles southwest of Port Arthur. Part of the NWR contains shoreline along the Gulf of Mexico characterized by a wide, relatively unvegetated foredune terrace consisting of fine-grained sand backed by a low dune system. The dunes provide storm protection for the NWR land.

Due primarily to a deficit of available sand both onshore and in the littoral system, natural- and human-induced subsidence, and the effects of Tropical Storm Frances, the shoreline in the 2.5 mile affected area was eroding at an average rate of 8-12 feet per year. The effect of the erosion was aggravated by recreational vehicular traffic and mechanical beach cleaning that prevented the establishment of dune stabilizing vegetation. Continued erosion resulted in the loss of public beach and storm surge protection as well as the threat to the integrity of transportation infrastructure, wildlife habitat, and coastal wetlands.

In order to revitalize the existing dune system and protect habitats and infrastructure at the McFaddin NWR, the USFWS in partnership with the GLO implemented a beach/dune system nourishment project. Two of the planned measures (dune construction and native grass planting) were completed this year, while the remaining measure (nourishment of 1,800 feet of beach) is planned for completion in the spring of 2002. The existing dune system was supplemented with imported sand, creating a dune 50 feet wide from toe to toe, five feet higher than current natural grade, and 1,775 feet long. Native dune vegetation was restored through the planting of native grasses (sea oats and panic grass) and other ground cover species in a checkerboard pattern.

In total, the project cost $325,000. The USFWS funded over 75% (or $250,000) of the project and the CEPRA program contributed the remaining amount. The new dune and vegetation is expected to benefit the area by providing protection for wildlife habitat and infrastructure and revitalizing the existing ecosystem. In addition, the measures are expected to reduce the public costs of post-storm response and infrastructure maintenance/relocation.

BESSIE HEIGHTS (#1019)

Bessie Heights Marsh is located north of the Neches River in southwest Orange County and northeast of Port Arthur, Jefferson County. Erosion poses an imminent threat to the Bessie Heights Marsh and the adjacent lower Neches River wetlands habitat. In particular, approximately 8,000 acres of emergent marsh have subsided, constituting the largest area of contiguous wetland loss in Texas. Wetland loss began in the 1930s, when oil was discovered in the Port Neches Field. The most significant losses occurred between 1956 and 1978 when approximately 70% (or 8,510 acres) of the lower Neches River emergent marshes were converted to open water.

Factors thought to contribute to marsh loss include subsidence associated with the removal of underground oil, gas, and ground water reserves; saltwater intrusion; petroleum production brine disposal; altered hydrology; and altered sediment deposition patterns. Additionally, the disposal of dredged material from the Neches River has created artificial levees that do not allow sediment deposition into the marsh.

A partnership was developed between the Texas General Land Office (GLO), Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service and local conservation groups in order to implement marsh restoration efforts. The first phase of these efforts was undertaken during this CEPRA project. This phase involved creating 222 acres (or 30% of the entire marsh) of open-grid terraces to restore and protect marsh vegetation. The terraces, created using dredged material from a nearby area owned by the TPWD, help to break the wind energy and reduce the turbidity that causes further erosion.
The project cost a total of $750,000, $100,000 of which was funded by CEPRA. The remaining $650,000 was paid for by other sources, including US Fish and Wildlife, federal coastal erosion funds, and Natural Resource Damage funds. The majority of the costs were spent in the construction of the terraces; however, some money was set aside for contingency planting in case some of the vegetation did not take hold and required replanting. The expected design life of the project is 30 years.

The wetland functions of greatest social significance, according to the WET method, include sediment stabilization, wildlife diversity/abundance, aquatic diversity/abundance, uniqueness/heritage, and recreation. Project partners emphasized the importance of the project for the protection and restoration of wetland habitat for endangered migratory waterfowl and for commercial and recreational fish species. The wetlands will also be important for trapping suspended sediments and pollutants and will help to convert potentially toxic hydrocarbons from vessel spills to less harmful forms. In addition, the partners involved in the project hope that it will serve as a model for other wetland protection and restoration efforts as well as to induce recreational and educational use of the Bessie Heights wetland area.

HALLS LAKE (#1020)

Halls Lake is located on the northwest side of West Galveston Bay in Brazoria County. A narrow isthmus separates the lake from the Gulf Intracoastal Waterway (GIWW) on its southwest side. Erosion of the bay side shoreline, due primarily to wind- and vessel-generated waves and regional subsidence, presented an imminent threat to the freshwater marsh habitat within the lake. Historic erosion was estimated at five feet per year, yet more recent data revealed estimates as high as 11 feet per year. Additionally, the bay barrier islands that once provided protection for the isthmus have disappeared, threatening a breach of the isthmus and exposure of the marsh to higher barge and boat wave energies and more saline water.

In order to protect the narrow isthmus from the heavy traffic and winds on the bay the Texas Parks and Wildlife Department (TPWD), installed approximately 3000 feet of shoreline protection along the GIWW side of the isthmus. After protecting the shoreline, the TPWD also created five acres of additional marsh habitat and acquired up to 475 acres of uplands surrounding Halls Lake. In total, the project cost $880,000, 25% of which (or $220,000) was provided by the GLO.

The wetland functions of greatest social significance, according to the WET method include: sediment stabilization, wildlife diversity/abundance, aquatic diversity/abundance uniqueness/heritage, and recreation. The sensitive marsh habitats important for waterfowl and various commercial and recreational fish species will be protected from the more saline waters and higher wave energies of the bay. The creation of additional marsh and acquisition of surrounding uplands will help establish footholds for wetland flora and fauna. Also, the project will directly and indirectly provide recreational (e.g., the restoration of productivity of game and non-game species) and educational (e.g., the education of visitors, students, and volunteers on the importance of coastal wetlands) benefits as well as benefits for commercial and sport fisheries. The TPWD hopes that this project might serve as a model for other wetland protection and restoration efforts.

NUECES BAY (#1041)

Since the 1950s, various small emergent islands have developed in Nueces Bay, located in Nueces and San Patricio Counties,. These one- and two-acre islands were likely created during the dredging of channels in the bay as shell from oyster reefs was cast to the adjacent bay bottom. Due primarily to extensive shell dredging (it is estimated that 24 million cubic yards of shell has been removed from the bay in last 100 years.) and the disappearance of shoreline vegetation protecting habitats, bay shorelines have been eroding at an average rate of three to five feet per year. Other factors of continued erosion include disease, droughts, excessive wave action caused by hurricanes and storms, and major activities such as oil exploration, dredging, and waterway traffic.

Erosion of the islands had resulted in the loss of hard substrate reef habitat and associated emergent islands, which greatly reduced the available habitat diversity for marine organisms and important rookery island habitat. These reefs and islands are an important benefit to the bay area because they provide nesting areas for colonial waterbirds and dampen wave impacts on bay shorelines. The retreat of the shoreline also resulted in more frequent and severe impacts on shorelines, loss of public and private property, and increased turbidity due to a lack of natural filtration of wetlands.

Under the CEPRA program, the GLO, in partnership with the Coastal Bend Bays & Estuaries Program, Inc., decided to focus on reestablishing and protecting six bird rookery islands in Nueces Bay. Geotubes and rock berms were placed around the perimeter of the islands in order to absorb wave energy while allowing vegetation to build up on the interior. Maintenance costs for this project are expected to be minimal; though the shroud around the geotubes may need replacing in 10 years and some patching of the shroud and geotubes may be required every two years. The design life is expected to reach 25 years. In total, the project cost $1,303,436. An analysis of alternative measures was conducted by engineers at Shiner Moseley & Associates, Inc. The analysis considered various types of protective structures, including geotubes filled with imported sand or onsite sand, concrete block mats, and rock berms. Geotubes filled with onsite sand in combination with shoreline infill were thought to be the most beneficial measures considering the cost estimates for each structure. The analysis also discussed creating a new six-acre island to provide additional area for bird rookery habitat beyond what could be supported by the existing islands.

By protecting the shoreline from wave action and reestablishing some of the lost island and reef habitat, the project is expected to enhance the area's natural resources, allow a greater variety of species to develop in bay system, increase bird nesting rates, and improve water quality through natural filter strips. Additionally, the project is expected to improve ecotourism as well as reduce the loss of public and private property.

NORTH DEER ISLAND (#1044)

North Deer Island is located in West Galveston Bay between Galveston Island and Tiki Island. The 144-acre island is the site of the largest and most heavily used colonial waterbird nesting area in Galveston. An estimated 50,000 – 25,000 pairs of birds (of fifteen different species) nest on the island annually. The island also contains a substantial percentage of valuable high quality salt marsh, which provides habitat for a variety of avian species as well as provides nursery habitat for commercially and recreationally harvested finfish and shellfish.

Erosion of the northern and southern ends of the island has threatened both of these valuable environmental assets. Due primarily to excessive wave action generated by waterway traffic in the nearby GIWW, the northern end of the island is eroding at an average rate of one to twenty feet per year. Other factors – including possible subsidence, damage caused by hurricanes and storms, and mass activities such as oil exploration and dredging – are also affecting the southern end of the island, resulting in an average erosion rate of one to three feet per year. Though a berm protects the west end of the island, the large marsh on the interior of the island would erode rapidly should this barrier be breached. Roughly 20 feet of high quality salt marsh on the east side of the island was lost as a result of Tropical Storm Frances in 1998.

The purpose of efforts undertaken by the GLO is to stabilize the eroding island shorelines in order to reduce habitat and island loss, and restore and preserve habitat affected by erosion. As such, a wave barrier was constructed both to attenuate wave energies and to allow suspended material to settle behind the structure, thereby fostering accretion of intertidal marsh lands. The project was made possible by the combined efforts of the CEPRA program ($100,000), TPWD, and the USCOE ($700,000).

OMEGA BAY (#1047)

Omega Bay is located just south of downtown La Marque, Texas in Galveston County. The project area consists of approximately 90 acres of open water that was formerly marsh habitat, which is divided by Interstate Highway 45. The area just west of the highway (21.5 acres) is the primary target area under this project.

Regional subsidence, due primarily to groundwater extraction for cooling refinery generators, caused approximately 30,000 acres of marsh to be lost in Galveston Bay. Particularly, between the 1930s and 1950s, the bay lost 400 acres of marsh habitat. As a result, the water column heights no longer support marsh plant species and, thus, the area has been converted to open water. Without marsh vegetation, waves are no longer attenuated and the shoreline is experiencing erosion. Subsidence has also intensified erosion damage due storm impacts.

The GLO, in partnership with the Galveston Bay Foundation, the USFWS, and Newpark Shipbuilding-Brady Island, Inc., attempted to mitigate further erosion of the shoreline by restoring the marsh habitat. The primary goal of the project was to reduce, or prevent, continued loss of marsh habitat in Omega Bay in order to attenuate wave energy, protect existing shorelines from further degradation, provide habitat for a variety of birds, fish, and shellfish, and re-establish a functional marsh ecosystem. The proposed efforts included the construction of terraces on which intertidal grasses would be planted. The terraces would be constructed from material excavated at the project site and designed in irregular shapes to mimic naturally occurring marsh areas. A hearty species of marsh grass with an expansive root system (*Spartina alterniflora*) would be planted on the terraces in order to restore the marshland habitat. This species has an additional benefit in that the algae that grow on the stems retract minerals and help purify the water.

An analysis of alternative designs was completed by Dames & Moore. Two alternatives were considered in the analysis: the aforementioned wetland restoration terraces and construction of a leveled area with backfill. Terracing proved to be the preferred option because of its lower costs and provision of habitat for a greater variety of species. The terraces create both a buffer to slow wave energy and a habitat for fish and shrimp.

In total, the project cost $333,625, of which $225,000 was paid by GLO, 50% of the total cost was covered by the Galveston Bay Foundation. According to the design, it is expected to take two years for vegetation to be full; and the expected design life is 30 years. Construction began in fall 2000 and was completed in the Fall of 2001.

The wetland functions of greatest social significance, according to the WET method include: sediment stabilization, wildlife diversity/abundance, aquatic diversity/ abundance uniqueness/heritage, recreation, nutrient removal/transformation, and sediment/toxicant retention. Terracing the bay is expected to prevent the continued loss of marsh habitat, which in turn will provide food and shelter for marine waterfowl and fishery species. Additionally, the marsh restoration efforts are expected to increase revenue from hunting, fishing, and ecotourism as well as increase public awareness of the value of marsh habitat.

DELEHIDE COVE (#1048)

Delehide Cove is located on the south shoreline of West Galveston Bay, adjacent to and just east of Galveston Island State Park in Galveston County. The project area encompasses approximately three miles of bay shoreline, including Delehide Cove, Hoeckers Point, Eckert Bayou, and Starvation Cove. The wetland habitats of these coves are integral components of the Texas Gulf coast and of the Galveston Bay estuarine ecosystems; yet, from 1956 to 1989, roughly 800 acres of marshland were lost due to erosion and subsidence.

The shoreline was eroding at an average rate of 2.1 feet per year. Wetland losses were apparently caused by a variety of causal forces, including dredging, stream cutting and filling, subsidence, sediment diversion, saltwater intrusion, and hydrologic alteration. Shoreline ridges, vegetated land spits, and other features that once protected intertidal marshes were disappearing. Additionally, subsidence increased the vulnerability of the marsh system to erosion during winter and during tropical storms.

The impacts of such erosion were numerous. Sea grasses virtually disappeared because of development, discharges, runoff, erosion, and dredging. Continued erosion of the shorelines and uplands separating more saline bay waters from palustrine and brackish marshes threatened important fresh to brackish water habitats. Additionally, the degradation of the wetlands threatened various endangered and threatened species that utilize the salt marshes and bay margin, including the brown pelican, peregrine falcon, reddish egret (nesting), roseate spoonbill (nesting), white-faced ibis (nesting), wood stork, mottled duck (nesting), osprey, black rail (nesting), snowy plover, piping plover, least tern, black tern, Gulf slat marsh snake, and Texas diamondback terrapin.

As a result of these imminent threats, local groups (Galveston West Bay Shoreline Restoration and Preservation Program, Galveston Bay Foundation, and local property owner associations) and state and federal agencies (Texas Parks and Wildlife Department (TPWD), U.S. Fish and Wildlife Service, National Marine Fisheries Service, and U.S. Army Corps of Engineers) came together to protect the 571 acres of wetlands (including 391 acres of estuarine marsh, 3 acres of palustrine marsh, and 177 acres of tidal flats). To protect the existing marsh and tidal flats, a 9,500-foot geotube breakwater was constructed along the project shoreline. This wave barrier will allow for the replacement of eroded shoreline features and reestablishment of a significant portion of the protective bay shoreline so that the remaining emergent tidal marsh areas will be protected from erosional scour. In addition to the constructed breakwater, 50 acres of estuarine intertidal marsh (*Spartina alterniflora*) and one acre of seagrass were planted to protect or restore several biological functions critical to the barrier island ecosystem (e.g., shorebird nesting habitat, high marsh and upland transitional areas, tidal pools, flats, and lagoons, freshwater wetlands, and foraging areas for both upland and aquatic species). The newly planted areas were also protected by a smaller 3,000-foot long geotube. The project cost a total of $1,344,000.

The wetland functions of greatest social significance, according to the WET method include: sediment stabilization, wildlife diversity/abundance and uniqueness/heritage. The project partners expect to protect and restore wetland habitat for waterfowl and for important commercial and recreational fish species. A secondary benefit anticipated for the project is the trapping of suspended sediment and pollutants and conversion of pollutants to less harmful compounds of biochemical action. Also, the project will directly and indirectly provide recreational and economic (i.e., increasing private property values and associated tax revenues) benefits as well as benefits for commercial and sport fisheries.

Moses Lake (#1050)

Moses Lake is located west of Galveston Bay and north of Texas City in Galveston County. The northern shore of the lake is adjacent to the Texas City Prairie Preserve (TCPP), a 3,100-acre coastal preserve owned and managed by The Nature Conservancy of Texas (TNC) since its donation in 1995 by Exxon/Mobil. Roughly 4,000 feet of coastal marsh habitat along the southern and eastern shorelines of the TCPP and 50 acres of intertidal marsh and shallow water habitat in a nearby cove was threatened by chronic erosion. The TCPP land provides habitat for the endangered Attwater's Prairie Chicken and the cove is highly utilized by migratory and resident songbirds and wading birds as well as juvenile fish, shrimp, crabs, and other marine organisms.

With an average loss of two to three feet per year, erosion of the shoreline was caused primarily by wind driven waves. The prevailing southeasterly winds provide a large fetch from which wave energies are built. In addition, wetland loss can be attributed to several causes, including dredging, stream cutting and filling, subsidence, sediment supply deficit, saltwater intrusion, and hydrologic alteration.

A natural berm existed prior to efforts undertaken in this grant, which protected some of the shoreline. However, the berm eroded to the extent that it was expected to have been breached within the year, resulting in the exposure of rich organic soils and delicate marshes to erosive wave energies. The project undertaken by CEPRA and TNC included the construction of a 4,000-foot breakwater, constructed of concrete riprap with a berm established landside. The breakwater was constructed parallel to the shoreline for the purpose of protecting existing marsh and 15 acres of proposed marsh just north of Texas City on the western shoreline of Galveston Bay. In addition to protecting the shoreline from erosive wave energies, the project also included the planting of 1.8 acres of smooth cord grass (*Spartina alterniflora*) on the interior of the barrier as a means of creating additional acreage of fringe marsh habitat. The design life of this project is expected to be 25 years with some maintenance of the berm and rock required.

Dames & Moore consulting engineers conducted an analysis of alternative measures. Two types of wave barriers were considered in the analysis: submerged sills and a nearshore breakwater. The analysis recommended the construction of the breakwater over the submerged sills for two primary reasons. While the sills inhibit sediment transport, they do not reduce the impact of the wave energies as much as the breakwater would. The sills, because they are submerged, also present a navigation hazard to area boaters.

The construction costs of the project totaled $330,520. TNC provided $97,000 while the remaining amount was funded through the CEPRA funds. The wetland functions of greatest social significance, according to the WET method include: sediment stabilization, wildlife diversity/abundance, nutrient removal/transformation, and uniqueness/heritage The primary benefits expected, according to project partners, include creation of highly productive habitats for marine life, protection and restoration of wetland habitat for waterfowl and for important commercial and recreational fish species, and creation of additional habitat for juvenile fish, crabs, and encrusting organisms. Another benefit of the project is that the breakwater and grasses will trap suspended sediment and pollutants and convert pollutants to less harmful compounds of biochemical action. Also, the project will directly and indirectly provide recreational benefits (e.g., the restoration of productivity of game and non-game species in the area) and educational benefits (e.g., the education of visitors, students, and volunteers on the importance of coastal wetlands) as well as benefits for commercial and sport fisheries.

GIWW McFaddin Reach (#1052)

McFaddin National Wildlife Refuge (NWR), managed by the U.S. Fish and Wildlife Service (USFWS), is located in the south central part of Jefferson County, approximately 12 miles west of Sabine Pass, Texas and 16 miles southwest of Port Arthur, Texas. Approximately 45,000 of the 55,000 acres of refuge are classified as wetlands providing important wintering habitat for migratory waterfowl and other birds and utilized by a variety of mammals, reptiles, and fish. Additionally, several endangered species are endemic to the area.

The NWR is split by the Gulf Intracoastal Waterway (GIWW), sharing over 20 miles of shoreline with the heavily utilized channel. Due to vessel wakes from traffic in the GIWW and various other factors (i.e., unstable substrate along the shoreline, natural- and human-induced subsidence, destructive forces of Tropical Storm Frances), the shoreline was eroding at an average rate of three to six feet per year, resulting in the loss of storm surge protection and wetlands. In fact, the GIWW had widened 300 to 500 feet as a result of chronic erosion. Without mitigation, continued erosion was likely to result in breaches in the bank that would allow saltwater into the adjacent marshes and threaten the wildlife habitat and the national refuge. Existing intrusions had already caused the entire marsh area to become more brackish, reducing floral and faunal diversity.

In order to prevent further erosion, the USFWS in partnership with the Texas General Land Office (GLO) installed a series of shoreline stabilization and erosion control measures. Due to the large size of the affected area, the agencies decided to take a phased approach. This phase of the project was primarily concerned with the south bank of the channel between mile marker 300 and 296. Two structures, a detached riprap breakwater and riprap revetments, were installed on the site in order to protect the shoreline from further erosive forces. Similarly, in order to preserve and enhance existing coastal wetlands and habitats, smooth cordgrass (*Spartina alterniflora*) was planted waterward of the bank and in other critical locations along the shoreline.

In total, the project cost over $1.5 million, $300,000 of which was requested from CEPRA funds. The wetland functions of greatest social significance, according to the

WET method, include sediment stabilization, wildlife diversity/abundance, aquatic diversity/abundance uniqueness/heritage, and nutrient removal/transformation. Benefits of the project anticipated by project partners include the protection of wildlife, protection of freshwater and intermediate tidal wetlands, the revitalization of the ecosystem, higher quality, healthy public beach, and reduced costs of post-storm response.

JUMBILE COVE (#1065)

Jumbile Cove is located on the southern shoreline of West Bay in Galveston County, west of the City of Jamaica Beach. Since 1930, the area had lost 40 acres of intertidal marsh, 38 acres of tidal flats, and 9 acres of prairie due to erosion. In total, approximately 87 acres of marsh had been converted into open water. Erosion of shorelines and uplands separating more saline bay waters from palustrine and brackish marshes had threatened important brackish water habitats. At the current rate of erosion, the remaining intertidal habitat would have disappeared within five years.

The shoreline was eroding at an average rate of 2.1 feet per year. Tropical storms and cold fronts caused erosive waves energy, particularly during frontal events from the north and northwest. Shoreline ridges, vegetated land spits, and other features that once protected intertidal marshes were disappearing. Additionally, subsidence increased the vulnerability of the marsh system to erosion during the winter and during tropical storms.

The Texas Parks and Wildlife Department (TPWD) applied for CEPRA project funding in order to protect and enhance existing intertidal marsh and tidal flats. TPWD constructed a 2,500-foot breakwater to protect the existing marsh habitat from further degradation. The break water was constructed using an 18-inch diameter geotube with protected UV shroud and has an expected design life of approximately 25 years. TPWD also constructed 12 acres of marsh mounds in order to restore elevations necessary to support intertidal marsh. The marsh mounds were constructed of material dredged on site and planted with Spartina.

Though the total costs of the project were $567,000, TPWD only requested $100,000 of those costs from the CEPRA program. Additional funding was sought from the National Coastal Wetlands Grant Program, the Environmental Protection

Agency, the National Fish and Wildlife Foundation, the Galveston Bay Estuary Program, the University of Houston, and Reliant Energy.

The wetland functions of greatest social significance, according to the WET method include: sediment stabilization, wildlife diversity/abundance, aquatic diversity/abundance, uniqueness/heritage, and nutrient removal/transformation. According to project partners, the project is expected to restore bird nesting habitat, improve water quality and conserve nearby infrastructure that was at risk as a result of the accelerated erosion rate.

While it is not possible to develop a single composite ranking of these projects, the multidimensional character of the qualitative assessment of wetland values and functions does allow an ordering of projects according to certain important attributes.

Table 10: Rank by Cost per Existing Wetland Acreage Protected

1. GIWW McFaddin Reach
2. McFaddin Dune
3. Halls Lake
4. Delehide Cove
5. Moses Lake

One important project attribute is the protection of existing wetland areas, since existing wetlands tend to yield the highest ecological and biological productivity compared to wetlands in the same class that must be either "restored" or "created." Thus, the top five projects ranked by this criterion are presented in Table 10. These five projects involved protecting existing wetland resources and incurred the least CEPRA cost per acre. Because these wetland sites are likely to be highly productive across a number of WET functions and values, their preservation could be viewed as a good investment of public resources.

Wetlands projects that are most likely to promote wildlife diversity/abundance, aquatic diversity/abundance, and recreation values could also be viewed as important due to their indirect support to valuable recreational activity. Based on the wetland evaluation information summarized for each project in Table 6, we can identify the top five projects based on their cumulative "high probability" assessments according to the three values listed above and the costs per acre.

Table 11: Rank by Cost and Wildlife, Aquatic, and Recreational Values

1. Halls Lake
2. Bessie Heights
3. Omega Bay
4. GIWW McFaddin Reach
5. Nueces Bay

These qualitative rankings put into relief the variety of crucial natural resource benefits generated by this set of CEPRA projects. This evaluation strongly indicates that the CEPRA Program's support of coastal wetland protection, restoration and creation provides direct benefits in stemming further losses of these critically important coastal resources.

A full benefit-cost analysis of coastal wetlands projects would require additional primary research to obtain Texas specific estimates of the indirect use and non-use values of Texas coastal wetlands. Given that multiple state and federal agencies have a vested interest in these coastal resources (e.g., TPWD, GLO, TXDOT, TCEQ, and NOAA); it should be possible to devise a research plan that involves both cost-sharing and a scope of work that meets multiple agency needs. Developing the methodologies and basic data would allow for a very useful quantification of the benefits of wetland restoration projects that would allow for comparisons among the projects in developed areas or dedicated recreational sites where costs and benefits can be specified.

In the meantime, it would be a mistake to prioritize projects where only direct costs and benefits are estimated. As the above excerpt from Molton et al. emphasizes, wetland protection projects definitely yield substantial economic gains, even if they are harder to specify in a comprehensive manner.

Figure 4: Partial Estimates of
Wetland Natural Resources Benefits

The total economic impact on the Texas coastal region of wetland-based recreation and wetland-dependent commercial fisheries is substantial. In 1993, the dock-side value of shellfish (brown, pink, and white shrimp; blue crab; and eastern oyster) and finfish (black drum, flounder, sheepshead, and snapper) landed commercially from the Galveston Bay system was about $11.6 million (Robinson et al. 1994). The total economic impact at the wholesale level from Galveston Bay alone was estimated at $35 million. The total economic impact of commercial fishing at the wholesale level coastwide is over $400 million annually, providing jobs for about 30,000 coastal residents. There were about 850,000 saltwater sport fishers in Texas during 1991 (Texas Parks & Wildlife Dept. 1993). Direct expenditures by these anglers totaled about $380 million and supported about 11,000 jobs in Texas (U.S. Fish & Wildlife Service, 1993). The total annual economic value of recreational fishing to users of Galveston Bay living in the Houston-Galveston area was estimated to be $75-150 million, with the total annual value of the bay for all recreational uses (7 million user-days per year) in the range of $115-200 million (Whittington et al., 1994).

In 1990-1994, 30,000-40,000 coastal waterfowl hunters pursued waterfowl populations that averaged about 1 million geese and 1.5 million ducks (Texas Parks & Wildlife Dept. unpubl. data). In 1991, the economic impact of waterfowl hunting and non-consumptive waterfowl use in Texas was about $96 million and $240 million, respectively (Teisl and Southwick, 1995). A substantial portion of this activity took place on the coast. In the spring of 1992, about 6,000 birdwatchers, an important segment of the rapidly expanding coastal nature tourism industry, poured into tiny High Island in eastern Galveston County (Eubanks et al., 1993). The total economic impact was estimated to be $4 million to $6 million over a two-month period.

Section IV. Conclusion

This report assessed the economic costs and economic and natural resource benefits of 23 CEPRA projects funded in Cycle 1. Specific information on the cost effectiveness of individual erosion control projects indicates that all projects yielded positive net benefits for citizens of the state. In aggregate terms, the 13 projects where direct economic benefits could be estimated yielded almost $128 million in net benefits to residents of Texas and the affected localities. These estimates indicate that for every dollar invested in CEPRA projects by Texas state government and local partners, over $16 dollars will be generated in economic benefits over the life of the projects. This 16-to-1 return on investment is based on a conservative set of assumptions used to derive benefit estimates.

For certain types of erosion control projects, especially projects that protect or restore wetland areas, the losses that are avoided with erosion protection are much harder to specify with precision. Nevertheless, the 10 CEPRA natural resource projects analyzed promoted critical coastal resource functions including: sediment or shoreline stabilization; promotion of aquatic and wildlife diversity and abundance; and preservation of site uniqueness and heritage. The CEPRA natural resource projects evaluated also were found to provide other wetland values and functions such as toxicant retention, nutrient removal, or flood flow alteration.

Because the 10 CEPRA projects score high in preserving aquatic and wildlife diversity, the indirect economic benefits of these projects are likely quite significant. Texas' wetland systems are the source and support environment of flora and fauna that generate billions of dollars from commercial and recreational use. In sum, this systematic evaluation of Texas Coastal Erosion Planning and Response Act Cycle 1 projects indicates that preserving coastal resources and assets is a public investment strategy yielding high returns for Texas taxpayers.

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