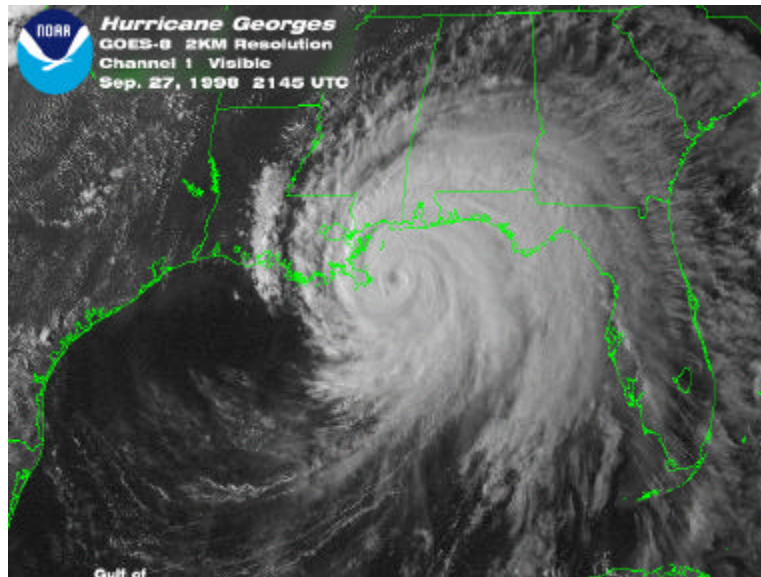


HURRICANE EARL
AND
HURRICANE GEORGES

**BEACH AND DUNE EROSION AND STRUCTURAL
DAMAGE ASSESSMENT
AND
POST-STORM RECOVERY PLAN
FOR THE
PANHANDLE COAST OF FLORIDA**



JANUARY 1999



**REPORT NO. BCS-99-01
BUREAU OF BEACHES AND COASTAL SYSTEMS
DIVISION OF WATER FACILITIES
DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF FLORIDA**

FOREWORD

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APPROVED BY

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EXECUTIVE SUMMARY

The hurricane recovery plan described in this report was developed to provide recommendations and cost estimates to assist in the recovery efforts of the coastal system in the Florida Panhandle following Hurricanes Earl and Georges. This recovery plan is intended to supplement the strategic recovery plan developed after Hurricane Opal impacted the Florida Panhandle coast in 1995. This plan identifies supplemental recovery projects and area-wide needs in addition to the recovery strategies already identified and under implementation following Hurricane Opal.

Plan recommendations are based on a staff review and analysis of erosion conditions and recovery needs throughout the Panhandle in Escambia through Franklin Counties. Monroe County was also severely impacted by Hurricane Georges; however, storm impact reporting and recovery initiatives were conducted separately outside the scope of this report.

The Panhandle coast of Florida has been severely impacted in recent years by the successive impacts of multiple storms and hurricanes, most notably Opal in 1995 followed by Earl and Georges in 1998. The result has been the loss of large volumes of sand from Panhandle beaches and upland dune and bluff areas. The recommended recovery plan includes sand restoration projects for identified critical erosion areas where erosion impacts threaten major development. Sand fill project areas were identified following on-site, field inspections by staff engineers, with assistance from contracted engineers, and acquisition and analysis of extensive beach, dune, and offshore survey data.

Natural recovery is still recommended in undeveloped and non-vulnerable areas as identified in the post-Opal recovery plan. This supplemental plan outlines additional assisted beach berm and dune restoration and revegetation in appropriate areas. Continued debris removal will be performed in conjunction with post-Opal efforts. Sand search and coastal monitoring studies and data collection is recommended as well as additional technical assistance for management of post-storm recovery efforts.

The total cost estimate for the work described in this plan is \$14.5 million, including \$13.7 million for county recovery projects and \$0.8 million for post-storm monitoring and support projects. County projects include supplemental beach and dune restoration and revegetation work in Escambia, Santa Rosa, Okaloosa, Walton, Bay, and Gulf Counties. The supplemental fill projects will expand on small-scale sand placement projects funded and implemented through the Federal Emergency Management Agency (FEMA). The FEMA projects, which are for temporary emergency protection only, provide a portion of the sand eroded from Hurricane Georges and do not include erosion recovery from Hurricane Earl, nor assist the Panhandle region in recovering major sand losses resulting from the cumulative impacts from multiple storms and hurricanes in recent years.

I. INTRODUCTION

This report provides a brief description of the impacts of both Hurricanes Earl and Georges to the Florida Panhandle coastal regions and, more importantly, provides a strategic management plan for recovery of damaged coastal resources. The plan includes cost estimates for implementing both remedial measures and initiatives for the long-term management of this area.

The coastal regions of the Panhandle counties of Florida have been significantly damaged in recent years by a series of major storms and severe hurricanes. The most significant impacts have resulted from the combined effects of Hurricane Opal in October 1995, Hurricane Earl in early September 1998, and Hurricane Georges in late September 1998. The result of these three hurricanes has been the continual erosion of beaches and dunes in some of the most highly-developed areas and most highly-visited areas by tourists in the Panhandle. Despite a concerted, persistent recovery program in the aftermath of Opal, the repetitive losses from the hurricanes in 1998 have continued to threaten the economic viability of much of the region and have left many areas vulnerable to future coastal storms.

In reviewing damages to the coastal system caused by these storms and hurricanes, three primary remedial response strategies for restoration of the system were evaluated:

Natural recovery of both the beach berm and dune/bluff areas to pre-storm conditions is expected to occur in many areas. In some areas it will be a slow process taking years or perhaps decades. That may be unacceptable to local citizens. However, all options should incorporate natural recovery to the extent acceptable within time and cost constraints. Natural recovery is especially appropriate for public lands such as local, state and federal parks. It is also appropriate in areas where an adequate setback existed prior to the storm and the existing post-storm beach/dune system provides ample protection for upland property and development. Natural recovery is only useful in areas with an adequate sand supply accessible to wind and water action.

Assisted natural recovery options predominantly intervene to accelerate the natural recovery of the beach/dune system. Mechanical placement of sand, use of sand fencing, and revegetation are viable components of this approach. Efforts can be made to restore berm features to provide protection to dune areas and upland development, and to restore and close gaps or blowouts in eroded dunes. These options are dependent on availability of sand sources, either from upland or from offshore sites. Sand fencing and revegetation are labor intensive options and must also be actively managed.

Mechanical restoration is normally reserved for areas where there are adequate economic or other social reasons to justify the activity. Areas suffering from cumulative erosional effects of storms, and with enough upland development to warrant a public investment of funds, are the most appropriate areas.

In order to perform needed sand restoration projects, sand source studies are needed. Use of offshore sand will result in the most economical means of restoring the eroded areas. Suitable sand sources should be available offshore in locations along the Panhandle coast within reasonably close proximity to identified restoration projects. Further evaluation of upland sources will also be included in the sand source studies. The sand source studies will identify suitable, available sources and will provide needed sand quality analyses to ensure that the material is of acceptable quality to match the native material of the Panhandle beaches.

Continued monitoring and data collection will be necessary during and subsequent to recovery activities in order to evaluate the effectiveness of restoration efforts and to assess the on-going condition and behavior of the coastal system. More detailed evaluations and studies of coastal regions experiencing chronic shoreline erosion exacerbated by the cumulative impacts of recent storms and hurricanes are needed. Specific evaluation of feasible management alternatives will provide options for proper management of these areas.

Post-storm response activities, in addition to restoration work and monitoring studies needed as part of the overall recovery effort include; structural alternatives, stormwater outfall remediation, and hazard mitigation planning. Post-Opal debris removal work has successfully removed extensive amounts of hazardous debris from beach and offshore areas. Additional clean-up work following the hurricanes of 1998 will have to be performed. Structural alternatives to beach restoration, such as the proposed bridge construction across the southern portion of St. Joseph Peninsula at Stump Hole is recommended as resolution of a severe erosion threat to an existing hurricane evacuation route.

DEFINITIONS

Beach – is the zone of unconsolidated material that extends landward from the mean low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation, usually the effective limit of storm waves. Unless otherwise specified, the seaward limit of a beach is the mean low water line. “Beach” is alternatively termed the “shore.”

Beach Berm – is a nearly horizontal part of the beach or backshore formed by the deposit of material (i.e., sand) by wave action.

Dune – means a mound or ridge of loose sediments, usually sand-sized, lying landward of the beach and deposited by any natural or artificial mechanism.

Erosion – is the wearing away of land or the removal of consolidated or unconsolidated material from the coastal system by wind or wave action, storm surge, tidal or littoral currents or surface water runoff. Erosion includes:

- (a) Landward horizontal movement of the mean high-water line or beach profile.
- (b) The vertical lowering or volumetric loss of sediment from the beach and dune or the offshore profile.

Inlet – also referred to as “Pass” is a short narrow waterway, including all related flood and ebb tidal shoals and the inlet shorelines, connecting a bay, lagoon, or similar body of water with a large parent body of water, such as the Gulf of Mexico, Straits of Florida, or the Atlantic Ocean.

II. SUMMARY OF HURRICANE IMPACT

This section provides a brief description of both Hurricanes Earl and Georges including a summary of beach and dune erosion impacts and structural damage. A more detailed account of storm impacts is contained in the appendices.

A. STORM DESCRIPTIONS

HURRICANE EARL

Hurricane Earl struck the Panhandle coast on September 2, 1998, making landfall just east of Panama City Beach. A depiction of Earl's storm track is provided in Figure 1 below. Hurricane Earl was a Category 1 hurricane with maximum sustained winds reaching 85 mph. The greatest convection and strongest winds associated with the storm were located east-northeast of the storm center. This aspect of the storm coupled with the higher, onshore-directed winds and associated storm surge and accompanying breaking waves resulted in most of Earl's destructive impact occurring in areas east of its point of landfall.

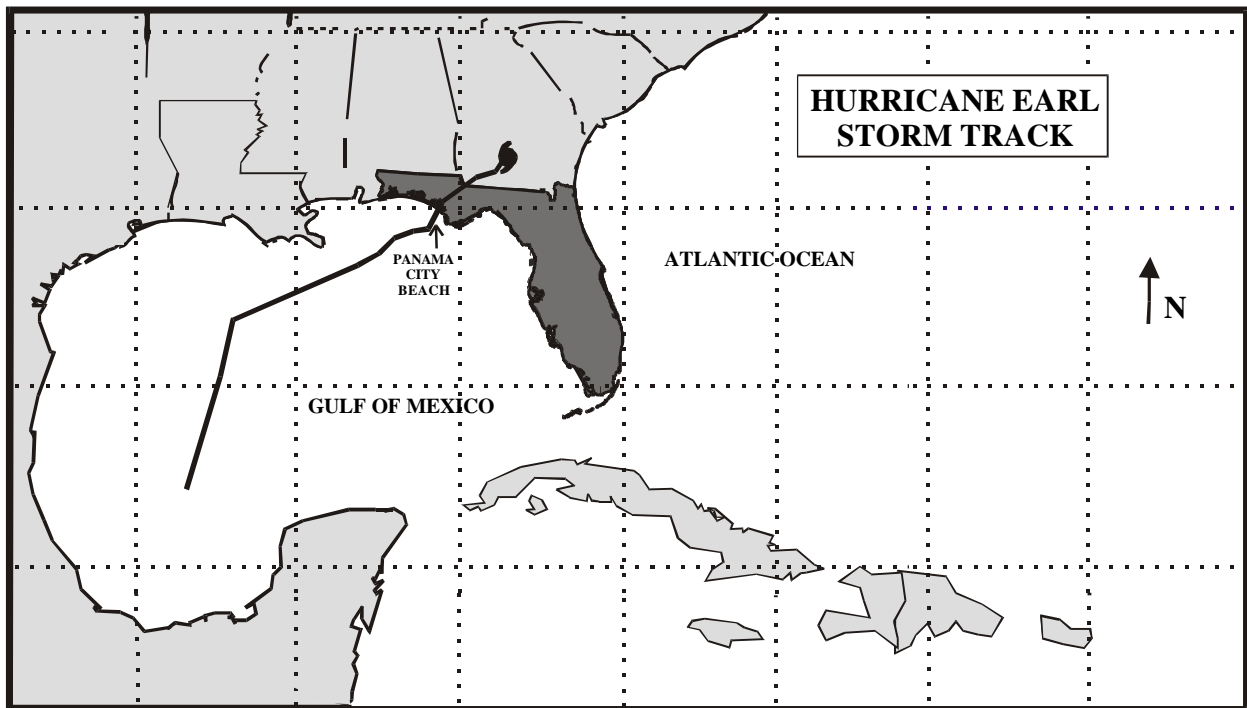


Figure 1. Hurricane Earl storm track making landfall on Florida Panhandle Coast.

The coastal areas sustaining the most significant and noteworthy impact from Hurricane Earl, and which will be described in this report, include Bay, Gulf, and Franklin Counties. The primary focus of post-storm inspections and assessments were the developed areas of these counties. Although not the focus of this report, storm impacts were also observed and reported along the low energy, non-sandy shorelines in coastal counties in the Big Bend region to the east of Franklin County.

HURRICANE GEORGES

Hurricane Georges made two landfalls in the continental United States after inflicting extensive structural damage and loss of life in its path across Puerto Rico, the Dominican Republic, and Cuba. A storm track for Hurricane Georges is depicted in Figure 2. The first landfall in the continental U.S. occurred on September 25, 1998, in south Florida, with the eye of the storm crossing Key West as a Category 2 hurricane. Maximum sustained winds at that time were recorded at 105 m.p.h. with gusts estimated at 115 m.p.h. Storm surge elevations were estimated at 4-5 feet National Geodetic Vertical Datum (NGVD). The windward coast fronting on the Straits of Florida of the middle and lower keys received the predominate impact from the storm surge and storm wave conditions. Shorelines of the sandy islands west of Key West also received a lesser but significant impact.

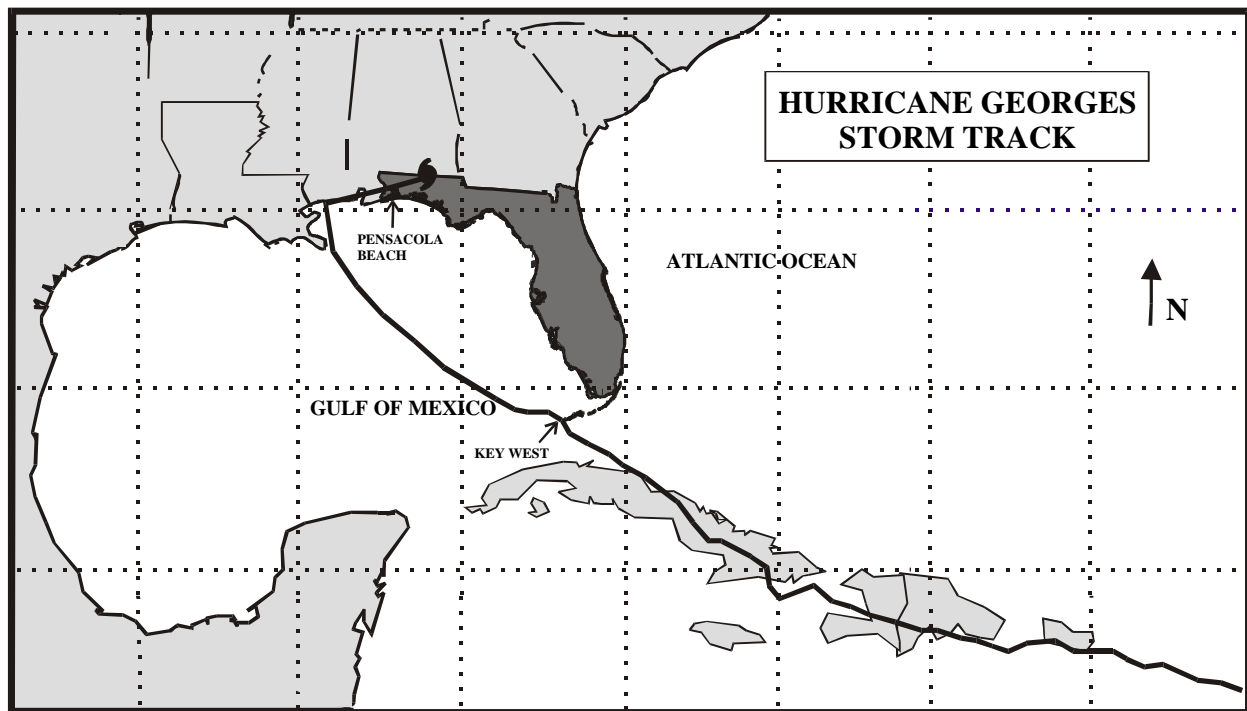


Figure 2. Hurricane Georges storm track crossing Key West and Florida Panhandle.

After crossing the Gulf of Mexico on a north-northwest track and intensifying slightly, Georges made its final landfall at Ocean Springs, Mississippi, about 85 miles west of the Florida/Alabama state line. Maximum sustained winds reached near 105 m.p.h. with gusts reported up to 172 m.p.h. Storm surge flooding of 10 to 15 feet above normal tide levels was estimated along the Mississippi coast while a storm surge of +7.7 feet (NGVD) was reported at Pensacola Beach by the United States Geological Survey.

The western Florida Panhandle received significant impact in Escambia through Bay Counties. While Hurricane Earl's major impact area was generally east of Mexico Beach, Georges' major impact area was generally west of Mexico Beach. The combined effect of these two hurricanes impacted the entire Panhandle coast, as was the case with the devastating and more severe impact of Hurricane Opal in 1995.

A summary of beach/dune erosion and structural damage is given below with more detailed descriptions of impacts provided in the report appendices.

B. BEACH AND DUNE EROSION SUMMARY

HURRICANE EARL

Many areas were still in the recovery process from erosional impacts resulting from Hurricane Opal, which may have had a limiting effect on the extent of erosion from Earl. There were some localized areas which did experience significant beach and dune erosion from Earl. Comparisons of post-storm beach and dune survey profiles with pre-storm profiles, where available, provided a means to assess the extent of erosion resulting from Earl. The Bureau of Beaches and Coastal Systems (BBCS) collected post-Earl profile data in much of Gulf County and portions of eastern Franklin County, as well as, the Mexico Beach area of Bay County. A summary of erosion for these areas is given in Table 1, which also includes erosion computations from Hurricane Georges for the western Panhandle. In areas where profile data was not available, aerial/ground observations were used to assess and document the extent of storm impact.

The most significant erosional impacts from Earl occurred in isolated locations at Alligator Point, Dog Island, and Little St. George Island in Franklin County, along most of the entire western shoreline of the St. Joseph Peninsula in Gulf County, and in isolated locations in Mexico Beach, as well as portions of Panama City Beach in Bay County.

The Panama City Beaches beach restoration project was already under construction when Hurricane Earl impacted the Gulf Coast. The project consulting engineering firm, Coastal, Planning and Engineering, Inc. (CPE), of Boca Raton, Florida, performed post-Earl survey data collection and prepared an erosion impact assessment for that area of Bay County. Limited post-Earl survey data was collected by CPE. Following collection of additional data after Hurricane Georges, CPE determined a combined average erosional loss from both hurricanes Earl and Georges in the Panama City Beaches project area of 9.1 cy/ft. More detailed results of the CPE storm erosion assessment for Panama City Beach are described in Appendix E for Bay County.

HURRICANE GEORGES

The entire westerly region of the Panhandle coast from Perdido Key in Escambia County eastward to Mexico Beach in Bay County experienced some level of impact from Hurricane Georges. Post-storm inspections by BBCS staff and analysis of post-storm survey data documented the areas along the Panhandle coast most significantly impacted by Georges. The erosion from Georges was not as severe as erosion from Hurricane Opal, but the combined impact of Opal, Earl, and Georges has resulted in substantial beach/dune erosion losses across much of the Panhandle coast. A summary of computed erosion from Hurricane Georges combined with the computed erosion from Hurricane Earl is given in Table 1. Illustrations of some typical beach and dune erosion comparative profiles from selected locations along the Panhandle coast are shown in Figures 3 through 6.

TABLE 1

BEACH AND DUNE EROSION SUMMARY

<u>COUNTY</u>	<u>RECESSION</u>				<u>EROSION VOLUME</u>	
	(County Avg., Max. in ft.)				(Above NGVD)	
	<u>Beach</u>		<u>Dune</u>		<u>Avg./Foot</u>	<u>Total</u>
	(2ft. Contour)		(10ft. Contour)		(Cubic Yds./Ft.)	(Cubic Yds.)
	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>		
ESCAMBIA						
Perdido Key (R1-32)	-26.0	-79	4.9	-43	-4.6	-146,194
Pensacola Beach (R110-139)	-74.0	-165	-31.0	-207	-18.4	-521,236
SANTA ROSA						
Navarre Beach (R192-214)	-64.0	-156	-36.0	-98	-14.9	-336,504
OKALOOSA						
Okaloosa Island (R1-15)	14.0	-56	1.9	-8	-4.5	-66,965
Destin (west, R17-32)	-20.0	-56	4.3	-8	-3.9	-53,892
Destin (east, R32-50)	1.9	-39	-0.3	-8	-4.1	-61,682
WALTON						
Western (R1-39)	-18.0	-70	-6.6	-20	-6.4	-264,000
Central (R40-79)	-1.4	-53	-6.8	-17	-3.7	-110,379
Eastern (R105-124)	-4.5	-125	-3.9	-23	-4.7	-238,070
BAY						
Panama City Beach	-----	not available	-----		-9.1*	-----
Mexico Beach (R128-144)	5.9	-26	-0.2	-18	-1.7	-26,481
GULF						
St. Joseph Spit (R70-106)	-49.0	-97	-10.0	-24	-8.0	-296,312
FRANKLIN						
Alligator Point (R196-231)**	9.7	-7	-2.6	-15	-0.2**	-6,468

*Panama City Beach is within an extensive beach restoration project; erosion volume is based on computations provided by Coastal, Planning and Engineering, Inc.

** The erosion values given for Alligator Point do not include some severely eroded locations between R211 and R214 particularly near R213.

Escambia County Beach and Dune Erosion

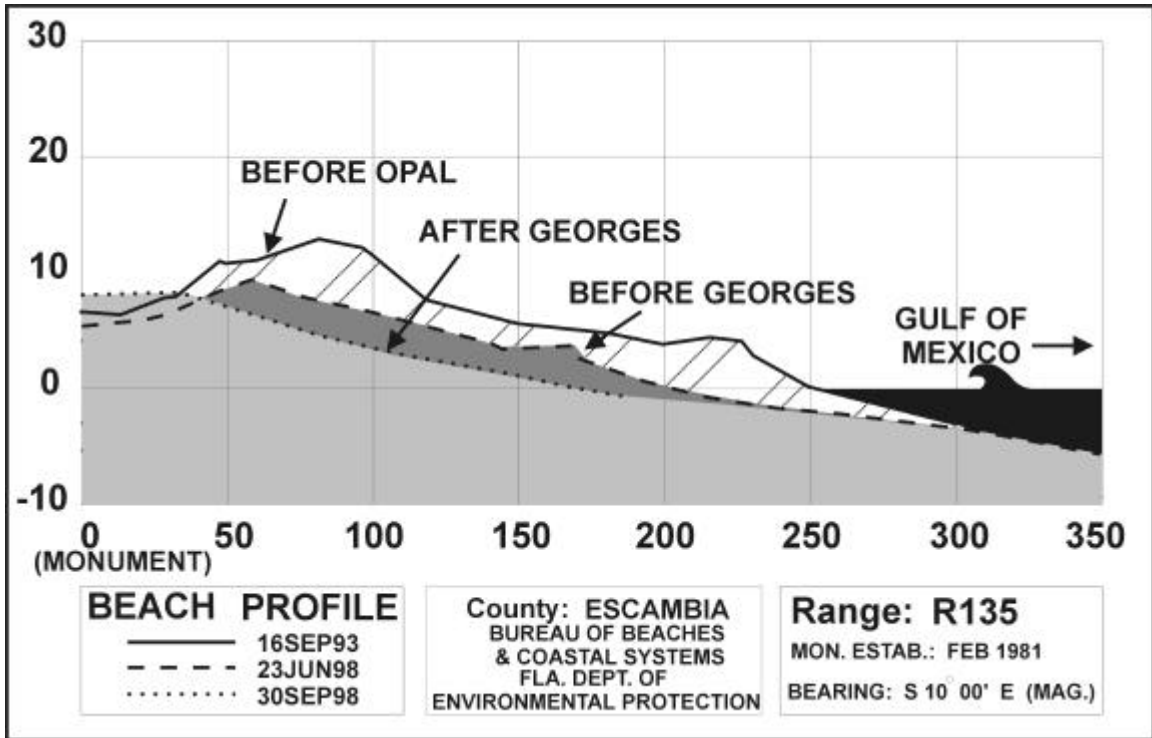


Figure 3. Erosion from Opal and Georges at R-135 in Escambia County.

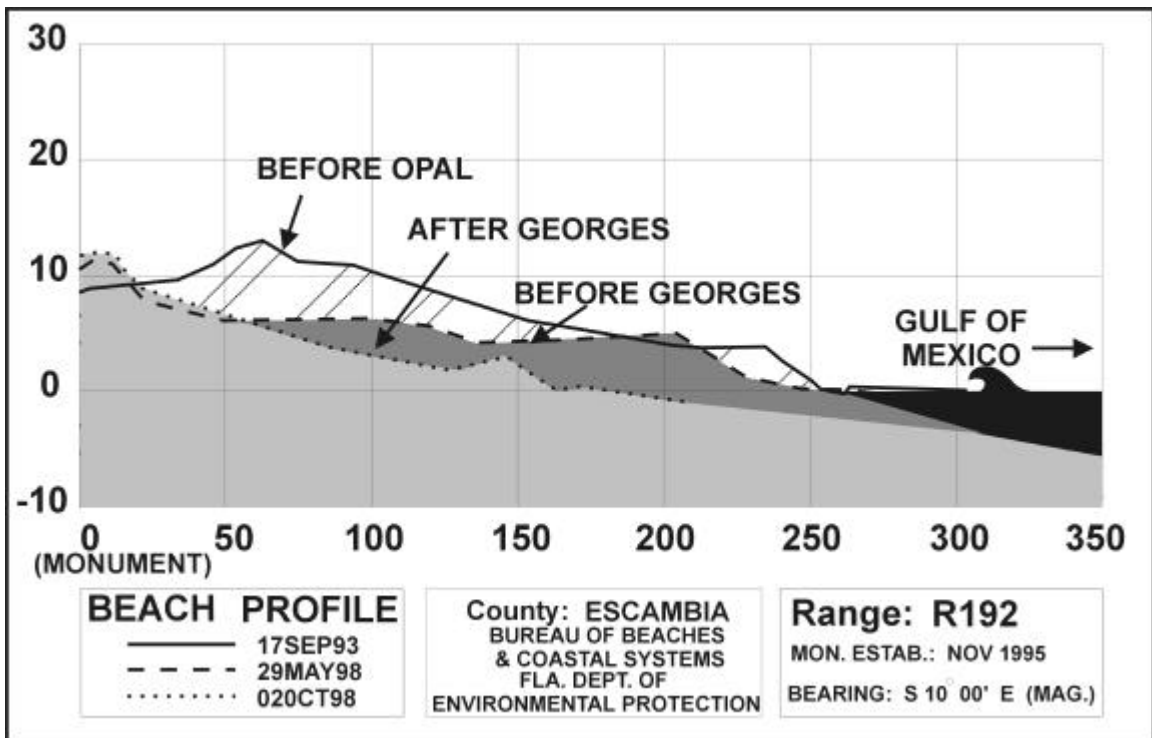


Figure 4. Erosion from Opal and Georges at R-192 in Escambia County.

Walton and Gulf County Beach and Dune Erosion

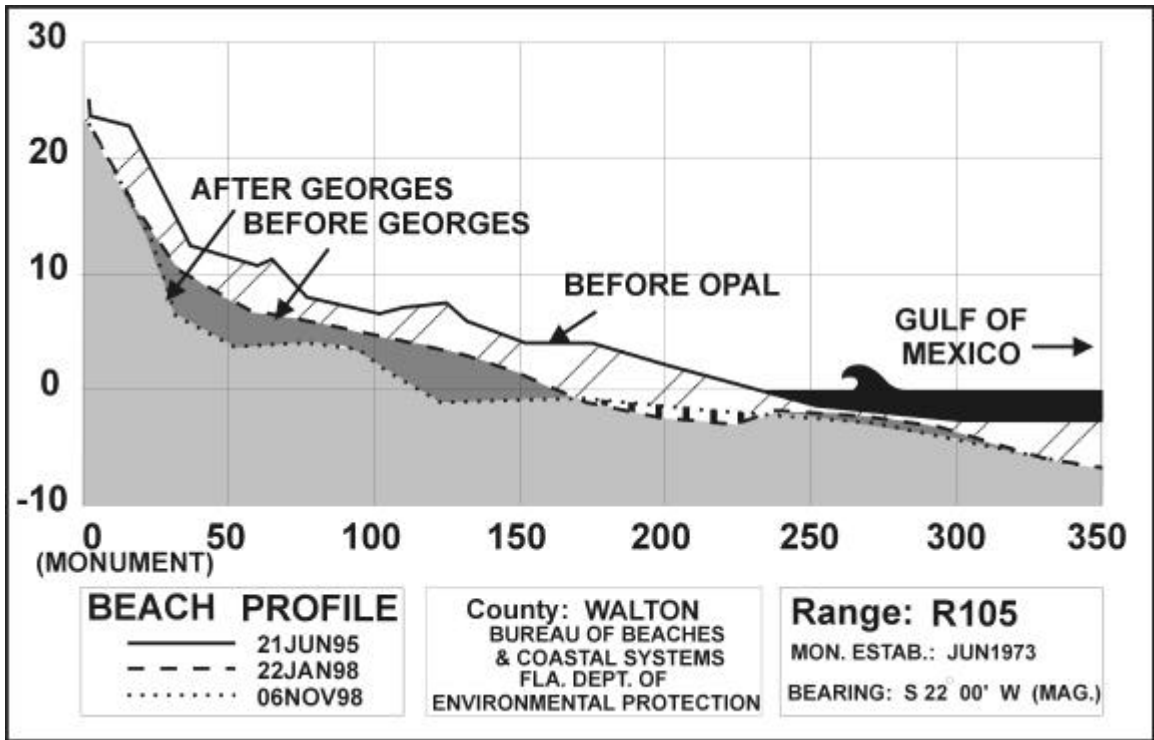


Figure 5. Erosion from Opal and Georges at R-105 in Walton County.

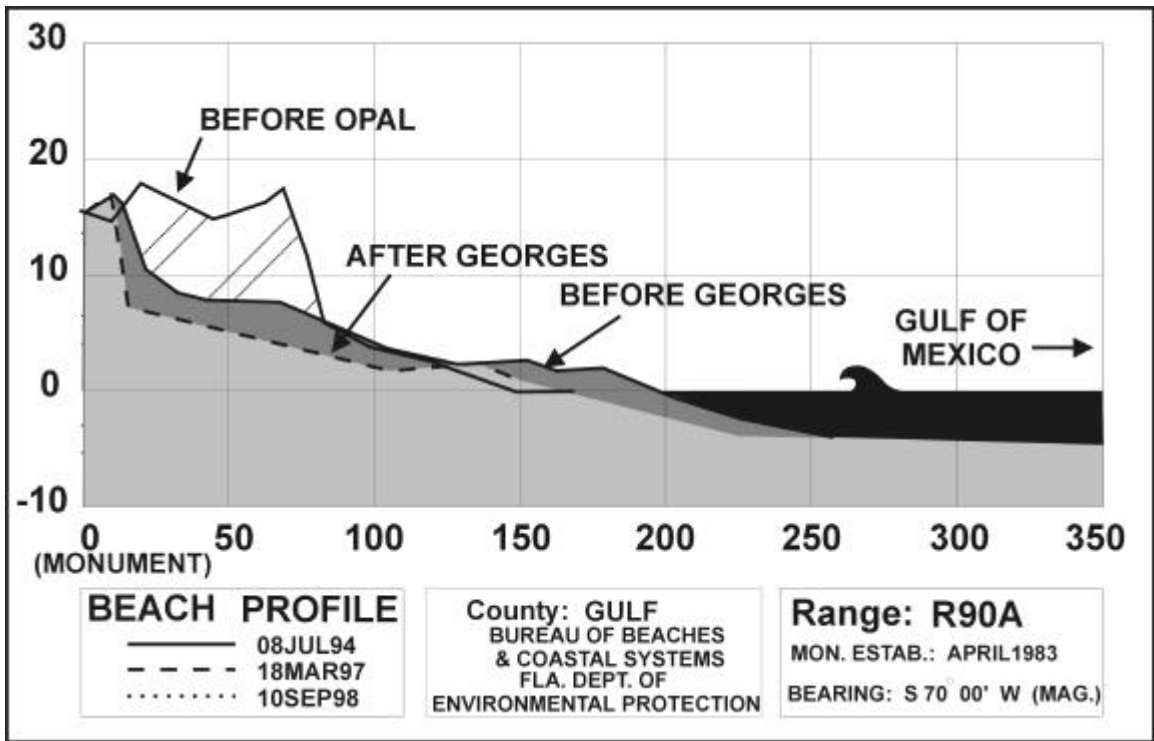


Figure 6. Erosion from Opal and Georges at R-90A in Gulf County.

The erosion computation values given in Table 1 reflect only areas where survey data was collected and is generally in developed areas where structures are threatened by erosion.

The more westerly areas, closer to the location of Georges' landfall, showed the greatest impact, as would be expected. The most severe erosion from Georges occurred in Escambia County in the Pensacola Beach area and Navarre Beach in Santa Rosa County. Other areas which experienced significant erosion included Perdido Key in Escambia County, portions of Okaloosa County including substantial widening of a breach through Norriego Point inside and adjacent to East Pass, portions of Walton County and the Panama City Beach area in Bay County.

C. STRUCTURAL DAMAGE SUMMARY

A summary of the structural damage throughout the Florida Panhandle resulting from both Hurricanes Earl and Georges is given below. A structural damage summary table which includes damage figures and totals for both storms combined is given following the summary. Damage in counties west of Bay County is attributable to Hurricane Georges, while damage in counties east of Bay County is attributable to Hurricane Earl. Damage in Bay County combines damage resulting from both storms. More detailed descriptions of the damage in each county is provided in the appendices.

HURRICANE EARL

A category one hurricane is not generally expected to cause substantial structural damage and Hurricane Earl only destroyed or substantially damaged ten buildings and 1300 feet of bulkheads and revetments. Two buildings were destroyed or substantially damaged in Gulf County at Cape San Blas where erosion conditions were extreme. The other eight buildings were destroyed or substantially damaged in Franklin County, including two on Alligator Point, one on Dog Island, four on St. George Island, and the lighthouse on Cape St. George. On the Southwest Cape at Alligator Point approximately 900 feet of road and 1300 feet of bulkheads and revetments were destroyed or substantially damaged. In addition to the damages on the coastal barriers, much of U.S. Highway 98 along St. George Sound was damaged between Carrabelle and East Point.

HURRICANE GEORGES

In contrast to the lesser structural damage of Hurricane Earl, the damage caused by Hurricane Georges was severe, particularly in the areas subject to the maximum winds and flooding (e.g., Florida Keys, Mississippi, and Alabama). In Florida, most of the damage from flooding, waves, and wind was in the middle and lower keys where a large number of residential buildings and commercial buildings were destroyed or sustained major damage when Georges crossed Key West as a category two hurricane.

In the Florida Panhandle 59 buildings were substantially damaged. Only one of these, a motel on Pensacola Beach, was damaged by the storm surge and erosion associated with the storm. The other 58 buildings were damaged by wind. The storm surge and waves destroyed 1125 feet of bulkheads in the Panhandle. Throughout the Panhandle from Panama City Beach to Perdido Key, most of the beach access walkways and stairs were damaged.

TABLE 2

SUMMARY OF STRUCTURAL DAMAGES *

<u>COUNTY</u>	BUILDINGS DESTROYED/ MAJOR DAMAGE	WALL/REVTMENT DAMAGE (FT.)
ESCAMBIA	35	0
SANTA ROSA	6	150
OKALOOSA	2	200
WALTON	0	0
BAY	16	775
GULF	2	50
FRANKLIN	8	1250
TOTAL	69	2425

* Majority of damage result of wind; damaged buildings include those landward of the coastal construction control line.

III. STORM RECOVERY AND MANAGEMENT ALTERNATIVES

Post-storm recovery alternatives recommended for each area depend on the amount of erosion that resulted from Hurricanes Earl and Georges, the relative amount of recovery that had taken place since Hurricane Opal, and the amount of development at risk in each area. Alternatives and related considerations are addressed below.

A. NATURAL RECOVERY

In the event of storm-induced beach and dune erosion in many areas, eroded sand material is deposited offshore in bar formations. During natural recovery processes, the offshore sand returns to the beach and provides sand for natural berm and dune rebuilding.

All efforts to promote natural recovery will be made. This is a preferred option for undeveloped areas. For a number of the eroded areas, however, natural recovery will not be sufficient. In overwash areas, sand has been removed from the Gulf fronting beach and dune system and will not return without intervention. In other areas, natural sand supply moving alongshore into eroded areas will not balance that which has been lost. Restoration efforts will be needed in these areas.

B. ASSISTED RECOVERY

In areas where natural recovery is not an adequate recovery option, such as areas with significant development which is vulnerable to the threat of storm damage, various human-assisted recovery alternatives may be appropriate. Alternatives include:

BEACH BERM AND DUNE RESTORATION/REVEGETATION

Beach berm restoration is the primary alternative for reestablishment of a wide sandy beach to provide a storm protection buffer for threatened upland development in areas subjected to high erosion stress where sand supply is limited and where the protective benefits of the project are high as compared to its cost. A number of indirect benefits are also derived from beach restoration projects, including recreational benefits and tourists and restoration of habitat for threatened and endangered species.

Beach restoration consists of placement of sand obtained from a source outside the active beach and dune system onto the beach to reestablish the beach berm and widen the beach. An illustration of a typical beach restoration design cross-section is shown in Figure 7.

Sand fill placed in a restoration project is usually obtained from an offshore location. The sand is typically excavated from the seafloor by hydraulic dredge, transported to the beach and discharged by pipeline. Upland sand sources may also be available. The

restored beach usually consists of a beach berm, at an elevation of about +7 to +10 feet, NGVD, extending seaward a distance of about 100 feet.

Sand fill used for restoration projects should be similar to the existing beach in terms of sand grain size, composition, texture, and color.

Dune restoration consists of filling gaps and low areas in existing dunes, adding sand to increase the width and height of dunes where structures are threatened, and restoring dunes which were entirely eroded. An illustration of a cross-sectional view of a typical dune restoration project is shown in Figure 7.

It is not essential that eroded dune areas be restored to their full pre-storm configuration. In many cases, a smaller, “starter” dune would provide sufficient restoration and allow nature to take over.

Sand material for dune restoration work should be derived from similar sources as those used for beach restoration and be compatible with the native sand material.

In most cases, dunes in areas with restored beach berms should be stabilized with vegetation. In some areas, revegetation combined with placement of sand fencing is recommended.

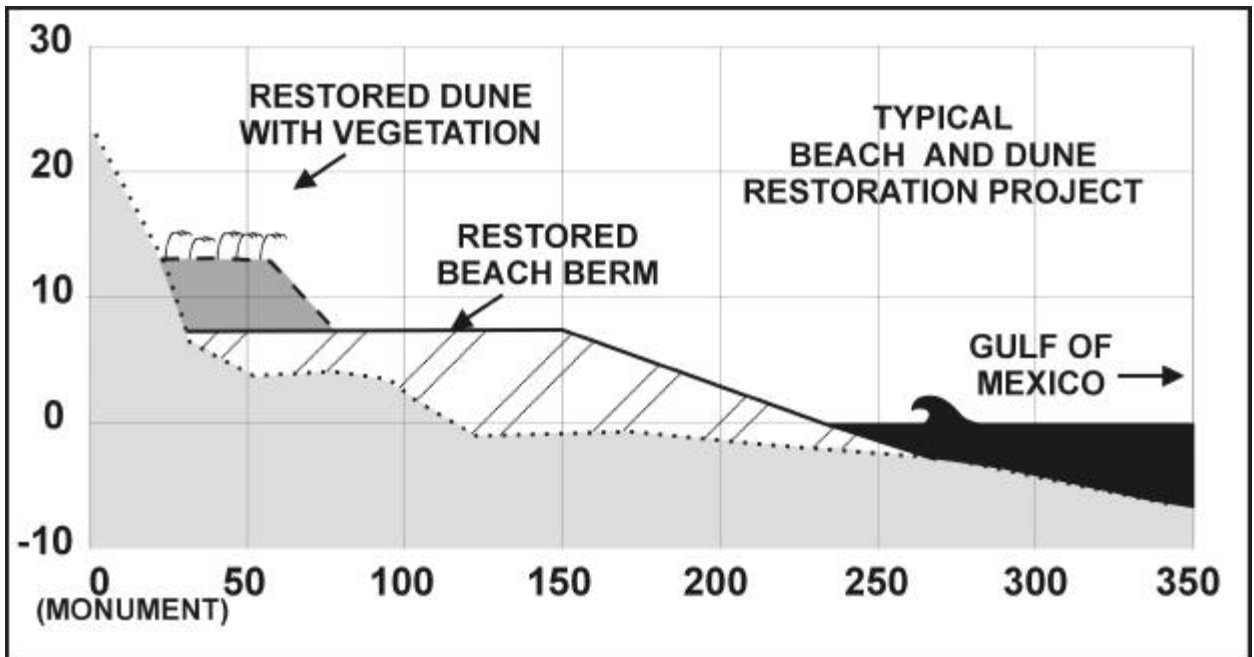


Figure 7. Typical cross-section of restored beach/dune system.

IV. SAND SEARCH STUDIES

The only existing offshore geophysical sand searches of significance have been those performed by the U.S. Army Corps of Engineers, Mobile District, and CPE, in preparation for the proposed Panama City Beaches restoration project. Approximately 9.5 million cubic yards of the best available beach quality sand, has been located in seven nearshore borrow sites. The borrow sites are located close enough for pumping onto the shore. The studies have indicated that this amount would be sufficient for the initial 8.32 million cubic yard Panama City Beaches project including one advance renourishment.

It is recommended that state funding be provided to conduct further sand search studies. Up to 2.0 million cubic yards of sand may be needed to replace sand eroded in the seven counties affected by Hurricanes Georges and Earl.

Cost Estimate: \$600,000

V. POST-STORM MONITORING AND SUPPORT

A. POST-STORM COASTAL MONITORING

There is a need to continue to monitor beach and dune recovery for purposes of assessing the recovery progress and any additional recovery needs, as well as, to improve our understanding of the recovery process. Additional funding is needed to perform surveys to assess beach and dune recovery and to assess performance of beach restoration and other recovery projects. Post-storm data needs to be incorporated into recalibration studies of the DEP storm surge and erosion models.

Cost Estimate: \$230,000

B. TECHNICAL SUPPORT AND CONTINGENCY

Hurricanes Earl and Georges have placed a major workload burden on the DEP staff, which already was experiencing an overload. The extent of damage to the beach and dune system and on-going coordination and project management with local counties and municipalities exceeds the ability of the existing staff. Therefore, OPS funds are needed to augment staff with special technical expertise. This supplemental assistance is expected to be needed for a minimum of two years at a cost of \$150,000 per year.

An additional cost contingency to cover a number of minor projects and recovery-related activities and issues is recommended to include costs such as:

- Removal of storm-related debris.
- Hazard mitigation/beach management planning assistance to local governments.
- Restoration of public dune walkovers.

Cost Estimate: \$560,000

VI. RECOMMENDED PLAN

A. DESCRIPTION OF PLAN

The recommended post-Earl/Georges recovery plan consists of a combination of natural and assisted recovery, inlet management and alternative measures. A detailed plan description for each of the Panhandle counties is presented in the Appendices. A number of specific projects are also identified with cost estimates. The plan includes activities and projects to accomplish the goal of achieving recovery of the Panhandle beaches and dunes from the erosive affects of Hurricanes Earl and Georges. Post-Opal recovery efforts were underway, but significantly undermined by the impacts of Earl and Georges.

The plan generally calls for assisted recovery throughout most of the developed areas to consist of beach berm and dune restoration, and revegetation. Post-storm monitoring and support needs are also identified. A beach erosion related roadway relocation project to construct a bridge to St. Joseph Peninsula in Gulf County is identified.

B. COST ESTIMATES

A summary of cost estimates for recovery work, unless specifically provided by local governments, are based in part on unit costs derived from estimates compiled by PBS&J based on similar post-Opal recovery activities.

Cost estimates for post-Georges recovery covers all state and local shares and have been discounted for any anticipated federal reimbursement. Cost estimates assume the sand search, post-storm monitoring and support work will be 100% state cost and does not establish a cost sharing requirement for county recovery projects. The cost of the road relocation and bridge in Gulf County is not included in the recommendation but should be referred to the appropriate funding source. A summary of all costs identified in this plan is below:

SUMMARY OF POST-EARL/GEORGES RECOVERY COST ESTIMATES

County Recovery Projects	\$13,084,500
Sand Search Studies	\$600,000
SUBTOTAL	\$13,684,500
Post Storm Monitoring and Support	\$790,000
TOTAL BEACH MANAGEMENT COST	\$14,474,500
Other Related Costs (DOT Funding) (Gulf County Road Relocation/Bridge)	\$5.8 million

APPENDICES

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ESCAMBIA COUNTY

I. STORM IMPACT

Although Hurricane Earl had no impact on Escambia County, Hurricane Georges had significant impact. On the morning of September 28, 1998, the eye of Hurricane Georges passed over Ocean Springs, Mississippi, about 85 miles west of the Florida/Alabama state line. Santa Rosa Island had not fully recovered from Hurricane Opal's devastating impact in 1995, which was significantly more severe than Georges' impact. Although Perdido Key had received minor erosion from Hurricane Danny's landfall in Alabama in 1997, it was spared the major impact of Opal in 1995.

- **Perdido Key**

Hurricane Georges was the most significant storm event to impact Perdido Key since Hurricane Frederic hit Alabama in 1979. Significant beach erosion was sustained at locations along Perdido Key. Moderate to major dune erosion occurred only in isolated areas in the eastern portion of the developed part of the Key in the vicinity of R26 through R32. Minor dune erosion occurred west of R26. Maximum measured beach recession (+2 foot contour) in the developed portions of Perdido Key reached -50 to -60 feet with maximum dune recession (+10 foot contour) up to -15 to -20 feet. Because the beach and dune system was previously very healthy and development generally did not encroach on the beach, little damage was caused to major structures by the storm surge and waves. There was extensive beach and dune walkway damage throughout the island. At the Vista del Mar Condominium a sand bag revetment was breached and erosion was beginning to undermine the building. In addition, Georges' winds inflicted major damages to 26 buildings on Perdido Key including destroying or substantially damaging four habitable major structures.

- **Santa Rosa Island**

The entire Escambia County portion of Santa Rosa Island sustained major beach and dune erosion. Along the Gulf Islands National Seashore at Fort Pickens between R79 and R107, major beach and dune erosion prevailed and the park road was covered with sand as it was during Hurricane Opal in 1995. Along Pensacola Beach, the developed segment of Santa Rosa Island, major beach and dune erosion was sustained and the sand feature known as the FEMA berm was substantially destroyed.

Erosion measured above 0.0 NGVD between DEP survey monuments R110 and R139 was on the order of -18.4 cubic yards/linear foot of beach with a total of over 500,000 cubic yards of erosion measured within the Pensacola Beach area. Average beach recession (+2 foot contour) in Pensacola Beach was measured at -74 feet with maximum measured beach recession reaching over -165 feet. Average dune recession (+10 foot contour) was measured to be -31 feet with maximum measured dune recession reaching over -200 feet. Extensive overtopping occurred with sand covering the roads and properties landward of the beach, although not as extensive as during Hurricane Opal.

The storm tides and waves caused damage to beach access walkways throughout Pensacola Beach as well as the understructures of six dwellings. The Seahorse Condominium (400 feet west of R114) was undermined and had two sections collapse on the beach and the Holiday Inn's parking area was destroyed (300 feet to 500 feet east of R118). In addition, Georges' winds inflicted major damage to eight buildings, including destroying a carport. Between Pensacola Beach and Navarre Beach to the east, the Gulf Islands National Seashore had major beach and dune erosion.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

Considerable portions of the erosion impacted areas of Escambia County are in undeveloped federal land and part of the Gulf Islands National Seashore, including eastern Perdido Key (R32-R67), Fort Pickens (R68-R107), and Santa Rosa Island (R141-R192). Western Perdido Key (R1-R12.5; R21.5-R32) and Pensacola Beach (R107-R139) are highly developed throughout with a mix of residential (single-family and multifamily) and commercial (hotels/motels and restaurants) structures. Perdido Key State Recreation Area extends between R12.5-R21.5. Much of the beachfront development in Pensacola Beach and some of the beachfront development on Perdido Key (particularly between R21.5-R32) are vulnerable to future storms.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

A. PLAN SUMMARY

The recommended plan for Escambia County is for natural recovery in most of the undeveloped areas of eastern Perdido Key, Fort Pickens, and Gulf Islands National Seashore, and assisted recovery utilizing dune restoration in the developed areas of Pensacola Beach and where needed to protect federal park facilities. Inlet sediment management is also recommended for Pensacola Bay Entrance to mitigate long term erosion of the adjacent beaches and to provide an additional source of material for dune restoration at Pensacola Beach.

B. DETAILED PLAN DESCRIPTION

1. Perdido Key (R30-R32) Assisted Recovery

The area between R1 and R32 on Perdido Key is a developed beach community with a mix of residential (single-family, multifamily) and commercial (hotels/motels and restaurants) structures. The beaches and dunes throughout the area were eroded, but the erosion was severe near R30-R32. Assisted recovery is recommended for R30-R32 and natural recovery for the remaining shoreline of Perdido Key.

Dune Restoration Project: Revegetation work is needed from R30-R32 to facilitate dune restoration in this area.

Cost Estimate:

Revegetation: \$68,000 (sea oats)

Total: \$68,000

2. Pensacola Beach (R107-R141) Assisted Recovery

This beach community is highly developed throughout with a mix of residential (single-family and multifamily) and commercial (hotels/motels, restaurants) structures. The beach and dune system was severely eroded and some of the beach and dune material was transported inland and lost as overwash material.

Fortunately, a portion of the overwash material has been recovered and returned to the beach as dune restoration material. However, this is only a relatively small amount of material. It also contains storm debris that will need to be removed. This debris removal should be conducted as soon as possible to allow natural and assisted beach and dune recovery to occur with as little disruption as possible.

The entire community is vulnerable to future storm flooding and erosion. To assist recovery of the beach and dune system and to mitigate against future storm damage to upland development, completion of beach and dune restoration work is recommended for the entire stretch of Pensacola Beach. The primary source of beach and dune restoration material for this recovery effort will likely be offshore deposits.

Additional material for continued beach and dune restoration to supplement offshore sources may be available from maintenance dredging of the navigational channel through Pensacola Bay Entrance. Funds would be needed to obtain the dredged material and transport it to Pensacola Beach for beach restoration activities, but it could be expected to be a relatively low cost and make use of any significant amounts of good quality sand which would otherwise be dumped at sea in the Gulf. No dredging work is planned in the near future.

Beach Berm and Dune Restoration Project: Fill material will be necessary if the beach berm and dunes are to be restored in this area to compensate for losses from the combined effects of Opal coupled with Georges. Dune revegetation should be used to protect the restored dune.

Cost Estimates:

Beach and dune construction: \$3,084,000

Revegetation: \$424,000 (sea oats)

Total: \$3,508,000

TOTAL COUNTY COST ESTIMATE: \$3,576,000

SANTA ROSA COUNTY

I. STORM IMPACT

- **Navarre Beach**

Navarre Beach sustained severe erosion damage in 1995 while receiving the worst of both Hurricanes Erin and Opal. Although not as severe as from Hurricane Opal, major beach and dune erosion was sustained and much of the road was covered with sand as the storm surge from Georges overtopped the low elevations on Santa Rosa Island. The storm surge and waves substantially destroyed much of the berm that had been constructed using FEMA and state recovery funds and flooded Navarre Beach from gulf to sound in numerous locations.

Average beach recession (+2 foot contour) in the Navarre Beach area between DEP monuments R192 and R214 was measured to be -64 feet with maximum beach recession reaching -156 feet at R123. Average dune recession (+10 foot contour) in this region reached -36 feet with maximum dune recession reaching over -98 feet at R209. An average beach and dune erosion volume above 0.0 (NGVD) in this area was -14.9 cy/ft. with a total erosion volume of -336,500 cubic yards.

There was extensive beach/dune overwalk damage and numerous power poles and lines were down along the road. Several buildings had understructure damage and the flooding destroyed 150 feet of wood retaining wall. In addition, Georges' winds inflicted major damage to six buildings at Navarre Beach.

- **Eglin Air Force Base**

Similar to Hurricanes Erin and Opal, although not as extensive as Opal, Hurricane Georges caused major beach and dune erosion along the 13.6-mile stretch of coast between Navarre Beach and Okaloosa County. The Air Force's dune restoration projects were substantially impacted and Santa Rosa Island was flooded from gulf to sound along several segments.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

The eastern third of Santa Rosa County is undeveloped federal land. The developed beach community of Navarre Beach occupies the western part of the county. This community is highly developed throughout with a mix of residential (single-family and multifamily) and commercial (hotels/motels and restaurants) structures. Much of the beachfront development in Navarre Beach is vulnerable to storm impacts.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

A. PLAN SUMMARY

The recommended plan for Santa Rosa County is a combination of natural recovery with assisted recovery in the developed area of Navarre Beach. Beach berm and dune restoration through placement of sand and revegetation is recommended for Navarre Beach.

B. DETAILED PLAN DESCRIPTION

Navarre Beach (R192-R210) Assisted Recovery

This beach community is highly developed throughout with a mix of residential (single-family and multifamily) and commercial (hotels/motels and restaurants) structures. There has already been some natural recovery of the beach. Natural dune recovery will be extremely slow given the extent of erosion that has taken place from storms dating back to Opal. Enhancement of the natural dune recovery processes should therefore be performed through placement of sand and revegetation with sea oats.

Beach Berm and Dune Restoration Project: Fill material will be necessary to restore the beach berm and dunes. Restored areas should be stabilized by planting sea oats in many areas, especially at the western end.

Cost Estimates:

Beach and dune construction: \$1,823,000
Revegetation: \$246,000 (sea oats)

Total: \$2,069,000

TOTAL COUNTY COST ESTIMATE: \$2,069,000

OKALOOSA COUNTY

I. STORM IMPACT

- **Okaloosa Island**

The developed, unincorporated stretch of Santa Rosa Island in Okaloosa County known as Okaloosa Island was severely impacted by Hurricane Opal in 1995. Over the last three years, the natural beach recovery as well as the assisted recovery activities by Okaloosa County were so successful that Okaloosa Island was no longer determined to be critically eroded with development vulnerable to erosion impacts. Hurricane Georges' impact only caused minor beach and dune erosion to this area, except near R8 where moderate dune erosion was sustained. The storm surge was probably 4 to 5 feet and only one beach access walkway was destroyed. In addition, two buildings had major damage due to the winds. Natural beach recovery is expected in this area.

- **Eastern Santa Rosa Island**

Between Okaloosa Island and East Pass (the Choctawhatchee Bay Entrance) is a low vulnerable stretch of U.S. Air Force property. The storm surge of Hurricane Opal completely breached the island destroying U.S. Highway 98 for about one half mile. Hurricane Georges' impact caused minor beach and dune erosion with the exception being accelerated erosion at the leeside of the concrete bulkhead and damaged parking area at the Air Force facilities. A few dune breaches and overwashes were identified along the beach.

- **Destin (West)**

The Destin beaches east of East Pass were substantially recovered from the erosion of 1995 during Hurricane Opal. However, Norriego Point has continued to erode and even breached in 1997 only to close and breach again during Hurricane Earl. During Georges the breach both widened and deepened. Erosion of the East Pass shoreline, which is designated as a critical inlet shoreline erosion area, has continued and 200 feet of bulkhead was damaged or destroyed during Georges. Minor beach and dune erosion was sustained throughout Destin and one beach access walkway was destroyed. At some isolated locations, such as R17 and R32, moderate beach berm erosion was measured with recession reaching as high as -50 to -60 feet.

- **Destin (East)**

Although there was minor structural damage, there was minor to moderate beach/dune erosion. A beach access walkway was destroyed at Henderson Beach State Park (R32-R39) along with numerous stairways at ends of walkways in Destin between R40 and R45. At James Lee Park (R47) all stairs were damaged and minor beach erosion was sustained. Berm recession (+5 foot contour) reached 100 feet at R39.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

The western half of Okaloosa County and the eastern 4.7 miles of Santa Rosa Island are generally undeveloped federal lands, which are part of Eglin Air Force Base. There are only a few scattered Air Force facilities in these areas; however, between them is the 3 mile beach community of Okaloosa Island (R1-R16). This community is highly developed throughout with a mix of multifamily residential structures and commercial (hotels/motels and restaurants) structures. East of East Pass, the City of Destin includes the developed areas between the inlet and Henderson Beach and between Henderson Beach and the Walton County line. Henderson Beach State Park is an undeveloped portion of the beach. The City of Destin, West area is highly developed with a mix of residential (single-family and multifamily) and commercial (hotels/motels and restaurants) structures. East of Henderson Beach State Park along the old U.S. 98 the City of Destin, East area is highly developed with multifamily residential structures and a few restaurants. There is also a developed public park access and recreational facilities.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

A. PLAN SUMMARY

The recommended plan for Okaloosa County is natural recovery in the undeveloped areas of Eglin Air Force Base, both west and east of Okaloosa Island, and at Henderson Beach State Park and assisted recovery in the developed areas of Okaloosa Island and Destin. Inlet sand management through sand bypassing to downdrift beaches is also recommended for East Pass (Choctawhatchee Bay Entrance) to mitigate long term erosion of eastern Santa Rosa Island.

B. DETAILED PLAN DESCRIPTION

1. Okaloosa Island (R1-R15) Assisted Recovery

This beach community is highly developed throughout with a mix of multifamily residential structures and commercial (hotel/motels and restaurants) structures. The beaches and dunes were eroded throughout the area. Long-term erosion may increase in the future if sufficient bypassing of inlet sand at East Pass to downdrift beaches is not performed.

There is no need for a beach restoration project at this time; however, the entire community will continue to be vulnerable to future storm flooding and erosion. Ultimately, inlet sand transfer to the west of East Pass can be expected to benefit Okaloosa Island.

Beach Berm and Dune Restoration Project: Beach berm and dune restoration shall be placed where the dunes were breached and overwashed. Vegetation should be placed along the restored dune areas.

Cost Estimates:

Beach and dune construction: \$293,000
Revegetation: \$65,000 (sea oats)

Total: \$358,000

2. Destin (R17-R32; R39-R50) Assisted Recovery

This beach community is highly developed with a mix of residential (single-family and multifamily) and commercial (hotels/motels and restaurants) structures. Long term erosion is not significant; however, Georges caused a large amount of erosion. The prospect for beach recovery along Destin is good because of the stabilizing influence of the East Pass east jetty. Dune recovery is expected to be slow; however, activities, such as sand fencing, are assisting the dune recovery process. Following completion of dune restoration activities, this area will remain vulnerable to future flooding from major storms.

Beach Berm and Dune Restoration Project: Beach berm and dune restoration is proposed to restore two identified eroded segments of shoreline. Vegetation should be placed along the restored dune areas.

Cost Estimates:

Beach and dune construction: \$1,785,000
Revegetation: \$259,000 (sea oats)

Total: \$2,044,000

TOTAL COUNTY COST ESTIMATE: \$2,402,000

WALTON COUNTY

I. STORM IMPACT

The impact of both Hurricanes Earl and Georges affected Walton County. Previously, Hurricane Opal inflicted severe erosion throughout the county. Generally, the areas showing the greatest erosion impact after Georges were those developed areas where the beach had been scraped after Opal.

- **Western Walton County**

Most of western Walton County had significant beach and dune erosion. However, major dune erosion was sustained along the dune fill project for 1300 feet west of the Pompano Joe's Restaurant and adjacent to the east wing of "The Loft" (R6 to 200 feet east of R6). Moderate beach and dune erosion was also sustained between R8-R11, from R14 to 400 feet east of R14 adjacent the Main Sail Condominiums, and between R17 and R18 at Gulf Pines. Numerous stairs and walkways throughout this area were destroyed.

- **Sandestin and Four Mile Village**

The beach throughout this area generally experienced minor beach and dune erosion, with the exception of some moderate dune erosion at R22-R23.5. Very minor erosion was apparent throughout the natural areas between R24-R41. Within the developed areas numerous walkways and stairs were damaged. All the outlets were flowing from the coastal lakes across the beach after Hurricane Georges due to the high rainfall.

- **Beach Highlands, Santa Rosa Beach, Dune Allen, Blue Gulf Beach**

Most of these areas had minor beach and dune erosion. However, moderate beach and dune erosion was sustained along Fort Panic Road (R43-R45). The Oyster Lake and Draper Lake outlets were flowing across the beach after Hurricane Georges. There were damages to numerous stairs and walkways throughout the area.

- **Blue Mountain Beach and Gulf Trace Beach**

This area sustained minor beach and dune erosion. There were damages to stairs and walkways throughout the area. Big Redfish Lake outlet and Little Redfish Lake outlet were open and merged at R65 and Alligator Lake outlet was also open.

- **Grayton Beach**

The severe storm surge flooding of the community of Grayton Beach during Opal in 1995 was not repeated during Georges. Generally minor beach and dune erosion was sustained throughout this area except at R71 which sustained moderate beach and dune erosion. Beach

stairs were damaged at R71 and at Grayton Beach State Park. The Western Lake outlet was flowing and peat was exposed all along the State Park beach.

- **Seaside and Seagrove Beach**

The natural areas (R79-R89, R92-R93, R94-R104) sustained very minor erosion. However, moderate erosion was sustained from Hinton Bishop Drive through One Seagrove Place (250 feet west of R90-R91), Eastern Lake Road fill area, and at Camp Creek Lake (R104-R105). Stairs were damaged throughout. Outlets were flowing from Eastern Lake, Deer Lake, and Camp Creek Lake, and peat was exposed all along these areas.

- **Eastern Walton County**

Minor to major beach and dune erosion took place in eastern Walton County during Hurricane Georges. Among the worst eroded dune areas were 500 feet west of R109 adjacent to a peat headland, R110 to 100 feet east of R110 in Seacrest Beach, R113 to 600 feet east of R113 at the Sand Cliffs Condominium, and within Inlet Beach (R122 to 300 feet east of R122, 400 feet to 450 feet east of R126). There were damages to stairs and walkways, and peat deposits were exposed throughout the area.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

Walton County has several developed segments and a few undeveloped stretches of natural beaches and dunes. The western 4.5 miles is highly developed with residential multifamily and single-family dwellings and commercial (hotels/motels and restaurants) structures. There is a checkerboard of high-density development (e.g., Edgewater, Main Sail, Grand Villas, Sandestin) and single-family/multi-family (Tang O Mar, Caribe, Gulf Pines, Four Mile Village), plus one travel trailer park. To the east are three miles of undeveloped land owned by the state called Topsail Hill. East of Topsail Hill along County Road 30A are the predominantly single-family residential communities of Sunrise Beach, Beach Highlands, Santa Rosa Island, and Dune Allen Beach. East of Dune Allen is the undeveloped Blue Gulf Beach and to the east is Blue Mountain Beach, which is developed with predominately single-family dwellings along with several multifamily developments and one restaurant. East of Blue Mountain Beach are the beach communities of Gulf Trace, Grayton Beach and Seaside, which mix mostly single-family developments with undeveloped segments. The eastern 8.5 miles includes the beach communities of Seagrove Beach, Seacrest Beach, and Inlet Beach, along with segments of undeveloped parcels. After Hurricane Georges, isolated areas of the County are very vulnerable to future storms including a few areas of western Walton County (R6, R8-R11, R14, R17-R18), Dune Allen (R43-R45), and eastern Walton County (R107-R115; R122-R127).

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

A. PLAN SUMMARY

The recommended plan for Walton County is natural recovery in the undeveloped areas of Topsail Hill, Blue Gulf Beach, Blue Mountain Beach, Gulf Trace, Grayton Beach,

Grayton Beach State Park, Seaside, Seagrove Beach, Deer Lake to Camp Creek Lake, Seacrest Beach and Dana Beach, and assisted recovery in the developed areas of western Walton County, Beach Highlands, Dune Allen Beach, Blue Mountain Beach and Inlet Beach.

B. DETAILED PLAN DESCRIPTION

1. Western Walton County (R1-R19) Assisted Recovery

This area is highly developed with residential multifamily and single-family dwellings and commercial (hotels/motels and restaurants) structures. There is a checkerboard of high-density development (e.g., Edgewater, Main Sail, Grand Villas, Sandestin) and single-family neighborhoods (Tang O Mar, Caribe, Gulf Pines, Four-Mile Village), plus one travel trailer park. Most of the beach and dune material was transported offshore.

Beach Berm and Dune Restoration Project: Beach berm and dune restoration is recommended for portions of western Walton County between R1 and R19.

Cost Estimates:

Beach berm and dune restoration: \$1,313,000
Revegetation: \$278,100 (sea oats)

Total: \$1,591,100

2. Fort Panic Area (R41-R48) Assisted Recovery

This area is highly developed with predominantly single-family dwellings along with a few multifamily dwellings. A substantial portion of the eroded beach and dune material was transported offshore. Natural dune recovery will be slow.

Beach Berm and Dune Restoration Project: Beach berm and dune restoration is recommended for this area.

Cost Estimates:

Beach berm and dune restoration: \$844,000
Revegetation: \$171,100 (sea oats)

Total: \$1,015,100

3. Dana Beach/Inlet Beach (R109-R127) Natural and Assisted Recovery

The area of Dana Beach is generally undeveloped with new infrastructure currently being provided as lots are subdivided. Inlet Beach is moderately developed with single-family dwellings between R122 and R124, undeveloped between R124 and R125, and

moderately developed between R125 and R127 with a mix of single-family and multifamily dwellings.

Beach Berm and Dune Restoration Project: Long term erosion is not significant. Most of the eroded beach and dune material was transported offshore. Dune recovery will be slow and complete recovery not likely given the high elevations and large volume lost.

Relocation may be a viable option for a couple of structures in this area.

Beach berm and dune restoration is recommended for selected areas of Dana Beach and Inlet Beach (R109 to county line).

Cost Estimates:

Beach berm and dune restoration: \$856,000

Revegetation: \$128,300 (sea oats)

Total: \$984,300

TOTAL COUNTY COST ESTIMATE: \$3,590,500

BAY COUNTY

I. STORM IMPACT

The impacts of Hurricanes Earl and Georges were only the latest of many storms which have depleted the beaches of Bay County since 1970, including a direct hit by Eloise, a category three hurricane in 1975, and the severe impact of Opal, which damaged nearly 350 buildings and destroyed some 11,730 feet of bulkheads and retaining walls in 1995. There was at least some traversible beach along nearly all of western Bay County after Opal. However, winter storms and a near brush with Hurricane Earl caused more erosion. Following Hurricane Georges, the beach conditions remain severely eroded and in a number of places no beach remains. Cumulatively, another 775 feet of walls were destroyed by Georges as well as numerous stairs, walkways and decks.

Coastal Planning and Engineering, Inc., under contract to provide engineering services for construction of the Panama City Beaches beach restoration project, evaluated beach profile surveys to assess Earl's erosional impact. Survey profiles obtained prior to Earl, as a part of the restoration project design work were compared to profiles obtained immediately following Earl along a 7500 foot segment of beach between survey monuments R85 and R93 which had been filled prior to Earl's impact. Computed erosion losses were determined to be an average of 13.2 cubic yards per linear foot (cy/ft.) of shoreline. When adjusted for overfill and lateral sand losses to areas outside the fill area, the erosion losses from the design fill volume was determined to be an average of about 5 cy/ft.

CPE performed additional post-storm analysis of profiles surveyed following Hurricane Georges along a 6600 foot segment of filled beach between R68.5 and R75 and determined a combined average erosion loss from both Hurricanes Earl and Georges of 9.1 cy/ft. This average erosion volume was based on survey data collected within restored segments of Panama City Beach. Observations by CPE were that erosion losses in the unrestored portions of the Panama City Beaches project area were substantial. However, survey data to quantify losses in these areas is not yet available.

- **Western Bay County**

Moderate to major erosion conditions prevailed throughout western Bay County between Phillips Inlet and St. Andrews Inlet. At Pinnacle Port between R1-R3 all buildings were undermined, one unit was damaged, and all walkways were damaged. A 30-foot wood return wall was damaged at R7, large decks were destroyed near R9, and four dwellings are in imminent danger at R12. Walls were destroyed at Nauticus Beach Motel (125 feet of wall located 450 feet to 300 feet west of R10), Dupree Street access (20 feet of wall located 100 feet east of R12), Pineapple Beach Villas (100 feet of wall located 125 feet to 25 feet west of R21), Seakove Motel (two 150-foot walls located 250 feet to 100 feet west of R27 and R27 to 150 feet east of R27), and the Fountainbleau (200 feet of wall located 400 feet to 200 feet west of R49). Drainage pipes were damaged at the 14th Street public beach access (R20), the Bonita Beach Condominiums (200 feet east of R26), the Landmark Condominium (350 feet

east of R31), a pipe at 700 feet east of R47 and at Crane Street beach access at R51. The greatest structural damages were caused by a tornado which crossed over the beach approximately 300 feet east of R51 jumping over the Fiesta Motel and totally destroying four-single family dwellings and substantially damaging eleven dwellings and a commercial building.

- **Eastern Bay County**

Additional erosion and overtopping caused by the storm surge was apparent along Shell Island after Georges. St. Andrew's Bay east entrance was substantially closed after Earl but was reopened by Georges. Two new inlets broke through the barrier on western Crooked Island as well as a third breach, which will probably be reclosed soon. On eastern Crooked Island (V036 – V041) severe erosion continues, however, Earl may have caused as much or more erosion than Georges. Mexico Beach had significant beach and dune erosion during Hurricane Earl in many areas, with some additional erosion occurring during Georges.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

The Panama City Beaches are intensely developed with a mix of single-family and multi-family residential structures and many hotels/motels, restaurants, lounges and recreation facilities including three fishing piers. St. Andrews State Recreation Area is undeveloped except for park facilities. East of St. Andrews Inlet there are over 22 miles of undeveloped beaches including Shell Island and Crooked Island. The eastern nearly 3 miles of Bay County beaches is the community of Mexico Beach, which is highly developed with predominantly single-family dwellings with some multifamily dwellings, several motels, a restaurant and fishing pier. The beach restoration project underway in Panama City Beach will resolve the current vulnerability of western Bay County beach development. Until completed, all unrestored areas will remain highly vulnerable. An emergency sand berm was constructed along portions of Mexico Beach following Hurricane Georges. Application has been made to FEMA to cover the cost of this work.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

A. PLAN SUMMARY

The beach restoration project that is currently underway in Panama City Beach will address poststorm recovery problems for western Bay County. An additional 660,000 cubic yards is being added to the project to offset erosion resulting from Hurricane Georges. Natural recovery is recommended for eastern Bay County east of St. Andrews Inlet. The east entrance to St. Andrews Bay is opening and closing with unknown effects on the tidal prism affecting St. Andrews Inlet and any associated impacts on the beaches of western Bay County. Monitoring is recommended. Assisted recovery is recommended for Mexico Beach to help the area recover from the cumulative effects of storms since Hurricane Opal. Additional sand should be added to the work completed

following Hurricane Georges. Sea oats should then be planted to stabilize the resulting dune.

B. DETAILED PLAN DESCRIPTION

1. Panama City Beach (R1-R92) Beach Restoration Project

A beach restoration project is currently underway in Panama City Beach, which was partially funded through post-Opal funding. An additional 660,000 cubic yards has been authorized for placement in the project to offset erosion resulting from Hurricane Georges. No additional funding for Post-Georges recovery work is being requested in this report.

2. Mexico Beach (R129-R138) Assisted Recovery

Mexico Beach is developed with predominantly single-family dwellings with some multifamily, several motels, a restaurant and fishing pier. Severe beach and dune erosion and structural damage occurred during Opal. This area has experienced long-term erosion associated with the impact of the Mexico Beach Canal Entrance. Sand bypassing operations at the canal entrance; however, have helped to maintain the shoreline position over the last twenty years.

Some beach berm and dune restoration is needed at this time to supplement continued sand transfer around the Mexico Beach Canal Entrance. Restoration work will include revegetation of filled areas with sea oats.

Beach Berm and Dune Restoration Project: Beach berm and dune restoration is recommended for a portion of the Mexico Beach area.

Cost Estimates:

Beach and dune construction: \$521,000
Revegetation: \$106,000 (sea oats)

Total: \$627,000

TOTAL COUNTY COST ESTIMATE: \$627,000

GULF COUNTY

I. STORM IMPACT

During the evening of September 2, 1998, the eye of Hurricane Earl made landfall on Shell Island in Bay County. The greatest erosion and damage caused by Earl was sustained in Gulf, Franklin, and Wakulla Counties. Coastal storms and major beach and dune erosion have been relatively common in Gulf County during the past 30 years. Prior to Earl, the most severe impacts have been inflicted by Hurricane Agnes (1972), Eloise (1975), Elena (1985), Kate (1985), and Opal (1995), and Tropical Storms Alberto (1994) and Beryl (1994). During Kate, 31 major structures were destroyed or sustained major structural damage while Opal destroyed or caused major damage to 26 major structures.

The impact of Earl in Gulf County varied from minor to major beach and dune erosion. In addition, one major structure was destroyed and another substantially damaged. Along the mainland coast of Gulf County (R1-R30), only minor beach erosion and no major damage was sustained. Along the northern 7.5 miles of St. Joseph Peninsula (R31-R68), minor beach erosion also occurred within the T.H. Stone-St. Joseph Peninsula State Park. The 2.1 miles to the south (R68-R81) sustained beach and dune erosion ranging from minor to major. Major beach and dune erosion occurred in the areas around R71 and R72. Further to the south (R81-R114), moderate erosion was interspersed with areas of major erosion southward to Cape San Blas. Major beach erosion was measured from R85 south through R106. Observations indicated major beach erosion southward through R114. Major dune erosion was measured at R85 and R86, R95 and R98, and around R101.

Post-storm beach and dune profiles surveyed along the Peninsula from R70 south through R106 were analyzed to document the erosion. Pre-Earl survey profiles from March 1997 were compared with post-Earl profiles from September 1998 to compute average and maximum beach and dune recession and volumetric change. A total of 27 profiles between R70 and R106 were used to compute beach and dune recession and volumetric losses. The average beach recession, based on the recession of the +2 foot contour, was measured to be -49 feet with a maximum beach recession of -97 feet at R85. The average dune recession, based on recession of the +10 foot contour, was measured at -10 feet with the maximum dune recession measured at -24 feet at R71. An average beach and dune erosion volume of -8 cubic yds/ft. was computed using the 27 surveyed profiles.

On the Cape adjacent to the Cape San Blas Lighthouse, the historic lighthouse keeper's house was destroyed and another building that housed Air Force personnel was substantially damaged. In the 5 years since 1993 the shoreline has receded approximately 200 feet at the lighthouse for a recession rate of -40 feet per year.

East of Cape San Blas, in the lee of the storm wave conditions of Hurricane Earl, accretion tapered into minor beach erosion. Comparisons of pre-storm and post-storm profiles collected

between R119 and R153 east of Cape San Blas consistently demonstrate beach berm erosion but very little dune erosion. Natural recovery of the berm following Earl is expected. Clam Bayou reopened as it does periodically during storm tides. Along a limited segment of Indian Peninsula at R159 moderate dune erosion was sustained.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

The mainland portion of Gulf County (R1-R31) is developed with single-family dwellings. The northern stretch of St. Joseph Peninsula between R32 and R75 is undeveloped within the St. Joseph Peninsula State Park. The remainder is characterized as follows: single-family dwellings between R75 and R77, an undeveloped area between R77 and R78, multifamily dwellings between R78 and R79, an undeveloped area between R79 and R81, single-family dwellings between R81 and R86, a state park specifically designed for the disabled between R86 and R87, an undeveloped area between R87 and R90, a couple of single-family dwellings and several multifamily dwellings between R90 and R91, an undeveloped area between R91 and R94, a lightly developed area with single and multifamily dwellings between R98 and R104, and a generally undeveloped area between R104 and R114 (except for the Air Force facilities at R110).

The area east of Cape San Blas, including Indian Peninsula, is moderately developed with single-family dwellings. Development along St. Joseph Peninsula is vulnerable to storm impact, while most of the development east of Cape San Blas is not threatened. The most vulnerable areas, where development may be threatened by future storms, are the identified critical erosion areas between R83 to R85 and R95.5 to R111.5. In the critical erosion area between R83 and R85 a number of single-family dwellings are threatened with a few dwellings in imminent danger of being undermined by major storm conditions. Severe erosion has continued along the critical erosion area between R95.5 and R111.5. The beach is completely gone gulfward of County Road C30E and the revetment at R106.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

Natural recovery of the beach is expected with the exception of the area between R100 and R114 where long-term erosion is expected to continue.

Beach berm and dune recovery will be a very slow process in this area. Assisted recovery is therefore recommended for selected areas where development will be at the most risk from future storms. These areas are selected locations in Port St. Joe and Cape San Blas. In these areas, additional sand will be brought in to help restore gaps in the remaining dune system. Sea oats will also be planted to help stabilize these areas.

1. Port St. Joe Beach (R1-R5) Natural and Assisted Recovery

This area suffered beach erosion from Hurricanes Earl and Georges. FEMA is expected to fund construction of an emergency protective berm for selected developed areas. Additional sand is needed for these areas to help them recover from the cumulative losses experienced

from storms dating back to Hurricane Opal. Vegetation is also needed to help stabilize the dune and assist with natural recovery processes.

Beach Berm and Dune Restoration Project: Additional sand and revegetation of selected areas are recommended.

Cost Estimates:

Beach berm and dune construction: \$495,000
Revegetation: \$120,000 (sea oats)

Total: \$615,000

2. St. Joseph Peninsula (R32-R114) Natural and Assisted Recovery

Except for the northern 2.2 miles which is accreting, the peninsula is eroding, with the most extreme erosion rates along the Florida gulf coast occurring in the vicinity of Stump Hole with rates as high as 15 feet per year. The Cape San Blas lighthouse has been relocated six times. Hurricane Opal inflicted severe damage to the beach and dune system along the peninsula and natural recovery is not expected, particularly south of R90.

Revegetation of selected areas is recommended for the selected developed areas of the peninsula.

Dune Restoration/Revegetation Project: Restoration work should consist of revegetating selected areas with sea oats.

Cost Estimates:

Revegetation: \$85,000 (sea oats)

Total: \$85,000

3. Stump Hole (R105-R106) Natural Recovery and Bridge Construction

Hurricane Opal overwashed St. Joseph Peninsula at Stump Hole and eroded virtually all of the sandy sediments from the beach leaving large exposed peat deposits. Hurricane Georges further eroded this area. Natural recovery is not expected, due to the limited sand supply. Revegetation and sand fencing would not be effective due to the lack of a viable beach or dune system. A study recently completed for this area has recommended that the most practical way to address the continuing problems at Stump Hole is to relocate the road and construct a bridge over the area. The cost of this bridge is estimated to be \$5.8 million which is not included as part of the county recovery costs.

TOTAL COUNTY COST ESTIMATE: \$700,000

FRANKLIN COUNTY

I. STORM IMPACT

When Hurricane Earl made landfall on September 2, 1998, Franklin County was substantially impacted by storm tides and waves. Along with beach and dune erosion, dwellings in Franklin County have sustained substantial structural damage from a number of storms over the past 30 years. Hurricane Agnes (1972) destroyed many structures at Alligator Point, Hurricane Elena (1985) destroyed or substantially damaged 22 major structures, Hurricane Kate (1985) destroyed or substantially damaged 159 major structures, and Hurricane Opal (1995) destroyed or damaged 8 major structures.

Most of Franklin County sustained beach and dune erosion from Earl, with many areas sustaining moderate to major erosion. Along with storm tide and wave damage, wind damage to structures was also sustained. In all, Earl destroyed or caused major structural damage to seven major structures.

Western Franklin County is generally undeveloped; however, major beach and dune erosion was observed along St. Vincent Island, Little St. George Island, and western St. George Island, west of Bob Sikes Cut. At the designated critical erosion area on Cape St. George, the 146-year old lighthouse was knocked off its pile foundation and now leans approximately 7 degrees as it rests on sand within the intertidal beach. The lighthouse was originally constructed in 1852, over 1200 feet inland from the beach.

Most of St. George Island east of Bob Sikes Cut sustained only moderate to minor beach and dune erosion. Between R75 and R76, one single-family dwelling was destroyed and three others damaged by high wind gusts. Along eastern St. George Island where the state park road was destroyed by Hurricanes Kate (1985) and Opal (1995), no further road damage was sustained but several beach access walkways were destroyed or damaged.

East of St. George Island, major beach and dune erosion was sustained along Dog Island. Near the island's critical east end a single-family dwelling was destroyed.

At the east end of Franklin County the coastal barrier complex between the tip of Alligator Point and the entrance to Ochlockonee Bay has over two miles of critical erosion and another two miles of noncritical erosion. The historic west end of Alligator Point (R194-196) sustained continued severe erosion during Earl. Although only sustaining minor beach and dune erosion between R196-R210 at the Southeast Cape, Alligator Point was substantially flooded between R196-R200. Adjacent to the Alligator Point Marina, a single-family dwelling was destroyed by wave action and flooding between R197-R198. Fences and decks were also damaged as well as another dwelling's understructure enclosure near R198.

The southwest Cape is one of the worst eroded areas in North Florida. Along Chip Morison Drive, over 900 feet of wall and revetment was damaged or destroyed west of the KOA

Campground. Post-storm survey profiles show -8 to -10 feet of dune recession at monument R211.

Back-fill behind a wooden retaining wall, which was destroyed, washed out in this area. To the east extending through R212, a rock revetment prevented extensive erosion and protected a segment of county road C370. Severe erosion was experienced in the dune and upland areas between R213-R215 and approximately 900 feet of County Road C-370 was destroyed. Also within this area, approximately 350 feet of wood retaining walls were damaged and a dwelling was destroyed 435 feet east of R214. The area eastward from R215-R220 sustained minor beach erosion. Further east at Lighthouse Point, moderate dune erosion (up to -10 to -15 feet) was sustained in the general area from R220-R221, although some corresponding beach accretion occurred. Northward towards Bald Point, the stretch of shoreline was substantially in the lee of storm wave conditions.

II. LEVEL OF DEVELOPMENT AND VULNERABILITY

Much of Franklin County's beaches are either undeveloped or sparsely developed. Remaining portions are either highly or moderately developed. The undeveloped areas include St. Vincent Beach, a national wildlife refuge, Little St. George Island and western St. George Island (between West Pass and Sikes Cut), a state preserve, the eastern 8.4 miles of St. George Island, a state park which does have some facilities, and about half of Dog Island. St. George Island between Sikes Cut and the State Park is moderately developed with predominantly single-family dwellings, which are set well back from the beach, one motel and a few multifamily residential structures. The remaining half of Dog Island is sparsely developed with single-family dwellings and one small motel. Alligator Point is highly developed west of Lighthouse Point and moderately developed north to Bald Point.

On St. George Island, only the portions of the state park and public recreation facilities between R110-R142 are vulnerable to future storm damage. All of the beachfront development on Dog Island and along the Southwest Cape and Lighthouse Point segments of Alligator Point is vulnerable. The most vulnerable areas are between R179-R186 on Dog Island, R210-R216 at the Southwest Cape, and R220-R225 at Lighthouse Point.

III. BEACH AND DUNE RECOVERY RECOMMENDATIONS

Natural recovery is recommended for western Franklin County including St. Vincent Island, Little St. George Island, St. George Island, and Dog Island. Monitoring is recommended for Dog Island. A study is recommended for Alligator Point, including a wave refraction analysis to determine the cause of chronic erosion problems and to develop management recommendations and alternatives on how the problems of this area should best be addressed.

Cost Estimate:

Alligator Point Erosion Study: \$120,000

TOTAL COUNTY COST ESTIMATE: \$120,000