HURRICANE OPAL

BEACH AND DUNE EROSION AND STRUCTURAL DAMAGE ALONG THE PANHANDLE COAST OF FLORIDA

by

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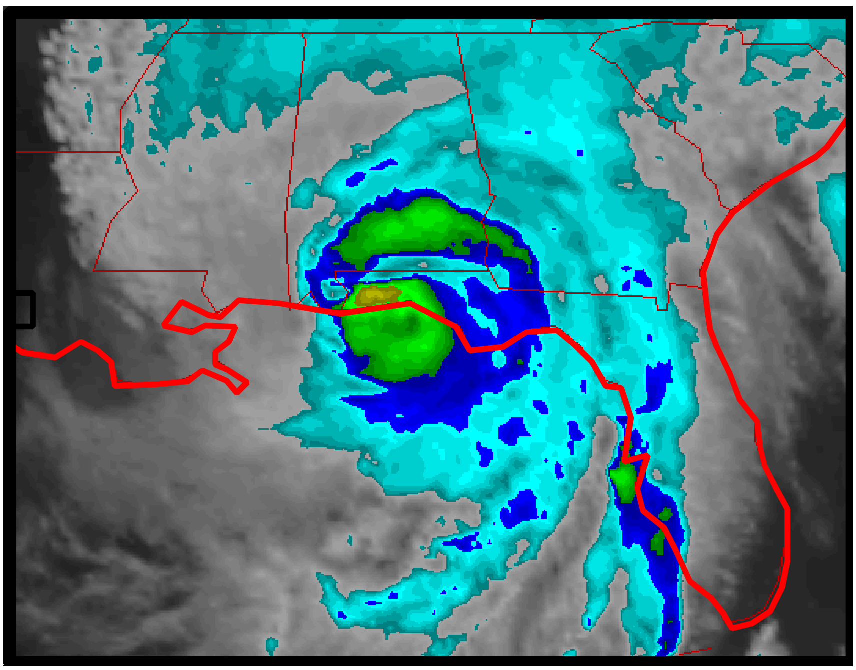

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BUREAU OF BEACHES AND COASTAL SYSTEMS
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Foreword

This report is a follow-up to an executive summary prepared in December 1995 entitled "Hurricane Opal: Executive Summary of a Report on Structural Damage and Beach and Dune Erosion Along the Panhandle Coast of Florida" (FL Bureau of Beaches and Coastal Systems, 1995). The executive summary presents a brief overview of the beach and dune erosion and structural damage resulting from Hurricane Opal, as well as, a brief discussion of post-storm response activities and issues including identification of critical erosion areas following Opal.

This report provides a more detailed, updated information regarding the impact of Hurricane Opal to the Florida coast. It includes a brief overview of Hurricane Opal, including a description of storm characteristics and parameters associated with Opal, an in-depth description and presentation of beach and dune erosional impacts, an updated, more detailed account of structural impacts, and more detailed comments related to post-storm response and recovery.

This post-storm report was prepared by Mark E. Leadon, P.E., Section Administrator of the Research, Analysis, and Policy (RAP) Section of the Florida Department of Environmental Protection (FDEP), Bureau of Beaches and Coastal Systems. Major contributions to this report were provided by Nhan T. Nguyen, Engineer I, of the RAP Section, and Ralph R. Clark, P.E. II, of the RAP Section. Analysis of information regarding storm characteristics and all beach and offshore data analyses presented in this report were performed by Mark Leadon and Nhan Nguyen. Structural damage accounting and assessments and identification of critical erosion areas were performed by Ralph Clark. Compilation of post-storm response and recovery information was performed by Mark Leadon.

Other staff of the Bureau of Beaches and Coastal Systems contributed to this report. Thomas M. Watters, P.L.S., provided extensive beach and offshore survey data, as well as high water mark data. Christine Foster provided extensive assistance in development of graphics and figures contained in this report. Photograph contributions were provide by Phil Flood, Emmett Foster, Paden Woodruff, Catherine Florko, and Lynda Charles.

This post-storm report was reviewed by an internal review group within the Bureau of Beaches and Coastal Systems and approved for circulation by the Chief of the Bureau of Beaches and Coastal Systems.

APPROVED BY

Alfred B. Devereaux, Jr., Chief
Bureau of Beaches and Coastal Systems

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I. Introduction

Hurricane Opal, which struck the Panhandle Coast of Florida on October 4, 1995, was one of the most severe hurricanes to impact Florida this century. Hurricane Opal caused more structural damage along the Florida coast than all hurricanes and tropical storms combined since 1975. Severe damage occurred across the entire Panhandle region from Escambia County through Franklin County, with coastal flooding extending, to a lesser degree, along the central Florida Gulf coast region southward all the way through Key West (Leadon, 1996). Opal=s damage resulting from coastal flooding and erosion exceeded that of Hurricane Andrew, Hurricane Eloise, and other severe storms of recent years.

The economic welfare of the Panhandle region is highly dependent on its beaches and dunes which provide storm protection to upland development and recreational resources for tourism. The value of construction setbacks and beach restoration as storm protection in eroded areas is clearly evident in relation to Hurricane Opal.

In terms of construction setbacks, structures with adequate setback from the shoreline sustained substantially less damage. The U.S. Army Corps of Engineers has estimated that a beach restoration project planned for Bay County prior to Hurricane Opal could have prevented 70% of the damages resulting from Opal in Bay County had it been completed prior to the storm occurrence. Damages from Opal along the central Gulf coast of Florida were significantly reduced as a result of beach restoration projects providing protection to upland development. Areas such as in Pinellas, Manatee, and Sarasota counties would probably have suffered damages from Opal comparable to the extensive damage from Hurricane Elena in 1985 were it not for the restoration projects constructed in the late 1980's and early ›90's in those areas.

The positive impact of the State of Florida=s coastal construction control line program was demonstrated as related to structural damage sustained from Hurricane Opal. The State of Florida coastal construction regulatory program requires habitable structures built seaward of the control lines to be constructed to design standards to survive the storm surge flooding, wave and erosion impacts associated with a major 100-year hurricane event. Opal provided a good case study of survivability of properly-designed versus poorly-designed structures during a major storm event.

The State of Florida responded to the shoreline emergency in a number of ways in the form of post-storm response and recovery assistancet. The Department of Environmental Protection=s (FDEP) Bureau of Beaches and Coastal Systems staff provided emergency assistance to property owners repairing or rebuilding damaged or destroyed structures, as well as, collecting and analyzing survey data and providing a post-storm damage report and strategic recovery plan. In response to the Department=s report and strategic recovery plan, the Florida Legislature provided $31.8 million to assist in the cleanup and recovery of the beaches and dunes across the Panhandle. These funds have contributed to man-assisted recovery activities proceeding in a responsive, effective manner to include extensive debris cleanup, dune restoration and revegetation, and beach restoration of the critically-eroded Panama City Beach. Natural beach and dune recovery has been relatively slow over the first year of post-storm monitoring presented in this report.

II. Storm Characteristics

An illustration of storm tracks of tropical storms and hurricanes for 1995 is given in Figure 1 below. Hurricane Opal was the 15th named storm during 1995, the most active storm season since 1933, with a total of 21 tropical storms or hurricanes. Opal reached Category 4 status (based on the Saffir-Simpson scale) as it approached landfall on October 4th 1995 with maximum sustained surface winds reaching 150 mph (Powell and Houston, 1995).

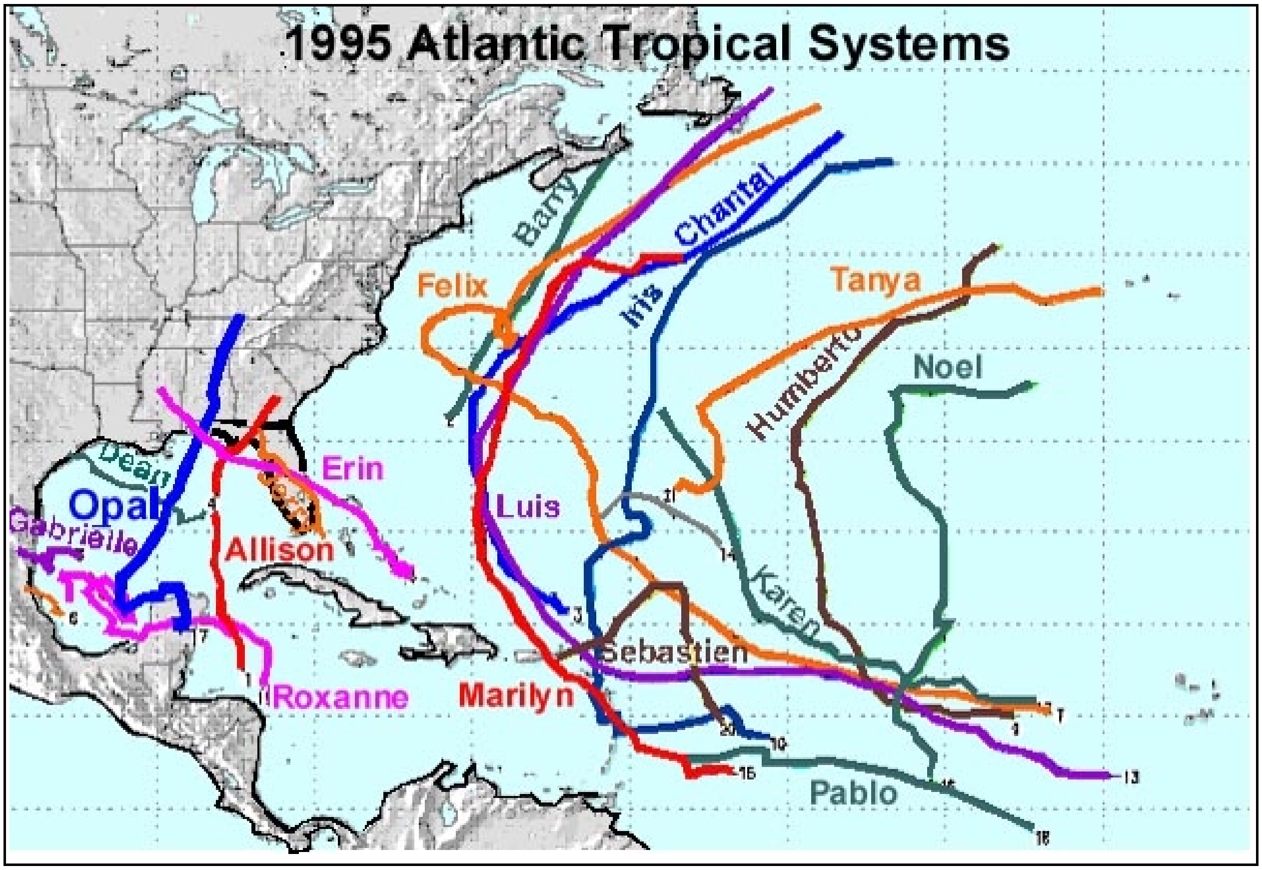

Figure 1. Storm tracks of tropical storms and hurricanes for 1995 season.

The graph given in Figure 2 on the next page depicts the Abest track@ central barometric pressure and wind speed for Opal based on data obtained from the National Hurricane Center. This graph is a composite assembled for this report based on information contained in a report by the National Hurricane Center (Mayfield, 1995).

The horizontal axis reflects the date and time as Opal traveled across the Gulf of Mexico with the time of landfall depicted as a vertical line. The dramatic increase in wind speed and the dramatic drop in central barometric pressure as Opal approached landfall is illustrated in Figure 2. Wind speed peaked and central pressure drop bottomed out just prior to landfall.

Fortunately, due to changes in atmospheric conditions, the winds reduced to about 110 mph at landfall. However, the inertial and momentum forces in the Gulf had already been established to produce excessively high storm surge and waves as the storm reached landfall.

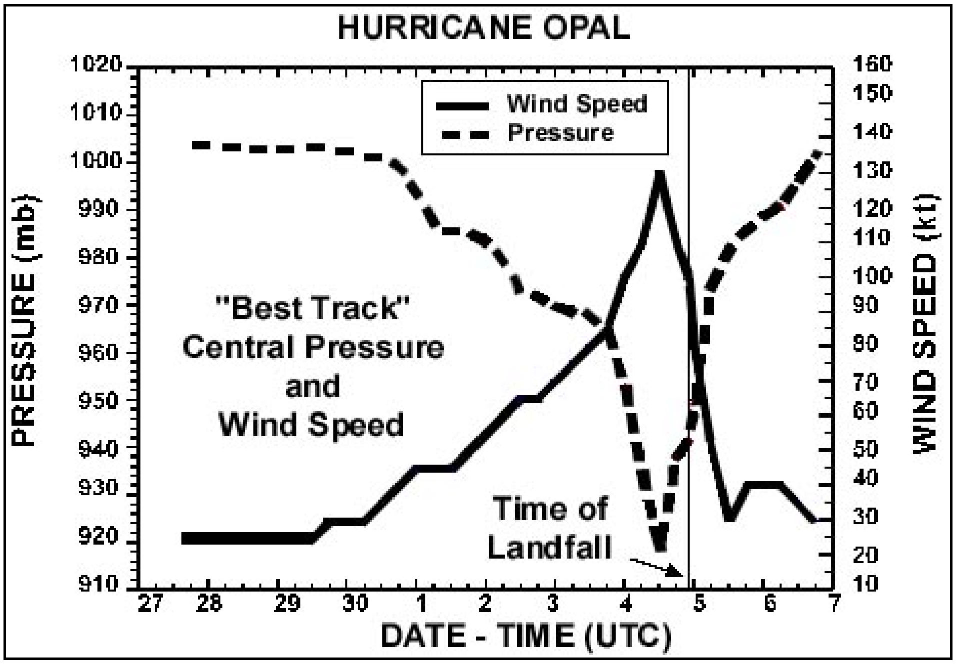

Figure 2. Best-track central pressure and wind speed

NOAA data collection stations which recorded data as Opal passed through the Gulf and onto land are depicted in Figure 3. The data stations collected wind and air pressure information, and the offshore NDBC buoys collected wave information, as well (NOAA,1995).

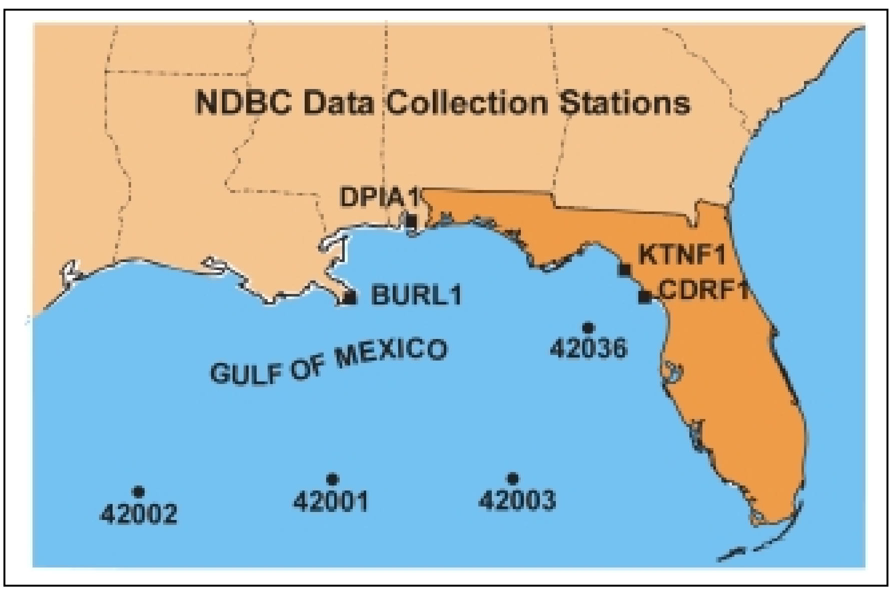

Figure 3. NOAA data collection which recorded Opal data.

Wave data collected at station 42036 which is nearest to the Florida coast is shown below in Figure 4. The illustration of the NOAA data at this station shows the dramatic increase in wave height and in average and dominant wave period at this particular buoy station as Opal traveled across the Gulf, even though Opal=s track was quite a significant distance westward of this station. Graphs of other NOAA data are given in Appendix A.

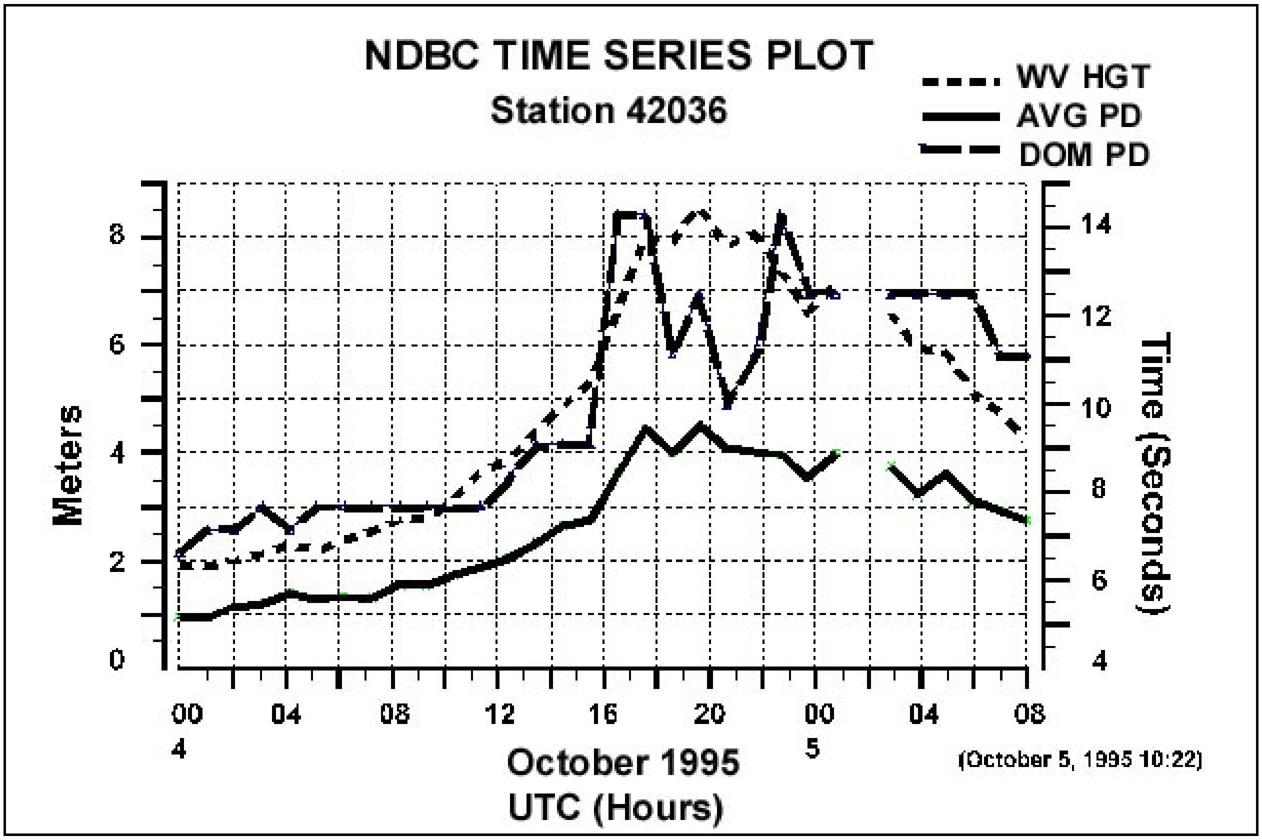

Figure 4. Wave data at NDBC buoy 42036 during passage of Opal.

Storm surge data obtained from a National Ocean Survey (NOS) tide gage (NOAA, 1995) located on the Panama City Beach pier is shown in Figure 5. The peak storm surge elevation is shown at +8.3 feet above the NGVD datum. The NGVD datum is the National Geodetic Vertical Datum, as established by the NOS (formerly called Amean sea level datum, 1929"). It is important to consider that the tide gage collected this data near the seaward end of the pier, several hundred feet seaward of the shoreline. Storm surge numerical model (Dean, 1994) and wave setup analyses (Wang, Chiu, and Dean, 1995) estimated a peak storm tide or storm surge at the shoreline to be from +12 to +16 feet (NGVD). This is consistent with a number of high water marks surveyed in the Panhandle by FDEP survey staff and other surveyors following Opal, some of which are depicted in Figure 6.

The high water mark elevations appear to confirm the estimated storm tide for Panama City Beach. The high water mark elevations shown in Figure 6 include those elevations which were located within a narrow zone immediately inland of the Gulf of Mexico shoreline extending

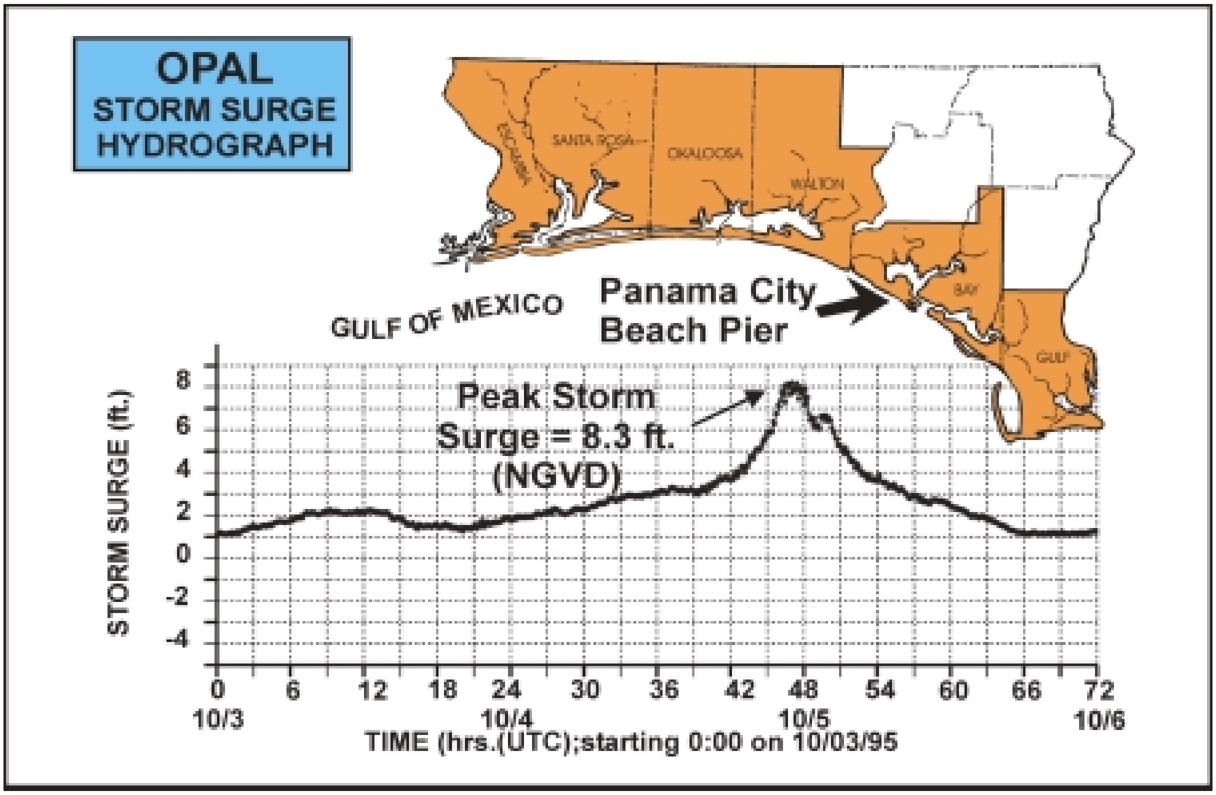

Figure 5. Storm surge hydrograph for Opal at Panama City.

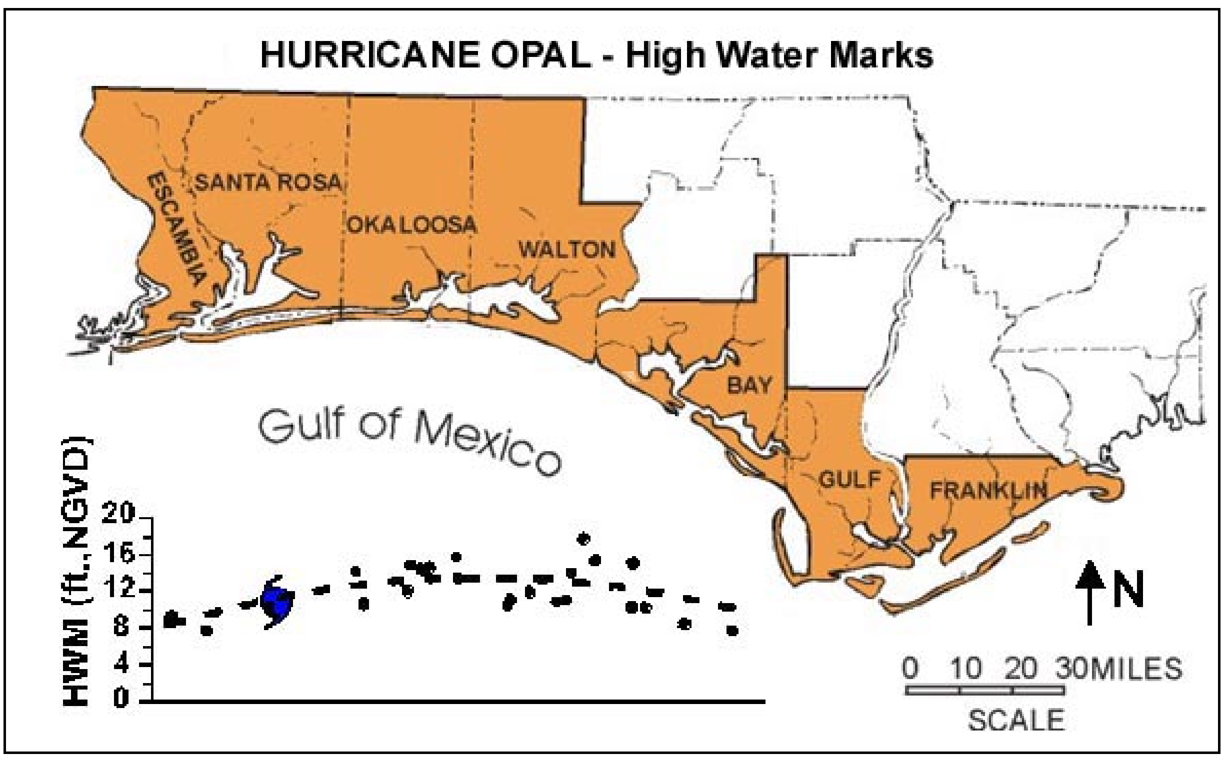

Figure 6. Surveyed high water marks after Opal along the Panhandle Coast.

values reflect storm surge, including wave setup, associated with Opal=s Gulf of Mexico storm tide. A number of high water marks from areas further inland from the coast were also obtained, but were not focused on and are not shown in this report. Many of these other elevation values were adjacent to inland bay areas which experienced the effects of increased tide elevations from Opal.

The high water elevations depicted in Figure 6 give a good representation of storm tide effects across the Panhandle region. However, the values shown should not be viewed as absolute storm surge elevations. For example, the highest value shown on the graph in Figure 6 is located in the Panama City Beach area. This does not mean that the highest storm surge from Hurricane Opal occurred in Panama City Beach. These are isolated water elevations which were obtained based on their availability and obtained in locations where wave effects and runup are assessed to be minimal, such as in stairwells, closets and other small, enclosed areas. These values, such as the highest value from Panama City Beach, may include some wave uprush effects, but should be more-or-less reflective of still water conditions.

The least-squares line of the high water data shown in Figure 6 gives a representation of storm tide distribution across the Panhandle region. The highest storm tide elevations, based on the trend line, occurred in the Okaloosa, Walton, and western Bay County areas. The highest storm tides, as expected, were located along the eastern side of the point of storm landfall. The location of storm landfall is shown on the graph in Figure 6 by the hurricane symbol which is located in eastern Escambia County.

The storm tide elevations and upward limits of wave impacts and uprush were further established by direct field observations. Wrack line/debris line markings were surveyed for the Federal Emergency Management Agency (FEMA) following Opal and were recorded at elevations up to and exceeding +20 feet (NGVD) which probably reflected wave uprush limits during the storm. During post-storm inspections conducted by FDEP staff, wave impacts and sand deposition were evident in first-floors of stuctures up to +17 to +18 feet above NGVD. Many multi-family structures, such as hotels and condominiums, particularly across the western Panhandle counties in areas such as Ft. Walton Beach, were inundated with sand throughout their first-floor rooms and hallways. Frequently, these structures, although their first floor elevations were at +14 to +15 feet above NGVD, were not undermined because large sand dunes seaward of these buildings were flattened by Opal and the eroded sand deposited 2 to 3 feet deep within the first floors. A detailed listing of storm surge and debris/wrack line elevations by FDEP survey monument and county is given in Appendix B.

Defining Characteristics

In addition to the wind, wave, and surge characteristics of Opal, a number of the so-called Adefining characteristics@ at the point of landfall were determined (Wang, Chiu, and Dean, 1995); including a central pressure deficit of -2.16 inches of mercury, radius of maximum winds initially estimated to be about 30 miles and later determined to be about 45-50 miles, forward speed of 23 nautical mph, hurricane direction (the angle of approach relative to the shoreline at the point of landfall) of 204 degrees from North, and the landfall location which was at a point within Pensacola Beach near the causeway or Gulf fishing pier.

III. Beach and Dune Erosion

In terms of beach and dune erosion, Hurricane Opal's substantial storm surge and breaking waves severely eroded the beach and dune system throughout the Panhandle Coast. Erosion impacts, on a more moderate scale, were also felt on beaches in Pinellas, Manatee, and Sarasota counties and to a lesser extent along the entire southwestern Florida coastline all the way to Key West. Extent of erosion along the Florida coast is depicted in Figure 7. The areas shown in Figure 7 as experiencing major coastal impact corresponded with the severely eroded beach and dune areas across the Panhandle region.

The FDEP Bureau of Beaches and Coastal Systems acquired substantial survey data in the Panhandle counties to document the beach and dune erosion caused by Hurricane Opal. The Bureau maintains a series of survey monuments along the coast, spaced generally on 1000 foot intervals, at which beach and dune profile survey data and offshore profile data is regularly collected. Fortunately, good pre-storm profile data for Bay and Walton was obtained.

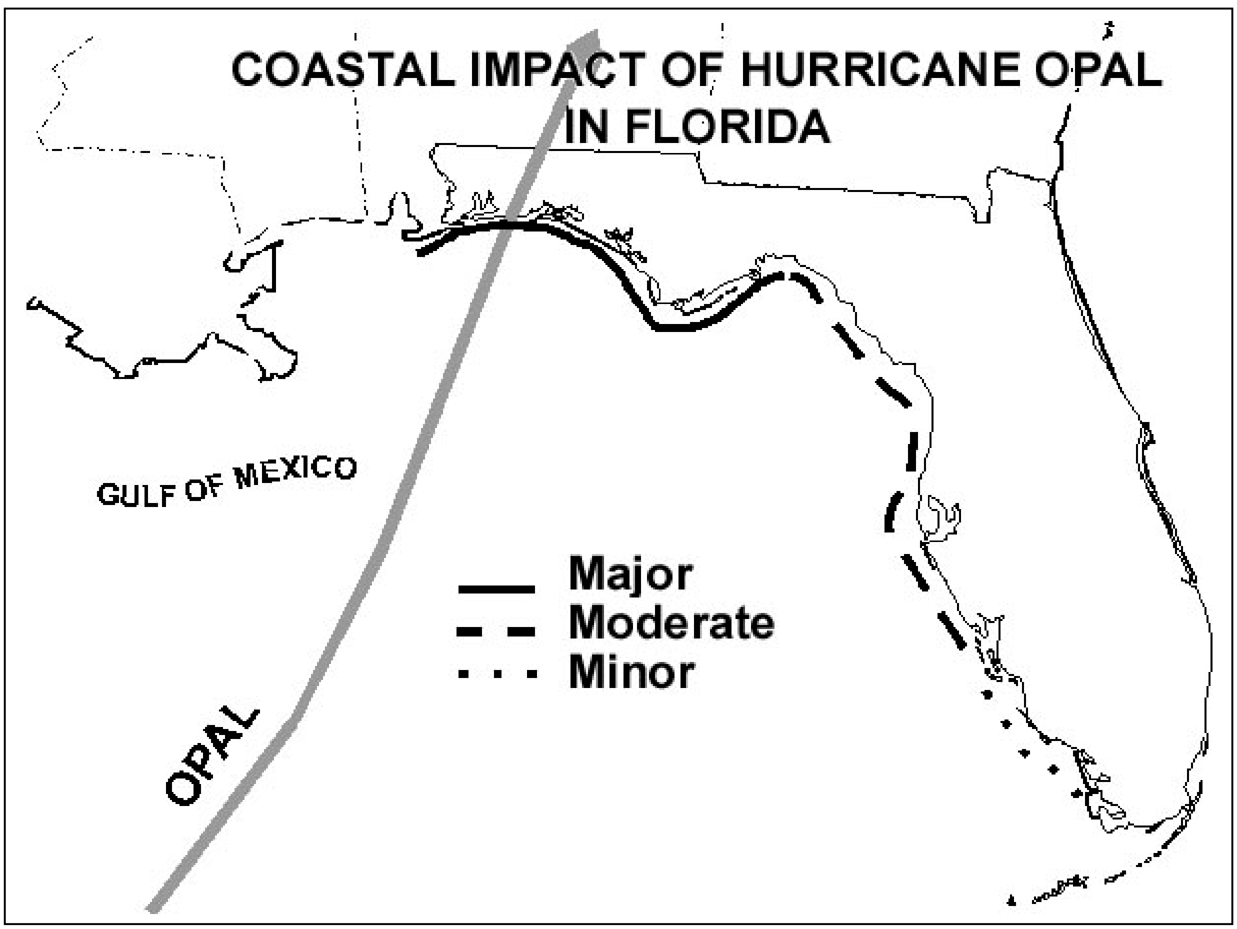

Figure 7. Extent of Opal=s erosional impact on Florida=s Gulf Coast.

Figure 8 (to right):
Areas of high, continuous dunes experienced substantial recession, as seen in the photo to the right of a critically eroded dune area in Walton County.

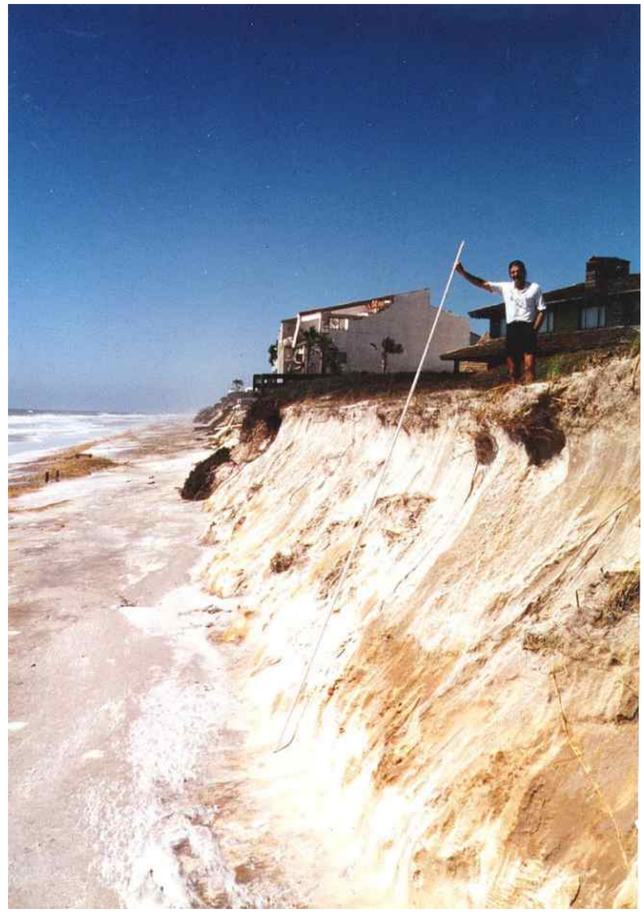

Figure 9 (below):
Lower dune areas experienced tremendous dune overwash.
The aerial view in the photo below is typical of overwash which occurred throughout the western Panhandle counties.

Portions of Hwy. 98 in this area just east of Ft. Walton Beach were completely washed out several hundred feet from the shoreline.

Extensive flooding which occurred is also seen in the photo below.

Beach and offshore profile data was collected by the Bureau survey staff in March of 1995 in Bay County and in June of 1995 in Walton County. This survey data provides a very good pre-Opal data set with which to compare post-Opal data collected immediately following the storm in those counties. Beach and dune profile data was collected by the Bureau staff in October 1995, in many cases within 4-5 days of Opal=s October 4th landfall. This data acquisition is of particular interest with regard to predictive dune-erosion modeling since previous post-storm data collected in Walton County after Hurricane Eloise in 1975 has been used extensively in model calibration analyses (Chiu and Dean, 1984; Kriebel, 1985).

Post-Opal beach and dune profile data collected in Okaloosa County within a few days to a month of the storm provides good data to evaluate storm impact. Pre-Opal data for Okaloosa County dates back to 1989. Available beach and dune profile data following Hurricane Erin in August 1995 (shown in plots at R-1 and R-36 in Figures 16 and 18) substantiates little profile change from Erin in Okaloosa County. Consideration of probable beach recovery after Erin further justifies use of the 1989 data as pre-Opal for erosional analyses. Pre-Opal data from Escambia and Santa Rosa counties was last collected in 1993. Data collected following Erin in August 1995 in those counties shows significant beach erosion, as well as, minor dune recession resulting from Erin prior to the subsequent erosion from Opal.

Table 1 summarizes beach and dune recession at the 2 and 10 foot contours, respectively, and volume loss above NGVD as a result of Opal in some of the Panhandle counties.

TABLE 1

BEACH AND DUNE EROSION SUMMARY

COUNTY	**RECESSION** (County Avg., Max. in ft.)				**EROSION VOLUME** (above NGVD)	
	Beach (2ft. Contour)		Dune (10ft. Contour)		Avg.Per Foot	Total
	Avg.	Max.	Avg.	Max.		
BAY	- 31	- 153	- 38	- 120	- 13 cy/ft	- 2.9 mcy
WALTON	- 35	- 76	- 45	- 155	- 27 cy/ft	- 3.6 mcy
OKALOOSA	- 40	- 208	- 52	- 170	- 18 cy/ft	- 1.3 mcy
ESCAMBIA/ SANTA ROSA	(- 50)	---	(- 150)	---	-----	-----

Note: Recession values for Escambia/Santa Rosa are based on limited but representative data.

(Added note on 12/22/99: For more on Escambia/Santa Rosa see Leadon, Coastal Sediments 99)

The profile data collected for Escambia and Santa Rosa counties was delayed for 2-3 months after Opal because survey control monuments had been washed out and destroyed. Therefore, due to beach recovery and sand relocations, limited data, and effects of Erin, volumetric computations for those counties are not shown in Table 1. Limited available data does show average beach and dune recession in the eastern portions of Escambia County (just east of Opal=s landfall) and Santa Rosa County on the order of 50 feet and 150 feet, respectively.

Post-storm data was collected in Gulf County in March 1997, well after the storm, but still gives a good idea of Opal-induced erosion in that county when compared with pre-storm data from 1993. Only minor erosion occurred after 1993 prior to Opal. Some profiles along a portion of St. George Island in Franklin County were obtained in June 1995, within just a few months prior to Opal, and then in June 1996, just a few months following Opal to give a good representation of Opal=s erosional impacts in that county. Visual observation further documented significant erosion on St. George Island and Dog Island, as well.

Due to lack of sufficient data, Gulf and Franklin counties, and for the most part, Escambia and Santa Rosa counties, are not included in the Table 1 summary. However, for Okaloosa, Walton, and Bay counties, the numbers are severe; an estimated total of about 8 million cubic yards of sand was eroded from above NGVD. It should be noted that the total volume loss for Bay County includes a volume estimated by extrapolating the average volume/foot loss value across the barrier island area between St. Andrews Bay Entrance and Mexico Beach, an area not surveyed.

Typical examples of beach and dune erosion, as well as, offshore profile response to Hurricane Opal are given on the following pages for each of the counties for which post-Opal data was collected. Map illustrations of each county are followed by example erosion plots extending eastward and including Escambia/Santa Rosa, Okaloosa, Walton, Bay, Gulf, and Franklin counties (Figures 10 through 39).

More detailed depictions of the alongshore variation of beach and dune recession and volume loss above NGVD for the Panhandle counties for which a significant number of post-Opal profiles are available are also given on the following pages, after the beach and dune profile plots, in Figures 40 through 42. Counties included in this analysis of Opal=s alongshore variation of erosional impacts are Bay, Walton, and Okaloosa counties, for which more favorable and extensive pre-Opal and immediate post-Opal survey data was available.

The illustrations in Figures 40 through 42 depict a map of the Gulf of Mexico shoreline of the particular county along the top of the figure with every tenth survey range monument shown followed by contour position change for the 2, 5, 10, 15, and 20 foot elevations and volumetric erosion. The recession and volume change computations are based on comparison of survey profile data collected before Hurricane Opal with the post-Opal data collected after the storm. Detailed listings of monument locations where post-Opal data was collected for Bay, Walton, and Okaloosa counties, the counties for which extensive data was collected, are included in Appendix C. Also included with the listings are the specific recession and volume change values computed for each of the monuments for which data was available. Profile overlay plots of the upland (above NGVD) for each of the monuments for which data was collected and evaluated for these counties are being compiled in separate companion volumes associated with this main report.

The maps of each of the Panhandle counties for which profile plots are shown on following pages are included with each particular county in order to depict the locations of the DEP survey monuments for the profile plot overlays. The maps depict all the DEP survey monument locations for each county. The monuments shown are located approximately every 1000 feet along the Gulf coastline, except for some of the Federal and other undeveloped lands.

In addition to the immediate post-Opal survey data of upland areas collected by FDEP, the Mobile District of the U.S.Army Corps of Engineers obtained a high-resolution bathymetric survey of the offshore region of in the vicinity of their planned beach restoration project at Panama City Beach. This data was obtained through the Corps= SHOALS technology and provides an excellent complimentary data set to the FDEP pre-Opal upland and offshore data and post-Opal upland data. The upland and offshore post-storm survey data for Bay County shown in these figures was collected within 4 days and 2 days, respectively, of the landfall impact of Hurricane Opal providing an excellent depiction of Opal=s impact.

Typical examples of profile comparisions for Bay County which include the offshore survey comparison are shown in Figures 43 and 44. The profile comparison plot shown in Figure 43 is typical of offshore response to Opal which occurred throughout most of Panama City Beach. Erosion occurred across the upland beach and dune areas and a pre-storm nearshore bar feature with corresponding deposition into a shallower nearshore area landward of the pre-storm bar feature and, also, into an extensive, deeper offshore bar formation. No pronounced nearshore bar erosion is seen in Figure 44 probably as a result of processes associated with the nearby St. Andrews Bay Entrance.

Similar deep-water deposition and profile response to Opal occurred across other areas of the Panhandle coast including areas of extensive overwash, such as in the western Panhandle areas. Examples of offshore change based on 3-month post-Opal surveys in Walton and Okaloosa counties are shown in Figures 45 and 46 and in Figures 47 and 48, respectively. Immediate post-Opal offshore surveys were not available for those counties. Observation and analysis of offshore changes related to Opal based on before and after surveys from Escambia, Santa Rosa, Gulf, and Franklin counties are not available due to lack of profile data before the storm which was not affected by other storms and/or long-term coastal processes.

The FDEP has conducted additional county-wide surveys of the Panhandle counties, three to four months after Opal=s landfall, and then one year (two year is planned) after Opal, which include both onshore and offshore areas. An evaluation and illustration of some of this data in comparison with the pre-Opal and post-Opal surveys in terms of long-term profile response and recovery is presented in Section V of this report.

Some photographs of other interesting, note-worthy erosional occurrences observed along the Panhandle Coast in the aftermath of Hurricane Opal are depicted on pages following the survey data analysis plots discussed above.

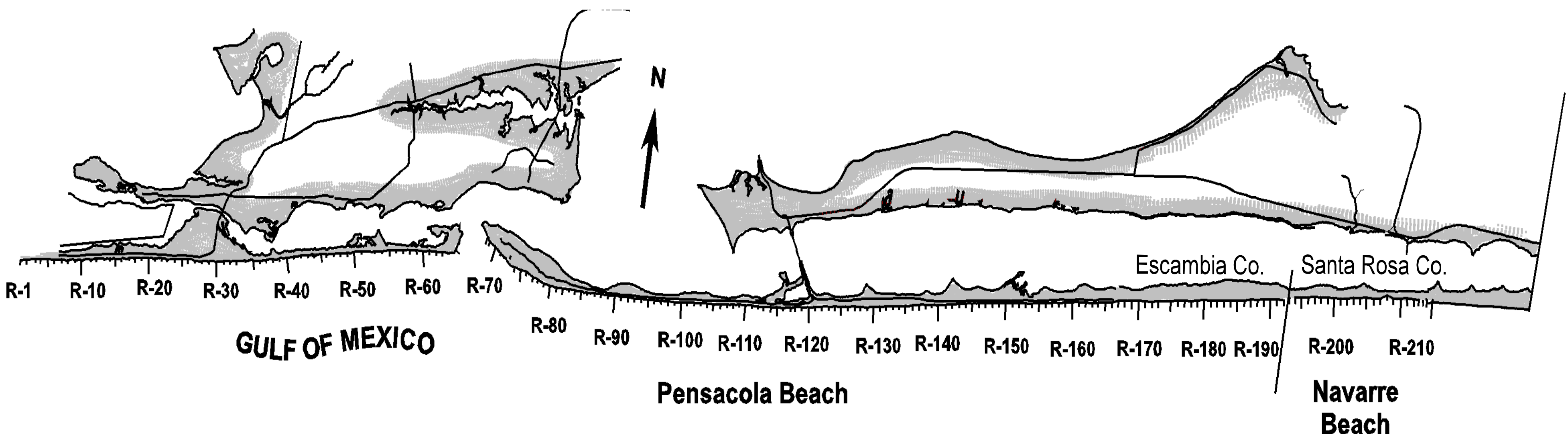

Figure 10. Escambia/Santa Rosa County Map with Locations of FDEP Survey Monuments.

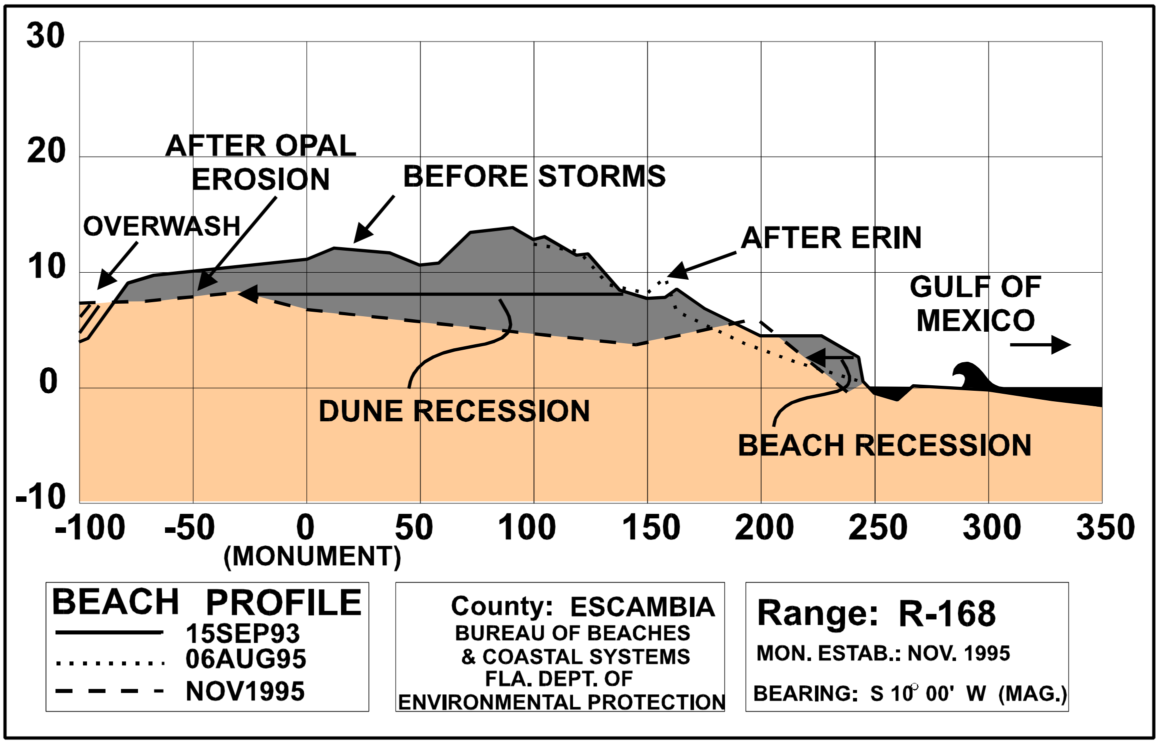

Figure 11. Beach and dune erosion from Opal at R-168 in Escambia County.

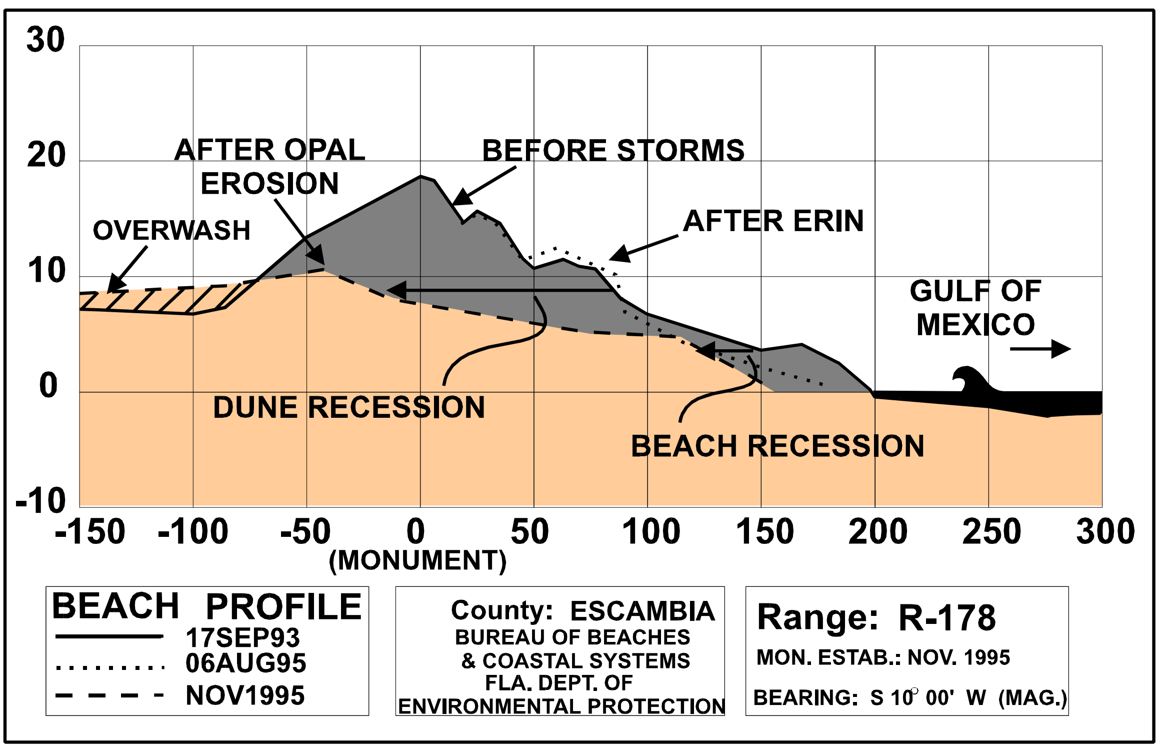

Figure 12. Beach and dune erosion from Opal at R-178 in Escambia County.

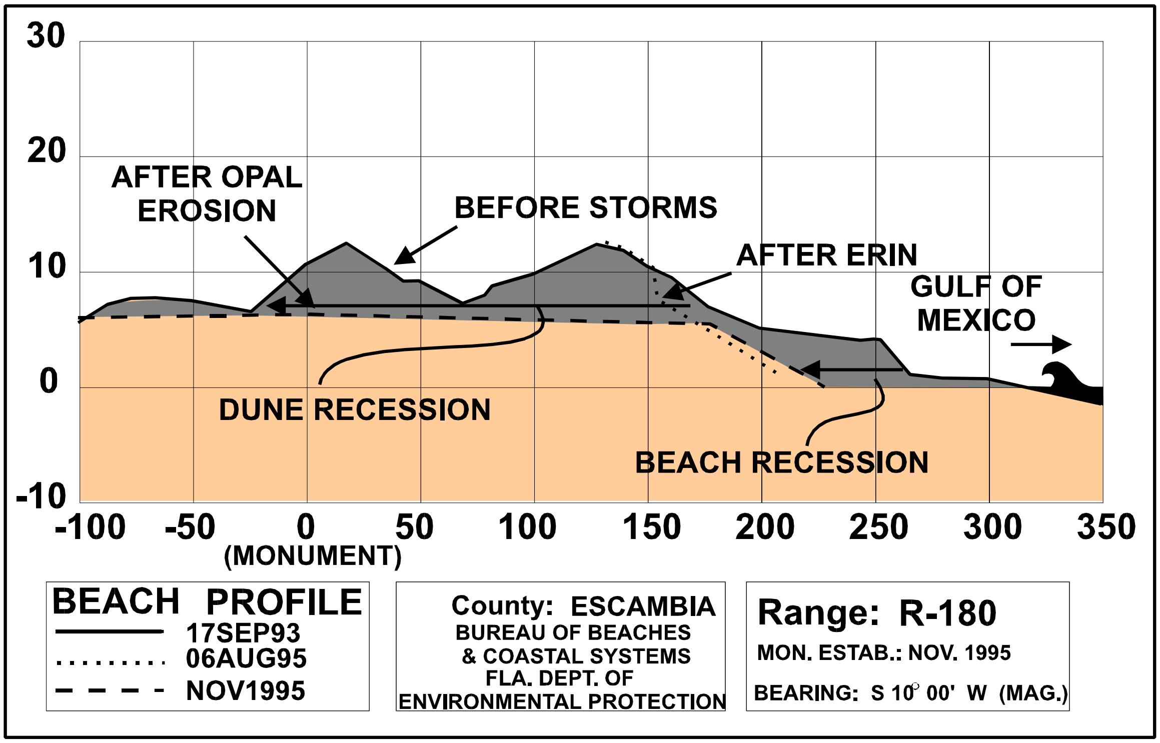

Figure 13. Beach and dune erosion from Opal at R-180 in Escambia County.

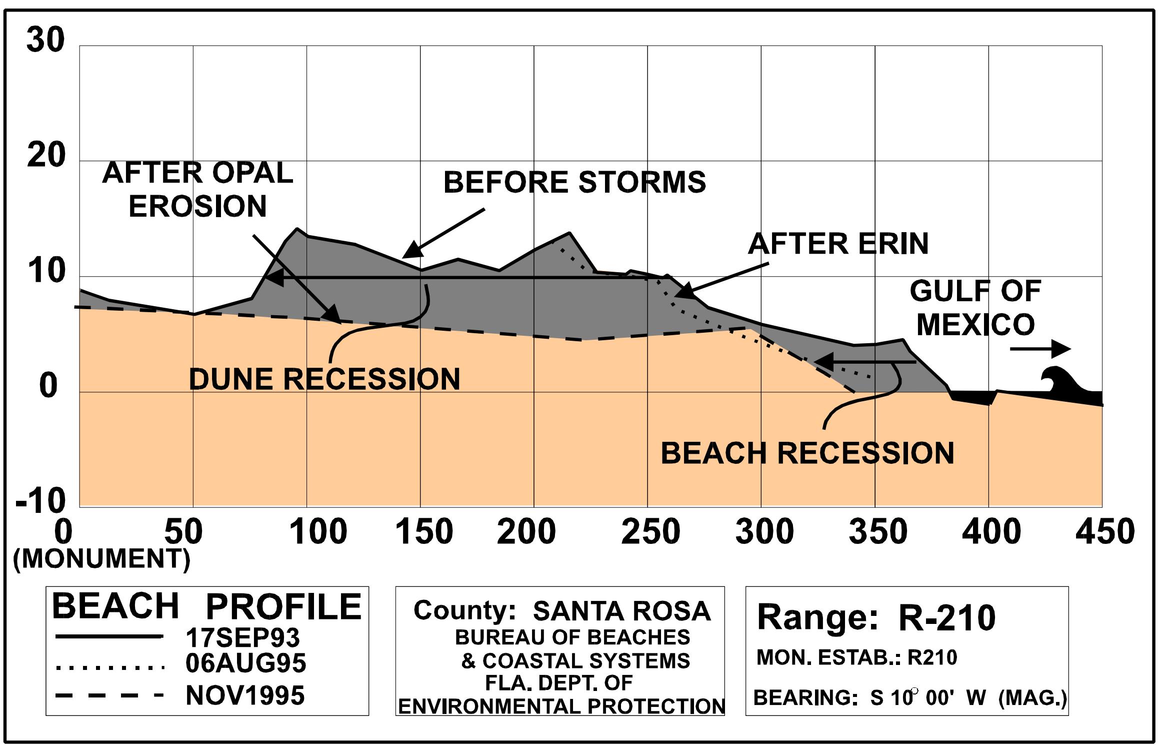

Figure 14. Beach and dune erosion from Opal at R-210 in Santa Rosa County.

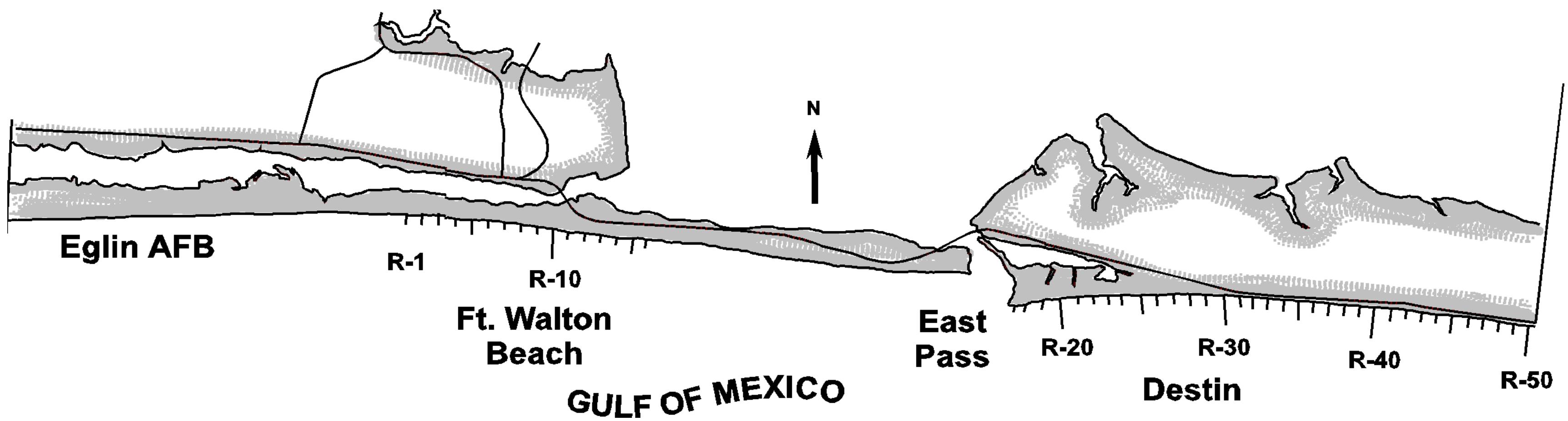

Figure 15. Okaloosa County Map Showing Locations of FDEP Survey Monuments

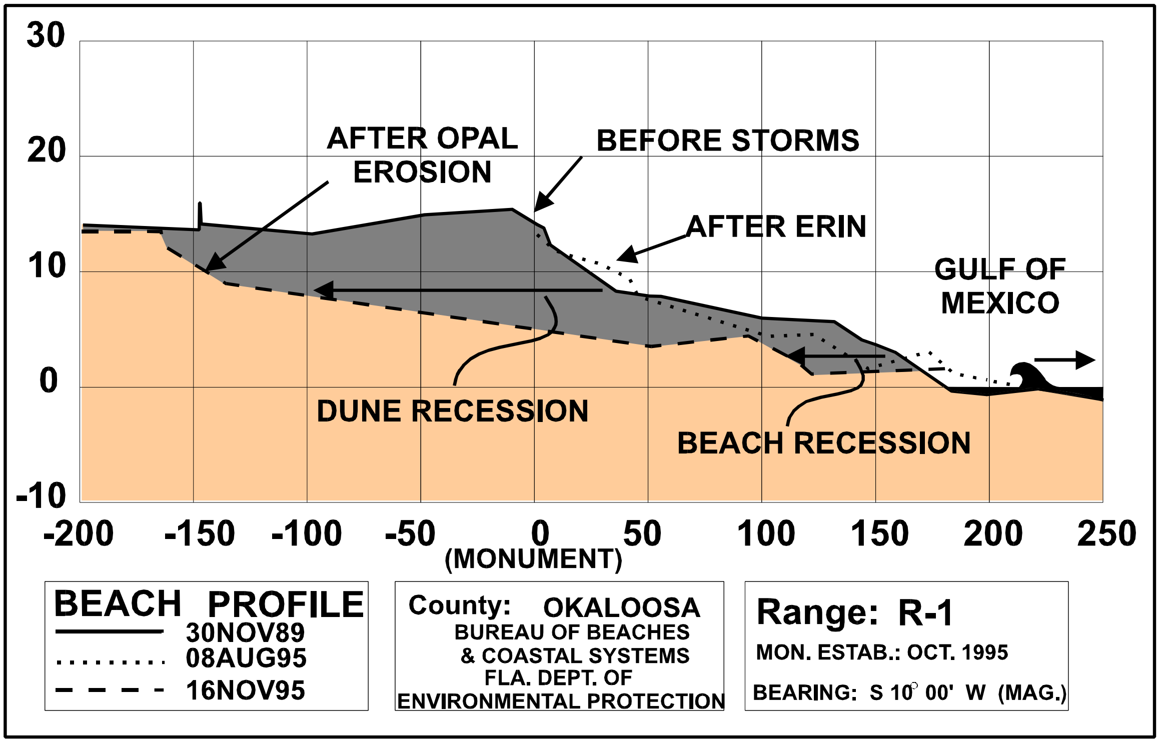

Figure 16. Beach and dune erosion from Opal at R-1 in Okaloosa County.

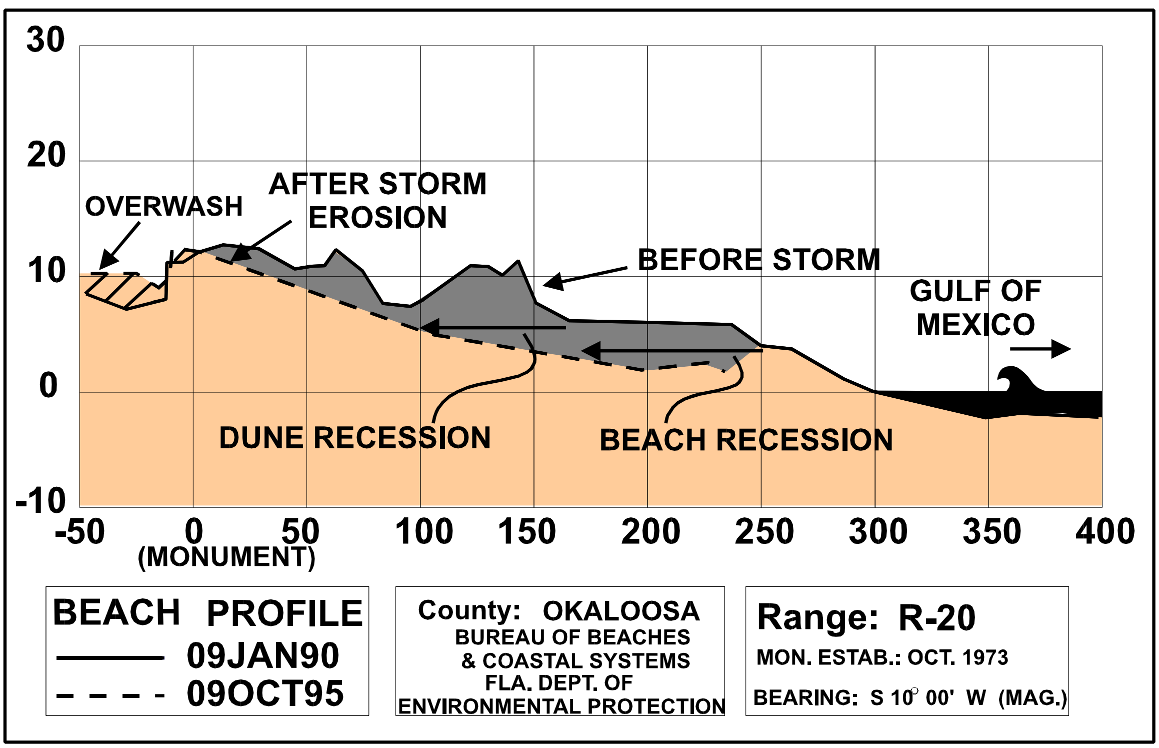

Figure 17. Beach and dune erosion from Opal at R-20 in Okaloosa County.

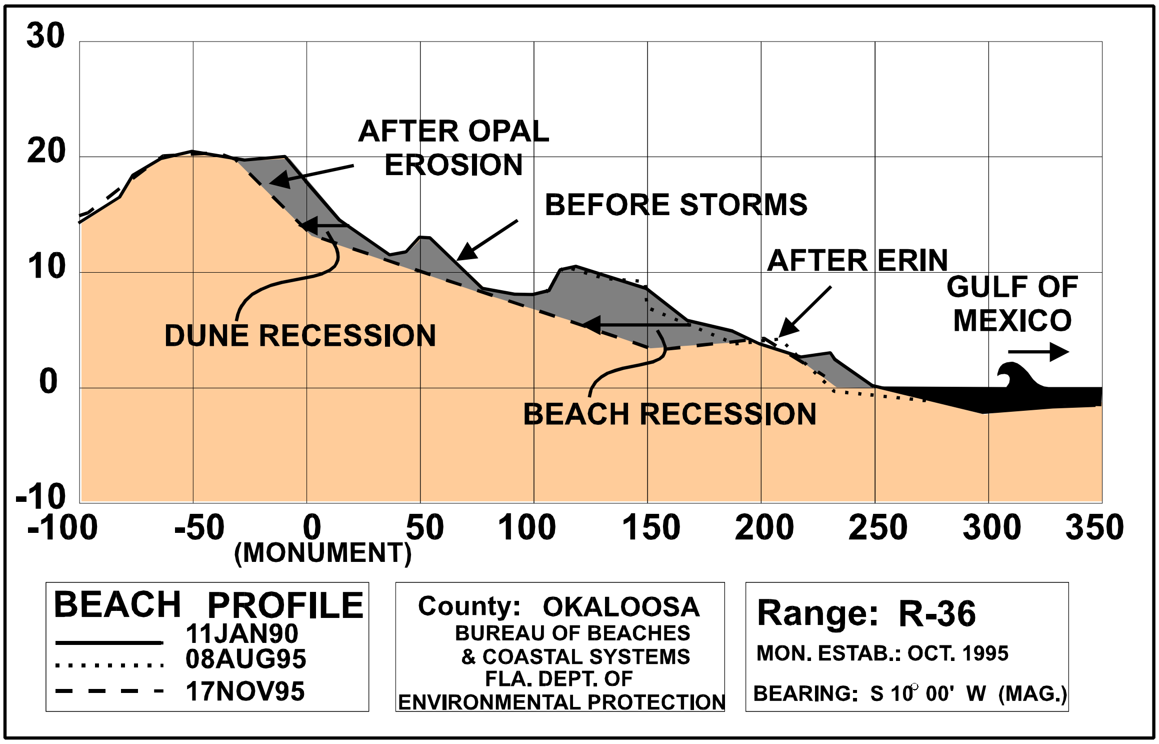

Figure 18. Beach and dune erosion from Opal at R-36 in Okaloosa County.

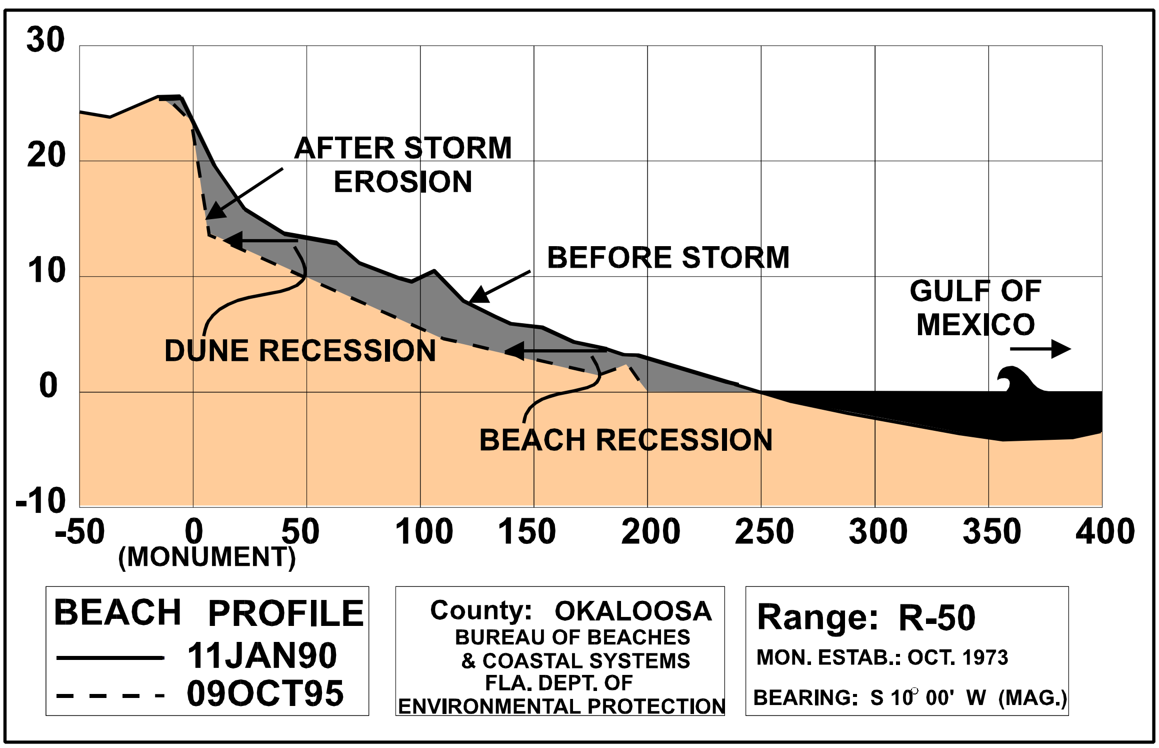

Figure 19. Beach and dune erosion from Opal at R-50 in Okaloosa County.

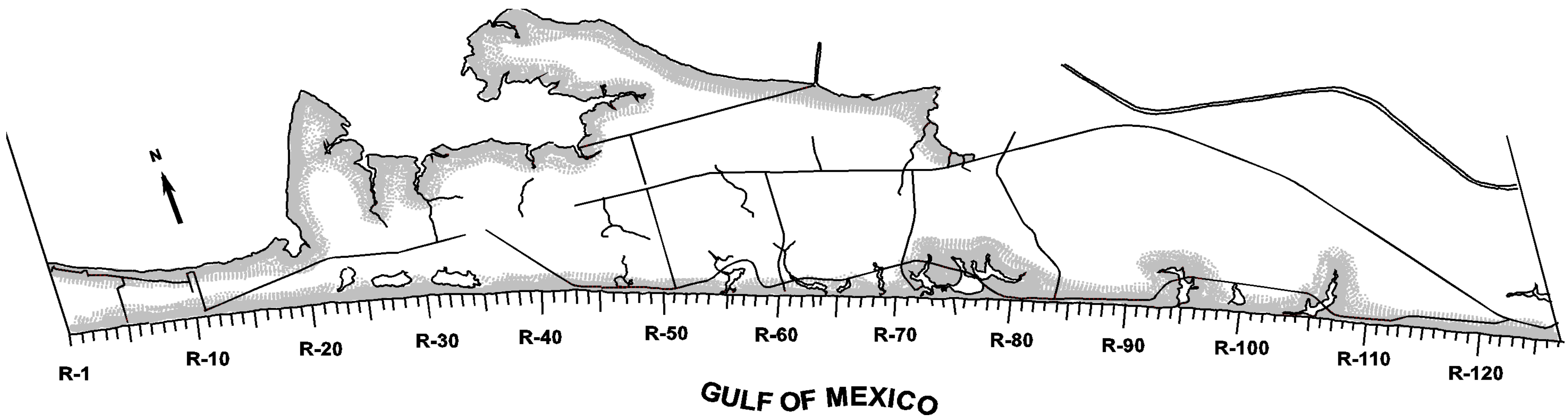

Figure 20. Walton County Map Showing Locations of FDEP Survey Monuments

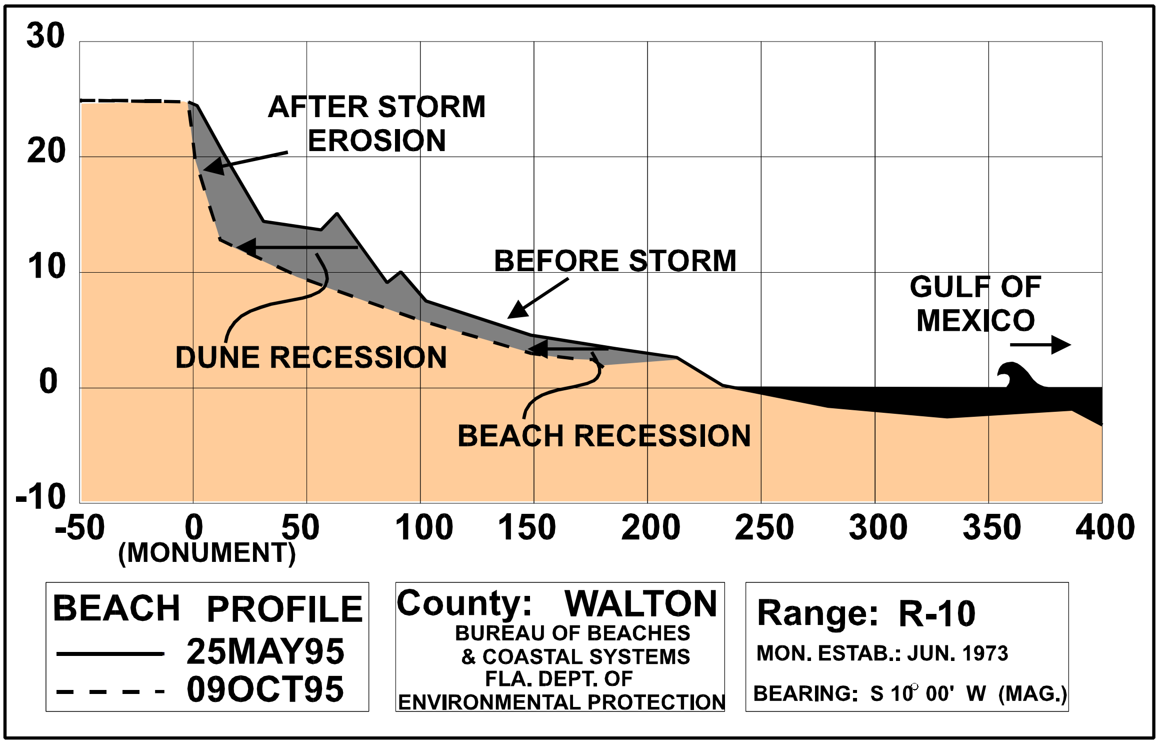

Figure 21. Beach and dune erosion from Opal at R-10 in Walton County.

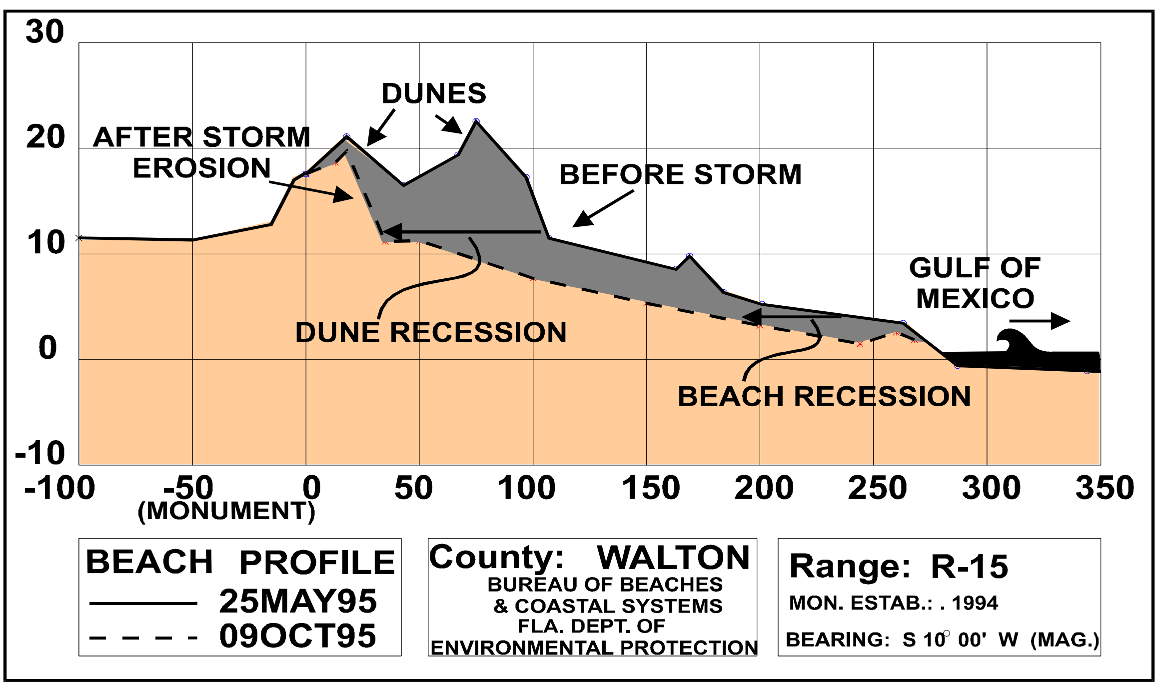

Figure 22. Beach and dune erosion from Opal at R-15 in Walton County.

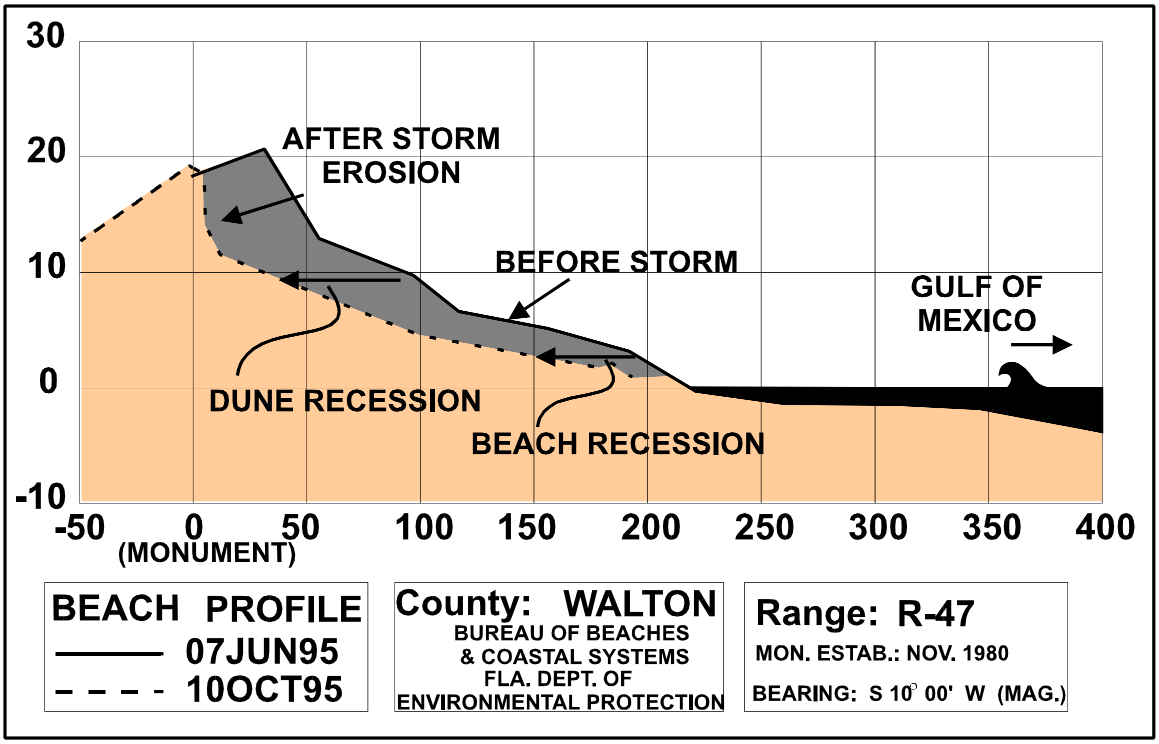

Figure 23. Beach and dune erosion from Opal at R-47 in Walton County.

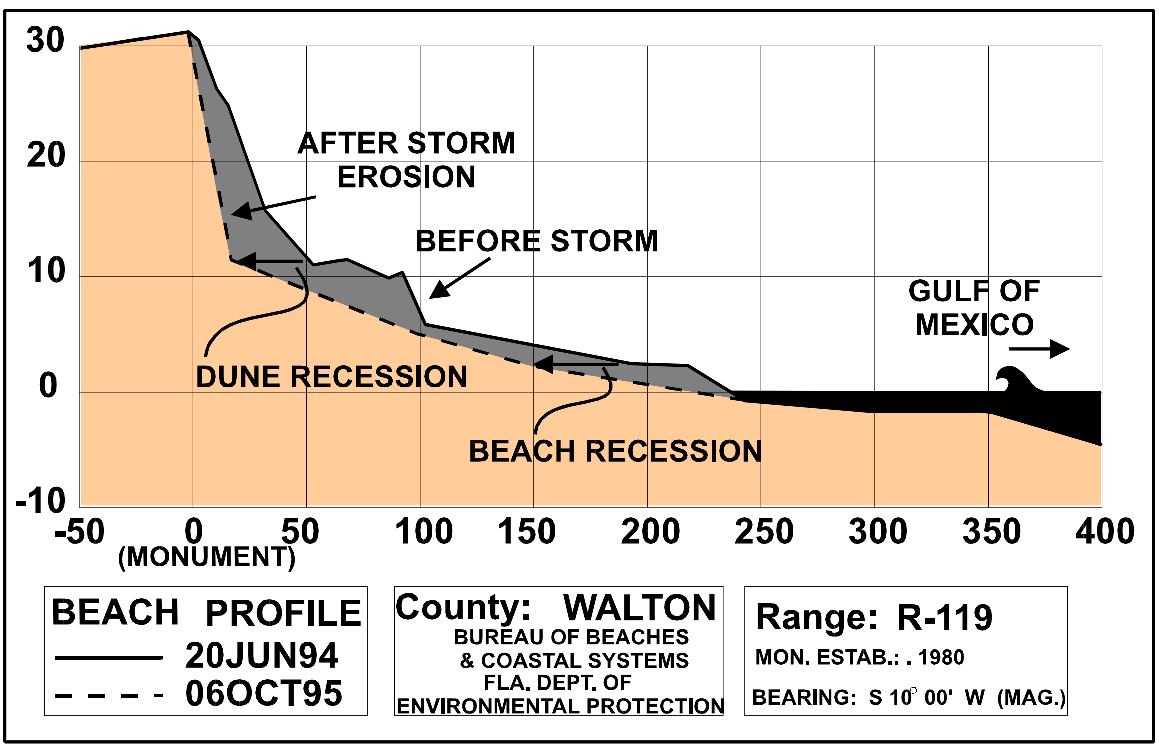

Figure 24. Beach and dune erosion from Opal at R-119 in Walton County.

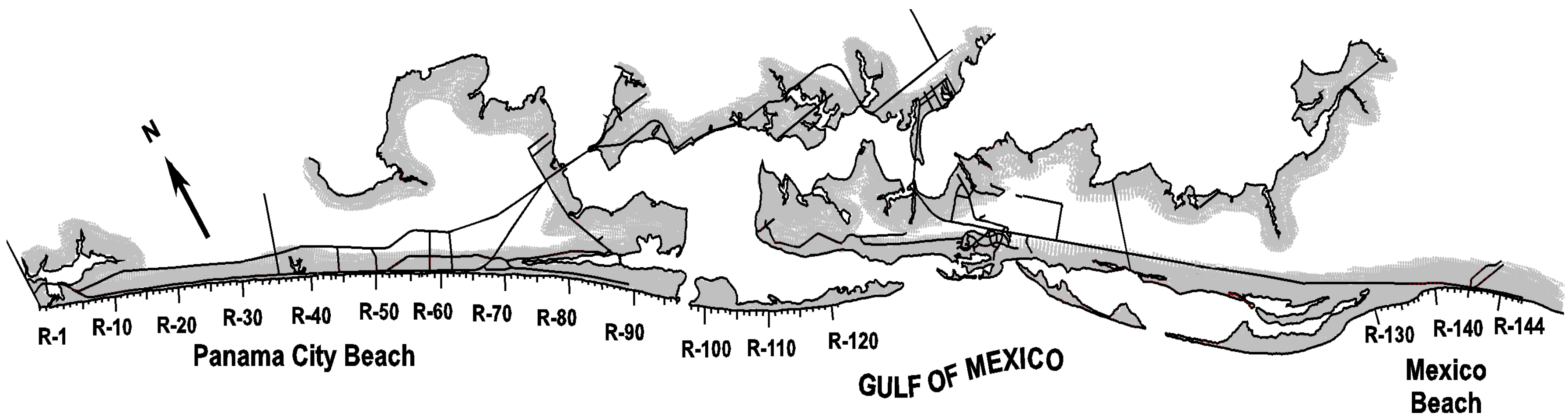

Figure 25. Bay County Map Showing Locations of FDEP Survey Monuments

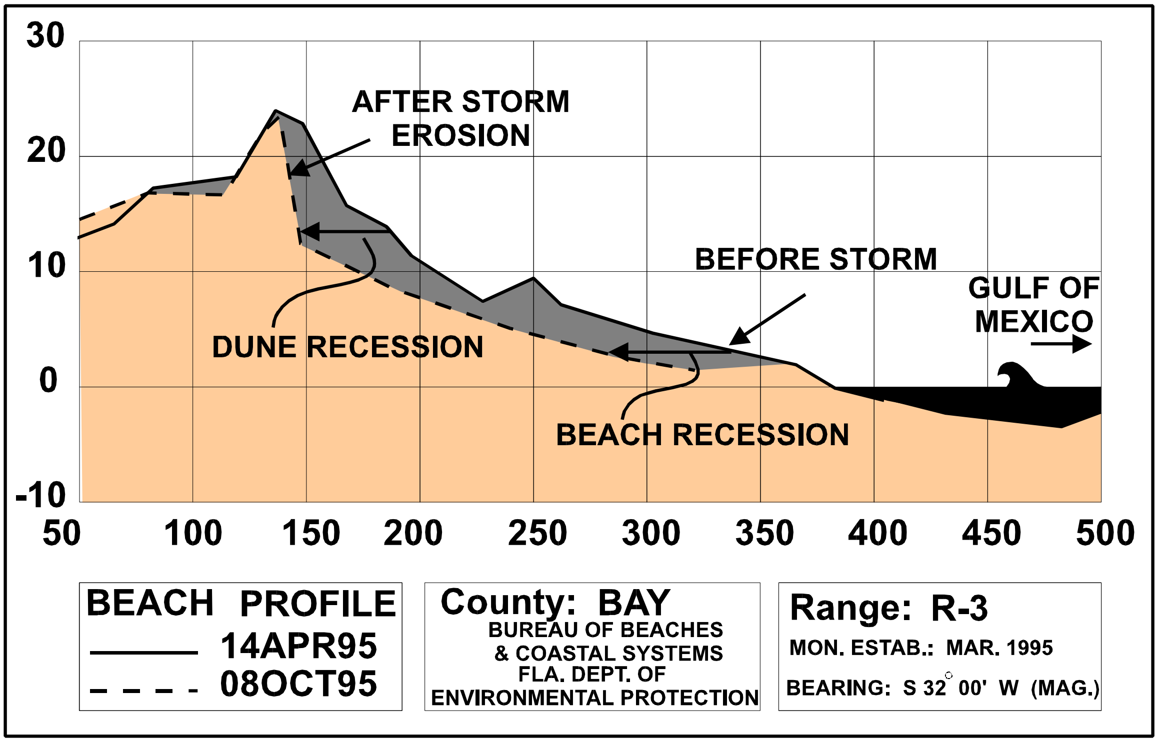

Figure 26. Beach and dune erosion from Opal at R-3 in Bay County.

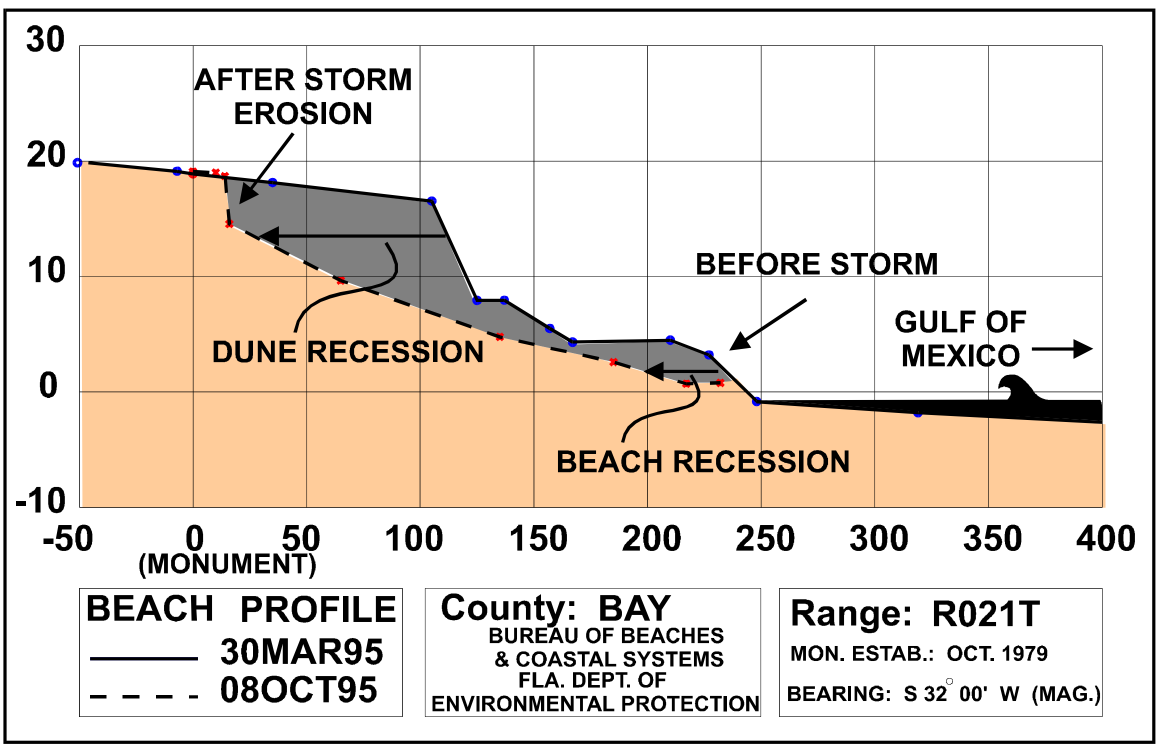

Figure 27. Beach and dune erosion from Opal at R-21T in Bay County.

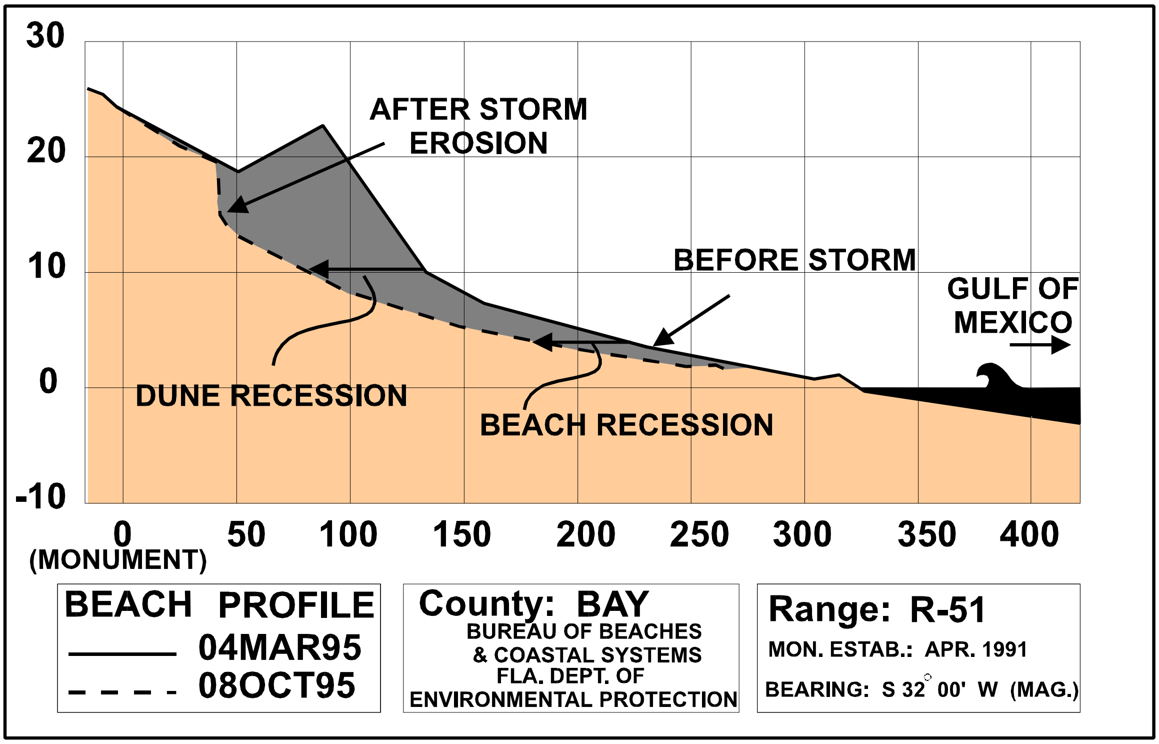

Figure 28. Beach and dune erosion from Opal at R-51 in Bay County.

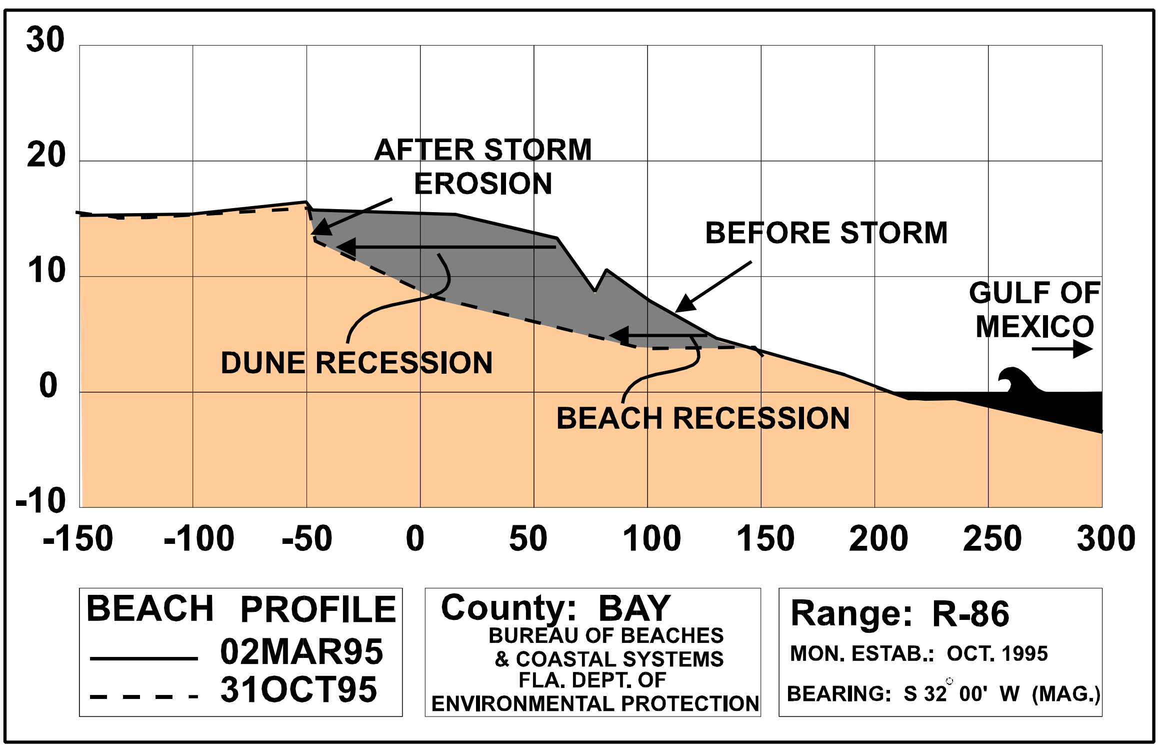

Figure 29. Beach and dune erosion from Opal at R-86 in Bay County.

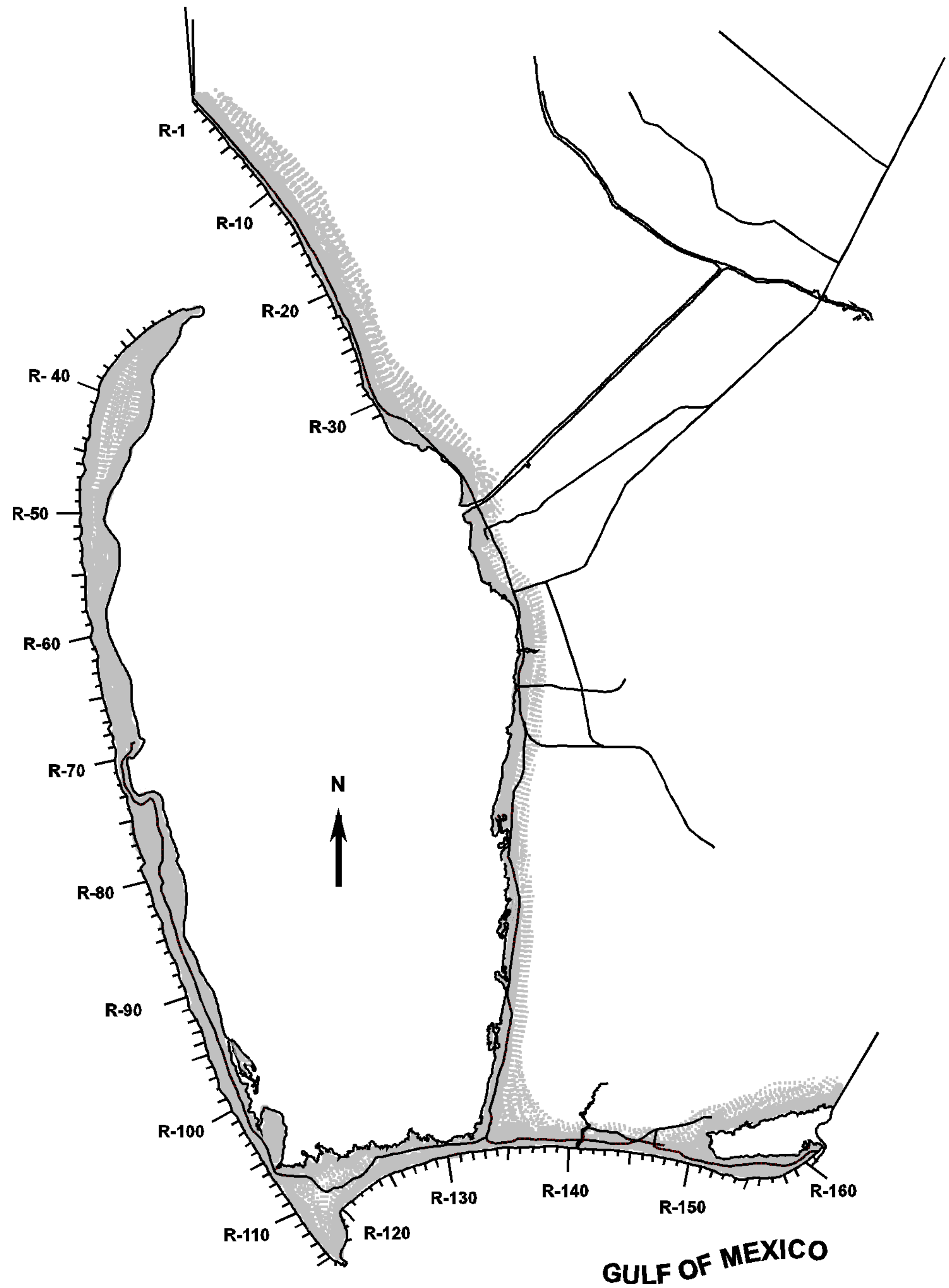

Figure 30. Gulf County Map Showing Locations of FDEP Survey Monuments.

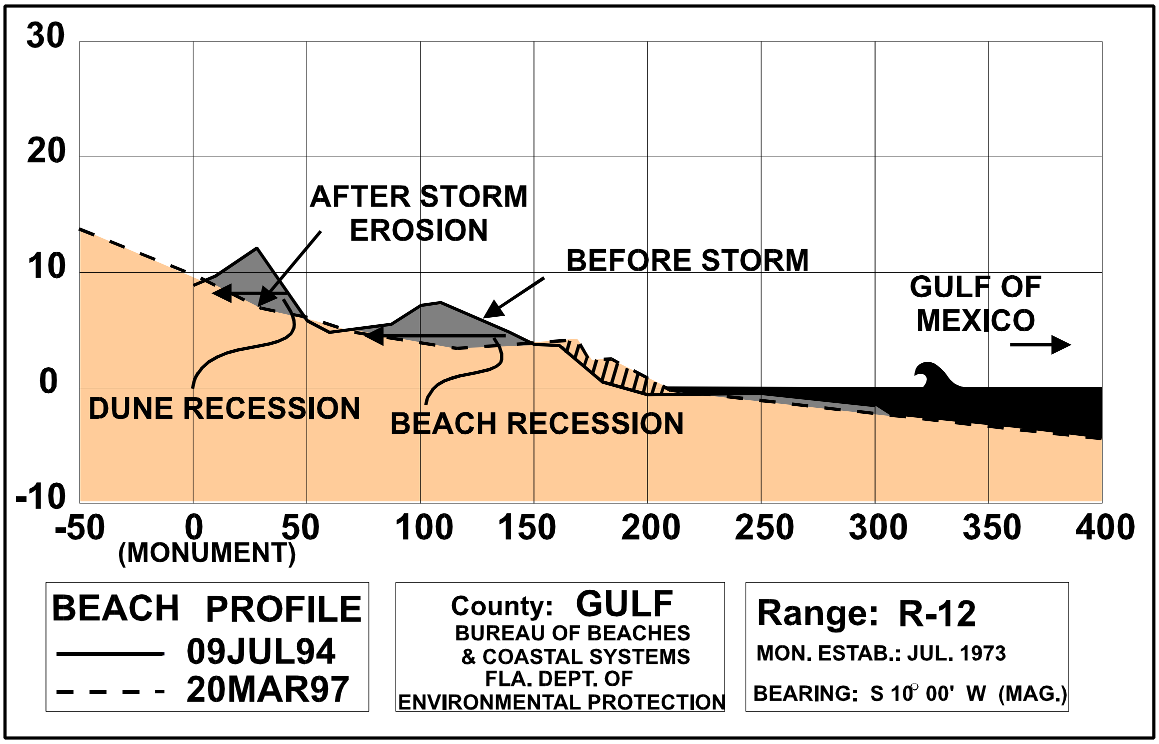

Figure 31. Beach and dune erosion from Opal at R-12 in Gulf County.

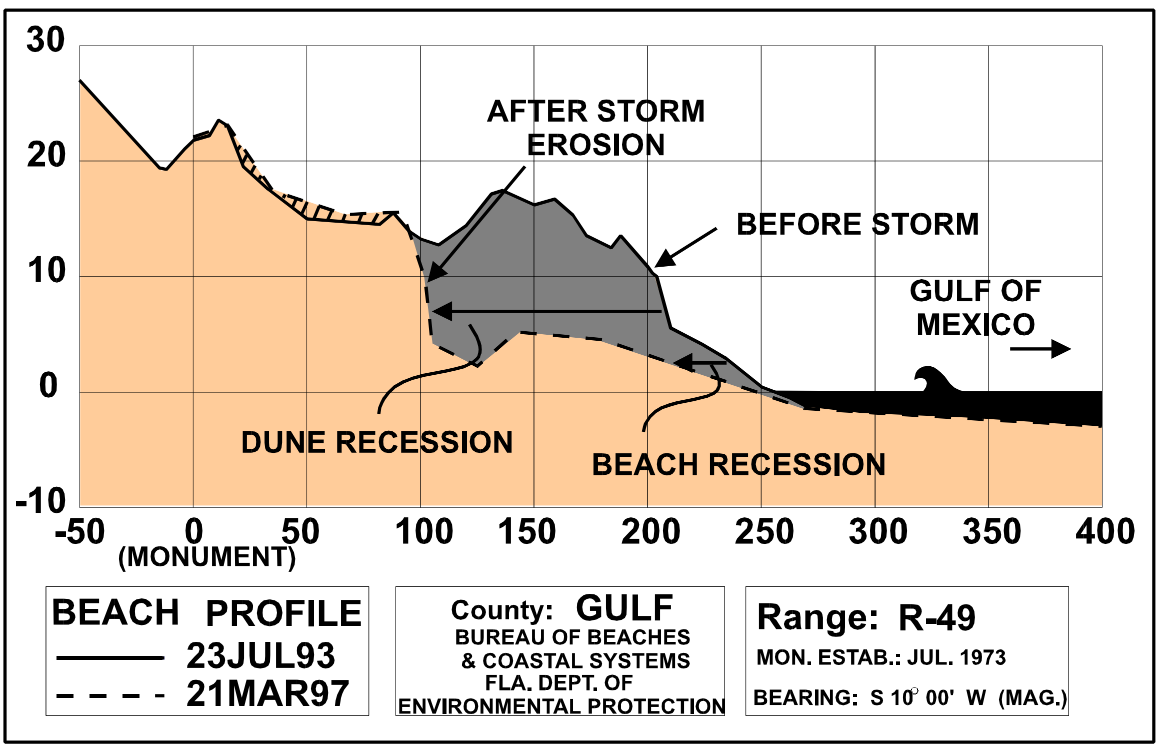

Figure 32. Beach and dune erosion from Opal at R-49 in Gulf County.

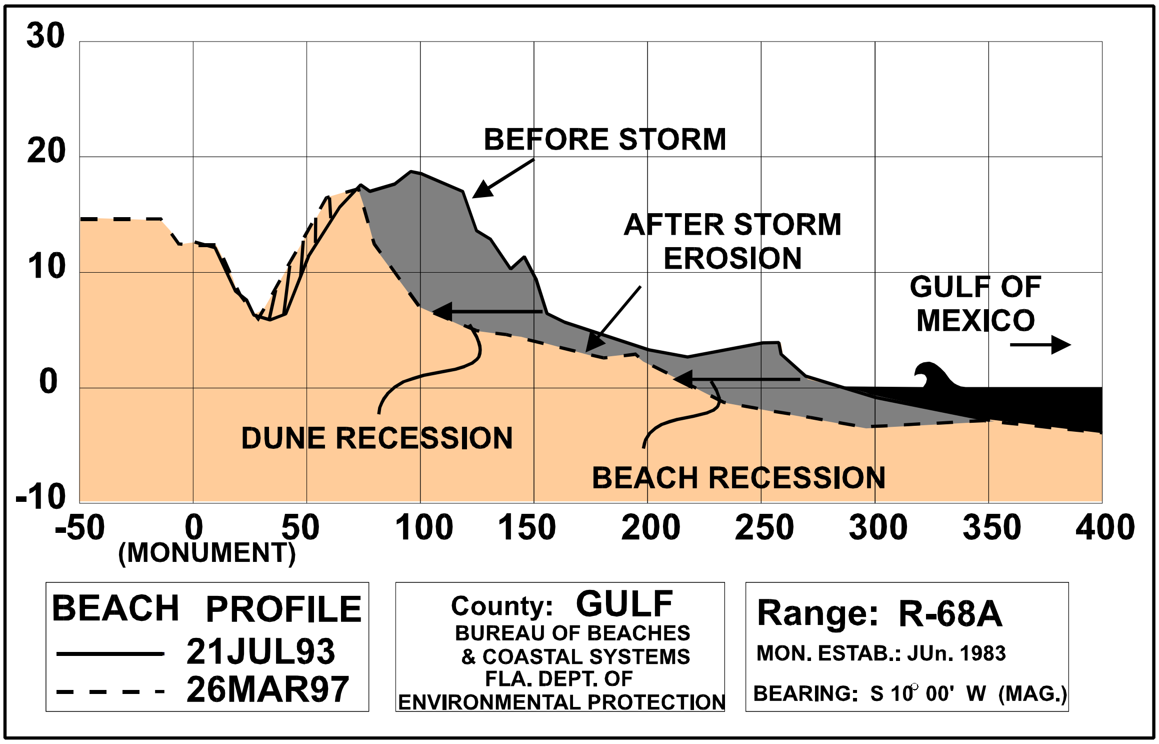

Figure 33. Beach and dune erosion from Opal at R-68A in Gulf County.

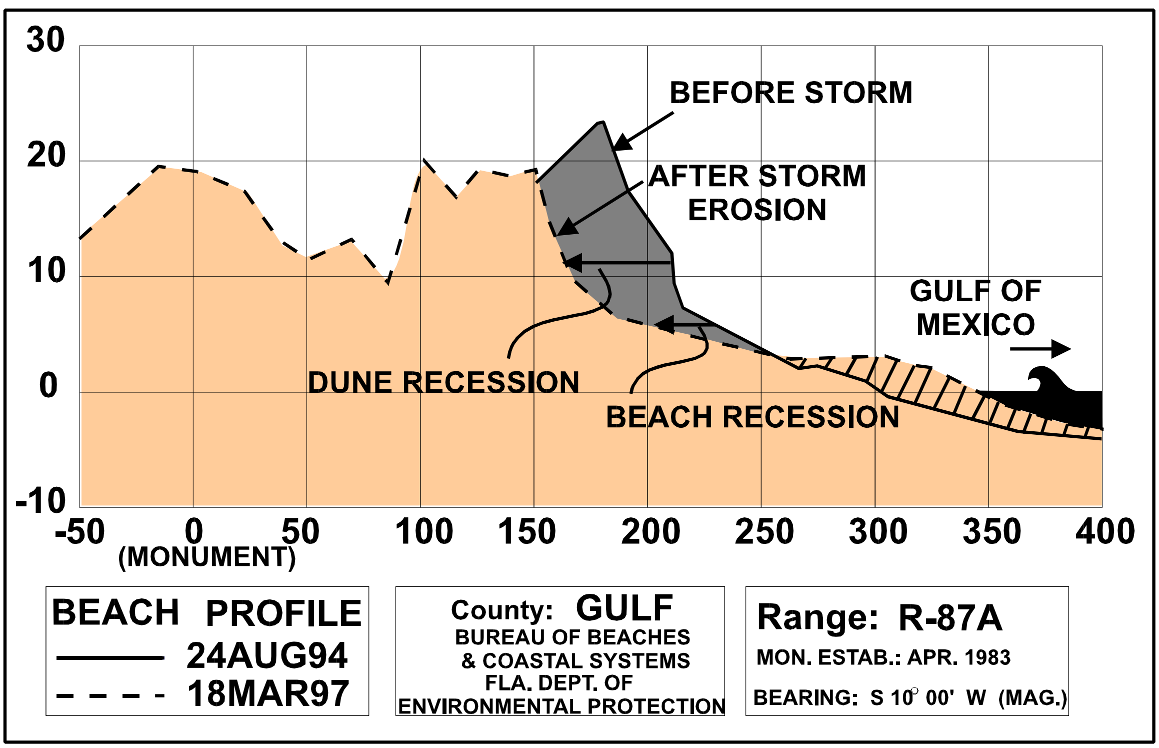

Figure 34. Beach and dune erosion from at R-87A Opal in Gulf County.

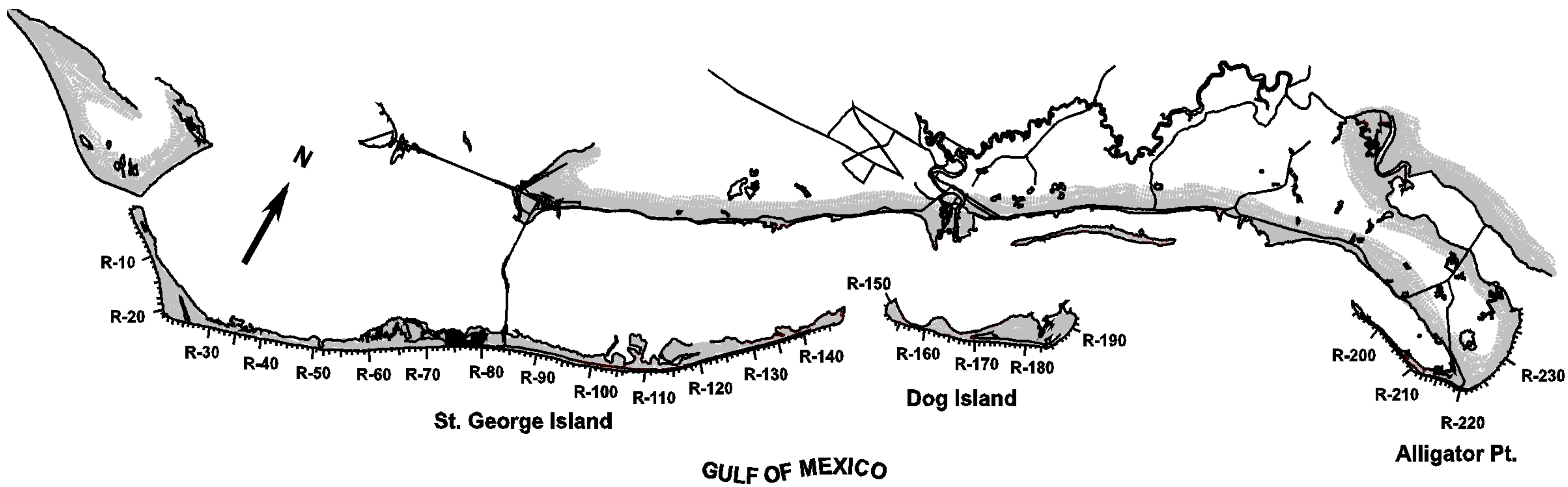

Figure 35. Franklin County Map Showing Locations of FDEP Survey Monuments

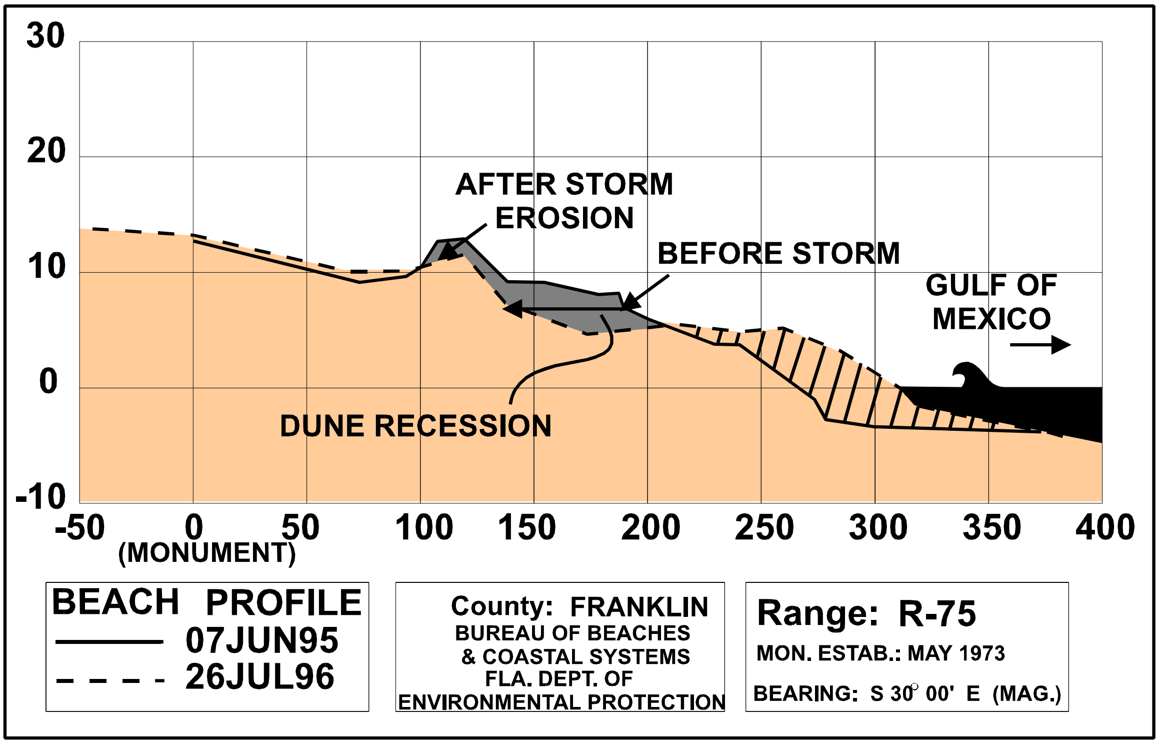

Figure 36. Beach and dune erosion from Opal at R-75 in Franklin County.

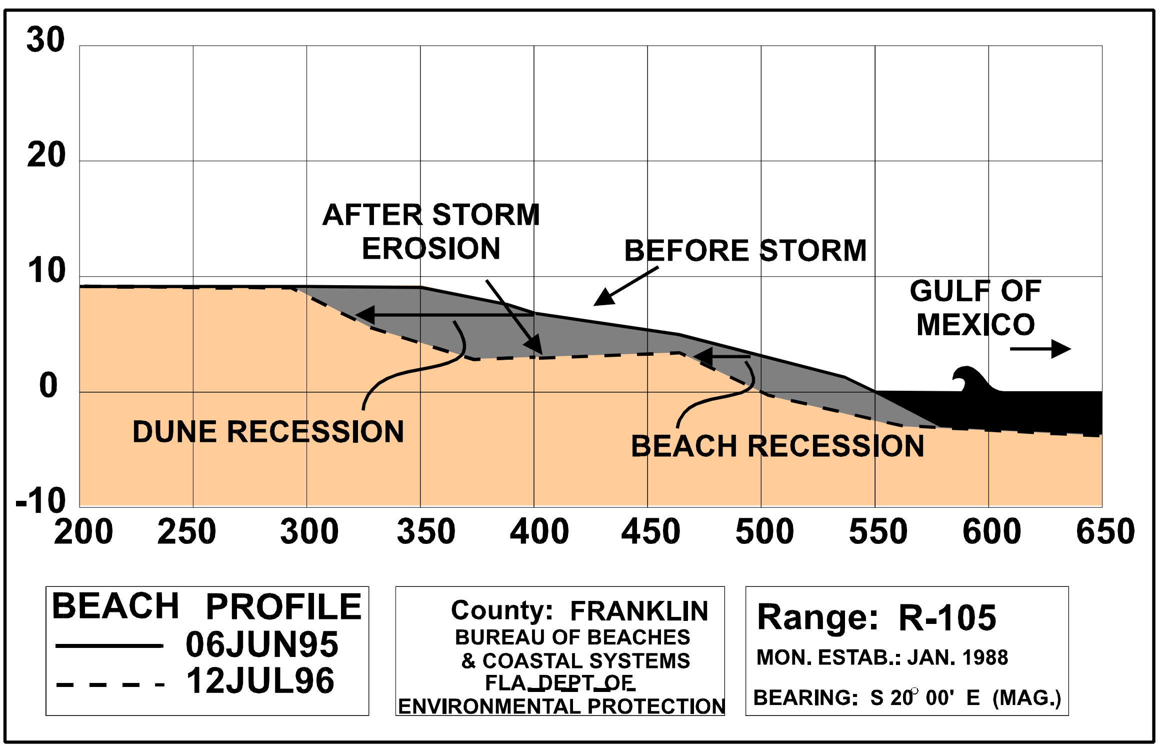

Figure 37. Beach and dune erosion from Opal at R-105 in Franklin County.

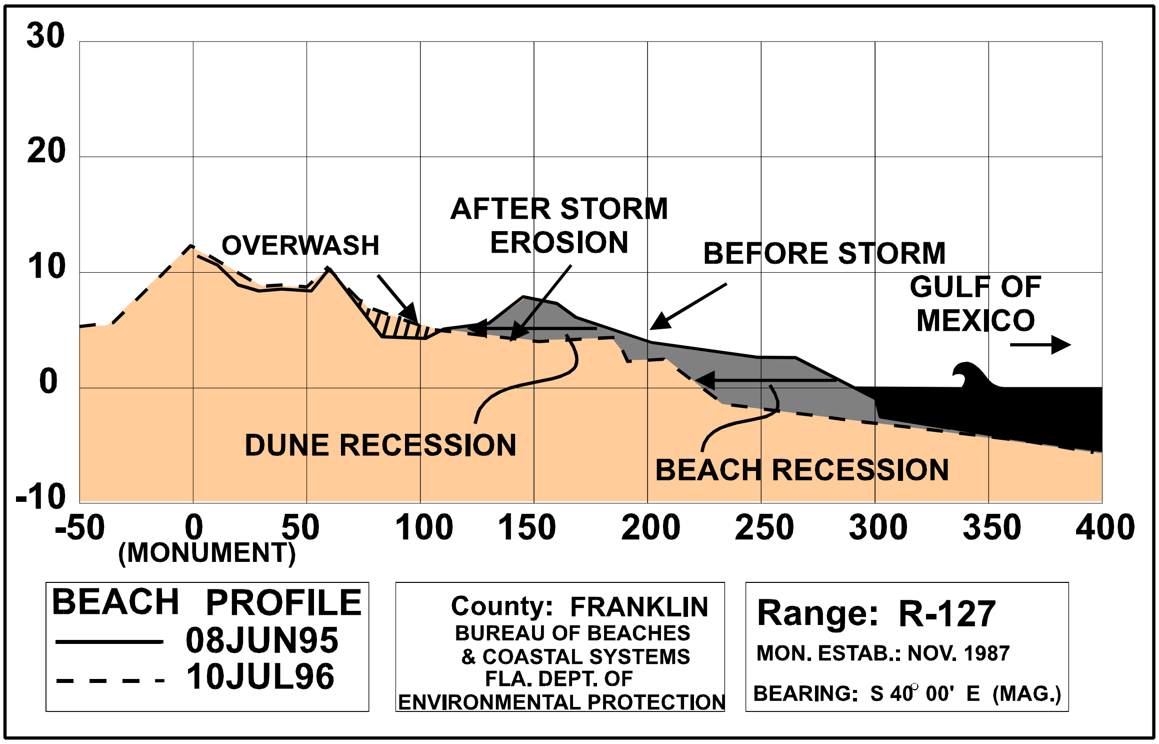

Figure 38. Beach and dune erosion from Opal at R-127 in Franklin County.

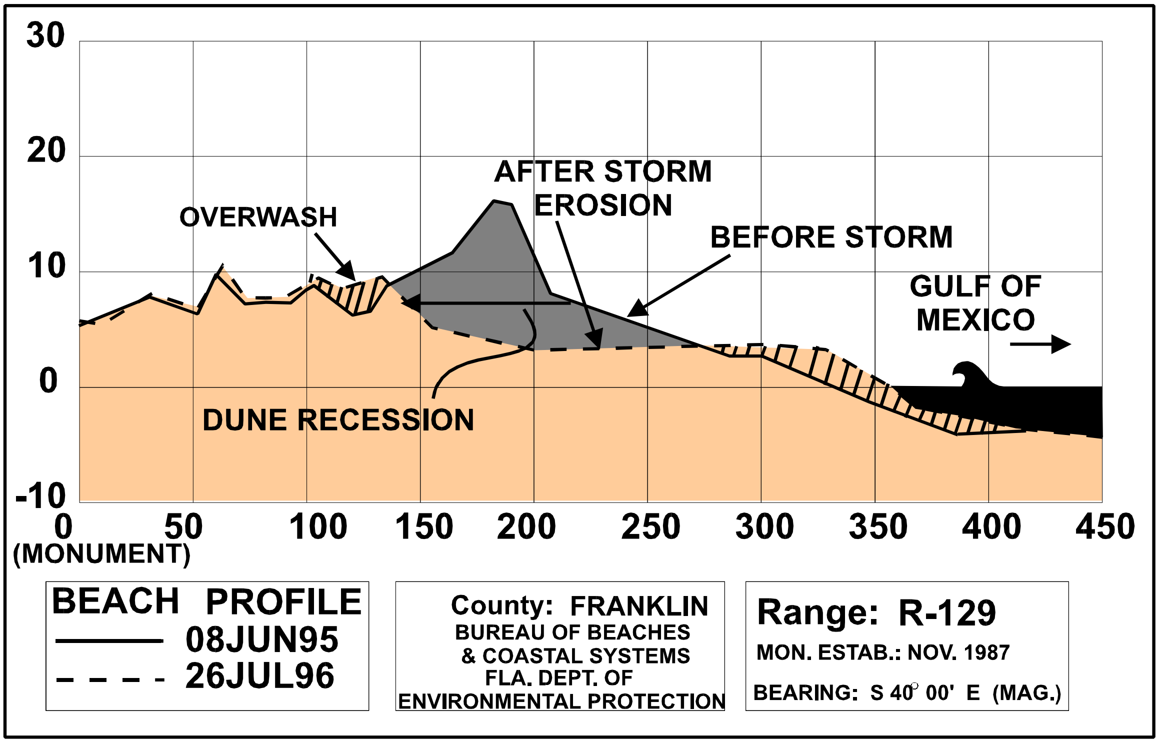

Figure 39. Beach and dune erosion from Opal at R-129 in Franklin County.

Bay County Beach and Dune Contour Recession and Volumetric Loss

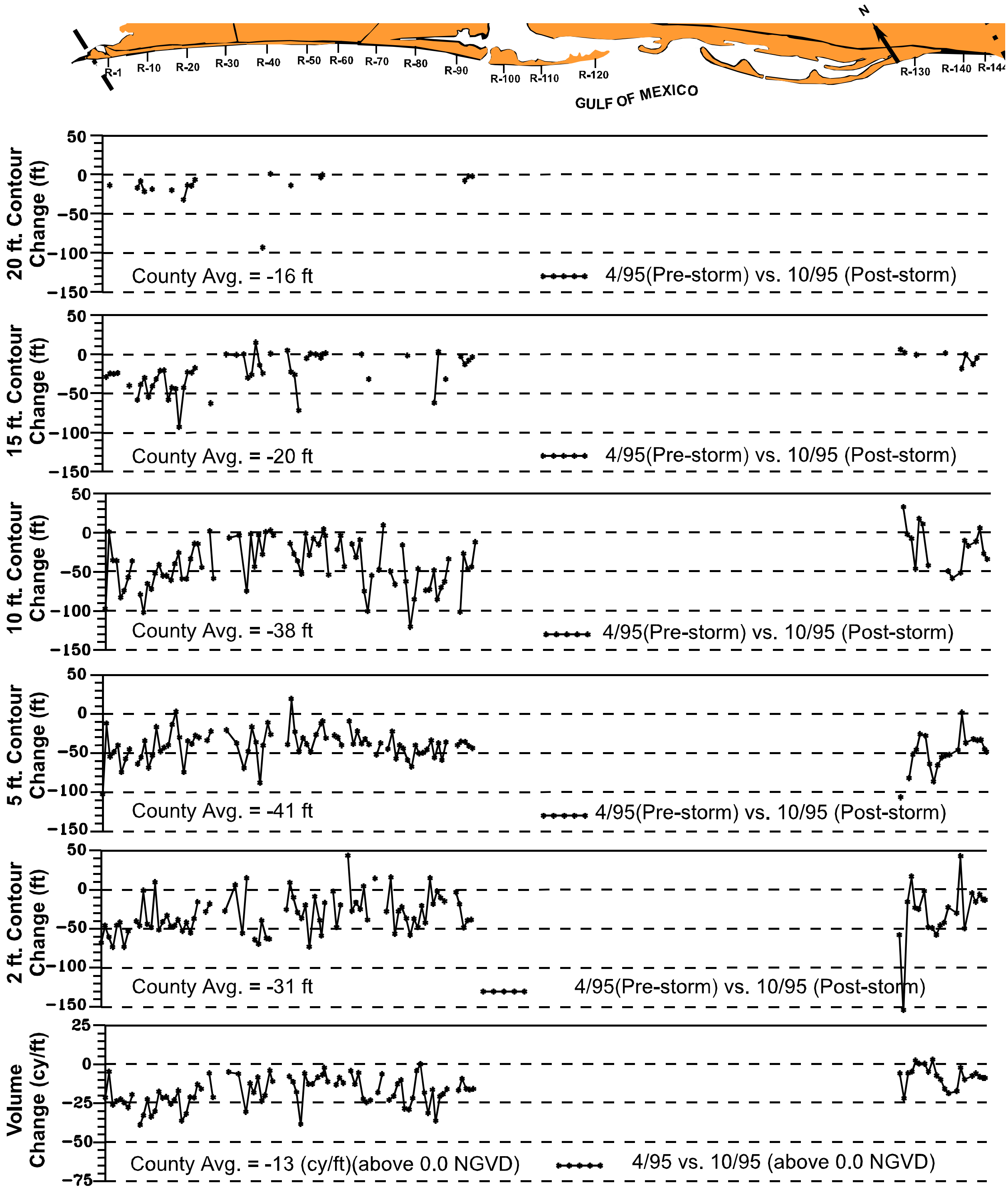

Figure 40. Alongshore distribution of 2, 5, 10, 15, and 20 foot contour recession and volumetric loss across Bay County.

Walton County Beach and Dune Contour Recession and Volumetric Loss

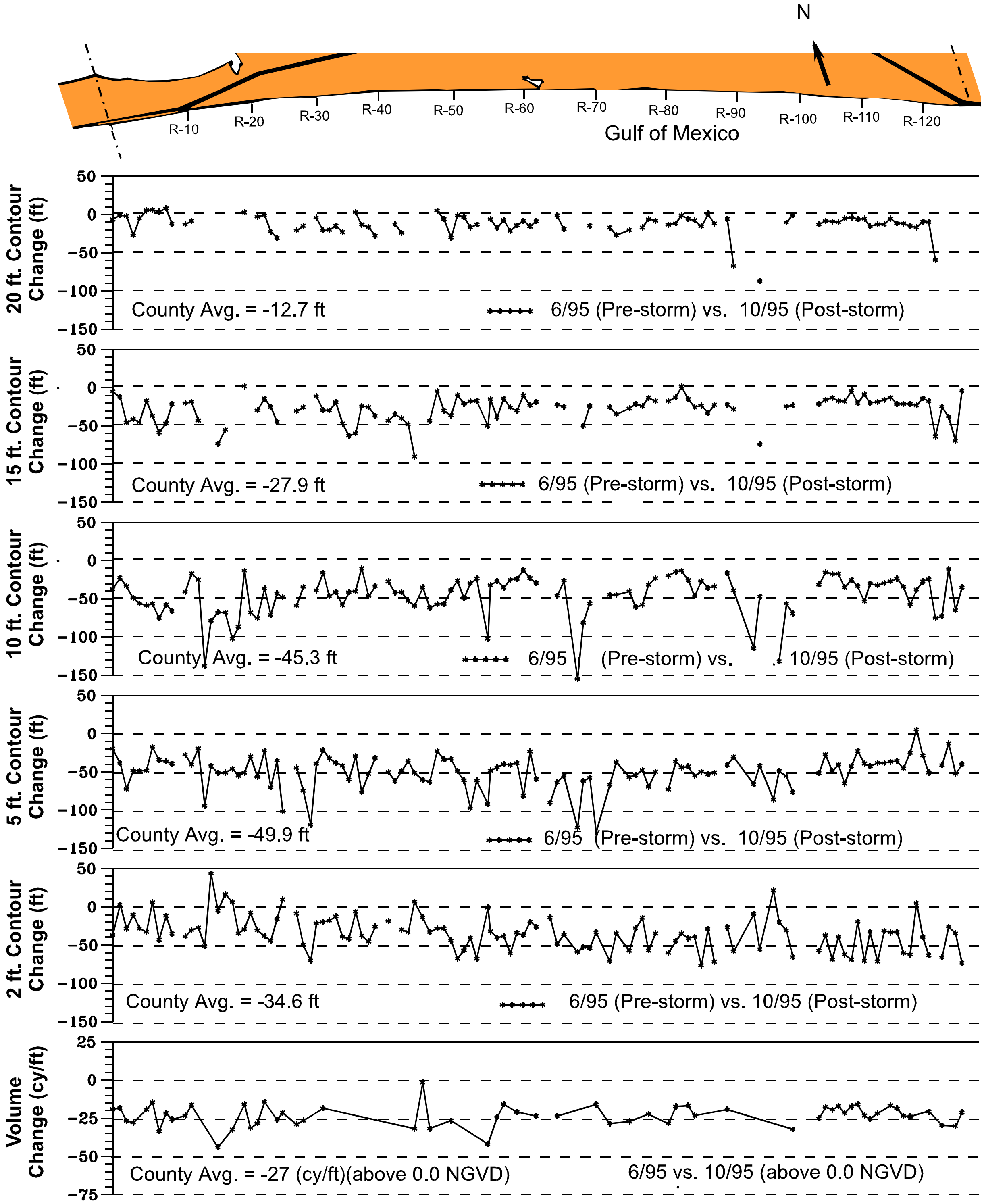

Figure 41. Alongshore distribution of 2, 5, 10, 15, and 20 foot contour recession and volumetric loss across Walton County.

Okaloosa County Beach and Dune Contour Recession and Volumetric Loss

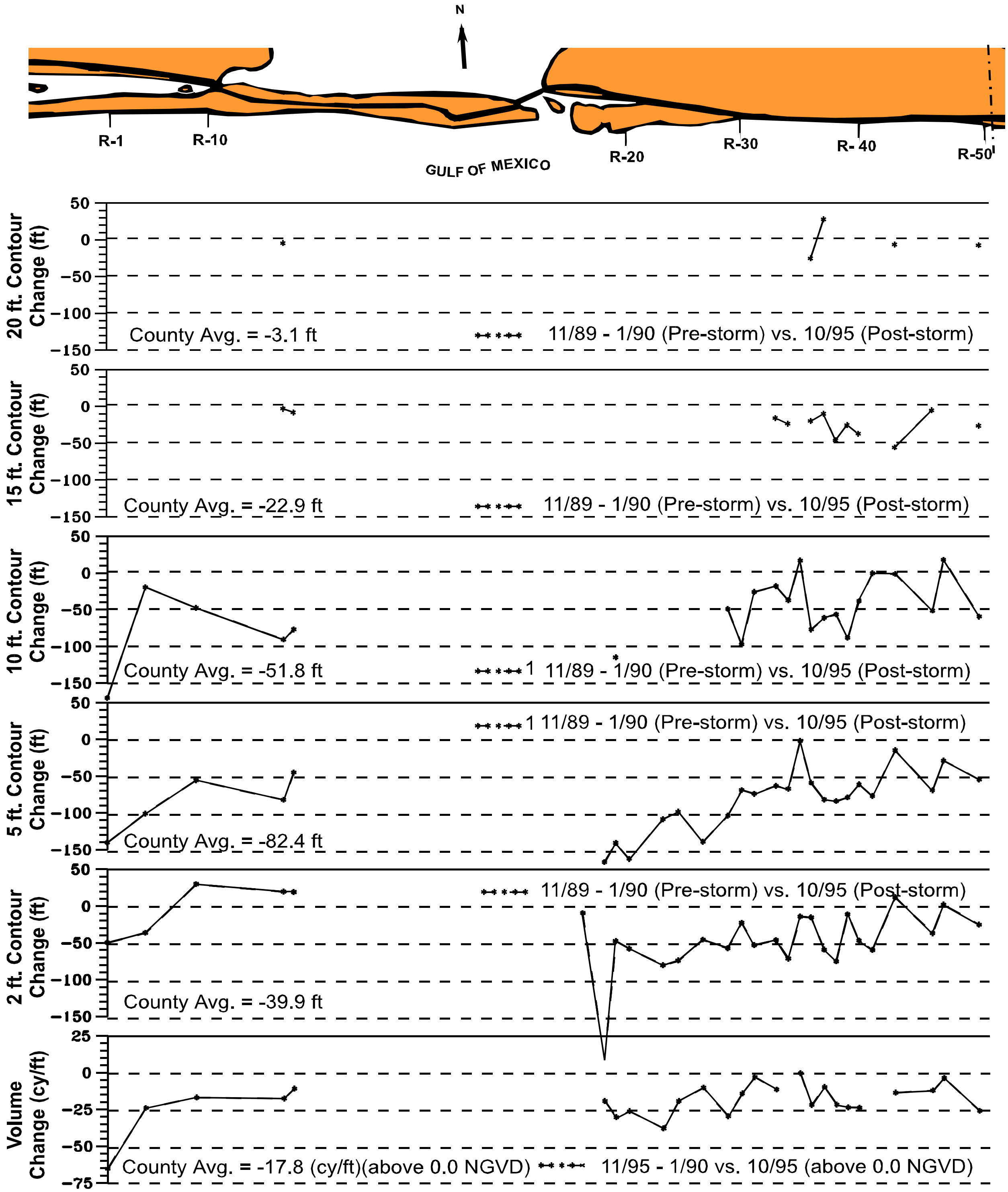

Figure 42. Alongshore distribution of 2, 5, 10, 15, and 20 foot contour recession and volumetric loss across Okaloosa County.

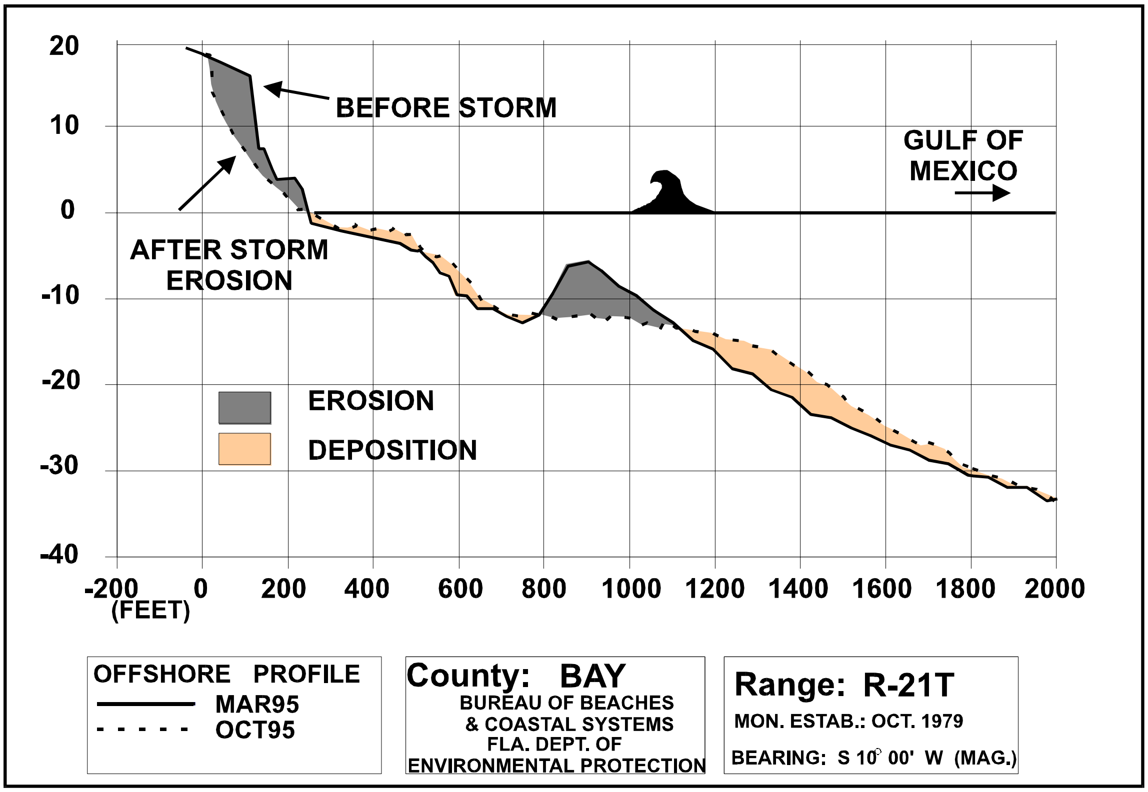

Figure 43. Dune erosion and offshore sand deposition at R-21T in Bay Co.

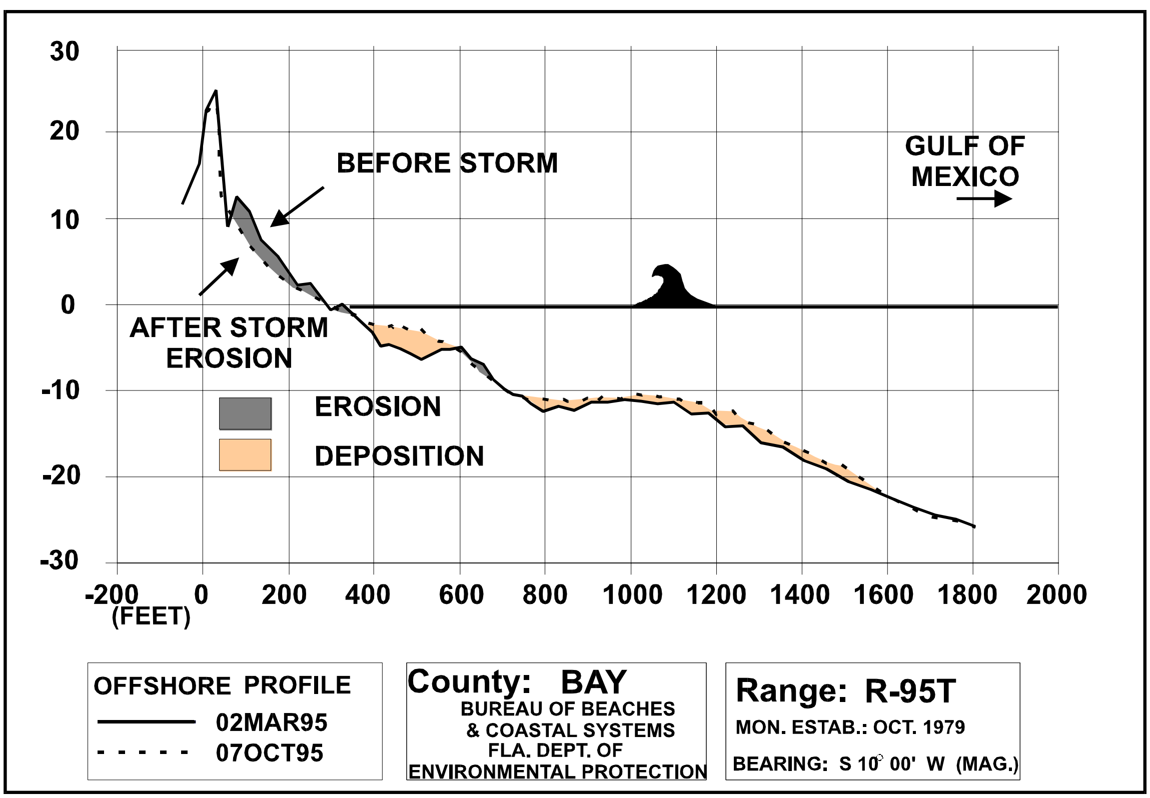

Figure 44. Dune erosion and offshore sand deposition at R-95T in Bay Co.

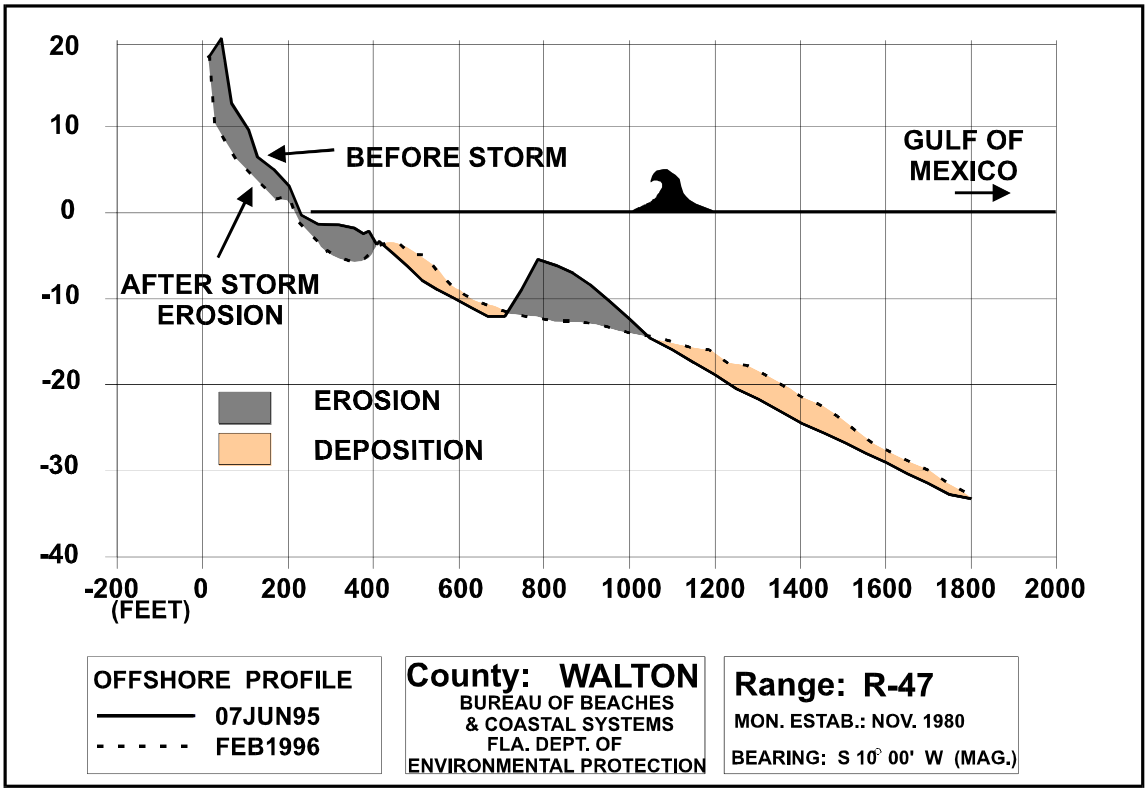

Figure 45. Dune erosion and offshore sand deposition at R-47 in Walton Co.

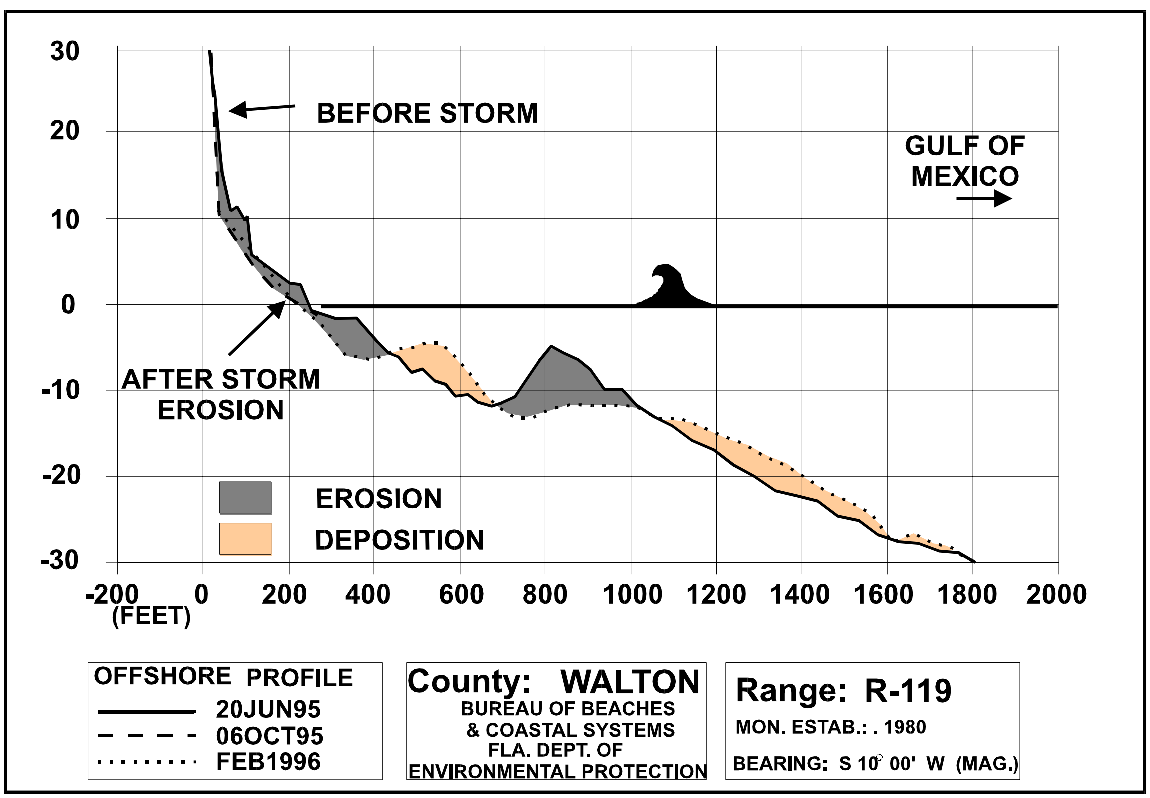

Figure 46. Dune erosion and offshore sand deposition at R-119 in Walton Co.

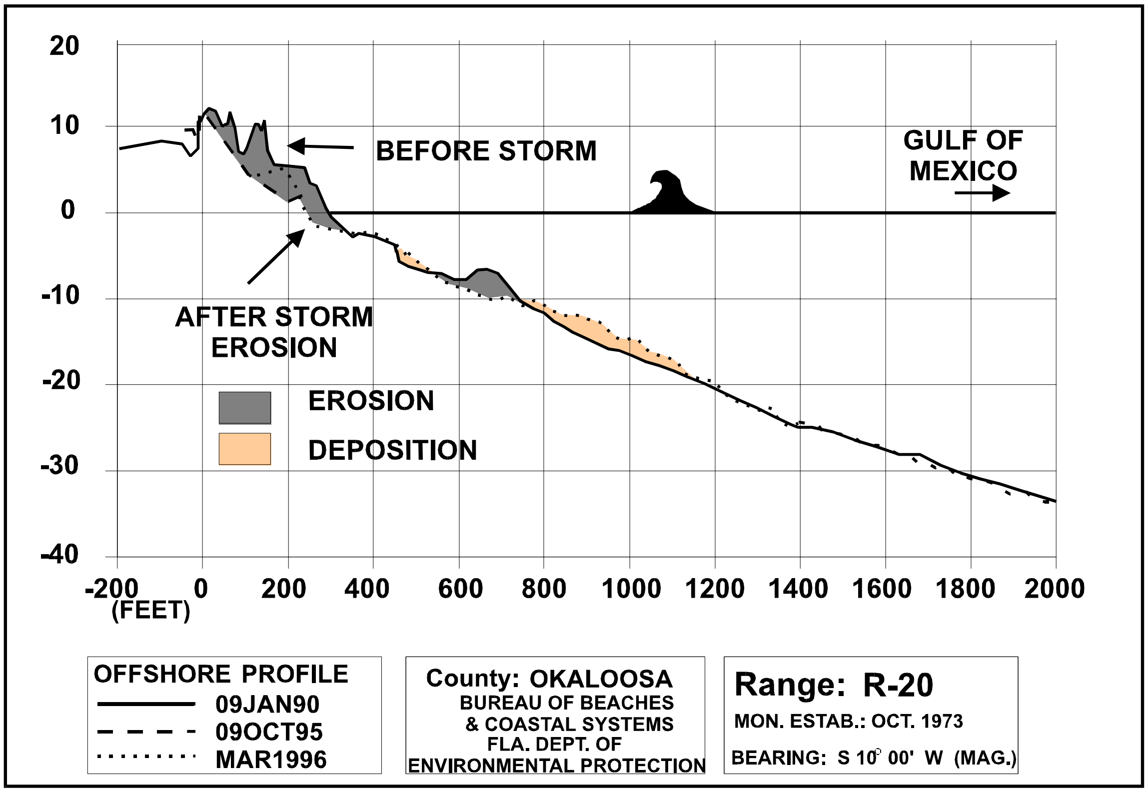

Figure 47. Dune erosion and offshore sand deposition at R-20 in Okaloosa Co.

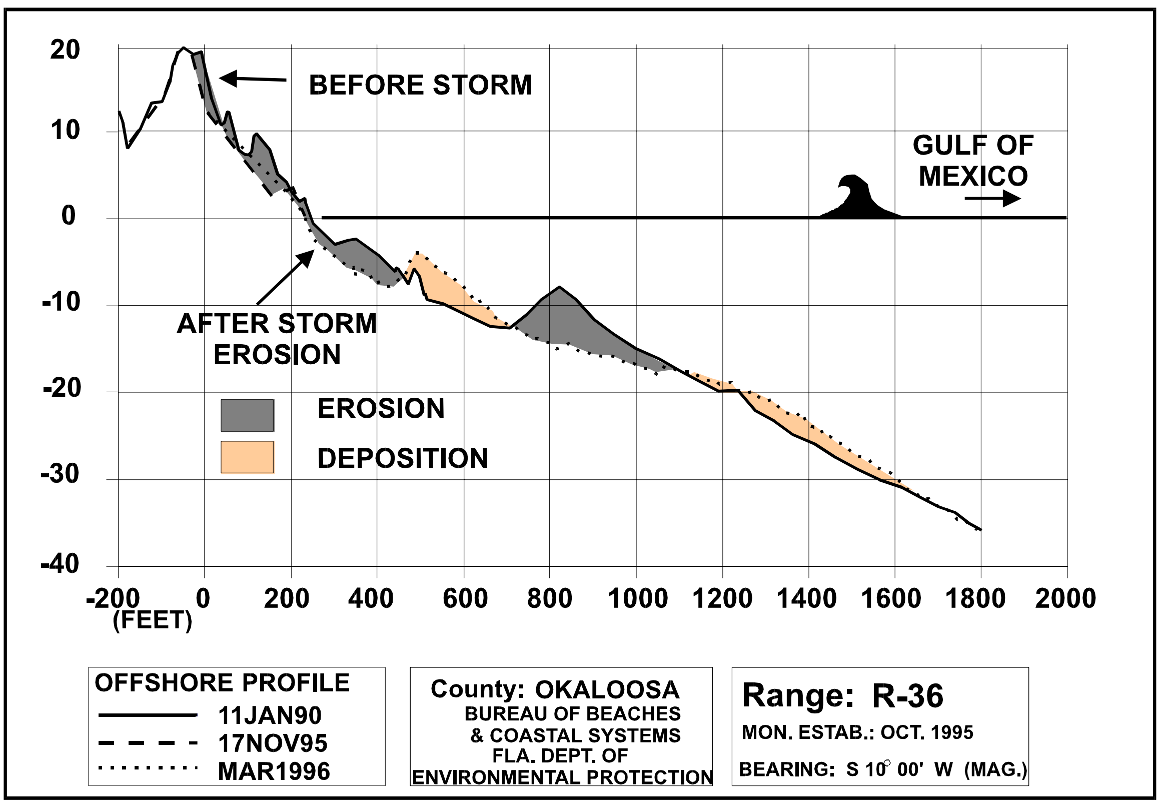

Figure 48. Dune erosion and offshore sand deposition at R-36 in Okaloosa Co.

Along the central Florida Gulf coast, a series of beach restoration projects provided valuable storm protection to coastal development. A simplified illustration of the extent of restoration projects along the central Gulf coast is given in Figure 49. The restoration projects generally are located within the more populated, developed areas which are most vulnerable to the threat of storm impact.

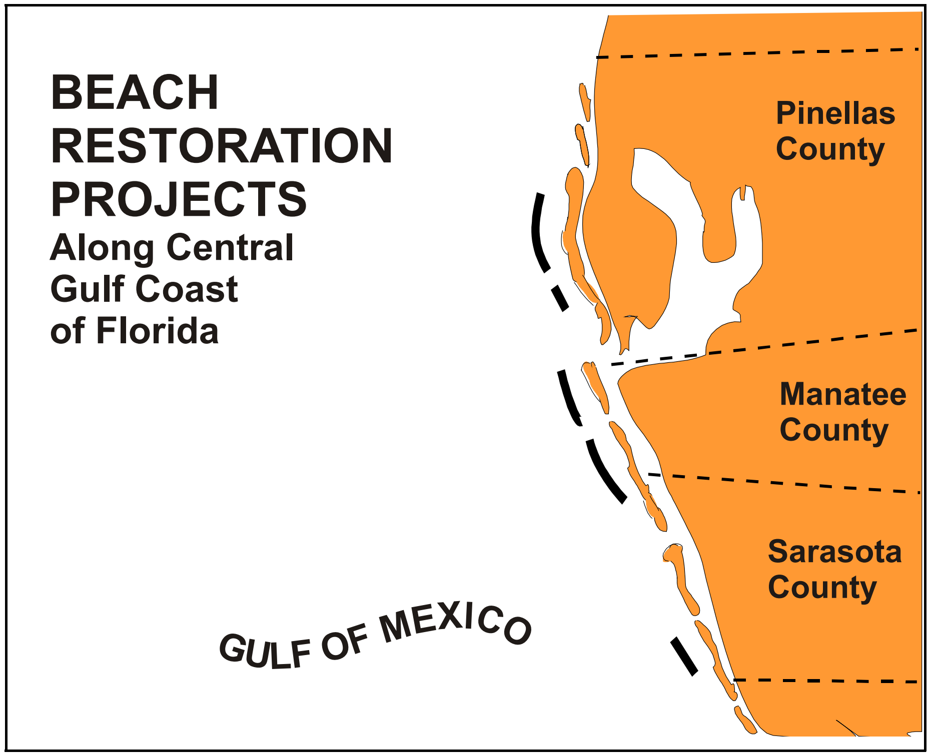

Figure 49. Beach restoration projects along central Gulf Coast of Florida

A view of erosion resulting from Opal along a critical segment of coastal roadway protected by beach restoration on Longboat Key in Sarasota County is shown in Figure 50 (Spadoni, 1995). Clearly, the restoration project provided valuable protection to this vital coastal road.

Figure 50. Erosion of beach restoration project on Longboat Key from Opal.

Other interesting, note-worthy erosional occurrences observed along the Panhandle Coast in the aftermath of Hurricane Opal are depicted in the following photographs.

Figure 51. Overwash deposition near Navarre Beach, Santa Rosa County. Note house transported by Opal and deposited into Santa Rosa Sound in the background.

Figure 52. Ground-level photo of the washout of U.S. Highway 98 just east of Ft. Walton Beach resulting from Hurricane Opal overwash (bay to left, Gulf to right).

Figure 53. Aerial view of erosional breach through Norriego Point connecting Destin-East Pass with Old Pass Lagoon (closed by USACOE after storm).

Figure 54. Ground-level view of breach through Norreigo Pt. At Destin-East Pass (looking toward Gulf of Mexico from Old Pass Lagoon).

Figure 55. Severe dune breach resulting from overwash in Escambia County (Direction of overwash is from left to right; ie, Gulf of Mexico to left, inland to right).

Figure 56. Cape St. George Lighthouse on Little St. George Island (already severe erosion area significantly worsened by Hurricane Opal.

IV. Structural Damage

Structural damage resulting from Hurricane Opal was severe across the Panhandle coast. The vast majority of damage within the coastal zone was due to the extensive storm surge and waves and associated erosion. Wind-induced damage was relatively minor. Most all of the damage occurred within a zone extending 200 to 300 feet from the shoreline, although damage was seen well landward of this distance. This most intensive damage zone coincided closely with the zone defined by the State of Florida's coastal construction control line (CCCL).

Table 2 provides a summary of structural damages which occurred in the Panhandle as a result of Hurricane Opal. Damages include severe damage (ie, greater than 50% of the structure destroyed) as well as total destruction. The figures in the summary below, as well as in the summary table on the following page, are revised damage figures from those previously compiled by R.R.Clark (Clark, in preparation) and reported by FDEP (FDEP, 1995).

TABLE 2
SUMMARY OF DAMAGES TO COASTAL STRUCTURES
(Structures with 50% or greater of structure destroyed)

County	Single Family Dwelling (SFD)	MultiFamily Dwelling(MFD)		Other Major Non-Habitable Structures	Armoring (feet)
		Bldgs.	Units		
Escambia	92	15	84	16	190
Santa Rosa	51	33	169	8	115
Okaloosa	41	76	484	57	3,450
Walton	80	19	77	6	1,475
Bay	145	200	1,057	49	11,730
Gulf	18	4	14	4	475
Franklin	7	0	0	0	0
Total	434	347	1,885	140	17,435

Note: The above summary is a revision of damage summaries previously reported by FDEP; Revised damage figures above were compiled by R.R. Clark.

Bay County sustained the most overall structural damage due to the high density of development and large number of structures which were not designed and constructed adequately to withstand the impacts of a major (ie, 100-year frequency) hurricane. The CCCL for Bay County had not been reestablished prior to Opal as it had been for the other Panhandle counties. Therefore, habitable structures in Bay were not required to meet the more stringent siting and design standards of the State's CCCL program intended to prevent structural damage from a major hurricane like Opal.

The positive effects of the CCCL on reducing storm damage through improved construction design and siting were clearly observed following Opal. Table 3 demonstrates the positive influence of the CCCL program on the Panhandle counties in preventing structural damage as related to Hurricane Opal. As shown in this table, over a quarter of the major habitable structures seaward of the CCCL's were permitted structures. Almost half of the non-permitted structures were seriously damaged or destroyed while only two permitted structures were seriously damaged.

TABLE 3

STRUCTURAL DAMAGE OF MAJOR HABITABLE STRUCTURES (MHS) SEAWARD OF CCCL ALONG PANHANDLE

County	**Number of MHS**		**Number of MHS Damaged**	
	Existing	**Permitted**	**Non-Permitted**	**Permitted**
Escambia /Santa Rosa	316	50	157	0
Okaloosa	134	24	53	0
Walton	443	196	71	1
Bay	600	45	341	1
Gulf	316	80	22	0
Franklin	377	181	7	0
Total	2186	576	651	2

Note: The above summary is a revision of damage summaries by R.R. Clark which were previously reported by FDEP.

It should be noted that the two permitted habitable structures which were damaged by Hurricane Opal were permitted under earlier, less-stringent permit standards. The damage to the single-family dwelling in Bay County, constructed in 1981, occurred to the portion of the structure located landward of the CCCL which was not required to be built to CCCL permitting standards. A statutory change in 1982 has since required all portions of permitted structures to conform to permit design standards.

The damaged single-family dwelling in Walton County was permitted in 1981, seaward of the old coastal setback line, prior to the CCCL reestablishment in 1982 which introduced more stringent permit design standards. The number of structures for Bay County listed in Table 3 are based on the location of an interim CCCL for Bay County adopted after Opal which was an additional 100 feet further upland than the original, pre-Opal CCCL for Bay County. The interim CCCL was subsequently adopted in 1996 as the reestablished CCCL for Bay County.

The performance of the permitted structures exposed to the same conditions as the non-permitted structures shows the positive effect of the CCCL program in reducing damages from major storms such as Hurricane Opal. The post-storm photographs shown in Figures 57 through 62 on the following pages are representative of the types of damage from Opal. Some of the photographs illustrate that design and siting of habitable structures were critical to survivability of the structures.

Pile-supported dwelling structures were able to survive the loss of soil support beneath habitable floors where structures on soil-bearing foundations could not survive erosional losses. Despite pile foundations, some habitable structures were still destroyed as a result of low, inadequate floor elevations which allowed storm surge and wave penetration into the habitable portions of the structures or as a result of inadequate pile penetration.

Habitable structures which were sited sufficiently landward of eroding dune blufflines survived any significant damage, as can be seen in the photos of structural damage in Gulf and Franklin counties on the following pages. In contrast, structures located in areas of eroding dune blufflines were undermined and sustained significant damage or destruction when not designed on adequate foundations to withstand the erosion, as seen in the photos.

A detailed description of structural damage which occurred along the Panhandle Coast as a result of Hurricane Opal is given in Appendix C of this report. The detailed structural damage account is presented in a county-by-county format and includes more detailed summary tables of structural damages for each county. The damage summary tables provide the same information listed in Tables 2 and 3 above, but are broken out in more detail as to specific type of structural damage.

POST-HURRICANE OPAL STRUCTURAL DAMAGE

Figure 57. Escambia County - Example of destroyed major habitable structure in Pensacola Beach.

Figure 58. Escambia County - Pensacola Beach. This shows the contrast between a pile-supported structure which survived Opal and a poorly-designed one which did not.

Figure 59. Walton County - Dune Allen. Contrast between a pile-supported structure which survived Opal and a poorly-designed one which did not.

Figure 60. Bay County - Panama City Beach. This shows a seawall which was destroyed and did not protect the severely damaged multi-family dwelling from Opal.

POST-HURRICANE OPAL STRUCTURAL DAMAGE

Figure 61. Gulf County - St. Joseph Peninsula. Poorly-sited and poorly-designed structure destroyed compared to permitted structures with better siting and design.

Figure 62. Franklin County - Dog Island. Major habitable structure with poor siting destroyed, over 150 miles from the point of landfall of Hurricane Opal.

IV. Post-Storm Response and Recovery

The aftermath of Opal presented a number of difficulties for property owners and local, state, and federal governments. Post-Opal response and recovery efforts will continue well into the future and include extensive rebuilding, as well as, dune and beach restoration work and other remedial projects.

One particularly problematic recovery issue has involved overwash sand removal and debris removal. The photo below (Northwest Florida Daily News, 1995) depicts a typical scene in the western Panhandle (Destin) where a roadway and other upland properties have been completely inundated by overwash sand. In some of the western Panhandle areas, such as Pensacola Beach and Ft. Walton Beach, extensive volumes of overwash sand were retrieved and placed back in pre-storm dune areas to assist in dune recovery efforts.

Figure 63. Typical Post-Opal aftermath depicting excessive overwash sand covering roads and upland properties (Gulf of Mexico is to the left beyond the gulf-front buildings).

A major concern has involved the potential of hazardous debris which may be buried beneath the sand or in nearshore areas. The photo shown in Figure 64 on the following page illustrates typical extensive debris which littered coastal areas following the storm.

Widespread beach scraping was undertaken in the weeks following Opal. The scraping generally consisted of bulldozing of sand from locations at or below the mean high water line and pushing the sand into upland areas at the base of an eroded dune or to partially reform an eroded dune. A photograph of a typical beach scraping operation is shown on the following page.

Figure 64. Typical Storm Debris in Panhandle Areas Following Hurricane Opal (Spyglass Drive area of Panama City Beach)

Figure 65. Typical Beach Scraping Along Panhandle After Hurricane Opal

The beach scraping can be expected to produce mixed results, particularly in areas where sand was already depleted from the active beach/dune profile either through overwash or longshore transport. Initial post-scraping inspections showed a lower, narrower beach in scraped areas compared to non-scraped areas. The FDEP authorized some limited-scale scraping to assist property owners and local communities in recovery efforts. Authorized scraping was to consist of excavation of no greater than one foot in elevation from the intertidal zone. However, in many cases, excavation greatly exceeded the authorized limits with bulldozer cuts in excess of three to four feet.

Long-term impacts of scraping are being analyzed in post-storm studies which are underway by the FDEP to further assess Opal's impact. The studies also include more in-depth studies of beach and dune erosion, overwash, and post-storm recovery of the beach and dune system. The studies will look at the effects of beach scraping on natural recovery processes. The FDEP has contracted with the University of Florida's Coastal and Oceanographic Engineering Department to perform much of these more extensive analyses. An engineering consulting firm, Post, Buckley, Schuh, and Jernigan, Inc., contracted by the FDEP to assist in post-storm recovery activities will also be analyzing overall response and recovery of the Panhandle coastal areas.

Post-Storm Recovery Plan

A post-storm beach and dune recovery strategic management plan for the Panhandle coast was developed by the FDEP in the initial months after Opal (FDEP, 1996) that identified critically-eroded areas following the storm. The critically-eroded areas, shown in Figure 66, generally correspond to the most highly-developed areas in the region which are most vulnerable to storms.

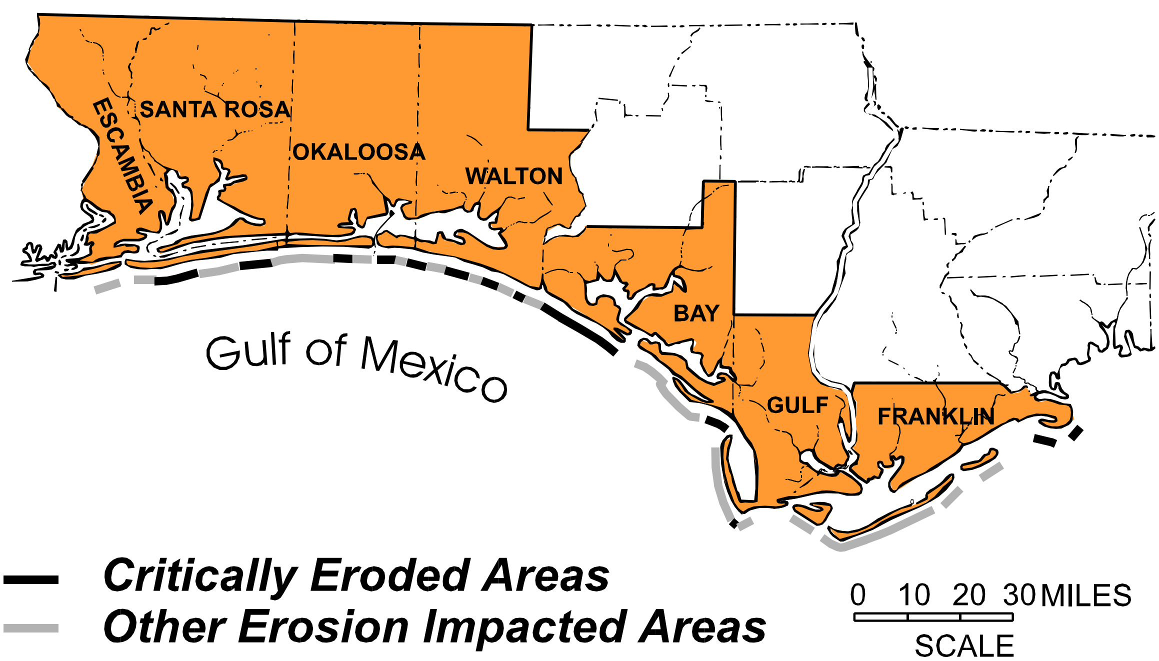

Figure 66. Illustration of the critically-eroded areas across the Panhandle Coast.

The six county northwest Florida Gulf of Mexico beaches extend across 221 miles, of which about 79 percent or 175.5 miles were determined to be significantly eroded by Hurricane Opal, as shown on the map illustration in Figure 66. A total of 65.5 miles of critically-eroded coast within this region, also highlighted on the map, were determined to have substantial development interests which were vulnerable to further damage unless mitigative, corrective action was taken. A listing of the designated critical erosion areas, their county location, and shoreline length is given in Table 4 below.

TABLE 4

EROSION PROBLEM AREAS VULNERABLE TO FURTHER DAMAGE AND REQUIRING MITIGATIVE ACTION

Area	County	Length, Miles
Pensacola Beach	Escambia	7.0
Navarre Beach	Santa Rosa	3.6
Ft. Walton Beach	Okaloosa	3.0
Destin	Okaloosa	2.9
Eastern Okaloosa	Okaloosa	2.1
Western Walton	Walton	5.2
Beach Highlands/Dune Allen	Walton	2.9
Blue Mountain	Walton	1.0
Seagrove Beach	Walton	3.1
Seacrest Beach	Walton	1.7
Panama City Beaches	Bay	17.5
Mexico Beach	Bay	2.8
St. Joseph Peninsula	Gulf	1.4
St. George Island State Park	Franklin	8.4
S.W. Cape, Alligator Pt.	Franklin	1.1
Lighthouse Pt.	Franklin	1.8
TOTAL		65.5

The recovery plan outlines recommended recovery measures and cost estimates for those measures. The major recovery projects identified include post-Opal debris removal and dune restoration work, as well as, beach restoration for Panama City Beach and improved inlet management, among others. Extensive dune restoration has been performed in the months following the storm through county-by-county implementation with FDEP assistance and oversight. Debris removal from submerged lands in the Gulf and inland waters has been performed by the State to augment upland debris removal by local governments. Photos on the following page depict dune restoration and debris removal projects performed under the plan. The house removal shown is the same house shown in Figure 51 deposited in Santa Rosa Sound.

Figure 67. Dune restoration work; sea oat planting and sand fencing; Panhandle Coast.

Figure 68. Marine debris removal; house deposited by Opal into Santa Rosa Sound.

F.E.M.A. Post-Storm Assistance

Following the impact of Hurricane Opal, the Federal Emergency Management Agency (FEMA) provided federal assistance to local governments and municipalities in post-storm recovery efforts. In order to protect vulnerable upland structures, FEMA directed a recovery program to construct temporary protective dunes in qualifying areas across the Panhandle. This program consisted of constructing a protection structure, in many cases in the form of a low-profile berm. Sand to construct the berm was obtained from retrieval of overwash sand, as performed in Pensacola Beach and Ft. Walton Beach, from beach scraping, as performed in much of Okaloosa, Walton, Bay and Gulf Counties, or from truck hauls from upland sources, as in Santa Rosa County. This protection was considered to be minimal and temporary.

FEMA has also provided funding to assist local governments in reconstructing damaged dune walkover structures at public access locations. FEMA funds were also provided to local governments to repair and replace damaged infrastructure. FEMA assistance was also provided to State parks for repair and replacement of infrastructure and of some of the park facilities. However, FEMA did not provide funds for dune restoration projects in the parks.

Beach and Dune Profile Response and Recovery

In addition to the beach and dune profile survey data obtained by FDEP which is discussed and displayed in Section III of this report, beach and offshore profile survey data was collected by FDEP at 3-month and 1-year post-storm intervals. A two-year survey is also being conducted at the time of this report preparation. Plot overlays of pre-Opal and post-Opal profiles, including the 3-month and 1-year survey data, at a number of FDEP monuments across the Panhandle are given on the following pages in Figures 69 through 76 and Figures 79 and 80.

The plot overlays include various combinations of profiles for Escambia, Okaloosa, Walton, and Bay counties. All plots include onshore and offshore data, except for the plot of profiles at R-178 in Escambia County. Bay County is the only county with immediate post-Opal offshore profile data. However, the 3-month post-Opal profiles collected in the other three counties still provide a good representation of the offshore response to Hurricane Opal.

The presentation of long-term profile response and recovery is not extensive in this report. For example, the effects of beach scraping is not examined herein. Other post-storm studies are being conducted under contract by the FDEP and are analyzing these effects in more detail. Some review and comments are provided below, particularly some insight into offshore profile response.

In terms of onshore post-storm response, comparison of profiles in the plot overlays shows varying effects along the western Panhandle region from Bay through Escambia counties. In Bay County, very little beach or dune recovery is seen in areas unaffected by man-assisted recovery activities such as shown at R-95T, although some berm recovery is seen. Beach scraping effects are seen at R-10 where the dune shows significant recovery as a result of scraping activities.

Onshore post-storm response in Walton County shows some berm recovery at R-15, but very little beach recovery at R-47, and no substantial dune recovery at these locations over the one-year post-storm period. Okaloosa County does show effects of beach scraping to establish the FEMA protective berm, as well as some man-assisted dune recovery. In Escambia County, berm recovery is evident in the one-year post-Opal surveys. Dune restoration activities were conducted extensively thoughout the Pensacola Beach portion of Escambia County where overwash sand was retrieved from upland areas and returned to the eroded dune areas. The photographs shown in Figures 77 and 78 illustrate this dune restoration work. The plotted profiles shown at R-168 and R-178 in Escambia County are both in undeveloped areas where no post-Opal dune restoration activities have been performed. Natural dune recovery is not seen in these undeveloped areas over the one-year post-Opal period. Eventual natural dune recovery is expected in the undeveloped areas.

In terms of offshore post-storm response, comparison of the various offshore surveys shows significant, on-going change within the nearshore regions (ie, above -12 ft., NGVD) with the nearshore bar seen in pre-Opal profiles being eroded and then fluctuating in shape and location over the post-Opal one-year period. This fluctuation is probably a response to minor storm activity which occurred in late summer/fall of 1996, as much as a response to post-Opal recovery. The deeper offshore portions of the profiles (ie, below -12 ft., NGVD) consistently show extensive deposition out to depths of -30 ft. (NGVD) and greater.

It is interesting that, in viewing this deeper water deposition on the Bay County profile plots, comparison of the immediate post-Opal profiles (from October 8, 1995) with the subsequent 3-month (January/February 1996) profiles shows initial lowering of elevations in the offshore deposition area. It would appear that sand from this offshore deposition area has been transported out of this area, presumably to shallower, shoreward depths. However, observation of the entire profile lengths does not readily reveal to where this sand may have been transported. In order to substantiate where the offshore sand has been transported to, an extensive volumetric computation over the entire profile length for all the available profiles would need to be conducted. Such an analysis has not been conducted as a part of this report.

It is also interesting that comparison of the 3-month to 1-year post-Opal surveys shows little, if any, elevation change in the deeper-water deposition area over that time period, even though the nearshore area shows continued elevation fluctuations. It appears that the offshore deposition area has reached some equilibrium-type condition. It is possible that the initial elevation lowering of the offshore area seen in comparing the immediate post-storm and the 3-month post-storm surveys was a result of consolidation or settling of the sand deposited by Hurricane Opal. Such consolidation, and subsequent lowering, was observed in dredge disposal deposits at similar offshore depths off Perdido Key following dredge disposal events (personal communication, Robert G. Dean).

Post-Opal Reconstruction and Rebuilding

In terms of rebuilding, the obvious issue was to rebuild to sufficient standards to prevent another occurrence like that experienced from Opal. A measure taken by the FDEP, in the wake of Opal, to assist in ensuring that damaged construction is rebuilt to improved design and siting standards

Bay County Post-Opal Profile Response

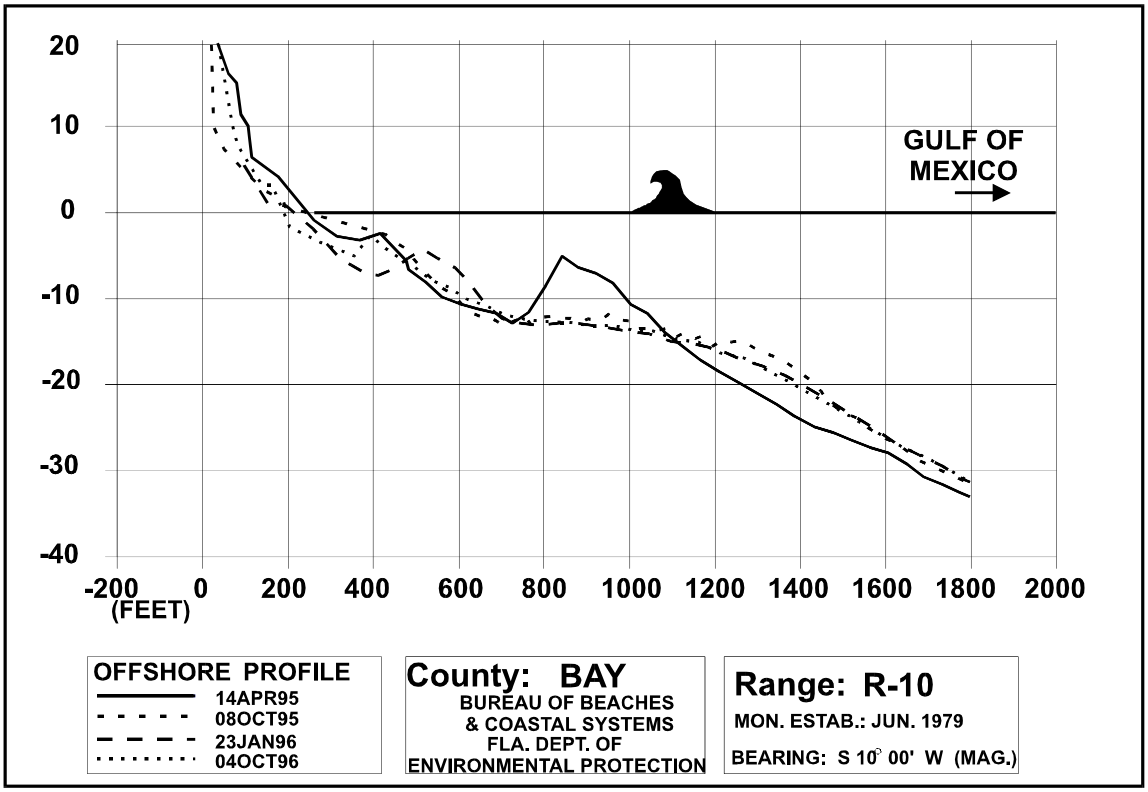

Figure 69. Pre-Opal through one-year post-Opal profile response in Bay Co.

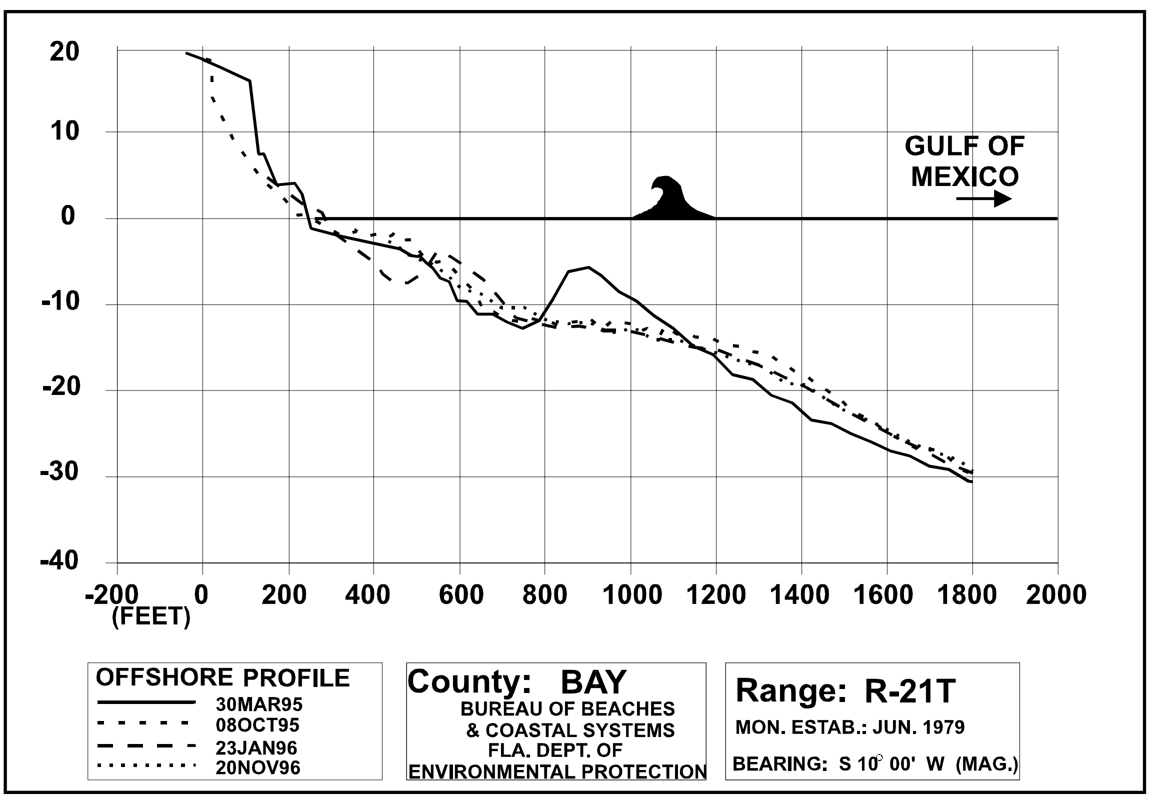

Figure 70. Pre-Opal through one-year post-Opal profile response in Bay Co.

Bay County Post-Opal Profile Response

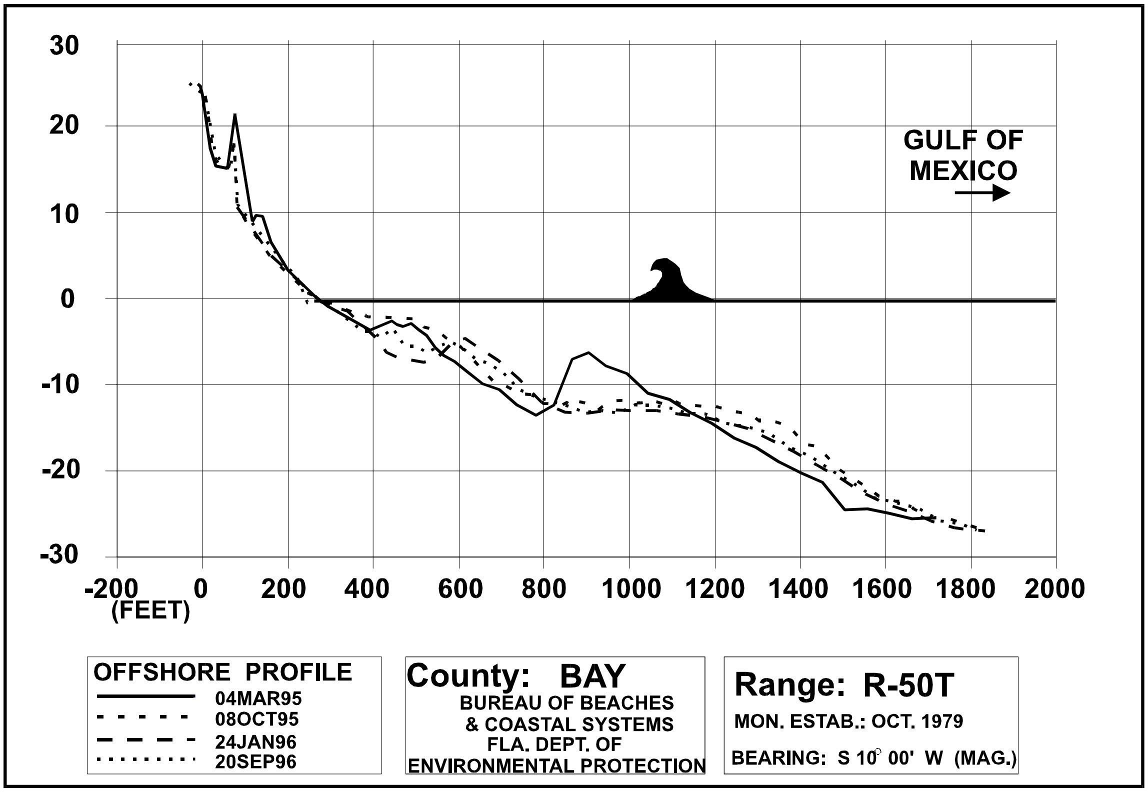

Figure 71. Pre-Opal through one-year post-Opal profile response in Bay Co.

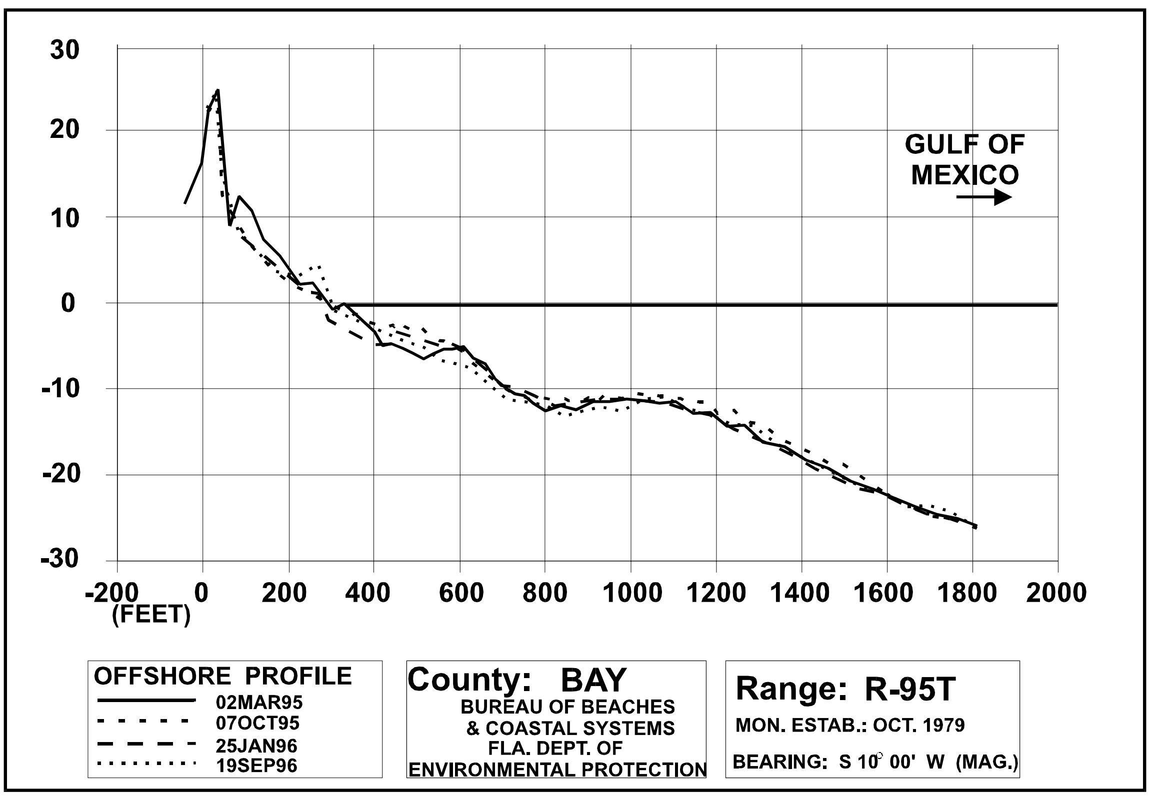

Figure 72. Pre-Opal through one-year post-Opal profile response in Bay Co.

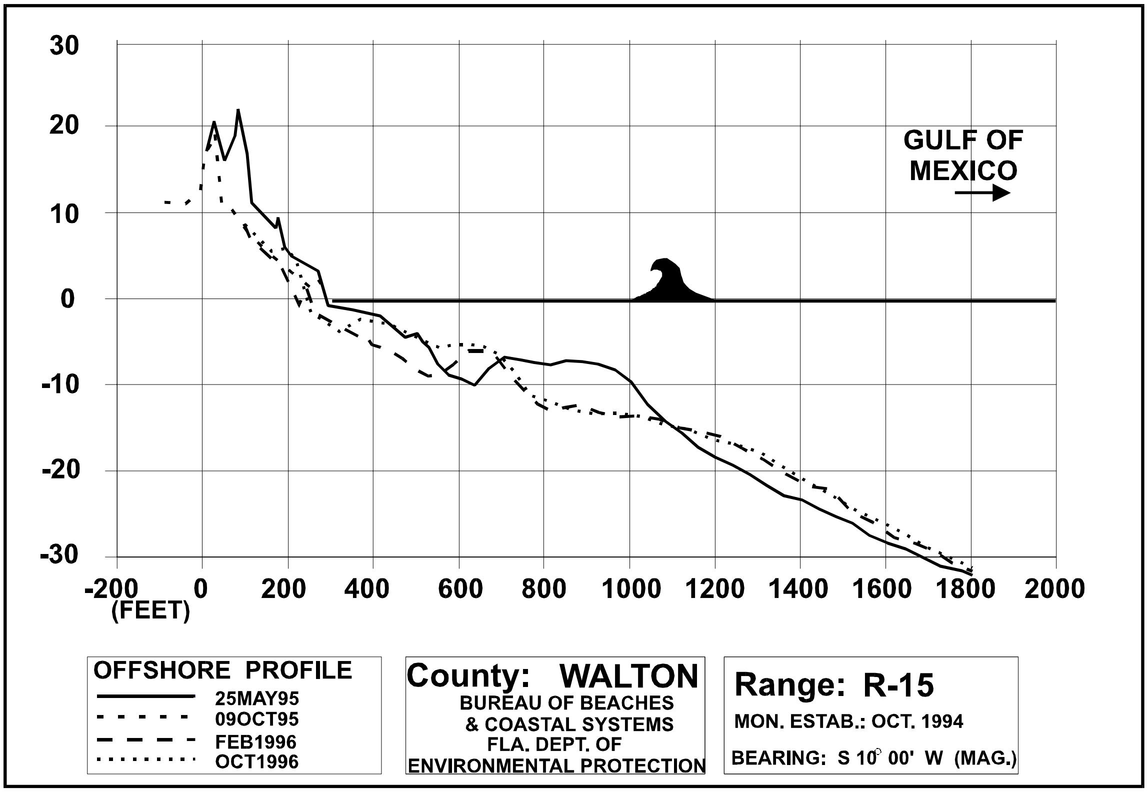

Figure 73. Pre-Opal through one-year post-Opal profile response in Walton Co.

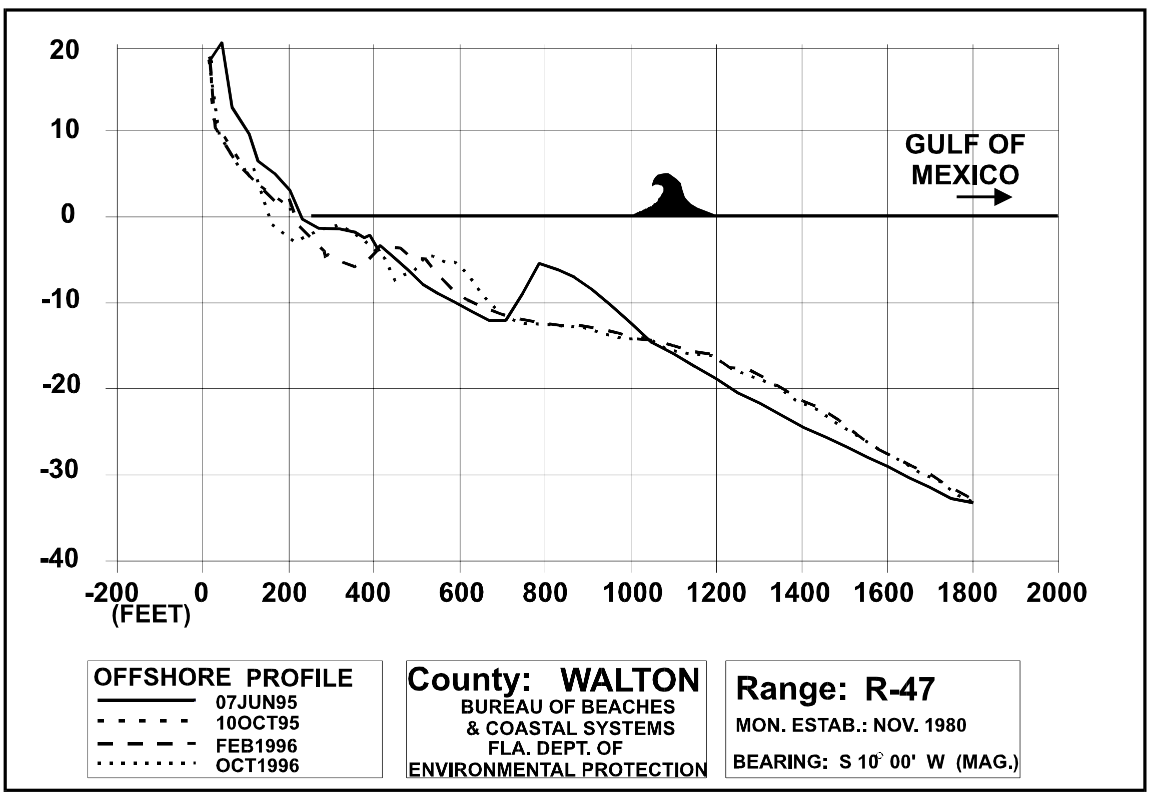

Figure 74. Pre-Opal through one-year post-Opal profile response in Walton Co.

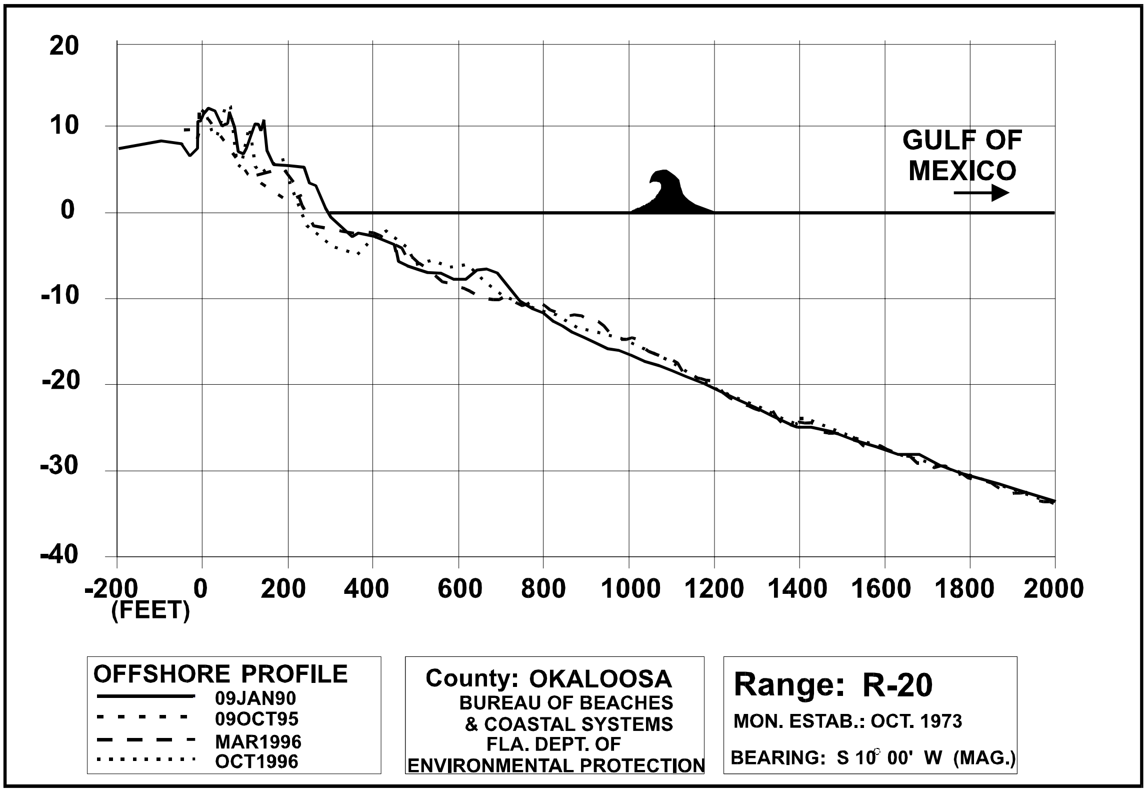

Figure 75. Pre-Opal through one-year post-Opal profile response in Okaloosa Co.

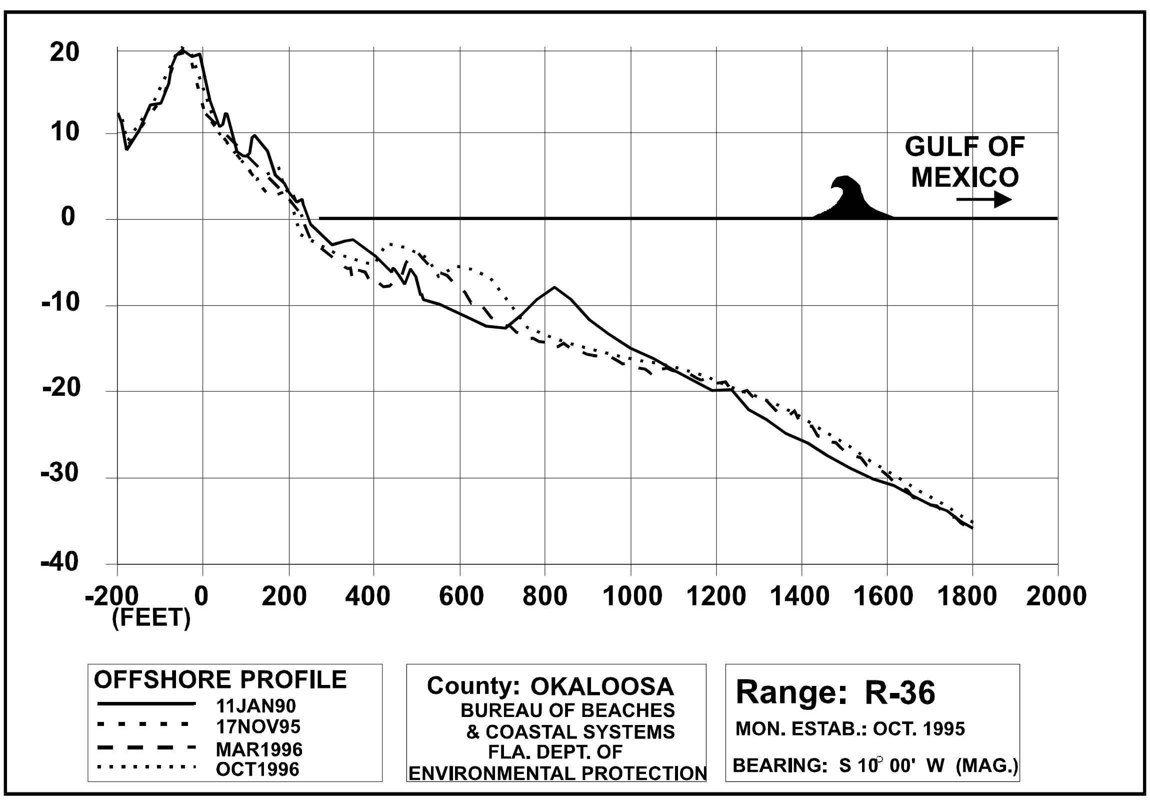

Figure 76. Pre-Opal through one-year post-Opal profile response in Okaloosa Co.

Figure 77. Redistribution of recovered overwash sand trucked back to eroded dune areas following Hurricane Opal in the Pensacola Beach area.

Figure 78. Redistributed sand recovered from overwash following Opal which was trucked back to eroded dune areas in the Pensacola Beach area.

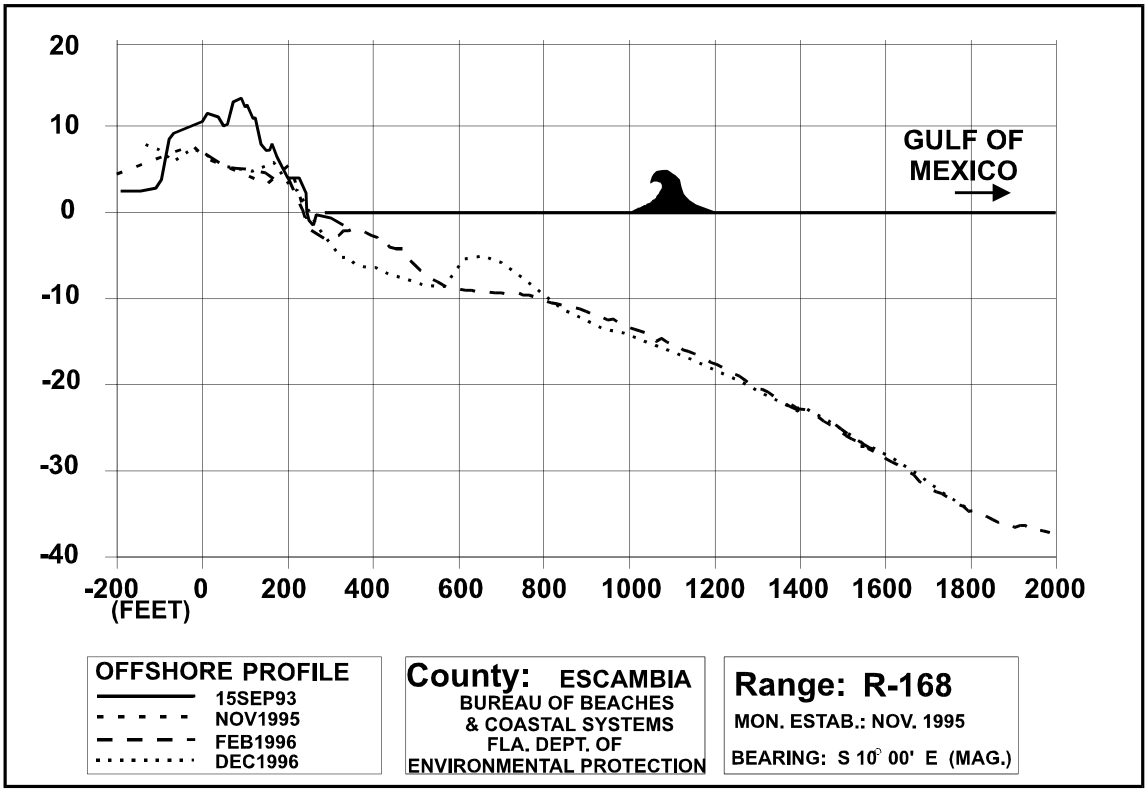

Figure 79. Pre-Opal through one-year post-Opal profile response in Escambia Co.

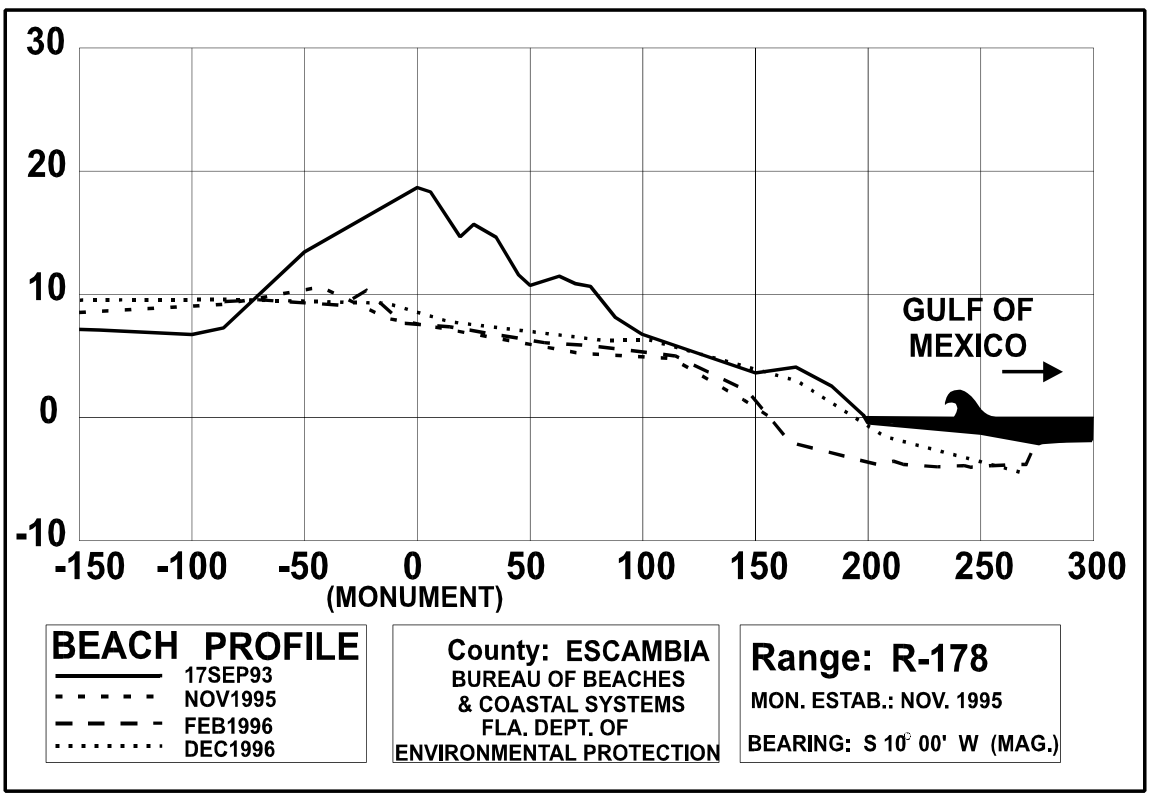

Figure 79. Pre-Opal through one-year post-Opal profile response in Escambia Co.

was establishment of an interim CCCL for Bay County an additional 100 feet further landward of the original CCCL/setback line. This has prevented many of the severely damaged and destroyed structures which were landward of the original line from being rebuilt to insufficient standards, since they now fall under the more stringent standards of FDEP. The interim CCCL was superceded by a new, permanent CCCL adopted by the State of Florida in February 1997. The new CCCL was in essentially the same location as the interim line.

Another measure adopted by the FDEP to improve survivability of habitable structures was to adopt a general elevation of +17 feet (NGVD) as a minimum for underside elevations for first level habitable, pile-supported floors for the entire Panhandle coast. These types of measures will help to ensure that, if all substantially damaged or destoyed major habitable structures across the Panhandle are rebuilt, over half of these structures will be FDEP-permitted structures and will significantly reduce the potential for the type of devastating damage from Opal in the future.

Structural damage photos shown in Section III of this report illustrate survivability of elevated, pile-supported habitable structures in comparison to poorly-designed structures which were destroyed by Hurricane Opal. The photo shown below illustrates two permitted, pile-supported, habitable structures under construction which are typical of structures being constructed to FDEP design and siting standards. These structures are located in Walton County just west of Grayton Beach State Park and are designed to withstand potential hurricanes of the intensity of Hurricane Opal.

Figure 81. FDEP-permitted habitable structures under construction following Opal.

V. Conclusion

In terms of both erosion and structural damage, Hurricane Opal may prove to have been the most destructive storm ever to impact the coastal zone of Florida. Opal's impact was severe across the Panhandle counties of Florida and extended on a lesser scale throughout the entire Gulf coast of Florida all the way through Key West. The most extensive damage was the result of the storm surge and accompanying wave heights and erosion.

Hurricane Opal reached near Category 5 status with winds near 150 mph, although wind speeds dropped just prior to landfall. NOAA wave buoys in the Gulf of Mexico recorded wave heights exceeding 8 meters with periods of 14 seconds. Evidence of storm surge and wave impacts in coastal buildings reached as high as +17 to +18 feet (NGVD). Measured high water marks validated the storm surge estimates which were based on tide gage data collected by NOS.

Structural damage assessments performed by the Bureau clearly demonstrated the effectiveness of the CCCL program in drastically reducing damages sustained by a major hurricane event. Over a quarter of the 2186 habitable structures which existed seaward of the control lines from Escambia through Franklin counties prior to Hurricane Opal were permitted by the DEP. A total of almost a third of these existing structures, or 651 habitable structures, were destroyed by Opal. Only two of the destroyed structures were permitted by FDEP. A total of over 3 miles of rigid coastal armoring structures were destroyed by Hurricane Opal.

A number of problems were encountered during the post-Opal response and recovery period including retrieval of sand which was transported inland by overwash processes, much of it containing construction debris, as well as, the potential of hazardous debris being buried in beach and nearshore areas. Local governments, in conjunction with State and Federal assistance, were very diligent in response and recovery efforts. A recovery strategic management plan was developed by the FDEP in which critical erosion areas were identified with recovery options and costs. State funding support was provided by the Florida Legislature in order to conduct beach and dune restoration activities and debris cleanup across the Panhandle coast.

The rebuilding process will continue for years following the storm. Continued restoration and remedial assistance will be needed to ensure a full and rapid recovery of the beaches and dunes in the Panhandle, particularly in view of the economic importance of those beaches. Improved building standards for habitable structures seaward of the State's coastal construction control lines will ensure increased survivability potential for rebuilt structures seaward of CCCL's across the Panhandle coast.

Studies are underway to assess the recovery processes which include collection and analysis of extensive topographic and bathymetric survey data. Initial information over a one-year post-storm period shows natural beach and dune recovery to be slow. Offshore deposition of sand resulting from Opal has demonstrated very little change and little landward transport recovery over the first-year period. Man-assisted recovery has shown to be beneficial, although studies of full impacts of beach scraping are still underway, in addition to other post-storm studies.

VI. References

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6) Kriebel, D.L., 1985. Numerical Simulation of Time-Dependent Beach and Dune Erosion Due to Severe Storms. Coastal Engineering, Vol.9, September 1985.

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10) NOAA, 1995. National Data Buoy Center, data and graphics, via NOAA Internet access.

11) Northwest Florida Daily News, 1995. Post-Opal photo; Destin, FL (Fig. 63); by permission.

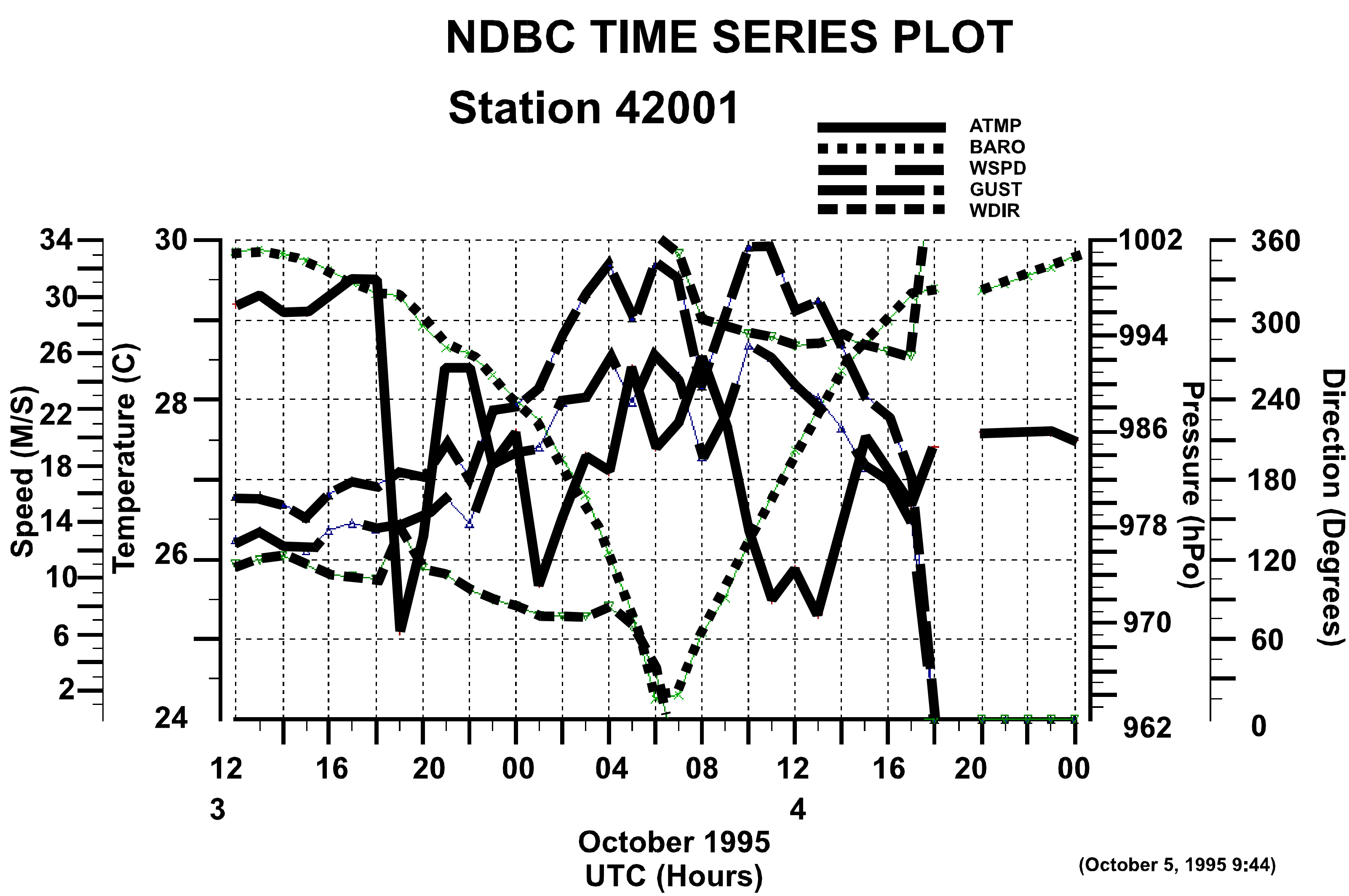
12) Powell M.D., Houston, S.H., 1995. Hurricane Opal at Landfall: A Complex Surface Wind Field (Preliminary Draft). NOAA Hurricane Research Division.

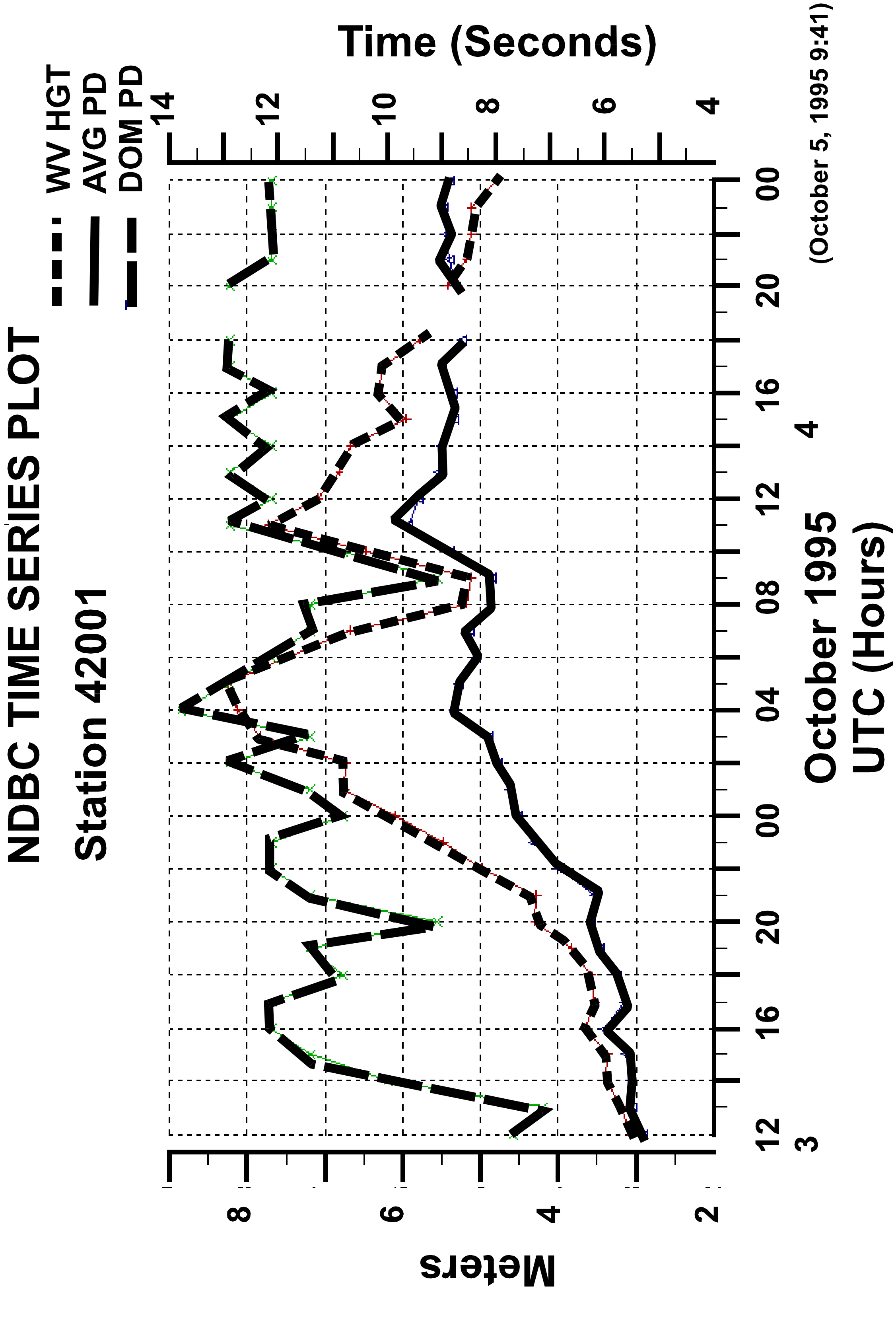
13) Spadoni, R., 1995. Report of Opal impact, Manatee/ Sarasota Co; photo, Longboat Key.

14) Wang, S.Y., Chiu T.Y., and Dean, R.G., 1995. preliminary analyses of Hurricane Opal storm surge hydrographic data, storm surge transformation, and defining storm characteristics.

Appendix A

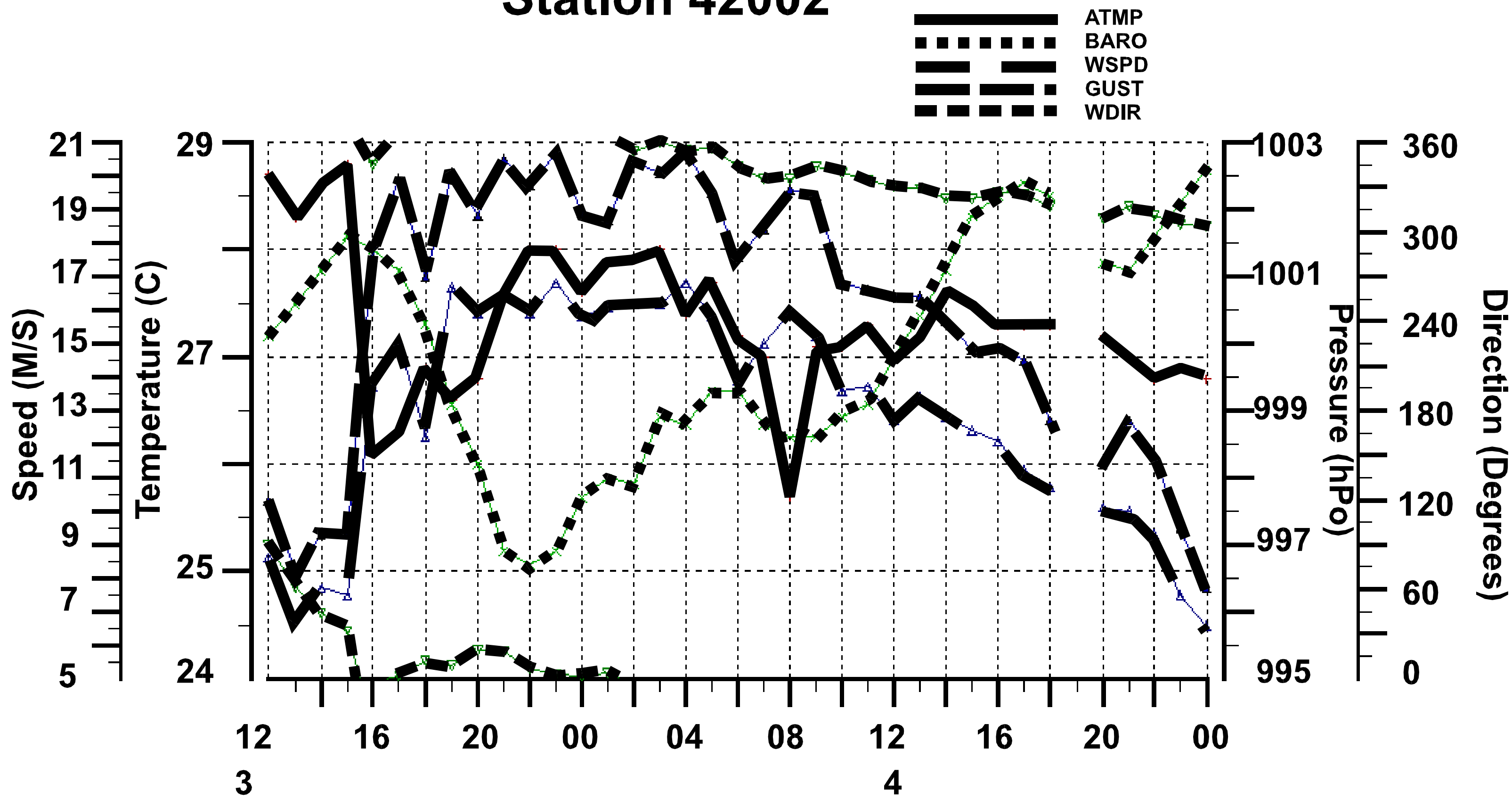
NOAA Gulf of Mexico
NDBC Wind and Wave Data Graphs


NDBC TIME SERIES PLOT
Station 42001
ATMP
BARO
WSPD
GUST
WDIR
Speed (M/S)
34 30 26 22 18 14 10 6 2
Temperature (C)
30 28 26 24
Pressure (hPo)
1002 994 986 978 970 962
Direction (Degrees)
360 300 240 180 120 60 0
12 16 20 00 04 08 12 16 20 00
3
4
October 1995
UTC (Hours)
(October 5, 1995 9:44)

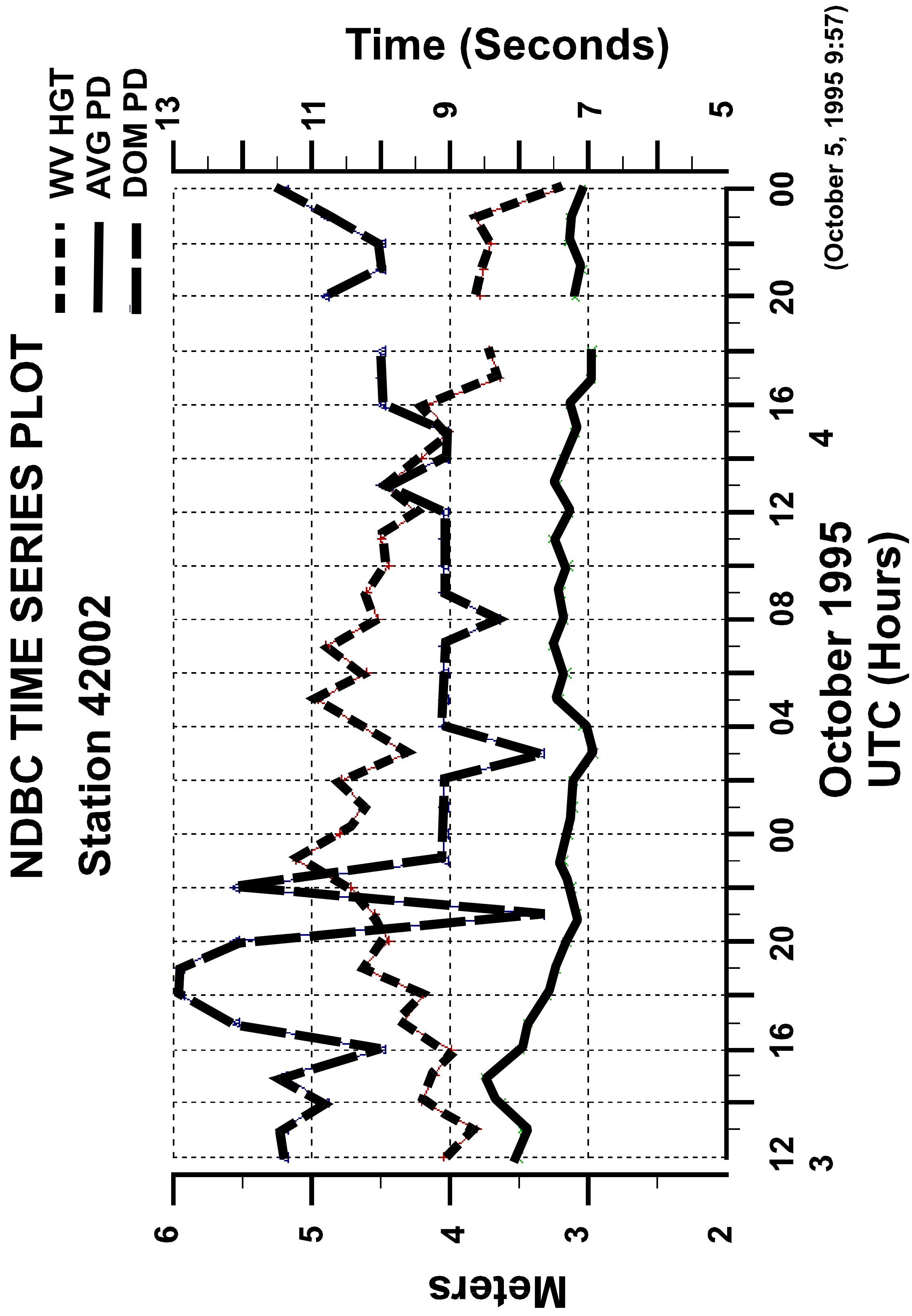

NDBC TIME SERIES PLOT
Station 42001
WV HGT
AVG PD
DOM PD
Time (Seconds)
14
12
10
8
6
4
Meters
8
6
4
2
12
16
20
00
04
08
12
16
20
00
3
4
October 1995
UTC (Hours)
(October 5, 1995 9:41)

NDBC TIME SERIES PLOT

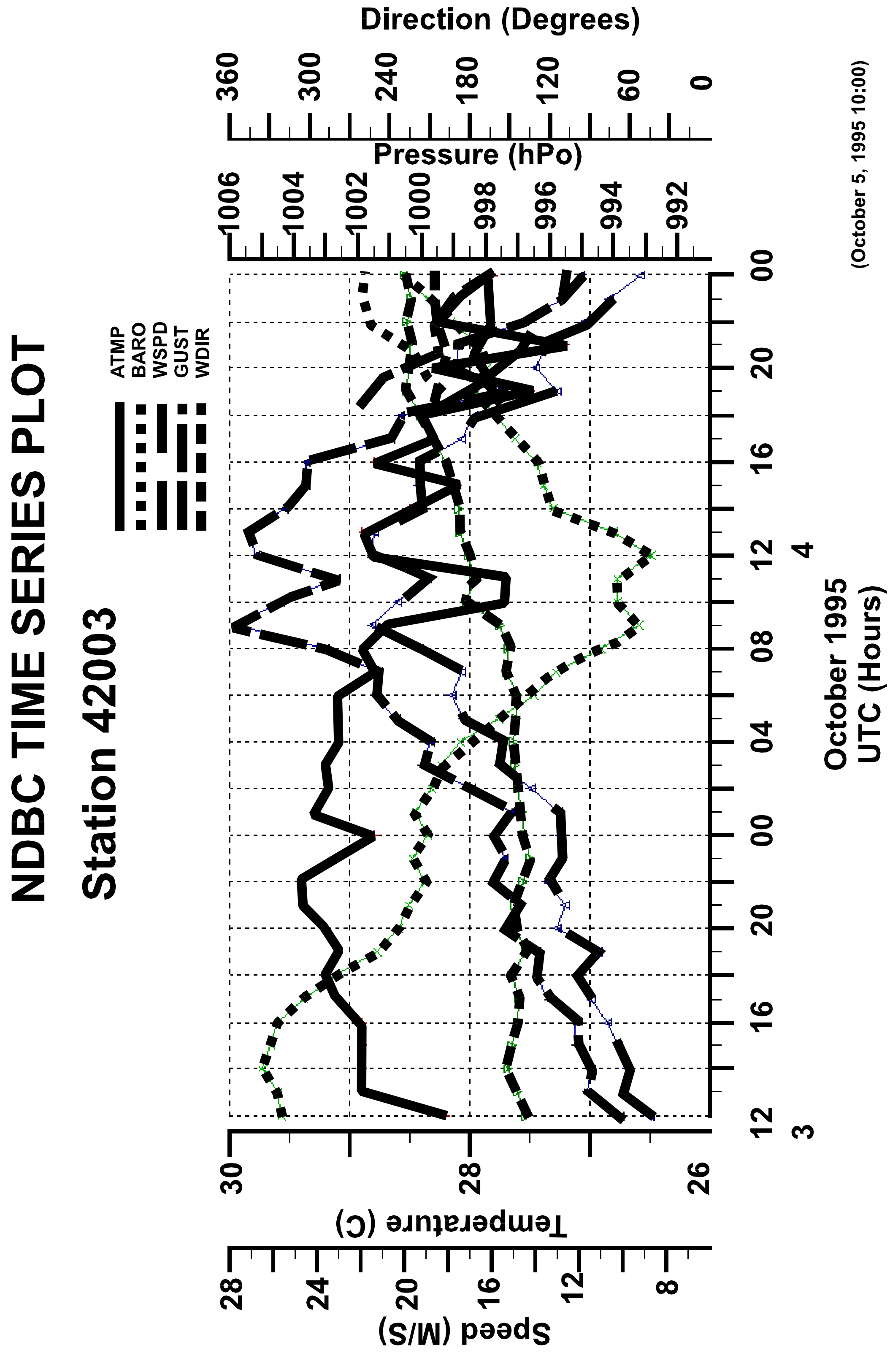
Station 42002



(October 5, 1995 9:51)



NDBC TIME SERIES PLOT
Station 42002
WV HGT
AVG PD
DOM PD
Time (Seconds)
Meters
October 1995
UTC (Hours)
(October 5, 1995 9:57)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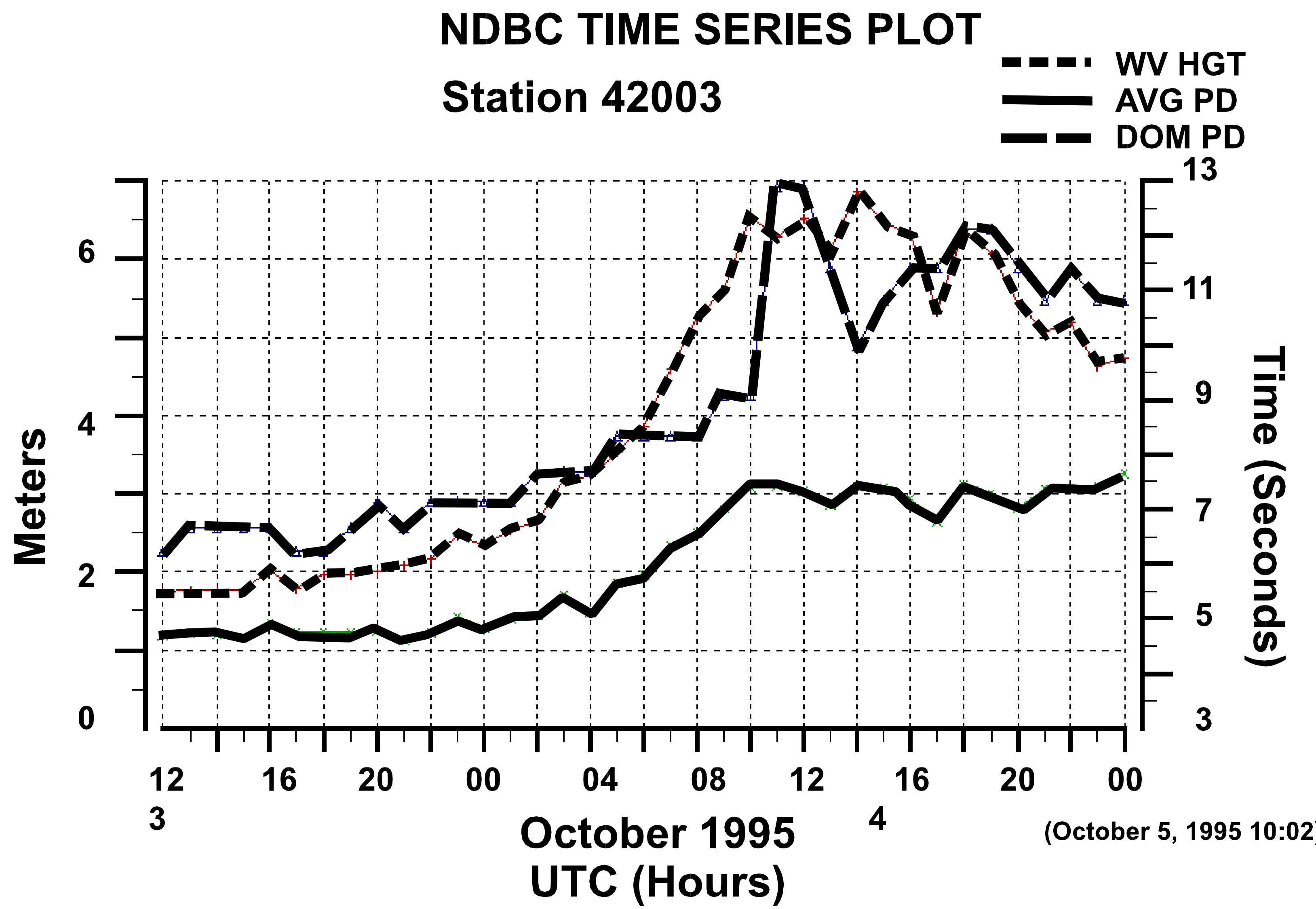
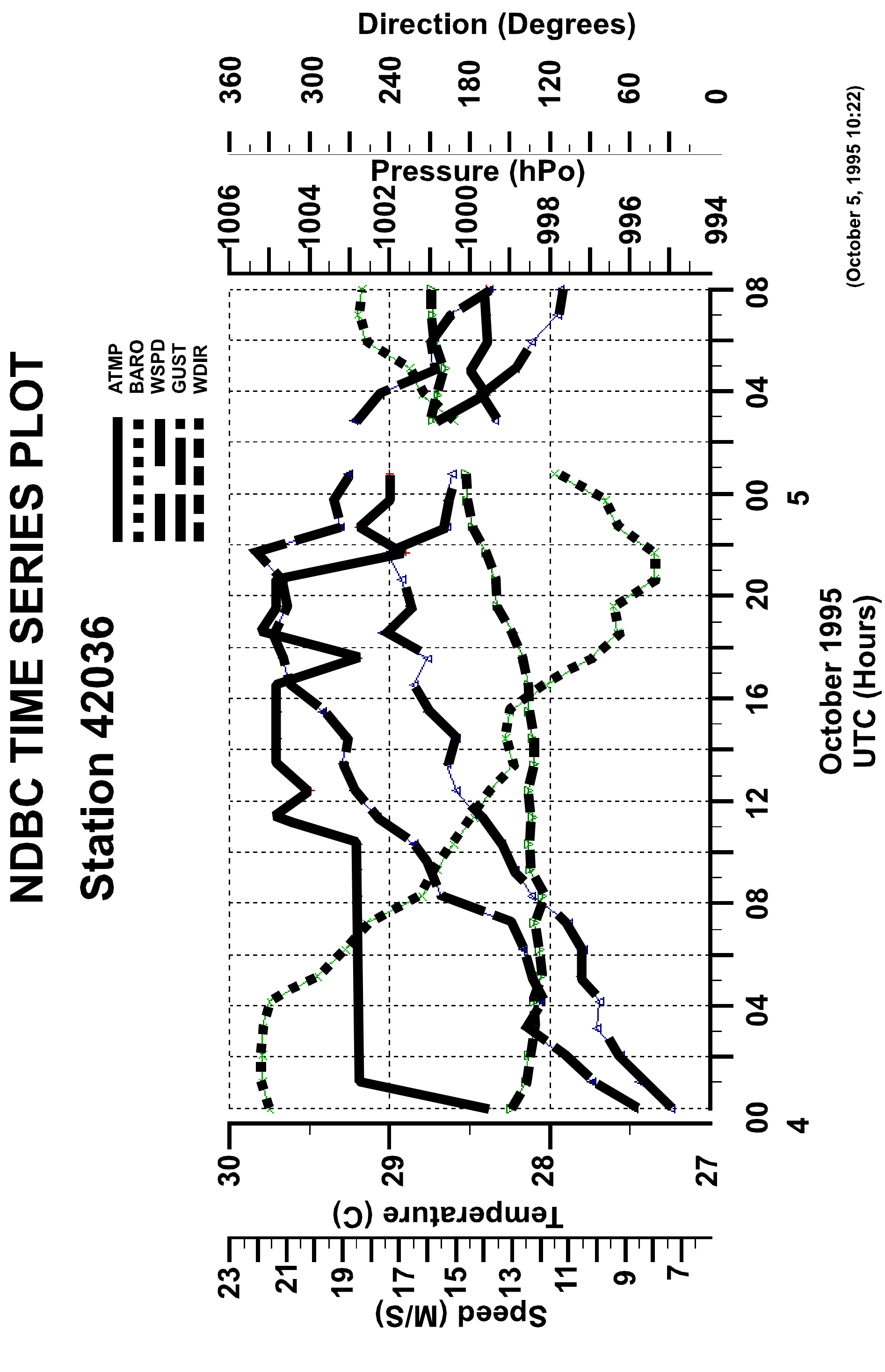
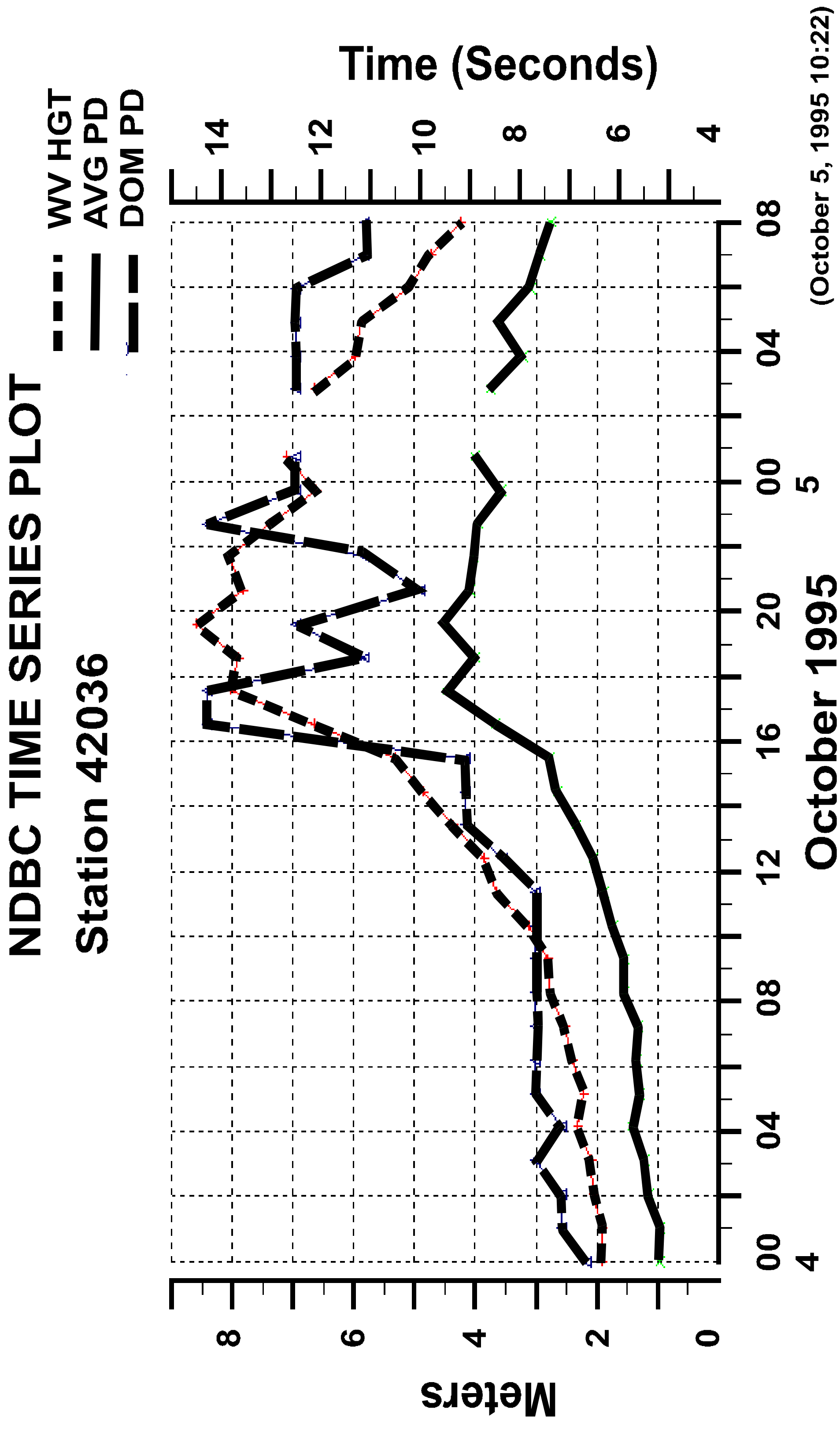
Station 42003
ATMP
BARO
WSPD
GUST
WDIR
Direction (Degrees)
Pressure (hPo)
Temperature (C)
Speed (M/S)
October 1995
UTC (Hours)
(October 5, 1995 10:00)

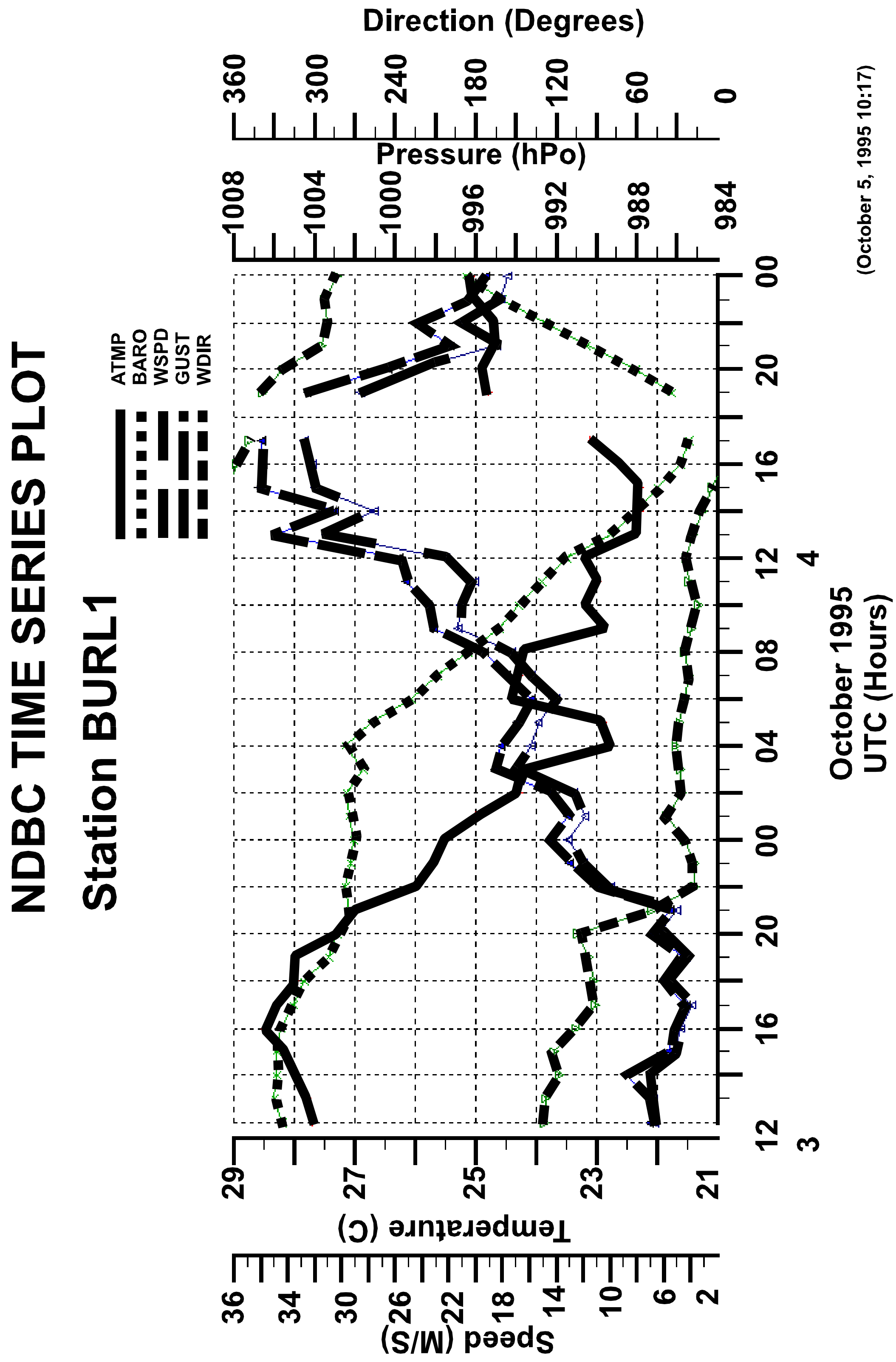

NDBC TIME SERIES PLOT
Station 42003
WV HGT
AVG PD
DOM PD
Meters
6
4
2
0
Time (Seconds)
13
11
9
7
5
3
12
16
20
00
04
08
12
16
20
00
3
4
October 1995
UTC (Hours)
(October 5, 1995 10:02)

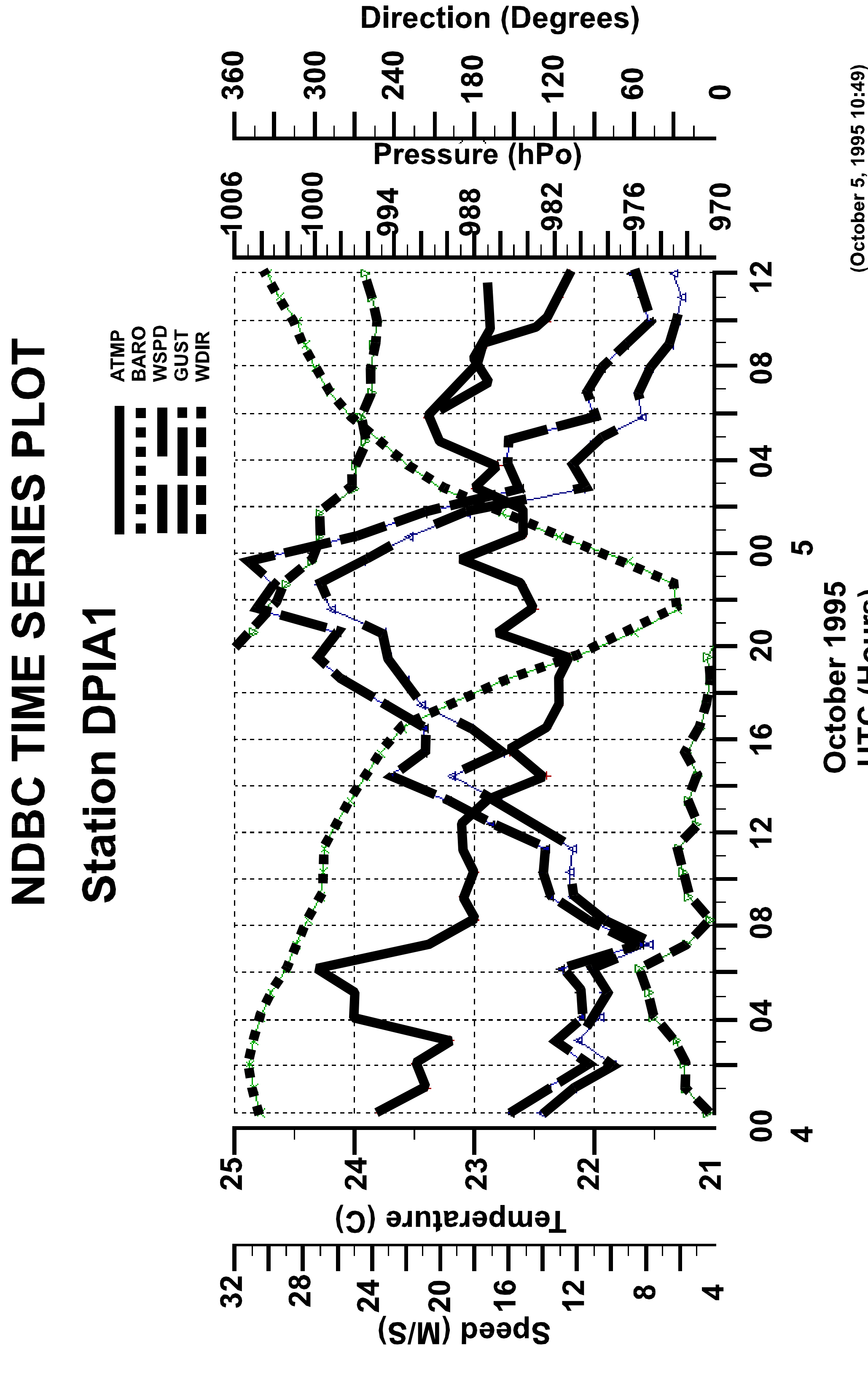


NDBC TIME SERIES PLOT
Station 42036
ATMP
BARO
WSPD
GUST
WDIR
Direction (Degrees)
360
300
240
180
120
60
0
Pressure (hPo)
1006
1004
1002
1000
998
996
994
Temperature (C)
30
29
28
27
Speed (M/S)
23
21
19
17
15
13
11
9
7
00
04
08
12
16
20
00
04
08
4
5
October 1995
UTC (Hours)
(October 5, 1995 10:22)



NDBC TIME SERIES PLOT
Station 42036
WV HGT
AVG PD
DOM PD
Time (Seconds)
14
12
10
8
6
4
Meters
8
6
4
2
0
00
04
08
12
16
20
00
04
08
4
5
October 1995
UTC (Hours)
(October 5, 1995 10:22)


NDBC TIME SERIES PLOT
Station BURL1
ATMP
BARO
WSPD
GUST
WDIR
Direction (Degrees)
360 300 240 180 120 60 0
Pressure (hPo)
1008 1004 1000 996 992 988 984
Temperature (C)
29 27 25 23 21
Speed (M/S)
36 34 30 26 22 18 14 10 6 2
12 16 20 00 04 08 12 16 20 00
3 4
October 1995
UTC (Hours)
(October 5, 1995 10:17)



NDBC TIME SERIES PLOT
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ATMP
BARO
WSPD
GUST
WDIR
Direction (Degrees)
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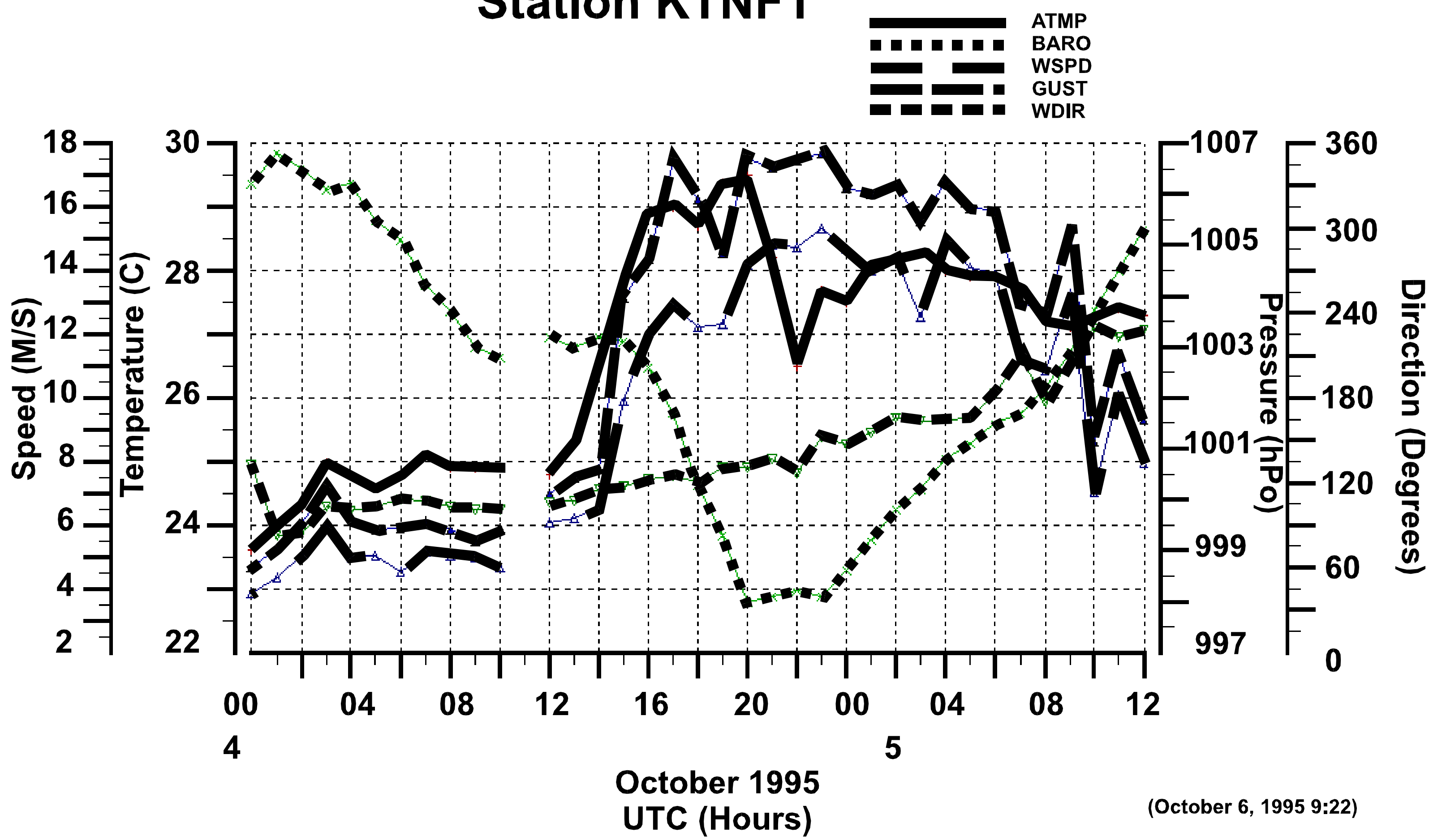
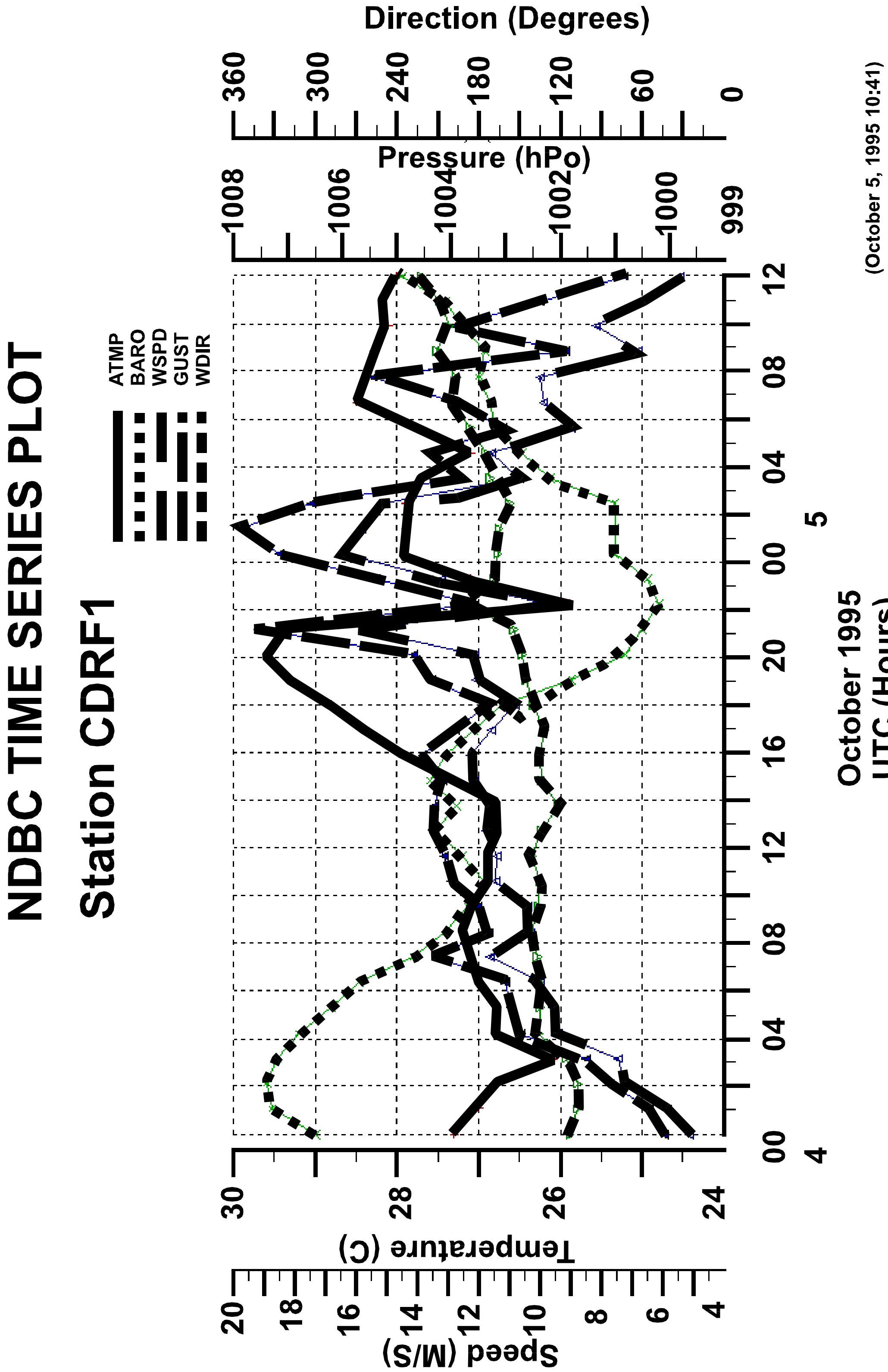
300
240
180
120
60
0
Pressure (hPo)
1006
1000
994
988
982
976
970
Temperature (C)
25
24
23
22
21
Speed (M/S)
32
28
24
20
16
12
8
4
00
04
08
12
16
20
00
04
08
12
4
5
October 1995
UTC (Hours)
(October 5, 1995 10:49)

NDBC TIME SERIES PLOT

Station KTNF1





NDBC TIME SERIES PLOT
Station CDRF1
ATMP
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WSPD
GUST
WDIR
Direction (Degrees)
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300
240
180
120
60
0
Pressure (hPo)
1008
1006
1004
1002
1000
999
Temperature (C)
30
28
26
24
Speed (M/S)
20
18
16
14
12
10
8
6
4
00
04
08
12
16
20
00
04
08
12
4
5
October 1995
UTC (Hours)
(October 5, 1995 10:41)

Appendix B

County-by-County High Water Mark and Debris/Wrack Line Location and Elevation Listing

Locations and Elevations of Hurricane Opal High Water Marks and Wrack/Debris Lines

COUNTY	D.E.P MONUMENT	STAND STILL WATER(SSW)	WRACK
BAY	R-4	11.03 ▲	-----------
	R-5	-----------	18.83 ▲
	R-6	14.15 ▲	-----------
	R-13	-----------	15.78 ▲
	R-16	-----------	18.43 ▲
	R-20	17.90 ▲	-----------
	R-40	15.24 ■	-----------
	R-56	-----------	23.18 ▲
	R-80	10.20 ●	-----------
	R-85	15.07 ▲	-----------
	R-97	10.25 ■	-----------
	R-122	8.40 ●	9.43 ▲
	R-123	-----------	11.28 ▲
	R-125	-----------	12.11 ▲
	R-130	7.60 ●	-----------
	R-135	13.50 ▲	-----------
WALTON	R-20	15.60 ●	-----------
	R-21	13.36 ▲	-----------
	R-70	10.50 ●	-----------
	R-72	11.00 ▲	16.63 ▲
	R-90	12.00 ●	-----------
	R-127	10.82 ▲	-----------
OKALOOSA	R-8	14.13 ▲	-----------
	R-10	10.70 ▲	-----------
	R-27	12.03 ▲	-----------
	R-30	14.80 ■	-----------
	R-40	14.30 ■	-----------
	R-46	14.59 ■	-----------
ESCAMBIA	R-85	8.59 ■	-----------
	R-89	9.36 ■	-----------
	R-125	7.67 ▲	-----------
	R-188	10.23 ■	-----------

LEGEND:
▲ Water Mark Obtained by FDEP
■ Water Mark Obtained from COE
● Debris Line Obtained from USGS map - wind & water line survey by Michael Baker

Appendix C

Listing of Hurricane Opal Contour Recession and Erosion Volume for Bay, Walton, and Okaloosa Counties by FDEP Monument

HURRICANE OPAL BEACH AND DUNE EROSION COMPUTATIONS
BAY COUNTY
COMPARISON OF 4/95 (Pre-Storm) vs. 10/95 (Post-Storm)

RANGE MONUMENT	CONTOUR RECESSION +2 FT.	+5 FT.	+10 FT.	+15 FT.	+20 FT.	EROSION VOLUME
R001	-67.905	-102.549	-97.000	-------	-------	-21.23
R002T	-45.561	-11.934	1.322	-28.895	-------	-4.62
R003	-60.271	-54.704	-35.059	-24.444	-13.626	-25.94
R004	-73.289	-48.993	-35.910	-25.036	-------	-23.42
R005T	-45.579	-39.932	-82.722	-23.736	-------	-22.25
R006	-41.716	-74.396	-74.000	-------	-------	-24.36
R007	-73.028	-57.011	-57.000	*******	-------	-27.47
R008	-53.000	-45.000	-36.174	-40.000	-------	-19.34
R009T	N/A	N/A	N/A	N/A	N/A	N/A
R010	-40.270	-63.732	-78.822	-58.206	-16.841	-38.71
R011	-46.028	-55.548	-101.580	-38.881	-8.289	-32.65
R012	-1.043	-34.123	-65.000	-30.000	-22.000	-22.26
R013T	-43.640	-68.796	-72.031	-54.624	-------	-33.55
R014	-48.000	-53.083	-51.884	-40.868	-18.807	-30.01
R015	9.791	-16.865	-40.754	-31.564	-------	-17.49
R016	-51.224	-47.901	-54.989	-21.012	-------	-21.51
R017T	-41.171	-42.788	-55.000	-20.822	-------	-20.77
R018	-32.963	-39.751	-60.627	-58.085	-------	-25.33
R019T	-46.741	-13.583	-39.925	-42.645	-20.000	-22.88
R020T	-46.111	2.999	-25.608	-44.132	-------	-16.88
R021T	-38.040	-29.536	-58.704	-92.779	-------	-36.13
R022	-52.686	-74.369	-58.995	-42.627	-32.000	-31.69
R023	-41.800	-34.432	-33.466	-22.975	-13.663	-20.91
R024	-55.091	-38.596	-13.969	-23.020	-14.258	-21.36
R025	-37.000	-27.493	-14.194	-17.493	-6.516	-12.74
R026	-16.000	-30.025	-44.000	-------	-------	-15.63
R027	N/A	N/A	N/A	N/A	N/A	N/A
R028T	-28.000	-33.789	2.138	-------	-------	-5.65
R029T	-18.000	-22.186	-58.250	-62.675	-------	-21.03
R031	N/A	N/A	N/A	N/A	N/A	N/A
R032	N/A	N/A	N/A	N/A	N/A	N/A
R033T	-27.060	-20.697	-6.436	0.000	-------	-4.87
R035	6.000	-37.176	-3.147	-.934	-------	-5.97
R037T	-55.575	-69.083	-74.237	0.000	-------	-30.38
R038	15.000	-47.808	-1.739	-30.000	-------	-12.15
R039	-------	-16.805	-43.145	-26.168	-------	-18.00
R040	-63.599	-35.899	-3.095	15.079	-------	-8.22
R041	-69.157	-87.682	-27.451	-13.691	-------	-23.37
R042	-39.143	-40.241	1.082	-24.025	-93.040	-19.90
R043	-61.984	-10.968	2.611	-------	-------	-4.01
R044	-63.012	-26.211	-3.233	.885	.768	-10.74
R045	N/A	N/A	N/A	N/A	N/A	N/A
R048	-25.336	-38.701	-13.708	4.784	-------	-7.65
R049	9.204	19.510	-26.936	-22.567	-13.799	-11.26
R050T	-9.767	-22.836	-36.000	-26.046	*******	-17.82
R051	-28.717	-47.825	-52.392	-71.656	*******	-38.23
R052T	-36.587	-30.722	-.967	-------	-------	-5.75

R053T	-19.906	-38.700	-28.464	-5.086	-------	-12.51
R054	-72.783	-48.376	-7.361	.874	-------	-12.46
R055T	-8.693	-26.595	-14.955	0.000	-------	-8.25
R056	-39.050	-11.702	4.568	-4.694	-3.590	-6.52
R057	-58.634	-9.211	-3.578	-.036	-.336	-2.10
R058	-16.874	-30.606	-53.536	1.480	-------	-11.00
R059	N/A	N/A	N/A	N/A	N/A	N/A
R060	-2.317	-27.280	-21.397	-------	-------	-13.00
R061	-47.990	-30.175	-3.628	-------	-------	-8.39
R062	-19.558	-39.781	-43.000	-------	-------	-11.85
R063	N/A	N/A	N/A	N/A	N/A	N/A
R064	43.634	-9.038	-14.294	-------	-------	-4.07
R065T	-27.387	-38.414	-31.419	-------	-------	-12.66
R066	-16.128	-21.839	-9.044	-------	-------	-5.31
R067	-24.788	-37.887	-74.514	-.049	-------	-22.06
R068	4.566	-31.962	-100.258	*******	-------	-24.27
R069	-38.444	-38.836	-54.862	-31.652	-------	-22.92
R070	N/A	N/A	N/A	N/A	N/A	N/A
R071T	14.284	-51.973	-46.836	-------	-------	-17.97
R072	-------	-37.116	9.615	-------	-------	-6.14
R073	N/A	N/A	N/A	N/A	N/A	N/A
R074T	-27.686	-44.557	-48.982	-------	-------	-22.74
R075	15.922	-22.515	-65.992	-------	-------	-20.32
R076T	-56.201	-56.941	-------	-------	-------	-12.56
R077	-27.512	-39.785	-15.626	-------	-------	-9.91
R078T	-21.987	-44.128	-62.195	*******	*******	-28.17
R079	-36.389	-58.647	-120.231	-1.655	-------	-28.93
R080	-57.757	-67.491	-84.811	-------	-------	-21.61
R081	-37.000	-39.871	-46.216	-------	-------	-4.09
R082	-48.049	-50.366	N/A	-------	-------	.29
R083T	-20.815	-49.672	-73.760	-------	-------	-18.06
R084	-42.364	-45.555	-72.548	*******	-------	-31.14
R085	15.000	-33.903	-48.000	-------	-------	-16.23
R086	-18.000	-55.684	-85.000	-62.000	-------	-36.14
R087	-1.712	-37.118	-70.046	3.275	-------	-20.60
R088	-10.244	-58.765	-62.389	-------	-------	-18.98
R089	-14.477	-35.889	-33.537	-31.819	-------	-15.80
R090	N/A	N/A	N/A	N/A	N/A	N/A
R091	N/A	N/A	N/A	N/A	N/A	N/A
R092	-3.226	-39.727	-101.135	*******	-------	-16.48
R093	-18.382	-35.149	-26.671	-2.573	-------	-9.11
R094	-48.263	-35.583	-46.512	-12.998	-7.801	-15.49
R095T	-38.948	-41.061	-43.591	-7.667	-1.828	-16.30
R096T	-38.436	-43.663	-11.919	-3.389	-2.443	-15.73
R097	N/A	N/A	N/A	N/A	N/A	N/A
R122	-57.670	-106.192	32.910	6.249	-------	-5.62
R123	-153.763	*******	-2.259	2.168	-------	-21.64
R124	-15.611	-81.692	-7.382	-------	-------	-5.65
R125	16.941	-51.858	-45.873	-------	-------	-4.50
R126	-22.753	-45.513	18.190	-.555	-------	2.59
R127	-24.652	-25.623	10.959	-------	-------	.52
R128	-1.807	-27.690	-41.825	-------	-------	.50
R129	-48.062	-63.695	-------	-------	-------	-4.64
R130	-48.952	-86.262	N/A	-------	-------	3.13
R131T	-57.557	-65.752	N/A	-------	-------	-7.07
R132	-45.428	-55.226	N/A	-------	-------	-9.63
R133	-42.227	-53.128	-49.024	1.654	-------	-15.69

R134	-22.662	-51.992	-58.169	-------	-------	-18.51
R136	-29.710	-46.199	-51.103	-------	-------	-17.12
R137	43.122	1.775	-10.120	-18.000	-------	-1.97
R138T	-49.520	-36.799	-16.618	-.044	-------	-9.62
R140	-4.301	-32.038	-11.223	-12.806	-------	-7.36
R141	-15.462	-33.635	5.997	-4.365	-------	-5.69
R142	-5.958	-32.681	-26.492	-------	-------	-8.08
R143	-12.395	-45.241	-33.549	-------	-------	-8.57
R144	-13.058	-48.187	-------	-------	-------	-8.63
TOTAL AVERAGE	-30.931	-41.244	-37.515	-20.113	-16.004	-15.51

NOTE: AN "*****" NOTATION INDICATES THAT PRE-STORM DUNE ELEVATIONS AT THE PARTICULAR CONTOUR WAS COMPLETELY WASHED OUT OR ERODED.

NOTE: AN "-----" NOTATION INDICATES THAT THERE WAS NO DUNE CONTOUR EXISTING AT THAT ELEVATION.

NOTE: AN "N / A" NOTATION INDICATES THAT THE PROFILE DATA WAS QUESTIONABLE IN TERMS OF ACCURACY.

NOTE: EROSION VOLUME AVERAGE ABOVE IS NOT WEIGHT-AVERAGED TO ACCOUNT FOR VARYING DISTANCES BETWEEN MONUMENTS; WEIGHT-AVERAGED VOLUME COMPUTED TO BE -12.83 CU YDS PER LINEAL FT.

HURRICANE OPAL BEACH AND DUNE EROSION COMPUTATIONS
WALTON COUNTY
COMPARISON OF 5/95 (Pre-Storm) vs. 10/95 (Post-Storm)

RANGE MONUMENT	CONTOUR RECESSION +2 FT.	+5 FT.	+10 FT.	+15 FT.	+20 FT.	EROSION VOLUME
R-1	-36.978	-19.834	-36.905	-4.823	-6.344	-19.01
R-2	2.576	-38.430	-22.265	-12.208	-.355	-18.19
R-3	-28.414	-72.586	-33.551	-45.604	-2.114	-26.75
R-3A	-9.877	-48.241	-48.806	-41.222	-27.525	-27.74
R-4	-28.101	-48.341	-56.000	-45.000	-5.000	-24.48
R-5	-32.593	-48.084	-58.848	-16.850	5.463	-19.16
R-6	6.113	-17.179	-56.285	-37.000	5.867	-14.47
R-6A	-43.168	-34.332	-74.967	-58.850	3.580	-33.56
R-7	-11.759	-36.262	-57.482	-46.392	7.977	-21.62
R-8	-35.063	-39.447	-66.190	-21.449	-12.187	-25.72
R-9	N/A	N/A	N/A	N/A	N/A	N/A
R-10	-38.771	-27.444	-40.700	-20.431	-12.955	-23.28
R-11	-30.201	-40.508	-17.007	-18.342	-8.330	-16.25
R-12	-27.212	-19.334	-25.236	-43.000	-------	-17.75
R-13	-51.523	-94.174	-138.000	*******	-------	-35.07
R-14	44.000	-42.258	-78.858	*******	-------	-29.20
R-15	-5.153	-51.080	-67.584	-73.483	*******	-43.96
R-16	16.663	-50.758	-68.000	-55.000	-------	-37.09
R-17	6.190	-45.982	-102.322	*******	-------	-32.33
R-18	-34.494	-54.914	-86.356	*******	-------	-34.03
R-19	-28.614	-50.911	-12.916	1.703	2.765	-15.76
R-20	-7.777	-29.552	-67.934	*******	-------	-31.33
R-21	-30.549	-56.577	-75.185	-29.442	-2.844	-28.19
R-22	-38.487	-22.271	-36.435	-13.975	-.958	-14.21
R-23	-44.536	-70.245	-71.084	-25.406	-22.511	-25.27
R-24	-15.555	-35.575	-42.802	-44.727	-30.847	-25.95
R-25	9.977	-101.880	-47.802	-------	-------	-21.31
R-26	N/A	N/A	N/A	N/A	N/A	N/A
R-27	-8.539	-44.570	-59.113	-30.508	-20.990	-28.87
R-28	-49.752	-74.520	-34.211	-25.605	-15.000	-26.34
R-29	-70.077	-119.207	*******	-------	-------	N/A
R-30	-21.442	-39.480	-38.976	-11.000	-4.000	-18.50
R-31	-19.586	-21.634	-15.648	-29.386	-20.972	-18.55
R-32	-17.858	-32.220	-46.327	-29.759	-20.183	-18.20
R-33	-12.280	-38.259	-41.293	-19.000	-15.000	-18.86
R-34	-39.128	-42.191	-58.092	-47.000	-23.000	-35.76
R-35	-41.691	-60.162	-41.256	-63.000	*******	-34.57
R-36	-6.308	-29.301	-40.000	-60.000	3.000	-28.73
R-37	-37.692	-76.319	-9.868	-24.101	-13.583	-20.44
R-38	-45.469	-52.480	-46.004	-25.450	-16.562	-27.38
R-39	-25.748	-31.938	-33.362	-37.000	-28.000	-23.20
R-40	N/A	N/A	N/A	N/A	N/A	N/A
R-41	-18.687	-50.080	-27.266	-43.000	-------	-12.81
R-42	-------	-62.406	-42.035	-34.686	-12.785	-56.03
R-43	-30.000	-48.457	-41.261	-40.000	-24.000	-23.24
R-44	-33.000	-35.163	-52.682	-48.000	-------	-29.15
R-45	7.058	-51.029	-59.385	-90.135	-------	-31.86

R-46	-13.725	-60.696	56.954	-------	-------	-1.65
R-47	-33.021	-63.115	-61.874	-43.189	*******	-31.83
R-48	-28.000	-22.848	-56.884	-4.283	5.000	-6.14
R-49	-28.000	-33.923	-56.712	-30.000	-6.000	-20.36
R-50	-44.290	-33.049	-38.257	-36.235	-30.407	-26.41
R-51	-68.000	-48.949	-26.203	-9.263	-1.000	-18.65
R-52	-56.588	-61.323	-48.837	-21.000	-3.000	-24.49
R-53	-40.000	-97.522	-29.044	-17.884	-16.743	-27.51
R-54	-68.000	-61.504	-23.479	-17.137	-13.392	-22.32
R-55	-1.042	-92.153	-102.382	-49.807	-------	-41.88
R-56	-32.000	-48.154	-32.105	-15.079	-6.097	-14.98
R-57	-40.659	-44.121	-26.378	-39.382	-17.696	-24.25
R-58	-38.537	-40.063	-35.264	-14.100	-6.782	-15.78
R-59	-61.116	-40.708	-24.840	-25.815	-21.345	-31.29
R-60	-33.688	-38.450	-23.911	-29.963	-14.316	-20.92
R-61	-37.429	-81.147	-11.947	-9.986	-8.144	-13.40
R-62	-19.074	-23.614	-23.200	-22.927	-15.680	-24.09
R-63	-26.154	-59.607	-29.043	-18.687	-8.578	-23.48
R-64	N/A	N/A	N/A	N/A	N/A	-62.85
R-65	-14.000	-90.313	*******	*******	-------	-23.75
R-66	-48.217	-63.734	-45.590	-22.225	-1.252	-23.54
R-67	-36.228	-55.169	-26.307	-25.000	-19.000	-21.02
R-69	-59.000	-123.256	-155.000	*******	-------	-46.68
R-70	-52.090	-61.826	-81.643	-50.000	-------	-46.22
R-71	-53.846	-57.774	-55.928	-24.000	-15.000	-22.60
R-72	-33.396	-129.048	*******	*******	-------	-15.95
R-74	-71.105	-66.937	-44.964	-25.472	-17.200	-28.43
R-75	-34.454	-37.023	-44.483	-34.737	-27.363	-19.96
R-77	-57.644	-57.134	-40.321	-27.052	-20.385	-27.09
R-78	-27.667	-54.157	-61.131	-21.000	*******	-23.63
R-79	-14.128	-47.606	-58.056	-24.138	-17.004	-28.11
R-80	-56.840	-69.604	-31.447	-13.059	-6.129	-22.17
R-81	-34.732	-49.826	-23.084	-17.582	-8.143	-17.44
R-82	N/A	N/A	N/A	N/A	N/A	N/A
R-83	-60.196	-72.852	-19.721	-17.573	-13.623	-28.30
R-84	-44.544	-36.318	-14.511	-12.455	-11.515	-17.17
R-85	-34.551	-44.399	-13.248	1.735	-1.245	-3.49
R-86	-41.243	-42.971	-25.521	-14.830	-5.531	-16.68
R-87	-39.045	-55.145	-46.297	-25.417	-7.690	-23.24
R-88	-76.510	-49.538	-26.615	-23.450	-15.621	-19.00
R-89	-28.817	-53.042	-35.623	-33.000	1.000	-17.28
R-90	-72.000	-50.971	-33.766	-22.416	-11.760	-22.54
R-91	N/A	N/A	N/A	N/A	N/A	N/A
R-92	-26.765	-40.957	-16.324	-22.015	-5.626	-19.17
R-93	-58.160	-30.295	-39.347	-28.000	-67.000	-30.61
R-96	-8.889	-66.090	-114.599	*******	*******	-45.53
R-97	-55.000	-42.112	-47.208	-74.000	-87.000	-33.27
R-99	21.482	-86.245	*******	-------	-------	-42.16
R-100	-19.982	-48.958	-131.859	*******	*******	-104.16
R-101	-30.664	-55.556	-56.298	-24.569	-10.433	-30.15
R-102	-65.757	-76.662	-69.299	-23.353	-.315	-32.18
R-103	N/A	N/A	N/A	N/A	N/A	-90.43
R-104	N/A	N/A	N/A	N/A	N/A	N/A
R-105	-57.218	-51.458	-31.465	-21.159	-12.866	-24.98
R-106	-37.315	-27.207	-15.072	-15.720	-8.225	-17.60
R-107	-68.927	-48.738	-17.676	-12.932	-9.022	-19.35
W-108	-39.026	-40.226	-17.184	-17.289	-10.193	-17.00

R-109	-62.402	-65.209	-35.005	-17.838	-5.082	-21.76
R-110	-68.880	-42.290	-24.807	-3.790	-3.859	-17.13
R-111	-19.279	-22.858	-33.616	-20.084	-6.220	-15.86
R-112	-70.991	-39.394	-53.213	-8.265	-5.305	-23.29
R-113	-32.641	-42.609	-30.014	-20.292	-15.642	-25.36
R-114	-71.535	-38.135	-32.282	-18.668	-12.959	-21.73
R-115	-31.284	-38.526	-29.400	-15.953	-13.250	-19.20
R-116	-33.298	-36.726	-27.079	-12.776	-5.376	-16.58
R-117	-33.057	-35.838	-23.397	-21.636	-11.413	-18.48
R-118	-60.344	-45.432	-34.259	-21.342	-11.846	-23.43
R-119	-62.478	-25.026	-57.274	-21.348	-15.376	-23.95
R-120	5.034	5.488	-37.987	-23.108	-16.869	-16.02
R-121	-39.571	-28.562	-27.142	-13.754	-9.050	-15.34
R-122	-63.302	-50.743	-24.320	-17.685	-9.914	-20.54
R-123	-------	-------	-75.122	-64.000	-60.000	-56.53
R-124	-65.921	-41.455	-72.619	-25.109	-------	-29.54
R-125	-26.083	-12.351	-10.889	-38.000	*******	-27.25
W-126	-34.627	-52.187	-65.000	-69.501	-------	-30.09
R-127	-73.572	-40.059	-35.079	-4.038	-------	-21.12
TOTAL AVERAGE	-34.633	-49.926	-44.485	-27.938	-12.696	-26.13

NOTE: AN "*****" NOTATION INDICATES THAT PRE-STORM DUNE ELEVATIONS AT THE PARTICULAR CONTOUR WAS COMPLETELY WASHED OUT OR ERODED.

NOTE: AN "-----" NOTATION INDICATES THAT THERE WAS NO DUNE CONTOUR EXISTING AT THAT ELEVATION.

NOTE: AN "N / A" NOTATION INDICATES THAT THE PROFILE DATA WAS QUESTIONABLE IN TERMS OF ACCURACY.

NOTE: EROSION VOLUME AVERAGE ABOVE IS NOT WEIGHT-AVERAGED TO ACCOUNT FOR VARYING DISTANCES BETWEEN MONUMENTS; WEIGHT-AVERAGED VOLUME COMPUTED TO BE -26.63 CU YDS PER LINEAL FT.

HURRICANE OPAL BEACH AND DUNE EROSION COMPUTATIONS
OKALOOSA COUNTY
COMPARISON OF NOV89-JAN90 vs. 10/95 (Post-Storm)

RANGE MONUMENT	CONTOUR RECESSION +2 FT.	+5 FT.	+10 FT.	+15 FT.	+20 FT.	EROSION VOLUME
R-1	-49.649	-140.319	-170.000	*******	-------	-65.22
R-4	-36.290	-100.722	-19.183	*******	-------	-23.87
R-8	29.938	-55.550	-47.344	-------	-------	-16.78
R-15	19.676	-82.026	-90.306	-2.882	-4.634	-17.45
R-16	19.204	-44.827	-76.603	-8.000	-------	-10.73
R-17	-9.305	*******	*******	-------	-------	N/A
R-19	-208.069	-166.606	-------	-------	-------	-19.17
R-20	-47.452	-140.596	-114.555	-------	-------	-30.20
R-21	-57.731	-162.256	*******	-------	-------	-26.18
R-24	-80.308	-108.213	*******	-------	-------	-37.79
R-25	-73.888	-98.397	*******	-------	-------	-19.22
R-27	-45.549	-139.036	*******	-------	-------	-10.09
R-29	-56.984	-103.471	-48.837	*******	-------	-29.39
R-30	-22.536	-68.617	-96.825	*******	-------	-14.05
R-31	-52.809	-73.739	-25.545	-------	-------	-2.94
R-33	-46.000	-62.888	-17.610	-15.883	-------	-11.35
R-34	-71.264	-67.055	-36.915	-23.349	-------	N/A
R-35	-14.182	-1.758	17.147	*******	-------	-.18
R-36	-15.106	-58.739	-76.665	-19.851	-25.000	-21.88
R-37	-59.249	-81.557	-60.681	-9.667	28.000	-9.61
R-38	-75.000	-83.694	-56.195	-46.000	-------	-21.65
R-39	-10.761	-78.809	-87.983	-25.000	-------	-23.48
R-40	-46.684	-60.927	-37.926	-37.000	-------	-23.75
R-41	-59.451	-76.897	-.288	N/A	N/A	N/A
R-43	12.378	-14.709	-1.104	-55.557	-6.586	-13.49
R-46	-36.501	-69.053	-51.077	-5.000	-------	-12.00
R-47	2.083	-28.745	18.213	-------	-------	-3.46
R-50	-25.108	-54.442	-58.971	-26.108	-7.462	-25.83
TOTAL AVERAGE	-39.878	-82.357	-51.784	-22.858	-3.136	-19.59

NOTE: AN "*****" NOTATION INDICATES THAT PRE-STORM DUNE ELEVATIONS AT THE PARTICULAR CONTOUR WAS COMPLETELY WASHED OUT OR ERODED.

NOTE: AN "-----" NOTATION INDICATES THAT THERE WAS NO DUNE CONTOUR EXISTING AT THAT ELEVATION.

NOTE: AN "N / A" NOTATION INDICATES THAT THE PROFILE DATA WAS QUESTIONABLE IN TERMS OF ACCURACY.

NOTE: EROSION VOLUME AVERAGE ABOVE IS NOT WEIGHT-AVERAGED TO ACCOUNT FOR VARYING DISTANCES BETWEEN MONUMENTS; WEIGHT-AVERAGED VOLUME COMPUTED TO BE -17.82 CU YDS PER LINEAL FT.

Appendix D

County-by-County Detailed Structural Damage Descriptions and Listings

ESCAMBIA COUNTY

On October 4, the eye of Hurricane Opal passed through Pensacola Beach in Escambia County, the western most Florida county, which had not yet recovered from the impact of Hurricane Erin, the category one hurricane which two months earlier in August caused the worse storm impact since 1979. To the west of the eye only minor, mostly superficial damage occurred in the developed area of Perdido Key. In contrast, in Pensacola Beach on western Santa Rosa Island 123 major structures were destroyed or sustained major structural damage and countless others sustained nonstructural flood damage. This was twice the damage sustained during Hurricane Frederic in 1979, Pensacola Beach's worst prior storm damage.

Most of the widespread severe damage to beachfront structures along Pensacola Beach was due to the combined effects of erosion, storm surge flooding, and breaking wave loads. The major beach and dune erosion which occurred left upland structures with little protection from the hydrodynamic loads due to the storm surge and wave action. All grade level structures along the first tier of development adjacent the beach and numerous others along the second tier inland were destroyed. Many pile-supported dwellings were also destroyed which had insufficient elevations or inadequate pile penetration. A total of 90 single-family dwellings were destroyed which did not meet the current State coastal building requirements. The dwellings which did meet the current State requirements sustained only superficial damage such as lost roofing shingles, blown out porch screens, and lost breakaway walls or lattices in the understructure area.

Most of the destroyed single-family dwellings were located along Ariola Drive between DEP survey monuments R124 and R135. The first tier of beach dwellings along Ariola Drive totaled approximately 87 structures of which 55 were totally destroyed, 6 sustained damage to the understructure, one lost a room addition, one sustained major damage to a first floor, and 6 more were flooded and gutted. The 18 others which survived were built substantially to the State s coastal building requirements. Inland of Ariola Drive, another 21 dwellings in the second tier and one in the third tier of construction were destroyed. Countless other dwellings built on grade inland of Ariola Drive sustained major flooding without structural damage.

Beachfront multi-family dwellings to the east of Ariola Drive and commercial development along the western half of Pensacola Beach fared about as bad as the Ariola Drive dwellings. Destroyed were a total of 5 multifamily buildings (31 units), while another 8 multifamily buildings (30 units) and two hotel buildings (23 units) sustained major structural damage. Also destroyed were two restaurants, one recreation building, one swimming pool, and 11 other major structures. In addition, the Gulf of Mexico fishing pier at Pensacola Beach was totally destroyed. Coastal armoring is generally lacking in Pensacola Beach and only 190 feet of retaining walls were destroyed.

Escambia County damage was not just limited to the developed Pensacola Beach as major damages also occurred to the east and west within the Gulf Islands National Seashore. West of Pensacola Beach to Fort Pickens approximately 4.4 miles of park road were destroyed generally between R84 and R107 . East of Pensacola Beach to Santa Rosa County most of the 10 miles of park road were destroyed between R139 and R192 along with eleven clusters of roofed recreation decks and bathrooms plus numerous pedestrian walkways at the high use facility in the National Seashore. Only the inland segment of park road landward of the high use facility and more than 600 feet inland of the beach escaped major damage.

A detailed summary listing of structural damage sustained in Escambia County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms for inclusion into damage summary tables contained in Section IV in the main body of this report.

Storm surge measurements obtained by still water line survey measurement, as well as, wave uprush limits based on rack line/debris line measurements listed by DEP survey monument are contained in Appendix A of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN ESCAMBIA COUNTY

Single-family Dwellings Destroyed	90		
Single-family Dwellings Damaged	2		
Multi-family Dwellings Destroyed	5	(Buildings)	31 (Units)
Multi-family Dwellings Damaged	8	(Buildings)	30 (Units)
Hotel/Motels Destroyed	0		
Hotel/Motels Damaged	2	(Buildings)	23 (Units)
Restaurants Damaged/Destroyed	2		
Recreation Buildings	1		
Trailers	0		
Military Structures	0		
Pools	1		
Piers	1		
Other Major Structures	11		
Buildings With Under Structure Damage	11		
Buildings With Roofs Damaged	0		
Buildings With Sides Damaged	1		
Concrete Bulkheads (Feet)	0		
Concrete Retaining Wall (Feet)	100		
Concrete Block Retaining Wall (Feet)	0		
Wood Retaining Wall (Feet)	90		
Aluminum Retaining Wall (Feet)	0		

SANTA ROSA COUNTY

Prior to 1995 the worst coastal damage sustained in Navarre Beach and Santa Rosa County occurred during the fringe impacts of Hurricane Camille (1969) and Hurricane Frederic (1979). Camille destroyed the outer portion of the old wooden Navarre Beach fishing pier and Frederic damaged the new concrete pier and a few single-family dwellings. In August, 1995, Hurricane Erin inflicted the most severe erosion and damage ever recorded in Navarre Beach as one beachfront structure was destroyed and nine others sustained major structural damage. At least ten other major structures inland from the beach also sustained major damage, mostly due to the wind as Navarre Beach was within the region of Erin's maximum winds.

It was highly improbable that less than two months later Opal would inflict its worst fury on this already hurricane-ravaged coastal community. Along with losing its entire infrastructure of roads and utilities, Navarre Beach also had 122 major structures destroyed or sustain major structural damage. Oddly, the gulf fishing pier survived, but 47 single-family dwellings, 20 multifamily buildings (94 units), and two hotel buildings (38 units) were destroyed while another 4 single-family dwellings and 11 multifamily buildings (37 units) sustained major structural damage. Also destroyed or sustained major structural damage were one recreation building, four trailers, two swimming pools, and one other major structure.

Out of approximately 108 gulf-fronting structures, 98 (over 90 percent) were destroyed or sustained major damage. As in Pensacola Beach, the structures which were destroyed did not meet the current coastal building requirements and were impacted by the combined effects of severe erosion, storm surge flooding, and wave action. Unlike in Pensacola Beach, structures were additionally impacted by higher wind loads.

The impact of the storm surge with wave action was severe, causing a number of structures to be carried 200 to 300 feet inland of their original location. Near the east end of Navarre Beach between R208 and R209 a major washover was experienced causing the seaward unit of a multifamily building to be destroyed even though it was located over 700 feet from the beach. Two other townhouse units on Santa Rosa Sound located about 1400 feet inland of the beach were also destroyed. One single-family dwelling was swept completely off Santa Rosa Island and deposited out into Santa Rosa Sound (shown in Figures 51 and in Figure 68 in the main report). As 99 percent of the barrier dune system was totally destroyed in Santa Rosa County, any redevelopment of infrastructure and roads will be threatened by even smaller storm events in the future.

A detailed summary listing of structural damage sustained in Santa Rosa County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in Section IV in the main body of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN SANTA ROSA COUNTY

Single-family Dwellings Destroyed	47		
Single-family Dwellings Damaged	4		
Multi-family Dwellings Destroyed	20	(Buildings)	94 (Units)
Multi-family Dwellings Damaged	11	(Buildings)	37 (Units)
Hotel/Motels Destroyed	2	(Buildings)	38 (Units)
Hotel/Motels Damaged	0		
Restaurants Damaged/Destroyed	0		
Recreation Buildings	1		
Trailers	4		
Military Structures	0		
Pools	2		
Piers	0		
Other Major Structures	1		
Buildings With Under Structure Damage	16		
Buildings With Roofs Damaged	11		
Buildings With Sides Damaged	3		
Concrete Bulkheads (Feet)	0		
Concrete Retaining Wall (Feet)	0		
Concrete Block Retaining Wall (Feet)	0		
Wood Retaining Wall (Feet)	115		

OKALOOSA COUNTY

History finally caught up with Okaloosa County during Opal s severe impact. Hurricanes Camille (1969), Frederic (1979), and Erin (1995) were far enough west, and Eloise (1975), Elena (1985), and Kate (1985) were far enough east so as only to leave minor to moderate beach and dune erosion along the county's coast with no major damage. Frederic (1979) did cause a breakthrough at Norriego Point between East Pass and Old Pass Lagoon. Though other storms spared the Okaloosa County coastline, Opal inflicted its maximum winds in combination with severe flooding and erosion.

The 20 miles of beach along eastern Santa Rosa Island was severely impacted by the storm surge and wave overtopping effects and even development along the north shoreline of Santa Rosa Sound seaward of U.S. Highway 98 and in downtown Ft. Walton Beach experienced severe coastal flooding. The western 12.3 miles of county beach within Eglin Air Force Base experienced substantial washover deposits from the beach and dune profile erosion and at least 20 major military structures were destroyed.

The 3-mile developed stretch of beach adjacent to Ft. Walton Beach and called Okaloosa Island lost up to 200 feet of vegetated dune seaward of the development as this beach community like Pensacola Beach and Navarre Beach was completely inundated by Opal's storm surge. At the midpoint of this beach community (R8), a still water storm surge level was measured to be +14.13 feet NGVD as determined by a mud line in the Sandman Motel located 400 feet landward of the beach. In Okaloosa Island, Opal destroyed 8 single-family dwellings, 3 multifamily buildings (17 units), and one hotel building (7 units) and inflicted major structural damage on 7 single-family dwellings, 24 multifamily buildings (179 units), and 16 hotel buildings (125 units). Also destroyed or sustaining major structural damage were two restaurants, one recreation building, two swimming pools, and six other major structures. In addition, the seaward portion of the Okaloosa County gulf fishing pier was destroyed. Although most of the damage was in the seaward tier of beach front development, at least 15 major structures sustained major damage between 600 and 800 feet inland from the beach, including three single-family dwellings inland of Santa Rosa Boulevard which were destroyed (one by wind and two by flooding).

The eastern 4.7 miles of Santa Rosa Island between Fort Walton Beach and East Pass experienced dune erosion so severe that a few large breaches in the dune field resulted in the creation of a temporary flowing inlet which destroyed about a 2.5 mile segment of U.S. Highway 98 (see photos in Figures 9 and 52 in the main report). This vulnerable stretch of beach is part of Eglin Air Force Base and 7 major military structures were destroyed along with 1330 feet of concrete bulkhead at the Officers Club and the Beach Club.

East of East Pass in the community of Destin substantial overtopping similar to that which occurred along Santa Rosa Island was experienced along Holiday Isles with part of the beach profile and substantially all the dunes being transported into Old Pass Lagoon as overwash. Norriego Point between East Pass and Old Pass Lagoon lost 80 feet of aluminum retaining wall, 600 feet of wood retaining wall, 5 condominium units, three construction/office trailers, and two other major structures. Most of the docks and marina facilities in Old Pass Lagoon sustained major damage. A still water storm surge level was measured to be +12.03 feet NGVD at the Holiday Beach Resort near the middle of Destin (R27), while approximately 2000 feet to the east another storm surge level was measured to be +14.32 feet NGVD at the Silver Beach Motel (R29).

Throughout Destin, Opal destroyed 21 single-family dwellings, 11 multifamily buildings (68 units), and six hotel buildings (9 units), and inflicted major structural damage on five single-family dwellings, and 15 multifamily buildings (79 units). Also destroyed or sustaining major structural damage were two restaurants, seven recreation buildings, five trailers, one pool, and three other major structures. As with the beach communities to the west most of the severe damage was located along the seaward tier of beach construction; however, 28 major structures were damaged inland of Gulf Shore Drive including three dwellings destroyed over 1000 feet from the beach and seven dwellings destroyed between 500 and 700 feet from the beach. Although there was much infrastructure damage in Destin it did not compare to the beach communities to the west. Much of the road system in Holiday Isles was covered with a layer of sand but U.S. Highway 98 was not impacted east of East Pass. The 1.4 mile segment of Henderson Beach (a state park) and the 2.1 mile beach segment at the east end of the county experienced little of the overwash losses experienced throughout the rest of the county. Countywide armoring losses totalled 3450 feet of concrete, wood, and aluminum bulkheads and retaining walls.

As with previous counties, a detailed summary listing of structural damage sustained in Okaloosa County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in Section IV in the main body of this report.

Storm surge measurements obtained by still water line survey measurement, as well as, wave uprush limits based on rack line/debris line measurements listed by DEP survey monument are contained in Appendix A of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN OKALOOSA COUNTY

Single-family Dwellings Destroyed	29				
Single-family Dwellings Damaged	12				
Multi-family Dwellings Destroyed	14	(Buildings)	85	(Units)
Multi-family Dwellings Damaged	39	(Buildings)	258	(Units)
Hotel/Motels Destroyed	7	(Buildings)	16	(Units)
Hotel/Motels Damaged	16	(Buildings)	125	(Units)
Restaurants Damaged/Destroyed	4			
Recreation Buildings	8			
Trailers	5			
Military Structures	27			
Pools	3			
Piers	1			
Other Major Structures	9			
Buildings With Under Structure Damage	38			
Buildings With Roofs Damaged	45			
Buildings With Sides Damaged	10			
Concrete Bulkheads (Feet)	1330			
Concrete Retaining Wall (Feet)	330			
Concrete Block Retaining Wall (Feet)	385			
Wood Retaining Wall (Feet)	925			
Aluminum Retaining Wall (Feet)	480			

WALTON COUNTY

Twenty years before Opal, Walton County sustained a major impact by Hurricane Eloise in 1975; however, while major beach and dune erosion was sustained only scattered structural damage occurred given the general lack of existing development. Significant coastal development has occurred in Walton County since 1975, although much of the more recent construction has met the current state building requirements. While Eloise's impact lessened towards the west end of the county, Opal's impact was severe county-wide.

Unlike the three Santa Rosa Island counties of Escambia, Santa Rosa, and Okaloosa, Walton County does not have a barrier island backed by a barrier lagoon. This segment of coast is characterized by a mainland beach backed by very high dunes which are occassionally breached by runouts from the numerous coastal lakes which are spread out along the coast. Lacking the low barrier island for the storm surge to overtop, there were some areas with very high wave uprush from Opal. Evidence of excessively high wave uprush limits was seen across the entire Walton County Gulf of Mexico shorefront as measured from debris lines which reached elevations up to and exceeding +20 feet (NGVD). Although there was some wind damage most of the Walton County damage was due to the storm surge, wave impacts, and erosion.

Throughout the county 60 single-family dwellings were destroyed and 20 more sustained major structural damage. One of the worse hit areas was a half mile segment near the west end of the county between R13 and R16. Between R13 and R14, at least 16 dwellings were destroyed and six others had major damage. Two of the dwellings had their roofs blown off and several others had segments of roof damaged, but most of the damage was due to the storm surge and wave action. Although the damage was to older dwellings, eight of the dwellings destroyed were completely landward of the Coastal Construction Control Line (CCCL) and outside of the State's regulatory jurisdiction.

Between R14 and R15 near Sand Trap Road, four more dwellings were destroyed including two completely landward of the CCCL. Also two others were damaged landward of the CCCL including one Sand Trap Road dwelling located 450 feet inland of the beach which was pulled off its foundation by the flood. Just to the east in Tang O Mar subdivision, three more dwellings were destroyed and two more substantially damaged between R15 and R16. Two of the destroyed dwellings located 20 and 100 feet landward of the CCCL were both transported inland on the storm surge and deposited approximately 250 feet landward of the CCCL or 450 feet landward of the beach. Another Tang O Mar dwelling located 550 feet landward of the beach was flooded and gutted by the storm surge and associated waves. Another area of concentrated damage in western Walton County was the Gulf Pines subdivision where eight out of ten dwellings between R17 and R18 were destroyed.

In central Walton County, there were 20 dwellings destroyed and seven others substantially damaged in the Beach Highlands and Dune Allen Beach communities between R41 and R52. Three of the dwellings were destroyed on Fort Panic Road (between R44 and R45), but three permitted dwellings to the west of the destroyed dwellings had no major damage. The dune line receded 110 feet at these dwellings which were located about 30 feet landward of the beach before the storm. West of the Oyster Lake outlet between R45 and R46 another four dwellings were destroyed, two others had foundation damage, and another located landward of the road and CCCL and 400 feet from the beach had its roof blown off. The dune line receded over 100 feet in this area and the road was also damaged. The four permitted dwellings immediately east of the Oyster Lake outlet were not damaged, but nine of the next 19 dwellings to the east were destroyed and four others were damaged. One of these dwellings located about 160 feet landward of the beach in the second tier of construction was transported 1200 feet further inland and deposited on the north shoreline of Oyster Lake.

In the beach community of Blue Mountain Beach between R58 and R64, major dune erosion occurred and a high water debris line of +20.9 feet NGVD was measured but little structural damage resulted from the storm surge, waves, and erosion. The winds on the other hand damaged eight single-family dwellings and two multifamily buildings (one of which had three units destroyed).

Another paradox occurred in Grayton Beach, an old community located between R71 and R73. In Grayton Beach, four dwellings were destroyed and nine others damaged, all landward of the CCCL, which at R72 is about 500 feet landward of the beach. The destroyed dwellings were located between 600 and 800 feet landward of the beach and the damaged dwellings were located between 450 and 1000 feet landward of the beach. The worse damage was seen along Barfill Street where all four destroyed dwellings and five of the damaged dwellings were all within an eleven house block about 350 feet in length. This low flood prone neighborhood is immediately landward of the old Western Lake outlet channel and on the southwest shore of Western Lake. Various road and bridge damage occurred along County Road C-30A at the north shore of Western Lake inland of Grayton Beach State Park.

East of Grayton Beach in the relatively new community of Seaside between R79 and R82, no major damage was sustained. All the development in this high dune area is substantially inland of the beach and was not threatened by the major dune erosion which occurred. Likewise, the major dune erosion along the older community of Seagrove Beach between R82 and R91 did not cause any major damage but did leave many dwellings threatened from future erosion. In Seagrove Beach, four dwellings and two multifamily buildings were damaged by the wind. Immediately east of Seagrove Beach at R94, four multifamily buildings were damaged by the storm surge and erosion next to the Eastern Lake outlet. Another multifamily building was damaged at the Deer Lake outlet at R98.

In eastern Walton County, damage was very sporadic as most of the newer development was situated far enough landward of the beach so as not to be impacted by the major dune erosion. Along Seacrest Beach, between R107 and R115, four single-family dwellings and three multifamily buildings were damaged by the wind. And at Inlet Beach between R122 and R127, two dwellings were destroyed and one damaged due to the storm surge and erosion. The vegetation line retreated between 100 and 150 feet in Inlet Beach as the erosion left many structures threatened by future storms.

In all, Walton County had 60 single-family structures, two multifamily buildings (21 units), and two hotel buildings (19 units) destroyed, while 20 single-family dwellings and 15 multifamily buildings (37 units) were substantially damaged. Also damaged or destroyed were one restaurant, one recreation building, three trailers, and one other major structure. Significant wind damage was also sustained by 60 additional buildings. In addition, while significant armoring is very scarce in Walton County there were 1475 feet of wood or concrete retaining walls destroyed.

As with previous counties, a detailed summary listing of structural damage sustained in Walton County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in Section IV in the main body of this report.

Storm surge measurements obtained by still water line survey measurement, as well as, wave uprush limits based on rack line/debris line measurements listed by DEP survey monument are contained in Appendix A of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN WALTON COUNTY

Single-family Dwellings Destroyed	60		
Single-family Dwellings Damaged	20		
Multi-family Dwellings Destroyed	2	(Buildings)	21 (Units)
Multi-family Dwellings Damaged	15	(Buildings)	37 (Units)
Hotel/Motels Destroyed	2	(Buildings)	19 (Units)
Hotel/Motels Damaged	0		
Restaurants Damaged/Destroyed	1		
Recreation Buildings	1		
Trailers	3		
Military Structures	0		
Pools	0		
Piers	0		
Other Major Structures	1		
Buildings With Under Structure Damage	22		
Buildings With Roofs Damaged	45		
Buildings With Sides Damaged	15		
Concrete Bulkheads (Feet)	0		
Concrete Retaining Wall (Feet)	80		
Concrete Block Retaining Wall (Feet)	260		
Wood Retaining Wall (Feet)	1135		

BAY COUNTY

Since 1970, Bay County had seen its share of major storms and had taken a direct hit by Hurricane Eloise, a category three hurricane, in 1975. But even Eloise's widespread damage was not as severe as that which occurred during Hurricane Opal, notwithstanding the distance from the eye's landfall at Pensacola Beach. Nearly 450 buildings were damaged in Bay County, including over 1300 units. In addition, some 11,730 feet of bulkheads and retaining walls were destroyed.

The wind damage was not particularly severe in Bay County and little significant damage was seen north of the beach-front road. Nearly all the significant damage was due to the storm surge, erosion, and wave activity impacting the gulf-front line of construction. Much of the developed Bay County coast west of St. Andrews Inlet to Phillips Inlet was fronted by a narrow eroded beach with little significant dune profile to provide sufficient protection from extreme storm conditions. In addition, most of the existing armoring was inferior by design or longevity and added to the catastrophic damage.

Most of the storm damage in Bay County was located within the first 100 feet landward of the Coastal Construction Control Line, which was only a name applied to the 1975 setback line pending reestablishment as a CCCL which defines the impact of a 100- year storm. Given that the development landward of the former setback line was outside of the state jurisdiction over coastal construction, generally all the widespread damage was to non-conforming structures not adequately designed or constructed for a major hurricane s impact. The immediate implementation of an interim Coastal Construction Control Line and the eventual adoption of the permanent CCCL eliminated the possibility of new non-conforming structures being built in the post-storm redevelopment period.

In the western unincorporated areas of Bay County between R1 and R22, the pre-storm beach conditions were generally good; however, much of the development was inappropriately sited too far seaward. Typical of inappropriate siting was the furthest west development of Pinnacle Port which consisted of seven multi-story concrete condominium buildings between R1 and R2 which had been constructed in the early 1970's under State of Florida protest but prior to State regulatory jurisdiction over coastal construction. The entire barrier dune system within the development was leveled and the buildings were sited beyond the seaward toe of the former dunes on grade-bearing foundations and with first floor levels which did not consider hurricane storm surge flooding. Opal destroyed all 24 first floor condominium units of the development as well as the recreation room, a vending room, eight storage rooms, a trailer, and a maintenance building located over 500 feet inland of the beach. In addition even many second floor rooms were flooded.

Destroyed along Front Beach Road or Alternate U.S. Highway 98 in unincorporated Bay County west of R22, were 19 single-family dwellings, four multifamily buildings (66 units), and twelve hotel buildings (49 units). Sustaining major structural damage were nine single-family dwellings, 22 multifamily buildings (59 units), and nine hotel buildings (18 units).

With the minor exception of the accreted beaches around Dan Russel City Pier (R40-R41) and the Bay County Pier (R57-R58), there was not enough pre-storm beach profile seaward of development within Panama City Beach to provide adequate protection to inappropriately designed and sited structures. As a result, 23 single-family dwellings, four multifamily buildings (23 units), and eleven hotel buildings (36 units) were destroyed in Panama City Beach between R25 and R73. In addition, sustaining major structural damage were nine single-family dwellings, 21 multifamily buildings (159 units), and 68 hotel buildings (486 units). Most of the Bay County fishing pier was also destroyed.

The unincorporated beach between St. Andrews State Recreation Area and Panama City Beach (R73-R92) had experienced severe long term beach erosion due to the creation of St. Andrews Inlet in 1935 and due to the mismanagement of the entrapped beach sediment that was removed from the navigation channel for 35 years and disposed offshore where it was lost to the beaches. Lacking sufficient beach protection, Opal's storm surge, erosion, and waves were severe in this area. The Gulf Drive and Spyglass Drive neighborhoods dramatize the catastrophic impact in this area. Along Gulf Drive between Luff Street (near R85) and Huff Street (R88), 24 single-family dwellings out of 34 were destroyed. On Spyglass Drive, along with five dwellings the entire road bed was destroyed. Between R73 and R92, 46 single-family dwellings were destroyed and nine more sustained major structural damage. In addition, four multifamily buildings (11 units) and 29 hotel units were destroyed, and 14 multifamily buildings (59 units) and 14 hotel buildings (52 units) sustained major structural damage.

East of St. Andrews Inlet there were two major structures destroyed on Shell Island. Although major dune erosion and severe overwash occurred along Shell Island and Crooked Island further east, these islands are generally undeveloped state and federal lands. Mexico Beach, the eastern most beach of Bay County is developed and experienced its worse storm damage ever during Opal. Hurricane Kate in 1985 had previously given Mexico Beach its worse damage, while lesser damages had been sustained during Hurricanes Agnes (1972), Eloise (1975), and Elena (1985). In the City of Mexico Beach between R128 and R138, 27 single-family dwellings and one duplex were destroyed and three more dwellings sustained major structural damage. In addition, eight units and the swimming pool of El Governor Motel were destroyed behind 430 feet of concrete bulkhead which failed.

In all, Bay County had 115 single-family dwellings, 13 multifamily buildings (102 units), and 23 hotel buildings (122 units) destroyed, while 30 single-family dwellings, 57 multifamily buildings (277 units), and 107 hotel buildings (556 units) were substantially damaged. Also damaged or destroyed were five restaurants, 13 recreation buildings, two trailers, 23 swimming pools, one fishing pier, and five other major structures. Significant wind damage was also sustained by 77 additional buildings. In addition there were 11,730 feet of bulkheads and retaining walls destroyed.

As with previous counties, a detailed summary listing of structural damage sustained in Bay County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in Section IV in the main body of this report.

Storm surge measurements obtained by still water line survey measurement, as well as, wave uprush limits based on rack line/debris line measurements listed by DEP survey monument are contained in Appendix A of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN BAY COUNTY

Single-family Dwellings Destroyed	115			
Single-family Dwellings Damaged	30			
Multi-family Dwellings Destroyed	13	(Buildings)	102	(Units)
Multi-family Dwellings Damaged	57	(Buildings)	277	(Units)
Hotel/Motels Destroyed	23	(Buildings)	122	(Units)
Hotel/Motels Damaged	107	(Buildings)	556	(Units)
Restaurants Damaged/Destroyed	5			
Recreation Buildings	13			
Trailers	2			
Military Structures	0			
Pools	23			
Piers	1			
Other Major Structures	5			
Buildings With Under Structure Damage	14			
Buildings With Roofs Damaged	40			
Buildings With Sides Damaged	37			
Concrete Bulkheads (Feet)	4220			
Concrete Retaining Wall (Feet)	770			
Concrete Block Retaining Wall (Feet)	4650			
Wood Retaining Wall (Feet)	2040			
Aluminum Retaining Wall (Feet)	50			

GULF COUNTY

Coastal storms and major beach and dune erosion have been relatively common in Gulf County during the past 30 years. Prior to Opal the most severe impacts have been inflicted by Hurricanes Agnes (1972), Eloise (1975), Elena (1985), and Kate (1985), and Tropical Storms Alberto (1994) and Beryl (1994). The most damages were experienced in Kate in 1985 when 31 major structures were destroyed or sustained major structural damage. In a similar magnitude of impact, Opal destroyed or caused major structural damage to 26 major structures, although Gulf County actually only received the fringe impact of Opal.

No storm surge data was obtained in Gulf County after Opal, but the +13.5-foot NGVD storm surge elevation measured in Mexico Beach is probably representative of the flood elevations experienced along the mainland of Gulf County and possibly along much of St. Joseph Peninsula. At the north end of Gulf County between R1 and R2, six single-family dwellings were destroyed and one other had major structural damage. However, between R2 and R30, no more significant damage was sustained given the nature of construction and the sheltering effect of St. Joseph Peninsula.

Major beach and dune erosion occurred along the entire length of St. Joseph Peninsula south to Cape San Blas. Between R31 and R69 the peninsula is undeveloped state park and no structural damages occurred. Within the developed portion of the park there were four major dune breaches between the gulf and St. Joseph Bay. Along the developed length of the peninsula between R75 and R106 at Stump Hole, seven single-family dwellings and three multifamily buildings (9 units) were destroyed, while four single-family dwellings and one multifamily building (5 units) sustained major structural damage. In addition, two buildings were damaged or destroyed at the Air Force property on Cape San Blas. The Air Force also lost 700 feet of paved road out to the rocket launching site along with 400 feet of revetment which was inappropriately constructed after Hurricane Kate. At Stump Hole about 2000 feet of County Road C30E was destroyed when a major breach truncated St. Joseph Peninsula from Cape San Blas. Stump Hole is a notorious critical erosion area subject to periodic breakthroughs.

As with previous counties, a detailed summary listing of structural damage sustained in Gulf County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in the main body of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN GULF COUNTY

Single-family Dwellings Destroyed	13	
Single-family Dwellings Damaged	5	
Multi-family Dwellings Destroyed	3 (Buildings)	9 (Units)
Multi-family Dwellings Damaged	1 (Building)	5 (Units)
Hotel/Motels Destroyed	0	
Hotel/Motels Damaged	0	
Restaurants Damaged/Destroyed	0	
Recreation Buildings	0	
Trailers	2	
Military Structures	2	
Pools	0	
Piers	0	
Other Major Structures	0	
Buildings With Under Structure Damage	6	
Buildings With Roofs Damaged	0	
Buildings With Sides Damaged	0	
Concrete Bulkheads (Feet)	75	
Concrete Retaining Wall (Feet)	0	
Concrete Block Retaining Wall (Feet)	0	
Wood Retaining Wall (Feet)	0	

FRANKLIN COUNTY

Franklin County only received the distant fringe impact of Opal, unlike the direct impacts of Hurricane Agnes (1972) when many structures were destroyed at Alligator Point, Hurricane Elena (1985) when 22 major structures were destroyed or sustained major damage, or Hurricane Kate (1985) when 159 major structures were destroyed or sustained major structural damage. Opal only destroyed or damaged seven major structures, all single-family dwellings.

Western coastal Franklin County is generally undeveloped; however, major beach and dune erosion was sustained along St. Vincent Island, Little St. George Island, and western St. George Island west of Bob Sikes Cut. East of Bob Sikes Cut along St. George Island construction setbacks and design precluded any significant storm damage. At the state park on the east end of St. George Island, a significant portion of road was destroyed or damaged.

Dog Island, east of St. George Island, had been experiencing continued erosion stress prior to Opal which inflicted major beach and dune erosion along its six and one-half mile length. Although most of Hurricane Kate's damage to Dog Island dwellings was due to wind, Opal's damage was due to erosion undermining foundations. Four dwellings were destroyed and two others sustained major structural damage as a result of Opal. Another single-family dwelling was also destroyed due to erosion undermining its foundation at the Southwest Cape on Alligator Point in eastern Franklin County, about 200 miles from the geographic landfall of Opal's eye.

As with previous counties, a detailed summary listing of structural damage sustained in Franklin County from Hurricane Opal is provided on the following page. This damage information was summarized in more general terms in Section IV in the main body of this report.

SUMMARY OF DAMAGES TO COASTAL STRUCTURES IN FRANKLIN COUNTY

Single-family Dwellings Destroyed	5
Single-family Dwellings Damaged	2
Multi-family Dwellings Destroyed	0
Multi-family Dwellings Damaged	0
Hotel/Motels Destroyed	0
Hotel/Motels Damaged	0
Restaurants Damaged/Destroyed	0
Recreation Buildings	0
Trailers	0
Military Structures	0
Pools	0
Piers	0
Other Major Structures	0
Buildings With Under Structure Damage	0
Buildings With Roofs Damaged	0
Buildings With Sides Damaged	0
Concrete Bulkheads (Feet)	0
Concrete Retaining Wall (Feet)	0
Concrete Block Retaining Wall (Feet)	0
Wood Retaining Wall (Feet)	0
Aluminum Retaining Wall (Feet)	0
Rock Revetment (Feet)	0