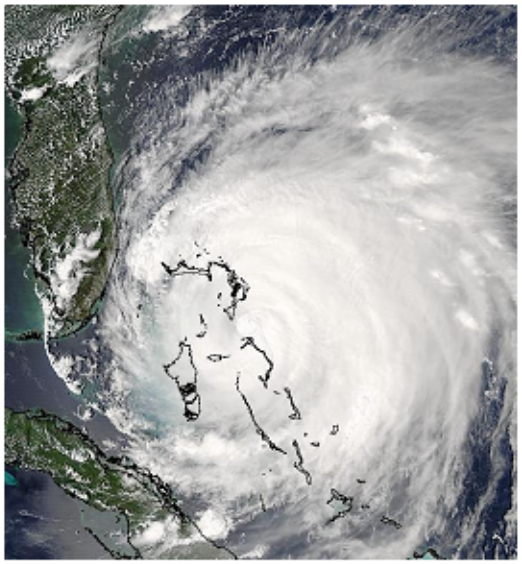
HURRICANE FRANCES

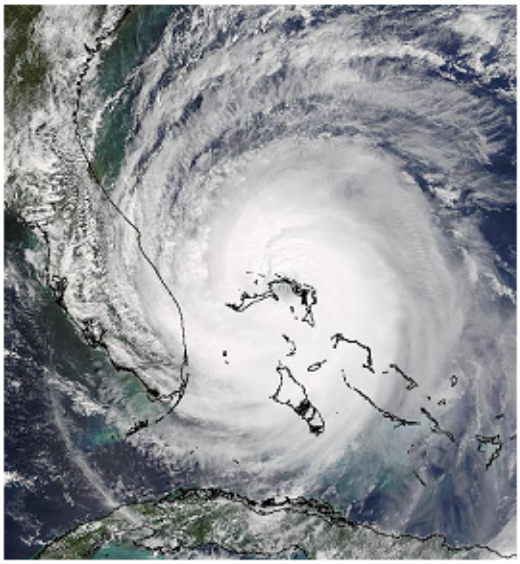
&

HURRICANE JEANNE

Post-storm Beach Conditions and Coastal Impact Report
with
Recommendations for Recovery and Modifications of Beach Management Strategies



NASA(Frances.A2004247.1824.2km) Satellite Photo of Hurricane Frances



NASA (Jeanne.A2004269.1615.2km) Satellite Photo of Hurricane Jeanne

Florida Department of Environmental Protection
Division of Water Resource Management
Bureau of Beaches and Coastal Systems
October 2004

Foreword

The Bureau of Beaches and Coastal Systems of the Florida Department of Environmental Protection is responsible for protection and management of the State's sandy beaches fronting the Gulf of Mexico, the Atlantic Ocean and the Straits of Florida and the regulation of coastal development adjacent to those coastal beaches. The monitoring and assessment of hurricane impacts to the State's beaches and coastal construction and the preparation of post-storm recovery responses and management strategies are important elements of the Bureau's responsibilities.

This report provides documentation of the impacts of Hurricanes Frances and Jeanne on the coast of Florida and preliminary recommendations for post-storm response activities. This report was prepared by the Coastal Engineering Section for the Bureau of Beaches and Coastal Systems. The report was written by Ralph R. Clark, P.E., P.L.S., with major contributions and preparation of graphics by James LaGrone, Coastal Engineer, and additional contributions by Robert Brantly, P.E. Field data of beach and dune erosion and structural damage were obtained by Ralph Clark, James LaGrone, Robert Brantly, Mark Taynton, Bobbie Nelson, Gene Varano, Bill Wilkinson, Phil Sanders, Jackie Thompson, Celora Jackson, Steve West, and Jennifer Cowart. Hurricane track assistance was provided by Ernest Besse. Aerial videography and oblique aerial photography were supplied by Stacey B. Roberts of PBS&J.

STATE OF FLORIDA, DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Michael R. Barnett, P.E., Chief
Bureau of Beaches and Coastal Systems

Table of Contents

Hurricane Frances

August 24 – September 6, 2004

Through October, the 2004 tropical storm season has produced 13 tropical storms and 1 subtropical storm in the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. Before the end of September, 2004, eight of these reached hurricane strength and six became major hurricanes reaching a Category 3 on the Saffir-Simpson hurricane intensity scale. Hurricane Frances, the sixth hurricane of the Atlantic Ocean, Caribbean Sea and Gulf of Mexico 2004 season, spawned from a tropical wave that drifted westward off the coast of western Africa. A low-pressure area developed from the wave and became recognizable as a tropical depression on August 24, 2004. In its initial advisory, the National Weather Service, Tropical Prediction Center (National Hurricane Center, Miami, Florida) located this depression near latitude 11.2 degrees north, longitude 36.0 degrees west, or about 870 miles west-southwest of the Cape Verde Islands. The movement was westward near 17 miles per hour (mph). Figure 1 illustrates the track of Hurricane Frances.

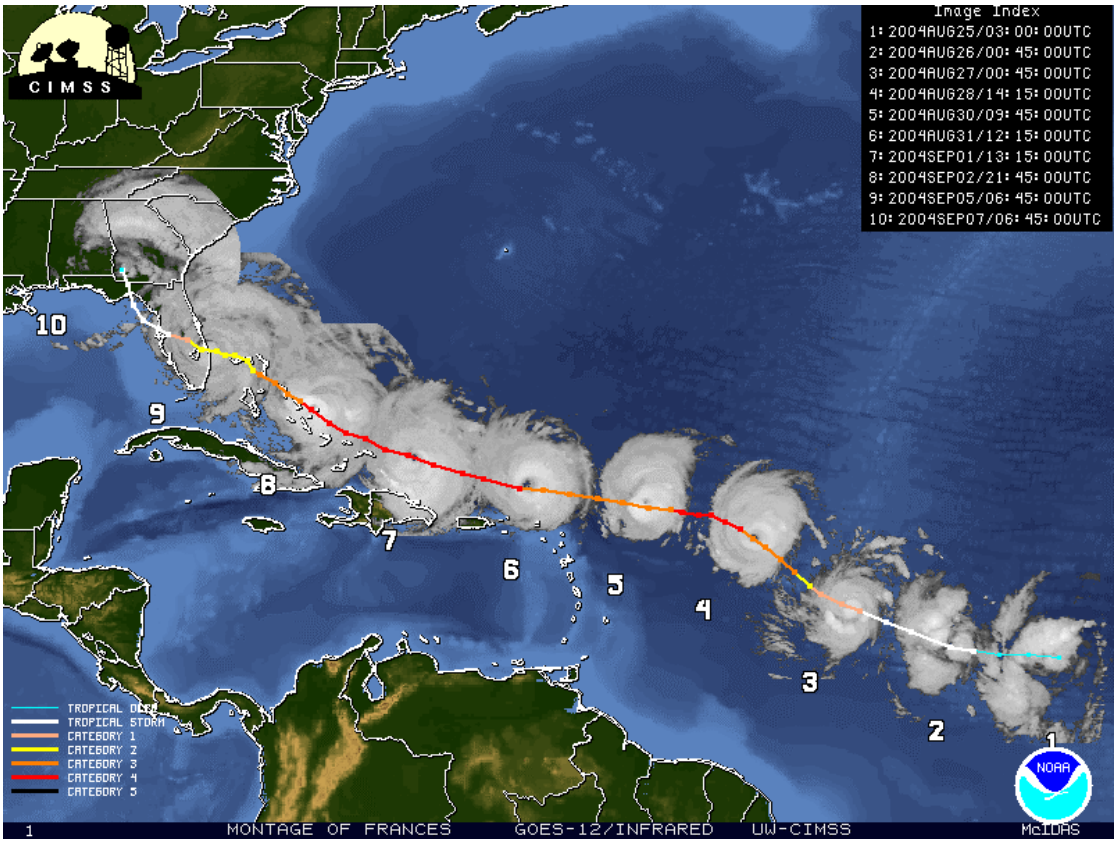


Figure 1: Montage of Hurricane Frances' Track and Satellite Photos

(Image courtesy of Cooperative Institute of Meteorological Scientific Studies (CIMSS) at University of Wisconsin

At 5:00 p.m. on Wednesday, August 25, the National Hurricane Center's (NHC) fourth advisory upgraded the depression to a tropical storm naming it Frances and locating it near latitude 11.6 north, longitude 40.5 west, or about 1420 miles east of the Lesser

Antilles. Movement was still west at 17-mph. At 5:00 p.m. Thursday, August 26, the NHC's eighth advisory upgraded Frances to a hurricane locating it about 1005 miles east of the Lesser Antilles moving west-northwest near 16-mph with winds near 80-mph.

Hurricane Frances strengthened and at 5 p.m. Friday, August 27, the NHC's twelfth advisory upgraded Frances to a Category 3 (major) hurricane. At this time Hurricane Frances was located about 800 miles east of the Leeward Islands and was moving northwest near 12-mph with maximum sustained winds of 115-mph. The next day, Saturday, August 28, the NHC upgraded Frances to a Category 4 hurricane with maximum sustained winds of 135-mph. Frances was located 690 miles east of the Leeward Islands and was moving northwest near 9-mph.

By Sunday afternoon, August 29, an U.S. Air Force Reserve "Hurricane Hunter Aircraft" flew into the eye of Frances and measured a minimum barometric pressure of 949 millibars (Mb) in an eye of 12 nautical miles. A subtropical ridge strengthened and expanded to the north of the hurricane causing Frances to realign its motion back to the west and slow down to 8-mph. On Monday, August 30, a National Oceanic and Atmospheric Administration (NOAA) P-3 "Hurricane Hunter Aircraft" measured a barometric pressure of 948-Mb with maximum sustained winds of 125-mph, and moving west at 14-mph. At that time tropical storm advisories were issued in the Leeward Islands, including Puerto Rico and the U.S. Virgin Islands.

By Tuesday, August 31, Frances had strengthened to a powerful Category 4 hurricane with winds of 140-mph moving west at 17-mph. Hurricane warnings were issued for the southeastern Bahamas and the Turks and Caicos Islands. On Wednesday, September 1, Hurricane Frances passed through the Turks and Caicos Islands and advanced into the southeastern Bahamas. Grand Turk Island reported a maximum sustained wind of 79-mph as the eye of Frances passed north of the island. By evening, hurricane advisories were posted throughout the Bahamas and east coast of Florida.

On Thursday, September 2, 2.8 million Florida residents from 32 counties were asked to evacuate to locations of safety. The 5:00 p.m. advisory from the NHC placed the hurricane near latitude 24.1 degrees north, longitude 74.8 degrees west, or about 375 miles east-southeast of Florida. The eye of Frances was over San Salvador in the Bahamas, where sustained winds of 114-mph were reported. The hurricane was tracking northwest at 10-mph.

Friday, September 3, sustained winds were reported to be 115-mph in the Abacos and 100 mph on Eleuthera Island. Frances slowed its west-northwest course to near 8-mph. Outer squalls began moving over the Florida east coast, and the 5:00 p.m. advisory from the NHC positioned Frances 200 miles east-southeast of Florida, with size comparisons to the state of Texas. Friday evening, Frances continued to slow to 6-mph and weaken to Category 2 status with maximum sustained winds of 105-mph. The Lake Worth C-MAN weather station reported a sustained wind of 44-mph with a gust to 52-mph, indicating weather conditions along the southeast coast of Florida were deteriorating.

Saturday morning, September 4, Frances moved slowly over Grand Bahama Island near Freeport. The 5:00 p.m. NHC advisory indicated Frances had stalled about 50 miles east-southeast of Palm Beach, Florida. The 11:00 p.m. NHC advisory placed the center of Frances' large eye, approximately 45 miles across, about 35 miles northeast of West Palm Beach drifting slowly west-northwest near 5-mph. This placed the western portion of the large eyewall over portions of St. Lucie, Martin, and Palm Beach Counties. The 1:00 a.m. NHC advisory on Sunday, September 5, reported the eye of Frances crossing south Hutchinson Island and making landfall near Sewall's Point, with maximum sustained winds of 105-mph. The Florida Coastal Monitoring Program Tower at Port Salerno reported a barometric pressure of 963.1 Mb.

By 5:00 a.m., wind gusts of 81-mph were reported from West Palm Beach and in excess of 90-mph at Lake Okeechobee. By 9 a.m. a wind gust of 124-mph was reported at Port Canaveral. Hurricane Frances tracked northwest across the Florida peninsula throughout the day, passing north of Okeechobee and continued through the communities of Frostproof and Bartow in central Florida. At 5:00 p.m., the NHC advisory placed the center of the eye about 20 miles east of Tampa with winds of 70-mph.

Early Monday morning, September 6, 2004, Tropical Storm Frances entered the Gulf of Mexico near New Port Richey after taking nearly 24 hours to cross the Florida peninsula. While crossing Florida, Frances caused record flood stages at Cypress Creek and Hillsborough River in Tampa and the second highest recorded flood stage on the Peace River at Bartow. Frances continued northwestward across the northeast Gulf of Mexico making a second landfall east of the St. Marks River on Labor Day with maximum sustained winds of 65-mph. The 11:00 p.m. NHC advisory downgraded Frances to a tropical depression near Albany, Georgia.

The tropical depression moved through Georgia and the Carolinas bringing significant rainfall and a severe outbreak of tornadoes. There were 106 tornadoes attributed to Frances. This is the second worst tornado outbreak in recorded history and the worse since a similarly sized Hurricane Beulah drifted into south Texas in 1967 spawning 112 tornadoes.

Hurricane Jeanne

September 13 –27, 2004

On September 13, the 11th tropical depression of the 2004 tropical storm season formed east of the Leeward Islands. At 5:00 p.m. the NHC issued a tropical storm warning for Puerto Rico and the U.S. Virgin Islands. Tuesday morning, September 14, the tropical depression crossed over Guadeloupe and was upgraded to a tropical storm named Jeanne. The 11:00 a.m. NHC advisory located Jeanne at latitude 16.6 degrees north, longitude 63.1 degrees west or about 135 southeast of St. Croix, U.S. Virgin Islands. Jeanne was tracking west-northwest at 12 mph. At 5:00 p.m. hurricane warnings were issued for Puerto Rico and the U.S. Virgin Islands as Jeanne continued to strengthen. Figure 2 illustrates the track of Hurricane Jeanne.

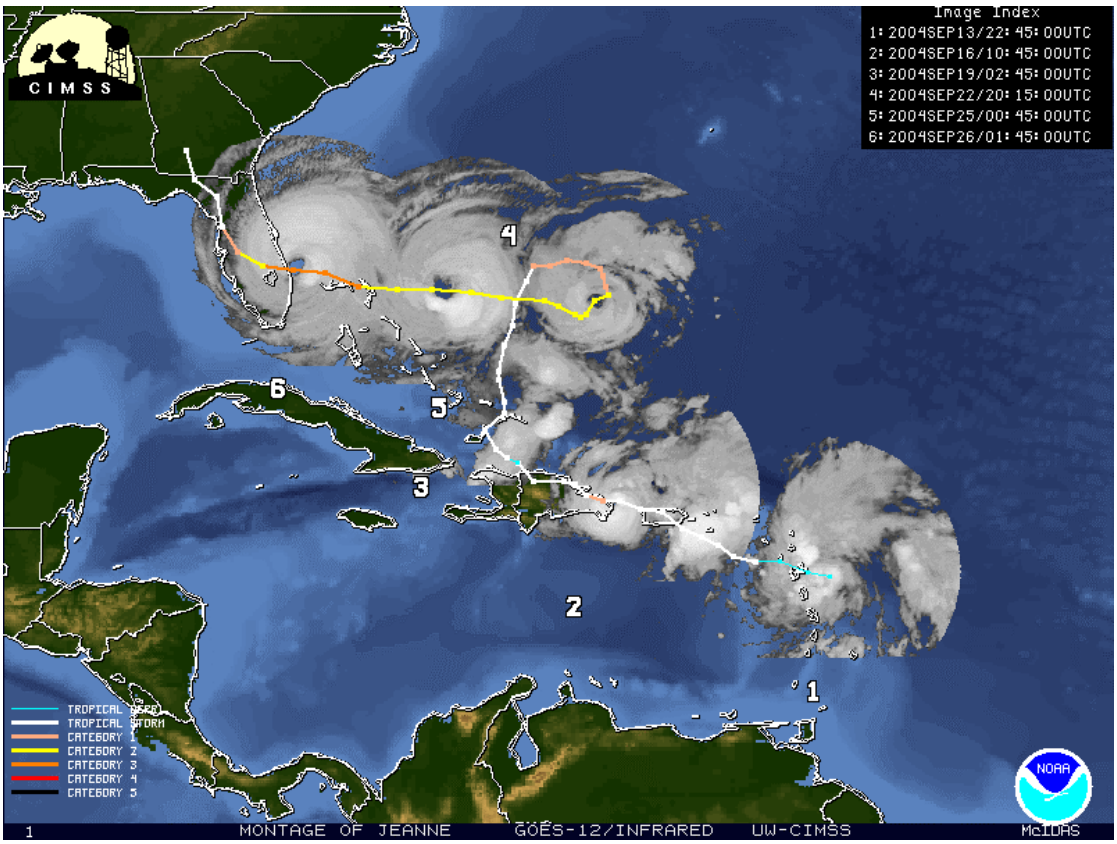


Figure 2: Montage of Hurricane Jeanne's Track and Satellite Photos

(Image courtesy of Cooperative Institute of Meteorological Scientific Studies (CIMSS) at University of Wisconsin

Tropical Storm Jeanne crossed Puerto Rico through the day and evening on Wednesday, September 15, with sustained winds of 70-mph. Several locations on the island reported more than 12 inches of rain and the town of Naguabo reported over 20 inches. Passing westward over the Mona Passage, Jeanne intensified to become the eighth hurricane of the season on the morning of Thursday, September 16. Category 1 Hurricane Jeanne drifted westward along the north coast of the Dominican Republic. As Jeanne weakened back to tropical storm strength it inflicted torrential rain throughout the island of

Hispanola. Jeanne continued to rain and weakened to a tropical depression on Friday afternoon, September 17. Throughout Friday evening and Saturday morning, Jeanne was nearly stationary off the north coast of Haiti, where severe flooding and mudslides occurred. Jeanne regained tropical storm strength and drifted slowly northwest toward the Turks and Caicos Islands. Crossing those islands Saturday afternoon, September 18, 2004, Jeanne became somewhat poorly organized and tracked erratically northward through the evening.

From Sunday through Monday, Jeanne took a slow northerly track and regained hurricane strength during the afternoon of Monday, September 20, about 370 miles east-northeast of Great Abaco Island. Tuesday and Wednesday, Hurricane Jeanne made a slow clockwise loop in the Atlantic and slowly strengthened. Thursday, September 23, and Friday, September 24, Jeanne tracked slowly westward toward the Bahamas. NOAA and U.S. Air Force reconnaissance aircraft reported maximum sustained winds of 100-mph. Hurricane warnings were issued for the Florida east coast Friday afternoon.

Saturday morning, September 25, Jeanne intensified to a Category 3 (major) hurricane, with maximum sustained winds of 115-mph. Powerful Hurricane Jeanne passed over Abaco Island and Grand Bahama Island Saturday afternoon and evening. A late afternoon NHC advisory reported a measured wind gust from Settlement Point on the west end of Grand Bahama Island at 98-mph. A Florida Coastal Monitoring Program wind tower in Vero Beach reported a wind gust of 63-mph.

The Saturday, September 25, 9:00 p.m. NHC advisory reported a sustained wind of 86-mph and a gust to 112-mph at the west end of Grand Bahama Island. The Vero Beach station reported a sustained wind of 55-mph, gusting to 68-mph. Crossing the Gulf Stream, Jeanne intensified slightly and Jeanne's eye grew to as much as 40 miles in diameter. Jeanne was approximately as large as Frances was three weeks earlier and landfall was forecast for the same coastal area of Florida. Before landfall, a wind gust to 94-mph was measured at Vero Beach. Near midnight, the center of Hurricane Jeanne made landfall at the House of Refuge on southern Hutchinson Island near latitude 27.2 degrees north, longitude 80.2 degrees west. The NHC reported that a NOAA P-3 research aircraft had determined that Jeanne had attained major hurricane Category 3 strength, with maximum sustained winds of 120-mph. At 1:00 a.m., Sunday, September 26, a wind gust of 106-mph was measured in Vero Beach.

Sunday, September 26, Jeanne tracked westward from the Florida east coast passing north of Lake Okeechobee. A 3:00 a.m. advisory reported wind gusts of 102-mph near Sebastian and 104-mph from a South Florida Water Management District station in Lake Okeechobee. A storm surge of three feet was reported on the south shore of Lake Okeechobee. A weakening Jeanne veered northwestward across central Florida, bringing hurricane force winds to the Orlando area for the third time in six weeks. A wind gust to 78-mph was measured at the Orlando International Airport. In Sanford, a section of U.S. Highway 17 was destroyed along the shore of Lake Monroe. Jeanne passed east of Tampa near noon and continued to weaken to tropical storm strength. A wind gust of 67-mph was measured in St. Petersburg. Tropical storm strength winds

between 48 and 70-mph were reported from Sarasota to Gainesville and St. Augustine. Through the evening Sunday, Jeanne tracked north along peninsula Florida, passing 40 miles east of Tallahassee. Monday morning, September 27, a minimal tropical storm Jeanne entered Georgia and continued northward weakening as it brought substantial rainfall to an already waterlogged southeast. The rainfall from Jeanne caused substantial flooding along the entire St. Johns River system, as many areas remained flooded throughout the following week.

Post-storm Beach Conditions and Coastal Impact Summary and Overview

Coastal property owners holding 20-year mortgages in Florida have a 20 percent chance of experiencing a 100-year storm surge event during the life of their mortgage. The odds of experiencing two 100-year events within the same month defy rational planning statistics. However, that is what occurred during September, 2004, when both Hurricanes Frances and Jeanne made landfall on Hutchinson Island only three weeks apart. Weather records in the United States have never recorded two hurricanes making landfall at the same location in one month. When Hurricane Jeanne made landfall, it also marked the first time for any individual state to be impacted by four hurricanes in one tropical storm season since 1886. It was also the first time for Florida to be impacted by four hurricanes since weather records began in 1851.

Figure 3 presents the combined tracks of Hurricanes Frances and Jeanne including a "landfall scale" inset showing the reported crossing points for the approximate centers of each hurricane's eye. Interestingly, Frances and Jeanne shared more than a common point of landfall. Both storms made landfall near midnight after crossing Abaco Island and Grand Bahama Island in the northern Bahamas. Each of the hurricanes measured over 400 miles across, and had large eyes over 40 miles in diameter. A major difference between the storms was their dynamics before landfall. Frances, formerly a powerful Category 4 hurricane, slowed its forward speed and weakened to a Category 2 hurricane, with maximum sustained winds of 105-mph at landfall. In contrast, Jeanne, weakly looped around in the Atlantic as a minimal hurricane before tracking westward, speeding up and intensifying to a Category 3 hurricane with maximum sustained winds of 120-mph at landfall.

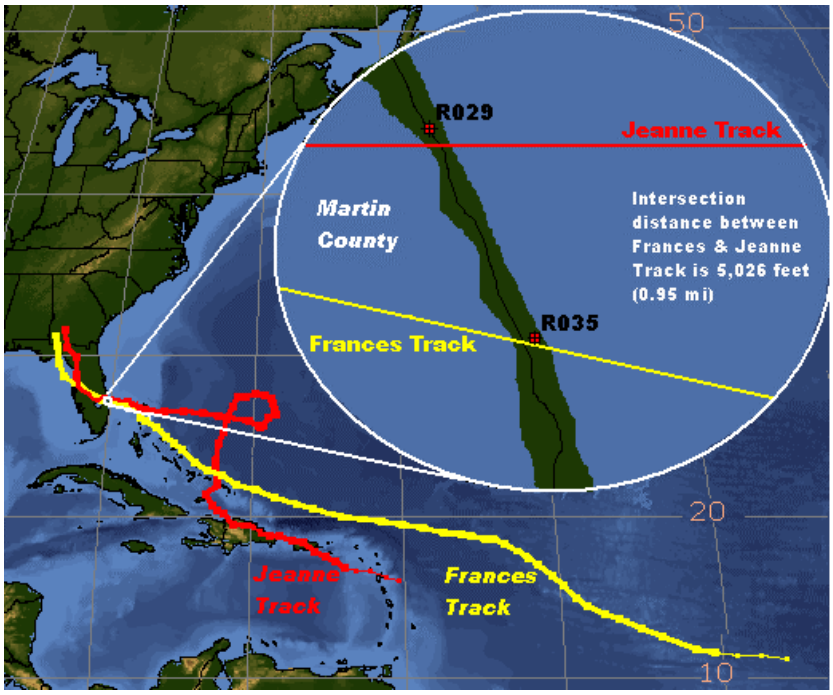


Figure 3: Combined Tracks of Hurricane Frances and Jeanne

The winds of each hurricane are graphically presented in the wind swath maps shown in Figures 4 and 5. The data was prepared and provided by the Hurricane Research Division (HRD) at the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanographic and Atmospheric Administration.

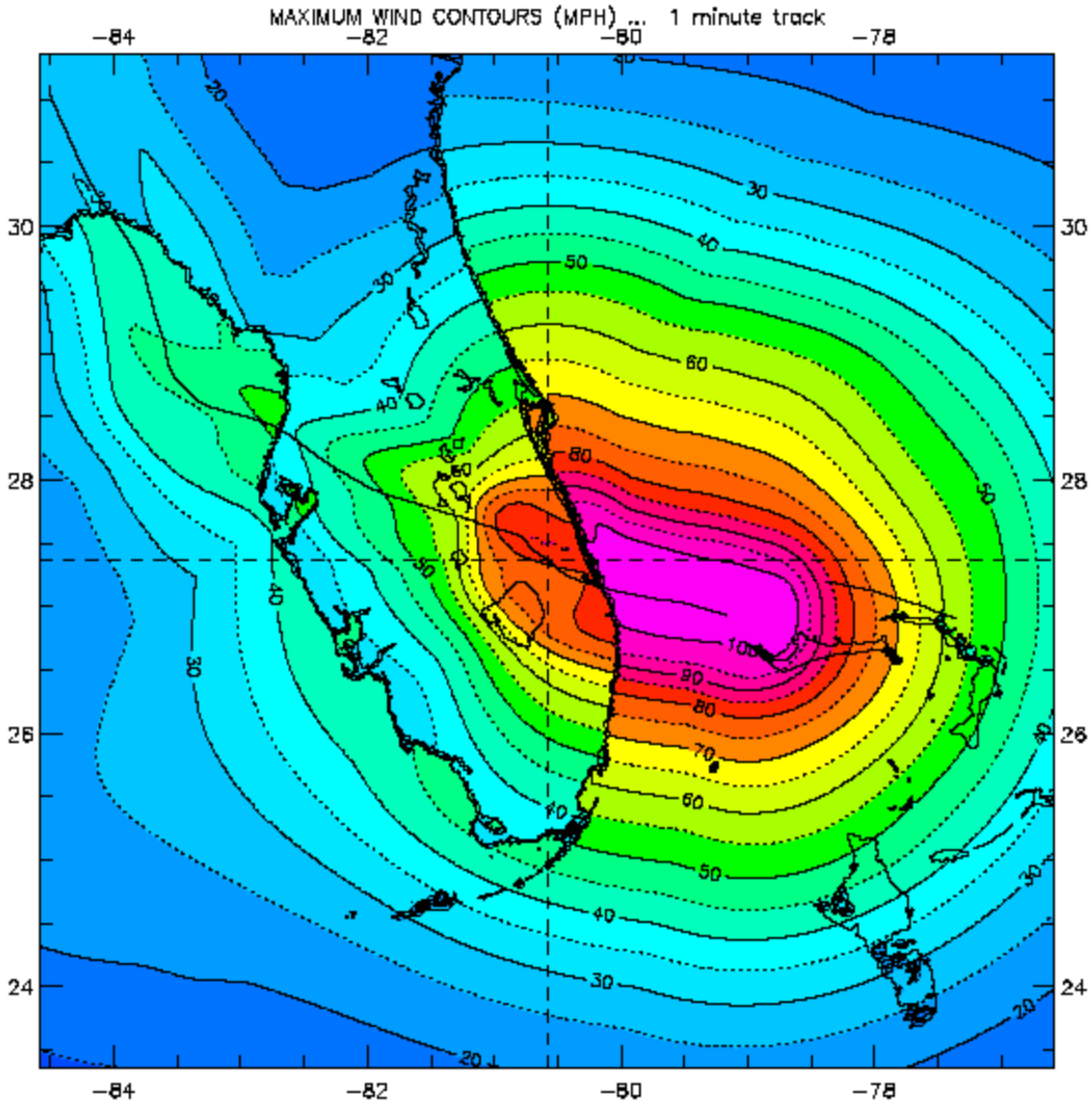


Figure 4: Surface Wind Fields Associated with Hurricane Frances

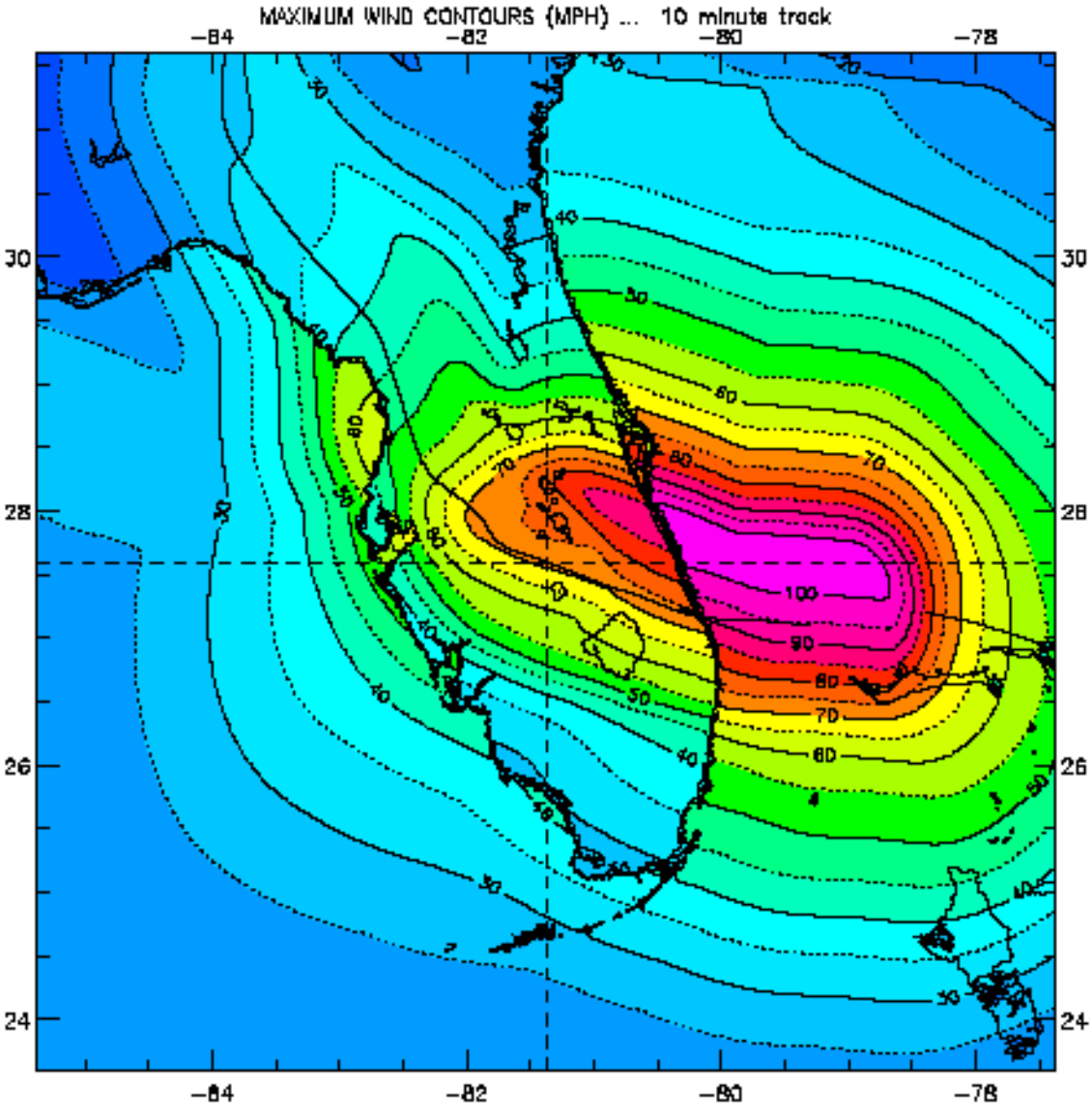
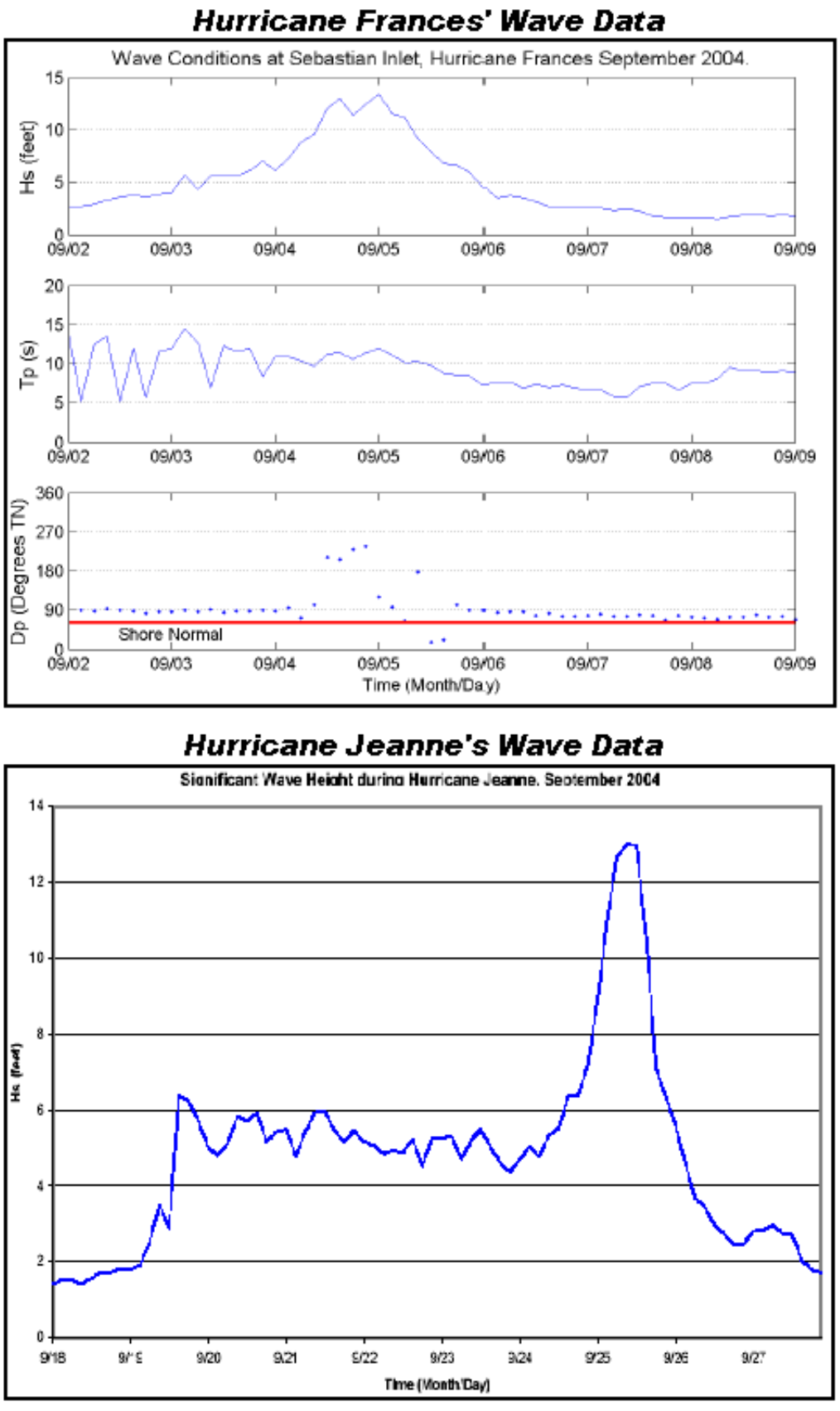


Figure 5: Surface Wind Fields Associated with Hurricane Jeanne

Initial estimates of the storm surge including wave uprush for Hurricane Frances was approximately +12 feet NGVD (based upon field data obtained at Avalon State Park in northern St. Lucie County). Although specific storm surge data has not yet been evaluated for Hurricane Jeanne, it was apparent from field observations that the storm surge from Jeanne was as high or even slightly higher than that experienced from Hurricane Frances.

Deep-water wave data were not available near the passage of the eye of either hurricane. Nearshore wave data was obtained by two sources during Hurricane Jeanne. Figure 6 illustrates wave data provided by a Florida Institute of Technology (FIT) wave gage located approximately 1,000 feet offshore and 1,500 feet north of Sebastian Inlet.



Lee E. Harris, Ph.D., P.E., Assoc. Prof. & Consulting Coastal & Ocean Engineer, Florida Institute of Technology, Melbourne

Figure 6: FIT's Wave Data For Hurricane Frances and Jeanne

Figure 7 presents wave heights and periods obtained by a Florida Coastal Forcing Project wave gage located off Spessard Holland Park in 8 meters of water, and by National Data Buoy Center wave gage off Cape Canaveral in 841 meters of water.

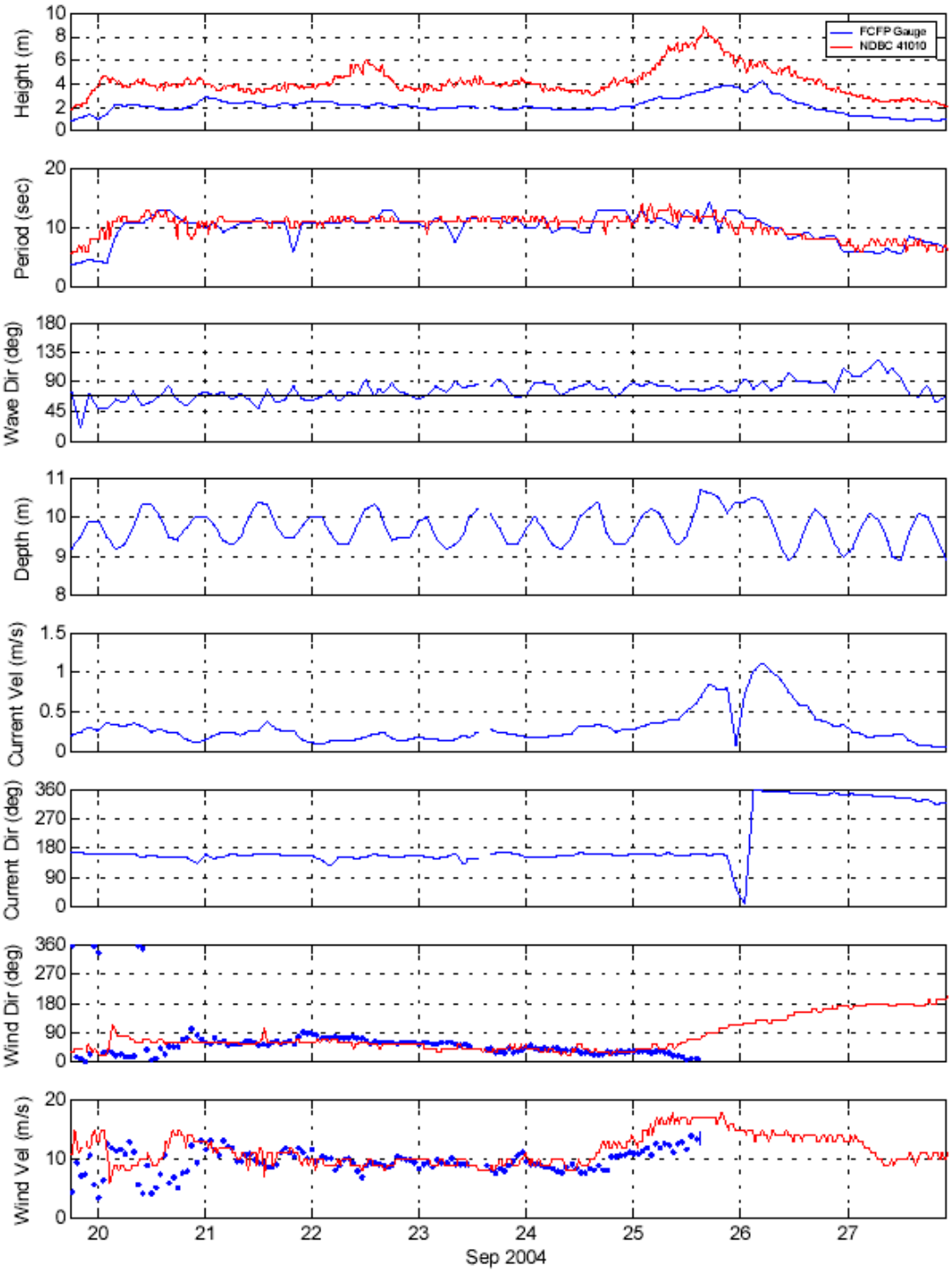


Figure 7: Wave Data off Spessard Holland Park

The coastal areas sustaining the greatest impact from each storm were generally the counties north of the point of landfall. Specifically, extending northward from the landfall point were northern Martin, St. Lucie, Indian River, Brevard, and Volusia Counties. The northeastern counties of Nassau, Duval, St. Johns, and Flagler sustained lesser (fringe) impacts. The counties of southwest Florida sustained beach and dune erosion impacts as would be expected from tropical storm strength conditions. The cumulative effect, however, on beach and dune systems already impacted from Hurricanes Charley and Ivan this season, is substantial in certain areas. This report provides a discussion of the beach and dune erosion conditions using a qualitative scale provided by Clark (1981) as shown in Figure 8. Detailed topographic and bathymetric surveys of the beach and nearshore of the impacted areas will provide a more quantitative evaluation. Local governments and the U.S. Army Corps of Engineers are currently surveying many areas. These detailed surveys will assist in quantifying impacts and in projecting the costs of the recovery recommendations and management strategies outlined on pages 85 – 88.

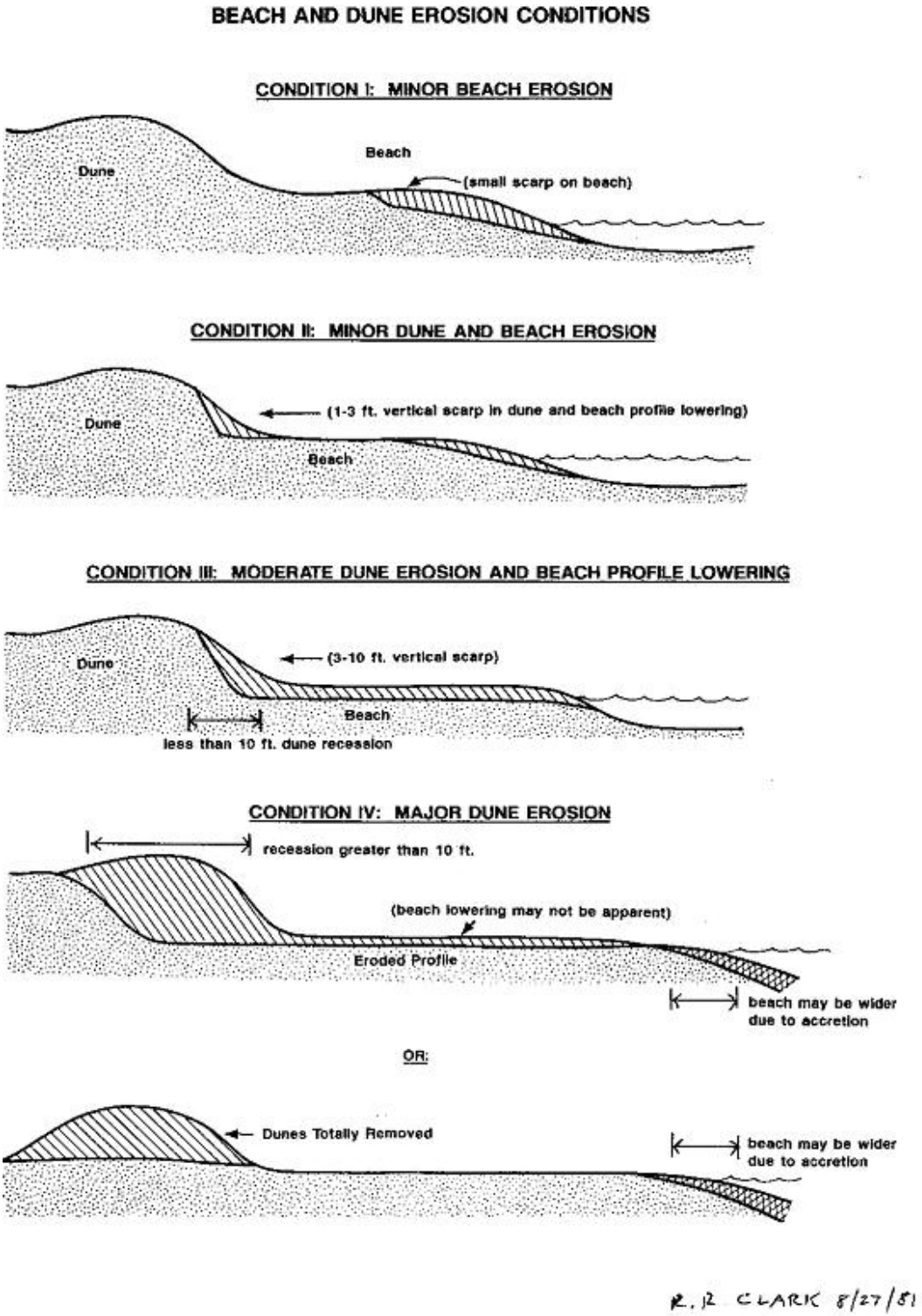


Figure 8: Beach and Dune Erosion Conditions

A summary of beach and dune erosion conditions is provided in Table 1 using the qualitative scale shown in Figure 8. A summary of substantial damages to major structures on the open coast of Florida is provided in Table 2**.** Table 2 summarizes damage within the coastal building zone as defined in Chapter 161, Florida Statutes. Pages 18 through 63 provide a county by county discussion of each storm's impact in specific areas. A qualitative description of the damage to coastal construction is provided for each coastal county significantly impacted.

Table 1: Beach and Dune Erosion Conditions after Hurricanes Frances and Jeanne

County	**Erosion Condition**
Nassau	I (minor)
Duval	
Little Talbot Island – Mayport (R1-R36)	I-II (minor)
Atlantic Beach – Neptune Beach (R36-R56)	III (moderate)
Jacksonville Beach (R69-R80)	II (minor)
St. Johns	
Ponte Vedra and northern county (R7-R33)	II (minor)
St. Augustine Beach (R141-R143)	IV (major)
Anastasia Island including Crescent Beach (R154-R197)	IV (major)
Summer Haven (R197-R208)	III (moderate)
Flagler	
Marineland and northern county (R1-R36)	III (moderate)
Palm Coast – North Flagler Beach (R36 to R71)	I-II (minor)
Northern Flagler Beach (R71-R78)	III (moderate)
Southern Flagler Beach (R78-R90)	I-II (minor)
Flagler Beach south of the revetment (R90-R94)	IV (major)
Southern county (R94-R100)	III (moderate)
Volusia	IV (major)
Brevard	
North of Cape Canaveral	II-III(moderate)
Cape Canaveral to Canaveral Inlet	Accretion
Canaveral Inlet to Sebastian Inlet (R1-R218)	IV (major)
Indian River	
Sebastian Inlet to Rio Mar (R1-R86)	IV (major)
Rio Mar Reef embayment (R86-R95)	II (minor)
South County (R95-R119)	IV (major)
St. Lucie	IV (major)
Martin	
Hutchinson Island (R1-R42)	IV (major)
Northern Jupiter Island (R43-R77)	II-III(moderate)

Table 1: Beach and Dune Erosion Conditions after Hurricanes Frances and Jeanne

County	**Erosion Condition**
Town of Jupiter Island (R77-R121)	II (minor)
Blowing Rocks (R121-R127)	III (moderate)
Palm Beach	
Northern county (R1-R12)	III (moderate)
Jupiter Inlet to Lost Tree Village (R13-R51)	II (minor)
Singer Island (R51-R75)	III (moderate)
Palm Beach Island (R76-R151)	III (moderate)
Southern county (R152-R227)	II (minor)
Broward	I (minor)
Dade	I (minor)
Collier	I (minor)
Lee	I (minor)
Charlotee	I (minor)
Sarasota	
County Wide	I-II (minor)
Except	
South Siesta Key (R75-R77)	III (moderate)
Manatee	
County Wide	I-II (minor)
Except	
North Anna Maria Island (R3-R5)	III (moderate)
Pinellas	
County Wide	I-II (minor)
Except	
Clearwater Beach Island to northern Sand Key (R32- R57)	III (moderate)
Upham Beach	IV (major)
Pass-a-grille Beach	IV (major)
Wakulla	I (minor)
Franklin	
County Wide	I (minor)
Except	
Lighthouse Point (R221-R222)	II (minor)

Table 2: Substantial Damages to Major Structures Attributed to Hurricanes Frances and Jeanne within the Coastal Building Zone

County	Hurricane Frances				Hurricane Jeanne			
	SFD	MFD	OMS	Total	SFD	MFD	OMS	Total
Nassau	3	0	0	3	0	0	0	0
Duval	0	2	0	2	0	3	0	3
St. Johns	12	5	0	17	0	0	1	1
Flagler	0	1	1	2	0	0	2	2
Volusia	32	13	1	46	8	25	12	45
Brevard	95	99	62	256	214	86	46	346
Indian River	54	23	18	95	110	59	24	193
St. Lucie	50	21	29	100	4	22	14	40
Martin	4	16	0	20	4	5	2	11
Palm Beach	0	1	1	2	0	0	0	0
Broward	0	0	1	1	0	0	0	0
Sarasota	0	0	0	0	0	0	2	2
Pinellas	0	0	0	0	0	3	0	3
TOTAL				**546**	**TOTAL**			**644**

SFD – Single-Family Dwellings
MFD – Multifamily Dwellings including condominiums, townhouses, apartments, hotels, and motels
OMS – Other Major Structures including commercial buildings (restaurants, stores, beach bars, etc.), recreation buildings, and nonhabitable major structures (piers, pools, pavilions, parking lots, roads, bridges, and towers)
Note – Not included in this summary are minor structures (i.e., walkways, decks, driveways, patios, etc.), coastal and shore protection structures (i.e., seawalls, revetments, sills, groins, jetties), minor damage to major structures, or structures located inland of the coastal building zone.

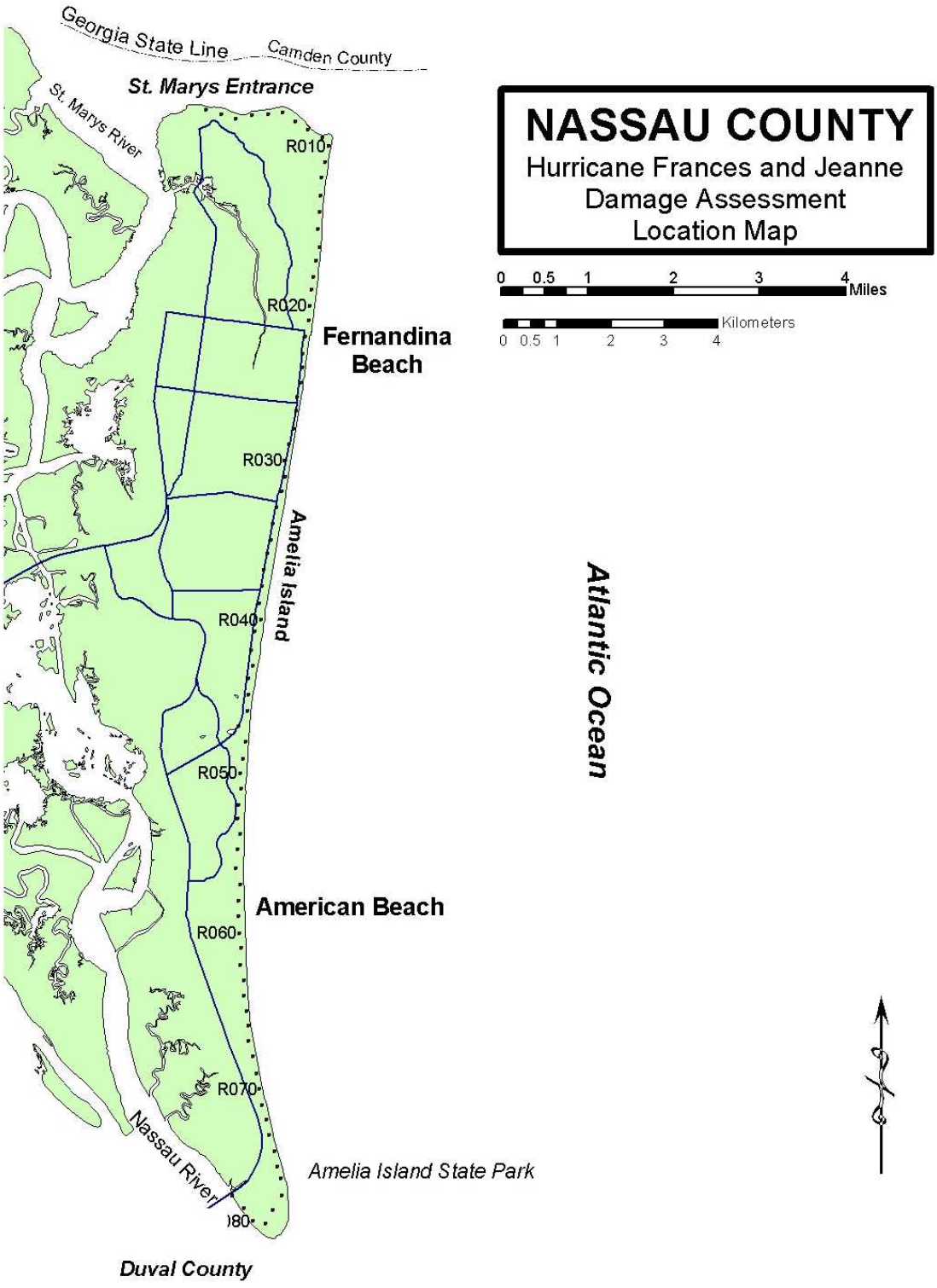


Figure 9: Nassau County Location Map

Nassau County

Within Nassau County, Amelia Island is the northernmost barrier island on the northeast coast of Florida. The island is 12.7 miles long between the St. Marys River Entrance separating Georgia from Florida on the north to Nassau Sound on the south (Figure 9). The St. Marys River Entrance has a federal navigation channel that likely experienced significant shoaling due to Hurricanes Frances and Jeanne.

Beach and Dune Erosion

Throughout the length of Amelia Island, only minor beach erosion (Condition I) prevailed during Hurricane Frances. The south tip of Amelia Island was approximately 250 miles from the center of both hurricanes' eyes at landfall. The northern 4.4 miles of ocean front beaches on Amelia Island (R9-R33) and the southern 3.1 miles (R61-R80) were designated as critically eroded prior to the impact of the two storms. No damage was observed to any coastal or shore protection structures. Continued beach erosion was observed at both the Fernandina Beach Nourishment Project and the South Amelia Island Beach Restoration Project. Follow-up surveys will be necessary to quantify any material losses from those projects.

Storm Damage

Wind damage was minor to moderate along the coast of Amelia Island during Hurricane Frances. The primary damages included lost roofing and siding, lost aluminum soffits and gutters, damage to signs and vegetation, and sand blown onto roads and upland properties. At least three buildings, all single-family dwellings, sustained major structural damage. These dwellings, two in Fernandina Beach and one in American Beach, each received some form of major roof damage due to the high winds of Frances' rain bands or squalls. No additional major damage occurred during Hurricane Jeanne. In addition, the two ocean fishing piers on Amelia Island, which are located at R9 and R39, had no apparent damage from either storm.

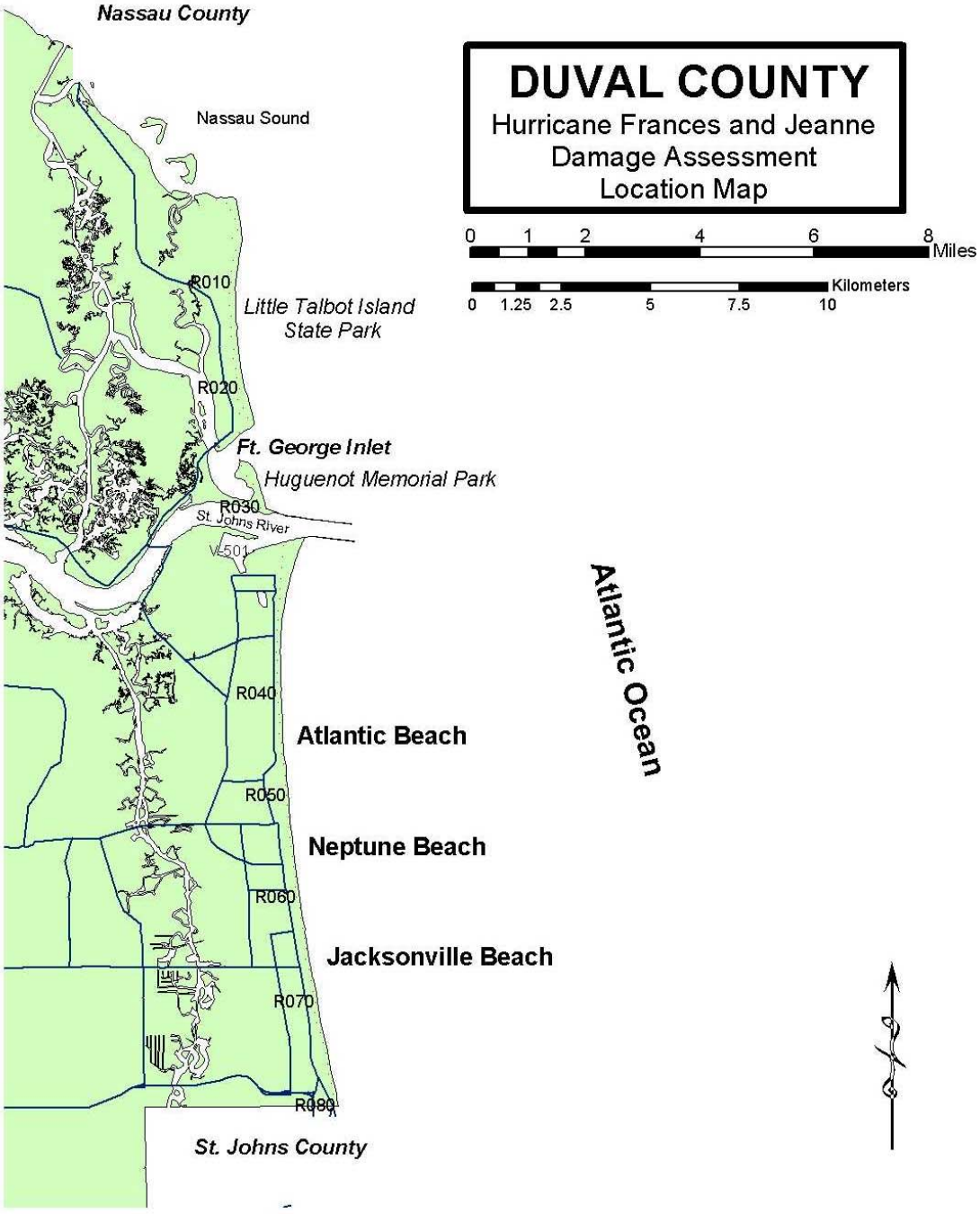


Figure 10: Duval County Location Map

Duval County

The coast of Duval County includes the barrier islands of Big Talbot Island fronting Nassau Sound, Little Talbot Island extending between Nassau Sound and Ft. George Inlet, and Wards Bank between Ft. George Inlet and the St. Johns River Entrance. The Duval County coast also includes the mainland beaches south of the St. Johns River Entrance, including Mayport Naval Station, Atlantic Beach, Neptune Beach, and Jacksonville Beach (Figure 10). There are 15 miles of Atlantic Ocean fronting beaches in Duval County. The St. Johns River Entrance has a federal navigation channel that likely experienced some additional shoaling from both Hurricanes Frances and Jeanne.

Beach and Dune Erosion

Throughout Duval County's beaches only minor beach erosion (Condition I) prevailed during Hurricane Frances. Hurricane Jeanne inflicted additional cumulative erosion throughout the county. Specifically, the reach between R36 and R56 (Atlantic Beach to northern Jacksonville Beach) sustained moderate beach and dune erosion (Condition III), and the reach between R69 and R80 (Jacksonville Beach) sustained minor beach and dune erosion (Condition II). The Duval County beaches extended approximately 230 and 245 miles from the center of both hurricanes' eyes at landfall. Prior to the landfall of the two storms, there were two critically eroded beach areas (R21-R25, 0.3 mile; and V501-R80, 10.1 miles), one critically eroded inlet shoreline area (R23-A1A bridge, 0.7 mile), and one noncritically eroded inlet shoreline area (2 miles along Big Talbot Island). The federal beach restoration project for the Duval County beaches south of the St. Johns River will need detailed follow-up surveys to quantify the loss of material from the project.

Storm Damage

Widespread minor wind damage was experienced along the Duval County coast similar to that observed in Nassau County during Hurricane Frances. Only two major structures sustained major structural damage, both condominiums with major roof damage in Jacksonville Beach. Hurricane Jeanne caused little additional significant damage along the coast of Duval County, which was battered by wind gusts to 60-mph. Two condominiums on First Street had major wind damage and First Street flooded from 2nd to 4th Avenue and from 11th to 14th Avenue in Atlantic Beach. A Neptune Beach motel sustained major wind damage, and seven dune walkovers were damaged in Atlantic Beach. In addition, unlike most of the ocean fishing piers along the central and southeast Florida coast, the newly constructed (and not yet completed) Jacksonville Beach fishing pier sustained no apparent damage from either storm.

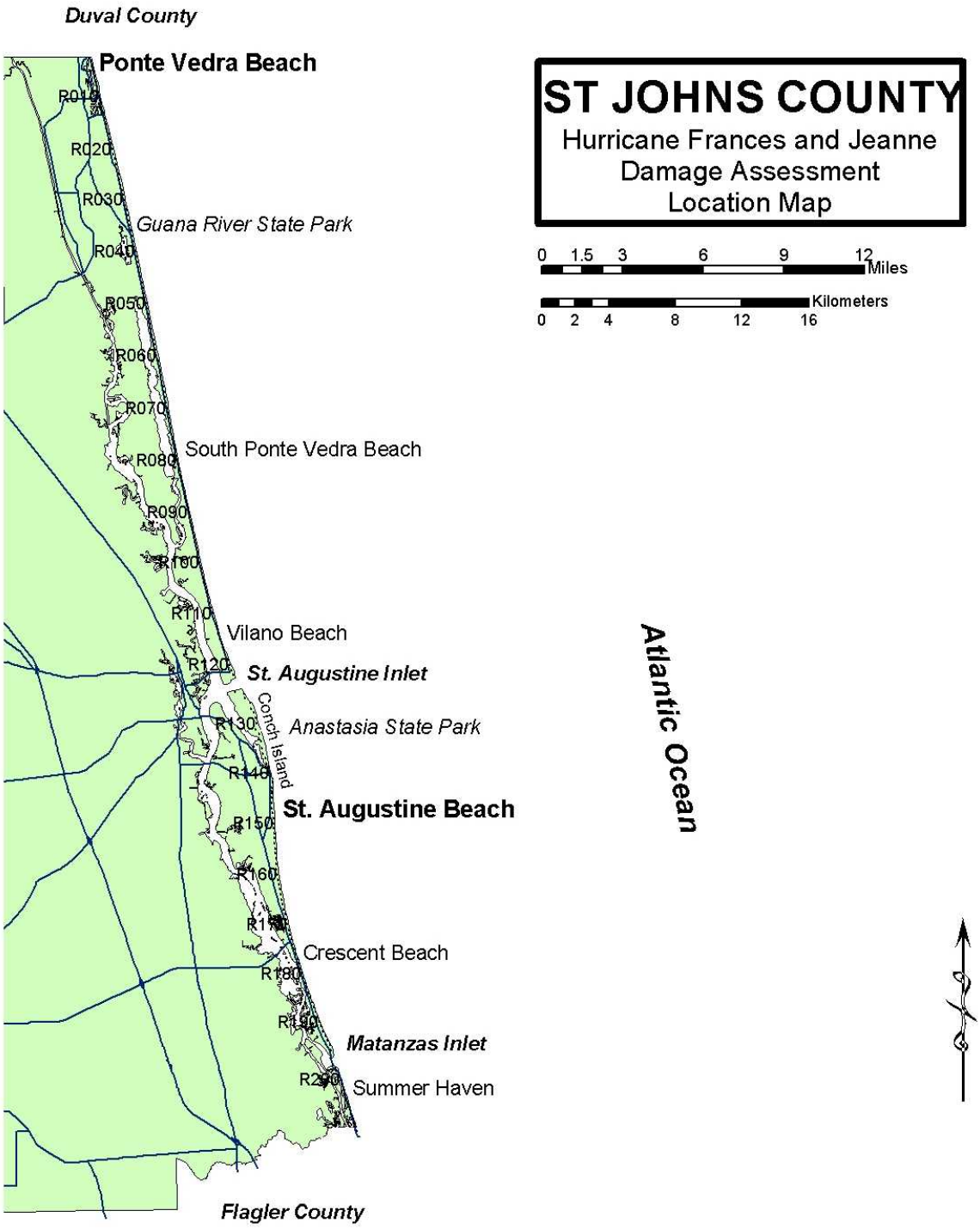


Figure 11: St. Johns County Location Map

St. Johns County

The St. Johns County coast extends for 41.1 miles between Duval and Flagler Counties and includes the barrier beach communities and major park systems of Ponte Vedra Beach, Guana River State Park, South Ponte Vedra Beach, Vilano Beach, Porpoise Point, Conch Island (Anastasia State Park), St. Augustine Beach, Crescent Beach, Fort Matanzas National Monument, and Summer Haven (Figure 11). St. Augustine Inlet between Vilano Beach and Conch Island has a federal navigation project, which likely experienced significant shoaling due to both Hurricanes Frances and Jeanne. Continued shoaling was also observed at Matanzas Inlet between Anastasia Island and Summer Haven near the south end of the county.

Beach and Dune Erosion

Along St. Johns County after Hurricane Frances, post-storm erosion conditions generally varied between minor beach erosion (Condition I) and minor beach and dune erosion (Condition II) with the exception of St. Augustine Beach (R141-R143), where major beach and dune erosion (Condition IV) was observed. Hurricane Jeanne exacerbated Hurricane Frances-induced erosion impacts along the St. Johns County coast. These beaches extended approximately 190 to 230 miles from the center of both hurricanes' eyes at landfall. Prior to landfall of the two storms, there were three critically eroded areas: R110-R117, 1.4 miles at Vilano Beach; R132-R152, 3.8 miles along Conch Island and northern Anastasia Island; and R197-R209, 2.4 miles between Matanzas Inlet and Flagler County. There was also one noncritically eroded area (R193.5-R196, 0.5 mile north of Matanzas Inlet) in St. Johns County.

Specifically, following Frances, Condition II erosion was observed at Anastasia State Park and at Summer Haven. The tropical storm strength winds of Frances along the St. Johns County beaches transported sand inland over sand dunes, causing accretion of sand deposits in upland areas. Unlike conditions during Hurricanes Floyd and Irene in 1999 and Tropical Storm Gabrielle in 2001, Summer Haven did not experience storm surge washovers, and the road remained undamaged. However, the federal erosion control project at St. Augustine Beach sustained significant erosion. Hurricane Jeanne caused additional erosion losses. Along Ponte Vedra and northern St. Johns County (R7-R33), Condition II erosion prevailed. Localized Condition III erosion was observed immediately south of a rock revetment at R117 in Vilano Beach. In St. Augustine Beach near the pier (R141-R143), Condition IV erosion of the federal beach restoration project continued causing the complete exposure of the revetment built after the storms of 1962 (Ash Wednesday Storm) and 1964 (Hurricane Dora). Future surveys by the U.S. Army Corps of Engineers and St. Johns County (the project's local sponsor) will quantify the beach erosion losses from the project area. To the south, much of Anastasia Island (R154-R197) from St. Augustine Beach through Crescent Beach to Matanzas Inlet sustained major beach and dune erosion (Condition IV)(Photo 1). South of Matanzas Inlet, in Summer Haven (R197-R208) Condition III erosion was observed, and south of the revetment (R201.2 and R201.5) the narrow barrier breached once again.

Photo 1: Anastasia Island Erosion at R193

Storm Damage

Widespread minor to moderate wind damage was observed along the St. Johns County beaches from the winds of Hurricane Frances that gusted to 82 mph at St. Augustine. Along with damages to roofing, siding, fences, signs and vegetation, there was major structural damage to 12 single-family dwellings and 5 multifamily dwelling structures, primarily due to high winds associated with rain bands or squall lines. Among these, in South Ponte Vedra, an old pile-supported single-family dwelling on the beachfront (350 feet north of R77) was substantially destroyed by wind loads. No damage was sustained to the St. Augustine Beach fishing pier (R142). The winds of Hurricane Jeanne gusted to 75 mph at St. Augustine. Most of the wooden beach/dune access walkways were damaged or destroyed by the storm tides and waves. At Summer Haven about 2000 feet of the old U.S. Highway A1A asphalt roadway was undermined and collapsed, generally between R205.5 and R207.5 (Photo 2). In addition, about 200 feet of a sandbag sill was destroyed south of R205.

Photo 2: Summer Haven Road Damage

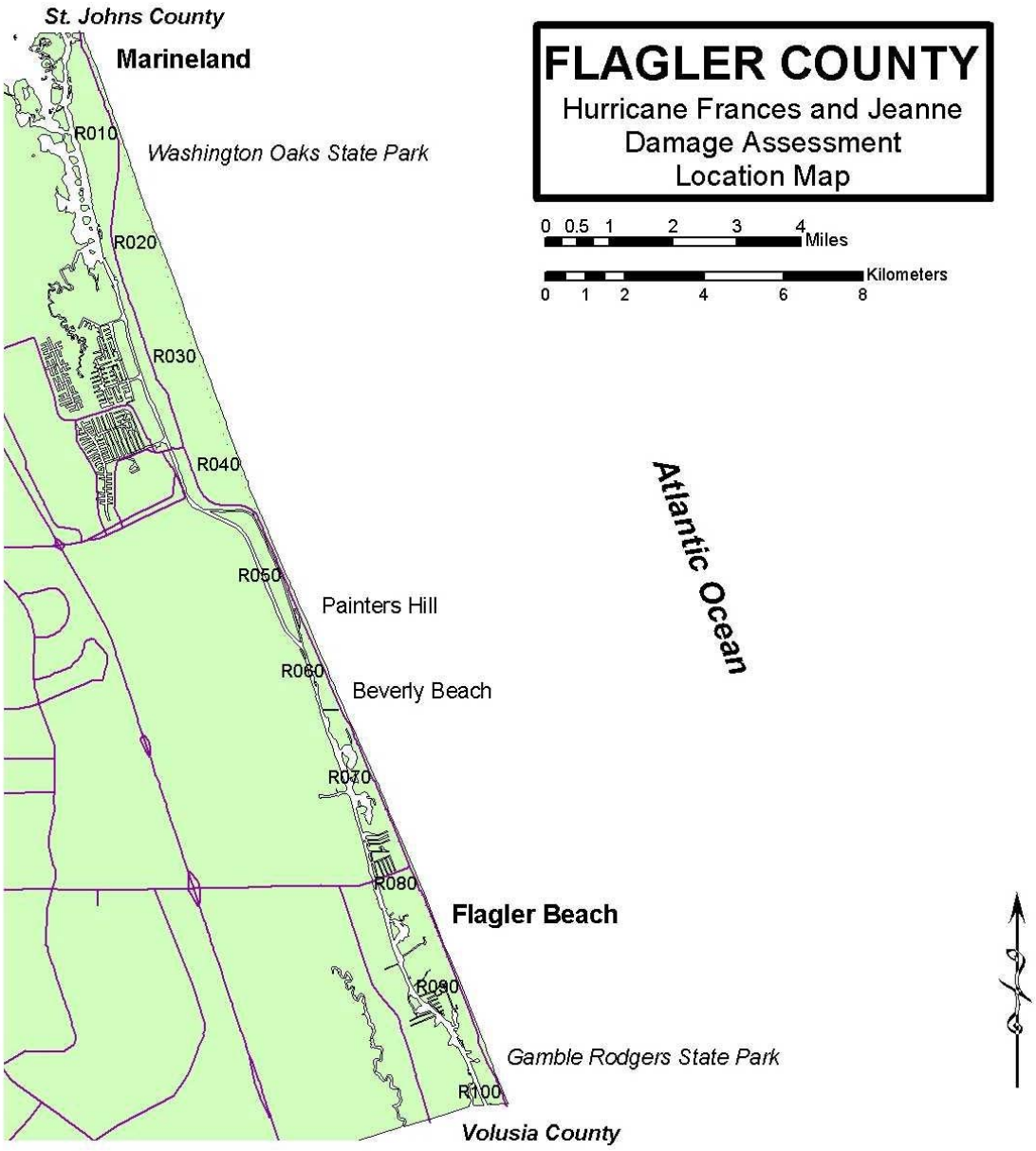


Figure 12: Flagler County Location Map

Flagler County

The Atlantic Ocean fronting beaches of Flagler County extend for 18.1 miles between St. Johns County and Volusia County that include the following communities and major parks: Marineland, Washington Oaks State Park, Painters Hill, Beverly Beach, Flagler Beach, and Gamble Rogers State Park (Figure 12). There are no inlets in Flagler County.

Beach and Dune Erosion

Prior to landfall of the two storms there were four designated critically eroded areas in Flagler County including Marineland (R1-R4, 0.6 mile), Painter's Hill (R52.3-R53.4, 0.1 mile), north Flagler Beach (65.2-R67, 0.3 mile), and southern Flagler Beach (R77-R91, 2.5 miles). Flagler County's beaches extended approximately 170 to 190 miles from the center of both hurricanes' eyes at landfall. No significant beach erosion was observed along Flagler County's beaches following Hurricane Frances. In fact, some accretion of the beaches was observed along the northern and central portion of the county. Hurricane Jeanne did cause significant erosion throughout the county, specifically to the northern part of the county (R1-R36) including Marineland, a northern segment of Flagler Beach (R71-R78), and the southern part of the county (R94-R100) sustained moderate beach and dune erosion (Condition III). The south end of Flagler Beach, south of the rock revetment (R90-R94) sustained major beach and dune erosion (Condition IV). Other segments of the county (R36-R71 and R78-R90) had Condition I to II erosion.

Storm Damage

During Hurricane Frances, Flagler County experienced widespread minor to moderate wind damage which added to that damage sustained three weeks earlier during Hurricane Charley's exit from the Florida northeast coast. Only two major structures in Flagler County sustained major damage from Frances. Near the south county line, a fourth floor condominium roof blew off the Ocean Beach Club at R98. At Flagler Beach near R79, the Flagler Beach fishing pier sustained structural collapse to the outer 30 feet of pier from the battering of Frances' storm waves. Hurricane Jeanne inflicted some additional damage along the coast. At Marineland, some minor damage was observed to the rock revetment, and at the south end of Flagler Beach (400 feet north of R95) two commercial buildings (Snack Jacks Restaurant and an adjacent office) sustained understructure damage, including minor damage to a few foundation piles with bracing. Beach access walkways throughout the county were damaged, including 40 of the 52 dune walkovers in Flagler Beach.

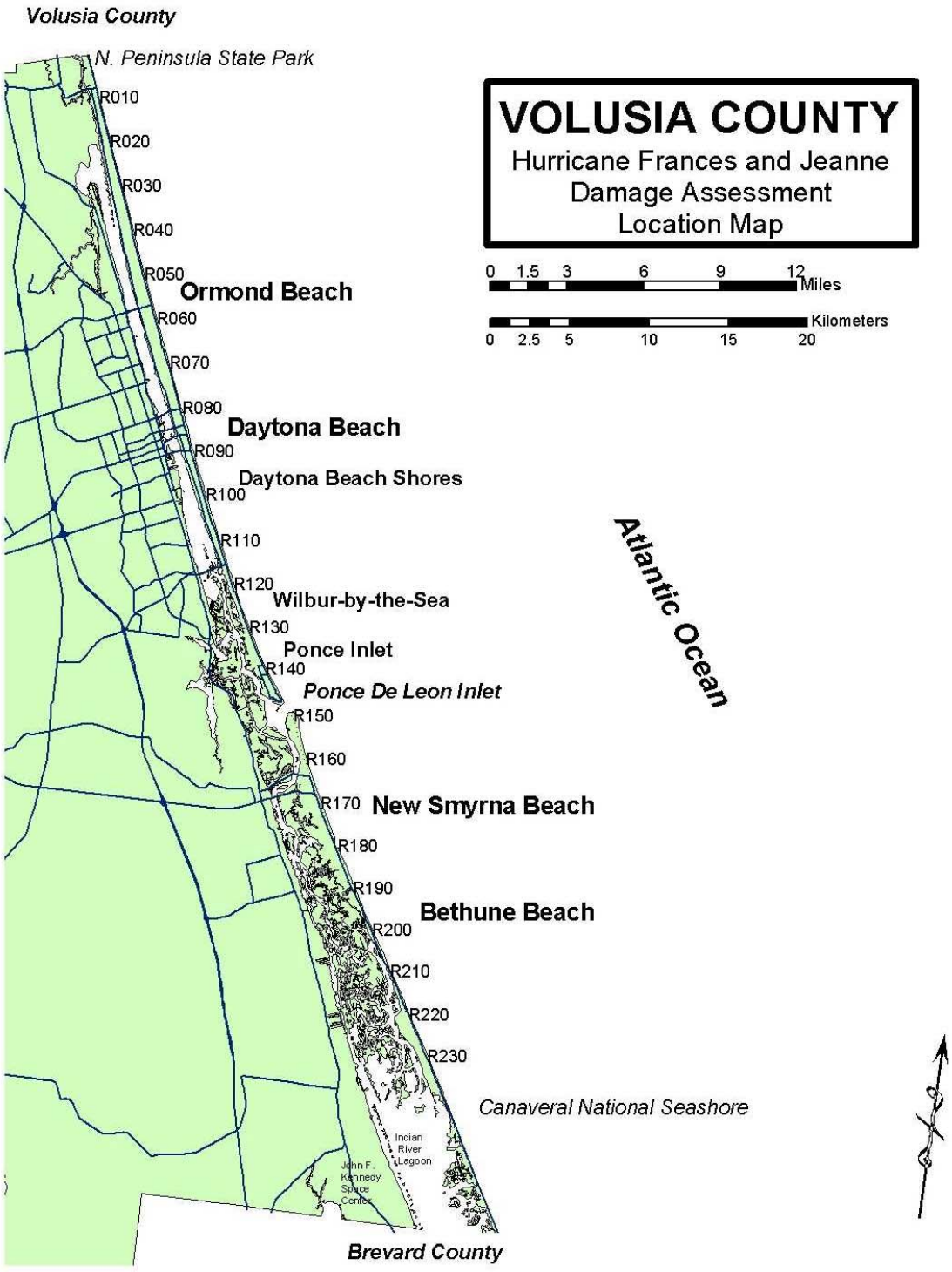


Figure 13: Volusia County Location Map

Volusia County

The southernmost of the five northeast Florida coastal counties, Volusia County extends for 48.8 miles between Flagler and Brevard Counties. Volusia County includes the following barrier beach communities and major parks: North Peninsula State Park, Ormond-by-the-Sea, Ormond Beach, Daytona Beach, Daytona Beach Shores, Wilbur-by-the-Sea, Town of Ponce Inlet, Ponce de Leon Inlet State Park, New Smyrna Beach, Bethune Beach, and Cape Canaveral National Seashore (Figure 13). Prior to landfall of the two storms Volusia County had two designated critically eroded areas (16.7 miles), one noncritically eroded area (1.1 miles), and one critically eroded inlet shoreline area (0.6 mile). The Volusia County beaches extended approximately 130 to 170 miles from the center of both hurricanes' eyes at landfall.

Ponce de Leon Inlet

Ponce de Leon Inlet near the middle of Volusia County has a federal navigation project, which appeared to sustain significant shoaling with the passage of Hurricanes Frances and Jeanne. The north shoreline of Ponce de Leon Inlet is designated as critically eroded; however, a recent landward extension of the north jetty appears to have stabilized this shoreline. Following the impact of both Hurricanes Frances and Jeanne, the south shoreline (R149) of the inlet was observed to have sustained major erosion (Condition IV); however, there does not appear to be a threat to structures or recreation areas by this erosion.

North Peninsula Beach and Dune Erosion

An 8.3-mile segment of beach (R57-R103) along Ormond Beach, Daytona Beach, and Daytona Beach Shores was designated as critically eroded prior to the two storms. After the passage of Hurricane Frances, northern Volusia County to Ponce de Leon Inlet was observed to have post-storm erosion conditions generally increasing from minor beach erosion (Condition I) to minor beach and dune erosion (Condition II). The erosion impact of Hurricane Jeanne was even more severe to the northern Volusia County beaches. Generally, major beach and dune erosion (Condition IV) was sustained throughout the north peninsula.

South Peninsula Beach and Dune Erosion

The 8.4 miles of beaches (R161-R208) south of Ponce de Leon Inlet within New Smyrna Beach and Bethune Beach were designated as critically eroded prior to the two storms. The 1.1-mile segment of shoreline (R208-R214) south of Bethune Beach within the Cape Canaveral National Seashore was also designated a noncritically eroded area. Throughout southern Volusia County south of Ponce de Leon Inlet into the National Seashore, erosion conditions varied from moderate (Condition III) to major beach and dune erosion (Condition IV) after Hurricane Frances. More specifically, from Ponce de Leon Inlet southward through R177, Condition IV prevailed. South of R177, moderate beach and dune erosion (Condition III) prevailed. Bethune Beach (R194-R208) has been particularly susceptible to erosion and storm damage in the past 20 years. Most recently,

prior to this hurricane season, Hurricanes Floyd and Irene (1999) inflicted severe erosion including the destruction of over 1200 feet of the ocean front road (R201-R202). In contrast to the 1999 storm damage, Frances only caused moderate beach and dune erosion (Condition III) and no road damage, even though storm tides of 4 to 5 feet were experienced.

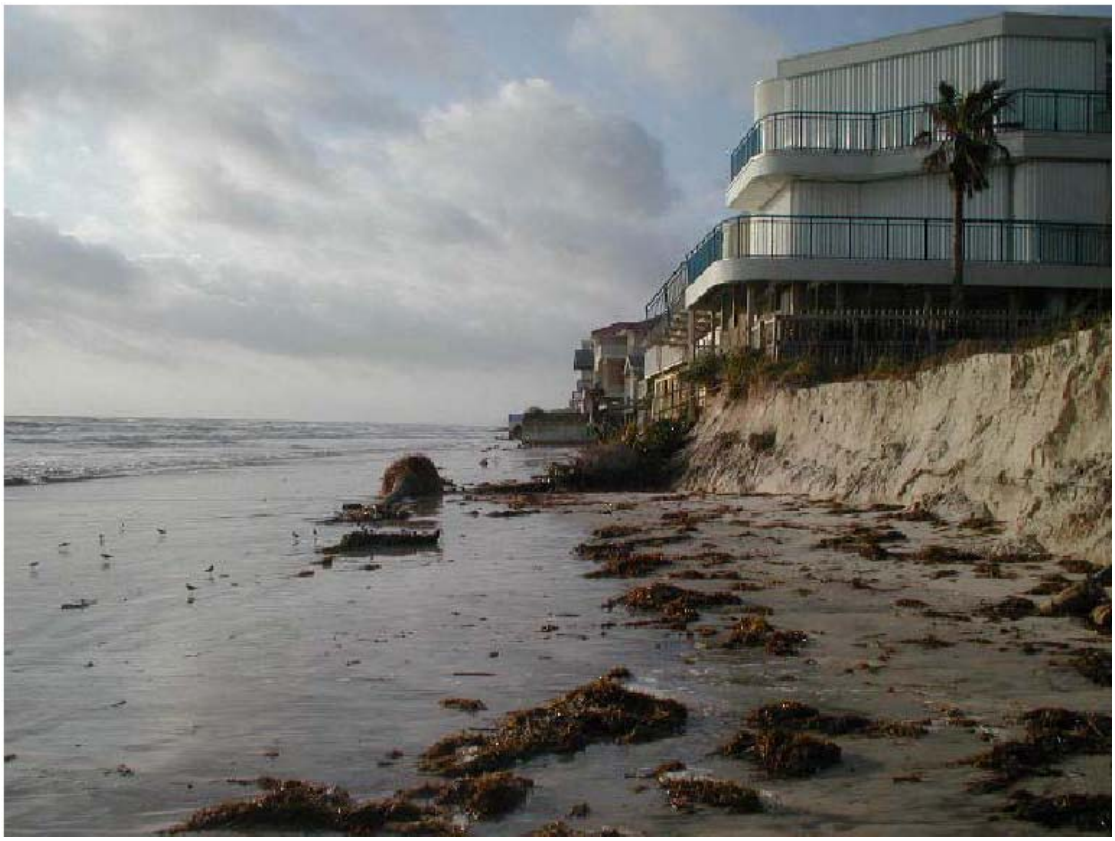


Photo 3: Major Beach and Dune Erosion, New Smyrna Beach

The Condition IV erosion impact of Hurricane Jeanne was particularly severe along New Smyrna Beach, where currently there is a complete loss of beach during high tide conditions (Photo 3). This loss of beach has led to the failure of a number of seawalls and created a pending storm threat to numerous upland dwelling structures. South of R193 throughout Bethune Beach and into the Cape Canaveral National Seashore, the Condition IV erosion that prevailed along New Smyrna Beach changed abruptly to accretion. Throughout Bethune Beach the beach berm grew to the point of covering the lower half of the coquina boulder revetments. This very unexpected result of two hurricanes' impact on an area that has historically been erosional is not readily explainable.

Seawalls and Other Coastal Protection Structures

There are no beach restoration projects in Volusia County although the north peninsula extending northward from Ponce de Leon Inlet to Daytona Beach Shores received beach fill from inlet channel maintenance dredging in the past. Many vertical seawalls and bulkheads, some with rock toe scour protection exist along Ormond Beach, Daytona Beach, Daytona Beach Shores, Wilber-by-the-Sea, Town of Ponce Inlet, New Smyrna Beach, and Bethune Beach. During Frances no damage was sustained by these structures. Bethune Beach has a coquina boulder revetment along two segments which was designed and certified for a 100-year storm event. Frances likewise inflicted no damage to these revetments. In contrast, Jeanne damaged and destroyed some 19 vertical seawalls countywide having a total length of 5,430 feet (Photo 4). Four of these damaged walls totaling 285 feet were located on the northern peninsula while 15 of these damaged walls totaling 5,145 feet were located in New Smyrna Beach. Once again there was no damage to the coquina boulder revetments in Bethune Beach. Unlike the scour caused by many vertical walls along the coast, the gradually sloping rock revetments appeared to have had no negative impact on the adjacent beach. In fact, sand even accreted on the revetments. Most of the concrete seawalls failed due to the same reasons including, lack of beach seaward of the walls, age of the structures, corrosion to the reinforcing steel, and lack of filter cloth behind the wall. A complete listing of the damaged and destroyed seawalls located by the Department's reference monuments is shown in Table 3.

Table 3: Summary of Destroyed Seawalls in Volusia County

Summary of Seawall Damages in Volusia County (All walls were reinforced concrete walls except as noted)	
Location (DEP R-monument)	**Length (feet)**
R93.85-R94	130
R115	30
R123.8	50[1]
R124.9	75[2]
R163-R163.25	350
R163.25-R163.35	125
R163.5-R163.7	200
R164.5-R164.6	100
R165-R165.4	420
R165.9	50
R169.15-R169.25	100
R171.3	50
R175.9-R176.3	400
R176.3-R176.8	550
R178-R179	875
R180.1-R180.85	750
R183.3	75
R183.55-R183.65	100
R191.25-R192	1000
Total	5,430

1 – Concrete culvert wall

2 – Wood bulkhead

Photo 4: Seawall Damage, New Smyrna Beach

North Peninsula Damage

Throughout Volusia County, there was widespread wind damage to roofing, siding, signs, awnings, carports, gas station covers, power lines, trees and shrubs. Many wooden beach access walkways were destroyed or damaged by the storm tides and waves. The north peninsula had experienced wind damage from Hurricane Charley's exit into the Atlantic Ocean following an August 13, 2004, landfall on the Gulf coast at Lee County. North of Ponce de Leon Inlet, Hurricane Charley was observed to cause major roof damage on at least 27 single-family dwellings, 16 condominiums/hotels, and three commercial buildings on the coast (about 46 ocean front major structures). Hurricane Frances additionally caused major damage to at least nine single-family dwellings and three hotels. Among these, a single-family dwelling was destroyed 250 feet north of R124. A portion of the roof of the Peabody Auditorium was also damaged. The Main Street Pier in Daytona Beach (R84) sustained no apparent significant structural damage; however, the Sunglow Fishing Pier (350 ft. north of R118) in Daytona Beach Shores had its seaward end destroyed. Hurricane Jeanne caused additional structural damage to the end of the Sunglow Fishing Pier. Jeanne also caused major damage to three single-family dwellings, 20 multifamily dwellings (mostly hotels and motels), a lifeguard tower, and five vehicle access ramps.

South Peninsula Damage

South of Ponce de Leon Inlet along New Smyrna Beach and Bethune Beach, Hurricane Charley was observed to cause major roof damage to 11 single-family dwellings and two multifamily dwellings. Perhaps due to its closer proximity to the eye of Hurricane Frances, the south peninsula area sustained greater wind damage in the second storm including major roof damage to 18 single-family dwellings and nine multifamily dwelling structures. In addition, three single-family dwellings were destroyed and two other single-family dwellings and a multifamily dwelling had major side damage. Hurricane Jeanne also caused wind, wave, and undermining damage to major structures in New Smyrna Beach (Photo 5). Major damage was sustained by five single-family

Photo 5: Building Undermined after Seawall Collapsed, New Smyrna Beach

dwellings, five multifamily dwellings, and a commercial building. Among the condemned buildings were a six-story, 62-unit condominium, two 33-unit condominiums, and a beach bar. In addition, a pool, a concrete pedestrian access ramp, and two vehicle access ramps were destroyed(Photo 6).

Photo 6: Pool Destroyed, New Smyrna Beach

Summary of Damage

In all, Hurricane Frances destroyed or caused major structural damage to 46 major structures along the coast of Volusia County. This followed Hurricane Charley, which caused major damage to 59 major habitable structures. Hurricane Jeanne destroyed or caused major damage to 45 major structures as well as 19 seawalls having a length of 5,430 feet (1.03 mile). Approximately 150 dune walkovers throughout the county were also destroyed or damaged.

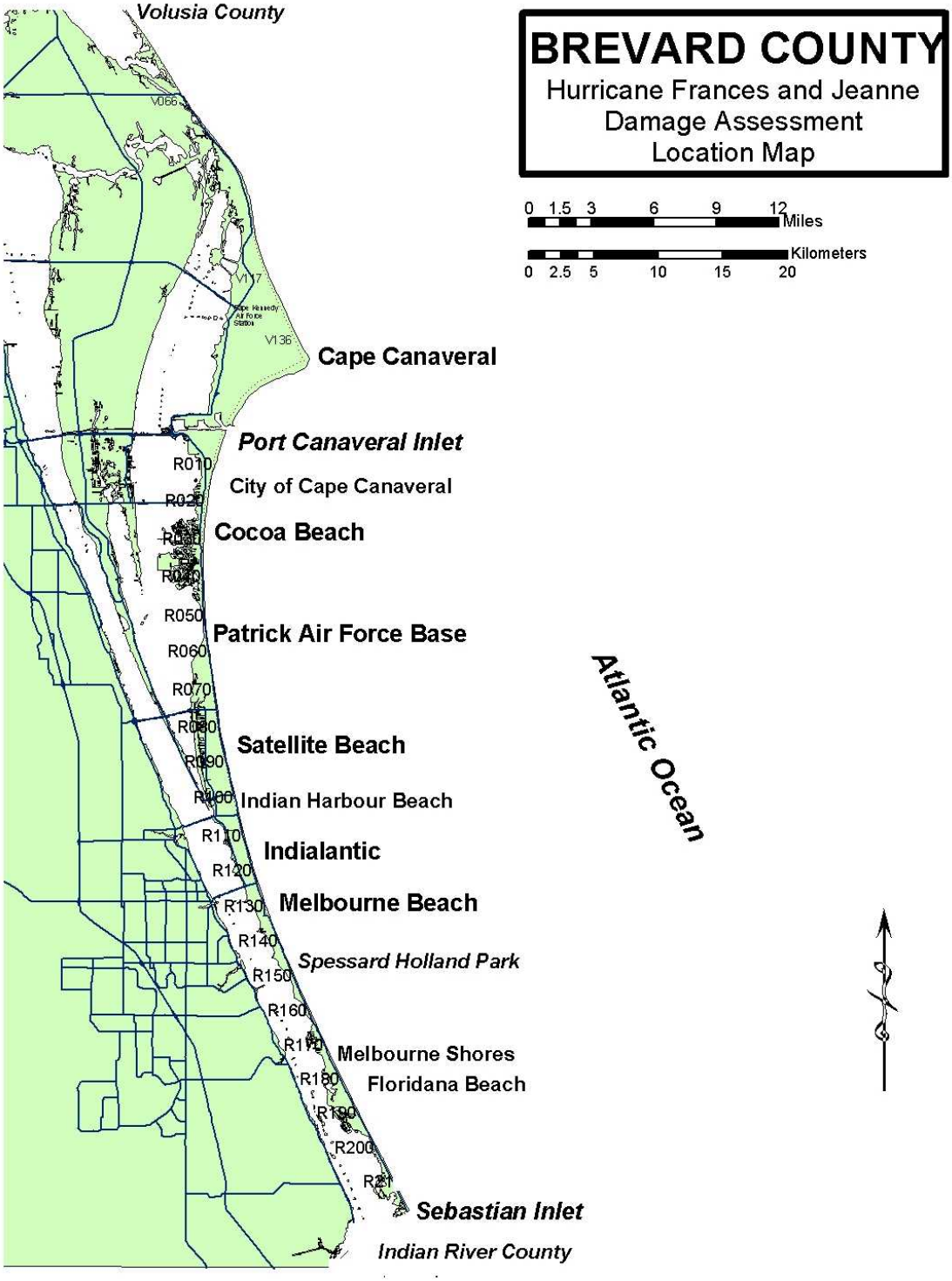


Figure 14: Brevard County Location Map

Brevard County

The longest of the central Atlantic coast counties, Brevard County extends for 71.6 miles between Volusia and Indian River Counties. Coastal Brevard County includes the following communities and parks: Canaveral National Seashore, Kennedy Space Center, Cape Canaveral Air Force Station, City of Cape Canaveral, Cocoa Beach, Patrick Air Force Base, Satellite Beach, Indian Harbour Beach, Melbourne, Indialantic, Melbourne Beach, Melbourne Shores, Floridana Beach, Archie Carr National Wildlife Refuge, and Sebastian Inlet State Park (Figure 14).

Canaveral Inlet

Canaveral Inlet, near the middle of Brevard County, is a federal port and navigation project that sustained substantial shoaling during Hurricane Frances due to the extended period of northeast swell that transported littoral sediment into the navigation channel. The Port of Canaveral was closed to ship traffic for a week before and after the storm, which reduced navigation depths from 41 to 27 feet in the channel. Before the shoaling could be dredged by the U.S. Corps of Engineers, Hurricane Jeanne contributed to additional shoaling in the channel. Closure of the port halted all cruise ship and cargo business at the world's second-busiest cruise ship port. Closure also cut off supplies of fuel, cement, lumber, and other cargo brought into Port Canaveral each week.

Sebastian Inlet

At the south end of the county, Sebastian Inlet (managed by the Sebastian Inlet Tax District), appeared to be flushed clear of sediment due to the strong current velocities that likely exceeded 10 feet per second during the storm surges of both hurricanes. The storms' effects on the bypassing bar (ebb tidal shoal) and on the flood shoals, including the sand trap, will only be realized after an updated bathymetric survey of the area.

Northern Brevard County Beach and Dune Erosion

After the passage of Hurricane Frances, the northern Brevard County beaches north of Cape Canaveral including the Canaveral National Seashore, Playalinda Beach, the Kennedy Space Center, and the Cape Canaveral Air Force Station, were observed to have post-storm beach conditions generally varying between minor to moderate beach and dune erosion (Condition II to III). These northern Brevard County beaches extended approximately 130 to 90 miles from the center of both hurricanes' eyes at landfall. Prior to landfall of these two storms, two shoreline segments along the Canaveral National Seashore were designated as noncritically eroded. These areas are not monitored.

A barrier breach with significant overwash occurred close to and north of the tip of Cape Canaveral. Significant overtopping occurred along the cape's north shore; however, accretion prevailed along the south shore of the cape. Hurricane Jeanne's passage brought pockets of Condition I to II erosion, however, most of the northern Brevard County beaches saw accretion.

Central Brevard County Beach and Dune Erosion

South of Canaveral Inlet along the northern portion of the Brevard County Shore Protection Project, within the communities of Cape Canaveral and Cocoa Beach (R1-R53) major beach erosion (Condition IV) was sustained during both Hurricanes Frances and Jeanne. This beach restoration project extended approximately 90 to 77 miles from the center of both hurricanes' eyes at landfall. Immediate post-storm surveys of the beach and nearshore after both storms show substantial losses from the beach restoration project. These surveys have shown volume losses generally between 15 and 25 cubic yards per foot of beach (Olsen & Associates, Inc.). See Figure 15 for comparative profiles that graphically present the project's erosion losses.

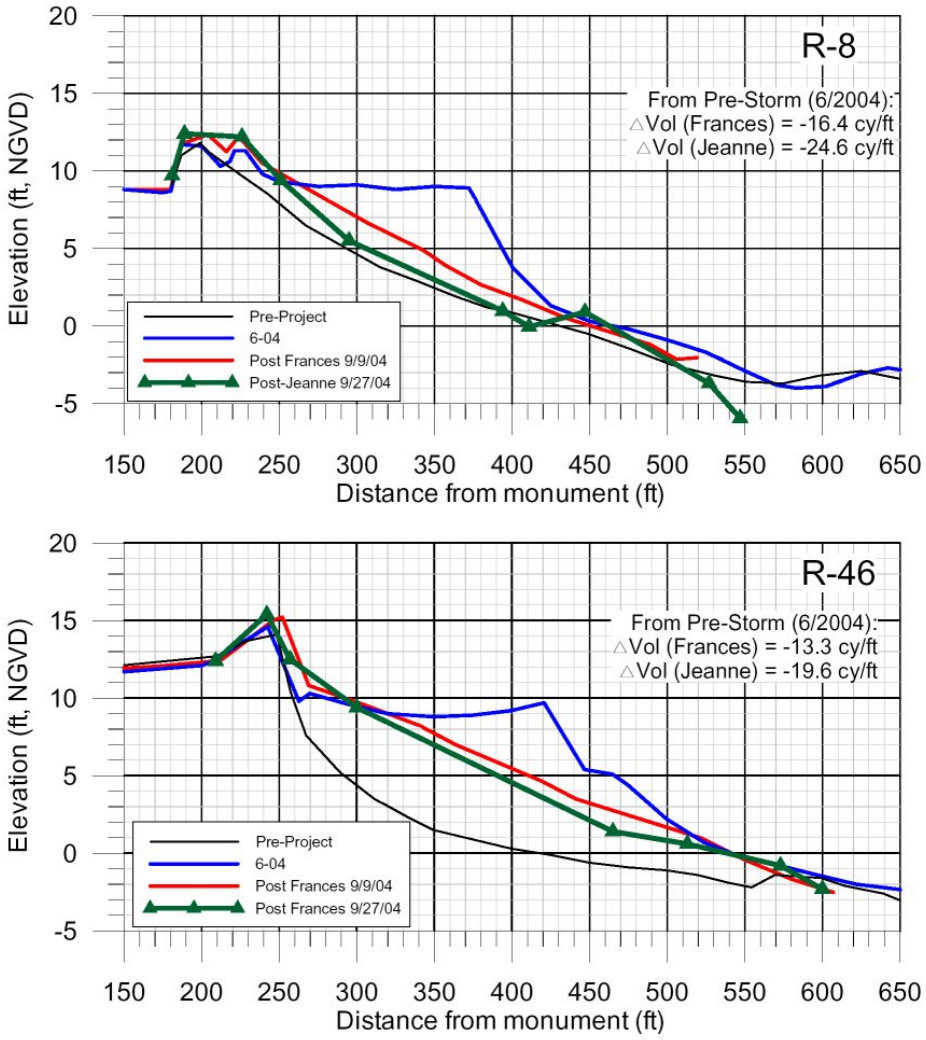


Figure 15: R8 & R46 Post-Storm Profiles (Olsen & Assoc.,Inc.)

South of Cocoa Beach, along the portion of the federal project that included Patrick Air Force Base (R53-R66), major beach erosion was sustained during both Hurricanes Frances and Jeanne. South of the project, between R68 and R75 at the Pineda

Causeway, Patrick Air Force Base sustained major beach and dune erosion (Condition IV) during both Frances and Jeanne.

Extending for 24.6 miles from Canaveral Inlet to Spessard Holland Park (R1-R137.5) the central Brevard County coast was designated as critically eroded prior to landfall of the two storms. Within this reach, the segment from R75 to R118 has not been restored due to delays with environmental impact studies of primarily the nearshore hard bottom, which includes intermittently exposed beach rock, exposed segments of the Anastasia formation, and newly developed *Sabellariid* worm rock. This roughly 8-mile segment within the communities of Satellite Beach, Indian Harbour Beach, Melbourne, and unincorporated Brevard County, sustained major beach and dune erosion (Condition IV) during Hurricane Frances. The additional Condition IV erosion from Hurricane Jeanne has resulted in a severely eroded coastal reach that has had a severe adverse impact on the coastal dune system as well as coastal development.

South Brevard County Beach and Dune Erosion

Along Indialantic and Melbourne Beach (R118-R137.5) the beach was recently restored in 2003. Located approximately 50 miles north of the eye walls of both hurricanes, this project experienced significant storm wave induced erosion from these storms. Both Hurricanes Frances and Jeanne caused major beach erosion (Condition IV) to the project but no significant dune erosion. Immediate post-storm surveys of the beach and nearshore after both storms show substantial losses from the beach restoration project. These surveys have shown volume losses generally between 15 and 35 cubic yards per foot of beach (Olsen & Associates, Inc.). See Figure 16 for comparative profiles that graphically present the project's erosion losses.

South of the Indialantic/Melbourne Beach restoration project, the southern Brevard County beaches sustained their worst erosion in 20 years since the Thanksgiving Holiday Storm of 1984. Hurricane Frances inflicted major beach and dune erosion (Condition IV) along the southern 15 miles of Brevard County beaches. With no opportunity to recover, Hurricane Jeanne inflicted the most severe erosion seen in the area in recorded history. Much of this stretch of beach was historically very stable, particularly from Floridana Beach southward. Only a small 0.4-mile segment (R196-R198) was designated as critically eroded after the impact of Hurricanes Floyd and Irene in 1999.

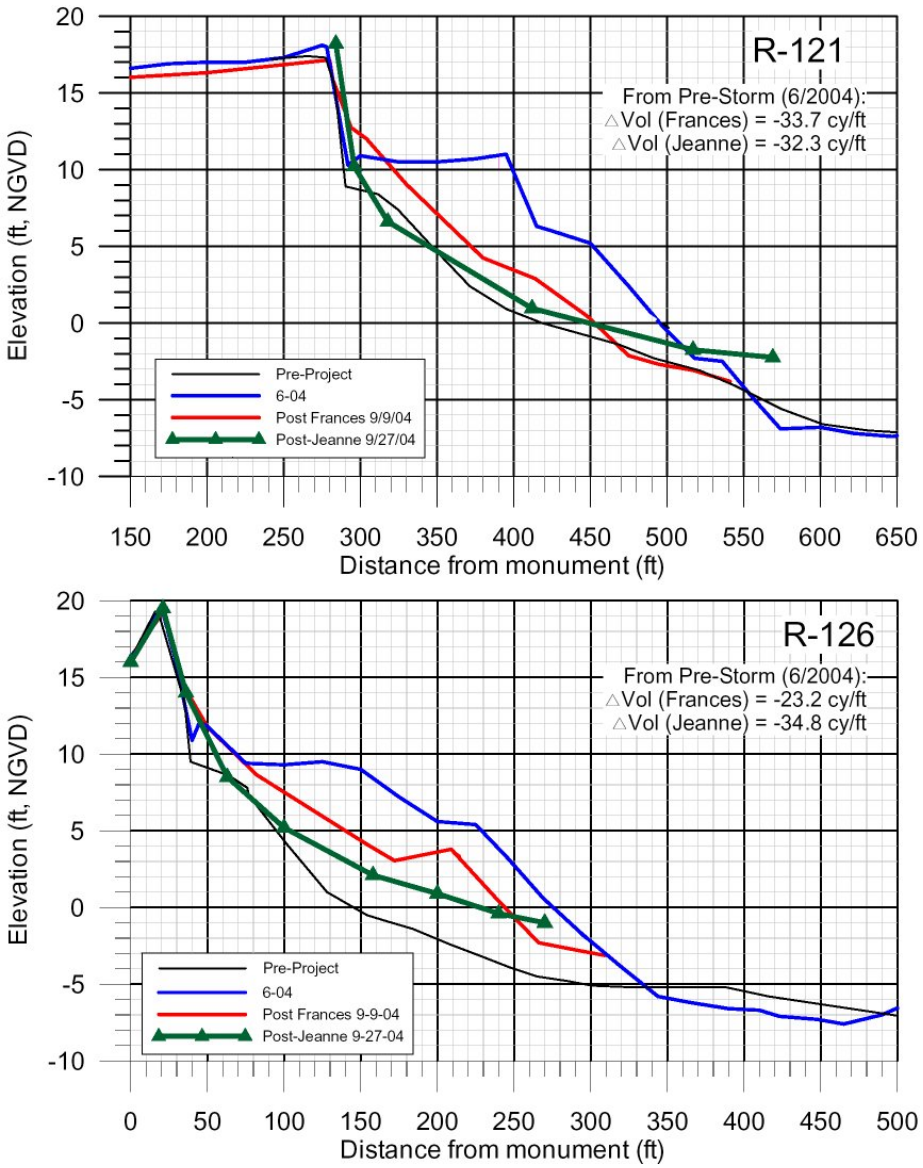


Figure 16: R121 & R126 Post Storm Profiles (Olsen & Assoc.,Inc)

North Brevard County Damage

Widespread moderate to major wind damage occurred throughout Brevard County during the sustained hurricane force winds (75 to 105-mph) of Hurricane Frances. At the Kennedy Space Center, the south wall of the Vehicle Assembly Building lost more than 52,000 square feet of the exterior walls and had extensive roof damage. Another building, where heat protection tiles and blankets are manufactured for space shuttles, lost about one-fourth of its roof. Hurricane Jeanne caused additional exterior damage to the Vehicle Assembly Building but it was minor in comparison to the impact from Frances.

Canaveral Inlet Damage

At Canaveral Inlet, besides the navigation channel shoaling, Hurricane Frances destroyed the north jetty's geotube groin that was constructed to prevent the longshore transport of sand from leaking through the north jetty. Both the north and south jetties constructed of granite boulders appeared to be undamaged. In addition, the south jetty's detached concrete fishing pier was not significantly damaged. In contrast, the south jetty's pier access walkway sustained approximately 900 feet of damage to the side rails. In addition, one of the port buildings sustained major roof damage. Hurricane Jeanne appeared to inflict only minor additional damage at the port, including additional damage to the geotube groin at the north jetty.

City of Cape Canaveral Damage

The northernmost beach community, the City of Cape Canaveral had moderate to major wind damage throughout but very little damage from the storm surge of Hurricane Frances. Two lifeguard stands were destroyed at Jetty Park (R1) and a number of beach walkways were damaged. Throughout the community there was wind damage to roofing, siding, awnings, windows, doors, signs, fences, trees, and shrubs. Sustaining major damage were nine single-family dwellings, 17 multifamily dwellings (condominiums, motels), and a restaurant on the Canaveral Pier. Five garage buildings were destroyed and another sustained major roof damage. Hurricane Jeanne caused additional but less damage in Cape Canaveral. Damaged were two multifamily dwellings (condominium, motel). Three garage buildings were destroyed or severely damaged. The Canaveral Pier sustained major wave damage to some of the bracing at the pier's seaward end and some minor decking damage, but no apparent pile damage.

City of Cocoa Beach Damage

Like the City of Cape Canaveral to the north, the City of Cocoa Beach was also protected by the recent beach restoration project. Wind-blown sand covered many oceanfront properties and street-ends but no significant flooding or storm surge damage was observed. During Hurricane Frances, widespread wind damage was sustained throughout Cocoa Beach and a possible tornado or microburst may have been the cause of substantially damaging three single-family homes on Barlow Avenue. Major damage was also sustained by 14 single-family dwellings, 20 multifamily dwellings (condominiums, motels), 11 commercial buildings, and three church buildings. A condominium's garage was also destroyed. The most notable damage was seen at the Cocoa Beach First Baptist Church (R41), where the steeple was blown off and impaled through the sanctuary's roof (Photo 7). Typical hotel/motel damage was seen at the Holiday Inn (R29) where three buildings affecting 502 rooms had major roof damage costing in excess of $3 million in repairs. As in Cape Canaveral, Hurricane Jeanne inflicted less damage in Cocoa Beach than during Frances. One single-family dwelling was destroyed and five single-family dwellings, three multifamily dwellings (condominiums, motels), seven commercial buildings, and a multifamily garage building sustained major damage.

Photo 7: Roof Damage, Cocoa Beach

Patrick Air Force Base Damage

South of Cocoa Beach, Patrick Air Force Base was also protected by a beach restoration project. The storm surge of Frances damaged some beach access walkways but caused no major damage. The wind blew sheets of sand across US Highway A1A and onto beach access parking lots. On the Base, a welding shop and one aircraft hangar were destroyed. Hurricane Jeanne caused little additional damage along the Base.

Central Brevard County Seawall and Revetment Damage

South of Patrick Air Force Base, the lack of a beach restoration project along the critically eroded beaches of Satellite Beach, Indian Harbour Beach, and the City of Melbourne, resulted in substantial damage being sustained during both Hurricanes Frances and Jeanne. At the Pineda Causeway Condominiums (R76) a 1000-ft. segment of sandbag revetment was damaged by Frances. This same sandbag revetment was destroyed by Jeanne (Photo 8). On the adjacent property to the south (Oceanus Condominium), Jeanne damaged 150 feet of a 500-ft. rock revetment. Two miles to the south at the Sand Castle condominium (R89) a 180-ft. concrete seawall was destroyed (along with a pool deck and patio) and the cap of a 115-ft. concrete seawall was damaged. At the East Wind condominium (R92), 400 out of 500 feet of a backshore sill was also damaged by Jeanne.

Photo 8: Pineda Causeway Condominiums Erosion and Revetment Damage

City of Satellite Beach Damage

Major damage was sustained during Frances along the entire coast of Satellite Beach. Sustaining major damage were four single-family dwellings, 23 multifamily dwellings (condominiums, hotels, and a triplex), 11 commercial buildings, a garage building, and a swimming pool. Hurricane Jeanne caused additional major damage. Notably, the Ramada Inn (near R86) sustained substantial exterior wall damage resulting in the building being condemned. At the Sea Villa (R92) the roofs were blown off two units, and another unit was undermined by erosion flanking the north return to a concrete seawall, resulting in these units being condemned. At Ocean Lane (R95), a single-family dwelling was destroyed by the dune erosion and waves of Jeanne (Photo 9). And at the south end of Satellite Beach at Shell Street (R97), three out of five single-family dwellings were destroyed along with a swimming pool (Photo 10). The middle house of the five was destroyed even though it was protected by a vinyl seawall. Hurricane Jeanne also caused major damage to three single-family dwellings, 19 multifamily dwellings (condominiums, motels), and three commercial buildings in Satellite Beach.

Photo 9: Ocean Lane Residence Destroyed, Satellite Beach

Photo 10: Damage to Residence on Shell Street, Satellite Beach

City of Indian Harbour Beach Damage

The small community of Indian Harbour Beach had a single-family dwelling and a multifamily dwelling damaged during Hurricane Frances, and a multifamily dwelling and a commercial building damaged during Jeanne. Inland from the coast, the building office reported about 500 of Indian Harbour Beach's 2,500 homes were damaged.

City of Melbourne and Unincorporated Brevard County Damage

Between Indian Harbour Beach and Indialantic (R105-R120) is a severely impacted three-mile coastal reach that includes both unincorporated area of Brevard County and a coastal segment of the City of Melbourne. Major wind damage was sustained along the entire oceanfront as well as the impact of major beach and dune erosion from Hurricane Frances. Destroyed or substantially damaged by Frances were three single-family dwellings, one commercial building, and one multifamily garage building. Frances also caused major damage to seven single-family dwellings, eight multifamily dwellings (condominiums, hotel), two commercial buildings, four garage buildings, and a pavilion.

Hurricane Jeanne inflicted even greater wind and erosion damage along this coastal segment. Notably at the Hilton Hotel (R106) a major seaward section of the exterior wall was lost and many of the 118 rooms were damaged. At the nearby Holiday Inn (R109) severe damage was sustained to multiple units of various floor levels of each building. At the north building at least seven units were destroyed, including three second floor units, one third floor unit, one fourth floor unit, and two fifth floor units. At the south building two more fifth floor units were destroyed. Many other units on all floors had various levels of damage due to wind and water. Hurricane Jeanne also caused major damage to seven single-family dwellings, 10 multifamily dwellings (condominiums, hotels, motels), eight commercial buildings, and one garage building.

The damage in Melbourne was not restricted to the beach area as substantial wind, wave, and flooding damages also occurred away from the coast along and east of U.S. Highway 1 fronting the Indian River Lagoon.

Indialantic and Melbourne Beach Damage

South of the beaches of Melbourne are the communities of Indialantic and Melbourne Beach. These two beach communities have been hotspots of erosion damage for the past thirty years. In October 1973, Tropical Storm Gilda sat off the coast over the Bahamas and caused severe erosion and wave damage along the beaches of these communities. In September, 1979, Hurricane David brushed the southeast Florida coast on an alignment parallel to and inland of the Brevard County coast, causing moderate wind damage and severe erosion in these communities. A beach restoration project in 1980 provided a substantial degree of protection from the Thanksgiving Holiday Storm in 1984, however, the eroded beach never recovered and was not restored again until 2003. Hurricanes Floyd and Irene in 1999, Tropical Storm Gabrielle in 2001, plus many northeasters through the years caused significant erosion and damage in these towns which are now protected by the recent beach restoration project. Given the severity of the erosion from Hurricanes Frances and Jeanne to the north and south of these communities, it can be

concluded with reasonable certainty that a large percentage of the ocean front buildings in these towns would have been destroyed or severely damaged to the point of condemnation today had there been no beach fill project. Along with predictive models of dune erosion, the experience accrued from studying the erosion and damage of past storms in these communities has provided us the confidence of being able to identify which structures in this area would probably no longer exist without the beach project's protection.

The 3-mile long beach project did not prevent the significant wind damage sustained in these towns and many street ends were deposited with sand, but little of the coastal dune system was affected. Hurricane Frances caused major wind damage in Indialantic to two single-family dwellings, eight multifamily dwellings (condominiums, motels), and one commercial building. Frances caused major damage in Melbourne Beach to six single-family dwellings, three multifamily dwellings (condominiums, motel), and one commercial building. Hurricane Jeanne caused major wind damage in Indialantic to two single-family dwellings, nine multifamily dwellings (condominiums, motel), and six commercial buildings. Jeanne also caused major wind damage in Melbourne Beach to five single-family dwellings and six multifamily dwellings, including a five-unit condominium and a four-unit condominium (R134) between 4th and 5th Avenues that had their roofs blown off and were substantially damaged to the point of condemnation.

South Brevard County Damage

South of Spessard Holland Park (R137) is a 15-mile stretch of southern Brevard County that historically has had a relatively stable beach and dune system. Although past northeasters and tropical storms have inflicted beach and dune erosion, generally the beaches and to some lesser degree the dunes naturally recovered following the storms. Only following Hurricanes Floyd and Irene in 1999 was a small segment of shoreline (R196-R198, 0.4 mile) designated critically eroded due to threatened upland development. Hurricanes Frances and Jeanne have severely impacted the entire 15-mile shoreline segment, with severe retreat in the coastal dune system and numerous structures now damaged or imminently threatened. This 15-mile segment includes pockets of different types of development including the older single-family dwelling communities of Melbourne Shores and Floridana Beach.

The southern Brevard County beaches extended approximately 65 to 50 miles north of the center of both hurricanes' eyes at landfall. This location put the strongest wind field of both hurricanes over the region, and therefore moderate to major wind and wave damage was widespread. Few structures seaward of A1A went unscathed and beach access walkways were generally all destroyed along the full length of the beach. In southern Brevard County, Hurricane Frances destroyed or substantially damaged nine single-family dwellings, a pool house, and a World War II observation tower (R187). Frances also caused major damage to 35 single-family dwellings, 21 multifamily dwellings (condominiums, motels), five commercial buildings, a church building, a garage building, a pavilion, and a pool.

Along southern Brevard County, Hurricane Jeanne's impact was even more catastrophic. Jeanne destroyed or substantially damaged 40 single-family dwellings, two motel buildings, a commercial building, two garage buildings, two pavilions, and a pool. Notably Jeanne destroyed a 100-ft. concrete seawall and a 50-ft. wooden return wall, causing a single-family dwelling to be undermined between R158 and R159. At R162, the 56-year old Sea Grape Manor, built by the U.S. Coast Guard in 1948, lost its two motel wings with 10 units and a garage building when the dune line receded about 50 feet (Photo 11). The winds of Jeanne blew roof sections inland up to 350 feet from the building spreading debris across U.S. Highway A1A. At least five of the units were undermined and collapsed on the beach. Jeanne also caused major damage to 146 single-family dwellings, 26 multifamily dwellings (condominiums, motels, and duplexes), four commercial buildings, and a garage building (Photos 12-15).

Photo 11: Destroyed Motel, Sea Grape Manor (R162)

Photo 12: Slab on Grade Failure

Photo 13: Damage to Residence, Floridana Beach

Photo 14: Pool Destroyed (R196)

Photo 15: Major Dune Erosion Threatens Residence

Sebastian Inlet Damage

At the south end of the county, Sebastian Inlet State Park sustained wind damage and flooding. The U.S. Highway A1A bridge across the inlet and the two boulder jetties sustained no apparent damage. A 200-ft. section of asphalt walkway was damaged by the flood waters along the north shore of the inlet. The north jetty fishing pier lost about 40 to 50 of the metal breakaway grates but had no significant structural damage. The pier was substantially restored in 2003 after sustaining damage from Hurricane Floyd in 1999. Frances and Jeanne also undermined the north jetty pier's concrete access ramp and caused various wind and water damage to various facilities within the park.

Indian River Lagoon Damage

South of Melbourne and away from the coast, U.S. Highway 1 was substantially damaged by the storm tides and waves of Hurricane Jeanne. The bridge over the Sebastian River was also damaged. Numerous businesses and residences along U.S. Highway 1 fronting the Indian River Lagoon were damaged. Hard hit were boat docks and shore-protection structures throughout the area. Particularly impacted by the winds of Hurricane Jeanne was the manufactured housing community of Barefoot Bay where about 90% of the 4,800 mobile homes were damaged.

Summary of Brevard County Damage on the Coast

In summary, Hurricane Frances destroyed or caused major damage to 256 major structures, including 95 single-family dwellings, 99 multifamily dwellings, 41 commercial and other buildings, and 21 nonhabitable major structures. Hurricane Jeanne destroyed or caused major damage to 345 major structures, including 214 single-family dwellings, 86 multifamily dwellings, 32 commercial or other buildings, and 13 nonhabitable major structures. Countywide, the Brevard County Building Department reported about 8,000 residences and 135 businesses damaged including over 300 structures totally destroyed or condemned. These back-to-back hurricanes will be the storms to which all future storms are compared in Brevard County for some time to come.

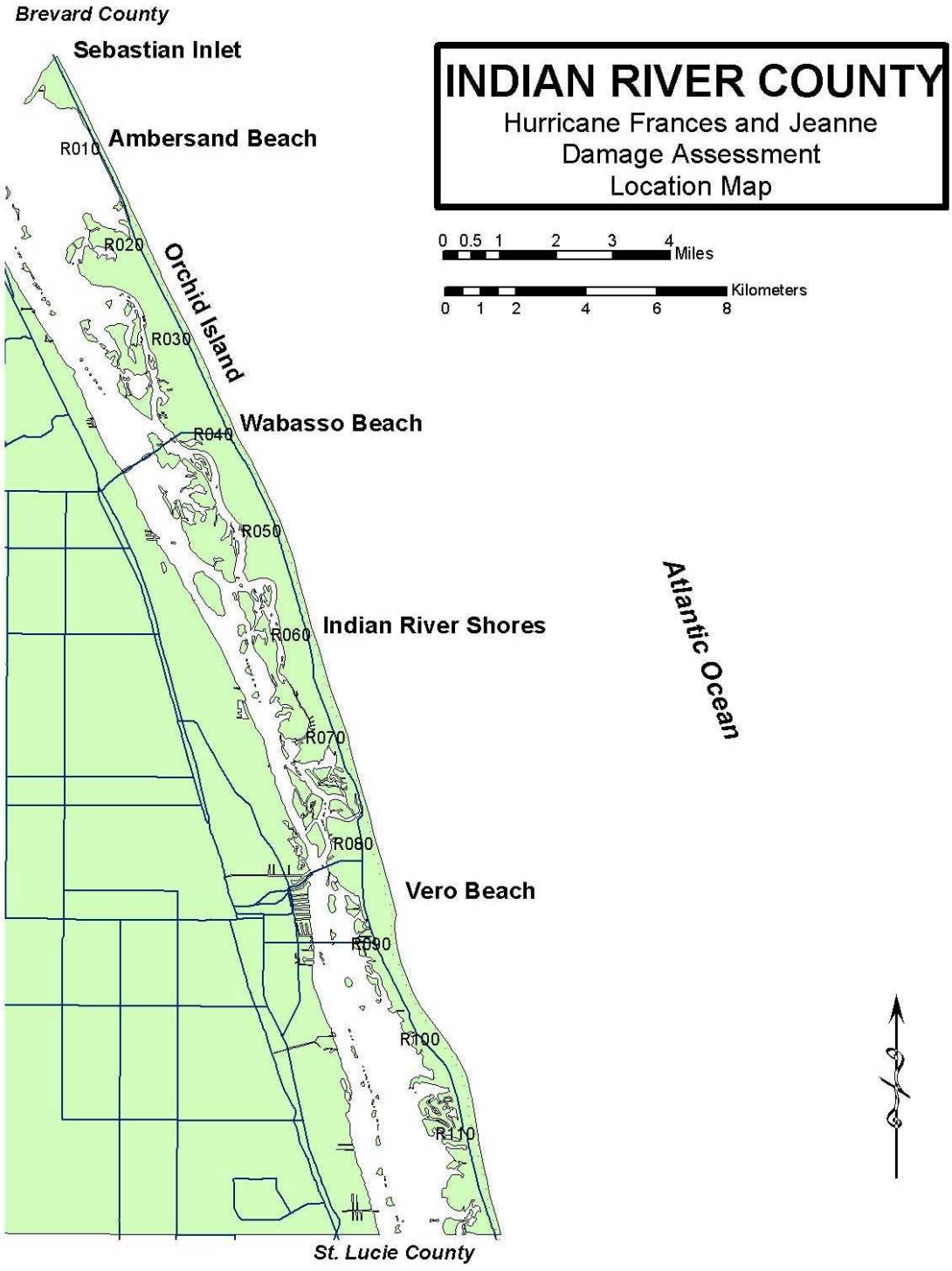


Figure 17: Indian River County Location Map

Indian River County

South of Brevard County, Indian River County extends for 22.4 miles along the central Atlantic coast. Coastal Indian River County includes the following communities and major parks: Sebastian Inlet State Park, Ambersand Beach, Indian River Shores, and Vero Beach (Figure 17). Prior to landfall of the two hurricanes, Indian River County had five designated critically eroded areas (9.1 miles) and four designated noncritically eroded areas (4.7 miles). The Indian River County beaches extended approximately 50 to 27 miles from the center of both hurricanes' eyes at landfall.

Beach and Dune Erosion

The proximity of Indian River County to the eye of both hurricanes at landfall placed the beaches within the strongest wind field and subjected the entire coastline to the peak storm tides and wave activity. Generally, major beach and dune erosion (Condition IV) was experienced throughout the county during Frances and Jeanne. The cumulative effect of both storms resulted in the most extreme erosion seen along the east coast of Florida in recent memory. Only within the sheltered embayment south of Rio Mar Reef (R86-R95) was an area of minor beach and dune erosion observed after each storm.

The northern three miles (R1-R17) south of Sebastian Inlet is designated as critically eroded threatening State RoadA1A, the Sebastian Inlet State Park (R1-R10), the MacClarty State Museum (R10-R11), and residential development along Ambersand Beach (R11-R17). The Sebastian Inlet Tax District periodically bypasses sand to the beach at the State Park. The museum has also been armored with a granite, rock revetment. After Frances the crest of the museum's revetment was visible, but after Hurricane Jeanne the entire revetment had become exposed. Beach restoration was conducted along Ambersand Beach in 2003. Major beach erosion, but only minor dune erosion, was observed along the beach fill project. Detailed follow-up surveys will document the material losses from the project.

Between Ambersand Beach and Wabasso Beach Park, Frances caused an average retreat in the dune line of about 20 feet. Jeanne caused an additional 30 feet of dune retreat on the average through this area. Seaward of three segments of vertical steel seawalls along this reach (R21.5, R27-R28, and R38-40), severe scour of the beach resulted from the storm tides and waves of both storms (Photos 16a & 16b). The leeside erosion impact caused by these walls was particularly severe. South of the two northern walls the dune recession was about 30 feet in comparison to the 20-foot average after Frances. At the seawall near R21.5, after Jeanne, there was a dune retreat of about 50 feet to the north and about 75 feet to the south. At the seawall between R27 and R28, after Jeanne, there was a dune retreat of about 60 feet to the north (from pre-Frances conditions) and about 50 feet to the south. The dune loss to the south of this wall was tempered by the fill placement activity of the affected lee-side property owner. South of the 1,800-foot long seawall along the Summerplace Subdivision, the Wabasso Beach Park sustained a cumulative dune retreat of about 80 feet and the complete loss of all the park's recreation facilities (Photo 17). This was the worst case of down-drift erosion impact from a Florida seawall in recent history.

Photo 16a: Severe Beach Scour Adjacent to Summerplace Seawall


Photo 16b: Loss of Material behind Seawall

Photo 17: Erosion and Damage , Wabasso Beach Park

The 2-mile reach north and south of Wabasso Beach (R37-R47.4) was designated as critically eroded prior to landfall of the two hurricanes. Given the severity of erosion and the new threat to development and recreation interests in the adjoining undesignated areas, new areas should now be designated as critically eroded. The northern 3.1 miles of Vero Beach (R70-R86) were also designated as critically eroded. Much of this area has experienced armoring, dune restoration, and small nourishment projects, although a major beach restoration effort has not yet materialized.

In southern Vero Beach (R103-R107) a 0.8-mile segment is designated as critically eroded. Due to the combined effect of both Frances and Jeanne, areas north and south of this reach should now be considered as critically eroded. The south end of Indian River County also had major flooding and overtopping of the storm surge that is thought to have been as high as +12 ft. NGVD.

Ambersand Beach Damage

Recent Hurricanes Erin (1995), Floyd (1999), and Irene (1999) each took their toll on the beaches, dunes, and structures of Ambersand Beach prior to the recent nourishment project. Protection provided by the nourishment project is evident when seen in comparison to the erosion and damage experienced southward through Vero Beach, or when compared to the south Brevard County damage and dune erosion. Had there not been a beach fill for protection from these two back-to-back extreme events, Ambersand Beach would likely have been substantially destroyed. Even though protected from the storm tides and battering waves of these storms, Ambersand Beach still sustained significant wind damages. Along with extensive wind damage to minor structures, cladding, fences, signs, trees and shrubs, a number of houses sustained major roof damage. Along Ambersand Beach , Hurricane Frances destroyed a single-family dwelling and caused major damage to 11 other single-family dwellings. Hurricane Jeanne destroyed or substantially damaged three single-family dwellings and caused major damage to 19 other single-family dwellings.

Damage between Ambersand and Wabasso (R20-R35)

South of Ambersand Beach are a mix of private properties and county parks. Between R20 and R35 Hurricane Frances damaged three single-family dwellings and two nonhabitable major structures. Two of these houses were in the Sanderling Subdivision (R33-R34), which was designated as critically eroded prior to landfall of the two storms. Jeanne inflicted severe erosion that caused five of the Sanderling Subdivision's houses to be undermined. In addition, a few houses had their roofs blown off. Also throughout this area, all the wooden beach access walkways were destroyed. At two Indian River County parks, Treasure Shores (R25) and Golden Sands (R32), the public handicapped beach access boardwalks were severely damaged.

Summerplace Damage

It is likely that many lessons in coastal management will be learned from the impact of these two hurricanes. Among the most difficult lessons dramatized by the subdivision of

Summerplace is that the construction of massive sheet-pile seawalls are not the solution to coastal protection in Florida. Hurricane Frances caused major damage to 14 homes in Summerplace. Hurricane Jeanne caused major damage to 17 homes, but 8 of those were essentially destroyed. When the Summerplace seawall is compared to the Ambersand Beach restoration project there should be no argument as to the more effective method of coastal protection. The seawall probably adversely affected the downdrift beach areas by depleting the adjacent shoreline and dune system of over 30,000 cubic yards of sand.

Wabasso Beach Damage

Although only 400 feet in length, the damage seen at Wabasso Beach Park was catastrophic (Photo 17). It is estimated that about 12,000 cubic yards of dune sand was lost by the combined effects of both storms. About 4,500 cubic yards of lost sand may be attributable to receiving the adverse impact of the adjacent seawall at Summerplace and another 7,500 cubic yards of lost sand may be attributable to the erosion impact of both storms. There is essentially no park remaining. Frances destroyed a 250-foot long pile supported elevated wooden boardwalk that had survived numerous storms and been repaired most recently after damages sustained during Hurricanes Floyd and Irene in 1999. In addition, Frances destroyed a lifeguard station and a pavilion at this popular beach recreation site. Jeanne took another landward bite out of this park and with it destroyed a large bath house building and the two remaining pavilions.

Wabasso to Indian River Shores Damage (R40-R52)

South of Wabasso Beach Park is the 1800-foot length of Disney's Vero Beach Resort. Approximately 60 feet of dune retreat was sustained from the combined effects of both hurricanes representing a loss of approximately 40,000 cubic yards of sand. Both storms caused major damage to the beach access boardwalk as well as wind damage to the resort hotel. South of Disney along Sea Oaks Way (R42-R44), both Frances and Jeanne caused wind damage to eight multifamily dwellings, destroyed swimming pool decks and dune access walkways, and left two buildings and two pools in imminent danger from future erosion. To the south, two additional multifamily dwellings (R48) had major roof damage and a pile-supported swimming pool (R46.65) was completely undermined. All the upland developments between R46 and R49 are now endangered from future storms.

Indian River Shores Damage

Between R52 and R55, two segments of backshore sills totaling 1850 feet in length were constructed in the late 1980's. Both of these coastal protection structures were constructed to provide dune bluff protection from high frequency storm events and were not designed for an extreme event like either Frances or Jeanne. Both of these backshore sills were totally destroyed and did not appear to have had any adverse physical impact on the beach or adjoining properties. However, their derelict remains are now a beach debris problem. As elsewhere along the county's shoreline, all the beach access walkways were substantially damaged or destroyed throughout Indian River Shores. In addition, there was major roof damage sustained by 15 condominium buildings and exterior wall damage by two condominiums.

Damage between Indian River Shores and Vero Beach (R65-R74)

South of Indian River Shores the severe combined erosion of Frances and Jeanne destroyed or substantially damaged many beach access walkways. Along this stretch of residential neighborhoods, Frances caused major damage to five single-family dwellings and Jeanne caused major damage to 12 single-family dwellings. In one particularly hard hit 1000-foot reach of shoreline (R71.2-R72.2) eight out of nine beach houses sustained major damage from the storms. In this reach two 100-foot long backshore sills were also destroyed. Between R73 and R74, at the site of the old Tracking Station, much of the field research facilities of Florida Institute of Technology were severely damaged or destroyed. At least four major structures sustained major damage at this facility.

Vero Beach Damage

Along the ocean-front of Vero Beach, the combined effects of both storms were particularly severe. Hurricane Frances destroyed or substantially damaged five single-family dwellings and seven multifamily dwellings (condominiums). Frances also caused major damage to 15 single-family dwellings, 12 multifamily dwellings (condominiums, motels), a commercial building, two recreation buildings, and five other nonhabitable major structures. Notably, the Ocean Gate (R74.7), a condominium in north Vero Beach, was undermined by dune erosion which also destroyed a 400-foot long backshore sill. The Sea Quay (R75), another condominium next to Ocean Gate, saw its old fishing pier substantially damaged, its pool deck destroyed and its dune substantially lost. The condominium to the south of Sea Quay also saw significant dune erosion.

However, the next condominium, Caledon Shores (R76) was the lone success story, owing its protection and lack of significant property loss to a unique 400-foot long coastal protection structure know as a Subsurface Dune Restoration System (SDRS) (Photo 18). This revetment type structure consists of 14 layers of sand filled geotextile tubes placed on a natural dune slope of 1:3 (vertical to horizontal). The system was largely untested until Hurricane Frances' storm surge and 30 hours of storm wave attack eroded all the dune material, leaving the SDRS completely exposed but structurally undamaged. In contrast to the severe scour caused by the vertical seawalls to the northern county beaches, the SDRS did not have any noticeable scour associated with it, primarily because of its natural gradual dune slope and its smooth transitional curves, and to a lesser degree to its covering of dune sediment.

Photo 18: Caledon Shores' SDRS

South of Caledon Shores and its SDRS, are three more condominiums (R76.4-R76.9). Frances eroded the frontal dune, destroyed a 500-foot long backshore sill and caused initial undermining of three buildings of the Ocean Club I and II. To the south are Jaycee Park and Conn Beach along Ocean Drive (R77-R79). Major dune erosion and damage took place along this popular beach area, including major damage to the asphalt parking (approximately 130 spaces) and seaward edge of pavement along 1500 feet of Ocean Drive. At the Racquet Club, a condominium at R79 west of Ocean Drive, the storm surge deposited sand in an overwash deposit 150 feet landward of the beach, covering a tennis court. South of Conn Beach and a 100-foot long vertical steel sheet-pile seawall, leeside dune erosion threatened one single-family dwelling and initiated undermining of another.

The 3,000-foot armored segment of beach between R80 and R83 includes the older section of Vero Beach's oceanfront. In this stretch of seawalls, 11 buildings (restaurants, condominiums, stores, and hotels) sustained major wind damage and two parking lots were damaged by undermining. The Gables, a condominium complex to the south at R84, sustained severe roof and gable damage from Frances' wind loads, which were measured gusting to 81 mph. The Rio Mar Reef departs the coast south of the Gables and the coastal embayment south of the Rio Mar Country Club was characterized by minor beach and dune erosion (Condition II) and less wind damage. South Beach Park had a lifeguard stand destroyed while six single-family dwellings and a condominium sustained major wind damage between R88 and R100.

South Vero Beach has a 0.8-mile segment (R103-R107) that was designated as critically eroded prior to landfall of the two storms. This area saw accelerated erosion conditions throughout the 1990's culminating in major erosion during Hurricanes Floyd and Irene in 1999. Limited beach scraping projects took place after both hurricanes in 1999 and a locally sponsored and planned beach nourishment project is still in the design and permitting stage while trying to balance sufficient fill placement with protection of nearshore hard bottoms. From R100 to the St. Lucie County line, Frances caused major damage to 10 single-family dwellings and a swimming pool. Two of these homes were substantially damaged due to erosion flanking their seawalls and two others sustained undermining of their seaward ends by the erosion.

Hurricane Jeanne impacted a Vero Beach area that was in an eroded and wind-damaged condition sustained from Hurricane Frances, and the second storm's damage was substantially greater (Photo 19). Jeanne destroyed or substantially damaged 10 single-family dwellings and 14 multifamily dwelling (condominiums). Jeanne also caused major damage to 36 single-family dwellings, 19 multifamily dwellings (condominiums, motels), 11 commercial or other buildings, and 5 other nonhabitable major structures.

Vero Beach, FL – Sept. 2004 Post-Hurricanes Frances and Jeanne (top) and Nov. 30, 1999 Aerial Photograph (bottom)

Photo Analysis by Dr. Lee E. Harris, P.E. and Tony Cimaglia, M.S., Florida Institute of Technology Photographs from NOAA (top) and FDEP (bottom).

Photo 19: Vero Beach, Florida

The Ocean Gate (R74.7) saw its two condominium buildings condemned after they were completely undermined by 75 feet of dune retreat (Photo 20). In addition, the recreation building between the condominiums was collapsed on the beach. The Sea Quay (R75) lost its swimming pool and saw the rest of its pier destroyed. The two four-story

buildings south of Sea Quay were both substantially damaged and significantly undermined and the recreation building was also totally destroyed. Next door, at R76, Caledon Shores sustained some major wind damage to its exterior walls but no additional erosion. The SDRS survived its second hurricane with no structural damage or beach impact. The remainder of Vero Beach sustained significant damages.

Photo 20: Ocean Gate, Vero Beach

The four condominiums south of Caledon Shores sustained major damage from winds and undermining (Photo 21). Jaycee Park and Conn Beach sustained additional major dune erosion. The 1500-foot segment of Ocean Drive (R77-R79) was substantially destroyed, raising questions about the prudence of rebuilding it (Photo 22). South of Conn Beach and a 100-foot long seawall, additional leeside dune erosion substantially damaged one dwelling and destroyed another. Along the older section of Vero Beach (R80-R83) that is armored, major wind damage was sustained by some 20 buildings (restaurants, condominiums, stores, and hotels). At the Gables (R84), most of the floors sustained severe damage resulting in the two condominiums being substantially destroyed (Photo 23).

Photo 21: Undermined Condominium, Vero Beach


Photo 22: Erosion and Road Damage following both Hurricanes, Conn Beach Park

Photo 23: The Gables, Vero Beach

Around the embayment south of the Rio Mar Country Club, where the golf course (R86-R87) was flooded, 10 single-family dwellings and two multifamily dwellings sustained major damage. The erosional south Vero Beach area experienced additional major damage to 20 single-family dwellings and a condominium. Seven of these homes were destroyed or substantially damaged by the storm surge, waves, and undermining of their foundations (Photo 24).

Photo 24: Destroyed Residence, South Vero Beach

Summary of Indian River County Damage on the Coast

In summary, Hurricane Frances destroyed or caused major damage to 95 major structures, including 54 single-family dwellings, 23 multifamily dwellings, three commercial or other buildings, and 15 nonhabitable major structures. Hurricane Jeanne destroyed or caused major damage to 193 major structures, including 110 single-family dwellings, 59 multifamily dwellings, 14 commercial or other buildings, and 10 nonhabitable major structures. Both storms also destroyed 2,550 feet of backshore sills. Countywide, the Indian River County Building Department reported over 49,000 residences damaged or destroyed.

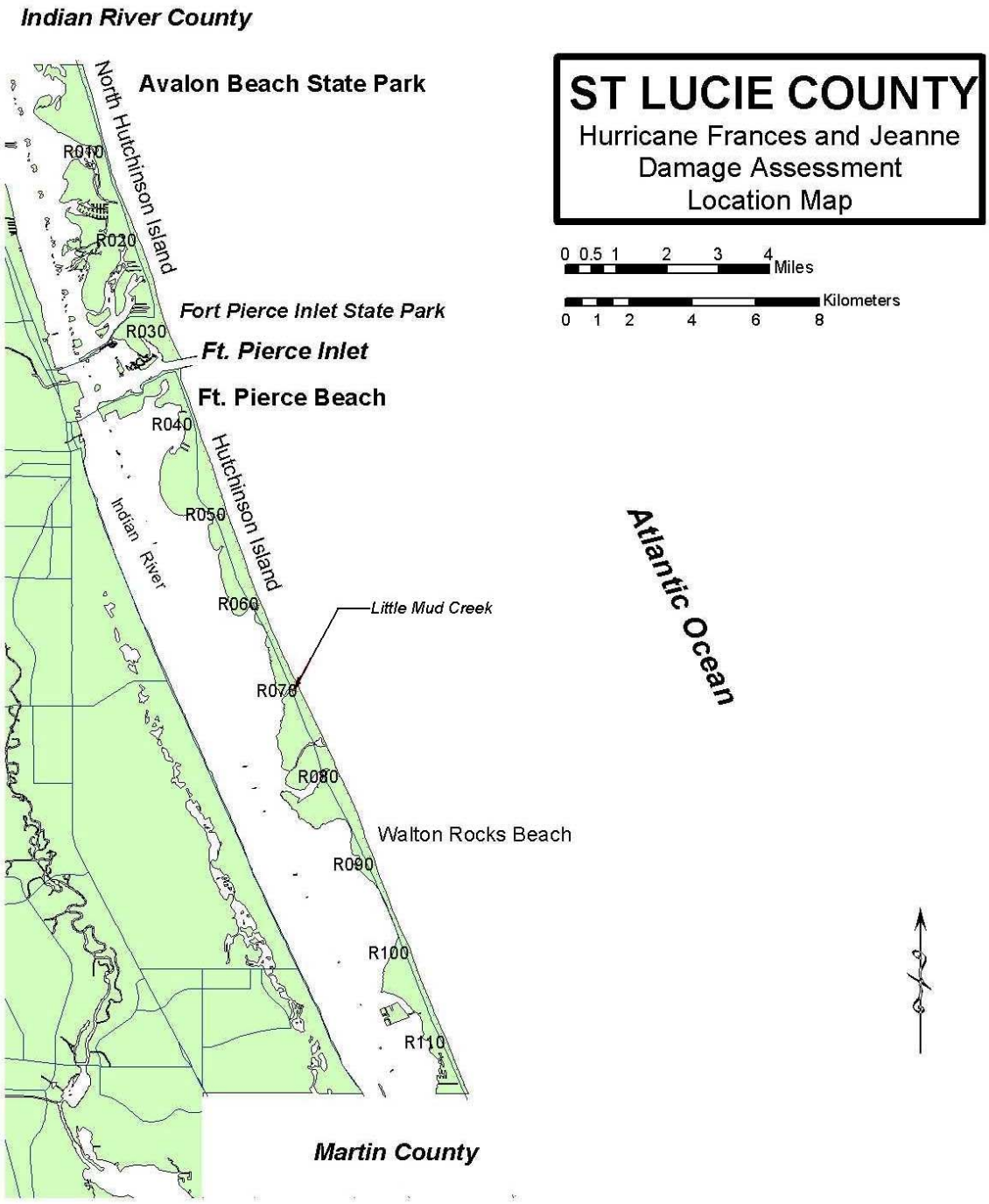


Figure 18: St. Lucie County Location Map

Saint Lucie County

The Atlantic Ocean fronting beaches of St. Lucie County extend for 21.5 miles between Indian River and Martin Counties (Figure 18). Prior to landfall of the two storms, two beach segments of St. Lucie County (5.7 miles) were designated as critically eroded. The northern critical erosion area (R34-R46) extends south from Ft. Pierce Inlet. Most of this area is a federal beach restoration project. The southern 3.4 miles of the county shoreline (R98-R115+1000) was also designated critically eroded. Ft. Pierce Inlet has a federal navigation project, and some shoaling likely occurred from Hurricanes Frances and Jeanne. The St. Lucie County beaches extended approximately 27 to 5 miles from the center of both hurricanes' eyes at landfall, placing St. Lucie County in the region of the highest storm surge.

Beach and Dune Erosion and Storm Surge on North County Beaches

Generally, major beach and dune erosion (Condition IV) was experienced throughout St. Lucie County during both Hurricanes Frances and Jeanne. In areas where no dunes or only low profile dunes existed, substantial inland flooding was experienced 300 to 400 feet inland from the beach.

The county beaches north of Ft. Pierce Inlet (R1-R33) sustained major beach and dune erosion. Historically, this stretch has been relatively stable and even accretional approaching the inlet. At R6, within Avalon State Park, the public beach access site was severely impacted by both Frances and Jeanne. Frances caused severe erosion resulting in a dune retreat of between 50 and 60 feet that undermined the seaward edge of the parking lot (Photo 25). Beach and dune erosion attributed to Hurricane Jeanne continued through the parking lot, resulting in a cumulative dune retreat of about 100 feet.

A high water mark represented by a wrack line after Hurricane Frances was located at an elevation determined by the Department's vertical elevation on monument R6, which was +12 ft. NGVD. It is believed that this high water mark is indicative of the storm surge generally throughout the region and represents a 100-year frequency combined storm tide level from St. Lucie, Indian River, and northern Martin Counties. The storm tide of Hurricane Jeanne was comparable, if not slightly, higher.

Photo 25: Avalon State Park after Frances, North St. Lucie County (R6)

Beach and Dune Erosion and Storm Surge on Hutchinson Island

South of Ft. Pierce Inlet the beach was recently nourished. Although the beach berm did not appear to be significantly eroded from either storm it is likely that follow-up surveys will reveal significant volumetric losses of sand from the project area. Significant overwash was experienced throughout Ft. Pierce Beach during both storms between R36 and R44. The largest overwash deposits occurred between R37 and R39 and between R42 and R44. Up to three feet of sand was deposited on Ocean Drive, U.S. A1A. Also, between R44 and R48, substantial accretion resulted from the translation of beach nourishment material southward.

South of Ft. Pierce Beach along the sparsely developed reach of Hutchinson Island (R47-R98) major beach and dune erosion (Condition IV) occurred during both hurricanes. This region experienced severe storm surge flooding and major sediment washover deposits as much as 500 feet inland of the beach. Along the developed south St. Lucie County segment of Hutchinson Island major beach and dune erosion (Condition IV) and substantial inland flooding occurred during both hurricanes. Substantial dune overtopping and storm surge overwash was experienced throughout this area, resulting in many structures like swimming pools and ground floors of condominiums being flooded and filled with sand deposits (Photo 26). An average of 50 feet of dune line recession was experienced throughout south St. Lucie County in response to both hurricanes. A wide beach recovery berm was observed along this area seaward of a shore-parallel beach erosion trough.

Photo 26: Dune Erosion and Washover, South Hutchinson Island

Northern St. Lucie County Damage

North of Ft. Pierce Inlet, the beaches of St. Lucie County are sparsely developed between R1 and R25 and include the Avalon State Park. Condominium development between R25 and R28 is set back a substantial distance from what was a relatively stable stretch of beach, and most of the remaining beach to Ft. Pierce Inlet is part of the Ft. Pierce Inlet State Park. Throughout northern St. Lucie County, Frances caused major damage to 15 single-family dwellings, a restaurant, and a number of carports and garage buildings. Notably, at R2 the storm surge and waves of Frances destroyed a quadraplex and a portion of a backshore sill (Photo 27). At Avalon State Park's beach access sites, a 250-foot asphalt parking area was damaged at R6 and a 450-foot parking area near R8 was covered with sand. The handicapped beach access ramps at both sites were substantially damaged. Hurricane Jeanne caused additional wind damage throughout northern St. Lucie County to several condominium buildings. Two buildings at R18 and another near R21 had upper floors substantially damaged by Jeanne's winds. The storm surge of Hurricane Jeanne also substantially destroyed the Avalon State Park's parking areas at R6 and R8 (Photo 28).

Photo 27: Destroyed Quadraplex, North St. Lucie County (R2)


Photo 28: Avalon State Park after Hurricane Jeanne, North St. Lucie County (R8)

Ft. Pierce Beach Damage

Sustained winds were measured in Ft. Pierce at 80-mph, gusting to 108-mph. The south jetty at Ft. Pierce Inlet sustained significant damage to its asphalt walkway during both Hurricanes Frances and Jeanne. Protected by the recently nourished beach restoration project, the development of Ft. Pierce Beach did not sustain the severe impact experienced in Indian River County. There was, however, substantial flooding and sand deposition on the ground floors of many residences and businesses both seaward and landward of U.S. Highway A1A. Several condominiums with their parking garages and single-family dwellings sustained major wind damage during both hurricanes. Two houses had their roofs blown off during Hurricane Frances. The South Beach Ocean Park had damage throughout to its facilities including a destroyed pavilion. Throughout Ft. Pierce Beach during the storms was also moderate to major wind damage to minor structures, signs, power poles and lines, roofing, siding, trees and shrubs.

Damage between Ft. Pierce Beach and Normandy Access (R47-R98)

This largely undeveloped 10-mile stretch of Hutchinson Island experienced the severe flooding and overwash impacts of both storms. The most notable damage during Hurricane Frances was the structural collapse of the Little Mud Creek north bridge abutment (R69.5) (Photo 29). Designed for the lower flows typically experienced with a tidal creek adjacent the Indian River Lagoon, the bridge culvert could not carry the extreme flow of a 100-year storm surge and the north bridge abutment catastrophically collapsed. The beach access park and all its facilities seaward of the bridge was also totally destroyed. The storm surge from Jeanne also damaged a stretch of U.S. Highway A1A near R60 caused by the storm surge flowing across the road into Middle Cove. An additional 100 feet of road damage was sustained by the storm surge at R65.7. U.S Highway A1A was buried in sand by the storm surge overwash between R64 and R66. The Blind Creek bridge (R76) survived but Blind Creek Park was destroyed again as it was by Hurricane Irene in 1999.


Photo 29: U.S. Highway A1A Breakthrough at Little Mud Creek (R69.5)

Near R81, the Florida Power and Light (FPL) nuclear power plant saw its discharge canal threatened with breaching due to the toe erosion of the confinement berm. The FPL intake canal (R83) had erosion to its interior side slopes. To the south, Walton Rocks Beach Park and its facilities (R85-R87) sustained severe damage throughout the park from both storms. At the Dune Walk condominiums (R88.7), the north building had a balcony collapse and the recreation building had its roof blown off. More storm surge damage and lagoon shoreline erosion occurred at R94 and R97, causing significant damage to the south bound lane of U.S. Highway A1A.

South St. Lucie County Damage

The south St. Lucie County beaches were designated critically eroded following special surveys and studies after Hurricanes Floyd and Irene (1999). The majority of upland development along this 3.4-mile reach to the Martin County line is now imminently threatened from future storms. At least 16 multifamily dwellings (mostly condominiums, a motel and restaurant) saw flooding and interior damages to their ground floors from both storms. Several swimming pools were substantially filled with sand. Among the worst damage was observed near R106 at the Hutchinson Inn and Shuckers Restaurant. The roof blew off the Hutchinson Inn, a 21-room bed and breakfast motel, during Hurricane Frances, and the erosion, storm surge, and waves of Hurricane Jeanne substantially damaged the seaward end of the building. Next door the Shuckers Restaurant saw its seaward porch and decks destroyed, and the building had initial

undermining during Frances. The building then sustained substantial damage by the erosion, storm surge, and waves of Jeanne. The pool deck of the 60-unit condominium attached to Shuckers was also destroyed (Photo 30). A commercial building to the south at the Nettles Island beach access was also substantially damaged by the storm surge and waves of Jeanne. South of the Waveland Beach access, a 1,100-foot backshore sill was destroyed adjacent to the Island Crest condominiums during Frances. At the Marriott Courtyard (R115) three units of the eighth floor were substantially damaged by Jeanne's winds.

Photo 30: Erosion and Damage, South Hutchinson Island (R106)

Summary of St. Lucie County Damage on the Coast

In summary, Hurricane Frances destroyed or caused major damage to 100 major structures, including 50 single-family dwellings, 21 multifamily dwellings, six commercial or other buildings, and 23 nonhabitable major structures. Hurricane Jeanne destroyed or caused major damage to 40 major structures, including four single-family dwellings, 22 multifamily dwellings, four commercial or other buildings, and 10 nonhabitable major structures. Both storms also destroyed 1,300 feet of backshore sills. Countywide, the St. Lucie County Building Department reported nearly 17,000 residences and buildings sustained damage.

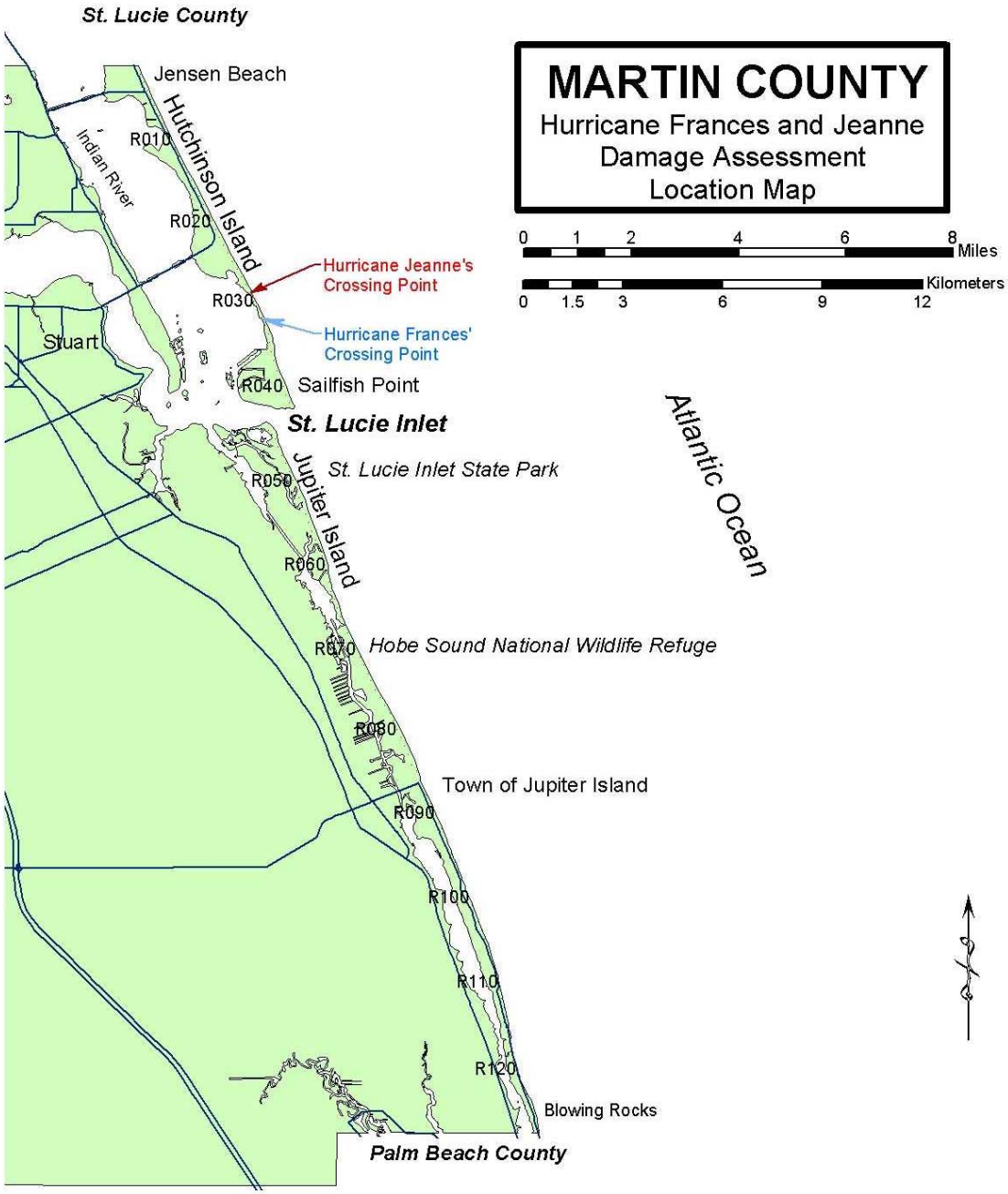


Figure 19: Martin County Location Map

Martin County

Martin County's ocean front beaches extend for 21.5 miles between St. Lucie County and Palm Beach County and include Jensen Beach, Sailfish Point, St. Lucie Inlet State Preserve, Hobe Sound National Wildlife Refuge, and the Town of Jupiter Island (Figure 19). Four beach segments of Martin County (15.8 miles) were designated as critically eroded prior to landfall of the two storms. The northern 4.5 miles of Martin County on Hutchinson Island (R1-R27) was designated as critically eroded and the beach is a federal beach restoration project. A small segment on south Hutchinson Island (R34.3-R35.7, 0.2 mile) is another segment that was designated critically eroded. Most of Jupiter Island south of St. Lucie Inlet (R45-R111) is designated critically eroded. Inlet sand transfer projects have nourished the beaches of the St. Lucie Inlet State Preserve and Hobe Sound National Wildlife Refuge. Erosion along this stretch has threatened wildlife habitat, including the potential to break through the barrier island at Peck's Lake. Also within the designated critical erosion area, the Town of Jupiter Island has a state and locally sponsored beach restoration project that has seen periodic nourishment over approximately 30 years. South of Blowing Rocks Preserve is another small area (R126-R127, 0.2 mile) designated as critically eroded.

Erosion of the Hutchinson Island Beach Restoration Project (R1-R25)

The eyes of both Hurricane Frances and Hurricane Jeanne made landfall in Martin County near the House of Refuge on south Hutchinson Island. The beaches of south Hutchinson Island sustained major beach and dune erosion (Condition IV) throughout from both hurricanes. Along Jensen Beach (R1-R9) the combined impact of both storms caused an average dune retreat of 30 feet. It is likely that little remains of the original beach restoration project in this area. Post-storm surveys should quantify the material losses. Even though the erosion impacted the coastal dune system, the remaining beach restoration project prevented even more significant losses from occurring.

From Bob Graham Park through the Indian River Plantation (R9-R25), the combined erosion of both storms caused an average dune retreat of 40 feet. This southern stretch of the dune restoration project is severely eroded and likely back to the pre-project conditions, leaving numerous development and recreation interests threatened. A low recovery berm exists along this reach. Between R18 and R20, a historical hot spot of critical erosion, the revetments fronting the Little Ocean Club and Place and the Islander 12 condominiums were exposed at their crests after Hurricane Frances, but totally exposed after the erosion of Hurricane Jeanne.

Erosion of the South End of Hutchinson Island (R26-R42)

The southern stretch of Hutchinson Island between R26 and R35 is characterized by exposed lime rock, narrow pocket beaches, and a perched dune system. Major dune erosion was sustained south of the beach project as evidenced by a 10 to 12-foot vertical dune escarpment near R26 (Photo 31). Major erosion of the perched dune system was sustained in the vicinity north and south of the House of Refuge (R27-R31). Significant exposure of rock is now observed in this area that was previously buried under dune

sediments. This erosion now threatens some upland development and McArthur Boulevard in this area.

Photo 31: Major Dune Erosion in Northern Martin County

Between the House of Refuge and Bathtub Reef Park, an average dune retreat of 40 feet was observed from the combined effects of both hurricanes(Photo 32). This area has historically been stable due to the rock formation. Substantial overtopping of the narrow barrier occurred during Jeanne between R30 and R31. The erosion along this area now threatens some 33 single-family dwellings seaward of McArthur Boulevard (Photo 33). At the Bathtub Reef park (R35) severe erosion, flooding, and overwash was sustained. This area is subject to dramatic advancement and retreat in the shoreline position. The storm surge overwash deposit extended some 300 feet landward of the beach and west of McArthur Boulevard. To the south along Sailfish Point (R36-R42) major beach and dune erosion (Condition IV) was sustained, however, only a couple buildings in the vicinity of R37 are now threatened due to their more seaward proximity to the beach than the remainder of the development.

Photo 32: House of Refuge after Jeanne

Photo 33: Undermined Residence, South Hutchinson Island

St. Lucie Inlet

Hutchinson Island and Jupiter Island are divided by St. Lucie Inlet, which has a federal navigation channel. St. Lucie Inlet was in the eye of both hurricanes. The shoaling across the semiporous north jetty and into the inlet's sand trap is readily seen by the exposure of sediment above water south of the inlet jetty at Sailfish Point. It is likely that severe shoaling took place within the inlet channel and the Atlantic Intracoastal Waterway channel possibly from reworked sediment from the flood tidal delta shoals of the Crossroads. Follow-up post-storm surveys will provide a more complete indication of the extent of inlet shoaling.

Jupiter Island Erosion

South of St. Lucie Inlet along the beaches of the St. Lucie Inlet State Preserve and the Hobe Sound National Wildlife Refuge (R43-R77), minor to moderate beach and dune erosion (Condition II to III) was sustained from both storms. Jupiter Island was in the lee of both storms, so did not experience the severe wind, storm surge, and waves that Hutchinson Island experienced. The area of beach adjacent Peck's Lake (R63-R67) broke through in 1965 during Hurricane Betsy; however, the leeside position to both Hurricane Frances and Hurricane Jeanne prevented a breakthrough from occurring during these storms. Overwash did occur during Hurricane Jeanne.

Between R75 and R121, the Town of Jupiter Island constructed a beach restoration project 30 years ago in 1974. This five-mile long project has been nourished periodically, with the most recent project nourishment constructed in 2002 (between R75 to R117). Hurricane Frances caused significant adjustment to the beach elevation contours by moving sand into the inshore bar and transforming the horizontal beach berm into a sloping profile. However, the beach fill prevented upland flooding by the storm surge and wave uprush, and no more than minor erosion of the dunes occurred (Condition II). Some fill material was lost from the project area, but a wide, natural recovery berm has accreted along the shoreline. Hurricane Jeanne did not erode this recovery berm, and the upland development remains well protected by the beach fill.

South of the Town of Jupiter Island (R121-R127) moderate beach and dune erosion (Condition III) was sustained by both storms along and south of Blowing Rocks Preserve. At least nine single-family dwellings are threatened between R126 and the Palm Beach County line.

Hutchinson Island Damage

The beach restoration project along the northern Martin County beaches (R1-R25) was in need of maintenance nourishment prior to the impact of both hurricanes. Even so, the project provided substantial protection to upland recreation facilities and development. The project is now in critical need of nourishment. Hurricane Frances caused major wind damage throughout this area including major damage to 16 multifamily dwellings (condominiums, hotel). Hurricane Jeanne also caused major wind damage to five multifamily dwellings.

South of the beach restoration project along McArthur Boulevard, Frances undermined two single-family dwellings, caused roof damage to two dwellings, and understructure damage to another. Jeanne inflicted damage to the pile foundations of two single-family dwellings, undermined two others, and caused understructure damage to three other dwellings. South of the House of Refuge (R30-R31) about 650 feet of McArthur Boulevard was destroyed. At the Bathtub Reef Park another 200 feet of McArthur Boulevard was damaged. Also destroyed was a 50-foot concrete return wall at R33 and a 200-foot backshore sill at R37. The Bathtub Reef Park including its bathroom building, large covered deck, walkways, and parking lot was totally destroyed from the impact of both storms.

Jupiter Island Damage

There was no major damage along Jupiter Island in Martin County.

Summary of Martin County Damage on the Coast

In summary, Hurricane Frances caused major damage to four single-family dwellings and 16 multifamily dwellings. Hurricane Jeanne damaged four single-family dwellings and five multifamily dwellings. Jeanne also damaged or destroyed two road segments totaling 850 feet in length, a 200-foot backshore sill and a 50-foot concrete seawall. About 7.5 miles offshore in 130 feet of water, the retired World War II naval vessel, USS Rankin, measuring 459 feet in length and placed on the Sirotkin reef was one of several artificial reefs off Martin County reported to have been substantially damaged by the hurricanes.

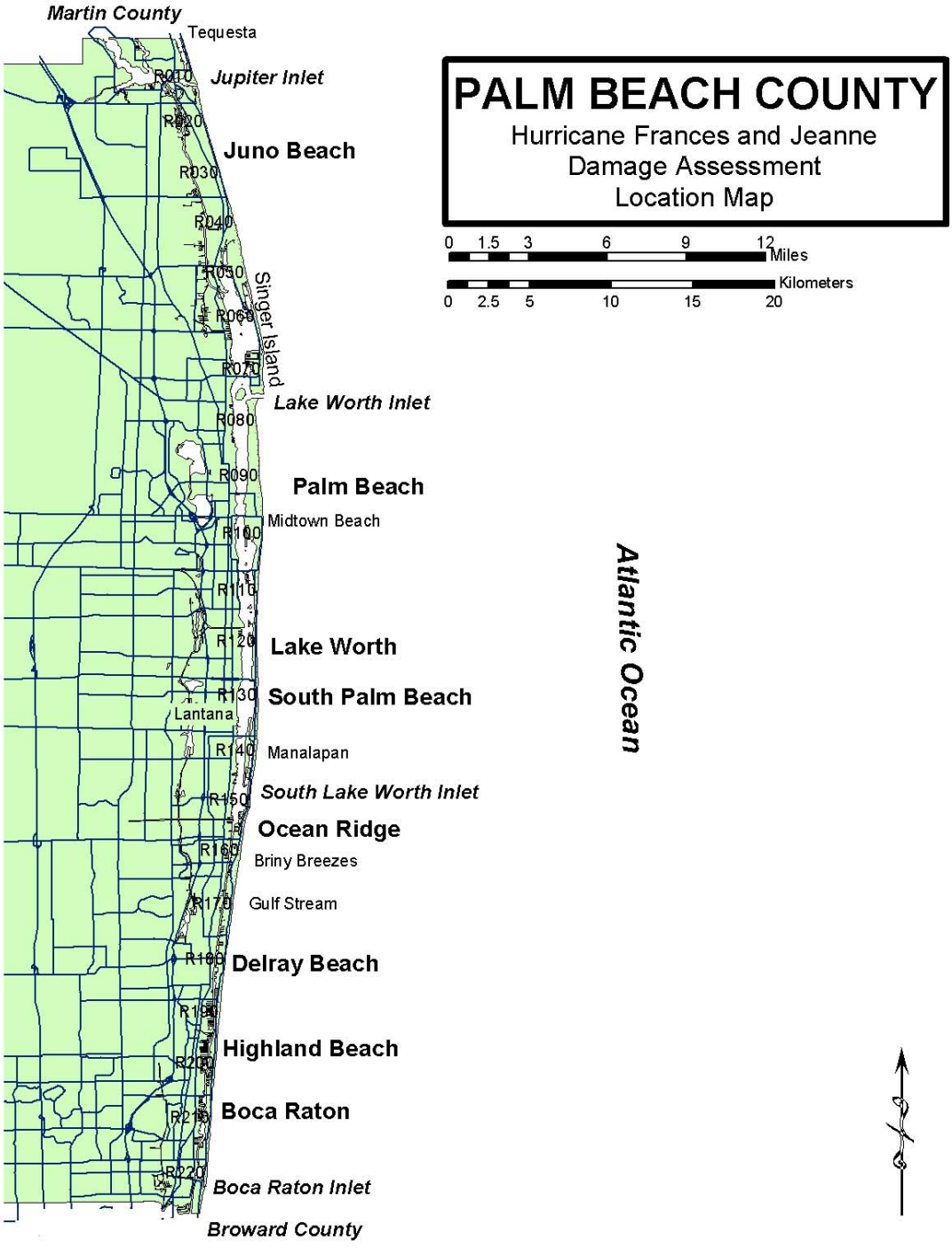


Figure 20: Palm Beach County Location Map

Palm Beach County

Palm Beach County beaches extend for 45.3 miles between Martin County and Broward County. Palm Beach County includes the following barrier beach communities and major parks: Tequesta, Jupiter Inlet Colony, Juno Beach, John D. MacArthur Beach State Park, Riviera Beach, Palm Beach, Lake Worth, South Palm Beach, Lantana, Manalapan, Ocean Ridge, Briny Breezes, Gulf Stream, Delray Beach, Highland Beach, and Boca Raton (Figure 20). There are eight designated critical erosion areas (30.7 miles) in Palm Beach County. Within these areas are five beach restoration projects and 4 inlet sand transfer projects.

Coastal Inlets

The four coastal inlets of Palm Beach County are Jupiter Inlet, Lake Worth Inlet, South Lake Worth Inlet, and Boca Raton Inlet. Lake Worth Inlet has a federal navigation channel that sustained shoaling from both Hurricanes Frances and Jeanne. A sand transfer plant constructed on the north jetty sustained no significant exterior damage, but the interior was flooded, causing damage to plant equipment. Wave run-up along the north jetty caused scour of the adjacent beach and overwash into the dune. The sand bypassing plants at both Lake Worth Inlet and South Lake Worth Inlet have a substantial quantity of material available after the storms to bypass material southward. Jupiter Inlet likely had shoaling, but the sand trap was recently dredged and the material hydraulically bypassed south of the inlet. Boca Raton Inlet, at the south end of the county also had a significant quantity of shoaling. Post-storm surveys will better define the quantity of material available for bypassing at these inlets.

Beach and Dune Erosion

Palm Beach County generally experienced moderate dune erosion and beach profile lowering from the impact of Hurricane Frances. The impact of Hurricane Jeanne was minor along most of the coast of Palm Beach County, perhaps because its path was located further north and because it moved through more quickly than Frances. Since much of the upland development is generally sited on the frontal dune, there are many structures now vulnerable to the impact of future storms, unless located landward of coastal armoring or protected by a beach restoration project. A particular area of concern is the critically eroded beaches of Singer Island (R60.5-R69).

Hurricane Frances caused a significant adjustment to the beach restoration projects by transporting sand into the storm bar and changing the horizontal beach berm into a sloping beach profile, but upland development remains well protected by the beach projects. Generally, Hurricane Jeanne did not erode the natural recovery berm accreting along the beach since the impact of Hurricane Frances.

The northernmost 1.9 miles of Palm Beach County (R1-R12) on Jupiter Island north of Jupiter Inlet, includes a 1.2-mile segment of critically eroded beach (R3-R10). In 1993, a dune restoration project was completed in Coral Cove Park (R5-R7.6), using sand trucked to the site from an upland source. Hurricane Frances caused moderate beach and

dune erosion (Condition III) exposing extensive outcrops of underlying rock formations and completely eroding the Coral Cove Park dune restoration project.

The 7.5-mile segment of coast from Jupiter Inlet (R13) south through to Lost Tree Village (R51) on Singer Island, includes a 5.0-mile segment of critically eroded beach (R12-R38). Beach restoration has been conducted at Jupiter-Carlin Park (R13.5-R19) and Juno Beach (R26-R38). Hurricane Frances caused minor erosion of the beach fill (Condition II), with moderate adjustment of the horizontal berm into a sloping beach profile. A natural recovery berm has begun to accrete along the beach.

The remaining 4.6-mile segment of Singer Island from John D. MacArthur Beach State Park to Lake Worth Inlet (R51-R75), includes a 1.7-mile segment of critically eroded beach (R60.5-R69). Historical erosion of the dune bluff threatens upland condominiums, and sand from upland sources has been placed to maintain the protective dune. Hurricane Frances caused moderate dune erosion and beach profile lowering (Condition III) exposing extensive outcrops of underlying rock formations. Hurricane Jeanne caused additional dune bluff retreat. Many of the upland structures are now vulnerable to damage from the impact of a major northeaster storm during the coming winter season.

The 15.6-mile long Palm Beach Island (R76-R151) includes a 10.9-mile segment of critically eroded beach at the Town of Palm Beach (R76-R128), and a 0.7-mile segment at South Palm Beach (R133-R137). Since most of the island's eroded beaches were already narrow, the moderate beach erosion (Condition III) caused by Hurricane Frances, resulted in no dry beach remaining seaward of the extensive coastal armoring in this area. Approximately 2,000 feet south of Lake Worth Inlet begins Reach 2 (R78-R90.4) of the Palm Beach Coastal Management Plan, where a wide beach within the fillet south of the inlet transitions to no dry beach seaward of the bulkheads. Further south, the Mid-Town Beach Restoration Project (R90.4-R101.4), completed in 1995 and nourished in 2003, experienced moderate erosion and loss of the beach fill (Condition III).

At the Phipps Ocean Park Beach Restoration Project (R116-R126), where construction is pending the completion of an environmental impact statement and issuance of a federal permit, Hurricanes Frances and Jeanne caused moderate dune erosion and beach profile lowering exposing extensive outcrops of underlying rock formations (Photo 34). Since the existing structures are generally sited on the frontal dune or immediately upland of a coastal armoring structure, the upland development is now vulnerable to damage from the impact of a strong northeaster storm during the coming winter season.

Photo 34. Erosion at Phipps Ocean Park

The remaining 15.4 miles of south Palm Beach County beaches from South Lake Worth Inlet through Boca Raton (R152-R227), generally experienced minor dune erosion and beach profile lowering (Condition II). A sand transfer plant constructed on the north jetty of the inlet sustained no significant exterior damage, but the interior was flooded causing damage to plant equipment. This stretch of coast includes a 3.3-mile segment of critically eroded beach at Ocean Ridge (R152-R168), a 2.9-mile segment of critically eroded beach at Delray Beach (R176-R190), and a 5.0-mile segment of critically eroded beach at Boca Raton (R204-R227.9). Beach restoration and nourishment has been conducted within each of these areas. The beach fill projects prevented storm damage to the upland property while experiencing adjustment from a horizontal beach berm at +9 ft. NGVD to a sloped beach profile with an unknown amount of fill material lost to the nearshore bar. Follow-up post-storm surveys will quantify the combined storm erosion losses from these projects.

Palm Beach County Damages

Upland major structures were not damaged by the storm tides or waves of Hurricanes Frances and Jeanne. A few beach and nearshore structures were impacted. On Jupiter Island, a 200-foot backshore sill (R4.5) was damaged by Frances and destroyed by Jeanne. On Singer Island, failure of a bulkhead panel at Jupiter Reef Club (R21) caused minor loss of backfill material and failure of concrete decking. The Juno Beach fishing pier sustained decking damage but no structural damage. On southern Singer Island, a

50-foot north return wall to a concrete seawall (R65.3) was destroyed. A high-rise condominium in Riviera Beach sustained major wind damage. The 37-floor Tiara is the tallest building in Palm Beach County (R70) and the winds of Frances tore away six-story lengths of exterior stucco paneling, revealing steel columns and beams(Photo 35). Many of Tiara's 320 units sustained severe rain and wind damage. The building had been in the process of renovation and contractors had removed the hurricane shutters. At Phipps Park, a portion of the road was undermined and dune walkovers were damaged. The only other significant structural damage was seen at the Lake Worth Pier (R128.55) where complete sections were destroyed, including the loss of piles, bents and decking (Photo 35).

Photo 35: Wind Damage, Riveria Beach (R70) & Damage to Lake Worth Pier

In summary, Palm Beach County saw major damage to only a pier and a condominium and two coastal protection structures totaling 250 feet in length.

Broward and Dade Counties

Broward County and Dade County beaches extend for 24 miles and 20.8 miles respectively south of Palm Beach County. On the leeside of both Hurricanes Frances and Jeanne, only minor beach erosion was observed along these beaches. However, because of the high energy storm wave conditions, several fishing piers sustained various levels of damage. The only major damage was sustained by the pier in Ft. Lauderdale, which saw its shore segment destroyed along with extensive decking damage. Fishing piers in Deerfield Beach, Pompano Beach, and Sunny Isles sustained decking damage without any structural damage. There was no damage to the Dania Pier.

Gulf of Mexico Coast of Florida

The beaches of the southwest Florida coast fronting on the Gulf of Mexico extend for over 210 miles from Cape Sable in Monroe County through Anclote Key in Pasco County. Except for Lee County, where Hurricane Charley made landfall on August 13, the southwest Florida beaches received the fringe impact of all four hurricanes that impacted Florida during the 2004 hurricane season. Even Key West and the distal sandy beach islands to the west, including the Dry Tortugas, sustained beach and dune erosion from at least Hurricanes Charley and Ivan. Surveys are being conducted at Fort Zachary Taylor Historic State Park and other state parks in the Florida Keys to assess cumulative erosion impacts and to determine quantities of sand needed to nourish critically eroded park beaches. Determining the erosion from only Hurricanes Frances and Jeanne is difficult given Charley's initial erosion followed by Frances' erosion, which then was followed by Ivan's erosion prior to Jeanne's erosion. In most areas the individual impact of each storm was minor yet the cumulative impact of all four storms was significant. The Big Bend coast and the Ochlockonee Barriers coast of north Florida were impacted by the passing of both Frances and Jeanne in their tropical storm stage. Although erosion was relatively minor in this area, impacts on shell fishing and marina facilities were reported to be significant.

Collier County

The beaches of Collier County experienced tropical storm force winds and wave activity from Hurricanes Frances and Jeanne. Only minor beach erosion was observed near Wiggins Pass (R17-R18) and along the beaches of Naples south of the Naples Pier (R73-R89). A one to two-foot lowering of the beach profile was observed along the beaches of Naples. Minor erosion was also reported from Marco Island, including Hideaway Beach, during Hurricane Jeanne.

Lee County

Lee County beaches were significantly impacted by Hurricane Charley. Subsequent erosion conditions were observed following Hurricanes Frances, Ivan, and Jeanne. At the north tip of Captiva Island, the beach profile was lowered by about 3 feet exposing the old revetment along the golf course of the South Seas Resort. Along Captiva Drive (State Road 867) between R96 and R98, the dune has eroded to within 10 feet of the roadway leaving a three-foot escarpment. Captiva Island, between R83 and R99, sustained moderate beach and dune erosion from Hurricane Frances and Hurricane Jeanne. On Bonita Beach, two dune walkovers were destroyed at R223 during Hurricane Frances, and Bay Road was flooded along with several single-family dwellings during Hurricane Jeanne.

Charlotte County

Charlotte County sustained minor beach erosion from the lee side of Hurricane Charley. Little additional erosion was observed during Frances. Northern Gasparilla Island (R59-R68) sustained minor beach erosion (Condition I). Don Pedro and Knight Islands also

incurred minor beach and dune erosion (Condition II), except on Don Pedro Island between R38 and R39, which sustained major dune erosion (Condition IV), from both Hurricanes Frances and Jeanne. At Stump Pass, significant shoaling continued, as a spit formation grows from the Stump Pass State Park southward into Stump Pass.

Sarasota County

Generally, minor erosion to the beaches and dunes (Condition I to II) was sustained throughout Sarasota County. At several hotspots, Condition III erosion was observed. Some major damage was sustained between R75 and R77 along the south end of Siesta Key north of the former location of Midnight Pass. At a single-family dwelling at R77, an aluminum bulkhead was partially destroyed and an adjacent pool and deck was destroyed. A 500-foot steel sheet-pile seawall along Blind Pass Road sustained damage to about 275 feet of concrete cap, and another single-family dwelling north of R77 sustained understructure damage. In addition, a boardwalk was damaged on Casperson and a pavilion was damaged in Venice.

Manatee County

Generally, Anna Maria Island experienced Condition I to II erosion. At the north end of the island (R3-R5), moderate beach and dune erosion was sustained (Condition III). Longboat Key also sustained minor beach and dune erosion (Condition II) north and south of the Yonkers seawall near R49. No major structural damage was observed.

Pinellas County

Throughout Pinellas County, Condition I and II erosion prevailed during Hurricane Frances. A localized shoreline segment of Condition III erosion was observed near R32 at the north end of Clearwater Beach Island at the site of the former Dunedin Pass (now closed). Hurricane Jeanne brushed near to and northeast of Tampa, causing strong tropical storm force winds along the beaches of Pinellas County. The Sunshine Skyway Bridge over Tampa Bay was closed due to the high winds. Clearwater Beach Island and northern Sand Key (R32 through R57) sustained Condition III erosion. Flooding occurred in the vicinity of the Sheraton Sand Castle (R53) on Sand Key. St. Petersburg Beach at Pass-a-Grille experienced Condition IV erosion. Upham Beach, south of Blind Pass, sustained substantial erosion after having just been nourished. Sunset Beach north of Blind Pass on Treasure Island also sustained minor beach erosion. In Clearwater Beach, the Travelodge on South Gulfview Boulevard lost a section of roof, which blew 150 feet and damaged the Red Roof Inn, crushing a fourth floor balcony. Nearby on Gulfview Boulevard a condominium also sustained major roof damage.

Big Bend Coast

Hurricane Frances entered the Gulf of Mexico north of Tampa as a tropical storm bearing winds of 65 mph before making a second Florida landfall near the Aucilla River in the St. Marks National Wildlife Refuge on the coast of Jefferson County. With little time spent over the waters of Apalachee Bay, Frances never regained hurricane strength. Hurricane

Jeanne never entered the Gulf of Mexico yet brushed close to Tampa before veering north to near Live Oak then west near Madison before heading north again up through Georgia.

Cedar Key had wind gusts to 65-mph where two of three charter boat docks were destroyed. The Florida Department of Agriculture estimated major shell-fish crop losses in the Cedar Key area due to the storm tides and wave activity.

Ochlockonee Barriers

North and south of the Ochlockonee River Entrance are the coastal barrier beaches of Alligator Point, Southwest Cape, Lighthouse Point, and Bald Point (all in Franklin County) and Mashes Sands (Wakulla County). Tropical Storm Bonnie made landfall along the length of Alligator Point on August 12 causing minor beach erosion in this area. Tropical Storm Frances made landfall on September 6, east of the St. Marks River placing these barrier beaches in the more quiet lee of the storm. Alligator Point sustained no erosion west of R210 and the Southwest Cape. At the Southwest Cape (R211-R220) minor beach erosion prevailed (Condition I). At Lighthouse Point (R221-R222) minor beach and dune erosion (Condition II) was sustained and threatened a single-family dwelling. This house was subsequently damaged by the waves in the fringe of Hurricane Ivan when it made landfall in Alabama. Along the beaches between Lighthouse Point and Bald Point (R223-R239) minor beach erosion continued. No damage was sustained by the facilities at Bald Point State Park. Across the Ochlockonee River Entrance in Wakulla County some minor beach erosion was observed at Mashes Sands. Hurricane Jeanne passed by far enough to the east of this region as to have no significant additional effect on these beaches.

Recovery Recommendations and Management Strategies

AREA-WIDE STRATEGIES AND RECOMMENDATIONS

Encourage expedited federal funding from the U.S. Army Corps of Engineers (USACE) to conduct maintenance beach nourishment of the federal shore protection projects.

Seek Federal Emergency Management Agency (FEMA) assistance to repair non-federal beach nourishment and dune restoration projects.

Conduct assisted recovery of the beach and dune system consisting of dune restoration and re-vegetation, with supplemental beach fill as needed, in areas where significant upland development is vulnerable to the threat of storm damage. Allow natural recovery in undeveloped areas, as appropriate.

Conduct removal from the active beach and dune system miscellaneous storm-generated debris, such as construction debris and derelict sand-fill geotextile armoring structures.

Support further sand search studies to locate sufficient upland and offshore sand resources to replenish storm-eroded beaches.

Conduct post-storm coastal monitoring to assess beach erosion impacts and to assess beach recovery progress and any additional recovery needs.

Provide beach management technical support to assist in coordination with local governments for hazard mitigation/beach management planning, removal of storm-related debris on beaches, and restoration of public dune walkovers.

Re-evaluate coastal construction design standards for re-validation for the Florida Building Code.

SITE-SPECIFIC RECOMMENDATIONS

Volusia County

- **North Peninsula**
  Natural recovery – Undeveloped lands seaward of US Highway A1A (R1-R39).
  Assisted recovery – Dune restoration and re-vegetation (R40-R145).
- **New Smyrna Beach/Bethune Beach**
  Natural recovery – Undeveloped lands or development set back from beach (R149-R161).
  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R161-R208). Accelerate the design and construction of a non-federal beach restoration project.

Brevard County

- **City of Cape Canaveral & Cocoa Beach**

  Interim beach nourishment, or if necessary, early construction of the scheduled maintenance nourishment of the Brevard County (North Reach) Shore Protection Project (R1-R53).

- **Satellite Beach & Indian Harbour Beach**

  Assisted recovery – Dune restoration and re-vegetation (R85-R118). Accelerate the design and construction of the Brevard County (Mid-Reach) Shore Protection Project in environmentally suited areas.

- **Indialantic/Melbourne Beach**

  Interim beach nourishment, or if necessary, early construction of the scheduled maintenance nourishment of the Brevard County (South Reach) Shore Protection Project (R118-R138).

- **South Brevard County**

  Assisted recovery – Dune restoration and re-vegetation (R138-R218).

Indian River County

- **Sebastian Inlet State Park & Ambersand**

  Interim beach nourishment, or if necessary, early construction of the scheduled maintenance nourishment of the Ambersand Beach Restoration Project (R3.5-R17).

- **North County Beaches**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R17-R70). Expedite design and construction of beach restoration at Wabasso Beach in environmentally suited areas.

- **Vero Beach**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R70-R86). Expedite design and construction of beach restoration in environmentally suited areas.

- **South County Beaches**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R100-R107). Expedite design and construction of beach restoration in environmentally suited areas.

St. Lucie County

- **North County Beaches**

  Natural recovery – Undeveloped lands or development set back from beach (R1-R33).

- **Ft. Pierce Beach**

  Early construction of the scheduled maintenance beach nourishment of the federal Ft. Pierce Shore Protection Project (R34-R46).

- **South County Beaches**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R98-R115); Accelerate completion of feasibility study, design and construction of beach restoration in environmentally suited areas.

Martin County

- **Hutchinson Island**

  Construction of the maintenance beach nourishment of the federal Martin County Shore Protection Project (R1-R27).

- **House of Refuge/Bath Tub Reef Park**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R27-R36).

- **Sailfish Point**

  Natural recovery – Development set back from beach and dune (R36-R44).

- **Jupiter Island**

  Natural recovery – undeveloped property (R45-R75, R117-R126) or developed property protected by beach nourishment project (R75-R117).
  Assisted Recovery – Dune restoration and re-vegetation with supplemental beach fill (R126-R127).

Palm Beach County

- **Coral Cove Park**

  Assisted recovery – Dune restoration and re-vegetation (R3-R10).

- **Singer Island**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R60-R69).

- **Lake Worth Inlet**

  Repair of the inlet sand bypassing plant.

- **Mid-Town - Palm Beach Island**

  Interim beach nourishment, or if necessary, early construction of the scheduled maintenance nourishment of the Mid-Town Beach Restoration Project (R90-R101).

- **Phipps Ocean Park Beach**

  Construction of the Phipps Beach Restoration Project (R116-R126).

- **South Palm Beach Island**

  Assisted recovery – Dune restoration and re-vegetation with supplemental beach fill (R133-R137).

- **South Lake Worth Inlet**

  Accelerated reconstruction of the inlet sand bypassing plant.

- **Ocean Ridge**

  Conduct interim beach nourishment of the Ocean Ridge Beach Restoration Project (R152-R168).

- **Boca Raton**

  Early construction of the scheduled maintenance beach nourishment of the north Boca Raton segment (R205-R212) of the federal Palm Beach County Shore Protection Project; Interim beach restoration of the non-federal South Boca Raton Beach Restoration Project.

Broward County

- Accelerate construction of the maintenance nourishment to replenish the federal Broward County Shore Protection Project to maintain project design requirements.

- **Hillsboro Beach**

  Accelerate construction of the maintenance nourishment of the Hillsboro Beach Restoration Project (R6-R12).

Dade County

- Reevaluate project needs in accordance with annual or post-storm monitoring data.

Southwest Gulf Coast

- Reevaluate project needs in accordance with annual or post-storm monitoring data.