Preliminary Hurricane Irma Post-Storm Beach Conditions and Coastal Impact Report Division of Water Resource Management Florida Department of Environmental Protection October 2017



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I. Introduction

Hurricane Irma made landfall on September 10, 2017, in the Florida Keys, and again on the Florida mainland at Marco Island. At landfall, Irma was a strong Category Four hurricane on the Saffir-Simpson hurricane intensity scale. This was Florida's first landfall of a major hurricane in twelve years since Hurricane Wilma made landfall in 2005 just south of Marco Island at Cape Romano. With the track of Irma northerly up the peninsula of Florida, most of the state felt some impact from either the winds, rain, or storm surge. Given the strongest winds, waves, and storm surge of Irma were from the east, the entire east coast of Florida was substantially affected. Beach erosion and coastal damage was the greatest along the Northeast Coast and Central Atlantic Coast of Florida, as well as in the Florida Keys and along the coast of Collier County in Southwest Florida. This report documents the post-storm beach conditions and coastal impact of Hurricane Irma. It will assist the Florida Department of Environmental Protection (Department) and local governments to identify areas where storm erosion has left upland development and infrastructure vulnerable to imminent damage from future storms, sand berms could be placed to fortify and assist in the recovery of the beach and dunes, and expedited permitting procedures are needed to assist homeowners in repairs and reconstruction.

The Department developed this Post-Storm Beach Conditions and Damage Assessment Report to quantify the damages caused by Hurricane Irma. This report provides an assessment of storm impact, beach and dune erosion, and structural damages to the coastal regions of Florida fronting the Atlantic Ocean, Gulf of Mexico, and Straits of Florida. Although extensive structural damage occurred well inland of the coast, the damage assessment in this report specifically focuses on damage within the coastal building zone, as defined in Chapter 161, Florida Statutes.

Following the impact of Hurricane Irma, two damage assessment teams were dispatched to the coastal areas affected by Irma, with the exception of the Florida Keys. Given the extent of damage within the Keys and the safety of the assessment teams, damage assessments were postponed for Monroe County. The damage assessment teams from the Department were as follows:

- Team 1: Ralph Clark, P.E., Coastal Engineer; Mike Manausa, Coastal Engineer; Tyler Boland, Surveyor
- Team 2: Guy Weeks, Planning Manager; Peter Bacopoulos, P.E., Coastal Engineer; Shane Duinkerken, Surveyor

These hurricane damage assessment teams conducted the detailed damage assessments for the following counties: St. Johns, Flagler, Volusia, Brevard, Collier, Lee, Charlotte, Sarasota, and Manatee. Additional

data, information, and assistance was provided to the teams by Volusia County, Brevard County, Indian River County, Martin County, Collier County, the Town of Jupiter Island, the South Ponte Vedra-Vilano Beach Property Owners Association, and various private coastal engineering firms. Post-storm vertical aerial photography provided by the National Oceanic and Atmospheric Administration (NOAA) greatly assisted the damage assessments of this report. This report is a preliminary document, and additional data and information on the substantial damage in Monroe County and the less substantially affected coastal counties, as well as quantitative volumetric and shoreline position changes, will subsequently be added when available.

II. Hurricane Irma: August 30 – September 15, 2017

Hurricane Irma, the fourth hurricane of the 2017 hurricane season for the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, spawned from a tropical wave that moved off the west coast of Africa. Satellite imagery indicated a large low-pressure area had become organized in the far eastern Atlantic, and Irma became the season's ninth tropical storm on Wednesday, August 30, 2017. Further intensification continued, and Irma reached hurricane strength on August 31, with a track that continued west-northwestward at over 10 miles per hour (mph). Throughout the day, Irma intensified rapidly, and reached major hurricane status as a Category Three hurricane, with maximum sustained winds of 115 mph. Irma continued tracking westward as a Category Three major hurricane until Monday, September 4 (Labor Day), when it underwent further rapid intensification to a Category Four hurricane, with maximum sustained winds of 138 mph. **Figure 1** illustrates the track history of Hurricane Irma combined with satellite imagery. This composite was developed by the Cooperative Institute of Meteorological Satellite Studies (CIMSS) at the University of Wisconsin – Madison.

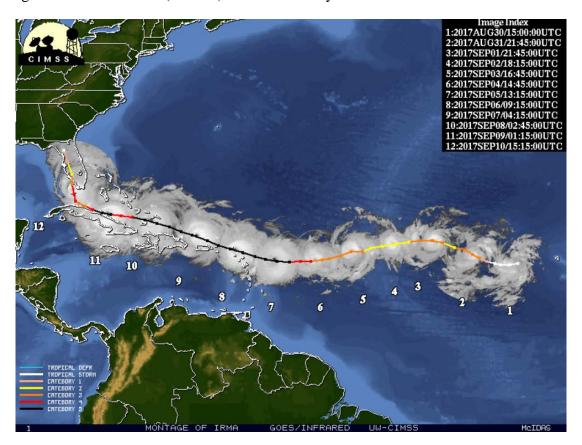


Figure 1. Hurricane Irma track with landfall in the Florida Keys and the Southwest Coast of Florida (Source: CIMSS/Univ. of Wisconsin-Madison).

On Tuesday, September 5, Irma strengthened further becoming a large Category Five hurricane, with maximum sustained winds of 185 mph. Hurricane advisories were announced for the northern Lesser Antilles, the Virgin Islands, and Puerto Rico. Wednesday morning, September 6, the eye of Irma passed over the island nations of Barbuda, St. Barthelemy, and St. Martin, causing catastrophic damage to the islands. On St. Barthelemy, at landfall as a Category Five hurricane, a minimum barometric pressure of 915.9 millibars was measured. An NOAA weather station on Barbuda measured a maximum sustained wind of 119 mph, and a maximum wind gust of 156 mph, before the anemometer failed to record. Throughout the day, Irma passed over the British and U.S. Virgin Islands.

Irma passed north of Puerto Rico Wednesday night into Thursday morning, September 7, and just north of Dominican Republic and Haiti through Thursday evening, bringing major damage along the northern coasts of these island nations. Some weakening occurred as the storm went through an eyewall replacement cycle, and Irma was reclassified as a Category Four hurricane on Friday, September 8, with maximum sustained winds of 156 mph. However, U.S. Air Force measurements indicated Irma reintensified Friday evening to Category Five status, with maximum sustained winds of 162 mph as it brushed the Turks and Caicos Islands and the southern Bahamas.

On Saturday, September 9, Irma passed over the Cuban Keys along the northern coast of Cuba. Throughout the day, the eye of Irma tracked west-northwesterly across land along the northern coast of Cuba, bringing catastrophic damages to the affected area. Late Saturday afternoon, the eye of Irma began to move away from the coast of Cuba into the Florida Straits. Given its nearly 24-hour track over land, Irma weakened somewhat to a Category Three hurricane, with maximum sustained winds of 110 mph.

Sunday morning, September 10, Irma made a turn to the north, and re-strengthened to a Category Four hurricane, with maximum sustained winds of 133 mph. The eye of Irma passed over the Florida Keys, with official landfall on Cudjoe Key at 9:10 a.m. To the west of the eye, a National Ocean Service station in Key West measured sustained winds of 71 mph, with a gust to 90 mph. The Key West Weather Service Forecast Office reported a gust to 91 mph. The eye of Irma moved away from the Keys in the late morning. A 75-mph sustained wind and an 87-mph gust was reported at the National Data Buoy Center C-MAN station at Fowey Rocks, adjacent to Biscayne Bay. A 109-mph gust was reported at Pines Middle School in Pembroke Pines.

By Sunday at noon, Irma's eye had substantially crossed Florida Bay. A 92-mph wind gust was reported at the Federal Aviation Administration station at Miami International Airport. At 3:35 p.m., the eye of

Irma made landfall again on the Southwest Coast of Florida at Marco Island, with an estimated intensity of 115 mph. A 130-mph wind gust was recently reported by the Marco Island Police Department. A sustained wind of 55 mph and a gust of 82 mph was reported at Naples Municipal Airport. A sustained wind of 63 mph and a gust of 84 mph was reported at Opa-Locka Executive Airport. At 6:00 p.m., a wind gust of 142 mph was reported at the Naples Municipal Airport. At 7:00 p.m., a wind gust of 88 mph was reported at the Southwest Florida International Airport in Fort Myers.

Throughout Sunday evening, Irma continued to track northerly through the Florida peninsula. At 10:00 p.m., the Juno Beach Pier in northern Palm Beach County reported a wind gust of 83 mph. The 11:00 p.m. advisories indicated that Irma had weakened to a Category Two hurricane, with 98-mph winds. Irma continued to weaken as it tracked northward along the western Florida Peninsula Monday morning, September 11. The eye dissipated, and by 5:00 a.m., Irma had weakened to a Category One hurricane, with maximum sustained winds of 75 mph. Hurricane-force winds continued to occur in a band well northeast of the center along the northeastern coast of Florida, with sustained winds of 69 mph reported in the Jacksonville area. Irma continued to weaken to tropical storm strength, and then to a depression Monday evening, as it tracked north-northwesterly out of Florida and across Georgia. Irma brought flooding rains to Northeast Florida, Georgia, and South Carolina.

Irma was a hurricane for nearly 12 days, which included over three days as a Category Five hurricane. When Irma made landfall in the Florida Keys, it was a Category Four major hurricane, and caused widespread damage throughout the Keys. It made a second landfall at Marco Island in Southwest Florida as a Category Three hurricane, and had a devastating impact on coastal communities of Collier County fronted by the Ten Thousand Islands (**Figure 2**). As it tracked northward across the Florida Peninsula, Irma weakened. Inland wind and flooding damages occurred throughout the peninsula to Orlando, as Irma weakened to a Category Two and a Category One hurricane. Irma continued to track northward across North Florida and into Georgia as a strong tropical storm, bringing widespread wind damage, particularly to trees. As the large rain bands blew into North and Central Florida off the Atlantic Ocean, the Northeast Coast of Florida experienced high tides, large waves, and gale force winds, causing major beach and dune erosion and widespread damage to coastal structures. These rain bands also carried numerous small tornados, as tornado damage was clearly discernable on the coast of St. Johns, Volusia, and Brevard Counties. In addition, the storm tide coupled with storm water runoff caused major flooding of the lower St. Johns River, which flooded Jacksonville.

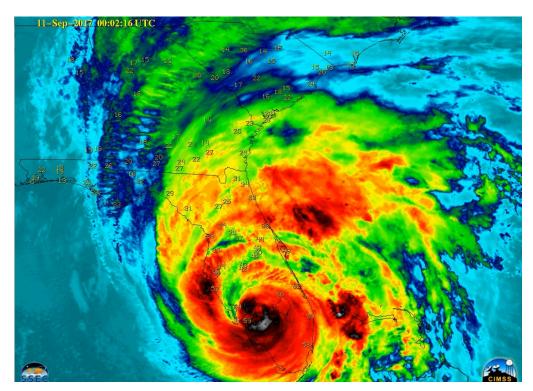


Figure 2. Hurricane Irma wind field after landfall in Florida (Source: CIMSS/Univ. of Wisconsin – Madison).

Substantial wind data is available from reporting stations throughout Florida. As this document presents the coastal impact on Florida, **Figure 3** maps strategic wind data reports by presenting peak wind gusts and maximum sustained winds from selected weather monitoring stations around the coast of Florida.

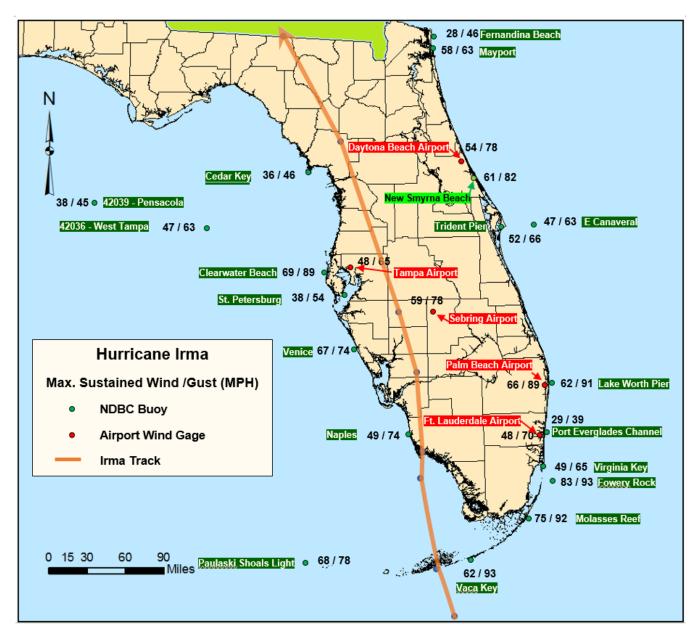


Figure 3. Hurricane Irma wind data from recording stations [Data sources – National Data Buoy Center; National Weather Service].

Storm tide data around Florida's coast is available from several of NOAA's recording tide gages. In addition to NOAA tide gauges, special storm-tide sensors that can measure the height, extent, and timing of the storm tide were deployed by the U.S. Geological Survey (USGS). Additional storm tide data from surveyed seaweed wrack lines and mud lines inside of buildings are not yet available. Wave data from seven National Data Buoy Center (NDBC) buoy stations, located in the Gulf of Mexico and the Atlantic Ocean, are available. A graphic depiction of the peak storm tide levels and wave heights during Irma is presented in **Figure 4**.

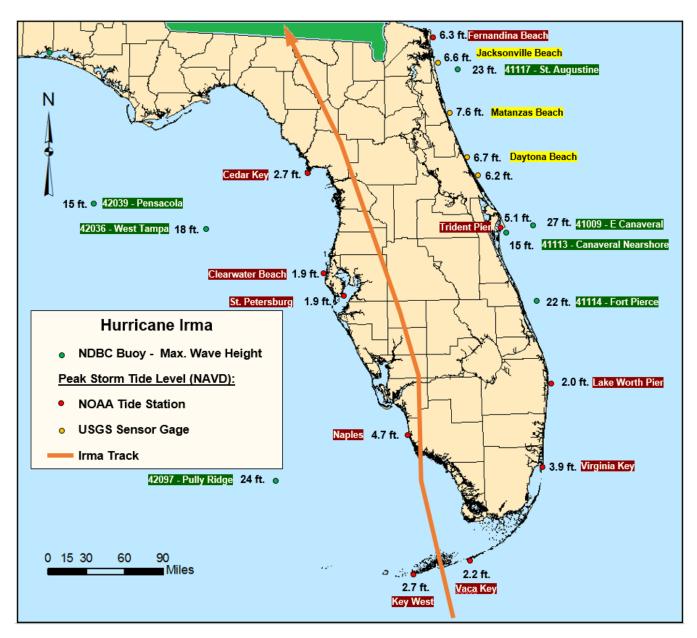


Figure 4. Hurricane Irma peak storm tide levels and maximum offshore wave heights [Data sources – NDBC; National Ocean Survey, NOAA].

The highest measured storm tide for the Southwest Gulf region was measured at the National Ocean Survey tide station located on the Naples Fishing Pier shortly after Hurricane Irma's landfall at Marco Island (**Figure 5**).

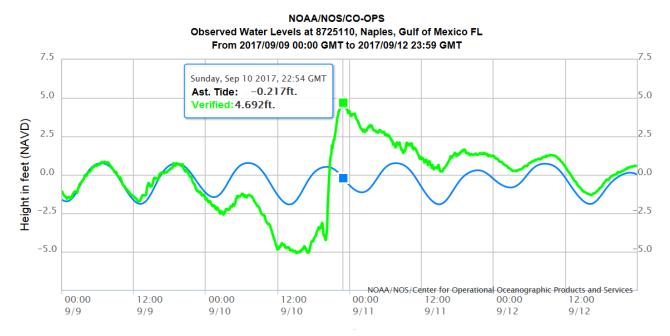


Figure 5. Measured gulf storm tide levels at Naples during Hurricane Irma [Data from National Ocean Survey, NOAA].

Noteworthy with the Naples measured tide data is the nearly 10-foot swing between the extreme low tide and the peak storm tide. North of Marco Island, including Naples, the position of the coast to the west of the hurricane's eye passage resulted in the initial winds blowing offshore. This resulted in a set-down or squat of the gulf water level, which at Naples was measured to be roughly five feet below 0.0 feet NAVD. As the eye of the hurricane passed inland, the wind field rotating around the eye shifted to onshore, resulting in the eventual peak surge of +4.7 feet NAVD. Along the entire Gulf Coast north of Marco Island, this squat and surge cycle continued to a lesser scale, as the hurricane tracked northward and weakened over land.

No tide gage data or storm surge data is currently available for the peak storm surge of Hurricane Irma at landfall, which would be located to the east of the eye in the vicinity of Everglades City in the Ten Thousand Islands. Given the flood damage reported and observed in that area, the hurricane's peak storm surge is likely substantially greater than at Naples, but has yet to be measured. The Atlantic Coast of Florida north of Cape Canaveral experienced storm tides of six to seven feet. The astronomical tides are higher in this region of the Florida coast, and when coupled with the persistent westward wind field of Irma and storm wave setup along the northeastern Florida beaches, significantly higher water levels were experienced. These higher water levels with onshore winds and waves resulted in major beach and dune erosion along the eastern coast of Florida, as well as widespread structural damages, primarily north of Sebastian Inlet.

III. Hurricane Irma Impact Summary and Overview

This section provides a summary of the beach and dune erosion, and structural damage, that occurred in the more substantially affected coastal counties. **Table 1** lists beach and dune erosion conditions around the State of Florida, starting with Northeast Florida and continuing southward, and then crossing to Southwest Florida and continuing northward. Only Florida's peninsular beaches are represented at this time, pending a more in-depth investigation of the beach conditions in the Florida Keys. Areas not assessed are listed as 'NA,' and areas with no erosion are listed as '- ', respectively. Reference or Range ("R") monuments are historical survey markers established by the Department that are spaced approximately every 1000 feet to measure beach erosion. A graphic depiction of the classification of beach erosion conditions is provided in **Figure 6**.

Table 1. Beach and Dune Erosion Summary.

Nassau County

Locations	Reference Monuments	Erosion Condition
Amelia Island	R1 - R59	NA
Amelia Island Plantation	R59 - R79	II

Duval County

Locations	Reference Monuments	Erosion Condition
Little Talbot Island	R1 - R30	NA
Mayport, Hanna Park	R31 - R43	NA
Atlantic, Neptune, and Jacksonville Beaches	R43 - R80	II - III

St. Johns County

Locations	Reference Monuments	Erosion Condition
Ponte Vedra	R1 - R46	II - IV
Guana Reserve	R46 - R67	NA
South Ponte Vedra	R67 - R101	II - IV
Vilano Beach	R101 - R119	III - IV
Porpoise Point	R120 - R122	II
Anastasia State Park	R123 - R141	NA
St. Augustine Beach, Crescent Beach	R141 - R196	III - IV
Summer Haven	R197 - R209	IV

Flagler County

Locations	Reference Monuments	Erosion Condition
Marineland to Washington Oaks	R1 - R16	IV
Palm Coast	R16 - R44	IV
Painters Hill	R44 - R60	IV
Beverly Beach and Flagler Beach	R60 - R100	II

Volusia County

Locations	Reference Monuments	Erosion Condition
Tomoka Preserve	R1 - R16	II
Ormond by the Sea	R16 - R57	II
Ormond Beach, Daytona Beach, Daytona Beach		
Shores	R57 - R118	II
Wilbur by the Sea, Town of Ponce Inlet	R118 - R135	II
North of Ponce de Leon Inlet	R135 - R148	III-IV
South of Ponce de Leon Inlet	R149 - R151.5	IV
New Smyrna Beach and Bethune Beach	R152 - R208	II
Cape Canaveral National Seashore	R208 - R234	NA

Brevard County

Locations	Reference Monuments	Erosion Condition
Cape Canaveral National Seashore	V1 - V62	NA
Kennedy Space Center	V63 - V167	NA
Canaveral Beach	R1- R5	IV
Canaveral Beach	R6 - R15	II - III
Cocoa Beach	R16 - R55	I - II
Patrick Air Force Base	R56 - R75	I
Satellite Beach	R76 - R96	II - III
Indian Harbor Beach (Shell St.)	R97 - R99	IV
Indian Harbor Beach	R100 - R109	III
Indialantic, Melbourne Beach	R110 - R142	I - II
South Brevard Beaches	R143 - R213	II - IV
Sebastian Inlet State Park	R214 - R219	II

Indian River County (from County Report)

mulan River County (from County Report)		
Locations	Reference Monuments	Erosion Condition
Sebastian Inlet State Park, Ambersand Beach	R1 - R17	III
Wabasso Beach	R17 - R55	III
John's Island	R55 - R72	III - IV
Vero Beach	R72 - R86	III
South Beach	R86 - R97	I
Seagrove to Moorings	R97 - R108	III
Moorings to Round Island Beach Park	R108 - R119	I

Martin County (from Town Report)

Locations	Reference Monuments	Erosion Condition
Hutchinson Island	R1 - R42	NA
Northern Jupiter Island	R43 - R76	NA
Town of Jupiter Island	R77 - R127	I

Collier County

Locations	Reference Monuments	Erosion Condition
Barefoot Beach	R1 – R16	I-II, IV
Delnor-Wiggins Pass State Park	R17 – R22	II-III
Vanderbilt Beach	R22 – R39	I-II
Pelican Bay Beach	R39 – R41	I
Naples	R42 – R89	II
Keewaydin Island	R90 – R127	NA
Sea Oat Island	V304 – V308	NA
Hideaway Beach	R128 - V311	II
Marco Island	R128 – R148	IV (berm) II (dune)
Kice Island	V323 – V332	NA
Morgan Island	V333 – V339	NA
Cape Romano	V341-V344	IV

Lee County

Locations	Reference Monuments	Erosion Condition
Gasparilla Island	R1 - R17	-
Gasparilla Island	R18 - R21	I
Gasparilla Island	R22 - R26	IV
Cayo Costa Island	R27 - R65	NA
North Captiva Island	R66 - R83	NA
Captiva Island	R84 - R98	II
Captiva Island	R99 - R109	-
Sanibel Island	R110 - R130	-
Sanibel Island	R131 - R154	II
Sanibel Island	R155 - R174	-
Estero Island (Ft. Myers Beach)	R175- R180	I
Ft. Myers Beach Pier	R181	IV
Estero Island (Ft. Myers Beach)	R182- R189	I
Estero Island (Ft. Myers Beach)	R190 - R194	IV
Estero Island (Ft. Myers Beach)	R195 - R199	I
Lovers Key	R213 - R221	I
Lovers Key	R221- R222	III
Big Hickory island	R222 - R225	NA
Bonita Beach	R226 - R239	-

Charlotte County

Locations	Reference Monuments	Erosion Condition
Manasota Key - Englewood Beach	R1 - R15	I
Manasota Key - Englewood Beach	R16 - R21	II
Knight Island and Don Pedro Island	R22 - R57	NA
Gasparilla Island	R58 - R68	I

Sarasota County

Locations	Reference Monuments	Erosion Condition
Longboat Key	R1 - R37	-
Lido Key	R37 - R42	II
Lido Key	R43 - R44	III
Siesta Key	R45 - R62	-
Siesta Key	R63 - R75	-
Siesta Key	R76 - R77	NA
Casey Key	R78 – R91	II
Casey Key	R92 - R99	-
Casey Key	R100 - R107	II
Venice Beach	R108 – R114	-
Venice Beach	R115 – R137	NA
Manasota Key	R138 - R149	IV
Manasota Key	R150 - R174	II
Manasota Key	R175 - R176	IV
Manasota Key	R176 - R183	-

Manatee County

Locations	Reference Monuments	Erosion Condition			
Anna Maria Island	City Pier - R2	II			
Holmes Beach, Bradenton Beach, Cortez Bch.	R2 – R33	-			
Coquina Beach	R34 – R36	II			
Longboat Key	R42-R45	IV			
Longboat Key	R45 – R67	-			

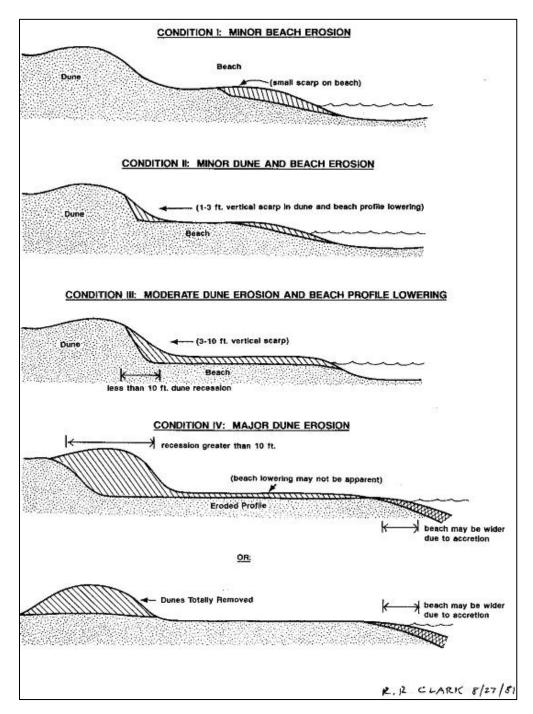


Figure 6. Beach Erosion Conditions I to IV.

Major Structural Damage

The most severe structural damage from Irma occurred in the Florida Keys and four small coastal communities adjacent the Ten Thousand Islands. Florida Keys damages have not yet been inventoried; during the coming weeks, when all the impacted areas can be safely accessed, the Department's coastal

engineers will conduct a damage assessment and the information included in a final post-storm conditions report.

Along the East Coast of Florida, the northeastern and central Atlantic counties with the greatest structural damages were St. Johns, Flagler, Volusia, and Brevard Counties. These counties were left vulnerable following the impact of Hurricane Matthew in October 2016. An overall summary of structural damage to major structures is given in **Table 2**. A summary of damage to coastal armoring, including seawalls, bulkheads, retaining walls, revetments, sills, or other rigid coastal protection structures, is provided in **Table 3**. Not included in this table is damage to rigid shore-protection structures like groins and breakwaters, or navigation structures like jetties. A more detailed description of these impacts by specific location is provided in Section IV of this report.

Table 2. Summary of Major Structural Damage to Major Structures by Hurricane Irma along the Coast of Peninsula Florida (Florida Keys not included).

County	# Single-Family Dwellings Damaged	# Multi-family Dwellings ¹ Damaged	# Other Major Structures ² Damaged	Total # Damaged ³
St. Johns	136	32	3	171
Flagler	61	7	10	78
Volusia	69	26	11	106
Brevard	55	126	36	217
Collier	188	24	19	231
Lee	1	2	3	6
Charlotte	1	0	0	1
Sarasota	0	0	1	1
Manatee	0	0	1	1
TOTAL	511	217	84	812

- 1) Multi-family dwellings include condominiums, townhouses, apartments, hotels and motels.
- 2) Other major structures include commercial buildings (restaurants, stores, beach bars, etc.), recreational buildings and non-habitable major structures (i.e., piers, pools, pavilions and parking lots).
- 3) 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, structures located inland of the coastal building zone, or structures with hydrostatic flooding damage caused by the storm surge or storm water runoff.

Table 3. Summary of Coastal Armoring Damage Caused by Hurricane Irma.

County	Armoring Damage in Feet	
St. Johns	3,470	
Flagler	160	
Volusia	100	
Brevard	50	
Broward	60	
Collier	3,575	
Lee	30	
TOTAL	7,445 (1.4 miles)	

IV. Detailed Damage Assessment by County

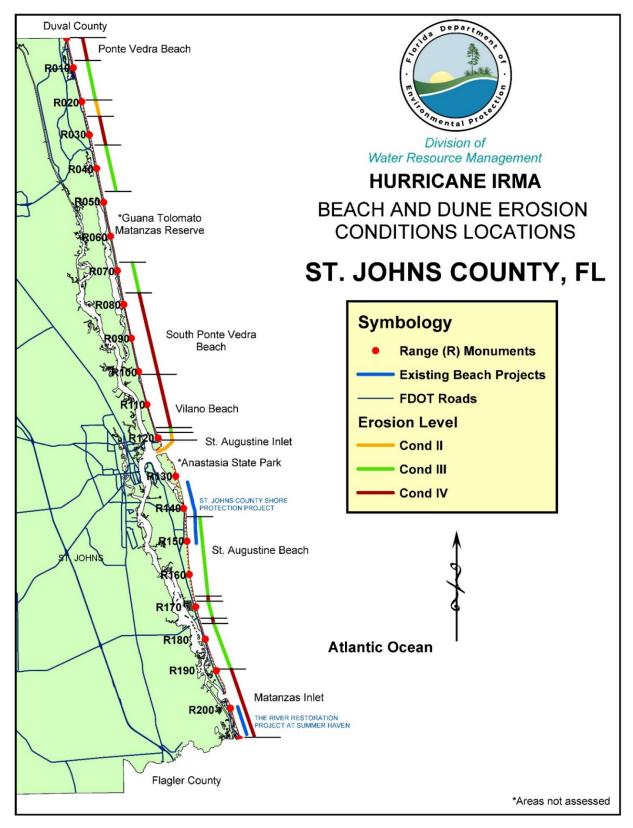


Figure 7. St. Johns County Beach and Dune Erosion Conditions from Hurricane Irma.

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 7**). St. Augustine Inlet between Vilano Beach and Conch Island has a federal navigation project, which likely experienced significant shoaling due to Hurricane Irma. Continued shoaling was also observed at Matanzas Inlet, between Anastasia Island and Summer Haven near the southern end of the county.

The net direction of longshore transport along the St. Johns County coast is generally to the south, with some drift reversals in the vicinity of the inlets. The northern coast of St. Johns County is characterized by moderate to high wave energy and relatively narrow, steep beaches. Anastasia Island to the south has relatively broad, gradually sloping beaches and large dynamic dune fields. At the southern end of the county, the Summer Haven beaches and dunes are a narrow strand between the Atlantic Ocean and the Matanzas River Lagoon (this segment of the Matanzas River is called the Summer Haven River by locals).

There are four critically eroded areas (15.3 miles) and one non-critically eroded area (0.5 mile) in St. Johns County. Near the center of the county north of St. Augustine Inlet is a critically eroded beach segment along South Ponte Vedra Beach and Vilano Beach (R76-R117; 8.1 miles), threatening private development as well as State Road AIA. South of St. Augustine Inlet, the northern 1.0 mile of Conch Island (R123-R128) is critically eroded, threatening beach mouse and shorebird nesting habitat. To the south, 3.8 miles of beach (R132-R152) along Conch Island and Anastasia Island through St. Augustine Beach are critically eroded, threatening development and recreational interests. Much of this area has a rock revetment, and inlet channel maintenance dredging disposal is being conducted. Beach restoration has been conducted in this area. The southern tip of Anastasia Island (R193.5-R196) has 0.5 mile of non-critical erosion north of Matanzas Inlet within the Fort Matanzas National Monument. The southern 2.4 miles of St. Johns County beaches (R197-R209) are critically eroded between Matanzas Inlet and the Flagler County line. The northern portion threatens State Road A1A and private development. Although the State Road A1A roadbed has been abandoned along the southern segment, wildlife habitat within the Matanzas River lagoon is being threatened with continued storm surge overwash and breaches. This area was recently restored by excavating overwash sediments from the river.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Irma in St. Johns County generally ranged between six and seven feet above sea level. USGS measured a storm surge in the southern portion of St. Johns County near Matanzas Inlet to be +7.6 feet NAVD. The St. Johns County coast was substantially impacted by Hurricane Matthew in October 2016, with major beach and dune erosion (Condition IV), and only minor natural recovery of the beach had taken place during the eleven months before Hurricane Irma. Irma's impact along the northern coast of St. John's County (R1-R118) north of St. Augustine Inlet was particularly severe, resulting in 115 buildings being left in imminent danger from another major storm (**Figures 8 and 9**).

South of St. Augustine Inlet, beach conditions have yet to be assessed along Anastasia Island State Park (R123-R140). Along the developed segment of Anastasia Island (R140-R193), including St. Augustine Beach, Crescent Beach, and Matanzas Shores, the island sustained moderate to major beach and dune erosion (condition III to IV). Major beach and dune erosion (Condition IV) was sustained along Matanzas Inlet National Monument (R194-R196) at the southern end of Anastasia Island north of Matanzas Inlet.

South of Matanzas Inlet (R197-R209), the beach community of Summer Haven sustained major beach and dune erosion (Condition IV). Hurricane Matthew's impact on Summer Haven in October 2016 was the most severe since Hurricane Dora in 1964, resulting in the federal revetment and old A1A being destroyed along with eight houses. Hurricane Matthew also caused a major tidal breach across the barrier near R204, which needed to be closed in an emergency project after the storm. Subsequent to Hurricane Matthew, a beach and river restoration project took place, which involved dredging overwash sand from the Matanzas River and constructing a barrier dune and nourished beach berm for roughly 5,000 feet between R200 and R205. Irma's impact was substantially less than Matthew's, as little damage was incurred to the revetment and old A1A between R197 and R200; however, roughly 90 percent of the fill from the beach and river restoration project appeared to have been lost from the fill template between R200 and R205. Part of this material was transported seaward, and part of the placement material was spread back into the river as overwash deposits. Low depressions in the barrier existed after Irma's passage, prompting emergency remedial fill placement to prevent a tidal breach from developing like the breach caused by Hurricane Matthew.

Storm Damage

Hurricane Irma caused roughly twice the coastal building damage in St. Johns County as was sustained during Hurricane Matthew. Matthew caused major structural damage to 86 major structures, whereas, Irma caused major damage to 171 major structures, including 15 that were destroyed. Ten single-family dwellings were destroyed by the storm surge, waves, and erosion in northern St. Johns County (Ponte Vedra, South Ponte Vedra, and Vilano Beach), and one single-family dwelling and four multi-family dwellings were destroyed by winds in southern St. Johns County (Anastasia Island) (**Figures 10 and 11**).

Less than half as much armoring damage was sustained from Irma as compared to Matthew. Matthew damaged or destroyed 7,690 feet of seawalls and revetments, whereas Irma damaged or destroyed 3,470 feet of seawalls and revetments (**Figure 12**). Some walls of lesser design strength were destroyed, and some walls were compromised when their return walls were flanked. Wall age was not an issue as most of the walls in northern St. Johns County are less than five years old.

Along with the erosion, storm surge, waves, and hurricane wind gusts, another major factor affected southern Anastasia Island at Matanzas Shores at a development that was well planned and reasonably well designed for the coastal environment. A tornado or suite of tornados made landfall in a major rain band, causing severe damage that resulted in four condominiums being destroyed and five condominium buildings, eight single-family dwellings, and a storage building sustaining major damage (**Figure 13**).



Figure 8. Major dune erosion threatening structure, Ponte Vedra.



Figure 9. Major dune erosion threatening structure, Ponte Vedra.



Figure 10. Single-family dwelling destroyed, Vilano Beach.



Figure 11. Single-family dwelling destroyed, South Ponte Vedra.



Figure 12. Seawall failure and single-family dwelling destroyed, South Ponte Vedra.



Figure 13. One of four condominiums destroyed by rain band tornado, Matanzas Shores.

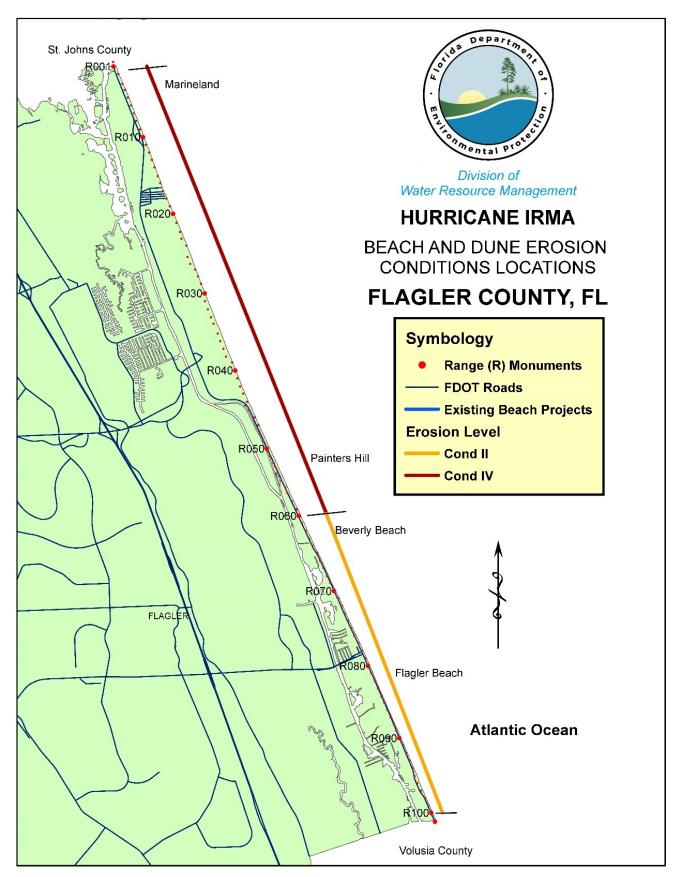


Figure 14. Flagler County Beach and Dune Erosion Conditions from Hurricane Irma.

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, Palm Coast, Hammock Dunes, Painters Hill, Beverly Beach, Flagler Beach, and Gamble Rogers State Park (**Figure 14**). There are no inlets in Flagler County.

The net direction of longshore transport along the Flagler County coast is generally to the south. The northern Flagler County coast is characterized by moderate to high wave energy and relatively narrow, steep beaches fronted by exposed Anastasia rock formations. The beach sediments of Flagler County are unique because of the presence of orange-colored, coquina shell fragments mixed with the quartz sand. The dune ridge along Washington Oaks State Park (R11-R16) is very low, due to the smaller fraction of fine grained silicate sediment that would facilitate the natural development of dunes through aeolian sediment transport. To the south, with less rock exposure and a greater percentage of silicate sediment on the beach berm, a higher dune ridge exists.

There are five critically eroded areas (6.5 miles) in Flagler County. Erosion at the northern 0.6 mile of beach (R1-R4) is threatening development and recreational interests at Marineland. This area has a rock revetment and coquina rock groins. Following storm damage by Hurricane Floyd in 1999, the revetment was restored and a new revetment constructed to the south at a more landward alignment with dune restoration. Following the impact of Hurricane Matthew in 2016, a 1.1-mile segment of Painters Hill (R50-R57) is critically eroded threatening development. A 0.9-mile segment of erosion at the northern Flagler Beach city limits (R65.2-R70) and 3.3 miles of erosion along southern Flagler Beach (R76-R94.8) threaten State Road AIA. Much of this southern area has a rock revetment. Following the impact of Hurricane Matthew in 2016, the southernmost 0.6 mile of Flagler Beach was added as critically eroded, threatening State Road AIA between R98 and the southern county line.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Irma in Flagler County generally ranged between six and seven feet above sea level. USGS measured a storm surge in southern St. Johns County near Matanzas Inlet to be +7.6 feet NAVD. The Flagler County coast was substantially impacted by Hurricane Matthew in October 2016, with major beach and dune erosion (Condition IV), and only minor recovery had taken place during the eleven months before Hurricane Irma. Irma's impact along the northern coast of Flagler County (R1-R60) north of Beverly Beach was particularly severe, resulting in 33 buildings being left in imminent danger from another major storm (**Figures 15**).

During Matthew, storm surge and waves overtopped the dunes and caused inland flooding along most of northern Flagler County, and a major dune breach occurred at Washington Oaks State Park. This breach was subsequently filled in, and a barrier dune was constructed along the park shore to prevent further overtopping. However, Hurricane Irma eroded all the constructed dune, and caused another dune breach to occur at the same location (**Figure 16**).

South of Beverly Beach, including Flagler Beach, the beach and dune erosion was not as severe as it was following Matthew. Minor beach and dune erosion was sustained along southern Flagler County (R60-R100) between Beverly Beach and Gamble Rogers State Park.

Storm Damage

Hurricane Irma caused roughly three times the coastal building damage in Flagler County as was sustained during Hurricane Matthew. Matthew caused major structural damage to 21 major structures, whereas, Irma caused major damage to 78 major structures. But Matthew destroyed 8,286 feet of coastal armoring, including a mile and one-half of boulder rock revetment in Flagler Beach, whereas, Irma only damaged 160 feet of two walls in northern Flagler County. None of the revetment fronting State Road A1A was damaged by Irma. Likewise, Matthew destroyed or damaged 3,350 feet of State Road A1A, but Irma caused no further road damage.



Figure 15. Single-family dwellings threatened along Painter's Hill.



Figure 16. Dune breach by storm surge of Irma, Washington Oaks State Park.

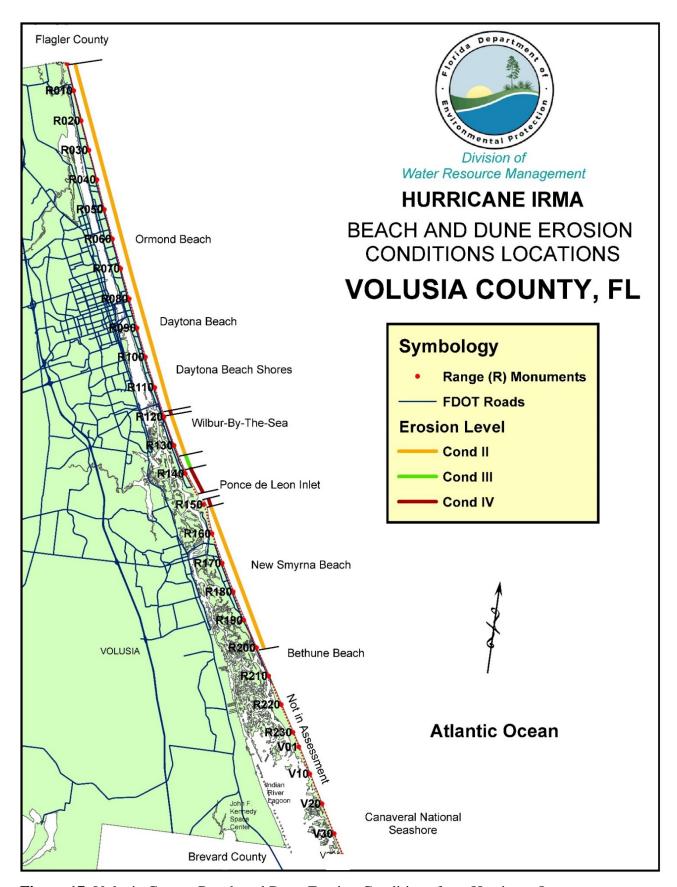


Figure 17. Volusia County Beach and Dune Erosion Conditions from Hurricane Irma.

Volusia County

Volusia County, the southernmost of the five northeast Florida coastal counties, 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 County Park, New Smyrna Beach, Bethune Beach, and Cape Canaveral National Seashore (**Figure 17**). Ponce de Leon Inlet between the northern and southern peninsulas of Volusia County has a federal navigation project, which experienced significant shoaling due to Hurricane Irma.

There are three critically eroded beach areas (21.0 miles), one non-critically eroded beach area (1.1 miles), and one critically eroded inlet shoreline area (0.6 mile) in Volusia County. Following the impact of Hurricane Matthew in 2016, a 1.6-mile segment (R24-R33) of northern Volusia County is critically eroded threatening State Road A1A. An 11-mile segment of beach (R57-R118) along Ormond Beach, Daytona Beach, and Daytona Beach Shores is critically eroded, threatening development and recreational interests, as well as sea turtle nesting areas where the dry sand beach has become very narrow. Most of this segment is armored with seawalls. The northern shoreline (0.6-mile) of Ponce de Leon Inlet is critically eroded, and threatens recreational interests at the county park. The 8.4 miles of beaches (R160.8-R207.8) south of Ponce de Leon Inlet within New Smyrna Beach and Bethune Beach are critically eroded. Private development and recreational interests are threatened, as well as sea turtle nesting habitat. Much of New Smyrna Beach is armored with seawalls, and much of Bethune Beach is protected by a boulder rock revetment. The New Smyrna Beach area has received inlet sand transfer material from maintenance dredging of the federal navigation channel within Ponce de Leon Inlet, and additional material from maintenance dredging of the Atlantic Intracoastal Waterway. A 1.1-mile segment of the Canaveral National Seashore (R207.8-R214) south of Bethune Beach is also noncritically eroded, without any threatened interests at this time.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Irma in Volusia County generally ranged between six and seven feet above sea level. USGS measured a storm surge in northern Volusia County to be +6.7 feet NAVD and in southern Volusia County to be +6.2 feet NAVD (see **Figure 4**). The Volusia County coast was substantially impacted by Hurricane Matthew in October 2016, with major beach and dune erosion (Condition IV); however, substantial natural recovery had since taken place as normal wave conditions returned sand to the beach from the nearshore waters. This substantial recovery during the eleven

months prior to Irma's impact made a positive difference in the beach conditions following the impact of Irma. Irma's impact along most of the northern peninsula of Volusia County (R1-R135) was minor beach and dune erosion (Condition II). Closer to Ponce de Leon Inlet, the conditions transitioned from moderate beach and dune erosion (Condition III) between R135 and R139, to major beach and dune erosion (Condition IV) between R139 and R148 at the north jetty (**Figure 18**).

Immediately south of Ponce de Leon Inlet was a half mile of major beach and dune erosion (Condition IV) between R149 and R151.5. The northward transport of the storm surge south of the southern jetty carried substantial overwash sediment into Ponce de Leon Inlet (**Figure 19**). This was a problem during Matthew and continued to be a major problem during Irma. The remainder of the southern peninsula of Volusia County sustained only minor beach and dune erosion (Condition II) between R152 and R202 at Bethune Beach. Beach conditions southward along Cape Canaveral National Seashore are not currently available.

Storm Damage

Hurricane Irma caused slightly more coastal building damage in Volusia County than was sustained during Hurricane Matthew. Matthew caused major structural damage to 75 major structures, whereas Irma caused major damage to 106 major structures. Conversely, Matthew destroyed 3,820 feet of coastal armoring, whereas, Irma only damaged 100 feet of one rock revetment in Volusia County. Much of the major damage due to Irma in Volusia County was due to winds (**Figure 20**). At Ponce de Leon Inlet, 225 feet of major damage was sustained on the granite boulder mound north jetty (**Figure 21**). The damage location was adjacent to the beach at the shoreward end of the structure. The boardwalk providing access to the jetty was also substantially damaged.



Figure 18. Major beach and dune erosion, Town of Ponce Inlet.



Figure 19. South jetty breach and overwash into Ponce de Leon Inlet.



Figure 20. Wind damage to condominium, Ormond Beach.



Figure 21. Major damage to north jetty and boardwalk at Ponce de Leon Inlet.

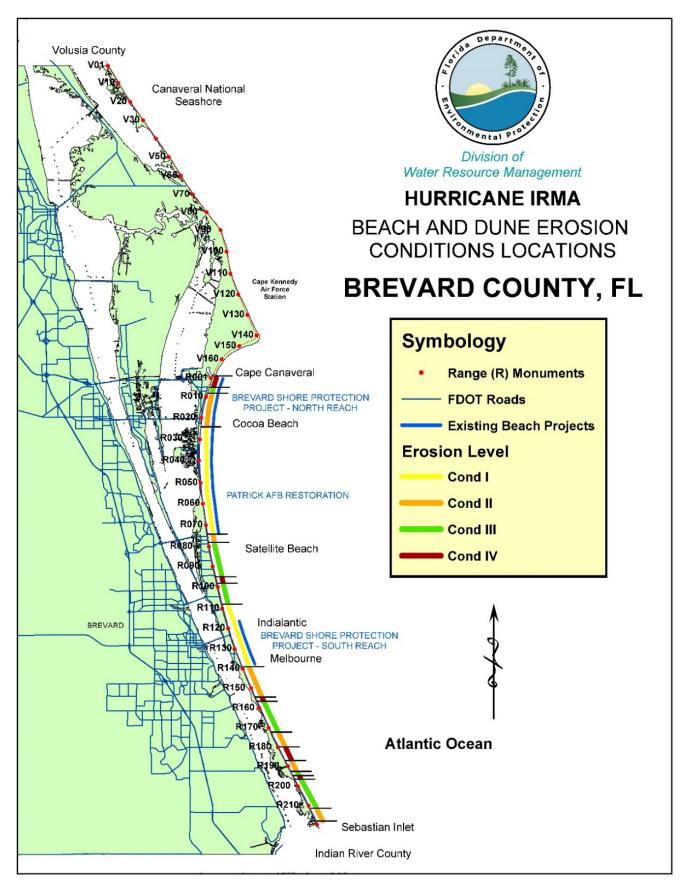


Figure 22. Brevard County Beach and Dune Erosion Conditions from Hurricane Irma.

Brevard County

The longest of the central Atlantic coast counties, Brevard County extends for 71.6 miles between Volusia and Indian River Counties (**Figure 22**). Coastal Brevard County includes the following communities and parks: Canaveral National Seashore, Kennedy Space Center, Cape Canaveral Air Force Station, Port Canaveral Jetty Park, 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. Port Canaveral Inlet, between Cape Canaveral Air Force Station and the City of Cape Canaveral, has a federal navigation project, which likely experienced significant shoaling due to Hurricane Irma; however, the port reopened to vessel traffic two weeks after Hurricane Irma, indicating shoaling had not disrupted the inlet's navigability as it did following Hurricane Frances in 2004. Continued shoaling was also apparent at Sebastian Inlet at the southern end of the county.

The net direction of longshore transport along the Brevard County coast is generally to the south. Most of the Brevard County coast is characterized by moderate to high wave energy and relatively narrow, steep beaches, except along the two federal shore protection projects at Canaveral-Cocoa Beach and Indialantic-Melbourne Beach, where the beaches are substantially wider with a more dynamic dune field.

There are two critically eroded areas (41.2 miles) and two non-critically eroded areas (12.1 miles) in Brevard County. Two areas along the Canaveral National Seashore (V320-V365 and V417-V436) are non-critically eroded. Both areas are located north of Cape Canaveral. A 4.7-mile segment along Kennedy Space Center (V365-V390) is critically eroded, threatening manned spacecraft facilities, launch pads, Phillips Parkway and buried infrastructure. From Port Canaveral Inlet extending 36.5 miles to the south is a long coastal segment (R1-R202) designated as critically eroded. Development, recreational interests, and wildlife habitat are threatened. Beach restoration projects have been conducted in the City of Cape Canaveral, Cocoa Beach, Patrick Air Force Base, Indialantic, and Melbourne Beach. Local dune restoration projects have been conducted along various shoreline segments in southern Brevard County.

Storm Effects and Erosion Conditions

The storm surge of Hurricane Irma in Brevard County generally ranged between five to six feet above sea level. USGS measured a storm surge in Port Canaveral to be +5.1 feet NAVD (see Figure 4).

Observations of erosion conditions from Irma, as well as observations of southern Brevard County

beaches during the offshore passage of Hurricane Maria on September 23 and 24, indicated that the wave uprush above the still-water storm surge elevation likely exceeded the measured storm surge by two or more feet creating a higher storm tide. The Brevard County coast was substantially impacted by Hurricane Matthew in October 2016 with major beach and dune erosion (Condition IV). Some natural beach recovery had taken place during the eleven months before Hurricane Irma, and the county conducted dune restoration projects along much of the southern Brevard beaches, where at least 65 buildings were threatened.

Beach conditions along the northern half of Brevard County north of Port Canaveral are not currently available. Immediately south of Port Canaveral Inlet (R1-R5), major beach and dune erosion was sustained during Hurricane Irma (Figure 23). Brevard County staff measured as much as approximately 40 feet of dune recession in this area. Throughout the remainder of the northern reach of the federal shore protection project (R5-R55), minor beach and dune erosion prevailed (Condition I to II). Along the beach restoration project at Patrick Air Force Base (R56-R75), minor beach erosion (Condition I) was observed. The mid-reach of the federal shore protection project has not yet been constructed for Satellite Beach and Indian Harbour Beach, and generally moderate beach and dune erosion (Condition III) was sustained, with some minor and some major dune erosion in isolated segments. In Indian Harbour Beach, there is a historic hot spot of erosion along Shell Street (R97-R99), which sustained major beach and dune erosion (Condition IV) (Figure 24). Along the southern reach of the federal shore protection project in Indialantic and Melbourne Beach (R110-R142), conditions varied between minor beach erosion (Condition I) and minor beach and dune erosion (Condition II). Along the southern Brevard County beaches (R143-R213), where substantial natural and assisted recovery had taken place, the beach conditions varied after Irma from minor beach and dune erosion (Condition II) to major beach and dune erosion (Condition IV) (Figure 25). Brevard County staff is currently calculating the volume losses from the dune restoration projects in this area. At the southern end of the county, along Sebastian Inlet State Park, minor beach and dune erosion (Condition II) was sustained.

Storm Damage

Hurricane Irma caused substantially more coastal building damage in Brevard County than was sustained during Hurricane Matthew. Matthew caused major damage to three major structures, whereas Irma caused major damage to 217 major structures. Damage to coastal buildings in Brevard County has only been exceeded by Hurricane Frances (256 buildings) and Hurricane Jeanne (346 buildings) in 2004. It is noteworthy that while Frances and Jeanne damaged buildings in Brevard County by the storm

surge, waves, erosion and wind loads, Irma only caused major building damage by its wind loads. Multiple tornadoes were also sighted, and pockets of damage clearly suggest tornadoes were carried cross-shore in the major rain bands of Irma.

At the northern end of Indialantic, tornado damage was observed where the entire roof of a condominium building was blown off, with a major section being transported over 600 feet across A1A and over a bank building onto a single-family dwelling (**Figure 26**). A total of 12 buildings, including six single-family dwellings, two condominium buildings, two commercial buildings, and a motel were damaged along a linear east-to-west path of tornado damage. Another tornado was also most likely the cause of damage to a beach-front high-rise hotel in Cocoa Beach, where major damage to the second, third, fourth, and fifth floors was observed (**Figure 27**). Severe wind damage was also sustained at beach front condominium buildings, where entire roofs blew off adjacent to the Pineda Causeway south of Patrick Air Force Base, and at Fifth Avenue in Melbourne Beach.

Storm surge and wave damage were observed at Jetty Park at Port Canaveral Inlet, where 850 feet of the inner railing of the fishing pier was destroyed along the segment parallel to the southern jetty. Major damage was also sustained to a 50-foot pier segment normal to the jetty where the concrete deck slabs were separated (**Figure 28**).



Figure 23. Major dune erosion at Jetty Park near R1 at Port Canaveral.



Figure 24. Major dune erosion at Shell Street, Indian Harbour Beach.



Figure 25. Major dune erosion, southern Brevard County.



Figure 26. Condominium roof section blown across A1A onto single-family dwelling by tornado in Indialantic.



Figure 27. Hotel severely damaged by an apparent tornado, Cocoa Beach.



Figure 28. Jetty Park fishing pier damage where concrete deck slabs were separated.

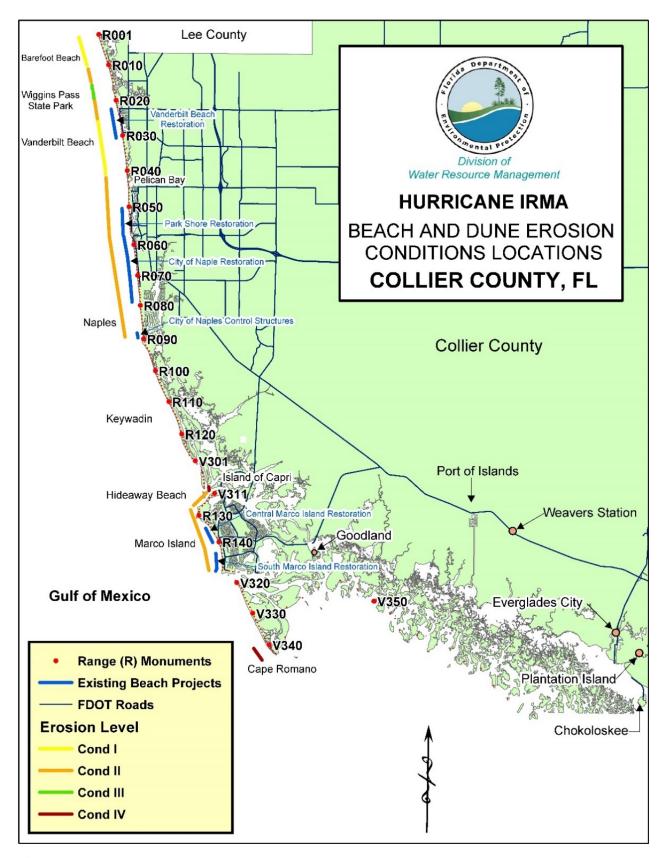


Figure 29. Collier County Beach and Dune Erosion Conditions from Hurricane Irma.

Collier County

Collier County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 29**), and has 34.1 miles of beaches extending southward from Lee County to the southwest tip of Cape Romano. Scattered small beaches also exist intermittently east-southeast of Cape Romano within the Ten Thousand Islands region. Coastal Collier County includes the following beach communities and major parks: Lowdermilk Park, Barefoot Beach County Park, Delnor-Wiggins Pass State Park, Vanderbilt Beach, Park Shore, Naples, Keewaydin Island, Sea Oat Island, Isle of Capris, Hideaway Beach, Marco Island, Kice Island, Morgan Island, Cape Romano, Goodland, Weavers Station, Everglades City, Plantation Key, and Chokoloskee. The net direction of longshore transport along the Collier County coast is generally to the south, with some drift reversals in the vicinity of inlets. This coast is characterized by low to moderate wave energy (Tanner, 1960), and narrow, relatively steep beaches – with the exception of Marco Island, which has a very wide, flat beach.

The segment of coast comprising the northern 16.5 miles of Collier County's beaches (R1-R89) is similar to a mainland coast. The tidal bays backing the coastal barriers lose their continuity south of Wiggins Pass (R16), and to the south is a line of small, discontinuous "back beach" water bodies and dredged channels (Balsillie and Clark, 1992). There are four coastal inlets along northern Collier County, including from north to south, Wiggins Pass, Clam Pass, Doctors Pass, and Gordon Pass. To the south of Gordon Pass (R89), the coast is characterized by seven gulf fronting barrier islands: Keewaydin Island, Sea Oat Island, Isle of Capri, Marco Island, Kice Island, Morgan Island, and Cape Romano. These Collier County barriers are separated by five coastal inlets, including Little Marco Pass, Capri Pass, Big Marco Pass, Caxambas Pass, and Blind Pass. There are also two unnamed inlets that bisect Morgan Island, as well as Morgan Pass between Morgan Island and Cape Romano. In southern Collier County, east-southeast of Cape Romano, are the northern approximately 12 miles of the Ten Thousand Islands. The gulf fronting islands of this large group of mostly mangrove forested islands are the result of vermetid reefs that have trapped both silicate and carbonate sands that have been transported across Gullivan Bay from shoals south of Cape Romano (Shier, 1969). The islands of this group within Collier County that have significant beaches include: Turtle Key, Gullivan Key, White Horse Key, Panther Key, and Round Key.

Prior to the 2017 hurricane season, there were eight critically eroded beach areas (14.8 miles), three non-critically eroded beach areas (5.1 miles), and one critically eroded inlet shoreline area (0.8 mile) in Collier County. In northern Collier County, a 0.4-mile segment of critical erosion exists north of

Wiggins Pass threatening sea turtle and gopher tortoise habitat. A 1.6-mile beach segment (R22.3-R30.5) is critically eroded threatening development interests in Vanderbilt Beach. This area is substantially armored with seawalls and has a beach restoration project. The City of Naples has two segments that are critically eroded, threatening development interests north and south of Doctors Pass. North of Doctors Pass (R45-R57.5) is a 2.4-mile critically eroded segment with the northern 1.1 mile included for the design integrity of the beach restoration project. Between Doctors Pass and Gordon Pass (R57.8-R89) is a 5.6-mile critically eroded segment. Most of Naples is armored with bulkheads, seawalls, and revetments, and these two critically eroded segments have a continuous beach restoration project.

South of Gordon Pass (R90-R111) is a 3.9-mile stretch that is non-critically eroded along the northern half of Keewaydin Island. Between Little Marco Pass and Capri Pass, Sea Oat Island has 0.9 mile of beach that is non-critically eroded. Marco Island has three areas that are critically eroded, threatening development interests. Along Hideaway Beach, the northern shore of Marco Island (H3-H11) fronting on Big Marco Pass has 0.8 mile of inlet shoreline that is critically eroded. The central gulf beach of Marco Island (R134.5R139) has 0.8 mile that is critically eroded, and the southern stretch of beach (R143-R148) has 0.9 mile that is critically eroded. All three critically eroded areas on Marco Island have beach restoration projects, and the northern segment also has a rock groin field along Hideaway Beach. Erosion on the two southern barrier islands in Collier County has progressed into the backshore mangrove forest, resulting in the loss of beach wildlife habitat. Following Hurricane Wilma (2005), a 1.6-mile segment of Kice Island (V23-V31.4) is critically eroded. South of Morgan Pass, Morgan Island has a 1.5-mile segment (V33.8-V41.8) that is critically eroded and a 0.3-mile segment (V41.8-V43.5) that is non-critically eroded.

Storm Effects and Erosion Conditions

Hurricane Irma made landfall on Sunday, September 10 at 3:35 p.m. EDT, with the geographic center of the eye crossing Marco Island on a northerly track. Irma's Category Three intensity winds and storm surge primarily impacted the Ten Thousand Islands region of Collier County. A wind gust of 130 mph was reported on Marco Island, and a peak gust of 142 mph was reported at the Naples Municipal Airport. The highest storm surge for Irma in Collier County, and probably in the State of Florida, has not yet been measured or estimated, but would have occurred in the Ten Thousand Islands region. On the weak side, or western side of the eye, the highest storm surge likely occurred on Marco Island. The surge elevation has not yet been surveyed; however, it is estimated to be about 6 feet above mean sea

level. Further north at Naples, a measured peak water level was obtained at the Naples Fishing Pier to be +4.7 feet NAVD (see **Figure 5**).

Irma caused major beach and dune erosion (Condition IV) at Cape Romano. Along Marco Island (R128-R148), the beach is wide and flat, with a low-profile dune fronting the upland. The minor erosion of the dune represented Condition II erosion; however, given the significance of the one to two feet of beach profile lowering across the beach berm, the beach erosion would be best described as Condition IV. The northern end of Marco Island sustained significant erosion resulting in mangrove being overtaken by the shoreline recession (**Figure 30**). Along the northern shore of Marco Island is a segment of beach called Hideaway Beach. This segment, which is stabilized by a T-groin field, sustained minor beach and dune erosion (condition II) (**Figure 31**). Erosion conditions are not currently available for the seven miles of beach on Keewaydin Island. Along Naples' beaches (R42-R89) and Vanderbilt Beach (R23-R35), minor beach and dune erosion (Condition II) was sustained.

At Wiggins Pass State Park, minor to major beach and dune erosion (Condition II to IV) was sustained, with the erosion becoming more severe within 2,000 feet of Wiggins Pass (**Figure 32**). North of Wiggins Pass, along Barefoot Beach County Park, minor to major beach and dune erosion (Condition II to IV) was sustained, with the erosion becoming more severe nearest to the inlet (**Figure 33**). Major erosion was also sustained along both the northern and southern shorelines of Wiggins Pass. Substantial shoaling is apparent at Wiggins Pass, as erosion off the adjacent beaches have developed large spits of sand on both sides of the entrance.

Storm Damage

Other than that sustained in the Florida Keys, Florida's worst coastal damage was experienced in five small coastal communities east-southeast of Marco Island. NOAA aerial photography permitted an inventory of the major damage to these communities. The major damage in these communities was due to the storm surge, waves, and high winds. Chokoloskee sustained major damage to 30 buildings, including at least three that were destroyed. Plantation Key sustained major damage to 43 buildings, including at least seven that were destroyed. Everglades City sustained major damage to 57 buildings, including at least eight that were destroyed. Port of Islands sustained major damage to 14 buildings, and Goodland sustained major damage to 68 buildings including seven that were destroyed.

There were no major structures on Marco Island destroyed; however, three multi-family dwellings along South Collier Boulevard (each a high-rise condominium building) sustained major roof damage due to the hurricane force winds. At the southern end of Marco Island, fronting on Caxambas Pass and the Gulf

of Mexico, 3,000 feet of boulder lime-rock revetment sustained minor damage (**Figure 34**). Numerous large armor stone boulders were displaced landward over the seawall cap. Landward of the seawall, many small apron rocks, with an approximate average diameter of one foot, were scattered landward across the upland. Fronting this revetment, at the southern end of the Marco Island beach, a 200-foot boulder mound terminal groin sustained minor damage consisting of displaced boulders. Offshore from the terminal groin, three detached boulder mound breakwaters sustained minor damage consisting of displaced boulders; however, the extent of the damage cannot be determined until a detailed survey is conducted by Collier County. At the northern end of Marco Island along Hideaway Beach, five of the boulder mound T-groins sustained minor damage consisting of displaced boulders. To the east of Hideaway Beach at the Ville de Marco West complex, 250 feet of concrete seawall was destroyed, and a condominium building was undermined (**Figure 35**). Another condominium building on the Isle of Capri, across Big Marco Pass from Marco Island, sustained major roof damage. Along the seven miles of shoreline on Keewaydin Island north of Marco Island, three single-family dwellings sustained major roof damage.

Most of the damage along the coast of the City of Naples was due to the storm surge and waves, with a little wind damage. One single-family dwelling, one parking garage, and one multi-family dwelling sustained major wind damage. The multi-family dwelling also sustained understructure damage to three units from the storm surge. Three ocean outfall pipes and the Naples Fishing Pier also sustained major damage due to the storm waves. In southern Naples, four timber groins also sustained major damage due to the storm waves, and a 125-foot long vertical concrete seawall sustained minor damage.



Figure 30. North Marco Island erosion.



Figure 31. T-groin field along Hideaway Beach.

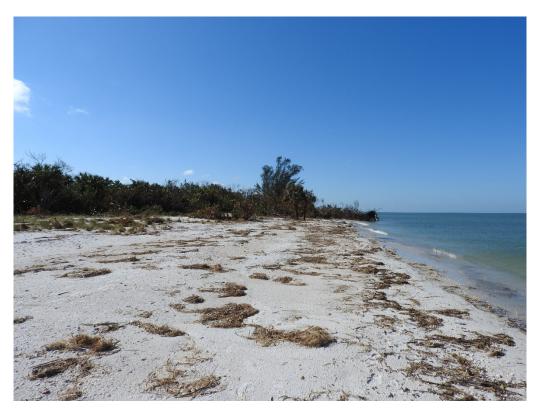


Figure 32. Major beach and dune erosion south of Wiggins Pass looking south.



Figure 33. Major beach and dune erosion north of Wiggins Pass looking south.

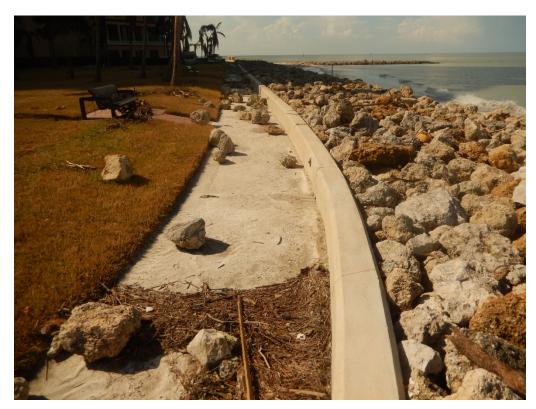


Figure 34. South Marco Island revetment damage.

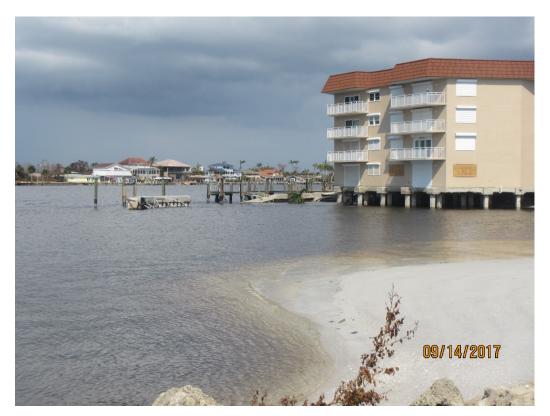


Figure 35. Seawall destroyed in Big Marco Pass.

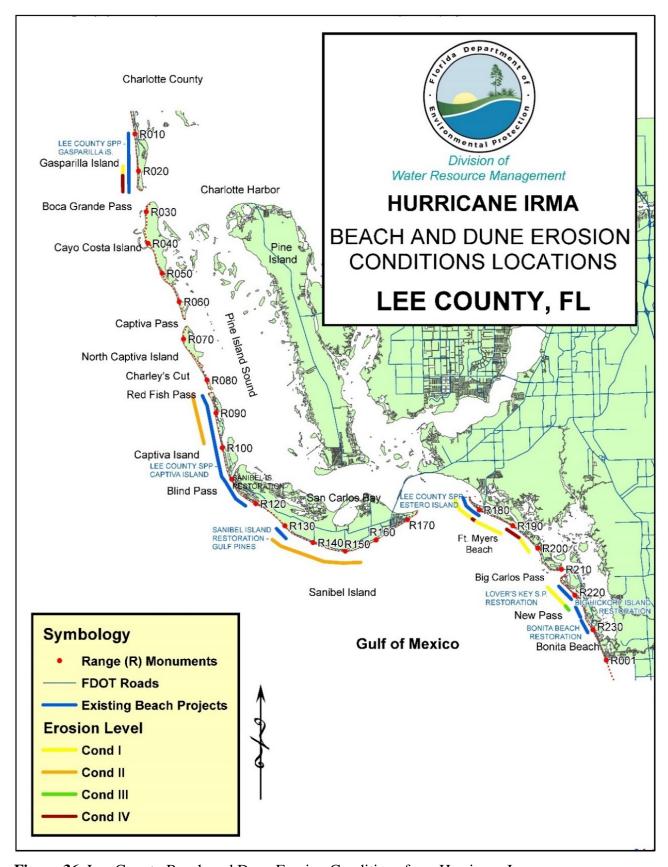


Figure 36. Lee County Beach and Dune Erosion Conditions from Hurricane Irma.

Lee County

Lee County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 36**), and has 47.3 miles of beaches extending southward from Charlotte County to Collier County. The coast of Lee County includes most of Gasparilla Island, Cayo Costa Island, North Captiva Island, Captiva Island, Sanibel Island, Estero Island, Lovers Key, Big Hickory Island, and Bonita Beach on Little Hickory Island. Lee County has eight coast inlets including Boca Grande Pass, Captiva Pass, Redfish Pass, Blind Pass, San Carlos Bay Entrance, Big Carlos Pass, New Pass, and Big Hickory Pass.

There are eleven critically eroded beach areas (22.4 miles), four non-critically eroded beach areas (5.3 miles), three critically eroded inlet shoreline areas (0.6 mile), and two non-critically eroded inlet shoreline areas (0.4 mile) in Lee County. The southern 4.0 miles of Gasparilla Island (R7-R26.7) is critically eroded, threatening development and recreational interests in the town of Boca Grande and the Gasparilla Island State Park. Much of this area has bulkheads, and inlet sand transfer has been conducted using Boca Grande Pass dredge material. The northern shoreline of Boca Grande Pass within the Gasparilla Island State Park (0.2 mile) is also critically eroded.

Three areas on Cayo Costa Island are non-critically eroded. The northern segment (R27-R33) extends for 1.1 miles, the central segment (R46-R52) extends for 1.2 miles, and the southern segment (R60-R65) extends for 1.0 mile. All of North Captiva Island is eroded. The northern shore fronting on Captiva Pass (R66, east 1000 feet) has critical inlet shoreline erosion threatening development interests. The northern 1.0-mile of gulf beach (R66-R71) is critically eroded threatening development interests, and from R71through R78 is 2.0 miles of non-critical erosion. The southern 0.8 mile of North Captiva Island extending into Redfish Pass (R79-R82.3) is critically eroded, threatening development and wildlife habitat. All of Captiva Island is critically eroded. The southern shore of Redfish Pass (R83-R84) has 0.2 mile of critically eroded inlet shoreline. This shoreline has a rock revetment with a terminal groin. The gulf beach from R84 through R109 has five miles that is critically eroded. This entire island segment is a beach restoration project.

The northern Sanibel Island beach (R109-R118) is critically eroded, extending 1.7 miles south of Blind Pass where the road, development, recreation, and wildlife habitat are threatened. Part of this segment received nourishment from the Captiva Island beach restoration project. Another segment (R129-R133) on northern Sanibel Island has 0.9 mile that is critically eroded, threatening development interests. This segment, in the neighborhoods of Gulf Shores and Gulf Pines, has a beach restoration project.

Ft. Myers Beach on Estero Island from R175 (-.4) to R200, has 5.0 miles that are critically eroded, threatening development and recreational interests. This entire segment is a beach restoration project. A 0.8-mile southern segment of Estero Island (R203-R207) is also critically eroded along the Little Estero Island Critical Wildlife Area. The northern shore of Lover's Key (R211-R213) fronting on Big Carlos Pass has 0.3 mile that is non-critically eroded. Most of the gulf beach extending from R214 to R222 has 1.5 miles that are critically eroded, threatening recreational interests and wildlife habitat in Lover's Key State Park. A beach restoration project was constructed in 2004. The southern shore of Lover's Key (R222) fronting on New Pass also has 0.1 mile of non-critically eroded inlet shoreline.

Between New Pass and Big Hickory Pass, Big Hickory Island (R222.7-R225.9) has 0.8 mile that is critically eroded, where wildlife habitat and recreation has been lost. South of Big Hickory Pass, Little Hickory Island (R226-R230) has 0.9 mile of critically eroded beach, threatening development interests in Bonita Beach. This area has a beach restoration project with bulkheads and two terminal groins at the northern end.

Storm Effects and Erosion Conditions

Coastal Lee County sustained greater impacts than the southwestern Florida counties to the north, but generally less than Collier County to the south. Most of Gasparilla Island sustained no observable erosion (R1-R17) or minor beach erosion (R18-R21). However, at Gasparilla Island State Park (R22-R26), major beach and dune erosion was sustained (Condition IV) (**Figure 37**). Beach conditions are not currently available for Cayo Costa Island (R27-R65) and North Captiva Island (R66-R83).

Most of Captiva Island (R84-R98) and the central third of Sanibel Island (R131-R154) sustained minor beach and dune erosion (Condition II) (**Figures 37** and **38**). Along Estero Island (R182-R199), generally minor beach erosion (Condition I) was observed, with the exception of a couple of hotspots adjacent coastal armoring (**Figures 39** and **40**). Likewise, minor beach erosion (Condition I) was observed along Lovers Key (R213-R221) (**Figure 41**), except for a hotspot at the southern end (R221-R222) where moderate beach and dune erosion was observed. Beach conditions are not currently available for Big Hickory Island. No erosion was observed along Bonita Beach at the southern end of Lee County.

Storm Damage

Six major structures in coastal Lee County sustained major damage, including one single-family dwelling, two multi-family dwellings, and three non-habitable major structures. Two bath houses at Lovers State Park sustained major wind damage to their roofs due to the skylights being blown out. One

of these bathhouses on the beach near R219 had additional interior rain damage. A parking garage structure collapsed in Ft. Myers Beach on Estero Island (**Figure 42**). In addition, approximately 30 feet of boulder rock revetment was damaged at Gasparilla State Park.



Figure 37. Erosion and damage to dune walkovers at the southern end of Gasparilla Island State Park, R26.



Figure 38. Captiva Island in South Seas Plantation development, R88.



Figure 39. Erosion at the southern end of Sanibel Island near R131.



Figure 40. Erosion at Ft. Myers Beach near R194.



Figure 41. Erosion at Ft. Myers Beach Pier near R180.



Figure 42. Minor erosion at the northern end of Lovers Key near R213.



Figure 43. Collapsed parking garage structure at Ft. Myers Beach near R201.

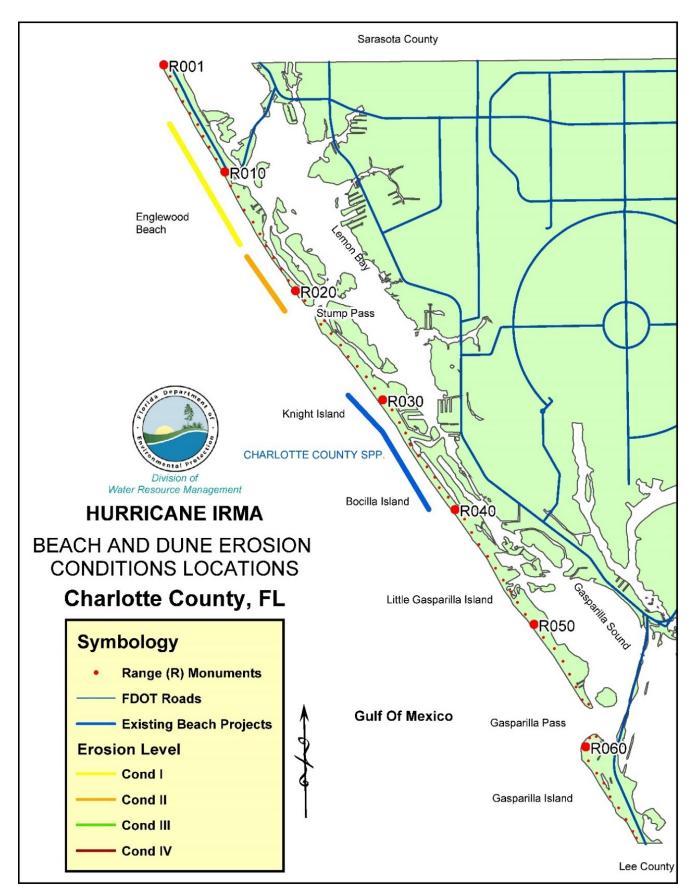


Figure 44. Charlotte County Beach and Dune Erosion Conditions from Hurricane Irma.

Charlotte County

Charlotte County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 44**), and has 12.2 miles of beaches extending southward from Sarasota County to Lee County. The coast of Charlotte County includes the southern half of Manasota Key, the Knight Island-Bocilla Island-Little Gasparilla Island barrier complex, and the northern mile and a half of Gasparilla Island. There are two natural inlets in Charlotte County: Stump Pass between Manasota Key and Knight Island, and Gasparilla Pass between Little Gasparilla Island and Gasparilla Island. Coastal Charlotte County includes the beach community of Englewood Beach and Stump Pass State Park.

There are three critically eroded areas (6.5 miles) and one critically eroded inlet shoreline (0.1 mile) in Charlotte County. The northern 3.8 miles of Charlotte County (R1-R21.2) along southern Manasota Key, including Englewood Beach and Stump Pass State Park, are critically eroded, threatening private development and public recreational interests. A few retaining walls and bulkheads exist north of Stump Pass State Park. The park is periodically nourished with Stump Pass maintenance dredge material. The southern inlet shoreline of Stump Pass (0.1 mile) is critically eroded, threatening residential development on Knight Island. Along Knight Island and Bocilla Island (R28-R40.5) are 2.3 miles of critically eroded beach, threatening private development. Beach restoration of this area has been conducted with Stump Pass dredge material. South of Little Gasparilla Pass, which is closed, is a 0.4-mile segment of critically eroded beach on Little Gasparilla Island. This erosion threatens private development.

Storm Effects and Erosion Conditions

Charlotte County was not significantly impacted by Hurricane Irma. The highest winds were directed substantially offshore until the storm's passage. Along nearly three miles of Manasota Key, minor beach erosion (Condition I) was observed (R1-R15). The southern mile of Manasota Key (R16-R21) sustained minor beach and dune erosion (Condition II) (**Figure 45**). Beach conditions are not currently available for the Knight Island-Bocilla Island-Little Gasparilla Island barrier complex (R22-R57). It was reported that a single-family home sustained major damage on Little Gasparilla Island. The northern end of Gasparilla Island within Charlotte County (R58-R68) sustained minor beach erosion (Condition I) (**Figure 46**).



Figure 45. Beach erosion at Stump Pass State Park near R16.



Figure 46. Beach erosion at the northern end of Gasparilla Island near R65.

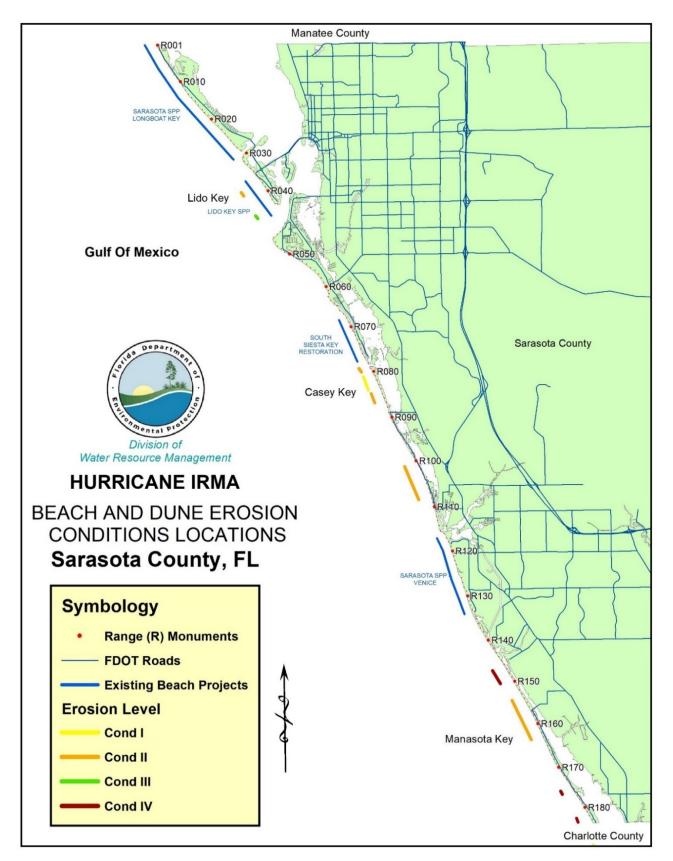


Figure 47. Sarasota County Beach and Dune Erosion Conditions from Hurricane Irma.

Sarasota County

Sarasota County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 46**), and has 34.7 miles of beaches extending southward from Manatee County to Charlotte County. The coast of Sarasota County includes the southern half of Longboat Key, Lido Key, Siesta Key, Casey Key, a mainland segment along Venice, and a northern segment of Manasota Key. Sarasota County has three inlets: New Pass between Longboat Key and Lido Key, Big Sarasota Pass between Lido Key and Siesta Key, and Venice Inlet between Casey and the City of Venice. Coastal Sarasota County includes the following beach communities: Town of Longboat Key, Lido Beach, City of Sarasota, and City of Venice.

There are eight designated critically eroded beach areas (24.2 miles), one non-critically eroded beach area (0.7 mile), and two critically eroded inlet shoreline areas (1.1 miles) in Sarasota County. The southern half of Longboat Key (R1-R29) between Manatee County and New Pass has 5.4 miles of critically eroded beach that has threatened development interests in the Town of Longboat Key. This area has a beach restoration project, and terminal groins exist at New Pass. The northern end of Lido Key fronting on New Pass is a critically eroded inlet shoreline area (R31, east 1500 feet) for 0.3 mile. Nearly all of Lido Key (R31-R44.5) has critically eroded beach that has threatened private development and recreational interests along 2.4 miles. Beach restoration has been conducted along the island and maintenance dredging material has been obtained from the federal navigation channel at New Pass. The southern shoreline of Big Sarasota Pass (R44A-R45) is critically eroded along 0.8 mile of Siesta Key. The threatened private properties along this inlet shoreline have bulkheads and rock revetments. At the northern end of Siesta Key south of Sarasota Point (R46-R48.4) is a critically eroded beach area that threatens private development and Beach Road. This 0.4-mile erosion area has rock revetments. Along the southern half of Siesta Key south of the Point of Rocks headland is a 2.4-mile long critically eroded beach area (R64-R77) that threatens private development. Some rock revetments exist in this area, and a beach restoration project has been constructed. Along the northern half of Casey Key (R81-R100.3) is a 3.7-mile long critically eroded beach area that threatens private development and the Casey Key Road. Much of this erosion area has rock revetments. Extending 5.1 miles south of Venice Inlet is a critically eroded beach segment (R116-R143) that has threatened development and recreational interests along the City of Venice, and to the south along a sewage treatment plant, Harbor Drive, and Caspersen Beach. This area has a beach restoration project, and numerous concrete bulkheads exist at the northern end of the City of Venice. To the south is a 0.7-mile segment of non-critical erosion (R143-R146.5) and a 0.3mile segment of critical erosion (R146.5-R148.3), threatening private development. The southern end of

Sarasota County (R160-R183.7) is critically eroded for 4.5 miles along Manasota Key, threatening private development as well as Manasota Key Road. Some rock revetments have been constructed in this area.

Storm Effects and Erosion Conditions

Sarasota County was not significantly impacted by Hurricane Irma. The highest winds were directed substantially offshore until the storm's passage, which was in a substantially weakened state. Where erosion was observed along the county's beaches, it was generally minor beach and dune erosion (Condition II). There was no discernable erosion along southern Longboat Key (R1-R37), Siesta Key (R45-R75), or portions of Casey Key (R92-R99), Venice (R108-R114), or Manasota Key (R176-R183). Moderate beach and dune erosion (Condition III) was observed at the southern end of Lido Key (R43-R44), and major beach and dune erosion was observed near the northern end of Manasota Key (R138-R149).

Storm Damage

A hotspot of erosion was observed near the southern end of Manasota Key (R175-R176), where more than 100 feet of the Manasota Key Road sustained major damage (**Figure 48**). Another hotspot of erosion was observed further south at R182, where a single-family dwelling is threatened (**Figure 49**).



Figure 48. Dune erosion that threatened Manasota Key Road near R175.



Figure 49. Dune erosion that threatened a residence near R182.

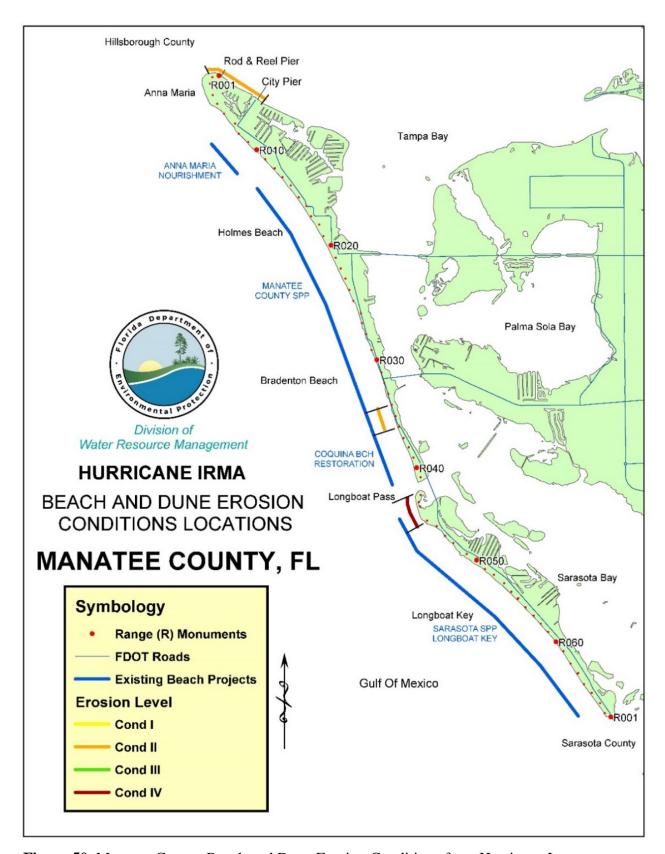


Figure 50. Manatee County Beach and Dune Erosion Conditions from Hurricane Irma.

Manatee County

Manatee County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 50**), and has 12.3 miles of beaches extending southward from Tampa Bay to Sarasota County. The coast of Manatee County includes all of Anna Maria Island and the northern half of Longboat Key. Coastal Manatee County includes the following beach communities and major parks: City of Anna Maria, Holmes Beach, Bradenton Beach, Coquina Beach Park, Cortez Beach Park, and the Town of Longboat Key. All of Manatee County is critically eroded. The full length of Anna Maria Island between the Rod and Reel Pier and Longboat Pass (R41.3) has 7.9 miles of critically eroded beach that has threatened development and recreational interests. This barrier island has a federal beach restoration project, and numerous bulkheads and revetments exist along the road and in front of private development. A groin field and terminal groin exist at the island's southern end. Between Longboat Pass and Sarasota County, the northern half of Longboat Key (R42-R67.3) has 4.8 miles of critically eroded beach that has threatened development and recreational interests. This barrier island has a beach restoration project, and numerous concrete bulkheads exist along the northern end fronting the private development.

Manatee County had three areas of erosion along its coastline from Hurricane Irma. The northern end of Anna Maria Island between R2 and the City Pier sustained minor beach and dune erosion (Condition II) due to the northeasterly winds of Irma (**Figure 51**). Major structural damage occurred to the City of Anna Maria Island's Pier from storm surge, wind and wave damage, with parts of the roof beams exposed. Minor beach and dune erosion (Condition II) occurred at Coquina Beach (R35) at the southern end of Anna Maria Island. Major beach and dune erosion (Condition IV) occurred on Greer Island at the northern end of Longboat Key (R43-R45) (**Figure 52**).

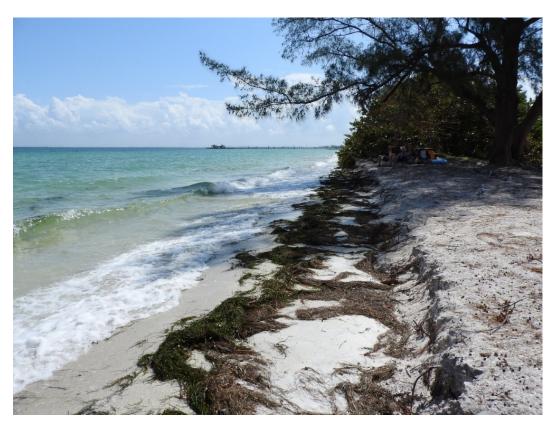


Figure 51. Beach erosion at the northern end of Anna Maria Island between R2 and City Pier.

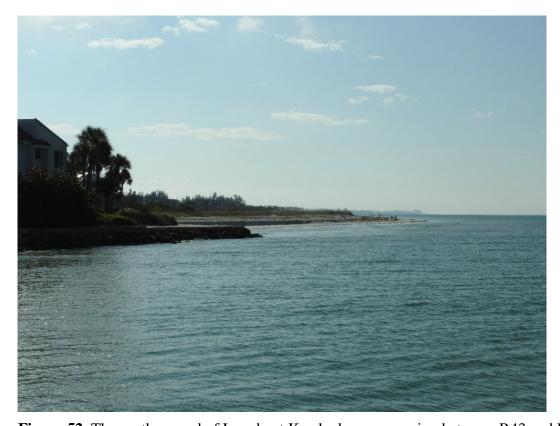


Figure 52. The northern end of Longboat Key had severe erosion between R43 and R45.