

# Management of a Beach Nourishment Project during the 2004 Hurricane Season

By

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## ABSTRACT

Construction of the 2004 Treasure Island/Long Key portion of the Pinellas County Federal Nourishment Project was interrupted four times by the passage of Hurricanes Charley, Frances, Ivan, and Jeanne, providing numerous coastal management challenges. An ambitious monitoring program conducted before, during, and immediately after construction quantified shoreline and volume changes within a few days following each storm. Project managers utilized these data in post-hurricane decision making. The most dramatic erosion occurred along the Upham Beach (Long Key) segment of the project, which was completed five days prior to the passage of Frances. This segment lost up to 60 m of shoreline during the month of September 2004, an amount nearly equivalent to one year of erosion documented during previous

nourishments. Based on these data, Pinellas County, the local sponsor, requested emergency storm repairs for Upham Beach, Pass-a-Grille Beach (also on Long Key), and Sunset Beach on Treasure Island. Because of resourceful interagency coordination and accessible pre- and post-storm data, repairs were initiated immediately following the storms. Despite the destructive impacts of the four hurricanes, the beaches of Sunset Beach and Upham Beach were returned to the original design templates, and an unscheduled emergency repair nourishment was completed on Pass-a-Grille Beach. A series of management and policy recommendations for local coastal managers are provided based on the experience gained during this unique project.

**Additional Keywords:** Beach erosion, storm impacts, beach nourishment, coastal management

## INTRODUCTION

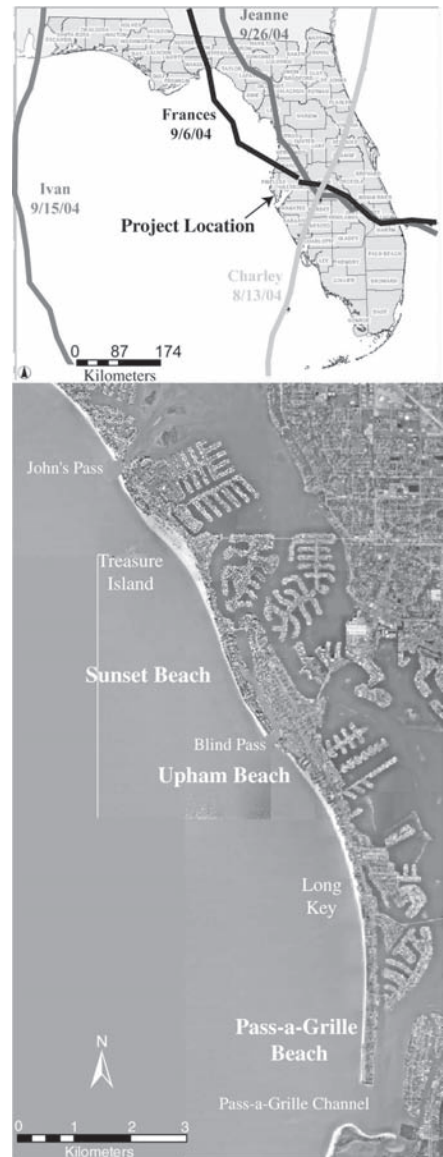
The Pinellas County Federal Beach Erosion Project was authorized by the Rivers and Harbors Act of 1966. The project, administered by the U.S. Army Corps of Engineers (USACE), provides for nourishment along the four developed barrier islands in Pinellas County. Two of those islands, Treasure Island and Long Key, which have been nourished repeatedly since the 1970s were nourished again in the fall of 2004. Due to their proximity, construction of the two separate beach fills has recently been combined, as in this project, which included the fifth renourishment of Upham Beach, on Long Key, and the seventh renourishment of Sunset Beach, on Treasure Island (Figure 1).

Upham Beach is one of the most rapidly eroding nourishment projects in the state of Florida. About 200,000 cubic meters of sediment is typically placed along less than 1 kilometer of the north end of Long Key, advancing the shoreline as much as 175 meters. The half-life for the Upham Beach project, the time at which 50 percent of the nourished material remains, is approximately one year (Elko, et al., 2005). Longshore currents transport the nourished material to the downdrift beaches; thus, Upham Beach has been labeled a "feeder beach" for the rest of Long Key (USACE, 1999).

## PROJECT AREA

The west coast of Florida is typically a low-energy system with annual average breaking wave heights of 0.3 meters (Tanner 1960) and a tidal range of about 0.8 meters (NOAA, 2004). The wind and weather conditions along this coast consist of prevailing breezes from the south during the summer and cold fronts that approach from the northwest during the winter, resulting in a net littoral drift to the south with several local reversals. Occasionally, tropical storms impact the west coast of Florida; however, 1921 was the last time a hurricane made direct landfall in Pinellas County.

Sunset Beach and Upham Beach are separated by Blind Pass (Figure 1). This wave-dominated tidal inlet has been stabilized with bulkhead-type seawalls and a weir jetty (Figure 2), resulting in the most structured inlet along Florida's west-central coast (Davis and Barnard, 2000). Blind Pass alternates as a borrow area for this nourishment project with other nearby sand sources, such as Pass-a-Grille Channel, the tidal inlet on the south end of Long Key, which was the borrow area for the 2004 project. Blind Pass was utilized as the borrow area in 1980, 1991, and 2000. Pass-a-Grille Channel and the ebb-tidal delta were last used as a borrow area in 1986 (USACE, 1999). Pass-a-Grille Beach is located at the south



**Figure 1.** Nourishment project locator map illustrating the tracks of the four hurricanes that affected Florida in 2004, the three nourished beaches (Sunset Beach on Treasure Island, Upham Beach and Pass-a-Grille Beach on Long Key), and the borrow area (Pass-a-Grille Channel). Note the numerous dredge-and-fill fingers in the back-barrier bay.

end of Long Key, adjacent to Pass-a-Grille Channel (Figure 1).

## HISTORIC MORPHODYNAMICS

Blind Pass was a large tidal inlet with a prominent ebb-tidal delta prior to the Hurricane of 1848, which breached John's Pass, 5 kilometers to the north. John's Pass captured much of the tidal prism of Blind Pass, and Blind Pass became unstable and began to migrate to the south in response to the direction of net littoral drift. As Blind Pass migrated to the south at the expense of the north end of Long Key, Sunset Beach, on the south end of Treasure Island, was created via spit elongation. In the mid 1900s, causeway construction and dredge-and-fill construction constricted and reduced the area of Boca Ceiga Bay by 28 percent (Davis and Barnard, 2000) (Figure 1), further reducing the tidal prism of Blind Pass.

Presently, southern Treasure Island (Sunset Beach) is sediment starved due to sediment trapping along the center of the island. The ebb delta of John's Pass, which is skewed to the south (downdrift), causes sediment bypassing far from the inlet mouth, resulting in a humpbacked barrier island (Fitzgerald, et al., 1984). The wide beach in the center of Treasure Island continues to prograde due to this bypassing mechanism, trapping sediment and starving the downdrift Sunset Beach. In addition, the first nourishment of Treasure Island in 1969 utilized a shore-parallel borrow pit about 600 meters offshore. The borrow pit exists today and may be modifying the wave climate thus contributing to the erosion of Sunset Beach.

When the first condos were constructed on northern Long Key (Upham Beach) in the 1960s, the ebb delta of Blind Pass was

collapsing and migrating onshore, creating an abnormally wide beach. Once Upham Beach was no longer protected from wave energy by the ebb delta, erosion began to dominate this region. Upham Beach now forms a headland with the condos and seawall in an advanced seaward position (Figure 2).

Presently, long jetties at Blind Pass and periodic dredging of the inlet interrupt the sand bypassing to the south; thus, preventing an adequate sediment supply from reaching Upham Beach. Elko and Davis (in press) describe the morphologic evolution of Long Key and Blind Pass in detail.

## FIELD DATA COLLECTION

An ambitious field-monitoring program was initiated prior to the 2004 nourishment construction with the goal of understanding and quantifying the processes governing immediate post-nourishment project performance. The field study was also intended to support future management decisions. Of course, the impact of four hurricanes was not anticipated, but was an interesting addition to the field study. Beach profiles were surveyed before, during, and immediately after construction such that the "post-nourishment" surveys for profiles on the south end of the project (where fill placement began) were measured on a different date than those for the northern profiles (Figure 3).

Beach profiles, offshore bathymetry, shoreline configuration, and offshore directional waves were measured from June to October 2004. Along Long Key, 21 profiles were surveyed with the closest spacing of about 100 meters within the northern, nourished portion. Profile spacing increased toward the south end of the

island where less change was anticipated. To measure nearshore changes and profile equilibration, traditional wading depth profiles (typically measured to -1.5 meters NGVD29) were extended to -3 meters. In many cases, the beach profile surveys extended offshore to the depth of closure, which is approximately -3 meters in southern Pinellas County (Wang and Davis, 1999). Offshore bathymetric surveys extending to -5 meters and 1,500 meters offshore were also collected in June, September (before the hurricanes), and October 2004 (after the hurricanes).

The high water line, berm crest, dune line, and other features (e.g., seawall) were mapped with an RTK GPS (Real Time Kinematic Global Positioning System) mounted on an ATV (All Terrain Vehicle). The high water line can be identified in the field readily and consistently from the rack line. The operator slowly drives the ATV along the morphologic feature of interest while the RTK records position and elevation values every second, with a spatial sampling interval of 1.5-2 meters. High water lines (hereinafter referred to as shorelines) were mapped prior to nourishment and after each storm event, and then overlain on digitally geo-referenced aerial photos. Resulting shoreline maps proved to be an invaluable management tool during the 2004 hurricane season (Figure 4).

Finally, a directional wave gauge was deployed about 600 meters offshore of the center of the Upham Beach nourishment project. Overall, the post-nourishment field data collection was well-planned and successful, and allowed for analysis of the immediate post-nourishment response, as well as the effect of multiple storm impacts on a recently nourished beach. The data were used in emergency management decision-making, as well as in the study of the mechanisms of post-nourishment pro-

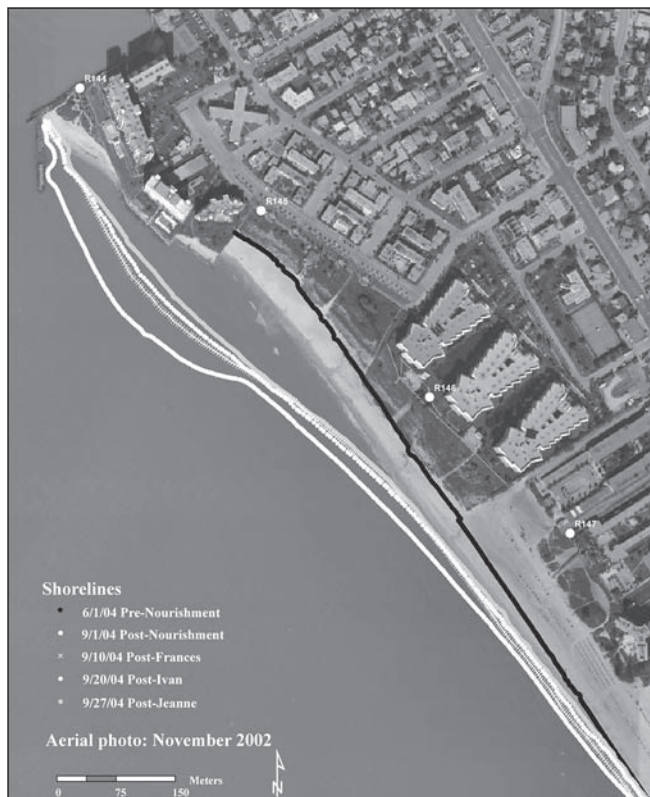


**Figure 2.** Aerial photo of Upham Beach in November 2003 prior to nourishment. Blind Pass is the tidal inlet with the most structural modifications on the west coast of Florida. Sunset Beach is in the background on the south end of Treasure Island.



**Figure 3.** Photo of Upham Beach nourishment on July 28, 2004, looking north, illustrating the direction of fill placement from south to north.





**Figure 4. Shoreline map for Upham Beach before and after nourishment, and after the passage of Frances, Ivan, and Jeanne. The background aerial photo was taken in 2002 prior to nourishment.**

file equilibration and planform adjustment. This paper focuses on the management application. Detailed examination of the nourishment performance is beyond the scope of this paper.

## 2004 NOURISHMENT PROJECT

The Long Key (Upham Beach) portion of the federal nourishment project began on July 7 and was completed on Sept. 1, 2004. The project supplied an unprecedented amount of material, approximately 280,000 cubic meters of sediment (40 percent more than the previous nourishment in 2000), to the northernmost 1 kilometer of the 7-kilometer-long barrier island. Sediment was excavated from the Pass-a-Grille Channel borrow area, 6 kilometers to the south, with a cutterhead suction dredge. The sand was pumped to the nourishment areas through a submerged pipeline located approximately 600 meters offshore. The contractor, Norfolk Dredging Company, placed the fill from south to north, in the opposite direction of littoral drift (Figure 3).

Several minor delays occurred during construction of the Upham Beach portion of the project, including demobilization of the dredge on Aug. 11, when Hurricane Charley was forecast to make landfall in

nual wave height.

Another delay occurred when the consultant determined that the project design was not providing an adequate volume of material to fulfill the advance mitigation requirement of the Florida Department of Environmental Protection (FDEP) permit. After construction, five geotextile T-head groins were to be installed on Upham Beach in an effort to retain the fill longer than the usual one year. Structures tend to cause downdrift erosion; also, as mentioned previously, Upham Beach is considered a feeder beach for the rest of Long Key. Thus, to mitigate for the potential of downdrift erosion in advance, additional fill was to be placed along the southern portion of the project that had not been nourished in the past.

Because the south end of the project was wider when construction commenced than when the project was designed, the required volume of advance mitigation was not achieved. Therefore, the design berm width along the northern portion of the project was modified to allow for the additional volume. Subsequent discussions with FDEP led to the first redesign of the fill template by the field engineer.

Hotel owners/managers along the south-

ern half of the Upham Beach project, which had not been nourished in the past, signed easements providing access to their property landward of the erosion control line (ECL); however, they were not informed of the project details. Information such as the project design, the direction of fill placement, and most importantly, how long the pipe would be on the hotel beach, was not adequately explained to the hoteliers. This lack of communication could have been easily avoided, but unfortunately discontented hotel managers claimed loss of business during construction. This illustrated the importance of proper public education during project implementation planning.

Several weeks after project construction began, weekly survey data indicated the formation of a large inter- to supra-tidal spit in the center of the nourishment project. The feature extended over 300 meters and resembled a spit elongating from the taper of the widest portion of the planform. The shoreline advanced 8 meters on average as the spit developed to a maximum elevation of 1.4 meters. The spit was first surveyed on Aug. 11, 2004, it persisted through the passage of Hurricane Charley, and then it was dispersed during the passage of Hurricane Frances in early September. The spit was composed primarily of coarse, shelly sand (Figure 5). This spit was likely the product of longshore transport of the nourished sediment, which had a mean grain size of 0.5 millimeters. Then, a selective transport process transported the coarse, shelly fraction onshore and the fine fraction offshore.

## HURRICANE FRANCES

Four days after completion of the Long Key segment, Hurricane Frances made landfall near Stuart, Florida on Sept. 5. The hurricane swept across the Florida peninsula and entered the Gulf of Mexico just north of Pinellas County (Figure 1) as a strong tropical storm. Nourishment of the Treasure Island segment of the project had not begun upon the passage of Frances, the strongest and closest passage (within 50 km of the project) of the four storms. The dredge was demobilized again to ride out the storm in a safe harbor in Tampa Bay.

During Frances, strong winds (> 18 meters/second) generated steep storm waves with maximum wave periods (T) of about 8 seconds and significant wave heights ( $H_{sig}$ ) of up to 1.8 meters, roughly six times the annual average wave height along this low-energy coast. The newly constructed Upham Beach lost 40 meters of shoreline

(Figure 4). The beaches along the un-nourished Treasure Island segment of the project lost 5-10 meters of shoreline, leaving little to no beach in front of the homes along Sunset Beach.

Pass-a-Grille Beach, on the south end of Long Key, was another area of significant erosion during the passage of Hurricane Frances. Shoreline surveys and beach profiles indicated the backbeach was removed at Pass-a-Grille Beach during Frances, and on average, 5 meters of dune erosion occurred. Several dune walkovers were severely damaged. Pass-a-Grille Beach was last nourished in 1991. This beach has traditionally been considered stable due to the influx of sediment from the erosion of the Upham Beach segment of the project located updrift.

### HURRICANE IVAN

After the passage of Frances, storm conditions subsided on Sept. 9, and construction of the Sunset Beach segment of the project began. Meanwhile, Hurricane Ivan intensified in the Gulf of Mexico, as did public interest among the residents of Sunset Beach, who had no protective beach remaining. Fill was placed along the southern 100 meters of the project, only 5 percent of the project length, before the third hurricane dredge demobilization occurred. Ivan, a Category 4 hurricane, traversed the Gulf of Mexico along a northward track nearly 500 kilometers offshore (Figure 1) and made landfall in Gulf Shores, AL, on Sept. 16. Ivan did not produce strong winds in Pinellas County (maximum wind speed, 10 m/s); however, the storm generated relatively large waves ( $H_{sig} = 1$  m,  $T = 12$  s) that approached the project area as a well-organized swell. Although the waves generated by Ivan were swell waves, the energy generated resulted in "storm" conditions along the project area. The wave height and wave period were both three times higher than typical for this coast.



**Figure 5. Photo of Upham Beach on Aug. 15, 2004, looking north, illustrating a spit that formed to the south from the widest portion of the nourished planform. The spit is outlined with a dashed line.**

After the passage of Hurricane Ivan, fill placement continued along the central portion of Sunset Beach. Only 60 percent of the Sunset Beach fill was in place when the impending Hurricane Jeanne forced the fourth dredge demobilization in 40 days. At this point, residents along the northern portion of the project were frantic. One resident snuck out in the middle of the night and raised the grade stakes in front of his house in hopes that the contractor would not notice. Of course, the next morning, the grade was readjusted to the proper design. However, this effort sparked an ad hoc town meeting on the beach that morning, complete with a reporter and cameraman, where residents expressed concern that we were not building the same project that was constructed during the previous project in 2000. The consultant had designed a similar but different project with a turtle-friendly slope (more gentle than typical nourished slopes) and a lower total volume of fill. Once again due to the lack of public education, the residents did not react favorably to a narrower beach than was constructed in 2000, particularly in the midst of an active hurricane season.

To address the lower design volume, Pinellas County submitted a permit modification to the FDEP requesting that the total volume be increased to match the 2000 volume. Pre- and post-nourishment beach profiles and photographs from the 2000 project, as well as turtle nesting surveys, were provided to Florida Fish and Wildlife Conservation Commission (FWC) and the FDEP. It was determined that scarping was not a problem on this beach, and a permit modification to increase the volume and the slope from 1:30 to 1:20 was granted. Consequently, the field engineer redesigned the fill template for the project for the second time.

On the south end of Long Key, an unusually narrow and flat beach profile produced by the passage of Hurricane Frances at Pass-a-Grille Beach allowed waves from Ivan to overwash Pass-a-Grille Beach, inundating the protective dune system that had been established in the early 1990s. Pinellas County decided to request an emergency permit on Sept. 17 due to the continued erosion of this beach, and the proximity of the dredge. The FDEP denied this request on Sept. 21, stating that the project did not appear to qualify as an emergency that "endangers the coastal system or health, safety, welfare or resources of the state" according to F.A.C. 62B-49.009(1).

### HURRICANE JEANNE

Hurricane Jeanne made landfall on Sept. 26 near Stuart, FL, very close to that of Hurricane Frances and only 22 days later. As with Frances, Jeanne weakened to tropical storm force as it passed within 80 kilometers of the project area. The passage of Jeanne also generated steep storm waves ( $H_{sig} = 1.7$  m,  $T = 8$  s).

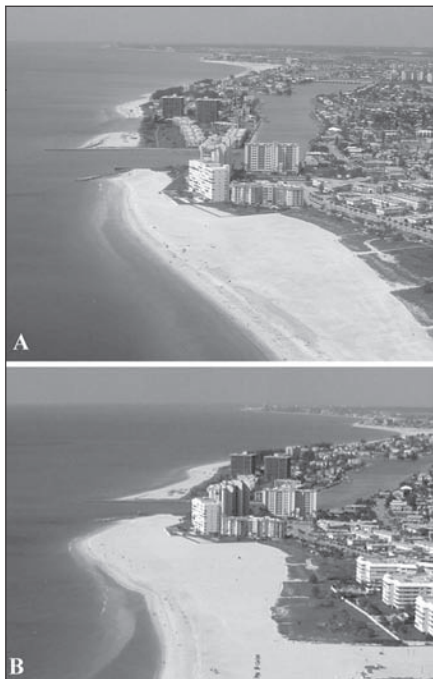
The fill on Upham Beach lost an additional 20 meters of shoreline (Figure 4, Figure 6A), for a remarkable total of 60 meters during the month of September. The recently placed fill on the south end of Sunset Beach also lost up to 20 meters of shoreline during the passage of Jeanne. Dune erosion exposed walkovers and sprinkler systems along the northern segment of this project, which had no fill in place prior to the storm (Figure 7A). A slightly higher intensity or longer duration storm would have likely undermined some of the infrastructure along the Sunset Beach portion of the project. In addition, Pass-a-Grille Beach continued to erode, enduring up to 20 meters of shoreline and dune recession during the hurricane season (Figure 8A, B).

### POST-STORM MANAGEMENT

The ability to quantify storm losses within days after the storms proved valuable, particularly when meeting with USACE representatives to discuss emergency mitigation strategies following the storms. The annual Florida Shore and Beach Preservation Association conference, which had been relocated from Captiva Island where Hurricane Charley made landfall, was held in Marco Island on Sept. 29, only three days after Hurricane Jeanne. Immediate quantitative shoreline and beach-volume change data based on the shoreline and beach profile surveys were presented to FDEP and Corps' representatives attending the conference.

Quantification of post-storm erosion immediately following the storms was again beneficial when several USACE representatives attended a press conference held by Florida Gov. Jeb Bush in St. Pete Beach on Oct. 8. The governor encouraged tourists to visit Florida beaches, highlighting St. Pete Beach as one of the beaches that was still open for business. Fortunately, the contractor cooperated by relocating the booster pump from the press conference area, and out of view of the cameramen. At the event, USACE displayed several posters of storm-induced beach erosion around the state. The Pinellas County poster was unique in that it presented quantified shoreline change data (Figure





**Figure 6. Aerial photos of Upham Beach (A) on Oct. 6, 2004, after the passage of Jeanne and (B) on Nov. 16, 2004, after the hurricane repair nourishment was complete. Comparison to Figure 4 illustrates that the post-nourishment shoreline (Sept. 1, 2004) extended from the north jetty.**

4), which was a valuable addition to before-and-after photos. As Congress prepared to issue an emergency supplemental bill to fund hurricane-related beach damages, the quantitative assessment of storm damage to Long Key and Treasure Island was invaluable.

Following the passage of Jeanne, Pinellas County submitted a second request for an emergency permit to repair storm damages at Pass-a-Grille Beach. Supporting documentation included the quantified volume loss, profile and plan view drawings of the proposed nourishment, sidescan sonar surveys illustrating the absence of nearshore hardbottom, borrow area information, and a statement from the Office of the County Attorney, which outlined that an emergency permit was justifiable according to 1) F.S. 252.36, because a state of emergency for Pinellas County had in fact been declared by Executive Order of the Governor, and 2) F.A.C. 62B-49.009(1), because a shoreline emergency, defined as “an unusual incident resulting from a hurricane or storm that caused erosion endangering the coastal system and resources of Pinellas County”, did in fact occur.

#### **POST-STORM DATA ANALYSIS AND NOURISHMENT REPAIRS**

The combination of post-storm data sharing, coordination with the USACE

and FDEP, and the pending emergency supplemental funding from Congress, spawned a two-month repair nourishment to replace the fill that was lost during the hurricanes. Essentially, Upham Beach and Sunset Beach were nourished twice in two months. First, USACE directed the contractor to return to the southern portion of the Sunset Beach project. This did not require significant construction mobilization (i.e., pipeline relocation) and was accomplished quickly. The Sunset Beach segment of the project was finally completed on Oct. 18.

The shoreline surveys documented dramatic shoreline recession within the Upham Beach project area during the month of September 2004. The widest portion of the nourishment project eroded 60 meters in 27 days, or 2.2 meters per day (Figure 4). Upham Beach nourishment projects typically erode at a rate of 70 meters/year (Elko, et al., 2005). For comparison, one month after completion of the previous nourishment in 2000, 90 percent of the material remained along this portion of the project. One month after this nourishment in 2004, only 50 percent of the placed fill remained at the widest, northern portion of the planform.

Returning to Upham Beach was a larger construction effort requiring pipeline relocation. USACE modified the construction contract to replace the eroded fill. This post-storm repair nourishment was also completed quickly on Oct. 28.

In the meantime, USACE, FDEP, and Pinellas County pooled resources to coordinate the funding, design, and contract modifications to execute a repair nourishment at Pass-a-Grille Beach. In response to Pinellas County’s second request, FDEP granted the emergency permit on Nov. 1. The template was finalized in the field and once again designed by USACE’s field en-

gineer. Amazingly this repair nourishment, which was not a part of the original project prior to the storms, progressed from inception to construction in 45 days.

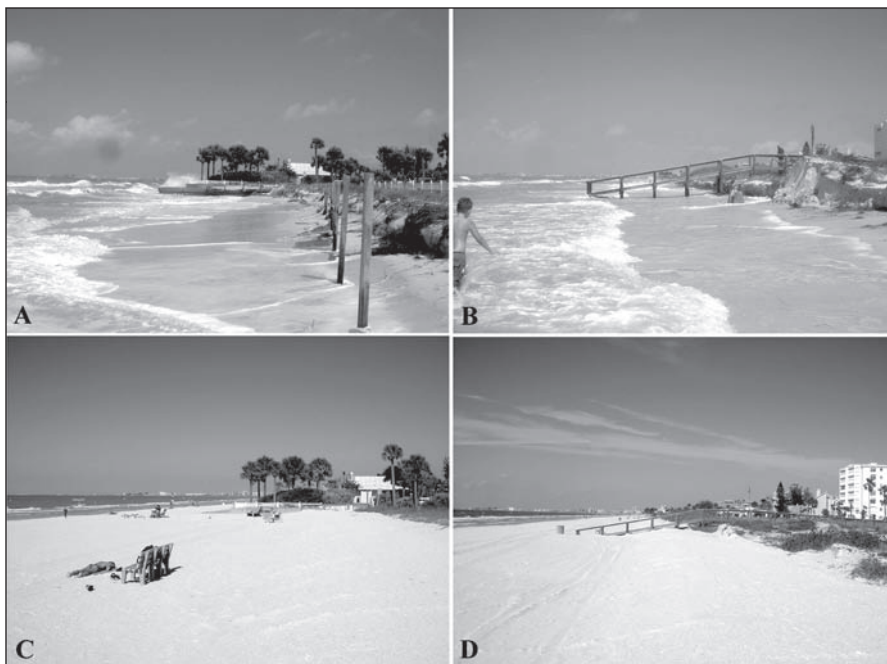
Pinellas County was fortunate to be in the midst of a nourishment project during the 2004 hurricane season. Having a dredge on site was certainly unusual, but taking advantage of that opportunity was only accomplished through persistent and well-informed local management. The post-storm repairs may not have been so comprehensive without a thorough local sponsor prepared with erosion quantities and analyses soon after each storm event. Ultimately, the beaches of Long Key and Treasure Island were repaired immediately following the exceptional hurricane season of 2004 -- a privilege that no other county in the state of Florida can claim. A comparison of photos of the beaches after the storms to photos just a few weeks later (Figures 6B, 7B and 8C and D) is testament to the efficiency and effort put forth by all of all organizations involved in the project.

#### **CONCLUSIONS AND RECOMMENDATIONS**

The Treasure Island/Long Key Federal Nourishment Project was under construction during the 2004 hurricane season. An intense coastal monitoring program allowed for quantification of storm damages to the beaches and recently placed fill within days of each storm event. The Upham Beach segment of the project, which was completed on Sept. 1, lost up to 60 meters of shoreline during the month of September, an amount equivalent to the shoreline recession that typically occurs in one year. County requests to the USACE and FDEP for emergency repairs were based on quantified shoreline and volume changes that were computed within days after the passage of the storms. This co-



**Figure 7. The north segment of the Sunset Beach nourishment project (A) on Oct. 2, 2004, after the passage of Jeanne and (B) on Oct. 29, 2004, after nourishment.**



**Figure 8. Pass-a-Grille Beach (A) and (B) on Sept. 27, 2004 after the passage of Jeanne and (C) and (D) the same locations on Dec. 19, 2004, after emergency nourishment.**

ordination led the initiation of emergency storm repairs immediately following the storms to restore the Treasure Island (Sunset Beach) and Long Key (Upham Beach) segments to the post-nourishment fill design templates. In addition, Pass-a-Grille Beach, on the south end of Long Key and adjacent to the borrow area, received an emergency beach fill to repair storm damages. Thanks to capable management, the beaches of Long Key and Treasure Island were restored to the original design

templates in spite of the hurricane season of 2004.

### RECOMMENDATIONS FOR PROJECT MANAGEMENT

1. Survey the beach before and immediately after nourishment, or request the as-built surveys. This allows for presentation of quantified damages to project managers and the public in the case of a major storm following nourishment.
2. Establish a good working relationship

with the contractor, USACE construction inspector, and USACE field engineer (the on-site project managers who make important construction decisions).

3. Communicate frequently with the district Corps office and the state regulatory agency, FDEP in this case (the upper level decision makers who are not on site daily).

4. Foster your relationship with federal, state, and local representatives.

5. Begin a public education campaign as soon as information about the project becomes available, including a Web site, public meetings, and mass mailings with project details -- particularly any changes from the previous nourishment.

### ACKNOWLEDGEMENTS

USACE field engineer was Andy Cummings, with the Tampa area office of the U.S. Army Corps of Engineers, who redesigned every portion of this project, putting in many hours of overtime during the 2004 hurricane season. The weekly (and sometimes daily) field work was organized by Dr. Ping Wang of the University of South Florida, and executed by his dedicated field crew: Dave Tidwell, Craig Tolliver, and Andy McManus. The consultant was Coastal Planning and Engineering Inc., and the innovative design engineer was Doug Mann. The contractor was Norfolk Dredging Company. Despite four demobilizations for weather, they incurred no damaged equipment, injuries, or public safety problems. Thanks to Dr. Wang and Dr. Richard A. Davis for thoughtful reviews.

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