

SBEACH Model Studies for the Florida Atlantic Coast:

VOLUME 1

Model Calibration in Brevard and St. Johns Counties
and

VOLUME 2

Model Application for Brevard, St. Johns, Volusia,
and Indian River Counties

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SBEACH Model Studies for Florida Atlantic Coast:
Brevard, St. Johns, Volusia, and Indian River Counties

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FOREWORD

The Florida Department of Environmental Protection's (FDEP) Bureau of Beaches and Coastal Systems (BBCS) is responsible for programs for the protection and management of beaches and coastal systems of the State of Florida. This responsibility includes evaluation of coastal processes through the use of analytical and numerical models. Modeling evaluations to simulate and predict beach and dune erosion of coastal areas resulting from episodic coastal storms are integral to the BBCS coastal management and oversight activities.

This report documentation summarizes work performed to provide estimates of beach and dune erosion for Brevard County, St. Johns County, Volusia County, and Indian River County resulting from high-frequency storm events through the use of the SBEACH model. The report documentation is divided into two separate report volumes. Volume 1 describes model calibration work performed during initial phases of the overall work in order to apply model input appropriate for use along this Florida Atlantic Coast study region. Volume 2 provides the SBEACH model application results for the four identified counties mentioned above, as well as, report appendices.

The work performed and described in this report was conducted under specific task order contained and described in a contract (BS-025) between the BBCS and the Florida State University (FSU) Beach and Shores Resource Center (BSRC). The SBEACH model was purchased as part of the Coastal Engineering Design and Evaluation System (CEDAS) from Veri-Tech, Inc.

The SBEACH model is distributed through Veri-Tech, Inc. based on a version of the SBEACH model prepared by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, USA. SBEACH (Storm-induced BEACH CHange) simulates cross-shore beach, berm, and dune erosion produced by storm waves and water levels. As conveyed by Veri-Tech, Dr. Magnus Larson of Lund University is the principal author of the SBEACH model.

The SBEACH model work performed and described in this report included no modifications/revisions to the model code. It is noted that no multiplier factors were applied to model results as additional work outside operation of the SBEACH model as part of the calibration work performed. SBEACH was operated according to the Veri-tech version interface. Model input parameters were maintained within the recommended range of values specified within the model software.

The model evaluation work and report preparation was performed by Mark Leadon, P.E., Program Director of the BSRC, and Nhan Nguyen, Research Engineer, of the BSRC. Contract task oversight for performance and completion of this work for the BBCS was conducted by Robert Brantly, P.E., and Subarna Malakar.

EXECUTIVE SUMMARY

Beach and dune erosion simulation for location along the Atlantic Coast of Florida was performed through use of the SBEACH numerical model. The SBEACH model simulation included beach and dune erosion estimates for high-frequency storm events for Brevard, St. Johns, Volusia, and Indian River counties. Initial work included model calibration in Brevard and St. Johns counties using measured topographic/bathymetric survey, storm tide, wave and weather data.

Sufficient survey data with available storm tide measurements from within all of the target counties (Brevard, St. Johns, Volusia, and Indian River) associated with coastal storms impacting these counties necessary for model calibration work could not be found at the time of this work. However, model calibration data applicable to these target counties was found for St. Johns County and Brevard County, two of the target counties, located within the central Atlantic Coast region of Florida. Sufficient pre- and post-storm ground survey and storm tide information, as well as concurrent wave data and information, was compiled and evaluated for model calibration.

Storm tide and wave data and information for model input for Hurricane Frances and Hurricane Jeanne from Brevard County and for the 1984 Thanksgiving Storm from St. Johns County was used in model calibration work. Model input parameters for sediment grain size were compiled from available documentation of measured data. Correlation between sediment grain size and beach slope was used to estimate grain sizes where no documentation of measured data was found. Based on sensitivity testing of sediment transport model input parameters, it was found that most of these parameter values should remain at the recommended default values. However, adjustment of the sediment transport parameter (K) and the coefficient for slope dependent term (ϵ) produced better model calibration results. Calibration results showed that higher K values appeared to correspond with flatter beach slopes and lower grain size values, and conversely, lower K values appeared to correspond with steeper beach slopes and larger grain size values.

Calibration work in Brevard County included use of nearshore wave data and water level measurements for Hurricane Frances and Jeanne, as well as, use of computed nearshore wave hindcast output along the entire Brevard County coastline. The SBEACH calibration produced good agreement between measured and modeled erosion profiles at several profile locations within two beach restoration project reaches. Calibration work in St. Johns County included use of storm tide model-generated hydrographs for the Thanksgiving Storm, as well as, nearshore wave hindcast output. The diversity of beach conditions in St. Johns County in terms of variations of beach slopes and mean sediment grain size values proved to be challenging, as well as, enlightening. Calibration results were considered to be successful, though not as good across the County as hoped.

SBEACH-generated erosion profiles for 15-yr and 25-yr storm events were produced for Brevard, St. Johns, Volusia, and Indian River counties which are considered to be supported by successful calibration evaluations and are contained in Volume 2 of this report documentation.

SBEACH Model Studies for the Florida Atlantic Coast: VOLUME 1 - Brevard, St. Johns, Volusia, and Indian River Counties

1.0 Background

Coastal resource protection and management responsibilities of the FDEP Bureau of Beaches and Coastal Systems (FDEP-BBCS) necessitates use of dune erosion modeling to assist in prediction of beach and dune erosion associated with coastal storms. The FDEP's CCCL erosion model by Dean and Chiu (1984, 2002) has been used extensively, particularly in 100-year storm erosion prediction for establishment of coastal construction control lines. The CCCLa erosion model by Dean and Malakar (1995) has been used extensively by the FDEP in prediction of high-frequency storm erosion.

A beach and dune erosion model developed through the U. S. Army Corps of Engineers (USACE) and used extensively by the USACE and coastal engineering consultants in Florida is the SBEACH (Storm-induced BEACH CHange) model. A detailed description of the model will not be provided herein. Detailed information on the SBEACH model can be found in SBEACH Reports 1, 2, and 3 (Larson and Kraus 1989a; Larson, Kraus, and Byrnes 1990; and Rosati, Wise, Kraus, and Larson 1993) which are available through the USACE Coastal & Hydraulics Laboratory website at: <http://chl.erdc.usace.army.mil/>

As a result of the on-going use of the SBEACH model in Florida, particularly by the USACE, the FDEP-BBCS contracted with the FSU-BSRC to conduct investigations using SBEACH. The contracted SBEACH work included specific application of SBEACH to estimate beach and dune erosion for 15 and 25 year storm events at selected locations along the Florida coast. Work completed in 2009 included model calibration in Panama City Beach and 15 and 25 year erosion profiles for Walton and Okaloosa counties (Leadon, Nguyen, 2009). Work completed in 2010, and described in this report, include model calibration work in Brevard and St. Johns counties, and 15 and 25 year erosion profiles for Brevard, St. Johns, Volusia, and Indian River counties.

2.0 Model Calibration

Review of available data for calibration of the SBEACH model for the Atlantic coast counties resulted in limited data of sufficient completeness and quality for calibration purposes. The available measured topographic and bathymetric survey data for pre- and post-storm comparison is limited in these counties. Initial review work included the compilation of storm tide measurements at two National Ocean Survey (NOS) tide gages at Mayport near the Atlantic Ocean entrance to the St. Johns River and at the Trident Pier at Canaveral Inlet.

A regional map in Figure 1 shows geographic vicinity locations of these two NOS tide gages within the study region. The regional map also highlights the locations of the four target counties for which SBEACH erosion simulations for 15 and 25 yr. storms were produced, Brevard, St. Johns, Volusia, and Indian River. Graphs shown in Figures 2 and

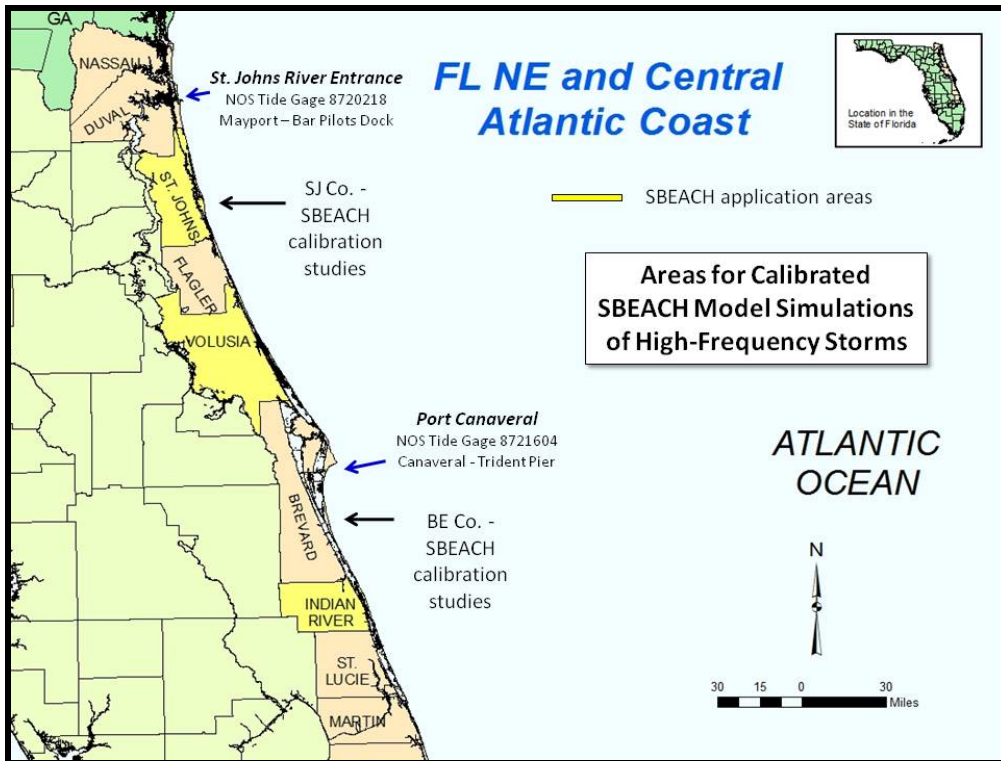


Figure 1. Regional location map showing 3 target study counties and NOS tide gages

3 depict (Leadon, 2009) storm tide elevations from measurements from these two tide gages. Identifiable measured storm tides and associated dates of occurrence at these two gages were compared with dates of documented storm and hurricane events contained in National Hurricane Center (NHC) reports. Storm tracks in the NHC reports were reviewed to confirm storm and hurricane events associated with the measured storm tides.

Survey data for counties within the study areas were then reviewed to isolate pre- and post-storm survey data for single storm/hurricane events for the model calibration work. Results of this exercise produced limited success. In most cases, it was found that successive surveys captured more than one storm/hurricane event. Therefore, most of the available survey data was considered to be unacceptable for model calibration work.

However, results of this screening process produced favorable data for SBEACH calibration at two locations within this overall Atlantic coast study region. One of these locations, and the first one evaluated, was in Brevard County within the north and south reaches of the County’s beach restoration project at Cocoa Beach and Melbourne Beach, respectively. The second location was throughout the entire Atlantic coastal length of St. Johns County.

Calibration work in Brevard County included data associated with two successive hurricane events in 2004, Frances and Jeanne. The calibration work in St. Johns County included data associated with a Northeaster-type storm in 1984, the Thanksgiving Storm.

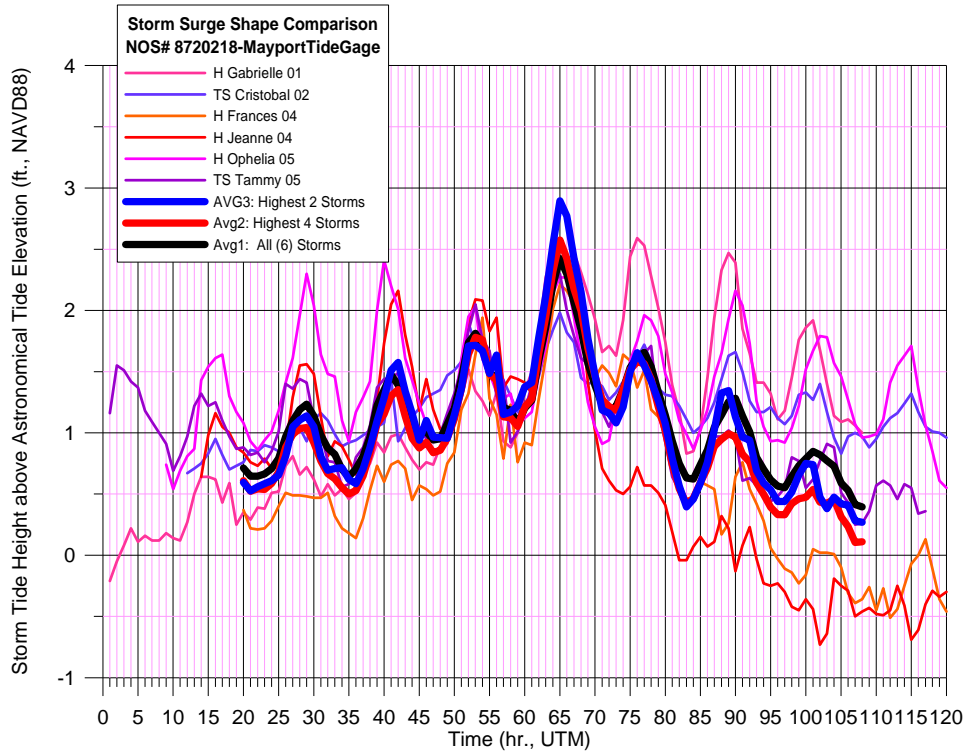


Figure 2. Storm tide elevations (above astronomical tide) from NOS tide gage at Mayport

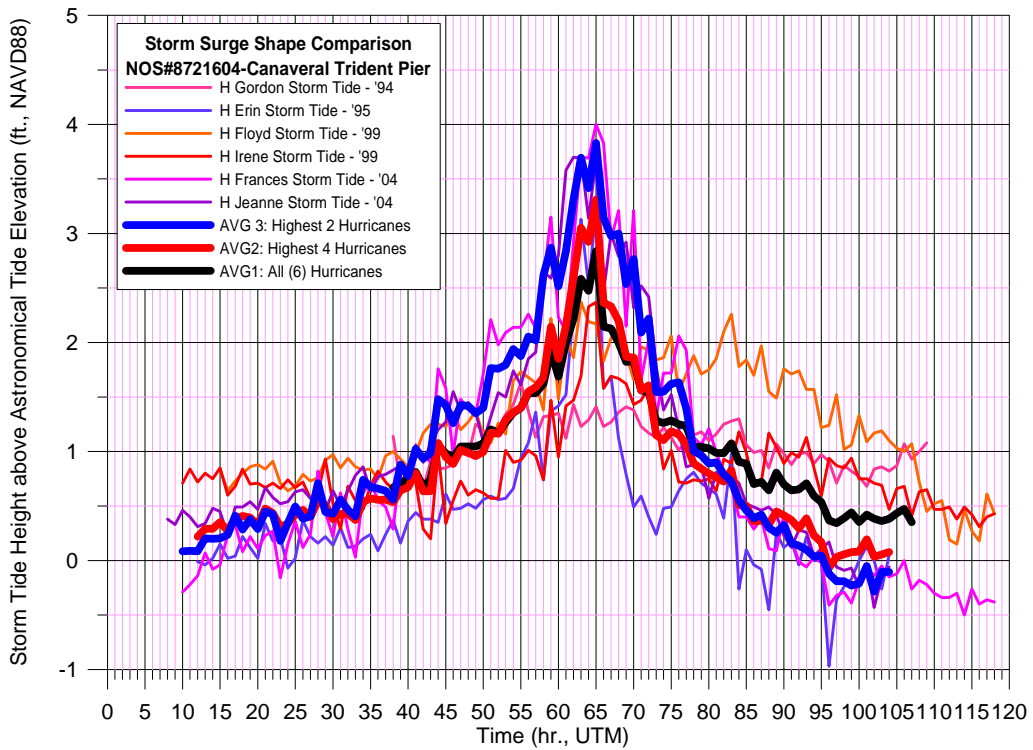


Figure 3. Storm tide (above astronomical tide) from NOS tide gage at Port Canaveral

Details about the data associated with these storm events, how it was used in calibration work, and the model calibration results are discussed below.

2.1 Brevard County Model Calibration

As a result of the initial screening process described above, it was found that sufficient storm-related data and information for SBEACH calibration work was available for Brevard County. It was also decided that model calibration work in Brevard County would be appropriate for use in model application for the four target study counties of Brevard, St. Johns, Volusia, and Indian River. Brevard County is adjacent to Volusia County to the north and Indian River County to the south and has characteristic similarities to these other counties along the central Atlantic coast of Florida.

2.1.a Measured Storm Data

Hurricanes Frances and Jeanne made landfall on the Atlantic Coast of Florida at nearly the same location in Martin County just two weeks apart in September 2004. Frances made landfall on September 5 and Jeanne made landfall on September 26. Storm tracks obtained from a National Hurricane Center Annual Summary report (NHC, 2006) are shown in Figure 4. Although topographic survey coverage in Florida east coast counties was very good before Hurricane Frances and after Hurricane Jeanne, timely response to obtain survey data in most affected coastal areas was not achieved.

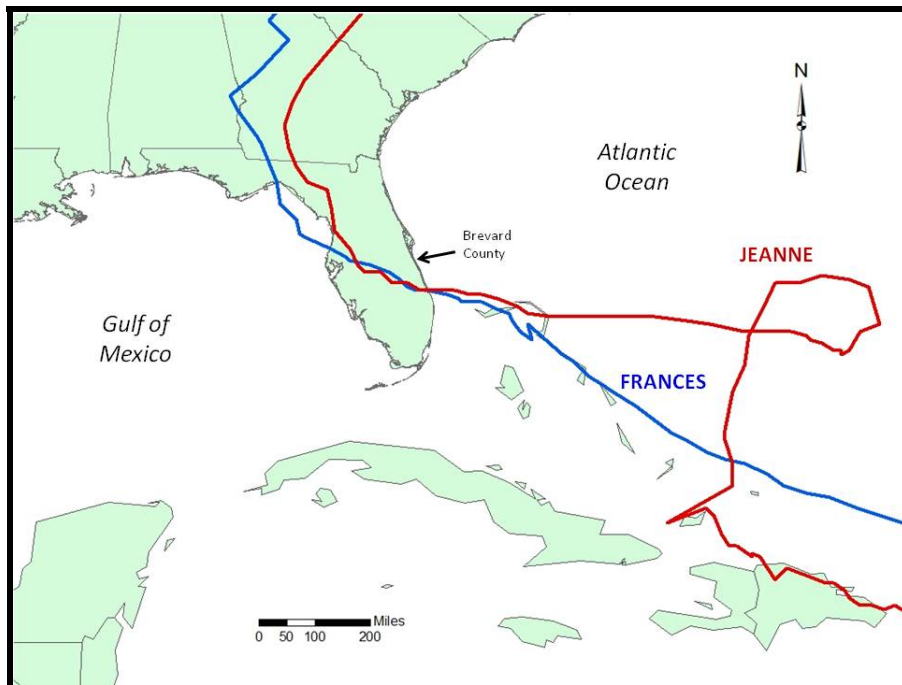


Figure 4. Map depicting storm tracks for Hurricanes Frances and Jeanne

However, Brevard County officials had the foresight to survey several profile locations within the County's beach restoration project after Frances and before Jeanne. The data

from these survey lines was obtained from Brevard County through Olsen Associates, Inc. and used in the SBEACH calibration work.

Storm tide data from the National Oceanographic and Atmospheric Administration (NOAA) - National Ocean Survey (NOS) tide gage at Canaveral Inlet provides water elevation data in close proximity to the profile survey lines used in the model calibration. Storm tide data for Hurricanes Frances and Jeanne were recorded by this NOS tide gage. The approximate location of this NOS tide gage is shown in Figure 6 further below.

In addition, two nearshore wave gages located along the Brevard County coast obtained storm tide and wave data during Hurricanes Frances and Jeanne. An acoustic Doppler current profiler (ADCP) gage installed at the Sebastian Inlet State Park obtained storm tide and wave data during both Frances and Jeanne. An ADCP gage at Spessard Holland County Park obtained storm tide and wave data for Hurricane Jeanne. In addition, nearshore wave hindcast information generated through STWAVE wave transformation modeling and output at 200 alongshore stations in Brevard County included wave information for Frances and Jeanne.

2.1.a.i Hydrographic Survey Data

As described above, it was very fortunate that Brevard County obtained beach profile data immediately following Frances that were obtained before Jeanne and then obtained profile data along the same lines immediately after Jeanne. A total of 7 profile lines were surveyed after Frances and prior to Jeanne; 5 lines in the North Reach portion of the County's beach restoration project, and 2 lines in the project's South Reach.

The locations of the North and South Reach project areas are shown in Figure 5, which also shows the locations of the two nearshore ADCP wave gages. The specific locations and associated FDEP range lines which were surveyed before and after Frances and Jeanne which were used in model calibration are shown in Figure 6 for the North Reach and Figure 7 for the South Reach. North Reach profile lines included R8, 17, 28, 36, and 46. South Reach profile lines include R121 and 126.

Although the total number of lines for the model calibration was small, the availability of these pre- and post-storm surveys was found to be essential for the SBEACH calibration work in Brevard County. As shown clearly in Figure 7, the ADCP wave gage at Spessard Holland Park was in close proximity to the southerly limits of the South Reach fill area. Pre-Frances profile lines were surveyed in May/June 2004 and post-Frances profile lines were surveyed on September 9, 2004. For Jeanne, the post-Frances survey lines of September 9, 2004 serve as pre-storm profiles and post-Jeanne profile lines were surveyed on September 27, 2004.

Since the post-Frances profile lines were surveyed within 4 days of Frances' landfall, very little post-storm beach recovery is seen on these profiles. The post-Jeanne profile lines were surveyed the day after Jeanne's landfall, so also do not show significant beach recovery effects to unfavorably affect the SBEACH model calibration work.

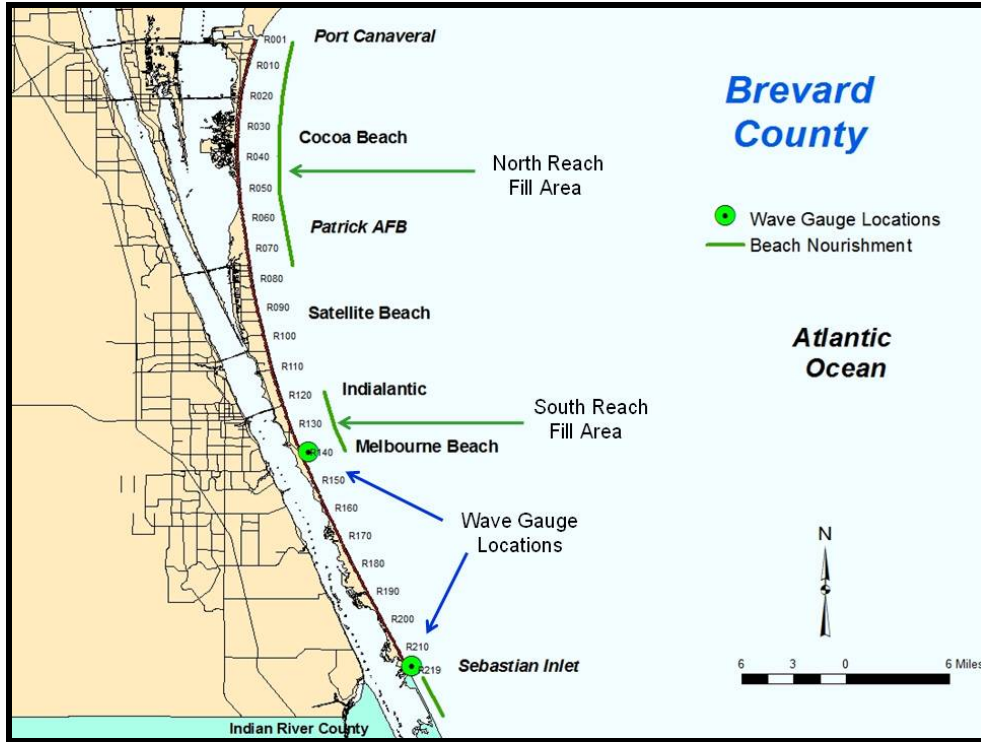


Figure 5. Locations of Brevard County beach restoration project areas and wave gages

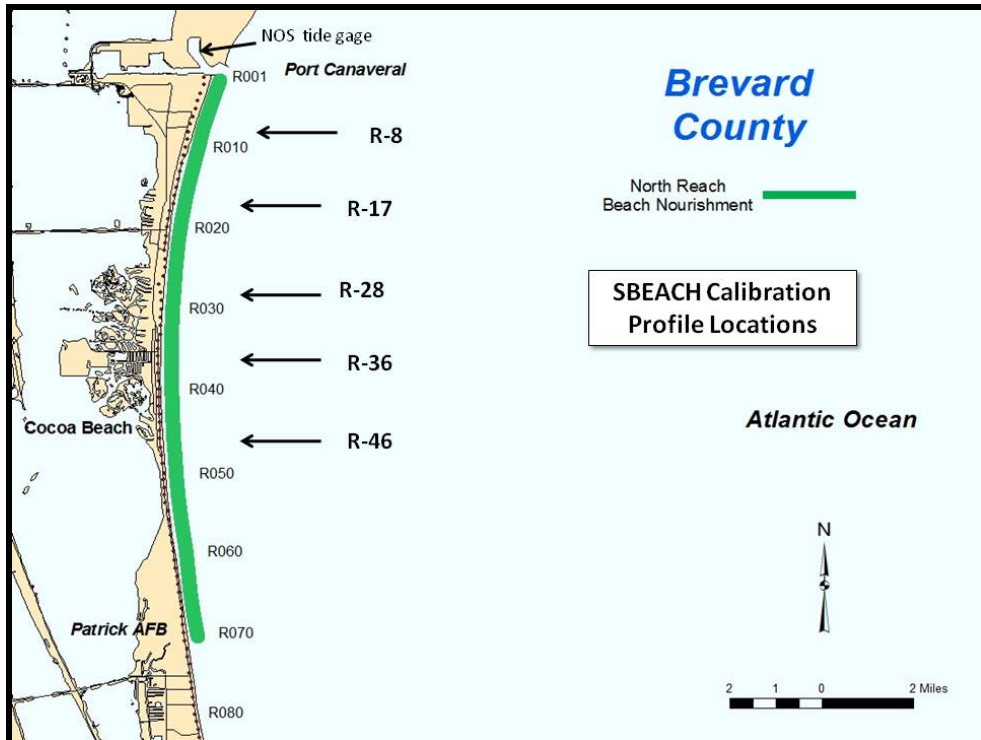


Figure 6. Locations of survey lines in the North Reach used in SBEACH calibration

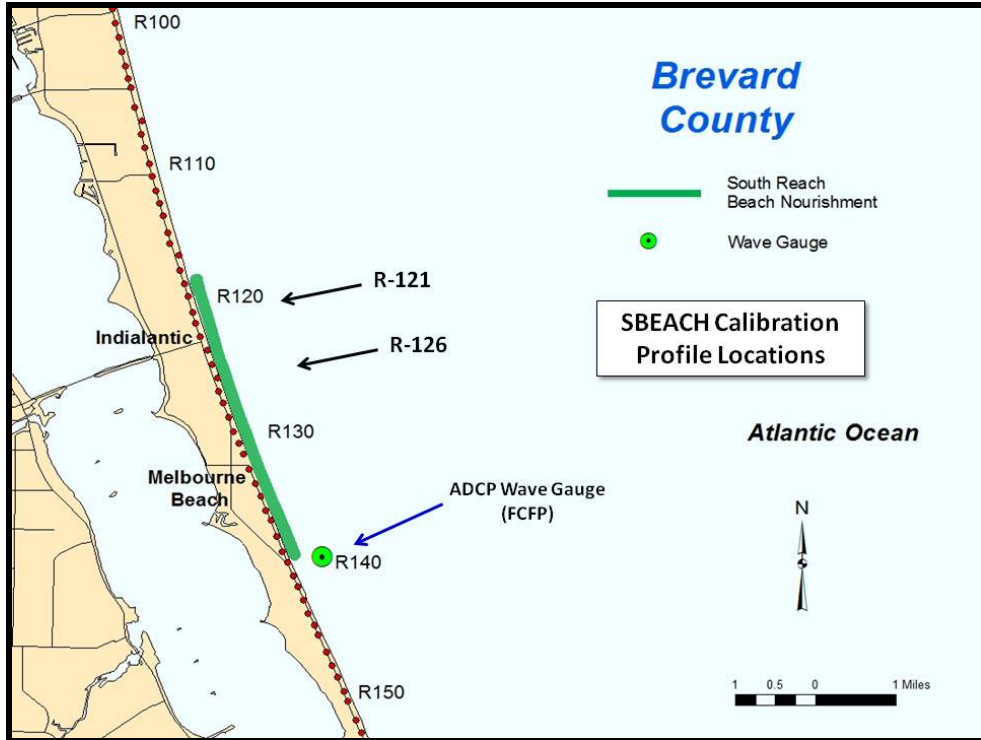


Figure 7. Locations of survey lines in the South Reach used in SBEACH calibration

2.1.a.ii Storm Tide Data

Storm tide data for Frances and Jeanne measured at the NOS tide gage Station 8721604 located just inside the Port Canaveral entrance at the Trident Pier was reviewed for use as input data into SBEACH. The storm tide data for these hurricanes obtained from the two ADCP wave gages was also reviewed for use as input into SBEACH. The ADCP gage at Sebastian Inlet State Park, installed and maintained by the Sebastian Inlet Tax District and located in approximately 28 ft. (NAVD) water depth north of the inlet, measured wave height, period, and direction and water elevation data for Hurricanes Frances and Jeanne. The ADCP gage at Spessard Holland County Park, sponsored by the FDEP-BBCS and installed and maintained by Surfbreak Engineering Sciences, Inc. and located in approximately 28 ft. (NAVD) of water depth, measured wave height, period, and direction and water elevation data for Hurricane Jeanne.

A graph of the measured wave and storm tide data for Frances from the Sebastian gage are shown in Figure 8. The measured storm tide from the NOS Canaveral-Trident Pier tide gage for Hurricane Frances is superimposed over the measured storm tide from the Sebastian gage. The two storm tide measurements track very closely except for the latter portion of the storm tide record between 48 and 72 hours in the graph in Figure 8 where the storm tide elevations at Sebastian drop significantly below the Canaveral elevations.

It is unclear what caused this drop in storm tide elevation and resulting deviation between the Sebastian gage and Canaveral gage records. A graph in Figure 9 shows measured

storm tide from Hurricane Jeanne from the wave gage at Spessard Holland park superimposed with storm tide measurements for Jeanne from the NOS Canaveral-Trident Pier tide gage. The storm tides from the two gages for Jeanne track closely. Based on the graphs in Figures 8 and 9, it was decided to use the storm tide measurements for Hurricane Frances from the Canaveral gage in model calibration simulations for Frances.

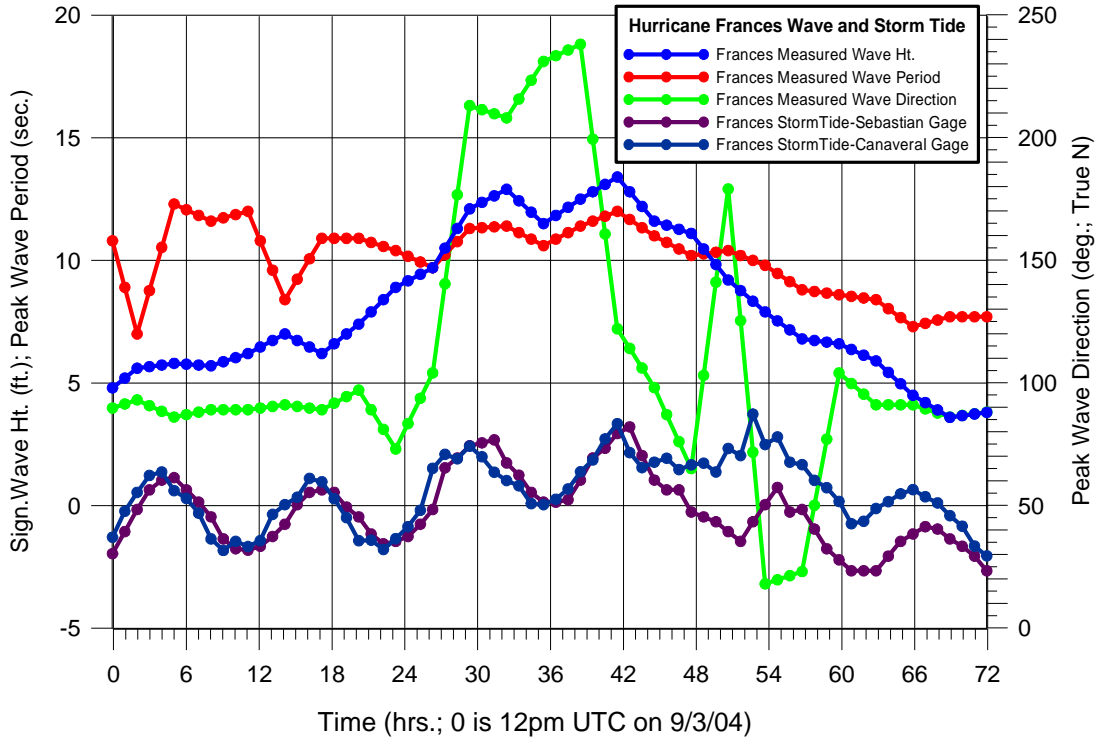


Figure 8. Measured wave conditions and storm tide at Sebastian gage and storm tide at the NOS Canaveral-Trident Pier tide gage

It is also noted that the graph on Figure 8 raises questions concerning the depicted wave direction measurements by the Sebastian gage during Hurricane Frances. The changes in wave direction during the 20-60 hour time interval in the graph are not considered to be realistic. These changes in wave direction during this time interval is not consistent with wind direction measurements from nearby sources including regional airports. The wave directions for Frances used in the SBEACH calibration work were based on average time series values for both North and South Reaches derived from Synthetic Wave Record (SWR) output described later in this report.

As described above, the graph of the measured wave and storm tide data for Jeanne from the Spessard gage are shown in Figure 9. The two storm tide records shown track very closely except that the Spessard storm tide is shown to be slightly higher than the Canaveral storm tide. The difference is likely the result of closer proximity of the Spessard gage to the location of the Hurricane Jeanne landfall.

For the model calibration work, the measured water elevation data from the Canveral NOS tide gage was used as storm tide input into SBEACH for Hurricane Frances. The measured wave conditions from the Sebastian gage for Frances were used for wave input into SBEACH. Adjustments to the wave heights were applied in order to better represent conditions along the Brevard County coast as will be discussed further below.

For the model calibration work, the measured water elevation data from the Spessard gage was used as storm tide input into SBEACH for Hurricane Jeanne. The measured wave conditions from the Spessard gage for Jeanne were used for wave input into SBEACH. As with Frances, adjustments to the wave heights were applied in order to better represent conditions along the Brevard County coast as will be discussed further below.

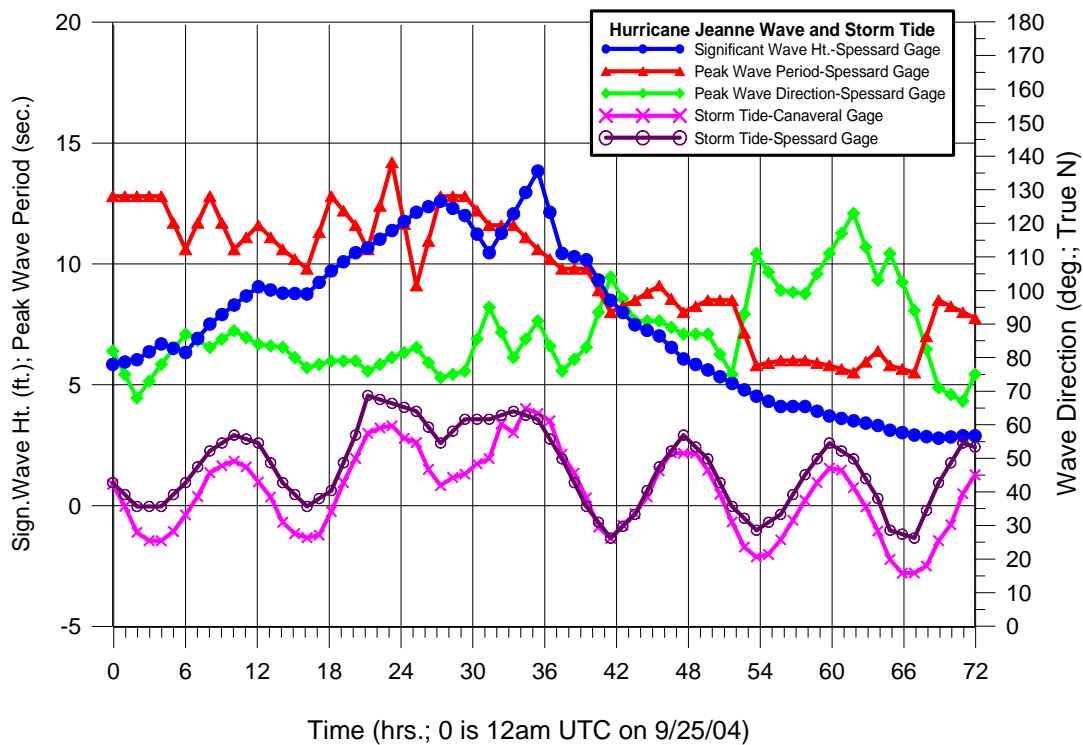


Figure 9. Measured wave conditions and storm tide at Spessard gage and storm tide at the NOS Canaveral-Trident Pier tide gage

Post-storm storm tide analysis reports for Hurricanes Frances and Jeanne by Wang and Manausa (2005) depict model generated peak storm tide elevations along the Brevard County coast. The peak elevations are reduced from south to north as distances increase from the location of storm landfall for both hurricanes. Based on storm tide measurements shown in Figure 8, no initial alongshore adjustment factors were applied to storm tide input used in SBEACH for Frances. However, alongshore reduction factors were applied to the storm tide measurements from the Spessard gage for Jeanne. These reduction factors were applied proportionally to the measured storm tide data based on

the model-generated peak storm tide elevations from Wang and Manausa. A depiction of the adjusted storm tide hydrographs for Jeanne used in the SBEACH calibration work at the calibration profile line locations is shown in the graph in Figure 10.

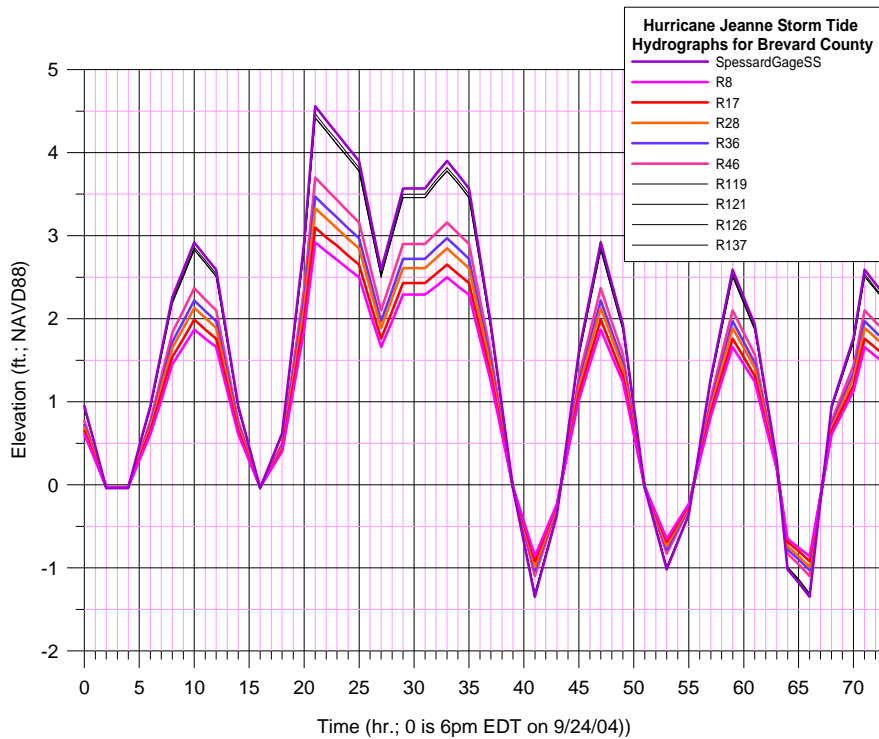


Figure 10. Measured storm tide at Spessard gage and adjusted storm tide hydrographs at calibration profile line locations.

2.1.a.iii Wave Data

Measured wave data used in the SBEACH calibration work is shown in Figures 8 and 9 above for Hurricanes Frances and Jeanne. Other than the questions regarding the wave direction measurements in Figure 8 discussed above, wave height, period, and direction measurements shown in these graphs are directly applicable for use in the calibration work. In fact, it is quite fortunate to have these measurements for these hurricanes at these locations with regard to model calibration work in Brevard County.

In addition to these gage measurements, nearshore wave hindcast output generated for the entire Brevard County Atlantic coast includes output information for both hurricanes as well. Surfbreak Engineering Sciences, Inc. (SES) was contracted to generate a 52-year wave hindcast database for Brevard County for the period January 1954 through December 2005 (SES, 2008). This Synthetic Wave Record (SWR) for Brevard County produced output including wave height, period, and direction values on 3 hour intervals at 200 stations along the approximate 10 m. (32.8 ft.) nearshore depth contour for the entire length of the Brevard County Atlantic coast. The illustration map in Figure 11 provides a depiction of these 200 SWR stations.

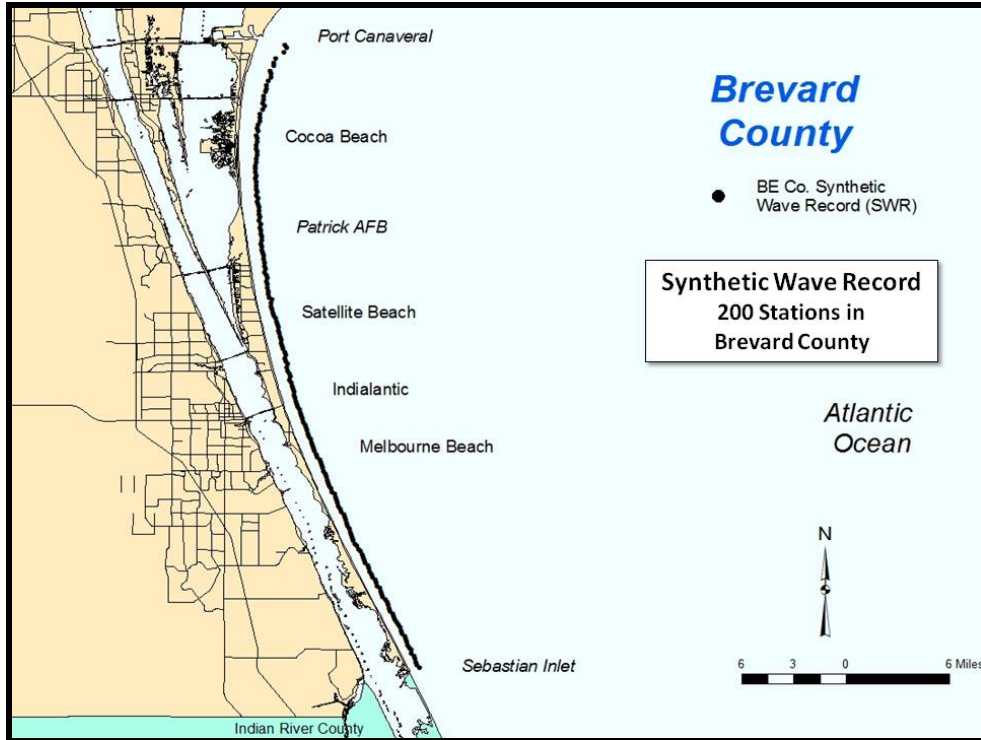


Figure 11. Location map of SWR stations along 10 m. depth contour in Brevard County.

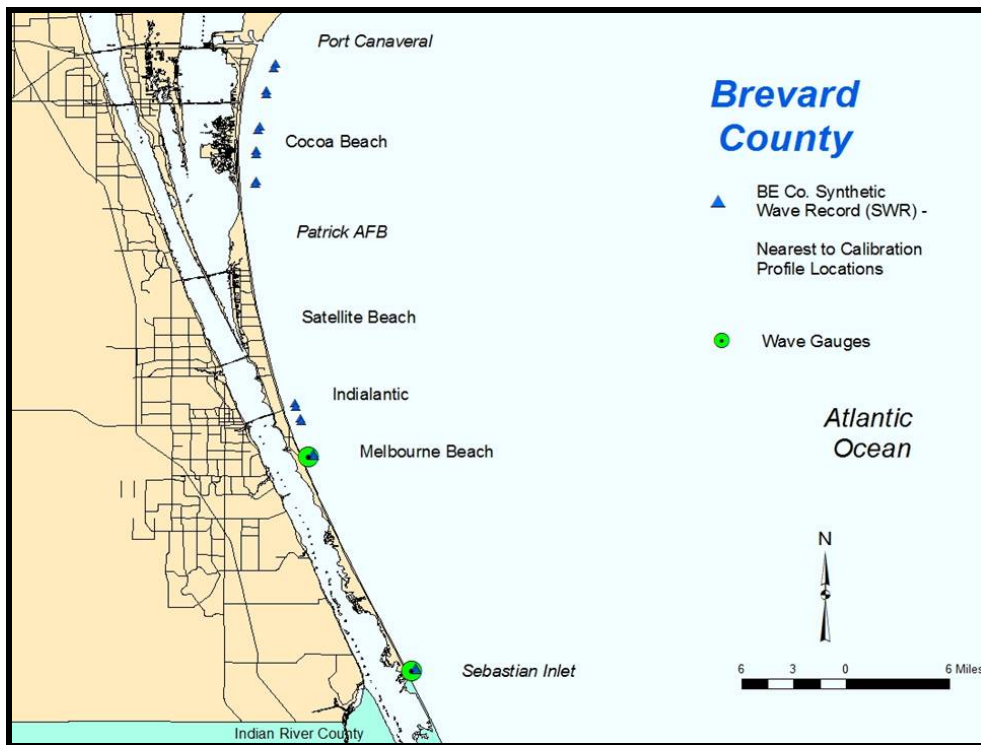


Figure 12. Map of SWR stations adjacent to calibration profiles and wave gages.

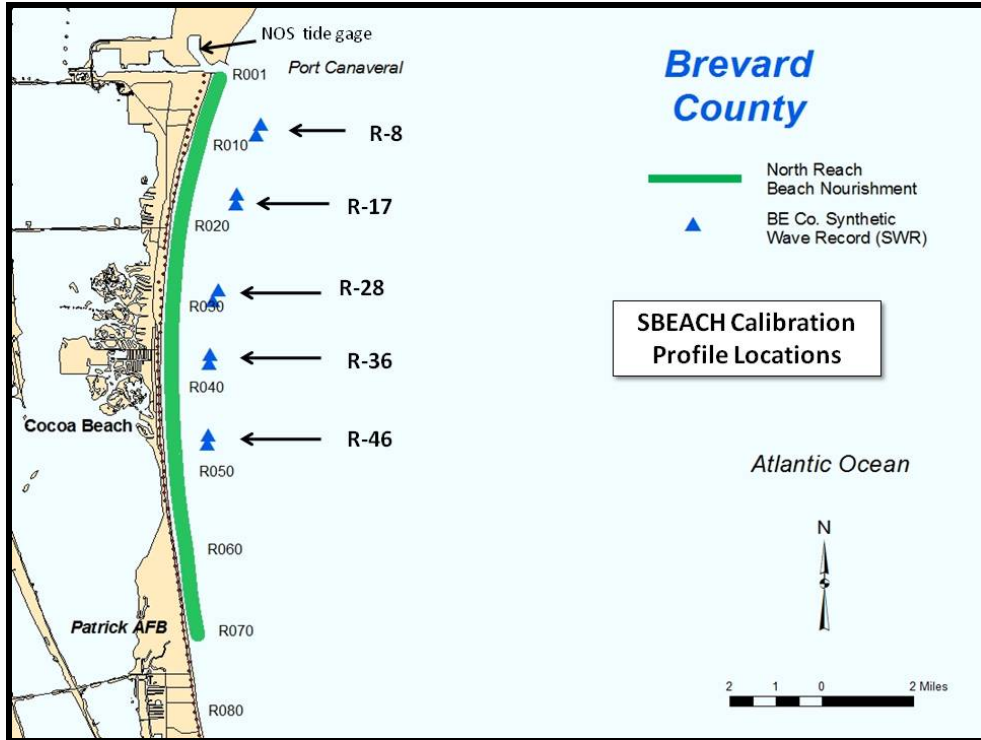


Figure 13. Map of SWR stations adjacent to calibration profiles in North Reach.

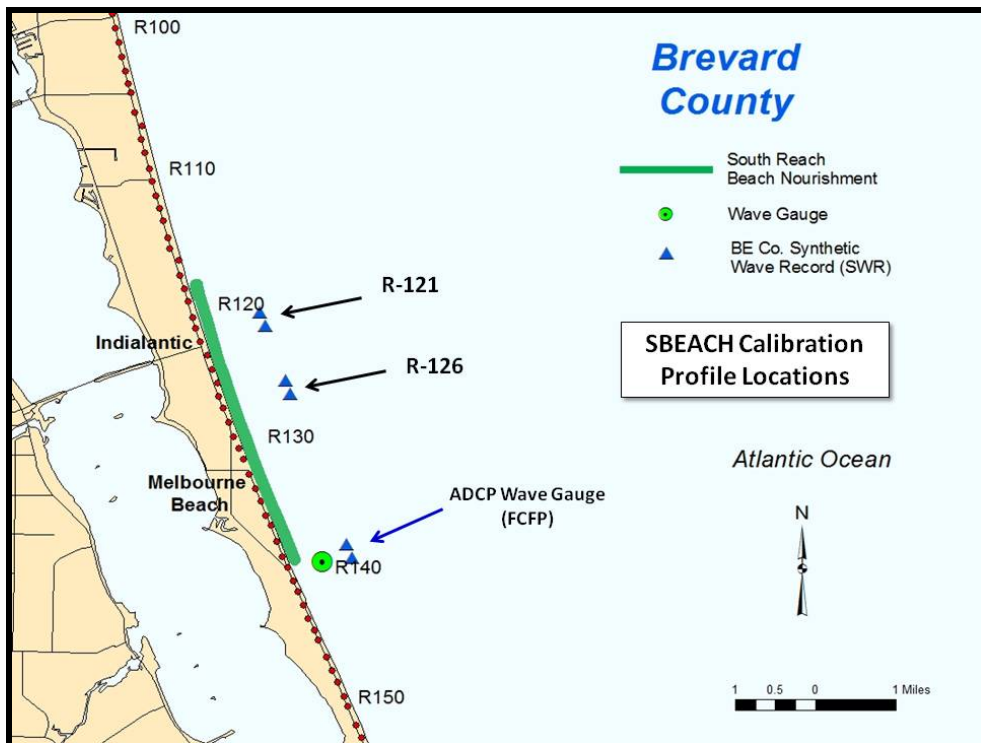


Figure 14. Map of SWR stations adjacent to calibration profiles in South Reach.

Computer program code was developed as a part of this SBEACH model calibration work in order to extract the wave height, period, and direction output, specifically for Hurricanes Frances and Jeanne, at specified alongshore station locations. The map in Figure 12 shows locations of SWR stations adjacent to the 7 calibration profile lines and the 2 wave gages where the SWR output was extracted. Weighted interpolation was applied to the extracted SWR output to obtain wave output coincident with the profile lines and gage locations. Closer views of these SWR stations adjacent to the calibration profile locations for the North Reach and South reach areas are shown in Figures 13 and 14, respectively.

Wave height output at these locations for Hurricane Frances superimposed with Frances wave height measurements from the Sebastian Gage are shown in Figure 15.

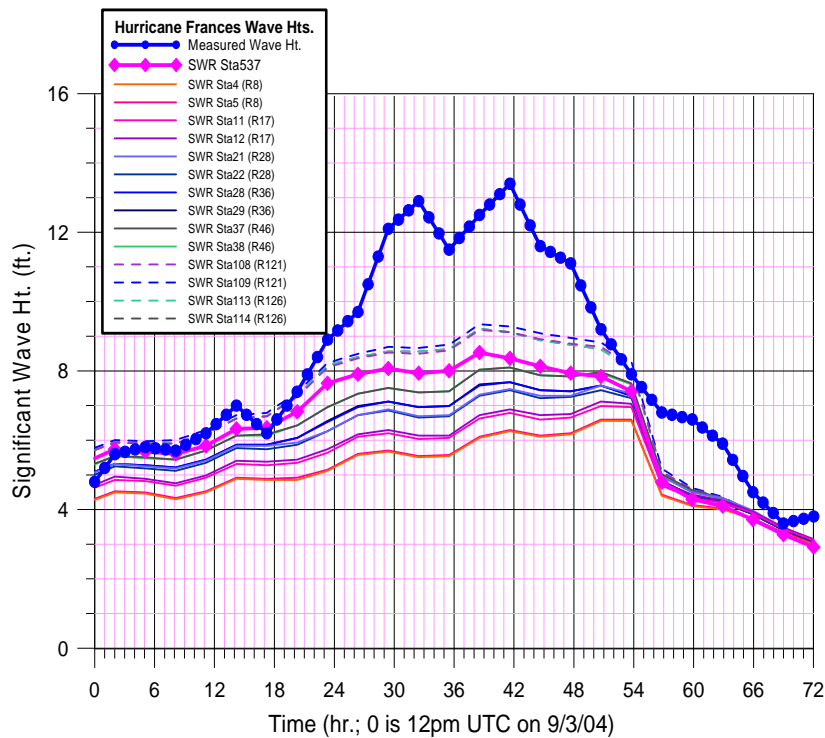


Figure 15. Measured wave heights from Sebastian gage and from SWR output.

The blue line in the graph in Figure 15 represents the measured wave heights for Frances from the Sebastian gage. The magenta line in the graph represents the SWR wave heights for Frances extracted at SWR Station 537 immediately adjacent to the Sebastian gage. As shown, the SWR wave heights show increased wave heights from Jeanne coincident with increased measured wave heights from the Spessard gage. However, the SWR heights do not correspond with the higher wave height values from the gage during the peak wave impact period of the hurricane.

The relative distribution of the SWR wave heights along the Brevard County coast is seen in Figure 15. The pairs of SWR wave height output on adjacent sides of each calibration profile line is shown in Figure 15. The wave heights are shown to be lower near the

north end of the County at R8, as would be expected, and increase southward through the North Reach. The SWR wave heights at the South Reach profile locations are actually higher than further south at the Sebastian gage location. The same occurrence is seen for Hurricane Jeanne as will be shown further below. In order to provide input wave condition for SBEACH that are considered to be the best representative wave conditions, the SWR alongshore distribution of wave conditions was applied in a relative manner to the measured wave conditions from the wave gages for both hurricanes.

The graph in Figure 16 shows wave heights for Hurricane Frances adjusted alongshore proportionally according to the SWR alongshore distribution. The proportional adjustments are based on relative comparisons of SWR values at peak wave heights during the storms. A similar procedure was applied for wave periods and wave directions.

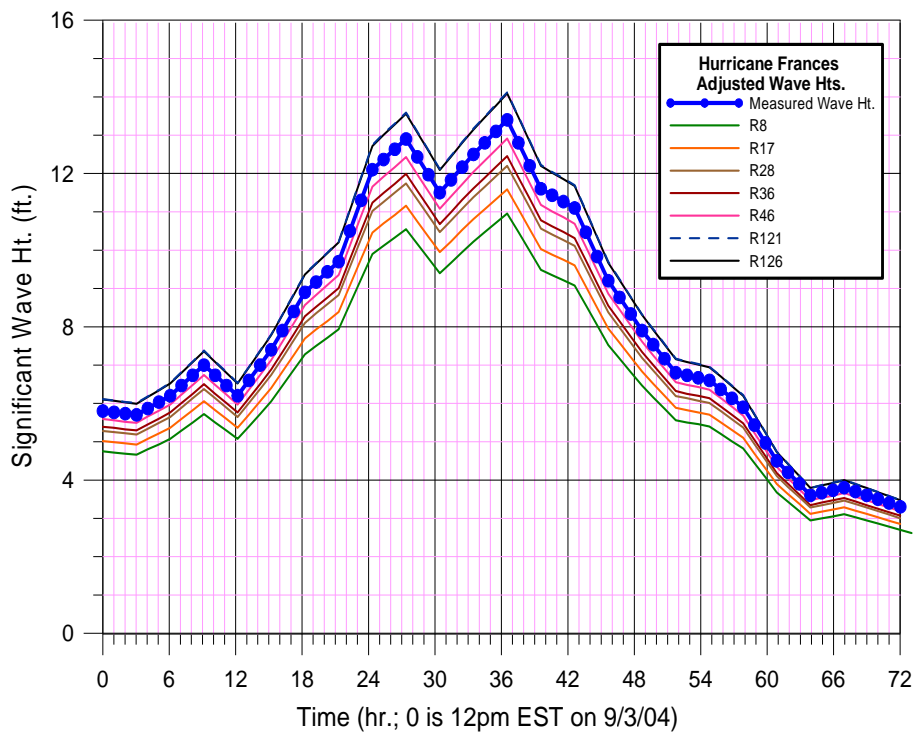


Figure 16. Wave heights for Frances from Sebastian wave gage and adjusted alongshore according to SWR wave height distribution.

Wave periods in the graph in Figure 17 are shown to be very consistent along the Brevard County coast at the calibration profile locations and relatively consistent with the measured values at the Sebastian gage. Therefore, based on Figure 17, the measured wave periods for Frances from the Sebastian gage were used as input in the SBEACH model calibration work. Based on previously described questions about the measured wave directions recorded by the Sebastian gage for Frances, average SWR wave direction output for the North Reach and South Reach shown in Figure 18 were used in SBEACH.

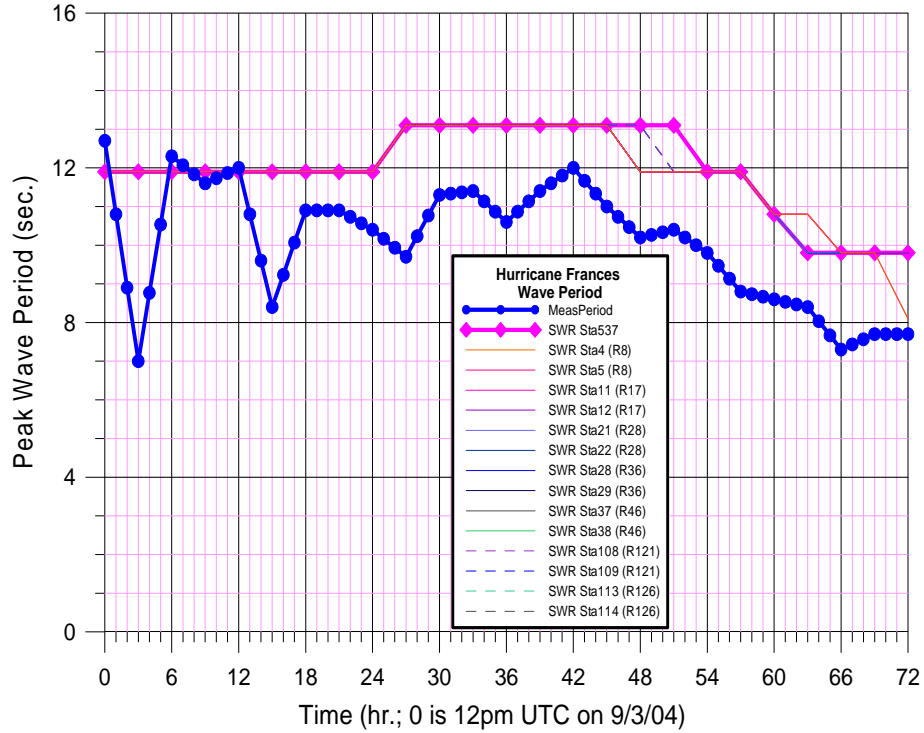


Figure 17. Wave periods for Frances from Sebastian gage vs. SWR wave periods.

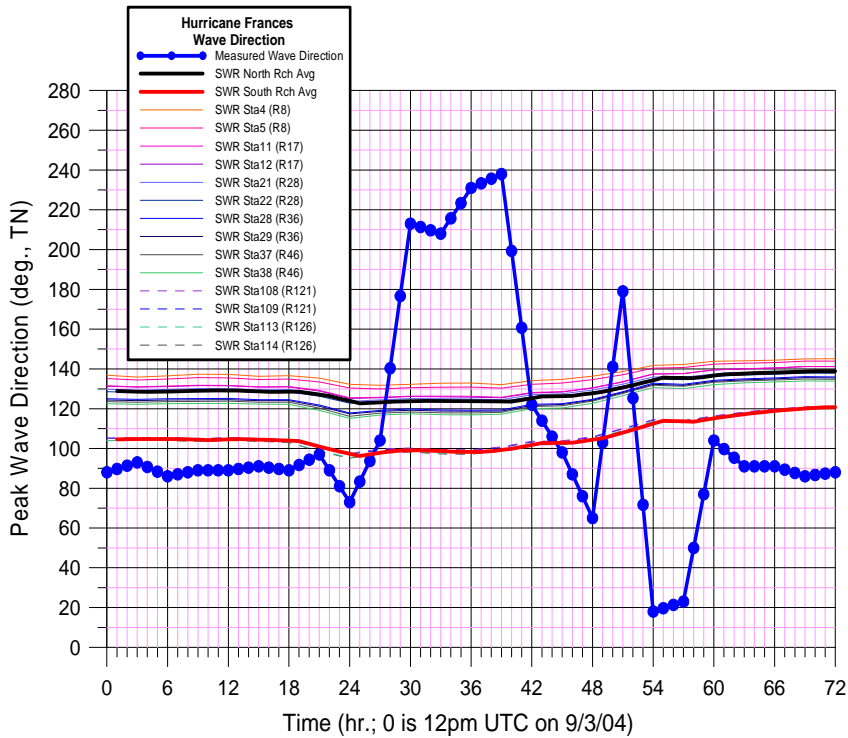


Figure 18. Wave directions for Frances from Sebastian gage vs. SWR wave directions.

Similar procedures to Hurricane Frances model input generation for SBEACH were applied for Hurricane Jeanne. Wave height output for Jeanne was extracted at the same SWR stations adjacent to the calibration profile line locations as shown in Figures 13 and 14. These SWR wave heights superimposed with wave height measurements for Hurricane Jeanne from the Spessard gage are shown in Figure 19.

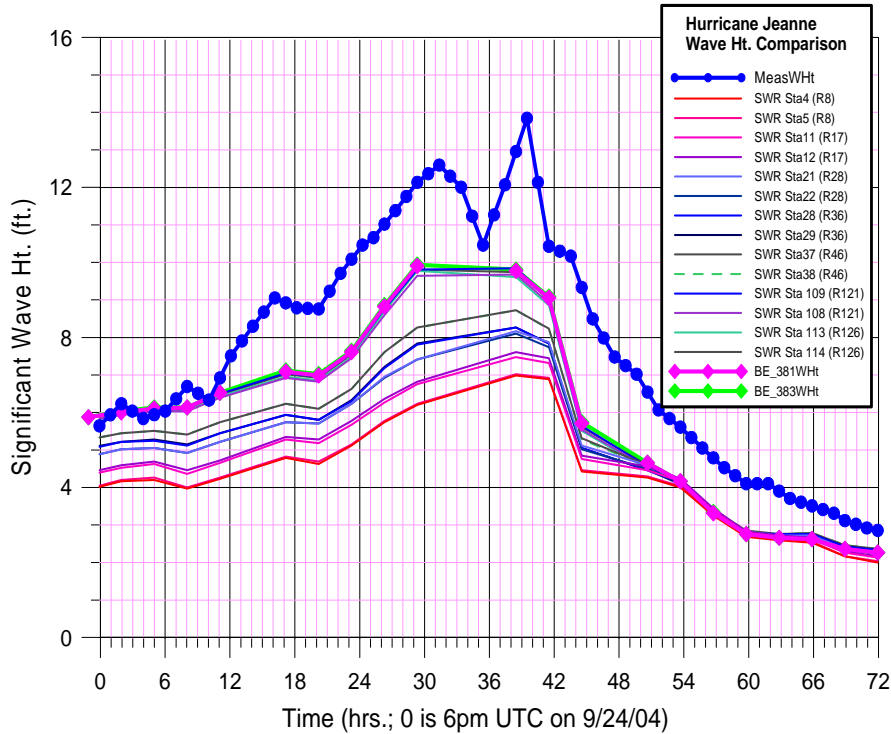


Figure 19. Measured wave heights from Spessard gage and from SWR output.

As with Frances, the blue line in the graph in Figure 19 represents the measured wave heights for Jeanne from the Spessard gage. The heavy magenta and green lines with data points in the graph represent the SWR wave heights for Jeanne extracted at the two SWR stations immediately adjacent to the Spessard gage. As with Frances, the SWR wave heights shown in Figure 19 show increased wave heights from Jeanne coincident with increased measured wave heights from the Spessard gage. However, as with Frances, the SWR heights do not correspond with the higher wave height values from the gage during the peak wave impact period of the hurricane.

The relative distribution of the SWR wave heights along the Brevard County coast is seen in Figure 19. The pairs of SWR wave height output on adjacent sides of each calibration profile line is shown in Figure 19. The wave heights are shown to be lower near the north end of the County at R8, as would be expected, and increase southward through the North Reach. The SWR wave heights at the South Reach profile locations, which are very near the Spessard gage, are shown to be essentially the same as the SWR wave heights at the SWR stations closest to the wave gage. As with Frances, in order to provide input wave condition for SBEACH that are considered to be the best representative wave conditions for Hurricane Jeanne, the SWR alongshore distribution of

wave conditions for Jeanne was applied in a relative manner to the measured wave conditions for Jeanne from the Spessard wave gage.

The graph in Figure 20 shows wave heights for Hurricane Jeanne adjusted alongshore proportionally according to the SWR alongshore distribution. As with Frances, the proportional adjustments are based on relative comparisons of SWR values at peak wave heights during the storms. A similar procedure was applied for wave periods and wave directions for Jeanne.

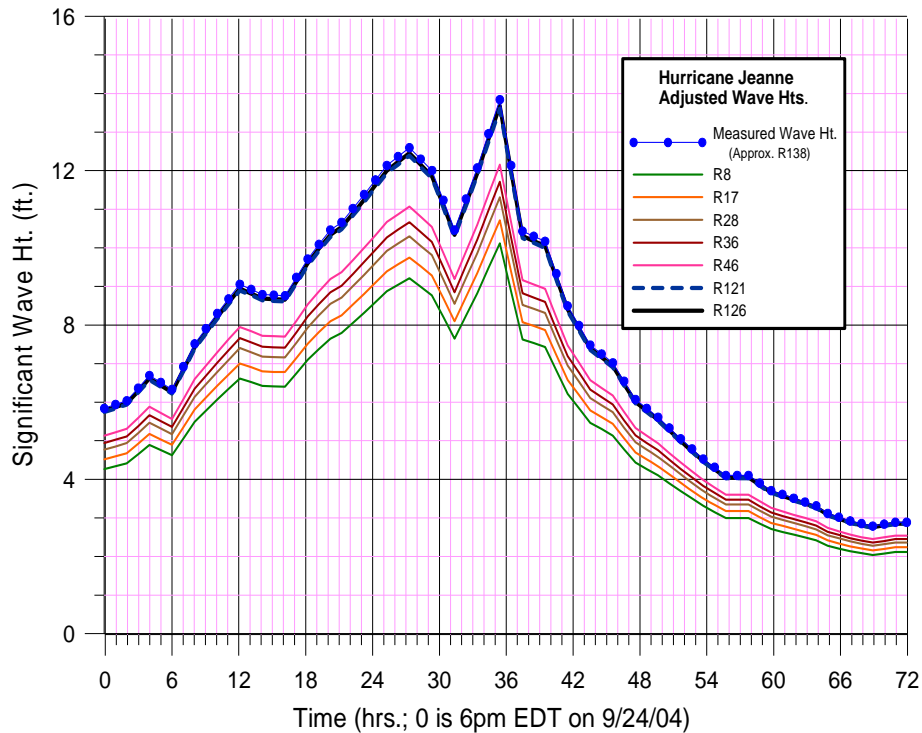


Figure 20. Wave heights for Jeanne from Spessard wave gage and adjusted alongshore according to SWR wave height distribution.

It is noted that wave heights shown in Figure 20 at the two calibration profile locations within the South Reach area, at R121 and R126, are essentially identical to the measured wave heights at the Spessard gage. This is the result of the close proximity of the profile locations to the gage location.

Wave periods in the graph in Figure 21 are shown to be very consistent along the Brevard County coast at the calibration profile locations and relatively consistent with the measured values at the Spessard gage. Therefore, based on Figure 21, the measured wave periods for Jeanne from the Spessard gage were used as input in the SBEACH model calibration work. As shown in Figure 22, the SWR wave directions are very consistent in both the North and South Reach areas. The averages shown for each Reach represent those areas well. The average for the South Reach is very close to the measured directions from the Spessard gage. Based on Figure 22, the average SWR wave direction values for each Reach are used as input for SBEACH calibration work.

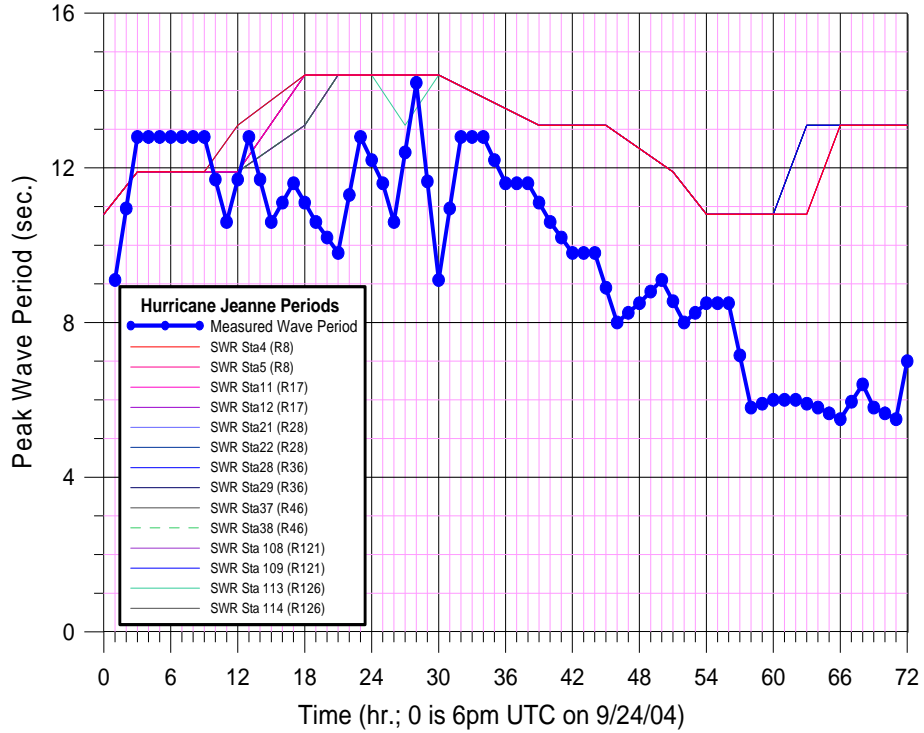


Figure 21. Wave periods for Jeanne from Spessard gage vs. SWR wave periods.

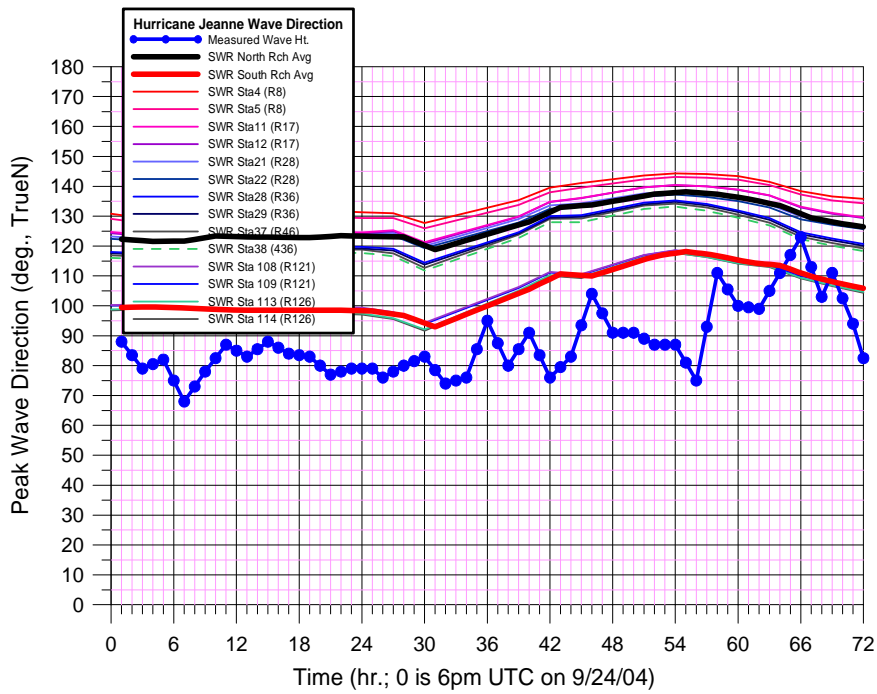


Figure 22. Wave directions for Jeanne from Spessard gage vs. SWR wave directions.

2.1.b Model Input Parameters

Primary input information required for application of the SBEACH model include data and information related to the coastal reach where the model is applied and to specific coastal storm conditions. The specific storm tide and wave data described previously above were incorporated into the SBEACH model for the required storm input. Required reach data included the topographic/ bathymetric survey data for the Brevard County study area for model calibration evaluation and other site-specific data and information, including sediment grain size and water temperature.

Other required reach-specific parameters include sediment transport parameters. The sediment transport parameters may be adjusted within recommended range of values limits. Adjustment of these values may assist in achieving improved model calibration.

A set of default values for the sediment transport parameters and other reach parameters is provided within the SBEACH model software. The default values and recommended range of values for reach-specific parameters including sediment transport parameters are listed in Table 1 below.

Specific parameter units are also shown in Table 1. Sensitivity evaluation was conducted in previous SBEACH calibration work in Panama City Beach (2009) by adjustment of each of the reach sediment transport parameters and other reach parameter variables throughout the range of values. Sensitivity testing also included evaluation of variations in reach (beach and offshore profiles) grid size and model execution time step. Sensitivity of including storm wind effects, as well as, utilizing wave randomization were also evaluated.

Results of the previous calibration work and sensitivity testing in Bay County (Leadon, Nguyen, 2009) assisted in the selection of input parameters for calibration work in Brevard County.

Table 1. Listing of SBEACH Input Parameters

Sediment Transport Parameters	Default Value	Range of Recommended Values
Transport rate coefficient, K	$1.75 \text{ e}^{-006} \text{ (m}^4/\text{N)}$	$0.25 \text{ e}^{-006} - 2.5 \text{ e}^{-006}$
Overwash transport parameter	0.005	0.002 - 0.008
Coefficient for slope dependent term, ϵ	$0.002 \text{ (m}^2/\text{s)}$	0.001 - 0.005
Transport rate decay coeff. multiplier, λ	$0.5 \text{ (m}^{-1}\text{)}$	0.1 - 0.5
Water temperature	20 (deg C)	0 - 40
Other Coastal Reach Parameters		
Landward surf zone depth	0.3 (m)	0.15 - 0.5
Effective grain size (mean D50)	0.35 (mm)	0.15 - 1.0
Maximum slope prior to avalanching	45 deg	15 - 90 deg

2.1.c Model Calibration Results

Results of previous sensitivity evaluation performed in Bay County described above were applied in initial SBEACH calibration work in Brevard County. Application of these previous results to Brevard County work resulted in setting most all of the reach input parameters at the default values for initial calibration work. However, as with Bay County, it was determined that improved model calibration results for Brevard County were achieved by increasing the transport rate coefficient parameter, K , and the coefficient for slope dependent term, ϵ , to the maximum values within the recommended range of values.

Therefore, a K value of 2.5×10^{-6} (m^4/N) and an ϵ value of 0.005 was used for the final model calibration for Brevard County. It is noted that vertical elevations for the model calibration evaluation work in Brevard County is in NAVD88. Other site-specific, storm-specific parameter values used in the calibration included sediment grain size which was based on data from the Brevard County beach restoration project. Sediment grain size from project data provided by the FDEP-BBCS and used in the SBEACH calibration work was set at 0.3 mm. Water temperature of 27 (deg C) used in Bay County was also used for Brevard County and other Atlantic coast counties.

It is noted that the model calibration evaluation in this study is focused on and, therefore, essentially limited to the upland beach and dune portions of the evaluated profiles. Detailed comparisons and analyses of measured versus computed profile response to the storm event simulations in offshore portions of the profiles were not conducted herein.

It is also noted that initial sensitivity testing in Bay County with wind speed and direction varied over a wide range of input conditions resulted in a conclusion that including wind effects in the model would not significantly alter the model results. Therefore, wind data for Opal and Ivan were not added to the storm input in SBEACH.

It was determined that the Sebastian and Spessard wave gages which measured wave and storm tide conditions through Hurricanes Frances and Jeanne, respectively, were located in water depths seaward of influences of wave set-up. Therefore, storm tides measured by these gages for these hurricanes are not considered to include any wave set-up effects. The gages were located in approximately 28 to 32 ft. (NAVD) water depths. Observation of SBEACH calibration work results show wave set-up effects computed by the model to be limited to locations within approximately 15-20 ft. (NAVD) water depths.

Further, storm tide measured by the NOS tide gage at the Canaveral Trident Pier and used in Hurricane Frances model simulations is shown in Figures 8 and 9 of this report to be consistent with storm tide measurements by the Sebastian and Spessard gages. It is also noted that the Canaveral gage is located in a turning/docking basin within the inlet sheltered and protected from wave effects.

As a result, there were no concerns regarding separating out wave set-up from the measured storm tide before conducting SBEACH calibration work, as was performed in

the Bay County model calibration work. No adjustments/reductions to the measured storm tide values from these two gages were required with regard to wave set-up influences being included in the measured storm tide, as was conducted in the Bay County calibration work.

Hurricane Frances Calibration Results

Based on the final model input values described above, initial model calibration results for Hurricane Frances were found to show fair agreement between measured and computed storm-generated erosion. Comparison of horizontal beach berm profile recession at one foot elevation contour intervals was conducted in the calibration evaluation. Average contour recession values for the 7 profiles evaluated for Frances are shown in Figure 23. As seen in Figure 23, contour recession from SBEACH (red line) under-eroded the measured recession (blue line) by a significant amount.

A review of maximum water elevation values from SBEACH output at each of the calibration profiles showed significantly lower peak storm tide elevations than values reported from the studies by Wang and Manausa (2005). The peak storm tide elevations from Wang and Manausa were model-generated based on specific hurricane-related parameters of Frances and Jeanne. As a result of the significant differences in the SBEACH and the Wang and Manausa peak storm tide elevations, a second iteration of calibration testing work was performed. For this additional testing work, the storm tide input from the initial calibration work was adjusted/increased a sufficient amount to produced maximum water elevation output from SBEACH very similar to peak storm tide values from Wang and Manausa.

Results of this second iteration calibration testing produced significantly better agreement between the SBEACH contour recession and the measured contour recession. In fact, these results show excellent agreement. The contour recession from SBEACH from this second iteration testing is shown in the graph in Figure 23 (green line). These results are considered to be valid calibration test results since the Wang and Manausa peak storm tide values are base on measured hurricane parameters including forward speed of the hurricane, radius to maximum wind, barometric pressure deficit, and storm track.

A graph is shown in Figure 24 of maximum (peak) water elevations from the initial calibration results at each calibration profile location, peak elevations from the Wang and Manausa report interpolated to the calibration profile locations, and the resulting elevations from the second iteration calibration testing as described.

In addition to the SBEACH-computed erosion shown in Figure 23 based on the measured wave data from Frances, computed erosion is also shown in Figure 23 based on constant wave input (cyan blue line). Model sensitivity testing was performed with constant wave input for comparison with the measured wave data results. A number of constant wave conditions in addition to default values given in SBEACH were evaluated. Wave heights of 10, 12, and 14 feet in combination with wave periods of 8, 9, 10, 12, and 14 seconds were evaluated. A wave height of 12 feet and wave period of 9 seconds resulted in the

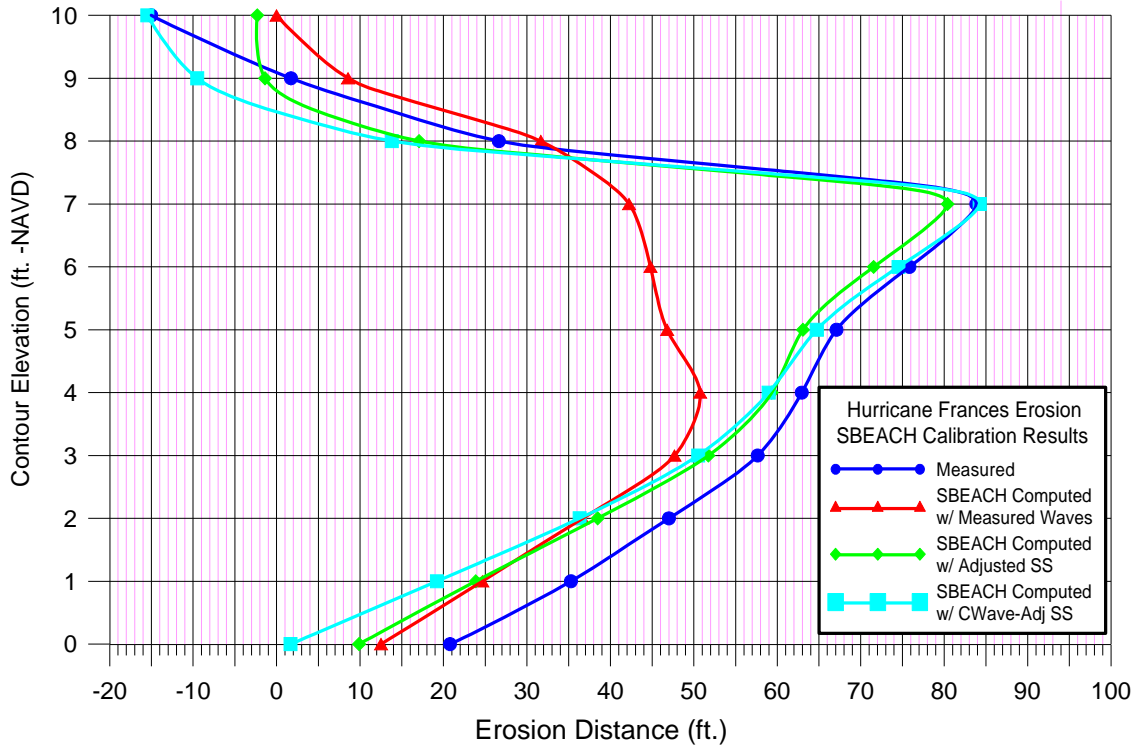


Figure 23. Pre- & post-Frances measured vs. computed erosion for SBEACH calibration

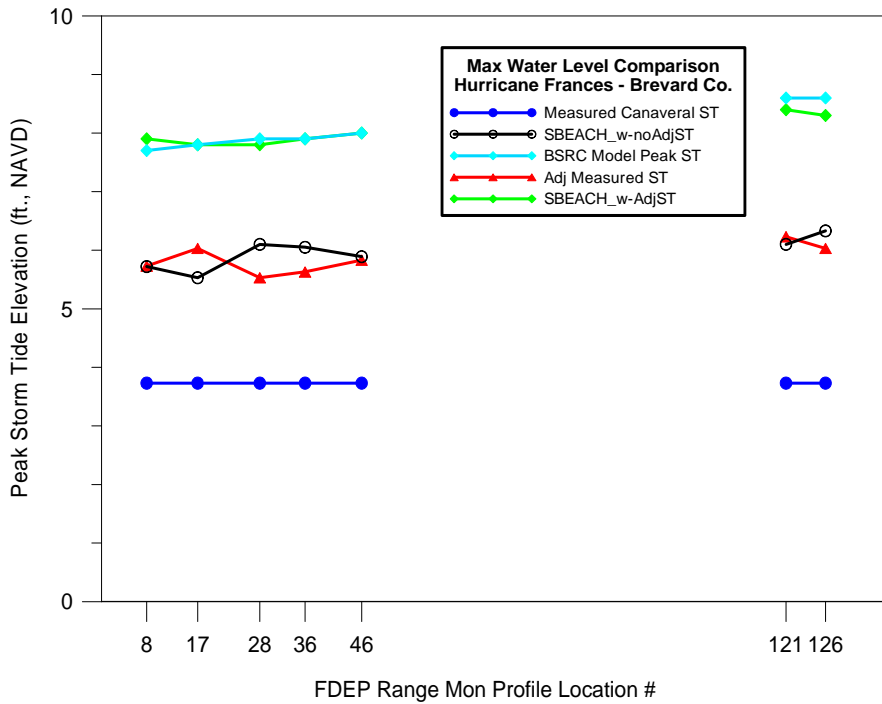


Figure 24. Measured and adjusted peak storm tide with initial and second iteration SBEACH max water elevation output vs. BSRC peak elevations

best agreement with the measured contour recession, as well as, with the SBEACH computed recession using the measured (adjusted) Frances wave data as model input.

The peak storm tide values reported by Wang and Manausa suggest associated storm return period for Frances in the Brevard County North and South Reach area locations of approximately 25-50 years. As such, it is noted that the peak storm tide elevations which occurred in Brevard County may have produced beach and dune erosion which is characteristic of a storm of greater return period than a 15-25 year high-frequency storm. However, the favorable calibration results for Frances are considered to be sufficient basis for use of the SBEACH model with the associated input parameters in high-frequency storm erosion analyses in central Atlantic coast counties in Florida.

Hurricane Jeanne Calibration/Verification Results

Based on the final model input values used in the Frances calibration, SBEACH model calibration/verification for Hurricane Jeanne was found to show good agreement between measured and computed storm-generated erosion. Comparison of horizontal beach berm profile recession at one foot elevation contour intervals was conducted in the Jeanne calibration/verification work. Average contour recession values for the 7 profiles evaluated for Jeanne are shown in Figure 25. As seen in Figure 25, contour recession from SBEACH (red line) compared well overall with the measured recession (blue line). The recession results using the measured wave conditions from the Spessard gage, adjusted to the specific calibration profile locations, show better comparison with the measured recession than the recession using constant wave input (green line). The same constant 12 ft. wave height 9 sec. wave period used for Hurricane Frances was used for Hurricane Jeanne.

Maximum water elevation values from SBEACH at each of the calibration profile locations compared favorably with the peak storm tide elevations reported by Wang and Manausa (2005). The maximum water elevations for Jeanne from SBEACH were higher than peak storm tide elevations from Wang and Manausa by an average of less than one foot. No second iteration SBEACH model simulations with adjusted storm tide elevations were performed as part of the Jeanne calibration/verification work.

It is noted that the 7 pre-Jeanne profiles used in the Jeanne SBEACH simulations were the same 7 post-Frances profiles surveyed by Brevard County. Hurricane Jeanne made landfall along the Florida Atlantic coast only 18 days after the post-Frances profile lines were surveyed. As such, these post-Frances surveyed lines serve well as pre-Jeanne profile surveys. However, it is also noted that these profiles were in a post-storm (Frances) eroded condition. This resulted in much less measured, and modeled, contour recession from Hurricane Jeanne as shown in Figure 25 compared to Hurricane Frances as shown in Figure 23. The peak storm tide elevations from Brevard County for Hurricane Jeanne correspond to high-frequency storm tide elevations for this coastal region. These model calibration results for Hurricane Jeanne further support use of SBEACH with the selected model input for high frequency storm simulations for this area. A summary listing of SBEACH model input parameters used in the Brevard County

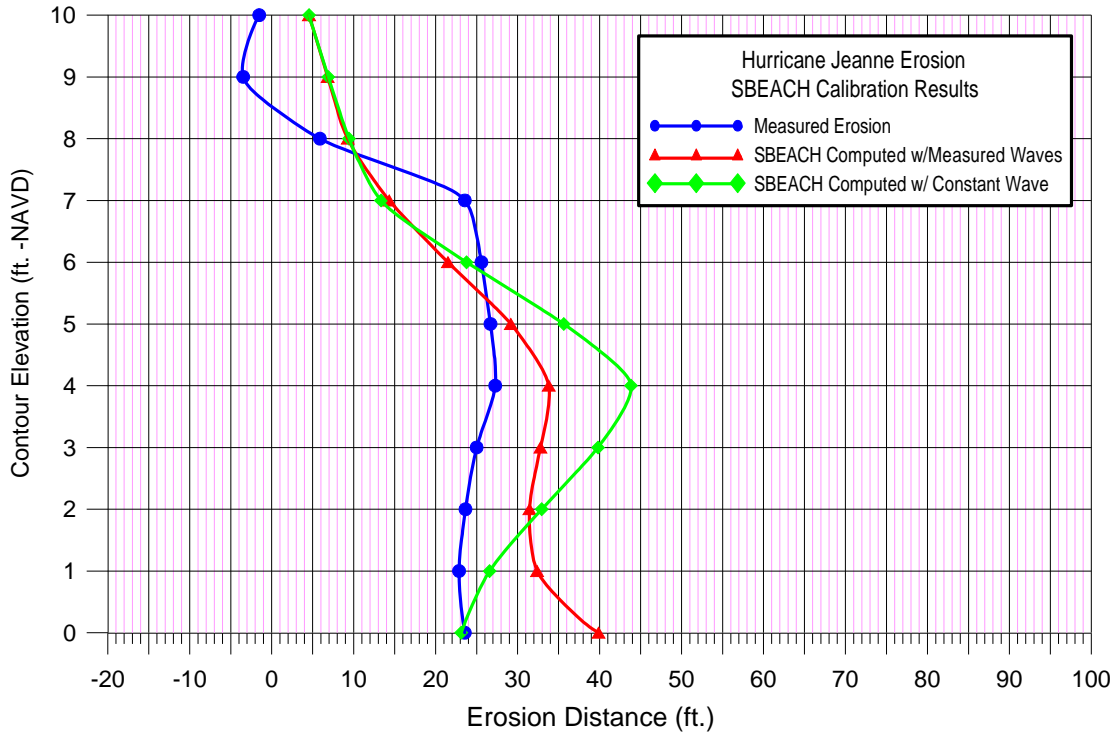


Figure 25. Pre- and post-Jeanne measured vs. computed erosion for SBEACH calibration model calibration/verification evaluation work with storm tide and wave data from Hurricanes Frances and Jeanne is listed below in Table 2.

Table 2. SBEACH Input Parameters Used in Model Calibration/Verification Work in Brevard County

Sediment Transport Parameters	Input Values Used in Brevard Co. Calibration/Verification Work
Transport rate coefficient, K	$2.5 \times 10^{-6} \text{ (m}^4/\text{N)}$
Overwash transport parameter	0.005
Coefficient for slope dependent term, ϵ	$0.005 \text{ (m}^2/\text{s)}$
Transport rate decay coeff. multiplier, λ	$0.5 \text{ (m}^{-1}\text{)}$
Water temperature	27 (deg C)
Other Coastal Reach Parameters	
Landward surf zone depth	0.3 (m)
Effective grain size (mean D50)	0.30 (mm) (N & S Reaches)
Maximum slope prior to avalanching	45 deg

Graphic plots of the measured pre- and post-storm profiles and SBEACH-generated post-storm erosion profiles are provided in Appendix I of this report documentation. Three sets of plots are provided in Appendix I, two sets for the Hurricane Frances calibration work and one for the Hurricane Jeanne calibration work.

2.2 St. Johns County Model Calibration

As a result of the initial screening process described earlier in Section 2.0, it was found that sufficient storm-related data and information for additional SBEACH calibration work was available for St. Johns County. It was also decided that model calibration work in St. Johns County would be particularly applicable for use in model application in two of the three target study counties; St. Johns and Volusia. St. Johns County is adjacent to Volusia County to the south and has some characteristic similarities to Volusia County adding to applicability of the additional calibration results.

2.2.a Measured Storm Data

An extratropical storm in the Atlantic Ocean off the coast of Florida during the Thanksgiving weekend in November 1984 caused severe beach and dune erosion along much of the Florida east coast. Two images in Figure 26 depict the '84 Thanksgiving Storm on November 23, 1984. The storm was at its most intense on November 23rd and 24th. A previous beach-dune erosion model calibration study by Dean, Chiu, and Wang (1993) for the CCCL erosion model used the Thanksgiving Storm and related data for model calibration. Related beach and dune profile survey data was obtained after the Thanksgiving Storm by the FDEP-BBCS at a number of FDEP range locations throughout St. Johns County. The FDEP-BBCS post-Thanksgiving Storm profile data was also used in this SBEACH calibration work. Other Thanksgiving Storm related information from the 1993 study was used in this SBEACH evaluation study also as will be described further below.

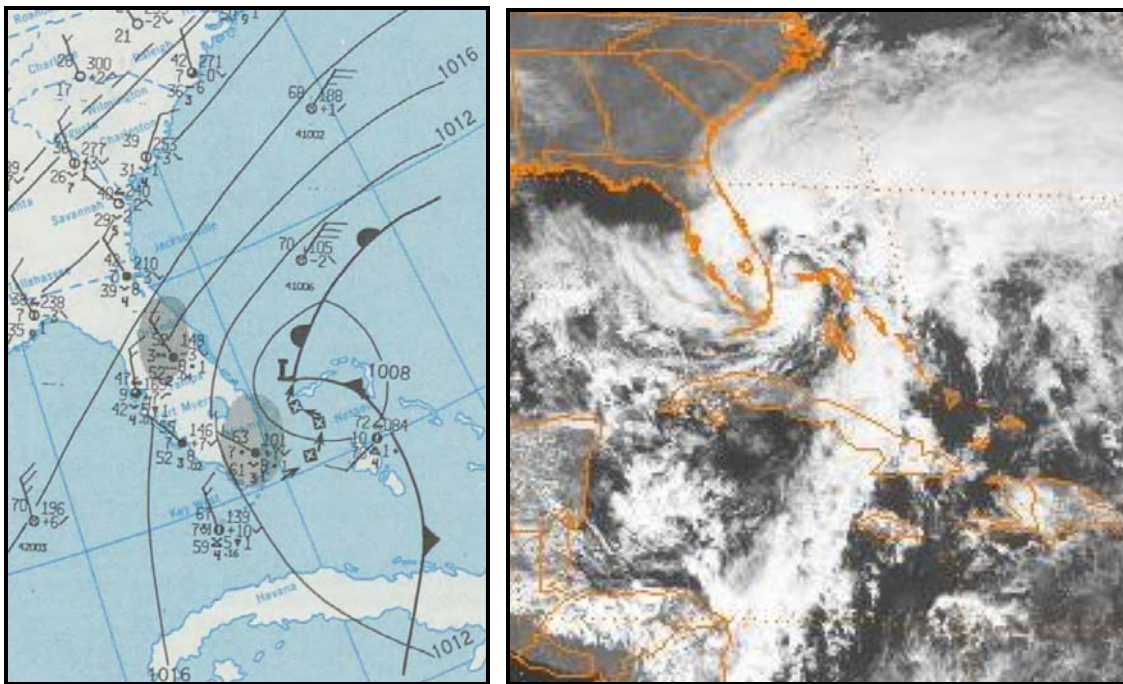


Figure 26. Archived November 23, 1984 weather map and satellite photo depicting Thanksgiving “Nor’easter” Storm off the SE coast of Florida.

The FDEP-BBCS pre- and post-Thanksgiving Storm survey data extends throughout St. Johns County. Initial review of this data clearly reflected a coastal area with considerable variation in beach profile slopes and shapes, and extent of beach and dune erosion. More discussion related to this survey data will be given in Section 2.2.a.i further below.

Storm tide information for input into SBEACH for model calibration work in St. Johns County was obtained from hydrographs developed by Dean, Chiu, and Wang (1993) in high-frequency model calibration studies. The 1993 study developed model-generated storm tide hydrographs for the 1984 Thanksgiving Storm. Three sets of hydrographs were developed and will be described in Section 2.2.a.ii further below.

Water depth data was obtained from a wave gage installed and maintained offshore of Marineland near the south St. Johns County line. The gage was installed and maintained in approximately 30 foot water depths by the University of Florida as a part of the Coastal Data Network (CDN) system. However, as described in the 1993 study referenced above, there are limitations with use of the water depth data from this gage for representing storm tide.

Wave data obtained by the CDN gage at Marineland data for the Thanksgiving Storm was also considered to have limitations for direct application as input for the SBEACH calibration work. As mentioned in the 1993 study report, the data was obtained at 6 hour intervals, so not providing a more complete time series of wave conditions optimal for erosion model calibration. The CDN wave data does serve as a benefit in validating other available wave information sources.

Such an available wave information source is the Wave Information Study (WIS) wave hindcast database compiled and administered by the U. S. Army Corps of Engineers-Coastal and Hydraulics Laboratory (CHL). The 1993 study report referenced above provides validation of the WIS wave heights in comparison with wave heights from the CDN Marineland gage. Further description of use of the WIS database in the SBEACH model calibration work will be described in Section 2.2.a.iii further below.

In addition, shallow water (10 m.) nearshore wave hindcast information generated through STWAVE wave transformation modeling and output at 200 alongshore stations in St. Johns County included wave information for the 1984 Thanksgiving Storm. This Synthetic Wave Record (SWR) developed by Surfbreak Engineering Sciences, Inc. for the FDEP-BBCS (SES, 2009) provided the same wave information for St. Johns County as was provided for Brevard County shown earlier in this report. The SWR wave information will be described further in Section 2.2.a.iii further below.

2.2.a.i Hydrographic Survey Data

As described above, the FDEP-BBCS obtained post-storm beach and offshore profile surveys throughout St. Johns County along many of the FDEP range lines following the Thanksgiving Storm. A total of 118 profile lines were surveyed in St. Johns County by the BBCS after the Thanksgiving Storm. The post-storm profile

surveys were obtained in early December 1984 for comparison with pre-storm profiles from May/June 1984. Profile lines for initial calibration work were selected from several coastal segments within the County based on the available post-storm survey data and varying beach conditions observed throughout the County. A map illustration depicting the location of these coastal segments used for initial model calibration work is shown in Figure 27.

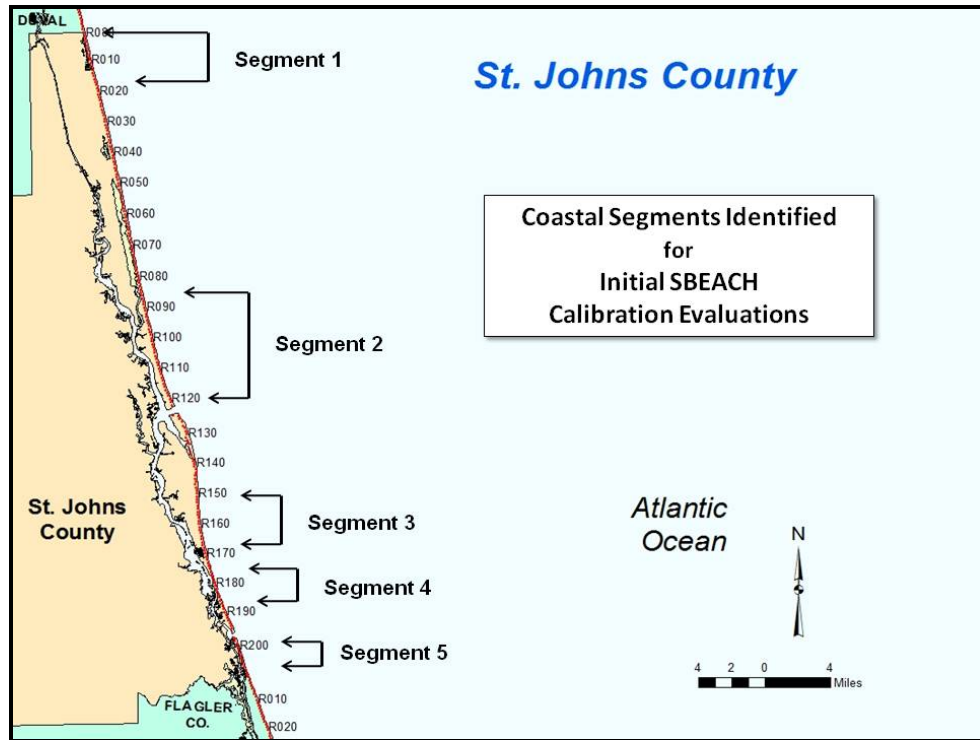


Figure 27. Profile locations for SBEACH model calibration in St. Johns County.

Specific FDEP range line locations for the 35 profiles evaluated within the identified coastal segments displayed above are shown in Figures 28 and 29. The profiles used in the initial calibration were used to conduct sensitivity testing of sediment transport parameters within SBEACH and beach parameters, such as sediment grain size and maximum slope prior to avalanching.

Following initial calibration work, a more comprehensive model calibration was conducted using profile data from all 118 range locations surveyed after the 1984 Thanksgiving Storm. The locations of the 118 profile locations are shown in Figures 30 and 31. Input parameters obtained through the initial calibration work were applied in the more comprehensive calibration work.

More discussion of model input parameters and sediment grain size evaluation, as well as, presentation of the initial and comprehensive calibration results will be provided in Sections 2.2.b and 2.2.c further below in this report.

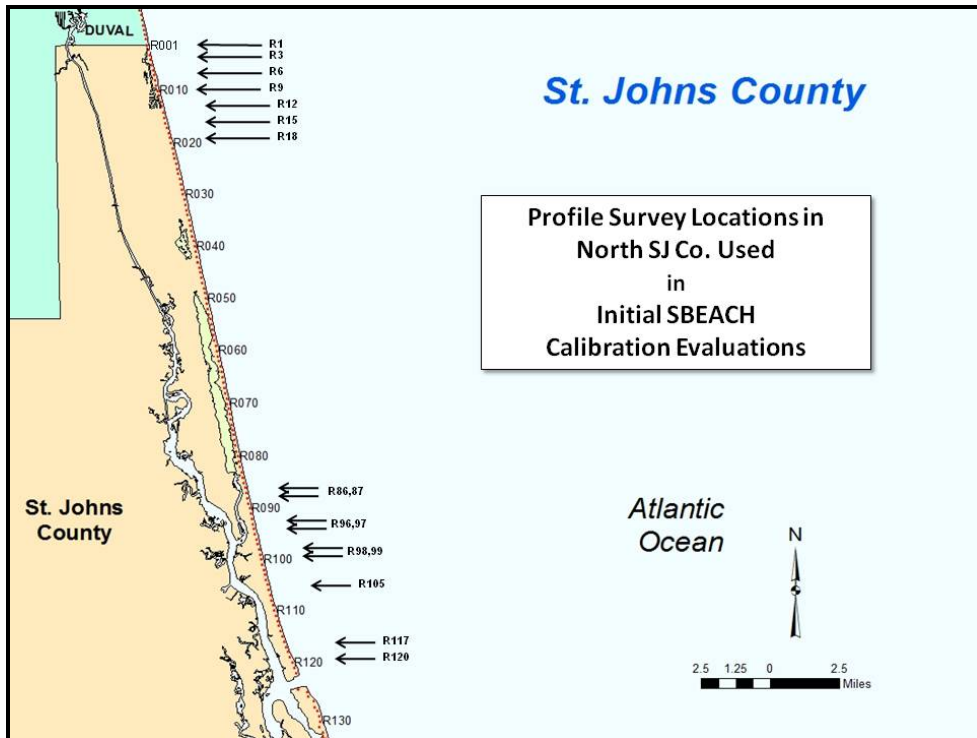


Figure 28. Profile locations for initial SBEACH calibration in north St. Johns County.

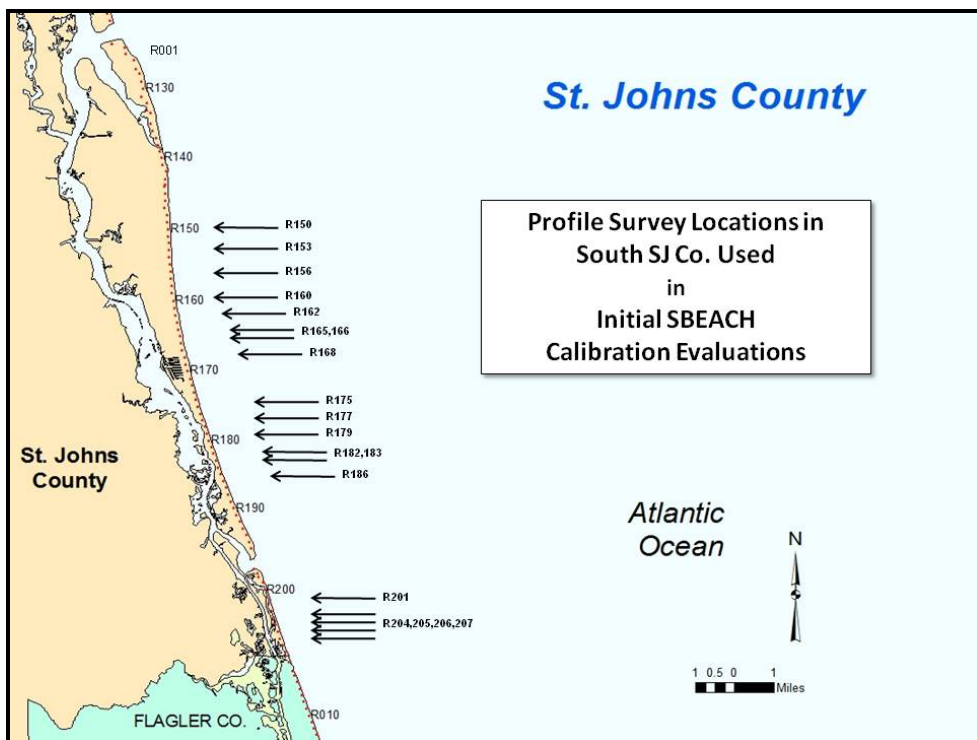


Figure 29. Profile locations for initial SBEACH calibration in south St. Johns County.

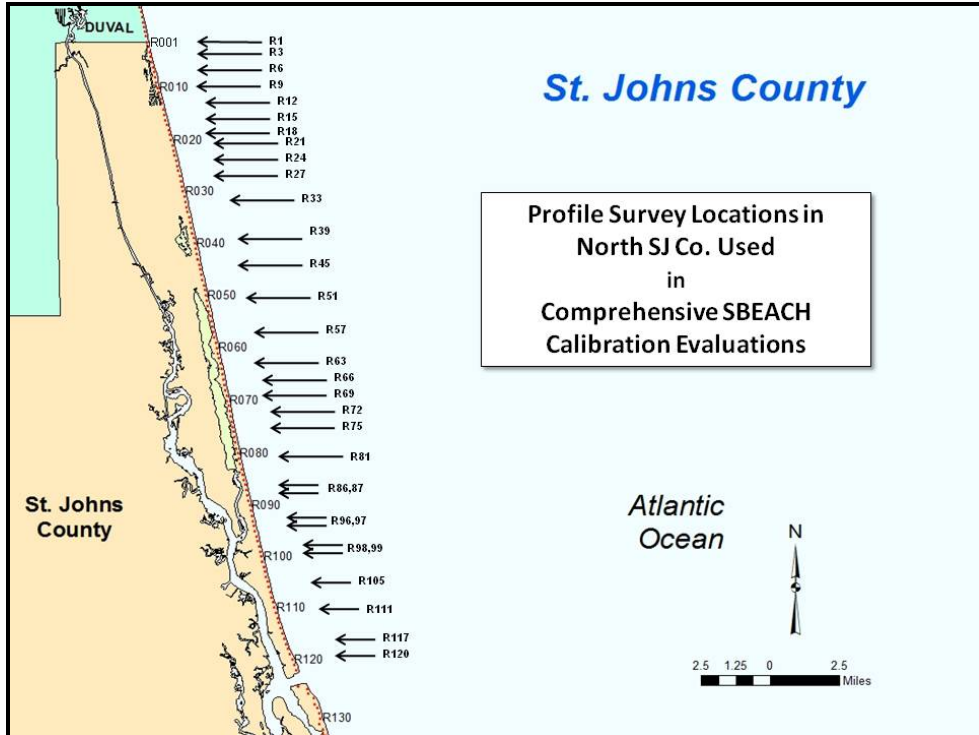


Figure 30. Profile locations for comprehensive SBEACH calibration in north SJ County.

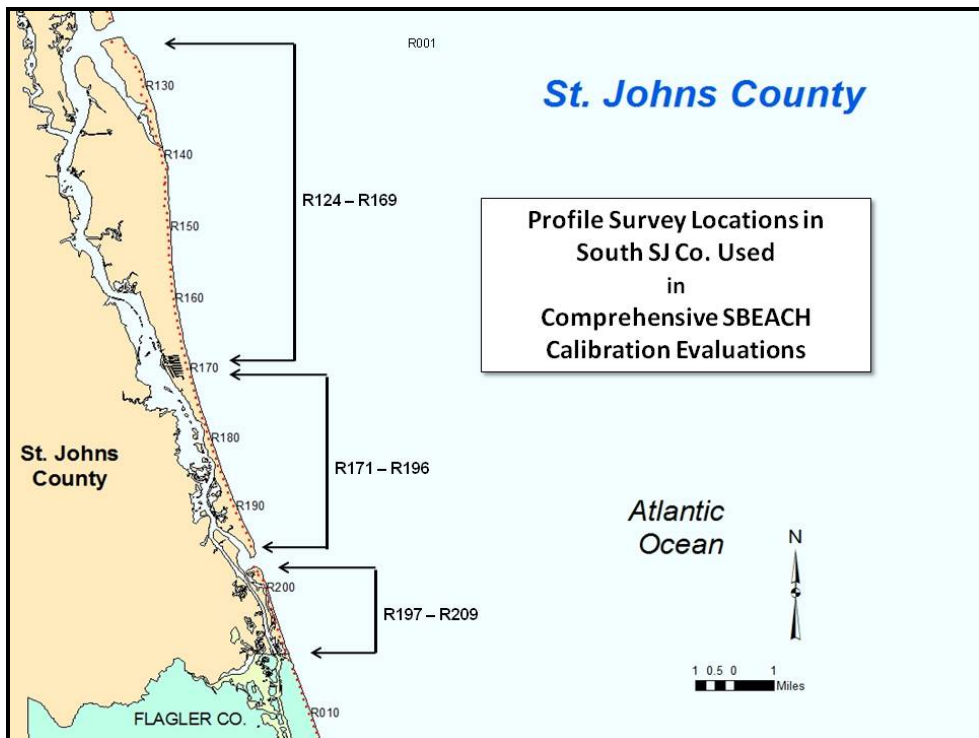


Figure 31. Profile locations for comprehensive SBEACH calibration in south SJ County.

2.2.a.ii Storm Tide Data

Measured storm tide data for the Thanksgiving Storm was found to be unavailable and/or limited in value for SBEACH model calibration purposes. Measured data from NOS tide gages, such as at the Mayport and Canveral gages, was unavailable for the November 1984 storm. Water depth measurements obtained by the University of Florida's CDN wave gage at Marineland was found to be limited. Limitations cited include the intermittent, discontinuous measurement intervals of every 6 hours, and doubt of meaningful measurements of the wind-induced component of storm surge being extracted from the CDN data.

Model-generated hydrographs were developed in the 1993 erosion model calibration studies by Dean, Chiu, and Wang. Three hydrographs were generated; one with no wave setup, one with wave setup, and a third hydrograph with 1.5 times the wave setup. Three sets of these hydrographs along north, middle, and south profile lines within the County were developed. These hydrographs were used in the SBEACH calibration work. A graph illustration of the hydrographs along the north profile line, re-produced from the 1993 study report, is shown in Figure 32.

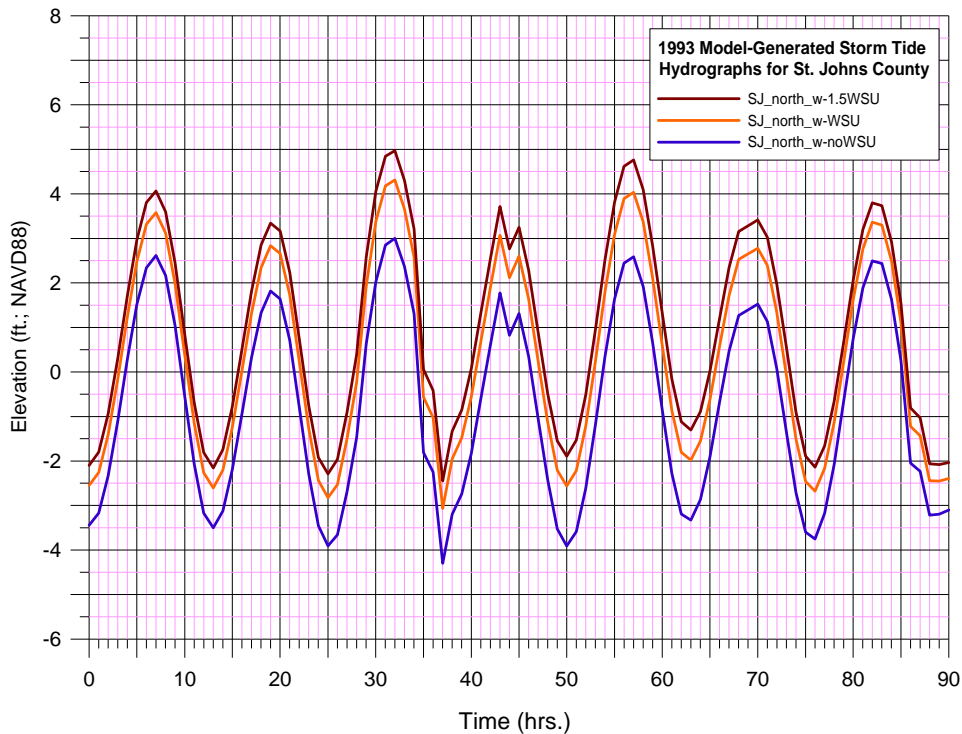


Figure 32. 1993 model-generated hydrographs for St. Johns County.

Since the SBEACH model computes wave setup within the model, the initial calibration tests used the hydrograph without setup included. Further discussion of results using this hydrograph and some additional follow-up testing work will be described in Section 2.2.c.

2.2.a.iii Wave Data

Measured wave data obtained by the UF-CDN wave gage at Marineland during the Thanksgiving Storm was reviewed during initial calibration testing work. As a result of issues and questions raised in the 1993 study referenced above, this measured wave data was not considered acceptable for use in the SBEACH calibration work. The WIS wave hindcast for the Thanksgiving Storm for locations off the north and south coastal regions of St. Johns County were used in the SBEACH calibration work. The illustration map in Figure 33 shows the locations of the WIS stations off the St. Johns County coast which vary in water depths offshore of between approximately 56 and 72 feet (CHL-WIS online database).

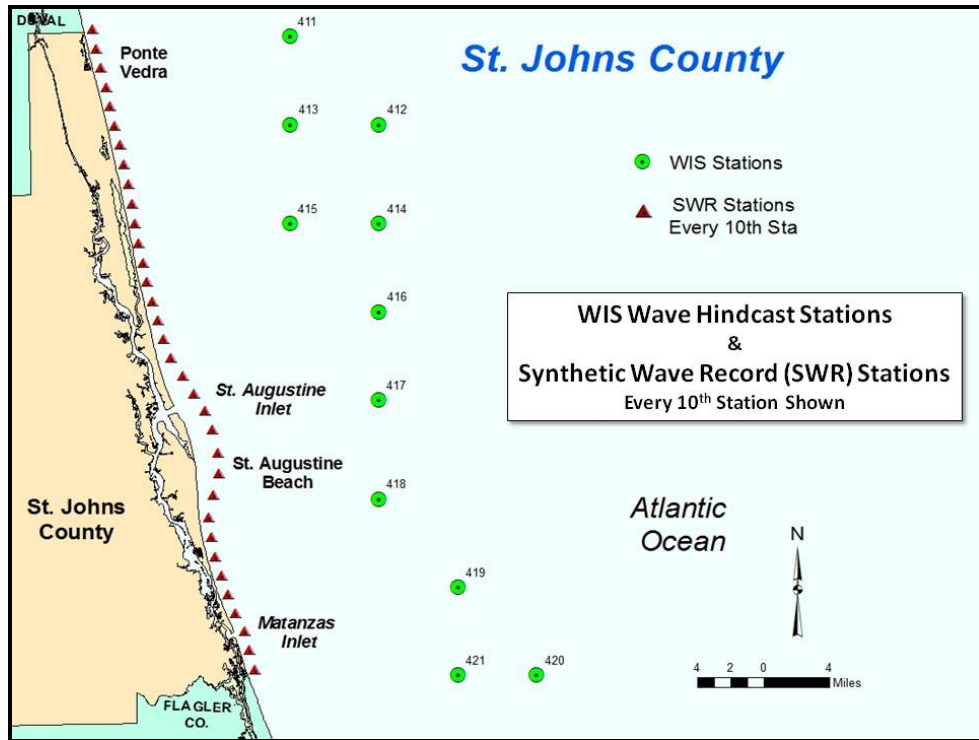


Figure 33. WIS & SWR wave hindcast stations off the coast of St. Johns County.

Wave heights during the Thanksgiving Storm for 4 of these WIS stations north of St. Augustine Inlet (411, 413, 415, and 416) and 3 south of the inlet (418, 419, and 421) are shown in the graph in Figure 34. It is seen that all of the stations north of St. Augustine Inlet are relatively consistent, and wave heights from stations south of the inlet are relatively consistent. As a result, one WIS station north of the inlet (415) and one WIS station south of the inlet (419) were chosen for further consideration as model input for SBEACH.

The wave time series for WIS stations 415 and 419 were transformed to 40 ft. water depths for use in SBEACH. Transformation was performed using the WISPH3 software included with SBEACH in the CEDAS software package. The transformed wave heights

are shown in Figure 34. In addition to the WIS wave hindcast database, shallow water wave hindcast output generated for the entire St. Johns County coast includes output information for the Thanksgiving Storm as well. Surfbreak Engineering Sciences, Inc. was contracted to generate a 54-year wave hindcast database for St. Johns County for the

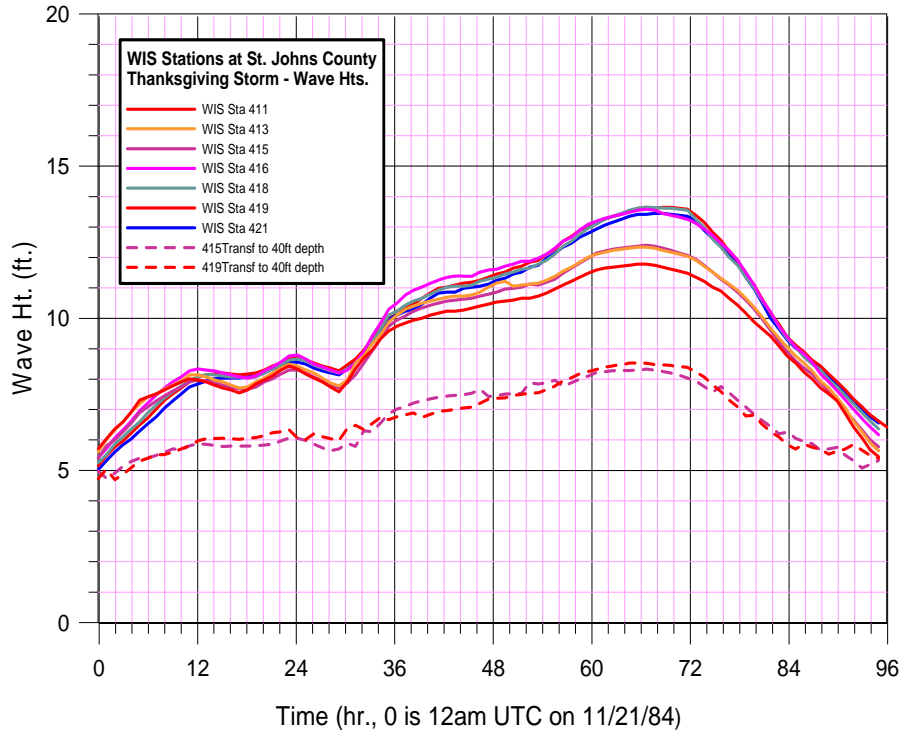


Figure 34. WIS hindcast and transformed wave hts. off the coast of St. Johns County for the 1984 Thanksgiving Storm.

period January 1954 through December 2007 (SES, 2009). This Synthetic Wave Record (SWR) for St. Johns County produced output including wave height, period, and direction values on 3 hour intervals at 331 stations along the approximate 10 m. (32.8 ft.) nearshore depth contour for the entire length of the St. Johns County Atlantic coast. The illustration map in Figure 31 provides a depiction of 33 (every 10th) of these 331 SWR stations.

Wave height, period, and direction time series from these 33 (every 10th) SWR stations were extracted for a 96 hour time period which included the peak wave conditions associated with the 1984 Thanksgiving Storm. Wave heights from selected SWR alongshore stations from north to south throughout the County are shown in Figure 35.

The SWR wave heights are seen to be very evenly, consistently distributed across the County's coast. Also shown in Figure 35 are wave heights for the two WIS stations north and south of St. Augustine Inlet, stations 415 and 419, transformed to a 10 m. water depth for comparison with the SWR wave heights. The transformed WIS wave heights are shown to be relatively similar and close to the SWR wave height values.

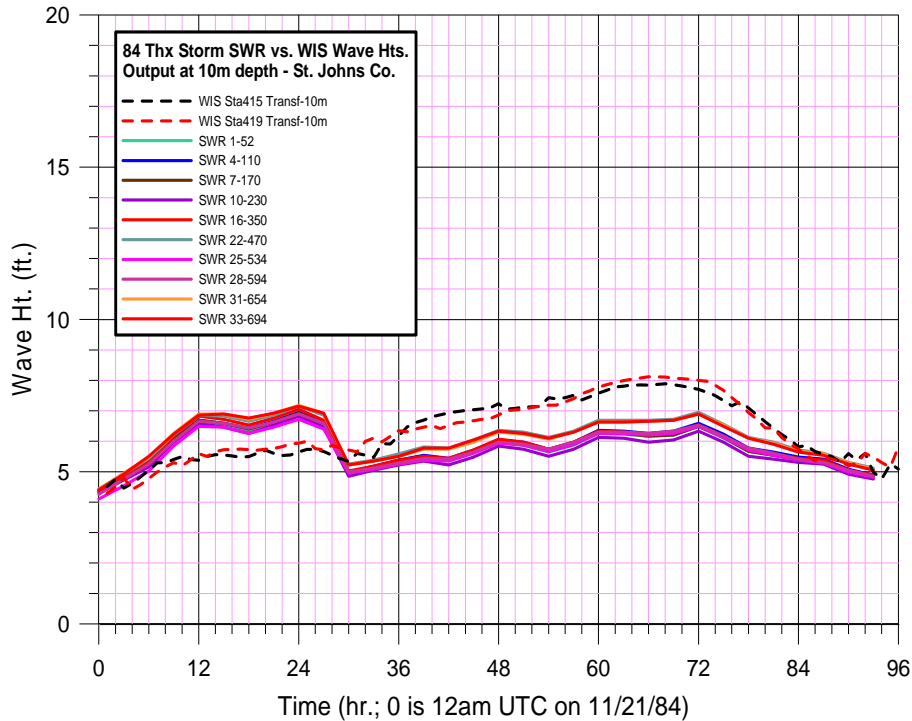


Figure 35. SWR wave hts. at selected stations along St. Johns County coast vs. WIS wave hts. for 415 & 419 transformed to 10m depth for the 1984 Thanksgiving Storm.

The SWR wave conditions are considered to represent state-of-the-art and most applicable shallow-water, nearshore wave conditions available for St. Johns County for use in coastal analytical modeling applications within the County. The close similarities between the WIS and SWR wave heights at the 10 m. water depth also provide support for use of transformed WIS wave conditions.

Since the survey profiles used in SBEACH in the calibration work extend to water depths of at or near -40 feet (NAVD), the WIS wave conditions for stations 415 and 419 transformed to -40 ft. water depths were used as wave input in SBEACH. A water depth of 40 ft. was set as an input setting in SBEACH. More discussion concerning wave input conditions in SBEACH will be given in Section 2.2.c regarding the model calibration results.

Wave period and direction for WIS wave hindcast stations 415 and 419, respectively, transformed by WISPH3 software to 40 ft. water depth are shown in Figure 36. Also, shown for comparison are the SWR wave period and direction time series extracted for the 1984 Thanksgiving Storm. The transformed-WIS and SWR wave periods are generally consistent except for during the latter part of the storm values shown.

The SWR wave direction values are shown to be generally from a more easterly direction than the transformed-WIS values. That is consistent with expectations since the SWR values are at 10 m. water depths vs. 40 ft. depths for the transformed-WIS values. The SWR waves have been more subjected to refraction effects, so more easterly in direction.

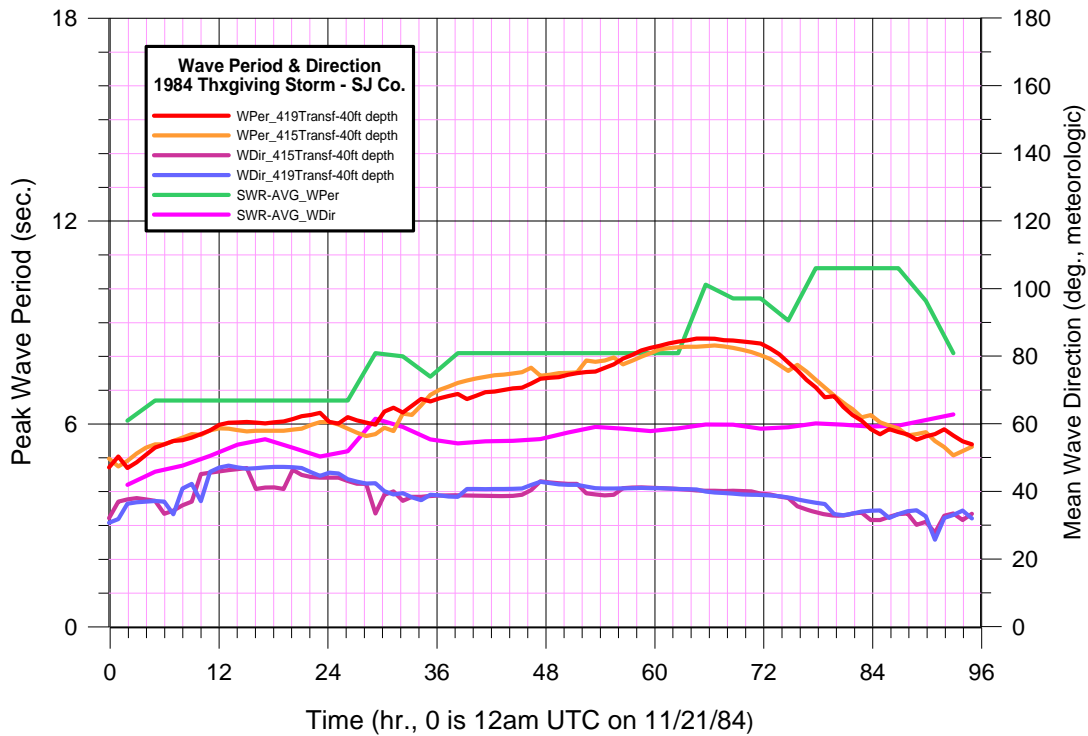


Figure 36. Wave period and direction for WIS 415 & 419 transformed to 40 ft. depth and avg. SWR for St. Johns County for the 1984 Thanksgiving Storm.

2.2.b Model Input Parameters

As with Brevard County discussed earlier in this report, primary input information required for application of the SBEACH model include data and information related to the coastal reach where the model is applied and to specific coastal storm conditions. The specific storm tide and wave data described previously above were incorporated into the SBEACH model for the required storm input. Required reach data included the topographic/ bathymetric survey data for the St. Johns County study area for model calibration evaluation and other site-specific data and information, including sediment grain size and water temperature.

Other required reach-specific parameters include sediment transport parameters. As with Brevard County, the sediment transport parameters may be adjusted within recommended range of values limits. Adjustment of these values may assist in achieving improved model calibration.

A set of default values for the sediment transport parameters and other reach parameters is provided within the SBEACH model software. The default values and recommended range of values for reach-specific parameters including sediment transport parameters were listed earlier in this report in Table 1 in Section 2.1.b. As with Brevard County, results of previous calibration work and sensitivity testing in Bay County were applied in the selection of input parameters for calibration work in St. Johns County.

In conducting initial SBEACH calibration work for St. Johns County, it was determined that a more detailed evaluation of specific reach parameters would be required to account for diverse beach conditions in St. Johns County and to achieve improved model calibration. This evaluation would include closer review of beach slope conditions and a more detailed review and compilation of information related to sediment grain size. A description of sediment grain size evaluation performed is given below.

2.2.b.i Sediment Grain Size Evaluation

The geologic and associated geomorphic characteristics of the beaches in St. Johns County vary considerably from north to south throughout the County's approximate 41 mile Atlantic Coast shoreline. Sediment grain size composition varies from predominantly fine-grain quartz sand to alternately predominant coarser coquina material along the County shoreline. A fairly detailed literature search for sediment data collection and analysis reference material produced limited information, particularly in terms of county-wide information.

A relatively old U. S. Army Corps of Engineers report (USACE, 1965) was the only available reference located which provided some county-wide information. A summary of information found in that report is contained in Appendix IV of this report. The sediment grain size information extracted from this report combined with previous personal site inspection observations were used to identify coastal segment locations for initial model calibration and initial model input parameters.

Some supplemental sediment grain size information was found from two additional sources. A geotechnical analysis report by Scientific Environmental Applications, Inc. (SEA, 2008) provide sediment grain size information for locations extending from just north of St. Augustine Inlet to approximately 9.5 miles north of the inlet. Documents from the USACE (2009) associated with the County's beach restoration project provide sediment grain size information for Anastasia State Park and St. Augustine Beach.

Review of this available information and the available FDEP hydrographic survey database supported an apparent correlation-type relationship between surveyed beach slopes and sediment grain size values found along the County's beaches. In order to evaluate this relationship in more detail, beach slope (actually beach slope inverse) values for the FDEP 1984 pre-Thanksgiving Storm profile surveys were plotted for St. Johns County as shown in Figure 37. Beach slopes were computed from the 0.0 elevation to 3 separate beach elevations, 5, 8, and 10 feet (NAVD) as shown in Figure 37.

Average beach slope values were computed for coastal segments with similar observed values. The average values shown were based on review of averages computed for each of the 3 beach elevations and review of beach profile plots. The beach slopes computed to the 5 foot elevation generally appear to be the most reliable since the higher elevations (8 and 10 foot) may be influenced by flatter beach berm topography, dune slopes, and/or coastal armoring structures. These effects can usually be confirmed when the beach slopes to the higher elevations differ significantly from the slopes to the 5 foot elevation

through observations from review of profile survey plots and/or aerial photography. Caution and care must be taken when observing beach slopes to take into account seasonal effects when beach slopes may steepen or flatten as a result of varying wave conditions during calmer summer months vs. stormier winter months.

Beach slopes were similarly computed for the 2007-08 FDEP surveyed profiles and plotted as shown in Figure 38. It is noted that comparison of the 1984 and 2007-08 beach slope plots show apparent influences in some segments of the County’s shoreline. The beach slopes appear to flatten in the northern part of the County (i.e., R1-60) which could be a result of continued southward spreading of beach restoration fill placement in Duval County to the north.

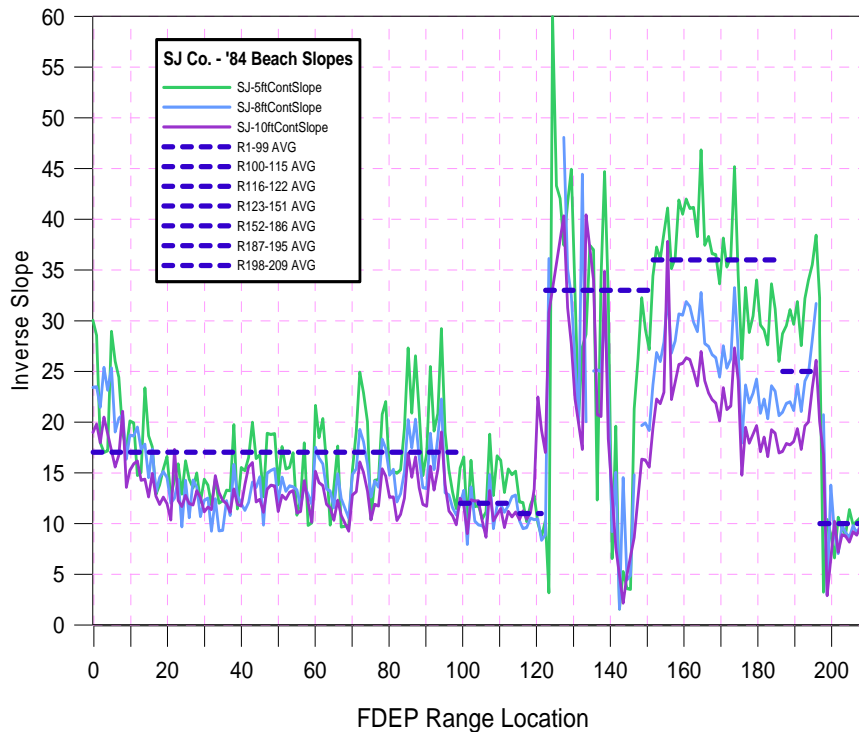


Figure 37. Inverse beach slope distribution for May 1984 profiles for St. Johns County.

Beach slope steepening is apparent in the South Ponte Vedra/Vilano Beach area (i.e., R60-100) which could reflect increased shoreline erosion effects, but also include some seasonal effects. A flattening of beach slopes shown in the southern part of Anastasia State Park through St. Augustine Beach (i.e., R135-160) shows the apparent influence of the beach fill placement in the County’s beach restoration project.

A more common, state-of-the-art relationship related to sediment grain size used in cross-shore coastal processes analyses involves the sediment scale parameter, A. Development and use of the A parameter has been discussed widely by Dean (2000) and others. In order to compare the compiled beach slopes shown in Figures 37 and 38 with A parameters for the same survey profiles, A parameters for the 1984 and 2007-08 St. Johns profiles were generated and plotted as shown in Figure 39 and 40, respectively.

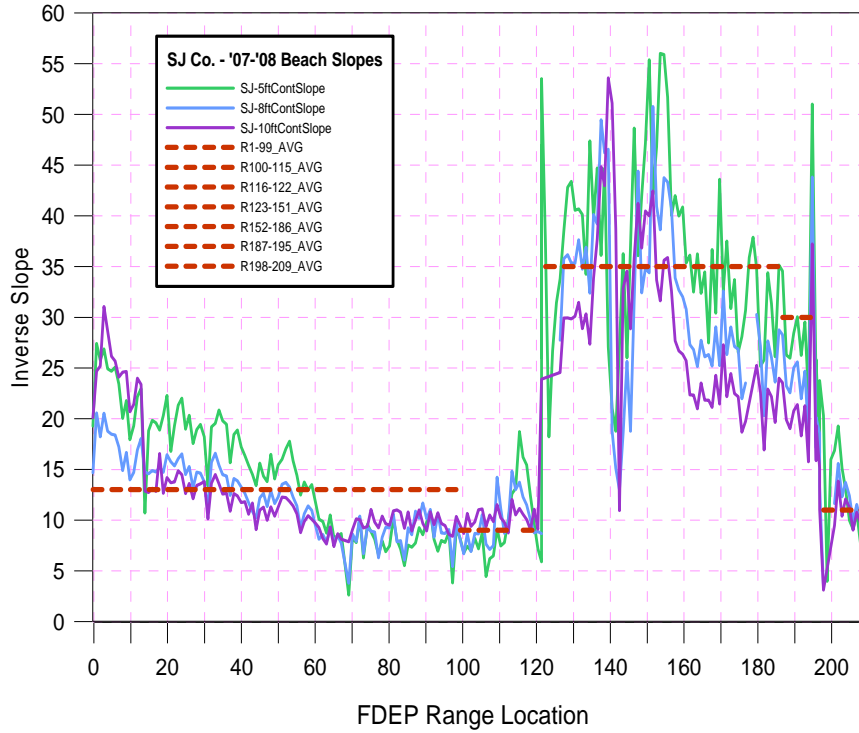


Figure 38. Inverse beach slope distribution for 2007-08 profiles for St. Johns County.

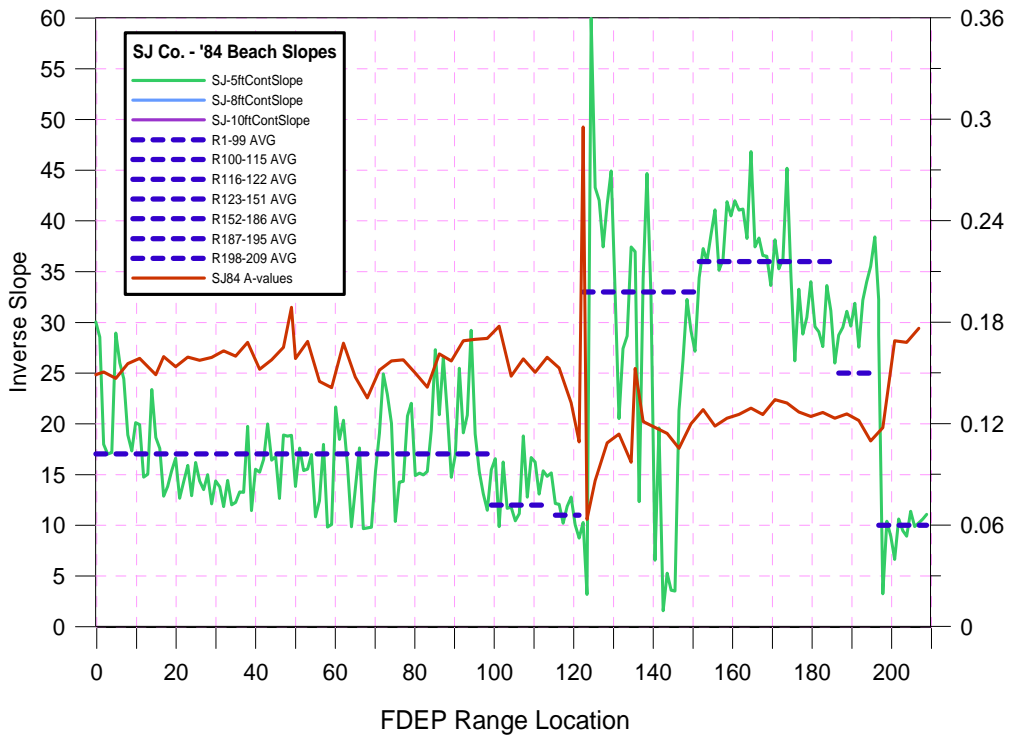


Figure 39. Inverse beach slope vs. A parameter for May '84 profiles for St. Johns County.

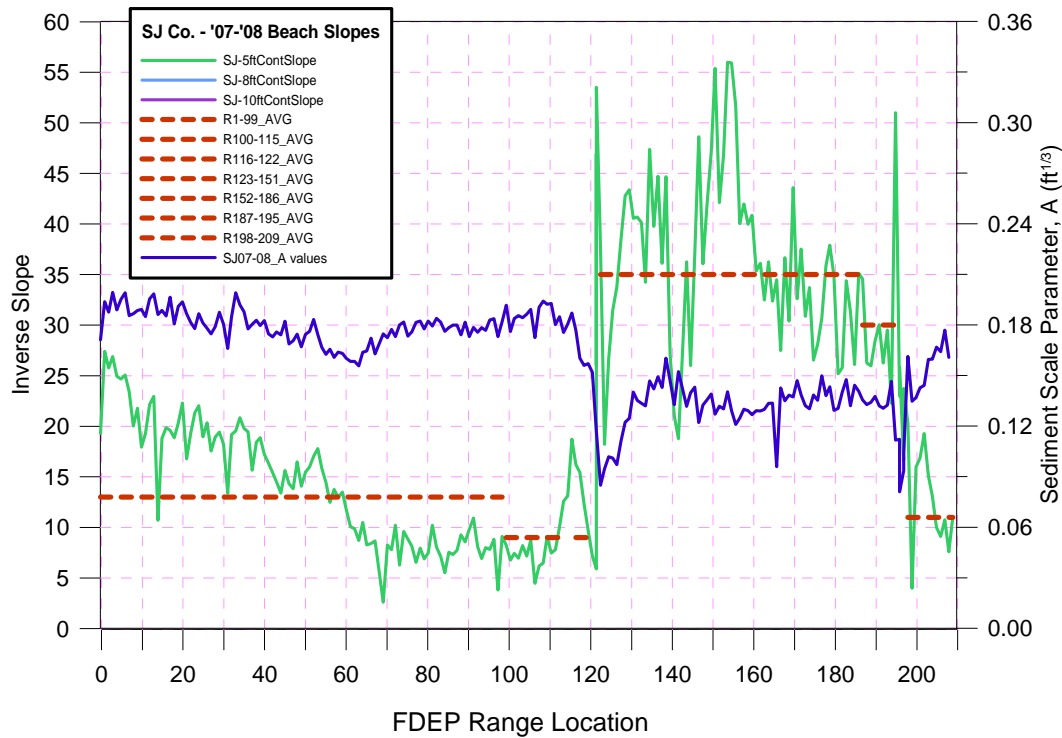


Figure 40. Inverse beach slope vs. A parameter for 2007-08 profiles for St. Johns County.

The graph in Figure 41 shows mean sediment grain size values vs. inverse beach slope based on the described available sediment grain size information for St. Johns County and the computed beach slopes shown in Figures 37 and 38. A power equation fit curve and confidence interval is shown in Figure 41 which demonstrates the observed relationship between mean grain size and beach slope.

As a result of limited available sediment grain size information found for Volusia, Indian River, and Brevard counties for use in SBEACH applications, the beach slope vs. mean grain size relationship identified for St. Johns County was applied to these two counties in order to obtain needed reach input parameters, including sediment grain size.

Beach slope values were computed and plotted for several FDEP surveys for Volusia, Indian River, and Brevard counties. Mean sediment grain sizes for these two counties were determined through application of the graph in Figure 41. Mean sediment grain size values obtained from Figure 41 were verified with sediment analysis field studies and documentation from these counties.

More detail about the field data and documentation is contained in the SBEACH application description for those three counties contained in Volume 2. Copies of all beach slope plots for Volusia, Indian River, and Brevard counties, as well as, St. Johns County are contained in Appendix V of this report.

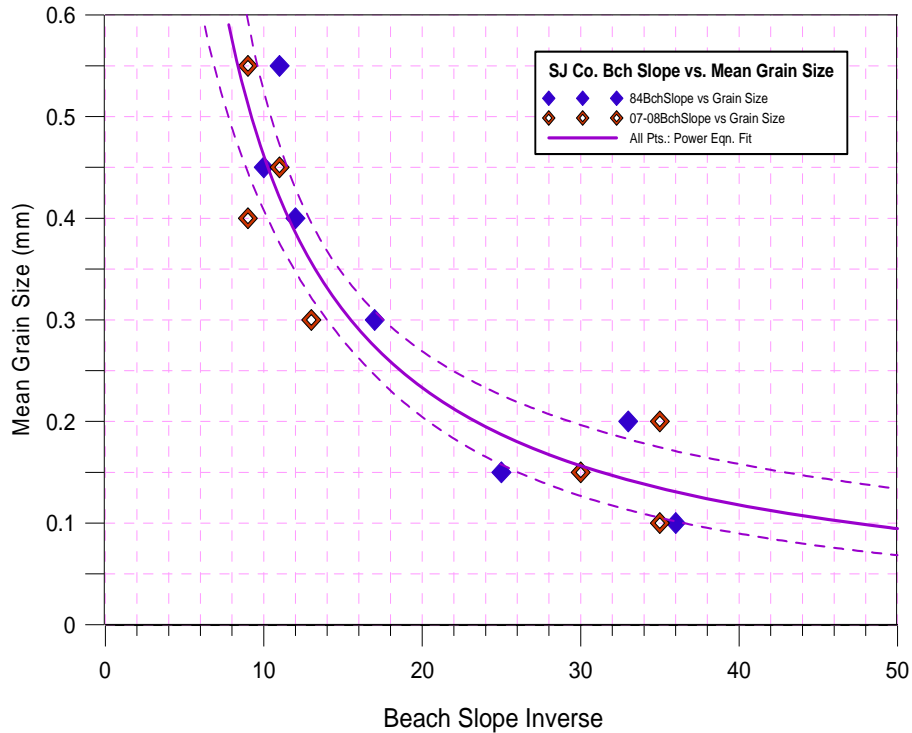


Figure 41. Sediment grain size vs. beach slope inverse for St. Johns County.

2.2.c Model Calibration Results

Results of previous model input parameter sensitivity evaluation work performed in Bay County (Leadon, Nguyen, 2009) and Brevard County described above were applied in initial SBEACH calibration work for St. Johns County. Application of these previous results to St. Johns County resulted in setting most all of the SBEACH “Reach” input parameters at the default values for initial calibration work. However, as shown above, significant variation in mean sediment grain size is found throughout St. Johns County and resulted in a range of “effective grain size” values applied in the identified calibration segments. The initial calibration work also resulted in significant variation in the “maximum slope prior to avalanching” (MSPA) reach input parameter. As shown in Figure 42, an apparent relationship is seen between variation in the MSPA parameter and beach slope variations.

It was also found that improved model calibration results for St. Johns County were achieved by adjustment of the transport rate coefficient parameter, K. The initial calibration results revealed an apparent trend in K variation related to variations in beach slope. The graph in Figure 43 demonstrates this apparent trend. A maximum value within the recommended range of values of 0.005 was applied for the “coefficient for slope dependent term, ϵ ” throughout St. Johns County except for Segment 5 at the south end of the county where the default value, 0.002, produced improve model calibration.

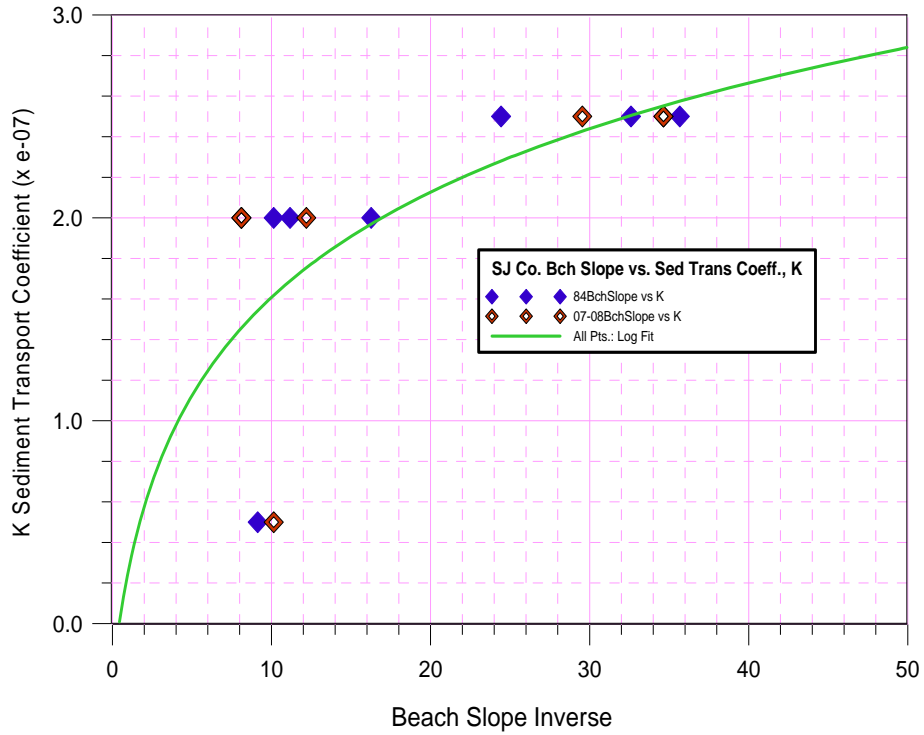


Figure 42. Sediment transport coefficient vs. beach slope inverse for St. Johns County.

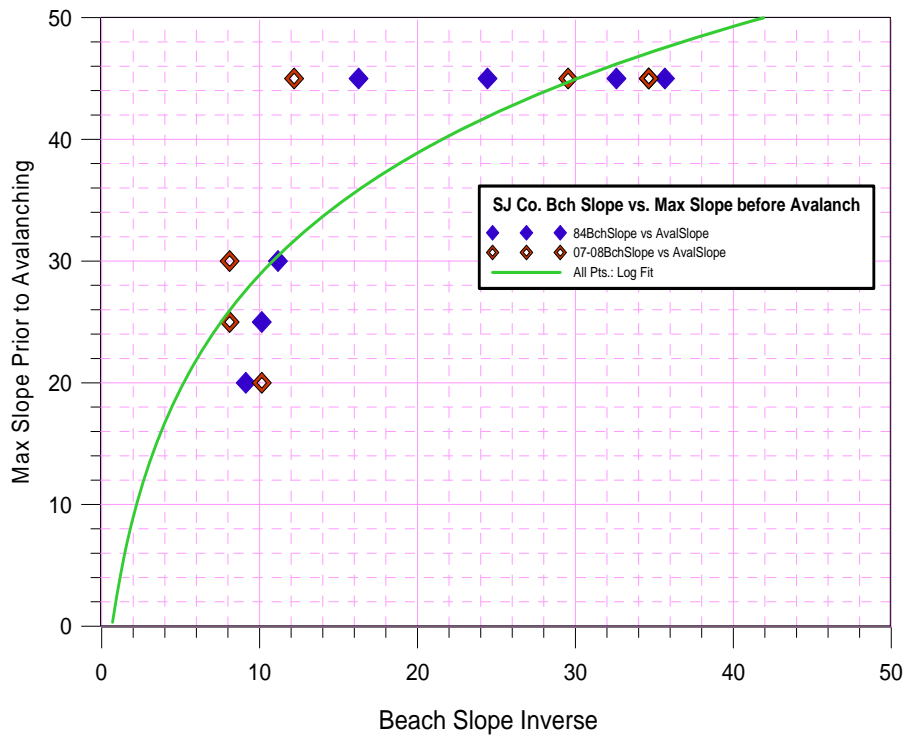


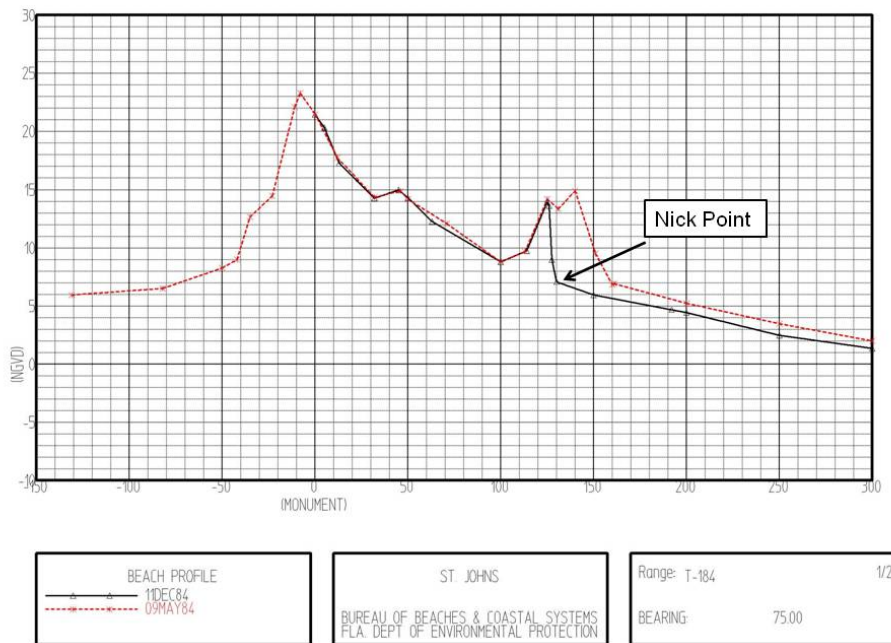
Figure 43. Max. slope prior to avalanching vs. beach slope inverse for St. Johns County.

Initial SBEACH Calibration for St. Johns County

Results from the initial calibration work produced erosion output from SBEACH which was significantly less than the measured erosion for the 1984 Thanksgiving Storm. A series of sensitivity testing was performed in which the model Reach input parameters were adjusted to ensure that the input was set at optimal values. This was followed by a detailed review of the measured erosion profiles throughout the 5 coastal segments established for the initial calibration work.

Concurrently, SBEACH output was compiled which listed maximum water elevations and wave run-up elevations. The maximum water elevation output values from SBEACH consistently occurred at or near the landward limits of storm tide penetration along the beach-dune profiles. The elevation limits of wave run-up consistently extended a couple feet above the maximum water elevations. It was observed that both the maximum water elevations and the wave run-up from these initial model calibration results were significantly lower than the observed location points on the post-storm profiles assumed to be the approximate storm tide/wave run-up elevation limits.

The observed upper elevation limits for storm tide and wave run-up effects from the post-storm profiles are generally clearly seen as the sharp transition point between the flat eroded beach slope and the steeper slope of the eroded dune face. The name identifier applied to this point is referred to as the “nick point” to signify the upper limit where the storm tide and waves have nicked into the beach-dune profile. An example of a profile depicting a clearly visible nick point is shown in Figure 44.



7-29-09

Figure 44. Example of observed “nick point” at or near maximum storm tide and/or wave run-up elevation on post-Thanksgiving Storm profile at R184 in St. Johns County.

Since the Reach input parameters were optimized in the initial calibration work and initial Storm input parameters produced under-predicted erosion, a closer review of the Storm input parameters was performed. Based on initial storm input parameters, the average nick point elevations were found to be significantly higher than average maximum water and wave run-up elevations from SBEACH.

As a result, it was decided to conduct an exercise in which the storm tide and/or wave input would be increased incrementally to obtain conditions where these elevations would match more closely. It was thought that performance of this exercise would produce model simulation more consistent with the measured and observed erosion conditions from the 1984 Thanksgiving Storm. These more consistent model simulation results would also strengthen support for the Reach input parameters to be used for the 15 and 25-yr storm erosion simulations with SBEACH presented in Volume 2. Any other considerations regarding modifications to the SBEACH model itself to improve model calibration, for example application of erosion multipliers, was beyond the scope and capability of this study work.

A series of model input storm tide and wave conditions were applied as a sensitivity-type testing approach. Both wave and storm tide conditions were adjusted (increased) in the series of tests performed. A total of 5 different conditions were applied during the Storm input adjustment tests. Condition 1 consisted of the initial condition tested which significantly under-predicted the measured storm erosion for the 1984 Thanksgiving Storm. Condition 1 included the transformed WIS waves and 1993 model-generated storm tide without wave set-up. It is noted that the calibration results presented in the 1993 study report by Dean, Chiu, and Wang used the model-generated storm tide hydrograph with wave set-up times 1.5 and a constant 10 ft. wave height over the 90 hour hydrograph time duration.

Conditions 2 through 5 included incremental increases in wave heights and/or storm tide and are listed in Table 3 below. The “transformed WIS” wave heights listed in Table 3 are based on transformation of the 1984 Thanksgiving Storm wave hindcast records for Stations 415 (for north SJ Co.) and 419 (for south SJ Co.) to a 40 ft. (NAVD) nearshore water depth. Transformed WIS wave height increases noted in Table 3 were based on proportional adjustments of the peak value increase.

Table 3
Test Conditions for SJ Co. SBEACH Calibration

<u>Condition</u>	<u>Wave Height (ft)</u>	<u>Storm Tide Peak Elevation (ft:NAVD)</u>
1	Transformed WIS	1993 model hydrograph w-out setup
2	Transf-WIS adj peak to 10'	1993 hydrograph w-out setup+2 ft. adj
3	Const.10' (8' for Seg5)	1993 hydrograph w-out setup+2 ft.adj
4	Transf-WIS adj peak to 10'	1993 hydrograph w-out setup+3 ft. adj
5	Const.10' (8' for Seg5)	1993 hydrograph w-out setup+3 ft.adj

The wave periods and directions for Conditions 2 and 4 were maintained the same as Condition 1. Wave heights, periods, and directions for Conditions 3 and 5 were set at constant values of 10 feet, 10 seconds, and 0 deg. (shore-normal), respectively, except for Segment 5 where values were 8 feet, 8 seconds, and 0 degrees, respectively.

The storm tide hydrographs for Conditions 2 through 5 were the same as for Condition 1, which was the 1993 model-generated hydrograph without wave set-up included, but increased proportionally based on the incremental adjustments listed in Table 3. Resulting SBEACH output for maximum water and wave run-up elevations was compiled for each condition listed in Table 3, averaged for each of the 5 initial calibration segments, and plotted. These plotted averages were superimposed with averages of the compiled nick point elevations for each of the 5 calibration segments for comparison. The results for SBEACH maximum water elevations comparison with nick point elevations are shown in the graph in Figure 45. The results for SBEACH maximum wave run-up elevations comparison with nick point elevations are shown in the graph in Figure 46.

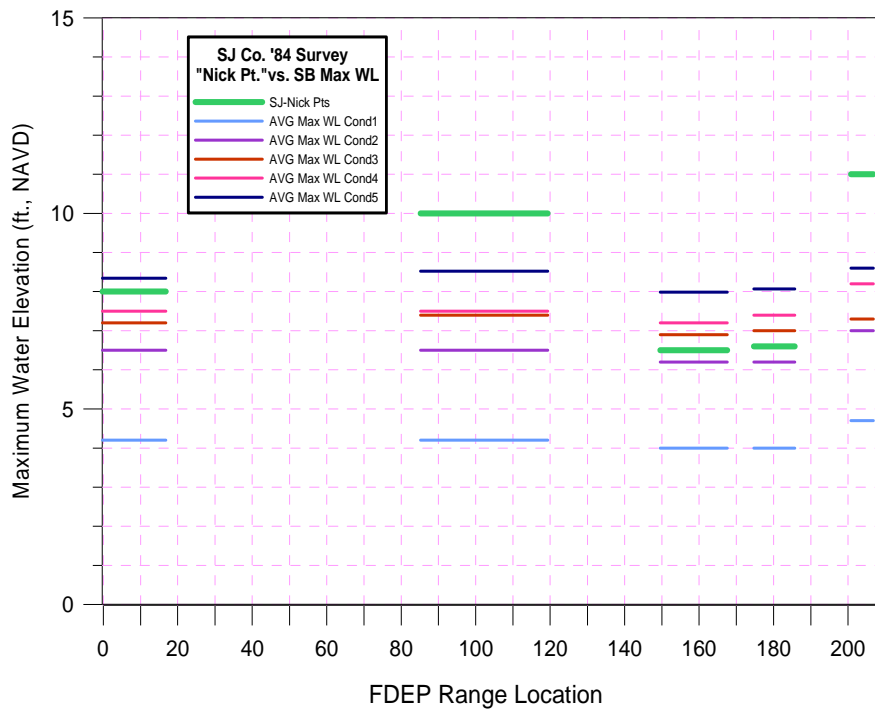


Figure 45. Comparison of observed “nick point” elevations vs. maximum water elevations from SBEACH for the 5 initial calibration coastal segments in SJ Co.

As shown in Figures 45, the maximum water level from Condition 1 input are significantly lower than the nick point elevations for all 5 segments. Figure 46 shows that the wave run-up elevations for Condition 1 input is also significantly below the nick point elevations for all 5 segments.

The Condition 1 storm input is still considered to be the best available storm tide and wave information, along with the recent SWR wave information compilation, for the

Thanksgiving Storm. However, as shown in Figures 45 and 46, the Condition 2 and 3 storm input conditions produce maximum water elevation and wave run-up elevations which are most consistent with the observed nick point locations.

The initial SBEACH calibration work showed that the SBEACH erosion simulation results were closest to the measured erosion for Conditions 4 and 5. However, as shown in Figures 45 and 46, the maximum water elevations exceeded the nick point elevations for Segments 3 and 4 and the wave run-up elevations exceeded the nick point elevations in all 5 segments. It is concluded that for the purposes of SBEACH calibration, the storm condition input adjustments applied herein were considered to be a justified and reasonable exercise.

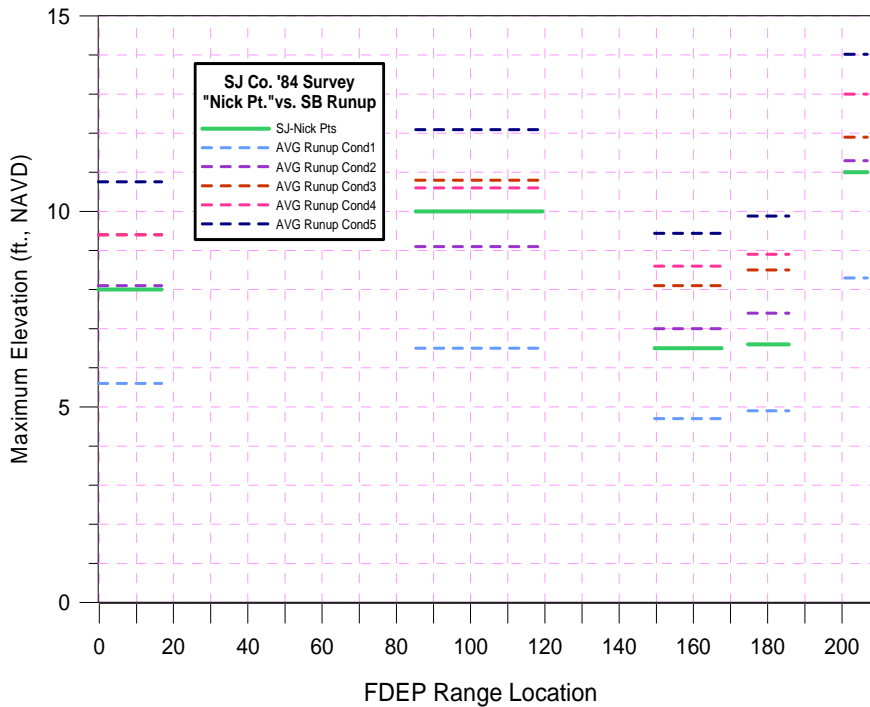


Figure 46. Comparison of observed “nick point” elevations vs. wave run-up elevation limits from SBEACH for the 5 initial calibration coastal segments in SJ Co.

As a result of the storm condition input adjustments described above, elevation contour recession plots were prepared for all 5 storm input conditions for all 5 coastal segments identified for the initial model calibration work. The plot for Segment 1 showing average measured recession for the 6 profile locations within Segment 1 vs. average recession for Conditions 1, 2, and 3 is shown in Figure 47. In lieu of presenting all plots showing the initial calibration work, it is preferred to move ahead and discuss and present results of the more comprehensive calibration work given below.

Comprehensive SBEACH Calibration for St. Johns County

The results of the initial calibration work in identifying appropriate model Reach input parameters, along 35 profile lines within the 5 identified coastal segments, were applied

in a more comprehensive manner to all 118 available profile lines containing both pre- and post-Thanksgiving Storm survey data. The Reach input parameters were distributed according to similarities in Reach conditions at profile locations within and near the identified 5 initial test segments. The complete listing of input parameters which were developed from initial and comprehensive calibration evaluation work and applied in St. Johns County for the 15- and 25-year storm erosion simulations is contained in Appendix VI of the report documentation.

Results of the comprehensive calibration work are shown in Figure 48 with average measured contour recession compared with average contour recession for Conditions 1, 2, and 3 for all 118 profile locations combined.

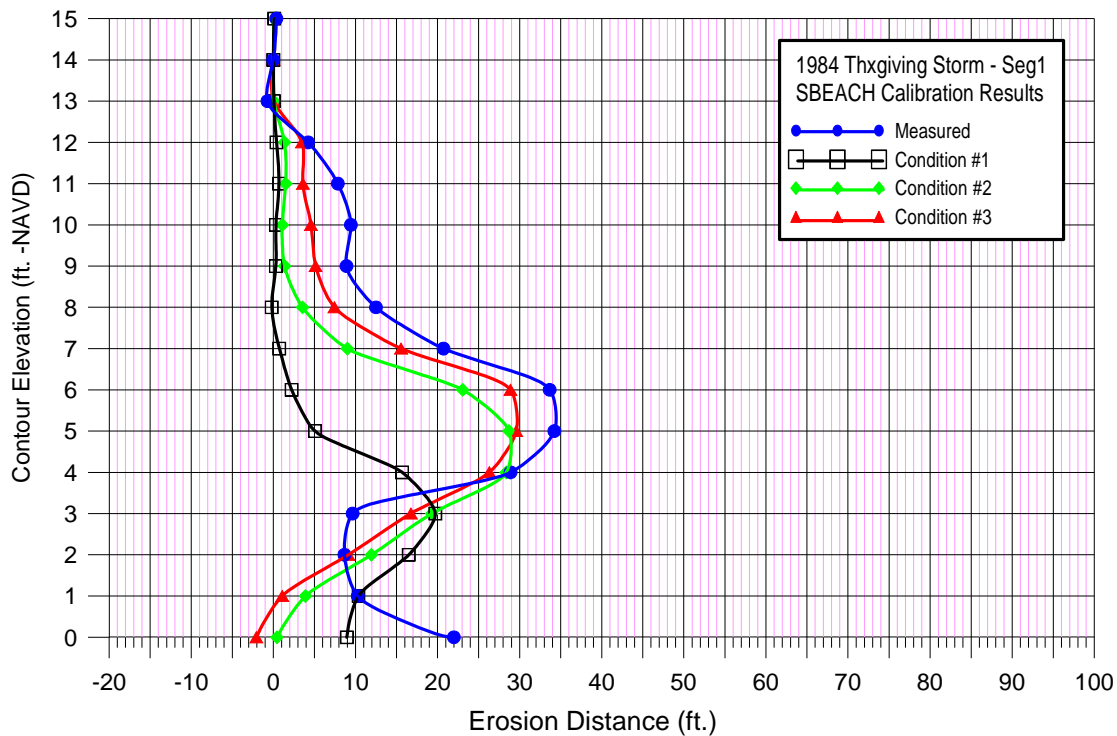


Figure 47. Contour recession comparison for Segment 1 from initial calibration work.

An additional model run was performed with the 118 calibration profiles using the 25-year storm hydrograph developed by BSRC (2009) for St. Johns County for high-frequency storm evaluations. Hydrographs for 15-year and 25-year storms were used for county-wide SBEACH model simulation runs for St. Johns County. Graphic plots of the hydrographs, as well as, reduced version used with SBEACH with wave set-up removed, are provided in Volume 2.

The graph in Figure 49 shows comparison of the average measured contour recession vs. average contour recession using the 25-year hydrograph. As seen, the two recession curves compare relatively well providing some additional support for use of SBEACH for high-frequency storm erosion modeling. It is noted that the peak storm tide of 5.0 feet (NAVD) for Condition 2 and 3 is lower than the peak storm tide values for a 25-year

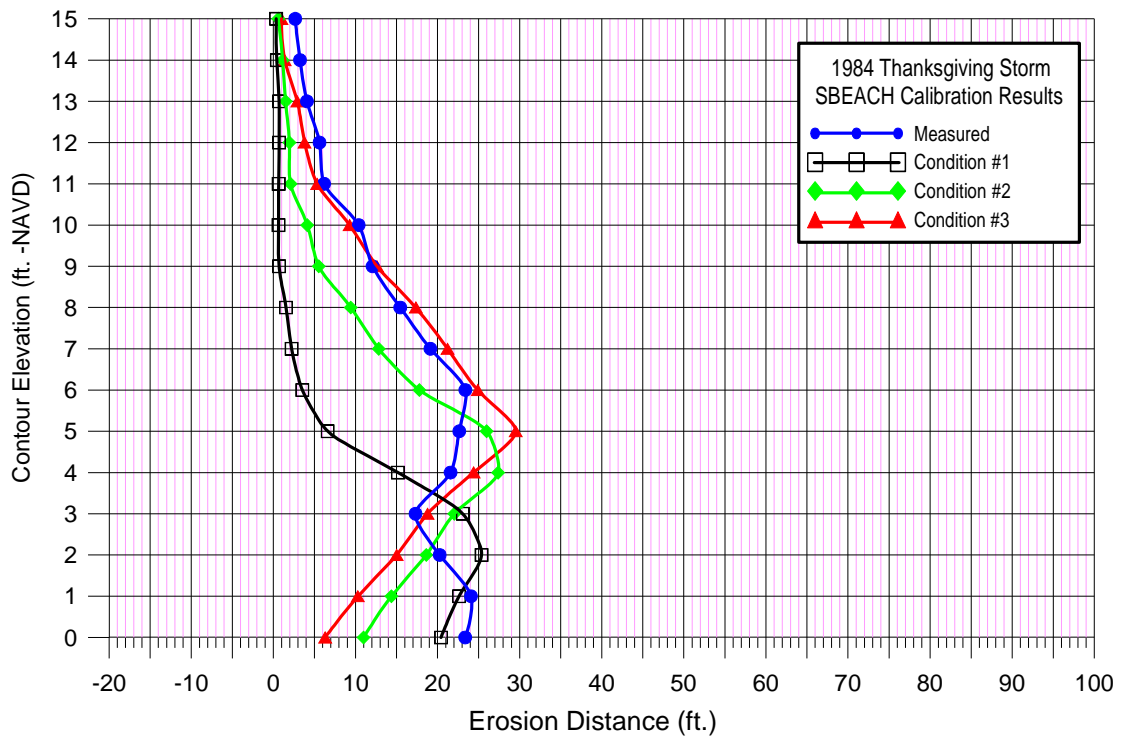


Figure 48. Contour recession comparison for 118 profile locations in St. Johns County.

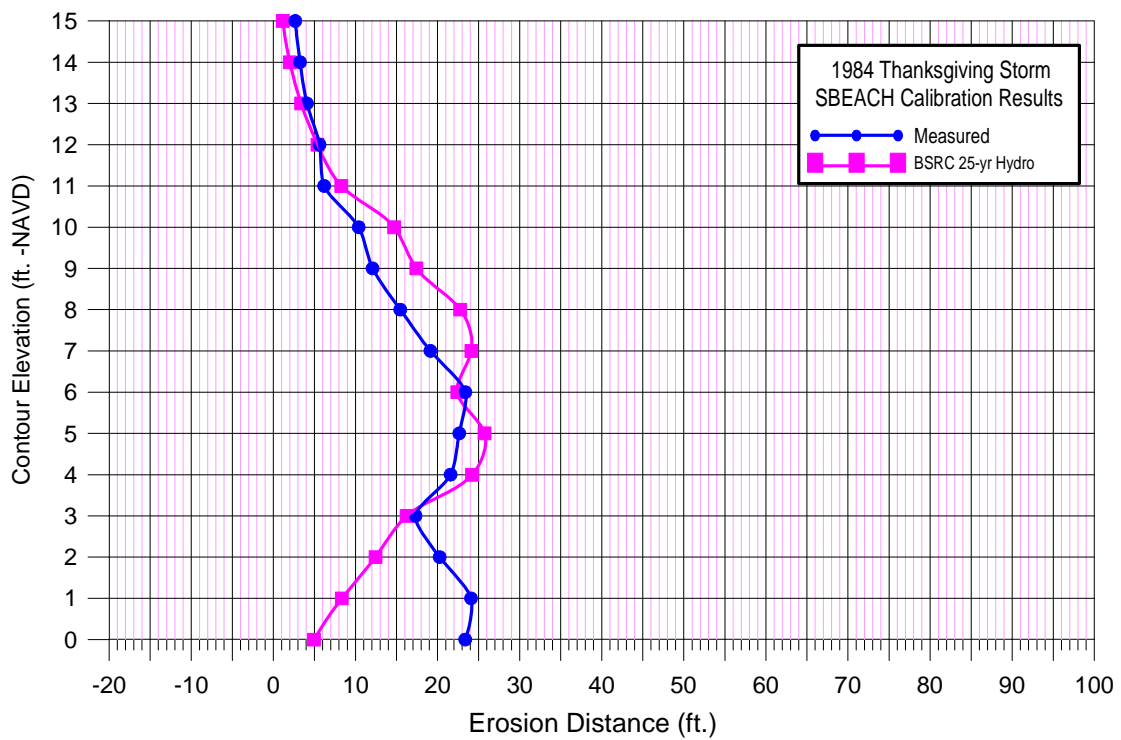


Figure 49. Measured vs. 25-yr. storm recession for 118 profile locations in SJ Co.

storm of between 5.4 feet and 5.9 feet (NAVD).

As with Brevard County, it is noted that the model calibration evaluation in this study is focused on and, therefore, essentially limited to the upland beach and dune portions of the evaluated profiles. Detailed comparisons and analyses of measured versus computed profile response to the storm event simulations in offshore portions of the profiles were not conducted herein.

It is also noted that initial sensitivity testing in Bay County with wind speed and direction varied over a wide range of input conditions resulted in a conclusion that including wind effects in the model would not significantly alter the model results. Therefore, wind data for the 1984 Thanksgiving Storm was not added to the storm input in SBEACH.

As with the Brevard County calibration work, graphic plots of the measured pre- and post-Thanksgiving Storm profiles and SBEACH-generated post-storm erosion profiles are provided in Appendices II and III of the report.

SBEACH Model Studies for Florida Atlantic Coast: Brevard, St. Johns, Volusia, and Indian River Counties

VOLUME 2

This volume contains presentation of the SBEACH model 15- and 25-year storm erosion simulation results for Brevard, St. Johns, Volusia, and Indian River counties. Volume 1 contains the Table of Contents, Foreword, Executive Summary, and Background portions of the report documentation for both report volumes. The report volumes are accompanied by report appendices in separate report components as listed in the Table of Contents in Volume 1. The report appendices include supporting information and results from SBEACH model calibration work presented in Volume 1. The appendices also contain the SBEACH 15- and 25-year storm erosion plots at all FDEP range locations in Brevard, St. Johns, Volusia, and Indian River counties.

3.0 St. Johns County SBEACH Application

3.1 Model Configuration

The SBEACH model configuration for St. Johns County for high-frequency storm erosion simulation, including model input parameters, was based on the model calibration results from St. Johns County described in Volume 1 of this report documentation. The specific Reach input values, including sediment grain size, maximum slope prior to avalanching, and sediment transport parameters were based on the model calibration work described in detail in Volume 1. Storm tide hydrographs developed by BSRC (2009) for 15- and 25-year storms were used as storm input in SBEACH for St. Johns County. As with the model calibration work in St. Johns County, consideration was given to accounting for the set-up component in the storm tide elevations, as well as, set-up computations within SBEACH. As a result, revised, adjusted versions of the FSU-BSRC hydrographs were used.

The BSRC hydrographs were adjusted down in elevation to compensate for the set-up generated by SBEACH. The hydrograph reductions were proportional reductions of the BSRC hydrographs based on trial and error evaluations performed during model calibration work for St. Johns County. Use of the adjusted BSRC hydrographs resulted in final average maximum water elevations with set-up values from SBEACH which were equivalent to the BSRC peak storm tide elevations for the 15- and 25-year storm tide hydrographs. A graph depicting the original BSRC 15- and 25-year storm tide hydrographs and the adjusted/reduced hydrographs used in the final SBEACH erosion model runs for St. Johns County is shown in Figure 51. A listing of recommended Reach and Storm input values for use in 15- and 25-year storm erosion simulations using SBEACH is contained in Appendix VI of this report. Time series values for the original and adjusted hydrographs for St. Johns County are tabulated in Appendix VII of this report.

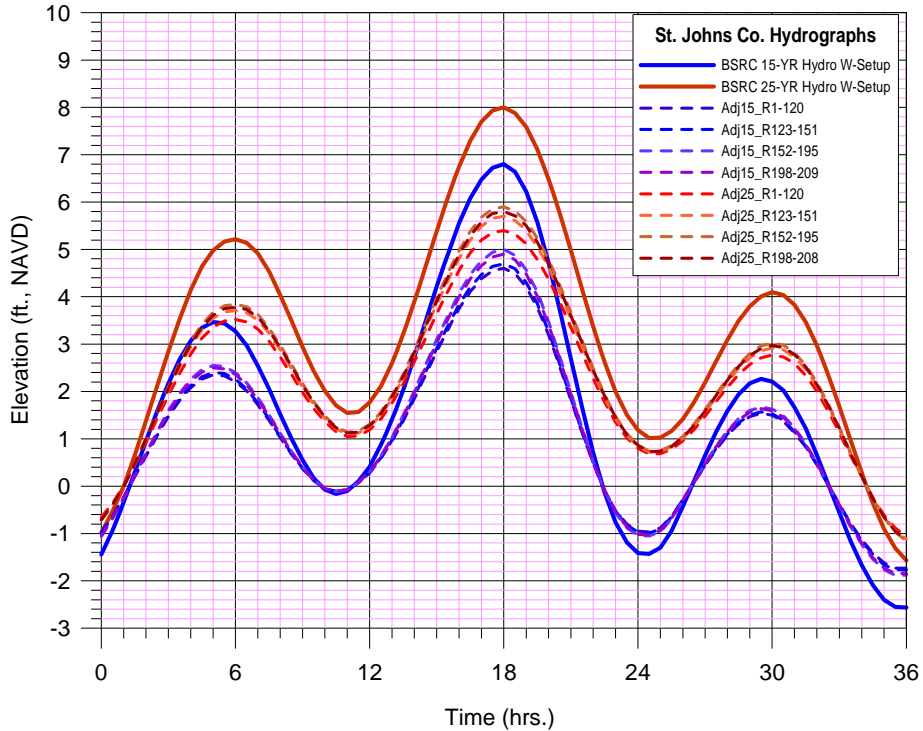


Figure 51. 15- and 25-yr BSRC and adjusted storm tide hydrographs for St. Johns Co.

Specific wave conditions associated with 15- and 25-year return interval storm events for SBEACH model input were not found to be available at the time of this study. Development of such wave conditions were beyond the scope of this study. However, testing performed during the model calibration phase of this study presented in Volume 1 of this report documentation provided constant wave conditions for use for high-frequency storm events. Therefore, the constant wave conditions listed in Appendix VI were used in the SBEACH model for the 15- and 25-year storm erosion simulations.

3.2 Model Application and Results

Graphic plots of the 15- and 25-year storm erosion profiles generated from SBEACH for St. Johns County for the 209 range location profiles are provided in Appendix VIII of this report. The survey profiles used as the input profiles in SBEACH are BBCS profiles from 2007/2008. The plots in Appendix VIII are shown in the NAVD88 vertical datum. The map in Figure 52 below depicts the FDEP profile range locations across the St. Johns County shoreline. An example of 15 and 25-yr erosion profiles obtained from SBEACH for FDEP range R120 is shown in Figure 53.

Graphic plot overlays of the measured pre- and post-storm erosion profiles and SBEACH-generated erosion profiles obtained from model calibration work are provided in Appendix I of this report. Three sets of plots are provided in Appendix I; one for the Thanksgiving Storm for St. Johns County, and two for Brevard County, for Hurricane Frances and Hurricane Jeanne.

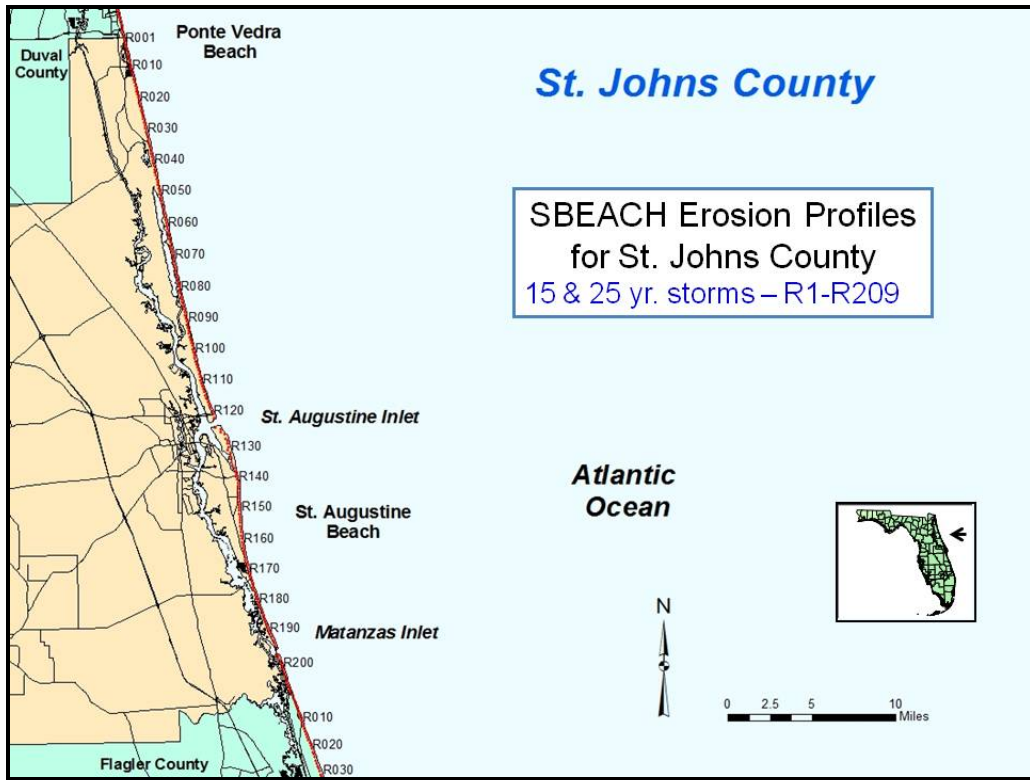


Figure 52. Map of FDEP profile range locations across the St. Johns County shoreline.

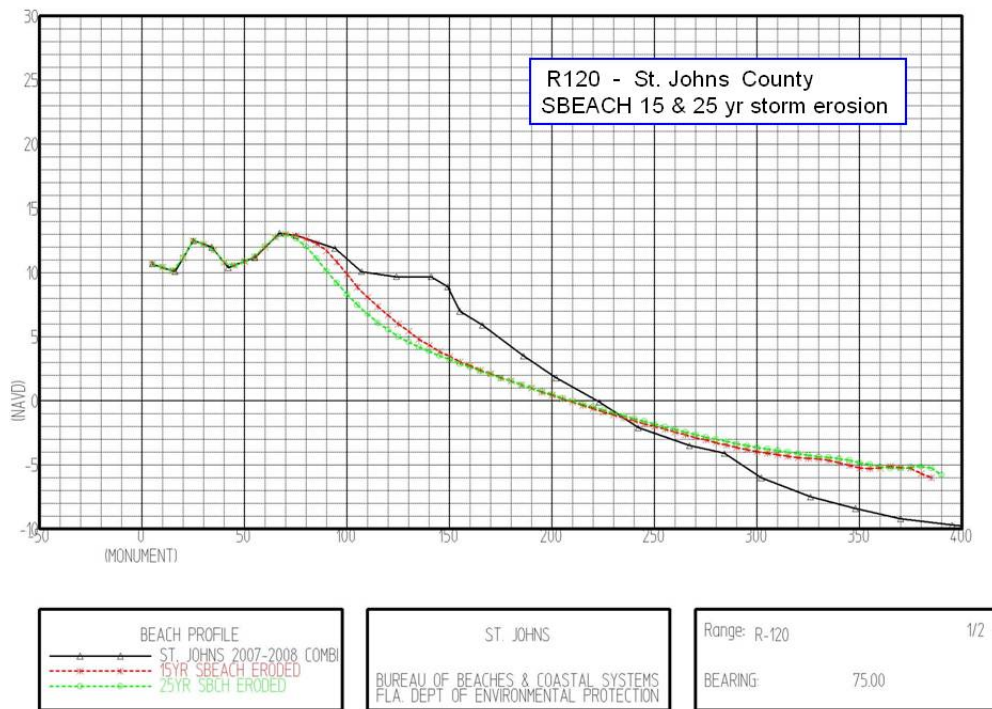


Figure 53. Example of 15 and 25-yr storm erosion profiles at R120 in St. Johns County.

4.0 Volusia County SBEACH Application

4.1 Model Configuration

The SBEACH model configuration for Volusia County for high-frequency storm erosion simulation, including model input parameters, was based on the model calibration results from St. Johns County described in Volume 1 of this report documentation. The specific Reach input values, including sediment grain size, maximum slope prior to avalanching, and sediment transport parameters were based on results from the St. Johns County calibration work.

The Reach input values for these parameters for Volusia County were generated from measured beach slopes from profile surveys of Volusia County and from relationships between these parameters and beach slope obtained from St. Johns County. A graph depicting beach slopes from 1987 profile surveys and average beach slopes for selected reaches along the County shoreline is shown in Figure 54. Graphs of beach slopes based on other available Volusia County profile survey data sets are contained in Appendix V. A graph of mean sediment grain size values for Volusia County based on application of the beach slope versus sediment grain size relationship from St. Johns County is shown in Figure 55. Mean grain size values of 0.15-0.2 mm. south of Ponce de Leon Inlet between R150-190 were verified by data collection reported by Taylor Engineering, Inc. (2003). Similarly, values for maximum slope prior to avalanching and sediment transport coefficient, K, were obtained through the relationships developed for St. Johns County presented in Volume 1 of this report documentation.

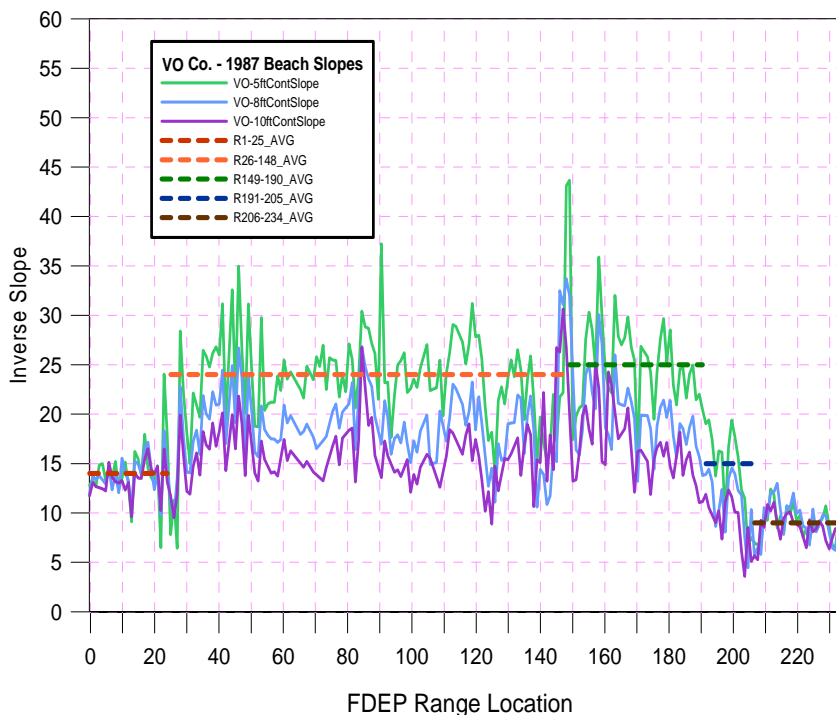


Figure 54. Beach slopes from 1987 profile surveys with selected averages for Volusia Co.

Storm tide hydrographs developed by BSRC (2009) for 15- and 25-year storms were used as storm input in SBEACH for Volusia County. As with the model calibration work in St. Johns County, consideration was given to accounting for the set-up component in the storm tide elevations, as well as, set-up computations within SBEACH. As a result, revised, adjusted versions of the FSU-BSRC hydrographs were used.

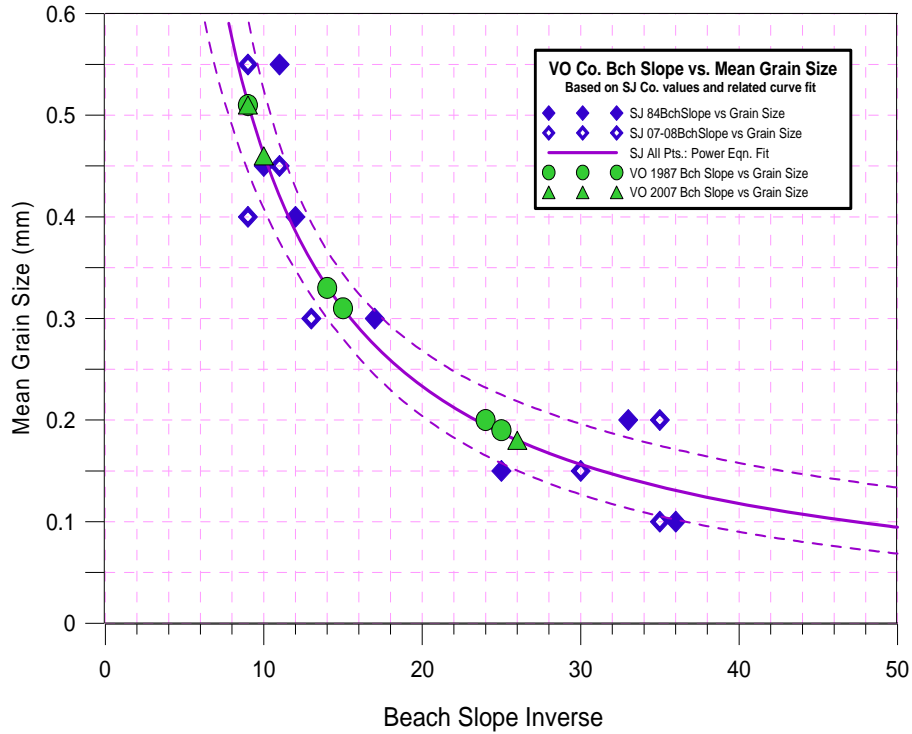


Figure 55. Sediment grain size values obtained from beach slopes measured from Volusia County profile surveys based on beach slope vs. sediment grain size relationship from St. Johns County.

The BSRC hydrographs were adjusted down in elevation to compensate for the set-up generated by SBEACH. The hydrograph reductions were proportional reductions of the BSRC hydrographs based on trial and error evaluations performed during initial SBEACH model application for Volusia County.

Use of the adjusted BSRC hydrographs resulted in final average maximum water elevations with set-up values from SBEACH which were equivalent to the BSRC peak storm tide elevations for the 15- and 25-year storm tide hydrographs. A graph depicting the original BSRC 15- and 25-year storm tide hydrographs and the adjusted/reduced hydrographs used in the final SBEACH erosion model runs for Volusia County is shown in Figure 56.

A listing of recommended Reach and Storm input values for use in 15- and 25-year storm erosion simulations using SBEACH is contained in Appendix VI of this report. Time

series values for the original and adjusted hydrographs for Volusia County are tabulated in Appendix VII of this report.

Specific wave conditions associated with 15- and 25-year return interval storm events for SBEACH model input were not found to be available at the time of this study. Development of such wave conditions were beyond the scope of this study. However, testing performed during the model calibration phase of this study presented in Volume 1

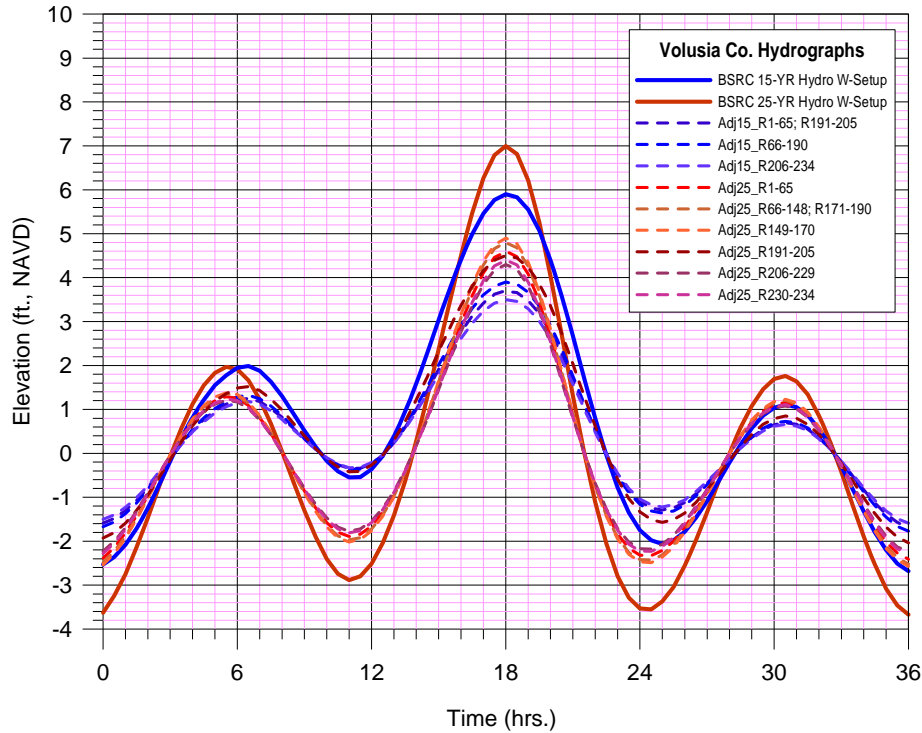


Figure 56. 15- and 25-yr BSRC and adjusted storm tide hydrographs for Volusia Co.

of this report documentation provided constant wave conditions for use for high-frequency storm events. Therefore, the constant wave conditions listed in Appendix VI were used in the SBEACH model for the 15- and 25-year storm erosion simulations.

4.2 Model Application and Results

Graphic plots of the 15- and 25-year storm erosion profiles generated from SBEACH for Volusia County for the 234 range location profiles are provided in Appendix IX of this report. The survey profiles used as the input profiles in SBEACH are BBCS profiles from 2007/2008.

The plots in Appendix IX are shown in the NAVD88 vertical datum. The map in Figure 57 below depicts the FDEP profile range locations across the Volusia County shoreline. An example of 15 and 25-yr erosion profiles obtained from SBEACH for FDEP range R196 is shown in Figure 58.

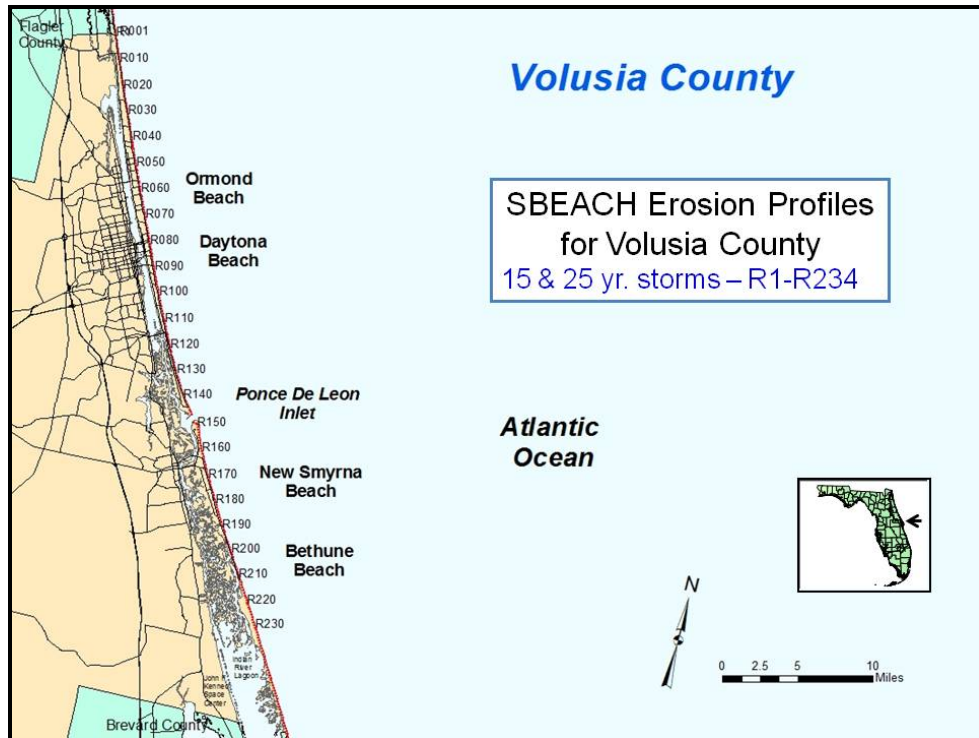
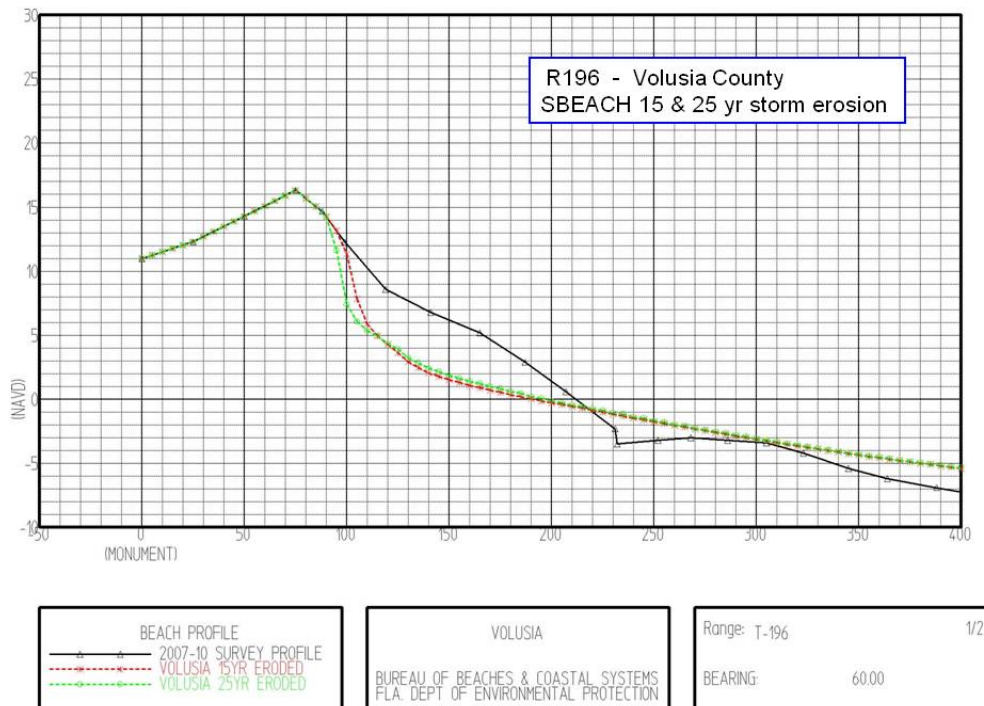


Figure 57. Map of FDEP profile range locations across the Volusia County shoreline.



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Figure 58. Example of 15 and 25-yr storm erosion profiles at R196 in Volusia County.

5.0 Indian River County SBEACH Application

5.1 Model Configuration

The SBEACH model configuration for Indian River County for high-frequency storm erosion simulation, including model input parameters, was based on the model calibration results from Brevard County and from St. Johns County described in Volume 1 of this report documentation. The specific Reach input values, including sediment grain size, maximum slope prior to avalanching, and sediment transport parameters were based on results from the St. Johns County calibration work.

The Reach input values for these parameters for Indian River County were generated from measured beach slopes from profile surveys of Indian River County and from relationships between these parameters and beach slope obtained from St. Johns County. A graph depicting beach slopes from a combined July 2006 profile surveys and average beach slopes for selected reaches along the County shoreline is shown in Figure 59. Graphs of beach slopes based on other Indian River County profile survey data sets are contained in Appendix V. A graph of mean sediment grain size values for Indian River County based on application of the beach slope versus sediment grain size relationship from St. Johns County is shown in Figure 60. Mean grain size values of 0.36-0.4 mm. for north Indian River County were verified by data collection reported by Corps of Engineers (1977) and Coastal Tech (2008). Similarly, values for maximum slope prior to avalanching and sediment transport coefficient, K, were obtained through the

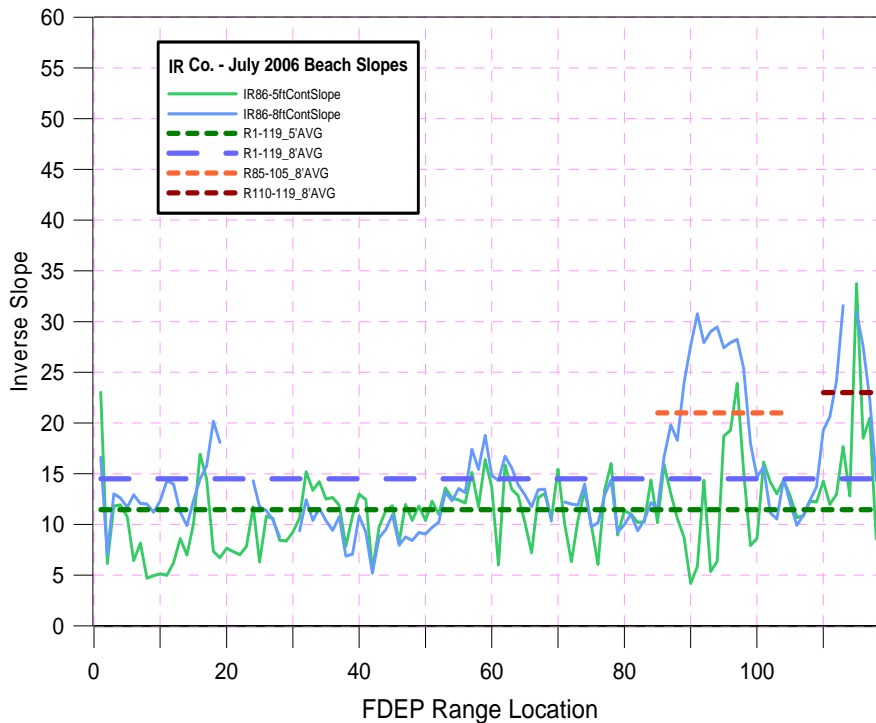


Figure 59. Beach slopes from 2006 profile surveys with selected averages for IR Co.

relationships developed for St. Johns County presented in Volume 1.

Storm tide hydrographs developed by BSRC (2010) for 15- and 25-year storms were used as storm input in SBEACH for Indian River County. As with the model calibration work in St. Johns County, consideration was given to accounting for the set-up component in the storm tide elevations, as well as, set-up computations within SBEACH. As a result, revised, adjusted versions of the FSU-BSRC hydrographs were used.

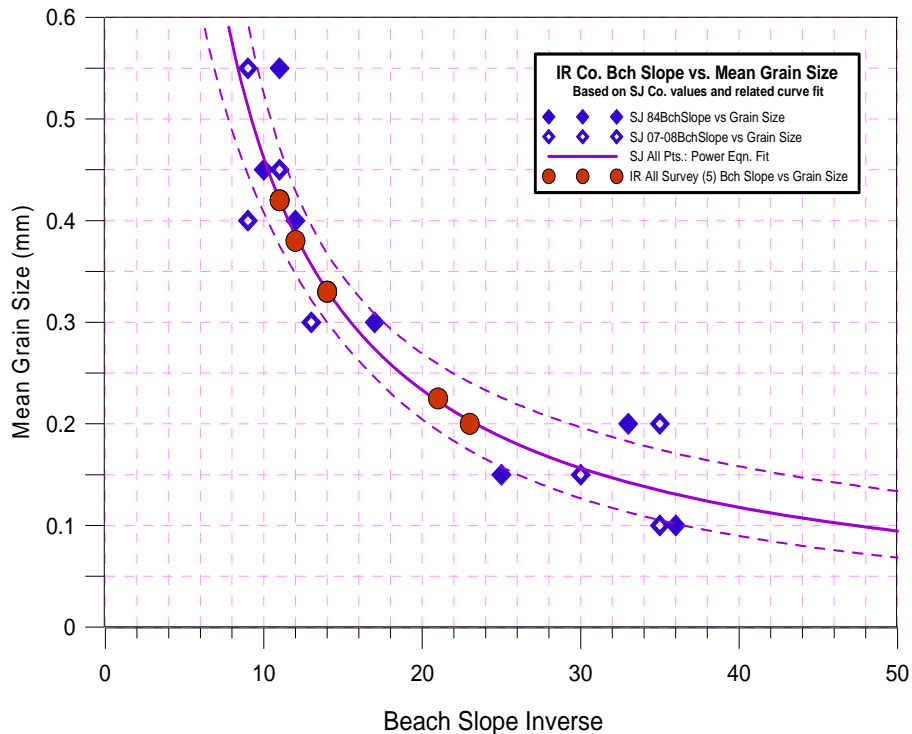


Figure 60. Sediment grain size values obtained from beach slopes measured from Indian River County profile surveys based on beach slope vs. sediment grain size relationship from St. Johns County.

The BSRC hydrographs were adjusted down in elevation to compensate for the set-up generated by SBEACH. The hydrograph reductions were proportional reductions of the BSRC hydrographs based on trial and error evaluations performed during initial SBEACH model application for Indian River County.

Use of the adjusted BSRC hydrographs resulted in final average maximum water elevations with set-up values from SBEACH which were equivalent to the BSRC peak storm tide elevations for the 15- and 25-year storm tide hydrographs. A graph depicting the original BSRC 15- and 25-year storm tide hydrographs and the adjusted/reduced hydrographs used in the final SBEACH erosion model runs for Indian River County is shown in Figure 61.

A listing of recommended Reach and Storm input values for use in 15- and 25-year storm erosion simulations using SBEACH is contained in Appendix VI of this report. Time

series values for the original and adjusted hydrographs for Indian River County are tabulated in Appendix VII of this report.

Specific wave conditions associated with 15- and 25-year return interval storm events for SBEACH model input were not found to be available at the time of this study. Development of such wave conditions were beyond the scope of this study. However, testing performed during the model calibration phase of this study presented in Volume 1

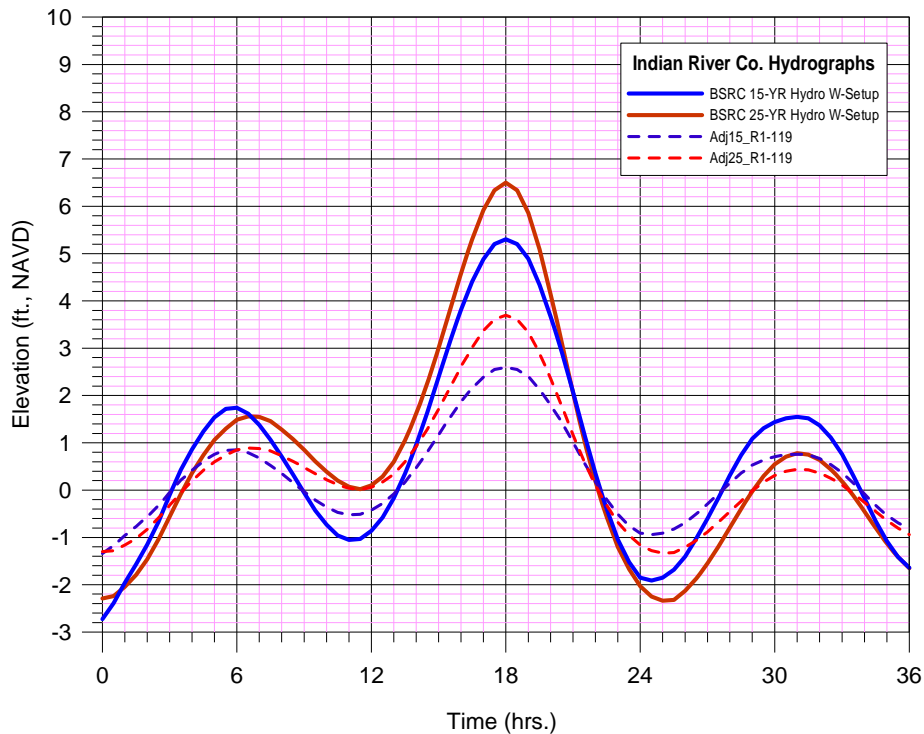


Figure 61. 15- and 25-yr BSRC and adjusted storm tide hydrographs for Indian River Co.

of this report documentation provided constant wave conditions for use for high-frequency storm events. Therefore, the constant wave conditions listed in Appendix VI were used in the SBEACH model for the 15- and 25-year storm erosion simulations.

5.2 Model Application and Results

Graphic plots of the 15- and 25-year storm erosion profiles generated from SBEACH for Indian River County for the 119 range location profiles are provided in Appendix X of this report. The survey profiles used as the input profiles in SBEACH are a combination of the most recent BBCS profiles from 2006, 2007, and 2008.

The plots in Appendix X are shown in the NAVD88 vertical datum. The map in Figure 62 below depicts the FDEP profile range locations across the Indian River County shoreline. An example of 15 and 25-yr erosion profiles obtained from SBEACH for FDEP range R50 is shown in Figure 63.

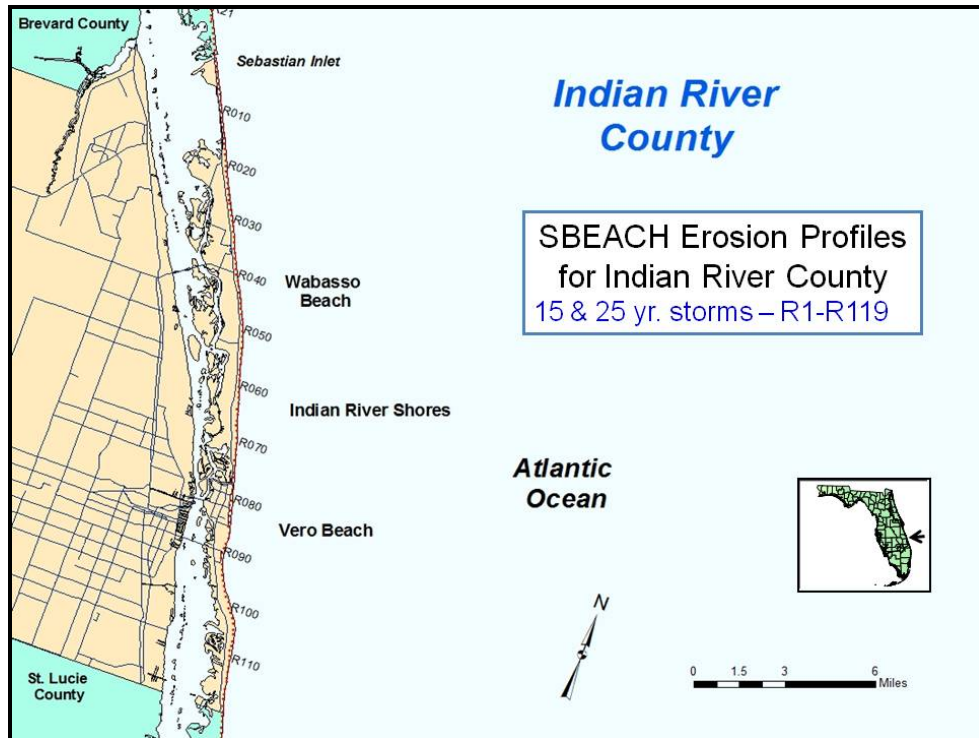
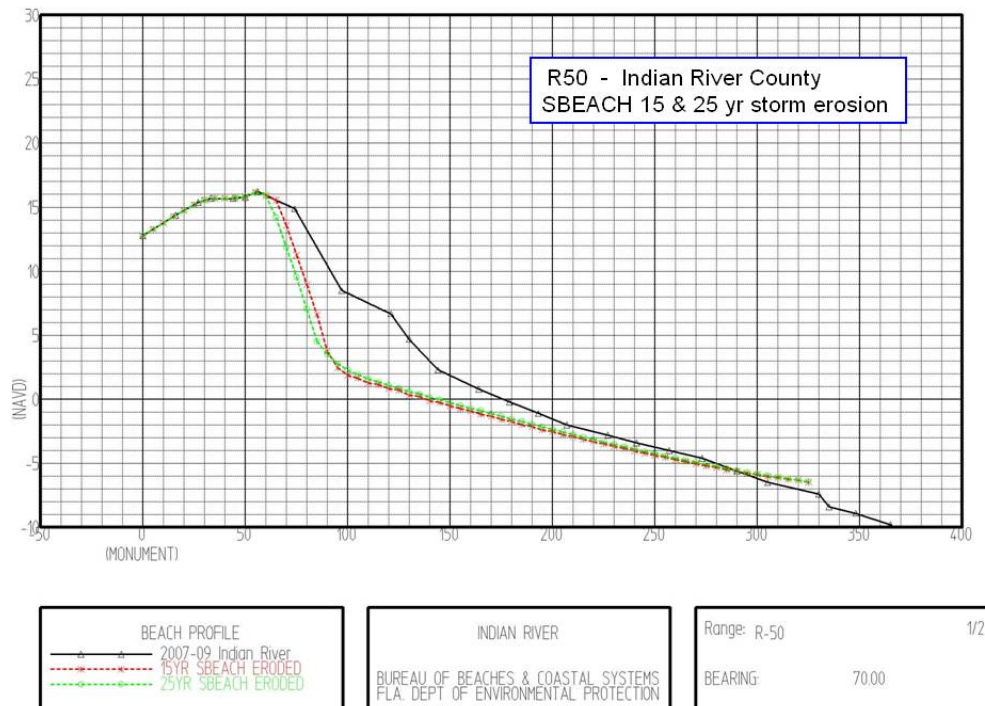


Figure 62. Map of FDEP profile range locations along Indian River County shoreline.



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Figure 63. Example of 15 and 25-yr storm erosion profiles at R50 in Indian River Co.

6.0 Brevard County SBEACH Application

6.1 Model Configuration

The SBEACH model configuration for Brevard County for high-frequency storm erosion simulation, including model input parameters, was based on the model calibration results from Brevard County and from St. Johns County described in Volume 1 of this report documentation. The specific Reach input values, including sediment grain size, maximum slope prior to avalanching, and sediment transport parameters were based on the results from the Brevard County and St. Johns County calibration work.

The Reach input values for these parameters for Brevard County were generated from measured beach slopes from profile surveys of Brevard County and from relationships between these parameters and beach slope obtained from St. Johns County. A graph depicting beach slopes from a composite of 2005-2006-2008 profile surveys and average beach slopes for selected reaches along the County shoreline is shown in Figure 64. A graph of beach slopes based on a Brevard County profile survey data set from 2002 is contained in Appendix V. A graph of mean sediment grain size values for Brevard County based on application of the beach slope versus sediment grain size relationship from St. Johns County is shown in Figure 65. Composite mean grain size values of 0.3 mm. for North and South Reach fill areas in the County's beach restoration project were verified by data collection reported in project design documents. Similarly, values for maximum slope prior to avalanching and sediment transport rate coefficient, K, were

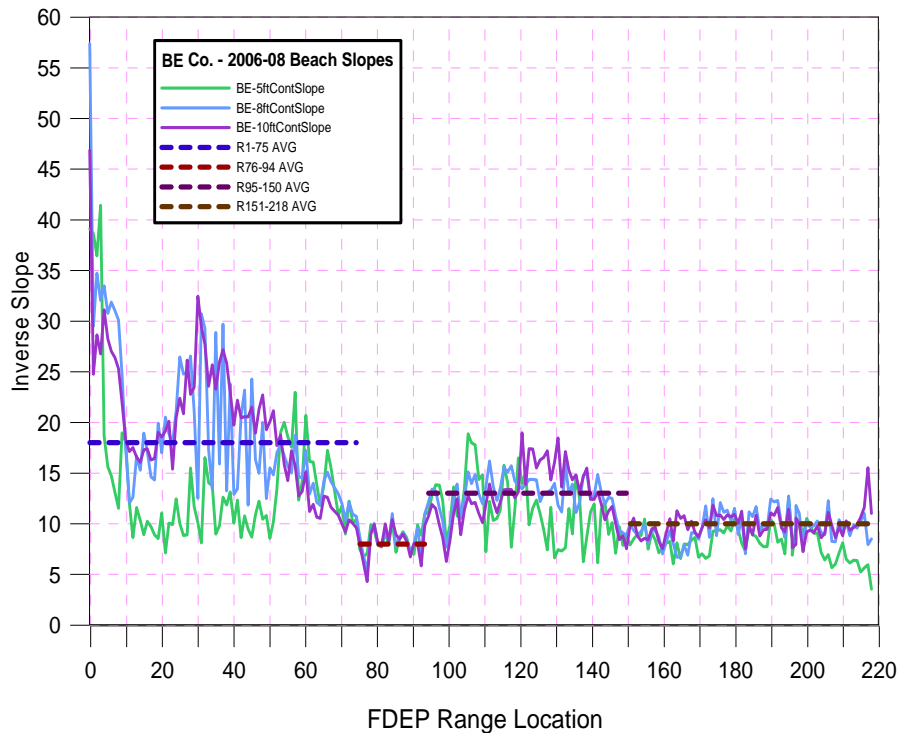


Figure 64. Beach slopes from 2006-08 profile surveys with selected averages for BE Co.

obtained through the relationships developed for St. Johns County presented in Volume 1.

Storm tide hydrographs developed by BSRC (2010) for 15- and 25-year storms were used as storm input in SBEACH for Brevard County. As with the model calibration work in St. Johns County, consideration was given to accounting for the set-up component in the storm tide elevations, as well as, set-up computations within SBEACH. As a result, revised, adjusted versions of the FSU-BSRC hydrographs were used.

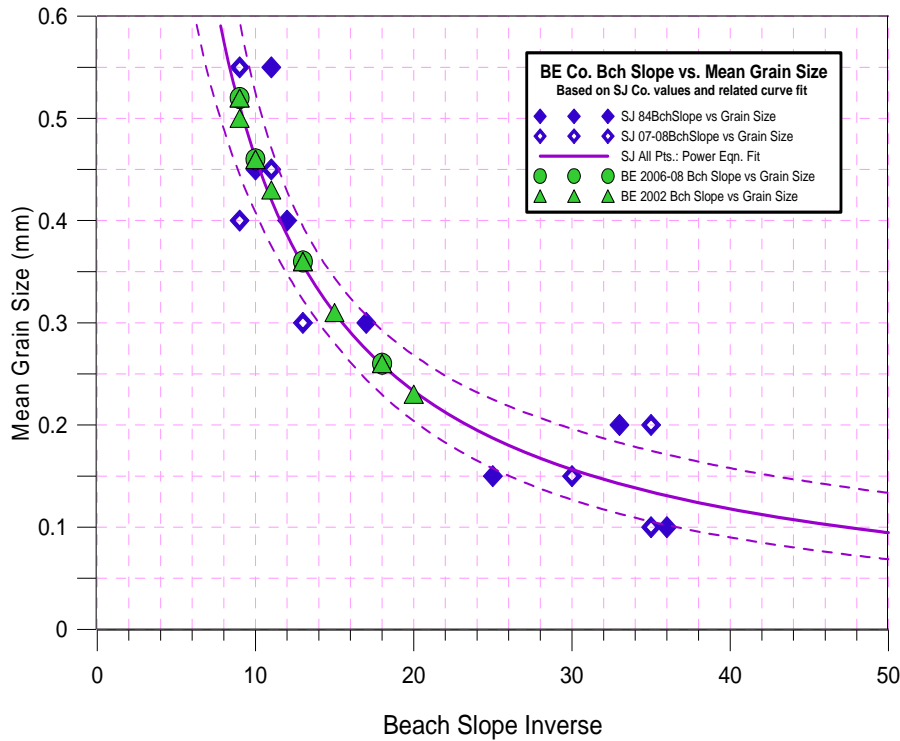


Figure 65. Sediment grain size values obtained from beach slopes measured from Brevard County profile surveys based on beach slope vs. sediment grain size relationship from St. Johns County.

The BSRC hydrographs were adjusted down in elevation to compensate for the set-up generated by SBEACH. The hydrograph reductions were proportional reductions of the BSRC hydrographs based on trial and error evaluations performed during initial SBEACH model application for Brevard County.

Use of the adjusted BSRC hydrographs resulted in final average maximum water elevations with set-up values from SBEACH which were equivalent to the BSRC peak storm tide elevations for the 15- and 25-year storm tide hydrographs. A graph depicting the original BSRC 15- and 25-year storm tide hydrographs and the adjusted/reduced hydrographs used in the final SBEACH erosion model runs for Brevard County is shown in Figure 66.

A listing of recommended Reach and Storm input values for use in 15- and 25-year storm erosion simulations using SBEACH is contained in Appendix VI of this report. Time series values for the original and adjusted hydrographs for Brevard County are tabulated in Appendix VII of this report.

Specific wave conditions associated with 15- and 25-year return interval storm events for SBEACH model input were not found to be available at the time of this study. Development of such wave conditions were beyond the scope of this study. However, testing performed during the model calibration phase of this study presented in Volume 1

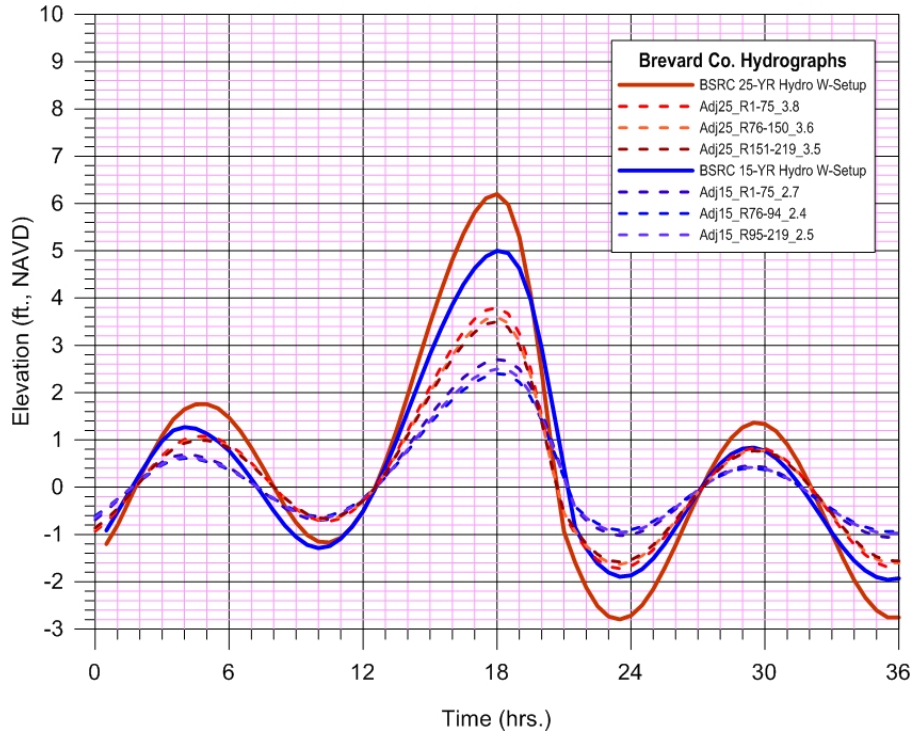


Figure 66. 15- and 25-yr BSRC and adjusted storm tide hydrographs for Brevard Co.

of this report documentation provided constant wave conditions for use for high-frequency storm events. Therefore, the constant wave conditions listed in Appendix VI were used in the SBEACH model for the 15- and 25-year storm erosion simulations.

6.2 Model Application and Results

Graphic plots of the 15- and 25-year storm erosion profiles generated from SBEACH for Brevard County for the 219 range location profiles are provided in Appendix XI of this report. The survey profiles used as the input profiles in SBEACH are a combination of the most recent BCS profiles at the time this report was prepared from 2006-08. The plots in Appendix XI are shown in the NAVD88 vertical datum. The map in Figure 67 below depicts the FDEP profile range locations across the Brevard County shoreline. An example of 15 and 25-yr erosion profiles obtained from SBEACH for FDEP range R50 is shown in Figure 68.

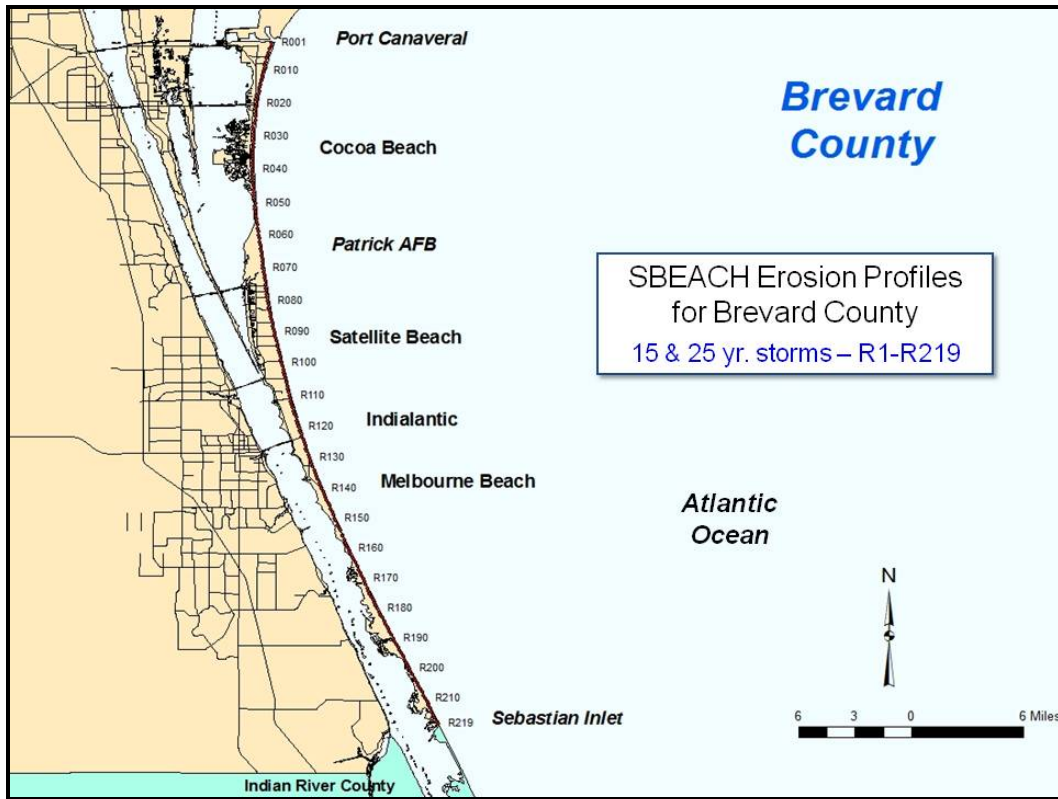
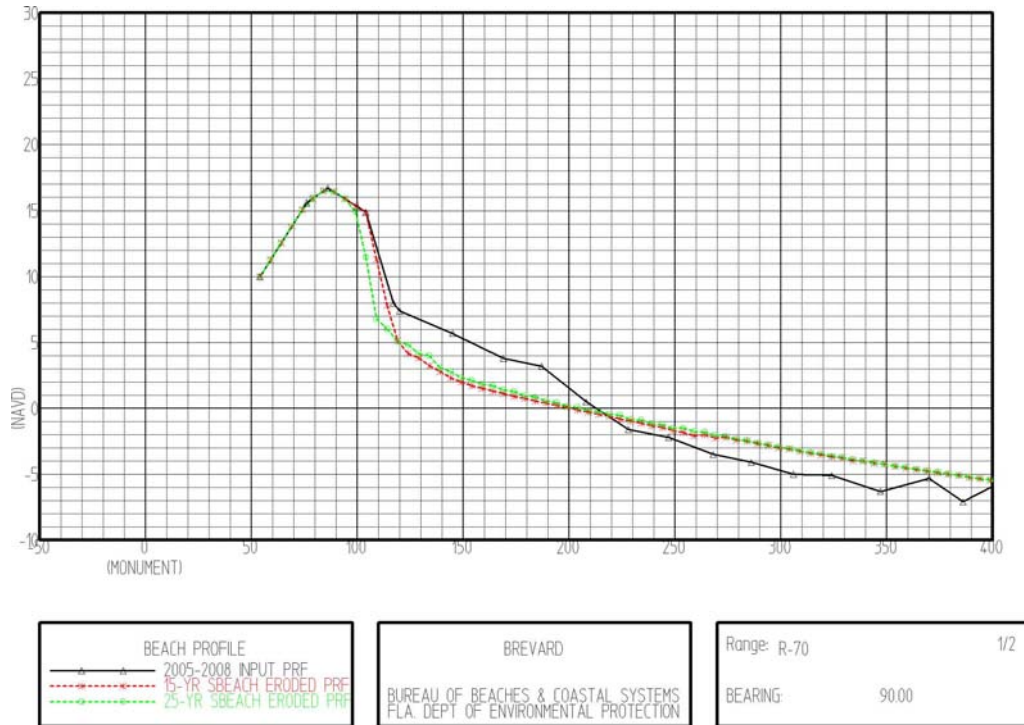


Figure 67. Map of FDEP profile range locations along Brevard County shoreline.



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Figure 68. Example of 15 and 25-yr storm erosion profiles at R70 in Brevard Co.

7.0 References

- 1) Brevard County, Pre- and Post-Hurricane Frances and Jeanne Beach Profiles from North and South Reaches of Brevard County Beach Restoration Project Monitoring Program, September 2004.
- 2) Coastal Technology Corporation, “Indian River County, Florida, Beach Preservation Plan”, December 2008.
- 3) Chiu, T.Y., and Dean, R.G., “Methodology on Coastal Construction Control Line Establishment”, FSU Beaches and Shores Resource Center, originally published in 1984; updated in June 2002. <http://bcs.dep.state.fl.us/reports/method.pdf>
- 4) Dean, R.G., Chiu, T.Y., and S.Y. Wang, “High-Frequency Storm Hydrograph Development and Erosion Model Calibration”, UF Department of Coastal and Oceanographic Engineering and FSU Beaches and Shores Resource Center, March 1993.
- 5) Dean, R.G., “Beach Nourishment Design: Consideration of Sediment Characteristics” Proceedings of the 13th Annual National Conference on Beach Preservation Technology, Florida Shore and Beach Preservation Association, May 2000.
- 6) Florida DEP Bureau of Beaches and Coastal Systems, “Hurricane Frances and Hurricane Jeanne– Post-storm Beach Conditions and Coastal Impact Report with Recommendations for Recovery and Modifications of Beach Management Strategies” October 2004.
http://bcs.dep.state.fl.us/reports/franjean/Hurricanes_Frances_&_Jeanne/Full_Report/Full_Report.pdf
- 7) Florida DEP Bureau of Beaches and Coastal Systems, beach and offshore hydrographic survey database, <http://www.dep.state.fl.us/beaches/data/his-shore.htm#ProfileData>
- 8) Florida State University-Beaches and Shores Resource Center, “Inclusion of Tropical Storms for the Combined Total Storm Tide Frequency Re-Study for St. Johns County, Florida”, October 2009.
- 9) Florida State University-Beaches and Shores Resource Center, “Inclusion of Tropical Storms for the Combined Total Storm Tide Frequency Re-Study for Volusia County, Florida”, December 2009.
- 10) Florida State University-Beaches and Shores Resource Center, “Inclusion of Tropical Storms for the Combined Total Storm Tide Frequency Re-Study for Indian River County, Florida”, December 2009.

- 11) Larson, M., and Kraus, N.C., “SBEACH:Numerical Model for Simulating Storm-Induced Beach Change – Empirical Foundation and Model Development”, USACE-CERC, Technical Report CERC-89-9 Report 1, July 1989.
<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Publications;559>
- 12) Larson, M., Kraus, N.C., and Byrnes, M.R., “SBEACH:Numerical Model for Simulating Storm-Induced Beach Change – Numerical Formulation and Model Tests”, USACE-CERC, Technical Report CERC-89-9 Report 2, July 1989.
<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=PUBLICATIONS;560>
- 13) Leadon, M.E., Nguyen, N.T., “SBEACH Calibration and Erosion Analysis for Walton County and Okaloosa County, Florida”, Beaches and Shores Resource Center, Florida State University, June 2009
- 14) Leadon, M.E., “Florida Atlantic Coast Tide Gage Data Evaluations” Beaches and Shores Resource Center, Florida State University, June 2010.
- 15) Malakar, S.B., and Dean, R.G., “Erosion Due to High Frequency Storm Events (18 Selected Coastal Counties of Florida)”, Dept. of Coastal and Oceanographic Engineering, University of Florida, November 22, 1995.
- 16) Rosati, J.D., Wise, R.A., Kraus, N.C., Larson, M., “SBEACH:Numerical Model for Simulating Storm-Induced Beach Change – Report 3, User’s Manual”, USACE-CERC, Instruction Report CERC-93-2, May 1993.
<http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=Publications;120>
- 17) Surfbreak Engineering and Sciences, Inc., “Development of a Nearshore Synthetic Wave Record for Brevard County, Florida”, Prepared for FDEP-Bureau of Beaches and Coastal Systems, April 2008.
- 18) Surfbreak Engineering and Sciences, Inc., “Development of a Nearshore Synthetic Wave Record for St. Johns County, Florida”, Prepared for FDEP-Bureau of Beaches and Coastal Systems, March 2009.
- 19) Taylor Engineering, Inc., “Volusia County Erosion Assessment Study for Shorelines South of Ponce de Leon Inlet to Canaveral National Seashore”, Prepared for Ponce de Leon Inlet and Port District, December 2003.
- 20) U.S. Army Corps of Engineers, Jacksonville District, “Beach Erosion Control Study on St. Johns County, Florida”, Report No. 53, March 1965.
- 21) U.S. Army Corps of Engineers, Jacksonville District, “Feasibility Report for Beach Erosion Control, Indian River County Beaches, Florida”, Preliminary Report Appendices, 1977.

- 22) U.S. Army Corps of Engineers, Jacksonville District, “Joint Coastal Permit Application, St. Johns County Shore Protection Project, St. Johns County, Florida”, August 2009.
- 23) U.S. Army Corps of Engineers, Waterways Experiment Station-CERC, “Shore Protection Manual”, Volumes I and II, 1984. Updated Coastal Engineering Manual available at USACE-WES Coastal and Hydraulics Laboratory.
<http://chl.erdc.usace.army.mil/>
- 24) USACE-WES, Coastal and Hydraulics Laboratory, Wave Information Studies (WIS) Hindcast Studies, http://frf.usace.army.mil/cgi-bin/wis/atl/atl_main.html
- 25) U.S.-NOAA, National Hurricane Center (various authors), Annual Summary reports for Atlantic Hurricane Seasons, 1994 through 2005,
<http://www.nhc.noaa.gov/>
- 26) U.S.-NOAA, National Ocean Service, Tides Online, <http://tidesonline.noaa.gov/>
- 27) Veri-Tech, Inc., CEDAS Software Package, <http://www.veritechinc.net/main.php>
- 28) Walton, T.L., Cheng, J., “Blindfold Testing of SBEACH Model”, FSU-BSRC, prepared for FDEP-BBCS, February, 2006.
- 29) Wang, R., Manausa, M., “Hurricane Frances Characteristics and Storm Tide Evaluation”, FSU Beaches and Shores Resource Center, May 2005.
<http://bcs.dep.state.fl.us/reports/strmtide/frances.pdf>
- 30) Wang, R., Manausa, M., “Hurricane Jeanne Characteristics and Storm Tide Evaluation”, FSU Beaches and Shores Resource Center, May 2005.
<http://bcs.dep.state.fl.us/reports/strmtide/jeanne.pdf>
- 31) Zarillo, G.A., “Geotechnical Analysis of Native Beach Samples Collected from St. Johns County, Florida”, Scientific Environmental Applications, Inc. (S.E.A.), Prepared for PBS&J, Coastal and Waterways Division, July 2008.

APPENDICES

for

SBEACH Model Studies for the Florida Atlantic Coast:

VOLUME 1

Model Calibration in Brevard and St. Johns Counties

and

VOLUME 2

Model Application for Brevard, St. Johns, Volusia,
and Indian River Counties

NOTE: Printed versions of the Appendices are not included with this printed copy of the report; all 11 Appendices are included electronically with the full text of the report and contained on the CD accompanying this report, and are available in downloadable pdf format on the FDEP Beaches and Coastal Systems website