Florida Statewide Regional Evacuation Study Program

Storm Tide Atlas

Flagler County

Volume 7-4
Book 3 of 6
Florida Division of Emergency Management
Northeast Florida Regional Council

Northeast Florida Region

2013

Includes Hurricane Evacuation Study
This Book is part of Volume 7 of the Statewide Regional Evacuation Study (SRES) Program and one of six county books in the Northeast Florida Storm Tide Atlas Series. Book 1 covers Clay County; Book 2 covers Duval County; Book 3 covers Flagler County, Book 4 covers Nassau County; Book 5 covers Putnam County and Book 6 covers St. Johns County. The Atlas maps identify those areas subject to potential storm tide flooding from the five categories of hurricane on the Saffir Simpson Hurricane Wind Scale as determined by NOAA's numerical storm surge model, SLOSH.

The Storm Tide Atlas, originally published in 2010 and updated with new SLOSH data in 2013, is the foundation of the hazards analysis for storm tide and a key component of the SRES. The Technical Data Report (Volume 1) builds upon this analysis and includes the revised evacuation zones and population estimates, results of the evacuation behavioral data, shelter analysis and evacuation transportation analyses. The Study, which provides vital information to state and local emergency management, forms the basis for county evacuation plans. The final documents with summary information will be published and made available on the Internet (www.nefrc.org) in September 2013.

The Atlas was produced by the Northeast Florida Regional Council with funding by the Florida Legislature and the Federal Emergency Management Agency through the Florida Division of Emergency Management.

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INTRODUCTION

A comprehensive emergency management program requires attention to four (4) key inter-related components: preparedness, response, recovery and mitigation. Preparing and avoiding or reducing potential loss of life and property damage - *preparedness and mitigation* - requires accurate and precise hazard and vulnerability analyses. These analyses are the foundation for evacuation and disaster response planning, as well as the development of local mitigation strategies designed to reduce the community's overall risk to disasters. This Atlas series provides information to state, county and local emergency management officials and planners for use in hurricane preparedness and coastal management in the Northeast Florida Region including Baker, Clay, Duval, Flagler, Nassau, Putnam and St. Johns counties (Figure 1). It was part of a statewide effort to enhance our ability to respond to a hurricane threat, facilitate the evacuation of vulnerable residents to a point of relative safety and mitigate our vulnerability in the future. The *Statewide Regional Evacuation Study Program* provides a consistent, coordinated and improved approach to addressing the state and regional vulnerability to the hurricane threat.

The specific purpose of this Atlas is to provide maps which depict storm tide heights and the extent of stillwater, storm surge coastal flooding inundation from hurricanes of five different intensities in the Northeast Florida area. The Atlas was prepared by the Northeast Florida Regional Council as part of the *Statewide Regional Evacuation Study Program*. The Study is a cooperative effort between the Florida Division of Emergency Management, the Florida Regional Planning Councils and other State agencies such as the DOT and DEO, NGOs such as the Red Cross and the county emergency management agencies.

THE SLOSH MODEL

The principal tool utilized in this study for analyzing the expected hazards from potential hurricanes affecting the study area is the Sea, Lake and Overland Surges from Hurricane (*SLOSH*) numerical storm surge prediction model. The SLOSH computerized model predicts the storm tide heights that result from hypothetical hurricanes with selected various combinations of pressure, size, forward speed, track and winds. Originally developed for use by the National Hurricane Center (NHC) as a tool to give geographically specific
warnings of expected surge heights during the approach of hurricanes, the SLOSH model is utilized in regional studies for several key hazard and vulnerability analyses.

The SLOSH modeling system consists of the model source code and the model basin or grid. SLOSH model grids must be developed for each specific geographic coastal area individually incorporating the unique local bay and river configuration, water depths, bridges, roads and other physical features. In addition to open coastline heights, one of the most valuable outputs of the SLOSH model for evacuation planning is its predictions of surge heights over land into inland areas.

The first SLOSH model basin was completed in 1979 and represented the first application of SLOSH storm surge dynamics to a major coastal area of the United States. The model was developed by the Techniques Development Lab of the National Oceanic and Atmospheric Administration (NOAA) under the direction of the late Dr. Chester P. Jellesnianski. In December 1998 the National Hurricane Center updated the SLOSH model for the Northeast Florida basin and most recently in 2011.

**Hypothetical Storm Simulations**

Surge height depends strongly on the specifics of a given storm including, forward speed, angle of approach, intensity or maximum wind speed, storm size, storm shape, and landfall location. The SLOSH model was used to develop data for various combinations of hurricane strength, wind speed, and direction of movement. Storm strength was modeled using the central pressure (defined as the difference between the ambient sea level pressure and the minimum value in the storm's center), the storm eye size and the radius of maximum winds using the five categories of hurricane intensity as depicted in the Saffir-Simpson Hurricane Wind Scale (see Table 1).

**Table 1  Saffir-Simpson Hurricane Wind Scale**

<table>
<thead>
<tr>
<th>Category</th>
<th>Wind Speeds</th>
<th>Potential Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>(Sustained winds 74-95 mph)</td>
<td>Very dangerous winds will produce some damage</td>
</tr>
<tr>
<td>Category 2</td>
<td>(Sustained winds 96-110 mph)</td>
<td>Extremely dangerous winds will cause extensive damage</td>
</tr>
<tr>
<td>Category 3</td>
<td>(Sustained winds 111-129 mph)</td>
<td>Devastating damage will occur</td>
</tr>
<tr>
<td>Category 4</td>
<td>(Sustained winds 130-156 mph)</td>
<td>Catastrophic damage will occur</td>
</tr>
<tr>
<td>Category 5</td>
<td>(Sustained winds of 157 mph and above)</td>
<td>Catastrophic damage will occur</td>
</tr>
</tbody>
</table>

The modeling for each hurricane category was conducted using the mid-range pressure difference ($\Delta p$, millibars) for that category. The model also simulates the storm filling (weakening upon landfall) and radius of maximum winds (RMW) increase.
Eleven storm track headings (WSW, W, WNW, NW, NNW, N, NNE, NE, E, ENE, Parallel) were selected as being representative of storm behavior in the Northeast Florida region, based on observations by forecasters at the National Hurricane Center. And for each set of tracks in a specific direction storms were run at forward speeds of 5, 15 and 25 mph and with two different Radius of Maximum Wind values – 20 and 35 statute miles. There were two datums run relative to NAVD88, with 8,283 storm tracks per datum, for a total of 16,566 total tracks as shown in Table 2.

Finally, each scenario was run at astronomical high tide. The tide level is now referenced to North American Vertical Datum of 1988 (NAVD88) as opposed to the National Geodetic Vertical Datum of 1929 (NGVD29) used in studies prior to 2010.

Table 2 Northeast Florida Basin Hypothetical Storm Parameters

Directions, speeds, (Saffir/Simpson) intensities, number of tracks and the number of runs.

<table>
<thead>
<tr>
<th>Direction</th>
<th>Speeds (mph)</th>
<th>Intensity</th>
<th>Tracks</th>
<th>Radius of Maximum Winds</th>
<th>Runs</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSW</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>30</td>
<td>20,35 miles</td>
<td>990</td>
</tr>
<tr>
<td>W</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>29</td>
<td>20,35 miles</td>
<td>957</td>
</tr>
<tr>
<td>WNW</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>25</td>
<td>20,35 miles</td>
<td>825</td>
</tr>
<tr>
<td>NW</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>20</td>
<td>20,35 miles</td>
<td>660</td>
</tr>
<tr>
<td>NNW</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>22</td>
<td>20,35 miles</td>
<td>726</td>
</tr>
<tr>
<td>N</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>20</td>
<td>20,35 miles</td>
<td>660</td>
</tr>
<tr>
<td>NNE</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>25</td>
<td>20,35 miles</td>
<td>825</td>
</tr>
<tr>
<td>NE</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>28</td>
<td>20,35 miles</td>
<td>924</td>
</tr>
<tr>
<td>ENE</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>30</td>
<td>20,35 miles</td>
<td>990</td>
</tr>
<tr>
<td>E</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>11</td>
<td>20,35 miles</td>
<td>363</td>
</tr>
<tr>
<td>Parallel</td>
<td>5,15,25 mph</td>
<td>1 through 5</td>
<td>11</td>
<td>20,35 miles</td>
<td>363</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>8,283</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Grid for the Northeast Florida SLOSH Model

Figure 2 illustrates the area covered by the grid for the Northeast Florida SLOSH Model. To determine the surge values the SLOSH model uses a telescoping hyperbolic grid as its unit of analysis with 83 arc lengths \((1 \leq I \leq 83)\) and 95 radials \((1 \leq J \leq 95)\). Use of the grid configuration allows for individual calculations per grid square which is beneficial in two ways: (1) provides increased resolution of the storm surge at the coastline and inside the harbors, bays and rivers, while decreasing the resolution in the deep water where detail is not as important; and (2) allows economy in computation.

The size of each grid square for the Northeast Florida model varies from approximately 0.08 square miles or 52 acres for grids along the St Johns River to the grids on the outer edges (within the depths of the Atlantic Ocean) where each grid is almost 1 square mile.

The Northeast Florida SLOSH Basin has been greatly refined from its older iterations. Previously, the Jacksonville Basin utilized in the 2010 Northeast Florida Regional Evacuation Study contained 7,885 grid squares. The newly released 2012 Jacksonville Basin contains 126,160 grid squares. While the size of the grid squares has remained the same, the proportion of smaller grid squares has dramatically increased. This Basin is now one of the finely resolved Basins in the Nation.

Storm Scenario Determinations

As indicated, the SLOSH model is the basis for the "hazard analysis" portion of coastal hurricane evacuation plans. Over 16,000 hypothetical hurricanes are simulated with various Saffir-Simpson Wind categories, forward speeds, landfall directions, and landfall locations. An envelope of high water containing the maximum value a grid cell attains is generated at the end of each model run. These envelopes are combined by the NHC into various composites which depict the possible flooding.
One useful composite is the MEOW (Maximum Envelopes of Water) which incorporates all the envelopes for a particular category, speed, and landfall direction. Once surge heights have been determined for the appropriate grids, the maximum surge heights are plotted by storm track and hurricane category. These plots of maximum surge heights for a given storm category and track are referred to as Maximum Envelopes of Water (MEOWs). The MEOWs or Reference Hurricanes can be used in evacuation decision making when and if sufficient forecast information is available to project storm track or type of storm (different land falling, paralleling, or exiting storms).

The MEOWs provide information to the emergency managers in evacuation decision making. However, in order to determine a scenario which may confront the county in a hurricane threat 24-48 hours before a storm is expected, a further compositing of the MEOWs into Maximums of the Maximums (MOMs) is usually required.

The MOM (Maximum of the MEOWs) combines all the MEOWs of a particular category. The MOMs represent the maximum surge expected to occur at any given location, regardless of the specific storm track/direction of the hurricane. The only variable is the intensity of the hurricane represented by category strength (Category 1-5).

All SLOSH runs of the hypothetical hurricanes were based on an initial water height of 1.0 feet and the resulting calculations of storm surge represent condition at time of high tide. All elevations are now referenced to the NAVD88 datum.

These surge heights were provided within the SLOSH grid system as illustrated on Figure 2. The range of maximum surge heights (low to high) for each scenario is provided for each category of storm (MOM) on Table 3. It should be noted again that these surge heights represent the maximum surge height recorded in the county from the storm tide analysis including inland and riverine areas where the surge can be magnified dependent upon storm parameters.
Table 3  Potential Storm Tide Height (s) by County
(In Feet above NAVD88)

<table>
<thead>
<tr>
<th>*Storm Strength</th>
<th>Clay</th>
<th>Duval</th>
<th>Flagler</th>
<th>Nassau</th>
<th>Putnam</th>
<th>St. Johns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>Up to 3.6’</td>
<td>Up to 6.6’</td>
<td>Up to 6.3’</td>
<td>Up to 6.8’</td>
<td>Up to 4.3’</td>
<td>Up to 6.5’</td>
</tr>
<tr>
<td>Category 2</td>
<td>Up to 5.6’</td>
<td>Up to 11.0’</td>
<td>Up to 12.6’</td>
<td>Up to 12.2’</td>
<td>Up to 6.7’</td>
<td>Up to 11.9’</td>
</tr>
<tr>
<td>Category 3</td>
<td>Up to 9.5’</td>
<td>Up to 19.9’</td>
<td>Up to 18.8’</td>
<td>Up to 16.7’</td>
<td>Up to 9.3’</td>
<td>Up to 19.9’</td>
</tr>
<tr>
<td>Category 4</td>
<td>Up to 13.5’</td>
<td>Up to 22.2’</td>
<td>Up to 24.2’</td>
<td>Up to 21.2’</td>
<td>Up to 12.4’</td>
<td>Up to 24.9’</td>
</tr>
<tr>
<td>Category 5</td>
<td>Up to 16.3’</td>
<td>Up to 28.2’</td>
<td>Up to 27.3’</td>
<td>Up to 27.7’</td>
<td>Up to 14.4’</td>
<td>Up to 29.6’</td>
</tr>
</tbody>
</table>

* Based on the category of storm on the Saffir-Simpson Hurricane Wind Scale
** Surge heights represent the maximum values from SLOSH MOMs

CREATION OF THE STORM TIDE ZONES

The maps in this atlas depict SLOSH-modeled heights of storm tide and extent of flood inundation for hurricanes of five different intensities. As indicate above, the storm tide was modeled using the Maximum of Maximums (MOMs) representing the potential flooding from the five categories of storm intensity of the Saffir/Simpson Hurricane Wind Scale.

Determining Storm Tide Height and Flooding Depth

SLOSH and SLOSH-related products reference storm tide heights relative to the model vertical datum, NAVD88. In order to determine the inundation depth of surge flooding at a particular location the ground elevation (relative to NAVD88) at that location must be subtracted from the potential surge height.¹

¹ It is important to note that one must use a consistent vertical datum when post-processing SLOSH storm surge values.
Surge elevation, or water height, is the output of the SLOSH model. At each SLOSH grid point, the maximum surge height is computed at that point.

Within the SLOSH model an average elevation is assumed within each grid square. Height of water above terrain was not calculated using the SLOSH average grid elevation because terrain height may vary significantly within a SLOSH grid square. For example, the altitude of a 1-mile grid square may be assigned a value of 1.8 meters (6 feet), but this value represents an average of land heights that may include values ranging from 0.9 to 2.7 meters (3 to 9 feet). In this case, a surge value of 2.5 meters (8 feet) in this square would imply a 0.7 meters (2 feet) average depth of water over the grid’s terrain. However, in reality within the grid area portion of the grid would be “dry” and other parts could experience as much as 1.5 meters (5 feet) of inundation. Therefore, in order to determine the storm tide limits, the depth of surge flooding above terrain at a specific site in the grid square is the result of subtracting the terrain height determined by remote sensing from the model-generated storm tide height in that grid square. ²

**Storm Tide Post-Processing**

The Atlas was created using a Toolset wrapped into ESRI’s ArcGIS mapping application, ArcMap. The surge tool was developed for the Statewide Regional Evacuation Study Program by the Tampa Bay Regional Planning Council, who had used a similar tool for the previous Evacuation Study Update (2006). This tool enabled all regions within the state of Florida to process the SLOSH and elevation data with a consistent methodology.

The tool basically performs the operation of translating the lower resolution SLOSH grid data into a smooth surface resembling actual storm tide and terrain; processing it with the high resolution elevation data derived from LIDAR. The image on the left represents how the data would look as it appears directly from SLOSH Model output.

Processing all the data in the raster realm, the tool is able to digest large amounts of data and output detailed representations of surge inundation.

² Note: This represents the regional post-processing procedure. When users view SLOSH output within the SLOSH Display Program, the system uses average grid cell height when subtracting land. Additionally, Volume 9 – the Depth Analysis Atlas provides detailed depth of surge inundation for each category of storm.
The program first interpolates the SLOSH height values for each category into a raster surface using spline interpolation. This type of interpolation is best for smooth surfaces, such as water and slow changing terrain. The result is a raster surface representing the surge height for a category that can be processed against the raster Digital Elevation Model from the LIDAR. The “dry” values (represented as 99.9 in the SLOSH Model) are replaced by an average of the inundated grids surrounding current processed grid. An algorithm performs this action utilizing the range of values in the current category of storm being processed.

Using this methodology, once the elevation is subtracted from the projected storm tide, the storm tide limits are determined. The output of the tool is a merged polygon file holding all the maximum inundation zones for Category 1 through Category 5. The output, depicted in this Storm Tide Atlas is determined consistent with the coastal areas throughout the state.

Additionally, Volume 9: Depth Analysis Atlas was created as a part of the Statewide Regional Evacuation Study Program to depict the surge depth ranges of the inundation as shown in Volume 7: Storm Tide Atlas. The surge depth ranges are the MOM (Maximum of Maximums) surge heights minus the ground elevations. This detailed depth data was modeled using GIS and included the same datasets used in the Surge Inundation Modeling that produced the storm tide limits.

Figure 8 presents a compilation of the Storm Tide Atlas for the region.
Figure 8: Storm Tide Limits for the Northeast Florida Region
VARIATIONS TO CONSIDER

Variations between modeled versus actual measured storm tide elevations are typical of current technology in coastal storm surge modeling. In interpreting the data emergency planners should recognize the uncertainties characteristic of mathematical models and severe weather systems such as hurricanes. The storm tide elevations developed for this study and presented in the *Storm Tide Atlas* should be used as guideline information for planning purposes.

Storm Tide & Wave Height
Regarding interpretation of the data, it is important to understand that the configuration and depth (bathymetry) of the Atlantic Ocean bottom will have a bearing on surge and wave heights. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water in close proximity to the shoreline, tends to produce a lower surge but a higher and more powerful wave. Those regions, like the Northeast Florida Region, which have a gently sloping shelf and shallower normal water depths, can expect a higher surge but smaller waves. The reason this occurs is because a surge in deeper water can be dispersed down and out away from the hurricane. However, once that surge reaches a shallow gently sloping shelf it can no longer be dispersed away from the hurricane, consequently water piles up as it is driven ashore by the wind stresses of the hurricane. Wave height is NOT calculated by the SLOSH model and is not reflected within the storm tide delineations.

Forward Speed
Under actual storm conditions it may be expected that a hurricane moving at a slower speed could have higher coastal storm tides than those depicted from model results. At the same time, a fast moving hurricane would have less time to move storm surge water up river courses to more inland areas.

Astronomical Tides
Surge heights were provided by NOAA at high tide. The tide level is referenced to North American Vertical Datum of 1988. The storm tide limits reflect high tide in the region.

Accuracy
As part of the Statewide Regional Evacuation Study, all coastal areas as well as areas surrounding Lake Okeechobee were mapped using remote-sensing laser terrains mapping (LIDAR3) providing the most comprehensive, accurate and precise topographic data for this analysis. As a general rule, the vertical accuracy of the laser mapping is within a 15 centimeter tolerance. However, it should be noted that the accuracy of these elevations is limited to the precision and tolerance in which the horizontal accuracy for any given point is recorded. Other factors such as artifact removal algorithms (that remove buildings and trees) can affect the recorded elevation in a particular location. For the purposes of this study, the horizontal accuracy cannot be assumed to be greater than that of a standard USGS 7 minute quadrangle map, or a scale of 1:24,000.

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3 Light Imaging Detection and Ranging
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POINTS OF REFERENCE

County emergency management agencies selected reference points which include key facilities or locations critical for emergency operations. The table below includes the map identification number, descriptions of the selected points and the elevation of the site. The elevation is based on the digital elevation data provided by the LIDAR. It should be noted that if the site is large, elevations may vary significantly. The table also provides the storm tide value from the SLOSH value and the depth of inundation (storm tide value minus the ground elevation) at the site.
Table 4: Flagler County Selected Points of Reference

<table>
<thead>
<tr>
<th>MAP ID</th>
<th>Name</th>
<th>Elevation</th>
<th>C1 DPTH(^4)</th>
<th>C2 DPTH</th>
<th>C3 DPTH</th>
<th>C4 DPTH</th>
<th>C5 DPTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water tower S Highway A1A &amp; S Central Ave near Ocean Palm Subdivision</td>
<td>16.7</td>
<td>-13.49</td>
<td>-11.50</td>
<td>-4.80</td>
<td>2.24</td>
<td>6.23</td>
</tr>
<tr>
<td>2</td>
<td>Flagler Beach Pier</td>
<td>11.8</td>
<td>-8.59</td>
<td>-5.45</td>
<td>0.86</td>
<td>6.68</td>
<td>10.79</td>
</tr>
<tr>
<td>3</td>
<td>East end of high-rise bridge on State Road 100 over Intracoastal Waterway</td>
<td>6.5</td>
<td>-3.37</td>
<td>-0.98</td>
<td>6.39</td>
<td>12.84</td>
<td>16.99</td>
</tr>
<tr>
<td>4</td>
<td>West end of high-rise bridge on State Road 100 over Intracoastal Waterway</td>
<td>11.8</td>
<td>-9.40</td>
<td>-7.47</td>
<td>1.16</td>
<td>8.02</td>
<td>12.30</td>
</tr>
<tr>
<td>5</td>
<td>Beverly Beach Town Hall</td>
<td>15.1</td>
<td>-9.63</td>
<td>-7.53</td>
<td>-0.95</td>
<td>4.17</td>
<td>8.15</td>
</tr>
<tr>
<td>6</td>
<td>East end of Hammock Dunes Bridge at Camino Del Mar Pkwy</td>
<td>10.9</td>
<td>-8.31</td>
<td>-0.46</td>
<td>3.75</td>
<td>8.35</td>
<td>12.67</td>
</tr>
<tr>
<td>7</td>
<td>Intersection of 16th Road &amp; A1A</td>
<td>9.7</td>
<td>-6.17</td>
<td>1.29</td>
<td>5.28</td>
<td>9.73</td>
<td>13.94</td>
</tr>
<tr>
<td>8</td>
<td>Surfview DR in front of Matanzas Shores Clubhouse</td>
<td>9.8</td>
<td>-6.06</td>
<td>0.87</td>
<td>4.99</td>
<td>9.27</td>
<td>13.28</td>
</tr>
<tr>
<td>9</td>
<td>A1A at Flagler County north boundary at Marineland</td>
<td>6.2</td>
<td>-0.54</td>
<td>4.57</td>
<td>8.80</td>
<td>13.00</td>
<td>17.03</td>
</tr>
<tr>
<td>10</td>
<td>Canopy Walk Ln in front of Clubhouse</td>
<td>12.1</td>
<td>-7.57</td>
<td>-1.57</td>
<td>2.73</td>
<td>7.40</td>
<td>11.99</td>
</tr>
<tr>
<td>11</td>
<td>Intersection of Palm Harbor Pkwy &amp; Palm Coast Pkwy</td>
<td>7.8</td>
<td>-4.82</td>
<td>2.68</td>
<td>7.00</td>
<td>11.69</td>
<td>16.29</td>
</tr>
<tr>
<td>12</td>
<td>Bull Creek Fish Camp at Dead Lake - west end of County Rd 2006 W</td>
<td>0.7</td>
<td>1.18</td>
<td>2.69</td>
<td>4.39</td>
<td>6.35</td>
<td>8.49</td>
</tr>
<tr>
<td>13</td>
<td>Bulow Village Campground</td>
<td>5.4</td>
<td>-3.69</td>
<td>-1.98</td>
<td>7.04</td>
<td>14.80</td>
<td>18.59</td>
</tr>
<tr>
<td>14</td>
<td>Palm Coast Plantation Entrance</td>
<td>16.1</td>
<td>-14.41</td>
<td>-10.19</td>
<td>-2.02</td>
<td>3.56</td>
<td>7.51</td>
</tr>
<tr>
<td>15</td>
<td>Mariners Dr entrance to Island Estates</td>
<td>10.1</td>
<td>-5.13</td>
<td>-0.08</td>
<td>4.03</td>
<td>8.64</td>
<td>12.96</td>
</tr>
<tr>
<td>16</td>
<td>Fire Rescue Station #22 at Club House Dr &amp; Palm Coast Pkwy NE</td>
<td>8.1</td>
<td>-6.39</td>
<td>2.54</td>
<td>6.96</td>
<td>11.69</td>
<td>16.63</td>
</tr>
</tbody>
</table>

\(^4\) DPTH refers to the depth of inundation at the site, in feet (storm surge value minus the ground elevation)
STORM TIDE ATLAS

The surge inundation limits (MOM surge heights minus the ground elevations) are provided as GIS shape files and graphically displayed on maps in the Hurricane Storm Tide Atlas for the Northeast Florida Region. The Atlas was prepared by Northeast Florida Regional Council under contract to the State of Florida, Division of Emergency Management, as part of this study effort. The maps prepared for the Atlas consist of base maps (1:24000) including topographic, hydrographic and highway files (updated using the most recent county and state highway data). Detailed shoreline and storm tide limits for each category of storm were determined using the region's geographic information system (GIS).

The purpose of the maps contained in this Atlas is to reflect a worst probable scenario of the hurricane storm tide inundation and to provide a basis for the hurricane evacuation zones and study analyses. While the storm tide delineations include the addition of an astronomical mean high tide and tidal anomaly, it should be noted that the data reflects only stillwater saltwater flooding. Local processes such as waves, rainfall and flooding from overflowing rivers, are usually included in observations of storm tide height, but are not surge and are not calculated by the SLOSH model. It is incumbent upon local emergency management officials and planners to estimate the degree and extent of freshwater flooding as well as to determine the magnitude of the waves that will accompany the surge.

Figure 9 provides an index of the map series, with those pages highlighted in yellow containing surge inundation.
Figure 9  Flagler County Atlas Map Index
NOTES ON STORM TIDE LIMITS

Historically, the SLOSH storm surge analysis had focused on “average” storm parameters (size and forward speed), although the intensity and angle of approach was modeled to include direct strikes and catastrophic intensity. In the 2013 Regional Evacuation Study Update, over 16,000 hypothetical hurricanes were included in the SLOSH suite of storms modeled varying forward speeds and the radii of maximum winds to include the large storm events and different forward speeds. This allowed for the development of a truer picture of the storm surge vulnerability in the region. The five categories of hurricane reflect a “worst probable” storm tide limit for hurricanes holding the wind speed constant (consistent with the Saffir Simpson Hurricane Wind Scale) while varying storm parameters include size, forward speed, and angle of approach.

This has led to some confusion regarding evacuation decision-making since hurricane evacuations are based primarily on storm surge vulnerability. The National Oceanic and Atmospheric Administration (NOAA) is working to enhance the analysis and prediction of storm surge. Direct estimates of inundation are being communicated in the NHC’s Public Advisories and in the Weather Forecast Office’s (WFO) Hurricane Local Statements. NHC’s probabilistic storm surge product, which provides the likelihood of a specific range of storm surge values, became operational in 2009, and the NWS Meteorological Development Laboratory is providing experimental, probabilistic storm surge products for 2010. In addition, coastal weather forecast offices will provide experimental Tropical Cyclone Impacts Graphics in 2010; these include a qualitative graphic on the expected storm surge impacts. Finally, the NWS is exploring the possibility of issuing explicit Storm Surge Warnings which could be implemented in the next couple of years. In all of these efforts, the NWS is working to provide specific and quantitative information to support decision-making at the local level. NOAA continues to emphasize that the hurricane forecasts are not 100% accurate and dependent upon many factors.

To the left are the storm tide limits identified for Flagler County under the five (5) categories of hurricane on the Saffir Simpson Hurricane Wind Scale. It is important to recognize the following:

- The surge tide values represent the highest surge height elevation above a standard datum (NAVD88) predicted by the model in the entire county and will only be appropriate for selected areas.
- Typically the highest surge tide values are NOT the surge heights predicted at the coast. The highest storm tide values are typically experienced inside bays and up rivers and inlets (water above ground).
- Storm Tide maximums by category of storm are presented on Table 3 of this document.
- For surge heights at specific locations, please refer to Table 4 which provides the actual inundation (water depth) at that site or Volume 9: Depth Analysis Atlas.

1http://www.nhc.noaa.gov/sshws_statement.shtml
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Notes:
1. Surge limits are based on still water storm tide height elevation above NAVD88 at high tide with no wave setup.
2. Total Storm Tide limits were derived from Maximum of Maximums surge heights over LiDAR based digital elevation.
3. The Points of Reference are locations determined to be relevant to emergency management officials.

Datum = NAD 1983, 1,000-m USNG

ATLAS LEGEND

Points of Reference
• CAT
• Spot Elevation
• HOSPITAL
• Evacuation Route
• NHD Water

Storm Tide Zones
Flagler County, 2013
Scale 1:24,000
Map Plate 12
USNG Page 17R MN 68 40

This map is for emergency planning purposes only. Hurricane evacuation decision-making and growth management implementation are local responsibilities. Please consult with local authorities.
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3. The Points of Reference are locations determined to be relevant to emergency managing officials.

Datum = NAD 1983, 1,000-m USNG
USNG Page 17R MN 56 45
Scale 1:24,000
Printed Pages in Yellow
Page 24
Notes:
1. Surge limits are based on still water storm tide height elevation above NAVD88 at high tide with no wave setup.
2. Total Storm Tide limits were derived from Maximum of Maximums surge heights over LIDAR based digital elevation.
3. The Points of Reference are locations determined to be relevant to emergency management officials.
Flagler County

ATLAS LEGEND

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Datum = NAD 1983, 1,000-m USNG

US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

This map is for emergency planning purposes only. Hurricane evacuation decision-making and growth management implementation are local responsibilities. Please consult with local authorities.

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Hurricane evacuation decision-making and growth management implementation are local responsibilities. Please consult with local authorities.

Produced by FLRegion Regional Planning Council/Florida Division of Emergency Management, 2012-2013

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Datum = NAD 1983, 1,000-m USNG

US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

Notes:

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US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

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US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

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US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

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ATLAS LEGEND
- Points of Reference CAT
- Spot Elevation
- HOSPITAL
- Evacuation Route
- NHD Water

Storm Tide Zones
Flagler County, 2013
Scale 1:24,000
Map Plate 25
USNG Page 17R MN 52 50

Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
Grid Zone Designation 17R

Produced by FLRegion Regional Planning Council/Florida Division of Emergency Management, 2012-2013

Printed Pages in Yellow
Page 29
Storm Tide Zones
Flagler County, 2013
Map Plate 26
USNG Page 17R MN 56 50

Notes:
1. Surge limits are based on still water storm tide height elevation above NAVD88 at high tide with no wave setup.
2. Total Storm Tide limits were derived from Maximums of Multiple models and LIDAR based digital elevation.
3. The Points of Reference are locations determined to be relevant to emergency management officials.

Datum = NAD 1983, 1,000-m USNG
100,000-m Square ID
Grid Zone Designation 17R

This map is for emergency planning purposes only. Hurricane evacuation decision-making and growth management implementation are local responsibilities. Please consult with local authorities.

Produced by FLRegion Regional Planning Council for Florida Division of Emergency Management, 2012-2013

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

Map Declination 5°46' W Changing by 4°30' W per yr

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Datum = NAD 1983, 1,000-m USNG
USNG Page 17R MN 60 50
Printed Pages in Yellow
Scale 1:24,000
Map Plate 27
Flagler County, 2013
Flagler County, 2013
Produced by FLRegion Regional Planning Council for Florida Division of Emergency Management, 2012-2013

Notes:
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Storm Tide Zones
Flagler County, 2013
Scale 1:24,000

Notes:
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ATLAS LEGEND
• Points of Reference CAT
• Spot Elevation
• HOSPITAL
• Evacuation Route
• NHD Water

Map Plate 28
USNG Page 17R MN 64 50

Page 32

Produced by FLRegion Regional Planning Council/Florida Division of Emergency Management, 2012-2013
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Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
Grid Zone Designation
17R
Mag. Declination
5°46' W
Changing by 4' 30" W per yr
Date 2009
Page 32

Printed Pages in Yellow
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Notes:
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Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

Map Orientation
Changing by 4' 30"W per yr
Date 2009
Changing by 4' 30"W per yr

Produced by FLRegion Regional Planning Council for Florida
Division of Emergency Management, 2012-2013

Printed Pages in Yellow
1:24,000 Scale
Flagler County, 2013

Produced by FLRegion Regional Planning Council for Florida Division of Emergency Management, 2012-2013

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Datum = NAD 1983, 1,000-m USNG

US National Grid 100,000-m Square ID
MN
Grid Zone Designation 17R

Flagler Tide Zones

Scale 1:24,000

Map Plate 36

USNG Page 17R MN 56 55

Printed Pages in Yellow
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Notes:
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Storm Tide Zones
Flagler County, 2013
Scale: 1:24,000
Map Plate: 37
USNG Page: 17R MN 60 55
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Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

Flagler Tide Zones
Flagler County, 2013
Scale 1:24,000
Map Plate 45
USNG Page 17R MN 48 60
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Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

ATLAS LEGEND
- Points of Reference
- CAT
- Spot Elevation
- HOSPITAL
- Evacuation Route
- NHD Water

Scale 1:24,000
Storm Tide Zones
Flagler County, 2013
Scale 1:24,000
Map Plate  53
USNG Page  17R MN 80 60

Notes:
1. Surge limits are based on still water storm tide height
   elevation above NAVD88 at high tide with no wave setup.
2. Total Storm Tide limits were derived from Maximum of
   Maximums surge heights over LIDAR based digital
   elevation.
3. The Points of Reference are locations determined to be
   relevant to emergency management officials.

ATLAS LEGEND
- Points of Reference CAT
- Spot Elevation 1
- HOSPITAL 2
- Evacuation Route 3
- NHD Water 4

Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation 17R

Produced by FL Region Regional Planning Council for Florida
Division of Emergency Management, 2012-2013

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Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R

produced by FL Region Regional Planning Council for Florida Division of Emergency Management, 2012-2013

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Produced by FLRegion Regional Planning Council for Florida

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Notes:
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2. Total Storm Tide limits were derived from Maximum of Nearshore to Overlying Digital Elevation Model.
3. The Points of Reference are locations determined to be relevant to emergency management officials.

Map Plate: 62
USNG Page: 17R MN 76 65

Flagler County, 2013
Scale 1:24,000

Storm Tide Zones

ATLAS LEGEND

- Points of Reference
- Spot Elevation
- Evacuation Route
- NHD Water

CAT
1
2
3
4
5

19°31'0"N
81°14'0"W
19°32'0"N
81°13'0"W
19°33'0"N
81°12'0"W

Datum = NAD 1983, 1,000-m USNG

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Page 52
Page 52
Page 52
Page 52
This map is for emergency planning purposes only. Hurricane evacuation decision-making and growth management implementation are local responsibilities. Please consult with local authorities.

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Map Produced by FLRegion Regional Planning Council for Florida Division of Emergency Management, 2012-2013

Datum = NAD 1983, 1,000-m USNG
Grid Zone Designation 17R
Scale 1:24,000
Printed Pages in Yellow
Page 53
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ATLAS LEGEND
- Points of Reference CAT
- Spot Elevation HOSPITAL
- Evacuation Route NHD Water
- NHD Water

Flagler County, 2013
Scale 1:24,000
Map Plate 73
USNG Page 17R MN 80 70

Page 56
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ATLAS LEGEND
- Points of Reference CAT
- Spot Elevation
- Hospital
- Evacuation Route
- NHD Water

Storm Tide Zones
Flagler County, 2013
Map Plate 79
USNG Page 17R MN 68 75
Scale 1:24,000
0 2,000 Feet
Page 59

Datum = NAD 1983, 1,000-m USNG

1:24,000 Scale
Not to Scale
Arrow
Changing by 4' 30" W per yr

Produced by FL Region Regional Planning Council/Florida Division of Emergency Management, 2012-2013

US National Grid
100,000-m Square ID
MN
17R
Grid Zone Designation

Grid Zone = NAD 1983, 1,000-m USNG

Datum = NAD 1983, 1,000-m USNG

Datum = NAD 1983, 1,000-m USNG

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ATLAS LEGEND
- Points of Reference
- Spot Elevation
- HOSPITAL
- Evacuation Route
- NHD Water

Datum = NAD 1983, 1,000-m USNG
US National Grid
100,000-m Square ID
MN
Grid Zone Designation
17R
Printed Pages in Yellow
1:24,000 Scale
Flagler County, 2013
Map Plate 83
USNG Page 17R MN 68 80
Page 63
Funding was provided by the Florida Legislature with funding from the Federal Emergency Management Agency (FEMA) through the Florida Division of Emergency Management. Local match was provided by Northeast Florida Regional Council and the counties of Baker, Clay, Duval, Flagler, Nassau, Putnam and St. Johns.

Florida Division of Emergency Management
Bryan W. Koon, Director
2555 Shumard Oak Boulevard, Tallahassee, Florida 32399
Web site: www.floridadisaster.org