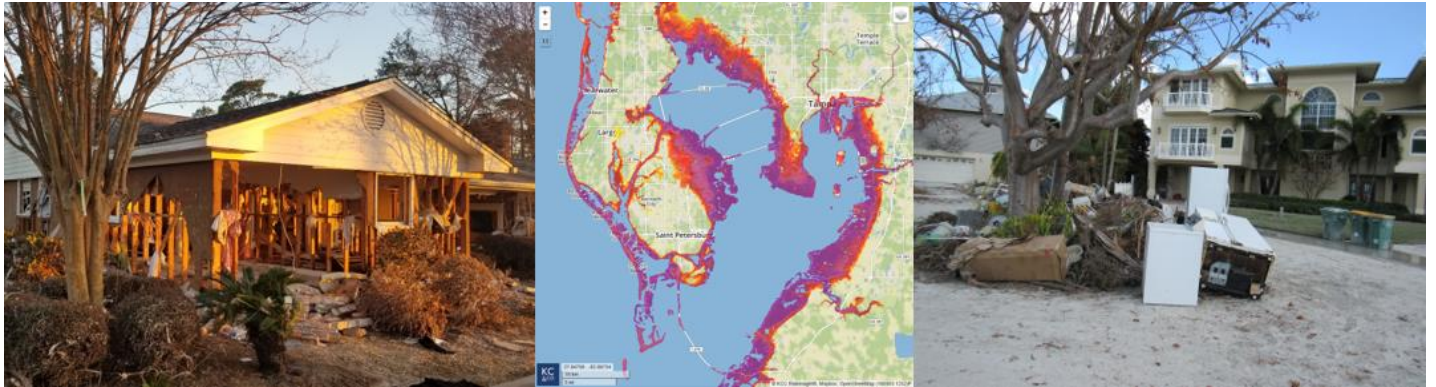


KCC US Flood Reference Model Version 1.0

RiskInsight® 4.10.2.140



Submitted in compliance with the 2017 Standards of the Florida Commission on Hurricane Loss Projection Methodology

DECEMBER 2, 2020



The Innovation and Technology Leader in Catastrophe Risk Modeling

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The Innovation and Technology Leader in Catastrophe Risk Modeling

February 29, 2020

Chair, Florida Commission on Hurricane Loss projection Methodology
Florida State Board of Administration
1801 Hermitage Boulevard, Suite 100
Tallahassee, FL 32308

Dear Commission Chair,

We are pleased to submit the Karen Clark & Company (KCC) US Flood Reference Model Version 1.0 for review and certification by the Commission. In accordance with the 2017 Flood Standards, we submit the data and analyses performed for the General, Meteorological, Hydrological and Hydraulic, Statistical, Vulnerability, Actuarial, and Computer/Information Standards. All model components have been reviewed by experts in the areas of meteorology, hydrology/hydraulics, statistics, vulnerability actuarial science, and computer science for completeness and compliance with the Commission's Standards, as documented in the Expert Certification Forms GF1-GF7. This document has also undergone editorial review in compliance with Form GF-8. The model is ready to be reviewed by the Professional Team.

Enclosed, please find eight bound copies of the KCC submission. Please let me know if you have any questions on the enclosed.

Sincerely,

A handwritten signature in black ink, appearing to read 'Nozar Kishi'.

Nozar Kishi
Vice President, Model Development

Flood Model Submission Checklist

A. Please indicate by checking below that the following has been included in your model submission documentation to the Florida Commission on Hurricane Loss Projection Methodology.

Yes	No	Item
✓		1. Letter to the Commission
✓		a. Refers to the signed Expert Certification forms and states that professionals having credentials and/or experience in the areas of meteorology, hydrology, hydraulics, statistics, structural engineering, actuarial science, and computer/ information science have reviewed the model for compliance with the standards
✓		b. States model is ready to be reviewed by the Professional Team
✓		c. Any caveats to the above statements noted with a detailed explanation
✓		2. Summary statement of compliance with each individual standard and the data and analyses required in the disclosures and forms
✓		3. General description of any trade secret information the modeling organization intends to present to the Professional Team and the Commission
✓		4. Flood Model Identification
✓		5. Eight bound copies (duplexed)
✓		6. Link e-mailed to SBA staff containing all required documentation that can be downloaded from a single ZIP file
✓		a. Submission document and Form AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs in PDF format
✓		b. PDF submission file supports highlighting and hyperlinking, and is bookmarked by standard, form, and section
✓		c. Data file names include abbreviated name of modeling organization, standards year, and form name (when applicable)
✓		d. Forms VF-3, Flood Mitigation Measures Range of Changes in Flood Damage, AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs, AF-2, Total Flood Statewide Loss Costs, AF-3, Personal Residential Standard Flood Loss Costs by ZIP Code, AF-4, Flood Output Ranges, and Form AF-6, Flood Probable Maximum Loss for Florida in Excel format
	✓	e. Forms VF-4, Coastal Flood Mitigation Measures, Mean Coastal Flood Damage Ratios and Coastal Flood Damage/\$1,000 (Trade Secret Item), VF-5, Inland Flood Mitigation Measures, Mean Inland Flood Damage Ratios and Inland Flood Damage/\$1,000 (Trade Secret Item), and AF-5, Logical Relationship to Flood Risk (Trade Secret Item) in Excel format if not considered as Trade Secret
✓		7. All hyperlinks to the locations of forms are functional
✓		8. Table of Contents

Yes	No	Item
✓		9. Materials consecutively numbered from beginning to end starting with the first page (including cover) using a single numbering system, including date and time in footnote
✓		10. All tables, graphs, and other non-text items consecutively numbered using whole numbers, listed in Table of Contents, and clearly labeled with abbreviations defined
✓		11. All column headings shown and repeated at the top of every subsequent page for forms and tables
✓		12. Standards, disclosures, and forms in italics, modeling organization responses in non-italics
✓		13. All graphs and maps conform to guidelines in II. Notification Requirements A.4.e
✓		14. All units of measurement clearly identified with appropriate units used
✓		15. All forms included in submission appendix except Trade Secret Items. If forms designated as a Trade Secret Item are not considered as trade secret, those forms are to be included in the submission appendix
✓		16. Hard copy documentation identical to electronic version
✓		17. Signed Expert Certification Forms GF-1 to GF-8
✓		18. All acronyms listed and defined in submission appendix

B. Explanation of “No” responses indicated above. (Attach additional pages if needed.)

All Flood Model Submission Checklist items have been provided with exception of Forms VF-4, VF-5 and AF-5 which are Trade Secret items and will be shared Professional Team during the onsite visit. _____

KCC US Flood Reference Model
Version 1.0 as implemented in
RiskInsight® 4.10.2.140



12/2/2020

Model Name and Identification

Modeler Signature

Date

Flood Model Identification

Name of Flood Model: KCC US Flood Reference Model
Flood Model Version Identification: 1.0
Interim Flood Model Update Version Identification: N/A
Flood Model Platform Name and Identifications: RiskInsight® 4.10.2.140
Interim Data Update Designation: N/A
Name of Modeling Organization: Karen Clark & Company
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Contact Person: Nozar Kishi
Phone Number: 617.423.2800
Fax Number: 617.423.2808
E-mail Address: nkishi@karenclarkandco.com
Date: December 2, 2020

Description of Trade Secret Information

The following items are trade secret information and will be presented to the Commission during the closed meeting and to the Professional Team during the onsite visit:

- Form VF-4, Coastal Flood Mitigation Measures, Mean Coastal Flood Damage Ratios and Coastal Flood Damage/\$1,000 (Trade Secret Item),
- Form VF-5, Inland Flood Mitigation Measures, Mean Inland Flood Damage Ratios and Inland Flood Damage/\$1,000 (Trade Secret Item)
- Form HHF-3, Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item)
- Form HHF-5, Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item)
- Form AF-5, Logical Relationship to Flood Risk (Trade Secret Item)

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General Flood Standards

GF-1 Scope of the Flood Model and Its Implementation

- A. The flood model shall project loss costs and probable maximum loss levels for primary damage to insured personal residential property from flood events.**

The Karen Clark & Company (KCC) US Flood Reference Model projects loss costs and probable maximum loss levels for primary damage to insured personal residential property from flood events through the implementation of current scientific, engineering, and actuarial principles.

- B. The modeling organization shall maintain a documented process to assure continual agreement and correct correspondence of databases, data files, and computer source code to slides, technical papers, and modeling organization documents.**

KCC maintains a documented process assuring continual agreement and correct correspondence of databases, data files, and computer source codes to slides, technical papers, and modeling organization documents. This includes procedures for peer review and consultations with subject matter experts (SMEs) prior to the presentation or publication of any slides or document.

- C. All software and data (1) located within the flood model, (2) used to validate the flood model, (3) used to project modeled flood loss costs and flood probable maximum loss levels, and (4) used to create forms required by the Commission in the Flood Standards Report of Activities shall fall within the scope of the Computer/Information Flood Standards and shall be located in centralized, model-level file areas.**

All information and software files used to develop, validate, project modeled flood loss costs and flood probable maximum loss levels, and create forms required by the Commission are stored in a central location. All documents and code are stored on Team Foundation Server (TFS), which is used as the single repository for all KCC code and allows version control of code and other documents and falls under the scope of the Computer/Information Standards.

- D. Differences between historical and modeled flood losses shall be reasonable, given available flood loss data.**

Considering the available flood loss data, the differences between historical and modeled flood losses are reasonable. Some differences are to be expected due to inconsistent reporting of flood losses, changes to exposure, and the reliability of historical flood data.

Disclosures

- 1. Specify the flood model version identification. If the flood model submitted for review is implemented on more than one platform, specify each flood model platform. Specify which platform is the primary platform and verify how any other platforms produce the same flood model output results or are otherwise functionally equivalent as provided for in the "Process for Determining the Acceptability of a Computer Simulation Flood Loss Model" in VI. Review by the Commission, I. Review and Acceptance Criteria for Functionally Equivalent Model Platforms.**

The KCC US Flood Reference Model is Version 1.0 and is implemented on RiskInsight 4.10.2.140.

- 2. Provide a comprehensive summary of the flood model. This summary should include a technical description of the flood model, including each major component of the flood model used to project loss costs and probable maximum loss levels for insured primary damage to personal residential property from flood events causing damage in Florida. Describe the theoretical basis of the flood model and include a description of the methodology, particularly the meteorology components, the hydrology and hydraulic components, the vulnerability components, and the insured flood loss components used in the flood model. The description should be complete and is not to reference unpublished work.**

The KCC US Flood Reference Model encompasses coastal and inland flooding. The model includes the following four components:

- Event Catalog Module
- Intensity Footprint Module
- Vulnerability Module
- Financial Module

Because the underlying cause of both perils is fundamentally different (inland flooding being driven by heavy precipitation and storm surge by high winds), these perils are modeled separately.

The KCC US Flood Reference Model is run on the RiskInsight® loss modeling platform which reads in the exposure data, applies the intensity footprints and the vulnerability functions, and estimates the insured losses using a comprehensive Financial Module.

Inland Flood Model

Event Catalog Module

The event catalog module defines the location, duration, and frequency of events. KCC scientists developed an event catalog including weather systems that can produce significant enough precipitation to cause inland flooding.

Producing the inland flood catalog began with generating a set of historical precipitation events that represents the range of precipitation amount, duration, and spatial extent that have caused inland floods in Florida. KCC scientists use data from the National Oceanic and Atmospheric Administration (NOAA) Climate Prediction Center (CPC), National Centers for Environmental Information (NCEI), and the Dartmouth Flood Observatory to develop distributions of the precipitation parameters.

The catalog of historical precipitation events is created from analysis of the CPC dataset of gridded daily precipitation with a period of record including the years 1948 to 2018. Historical event intensities are characterized by the maximum **total precipitation** that fell at a location during the event. To represent the probability of occurrence of an extreme precipitation event with a particular intensity, KCC scientists use the Pareto Type II distribution as recommended by Papalexiou et al. (2013). This theoretical distribution more effectively captures the most extreme events than the often-used gamma distribution (e.g. Yang et al., 2010; Fischer et al., 2012; Simoes et al., 2015).

Most flood events in south Florida are tropical in origin. By contrast, north Florida experiences flooding from both tropical and extra-tropical cyclones that results in a historically higher frequency of the most extreme precipitation events. As a result, the intensity distributions are generated regionally to represent relative differences in characteristic total precipitation amounts at different locations.

Extreme precipitation events that lead to inland flooding can occur over a timescale of several days (Lu et al., 2017; Wu et al., 2018). The start and end dates of historical events were determined following the methodology of Du et al. (2019) in which consecutive days with above average precipitation at a location constitute a unique event. Applying this methodology to the historical precipitation dataset results in a precipitation event duration for all historical events. The modeled precipitation event duration is computed as a function of the total precipitation amount using a relationship derived from a regression analysis of historical events. A lognormal distribution is fit to the residuals of the calculated duration and the historical duration to represent the variability of event timescales observed in the set of historical events. From this distribution, the low, expected, and high residuals are determined that define the duration of the model precipitation events.

The **spatial extent** of precipitation determines the area affected by an event and is highly correlated with the total precipitation amount. The modeled spatial extent is computed as a function of the total precipitation amount. The relationship between extent and total precipitation derives from a regression analysis of the events in the historical catalog. Variability around the calculated extent in the historical data is represented by a lognormal distribution. Given the event total precipitation amount, low, expected, and high values of spatial extent are drawn from the distribution for the model precipitation events.

Values of the total precipitation amount, duration, and spatial extent are assigned to precipitation events following the Joint Probability Method (JPM) and centered at over 300 locations covering the basins that affect Florida. This method has the advantage of representing the range of potential extreme precipitation events in Florida without introducing noise into the sample.

Flood potential depends not only on precipitation but also on the pre-existing soil moisture and surface water conditions. The initial pattern of soil moisture, and the initial surface water and subsurface water depths, determine the capacity of the ground for holding water and the potential for runoff to occur. These parameters respond to the recent precipitation history, meaning abnormally dry or wet conditions leading up to an extreme precipitation event will affect the severity of the resulting flooding. To properly initialize these parameters for model flood events, KCC scientists perform a model spinup of 60 days prior to the start of each model extreme precipitation event. The spinup is characterized by **initial precipitation** that corresponds to either the expected conditions, drier than average conditions, or wetter than average conditions. The likelihood of a model event having dry, wet, or the expected initial precipitation during the spinup period is determined following a gamma distribution fit to the historical precipitation dataset. Initial **surface water depth** and **subsurface depth** are derived from river daily discharge data from United States Geological Survey (USGS).

Each precipitation event is assigned an initial precipitation in addition to the other event characteristics. The outputs of the Event Catalog Module, the precipitation and initial conditions, are then used as the input into the Intensity Footprint Module.

Intensity Footprint Module

The inland flood intensity module simulates the surface water and riverine flooding at a 60-minute time step to generate the inland flood intensity footprints. The inland flood module contains three sub-components:

1. Water balance calculation
2. Surface and subsurface flow routing
3. Channel flow routing

Surface water flooding is modeled for 14,235 sub-basins in six watersheds affecting Florida. Given the precipitation on a 0.08° by 0.08° grid as input, the **water balance** for each sub-basin is calculated as:

$$W = P - ET - S - F_s$$

where

- W = the amount of water left in the sub-basin at each hour
- P = the total amount of the water entering each sub-basin from precipitation
- ET = evapotranspiration,
- S = soil moisture (water storage)
- F_s = hillslope surface runoff

The rate of evapotranspiration controls the amount of water that leaves each sub-basin without contributing to runoff or soil water. The water storage is calculated using the Clapp-Hornberger infiltration method. Finally, the hillslope surface runoff is dependent on the land cover and the soil type.

The water that accumulates on the surface during a heavy precipitation event can acquire flow. To calculate the **surface flow**, the inland flood intensity module applies kinematic wave routing method based on the Manning equation:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

where

Q = flow discharge

n = the roughness coefficient

A = flow area

R = hydraulic radius

S = slope

The maximum hillslope surface runoff depth for the duration of an event is recorded for each sub-basin and leads to surface flooding. The distribution and inundation depths of the pluvial flooding depends on how the surface water is distributed spatially within the sub-basin. The redistribution of the surface water, by down-elevation flow, is modeled at a high resolution using a cellular automata approach, following work by Ghimire et al. (2013) and Guidolin et al. (2016). In the cellular automata model, water flows according to differences in elevation on a high-resolution Digital Elevation Model (DEM) grid. Surface water collects in low-lying areas and places with slow drainage, leading to surface flooding.

In addition to surface water, **subsurface water flow** contributes to riverine flooding. Subsurface flow is modeled based on Darcy's law:

$$Q = KAi$$

where

K = hydraulic conductivity, and

i = hydraulic gradient (the sub-basin catchment slope)

The subsurface water flow is combined with the surface water flow to model the potential for riverine flooding.

The inland flood module utilizes a 2D hydraulic model to simulate the **channel flow depth** in channel and flood plain (if the channel is flooded). Channel discharge is calculated using the Muskingum-Cunge routing method. Based on the Manning equation, and standard assumptions about channel and floodplain geometry, the channel flow depth can be determined using the channel discharge.

Channel flow depth that exceeds the channel banks will inundate the surrounding floodplain to a depth determined by the water surface elevation and the surrounding topography. The **inland flood depth** is generated by combining the surface flooding water depth and the channel flooding water depth on a grid resolution of 30 meters. The greatest inundation depth for the duration of an event is recorded at each location on the high-resolution grid to produce the inland flooding footprint.

Storm Surge Model

Event Catalog Module

Storm surge occurs due to tropical cyclones and, as a result, the event generation component of the storm surge peril is derived from the KCC US Hurricane Reference Model V2.0. The storm surge Event Catalog includes storm surge footprints for over 30,000 hurricanes impacting Florida. Each event in the catalog is assigned parameters that are used to generate high-resolution intensity footprints for the event. The parameters are stored in a track file that is then used by the KCC US Flood Reference Model to generate storm surge footprints. The parameters specific to storm surge included in the hurricane track file are:

- Storm track
- R_{max}
- Forward speed
- Central pressure
- Peak wind speed at landfall or bypass point

The **storm track** is a significant parameter because it influences the maximum storm surge height. The observational dataset includes fewer than 80 landfalling and bypassing hurricanes in Florida—a sample too small to fully represent the pattern of storm tracks expected over a longer time period as represented by the model Event Catalog. Rather than tie the modeled events too closely to what has been observed in the last 100 years, KCC used the historical data and climatology to model storm tracks.

KCC scientists segmented the historical tracks according to lengths of coastline for which the tracks are or are expected to be similar and then analyzed the angles at which the historical tracks crossed the coast at landfall. Each landfall point in the model has three tracks associated with it—the mean track angle, and one standard deviation in either direction. Similarly, bypass points are designated in offshore areas where bypassing hurricanes have been observed and three tracks are assigned according to the observed track directions associated with each point. The movement of the storm after landfall or closest bypass is modeled using the general tendency for hurricanes to eventually curve to the north and northeast. The KCC track generation technique ensures that there is a smooth transition in track angle and consistent spacing between landfall and bypass points while maintaining the climatology of storm movement after landfall or closest bypass.

KCC scientists selected this track generation methodology for several reasons, including:

- Every track in the model is realistic and conforms to hurricane climatology.
- There is consistent spatial coverage and no geographical bias. No geographical point is over or under sampled as can happen with random sampling techniques.

The **radius of maximum winds (R_{max})** determines the geographical extent of the wind footprint for each event and the size of the area impacted by storm surge. Tropical cyclones that have a large R_{max} produce a greater extent of storm surge along the coastline due to their wide windfield. In accordance with published literature (Willoughby et al., 2006) and observed data, R_{max} is generated as a function of the peak wind speed at landfall (V_{max}) and latitude as shown below:

$$R_{max} = C_1 * e^{(C_2 * V_{max} + C_3 * latitude)}$$

The residual distances between observed R_{max} and the R_{max} calculated using the above formula are used to define the natural variability in this parameter for a given maximum wind speed and latitude. Deviations

from the calculated R_{\max} are applied to events in the catalog and are selected from a distribution of the observed residuals.

In general, stronger storms will have a smaller R_{\max} and weaker storms will have a larger R_{\max} . For each event in the catalog, the R_{\max} changes as the storm propagates and the wind speeds decay over land.

The **forward speed** of a tropical cyclone is not correlated with V_{\max} but is correlated with latitude. In general, as hurricanes move into the northerly latitudes, the forward speed increases. The peak storm surge and the extent of the inundation from the coastline both depend on the forward speed of the tropical cyclone. Forward speeds are selected from a distribution that represents the natural variation in this parameter.

Central pressure is used to estimate peak surge and captures tide impacts caused by the central pressure of a storm and by a storm's maximum winds. To calculate the expected central pressure at each landfall point, KCC scientists estimate the CP from the peak wind speed at landfall.

The **peak wind speed at landfall (V_{\max})** is defined as the peak 1-minute sustained wind speed at 10-meter height. KCC scientists employ statistical simulation techniques that ensure the distribution of V_{\max} is appropriate for each landfall point and that the pattern is consistent between landfall points. In the event catalog, there are no abrupt changes in V_{\max} between nearby landfall points except in areas where geography and/or meteorology warrant such changes.

KCC scientists use the historical data, statistical techniques, and meteorological expertise to develop the distributions. The historical data are derived from the normative sources, including HURDAT2 (Landsea & Franklin, 2013) and Ho et al. (1987) for historical storms for which HURDAT does not include the landfall wind speed.

KCC experts partition the historical data into regions of coastline for which the meteorological characteristics of tropical cyclones should be the same or very similar. The data are then fit to a Pareto distribution following the work of Palutikof et al. (1999), Brabson and Palutikof (2000), Jagger and Elsner (2006), and Emanuel and Jagger (2010). The parameters for the estimated Pareto distributions are used to generate the V_{\max} at landfall for each event in the catalog. To ensure consistency between neighboring landfall points and regions, the distribution parameters are smoothed at the region boundaries. The KCC sampling methodology ensures that the event catalog covers the full range of wind speeds at every landfall point.

Once the V_{\max} at each landfall has been determined, the CP is calculated using the empirical formula developed by Courtney and Knaff (2009), as shown below. This equation is also used to calculate the CP of historical hurricanes where the CP is unknown.

$$P_C = 23.286 - 0.483V_{srm1} - \left(\frac{V_{srm1}}{24.254}\right)^2 - 12.587S - 0.483\theta + P_e$$

where

V_{srm1} = storm-relative maximum windspeed P_C = central pressure

θ = latitude in degrees

S = size factor

P_e = environmental pressure (1013.25 hPa)

The size factor, S , can be calculated on an individual storm basis when wind radii information is available. The model central pressure is calculated using three values of S recommended by Knaff and Zehr (2007) for small, medium, and large size cyclones. For model storm central pressure, events with the "low" R_{\max} use the size factor for small storms, events with the "high" R_{\max} use the size factor for large storms and the expected R_{\max} events use the average size factor as reported by Knaff and Zehr (2007).

Once the event characteristics are defined, the track files for the events are created. Each track file contains for each hour—starting several hours before landfall and continuing until V_{\max} drops below 25 mph—the latitude and longitude of the track position at that hour, the V_{\max} , and the CP.

Intensity Footprint Module

The track files generated in the Event Catalog Module are read into RiskInsight® to produce the storm surge intensity footprints. Three calculations are completed at 5-minute intervals for the duration of the storm to generate the storm surge intensity footprints. The calculations include:

1. Peak storm surge
2. Storm surge height along the entire coastline
3. Inundation depth over land

The **peak storm surge** is calculated to capture impacts of water piling and changes of CP during a tropical cyclone. There is a direct relationship between maximum wind speed and central pressure demonstrated by published scientific literature (Courtney & Knaff, 2009). KCC scientists employ the equation below, adapted from NOAA's Technical Memorandum NWS TDL-46 (Jelesnianski, 1972), to calculate the peak storm surge (S_p) in feet as a function of central pressure (P_r) in hPa.

$$S_p = 0.00014 * (P_w - P_r)^2 + 0.21212 * (P_w - P_r)$$

where P_w represents the peripheral pressure in hPa. The calculated peak surge is adjusted by factors that account for the storm forward speed and track direction with respect to the coast, and the local bathymetry. This methodology aligns with published and widely accepted literature, including Conner et al. (1957), Welander (1961), Rao and Mazumdar (1966), Jelesnianski (1972), Hamblin (1978), Horsburgh and De Vries, (2011). These equations have been further refined with KCC analyses on historical storm surge data available through SURGEDAT, NHC Technical Reports, and the SLOSH model.

Extending from the peak storm surge location, **storm surge height along the coastline** is calculated as a function of distance from the R_{\max} . KCC scientists developed an empirical relationship between storm surge and R_{\max} based on more than 2,400 storm surge and storm tide measurements for 23 US hurricanes. In addition to better reflecting the asymmetry of storm surge around the peak caused by a storm's asymmetric wind profile than theoretical models, the empirical model shows good agreement with the observed data.

Using the distance from R_{\max} allows the model to take into account the size of the storm due to a larger R_{\max} , producing a larger extent storm surge footprint, as shown in scientific literature (Irish et al., 2008). To calculate the storm surge coastal profile, KCC scientists fitted an equation to the average storm surge heights derived from SURGEDAT observations and the NHC technical reports at different distances from the R_{\max} .

Once the storm height is calculated based on the peak storm surge, directional factors, shoaling factors, and local features are taken into account. As a storm approaches land, the angle between the hurricane event and the shore and the storm forward speed can impact the wind direction, affecting how much water is piled towards the shore and how much is pushed out to sea. In addition, local features like the bathymetry and concavity of coastlines, bays, and rivers impact the storm surge.

A storm moving quickly perpendicular to the shore is expected to produce a higher storm surge than a slower storm tracking parallel to the coastline. KCC scientists developed a **directional factor** to account for the track angle relative to the coastline. Directional factors capture the effects of different forward speeds and different angles between storm track and land. A storm moving close to perpendicular to the shore (~80 degrees) has a higher effect than other degrees, and a storm moving away from the shore has the lowest impact. These effects become more extreme as forward speed increases.

Shoaling impacts are determined by local bathymetry and coastal geometry and capture the way in which a wall of water increases in height when entering shallow waters. In general, areas with wider and shallower continental shelves will experience higher storm surge as more water can build up as the storm moves onshore.

Once the storm surge coastal profile is calculated, amplification caused by **local coastal features** is accounted for. In general, wide and short bays amplify storm surge because more water can approach the coast, and there is a smaller distance to the coastline. Barrier islands will typically lower the amplification. The long and narrow mouths of rivers feeding into bays and the ocean act like a funnel and experience amplification further inland even though amplification decreases with distance from coast. The angle the storm approaches a bay or river also impacts this amplification.



Figure 1 - Examples of Florida bays that impact coastal surge amplification

Extensive studies have been performed on the amplification of bays and mouths of rivers on the storm surge height such as Weisberg and Zheng (2006), Li et al. (2006), Peng et al. (2006), Fritz (2007), Edmiston et al. (2008), Rego and Li (2010), Sheng et al. (2010), Needham et al. (2015), and Chiu and Small (2016). These studies combined with actual observation from SURGEDAT were used to calculate the amplification factors. In addition to the local features, the angle the storm approaches the local feature determines if the wind is pushing the water perpendicular to the feature (high impact) or parallel to the feature (less impact).

After adjusted storm surge heights along the coast have been determined, **inundation depth over land** must be calculated to represent the depth of storm surge water above ground elevation. Land cover, ground elevation, and the speed of the storm all impact storm surge attenuation.

Different **land cover** with different roughness impacts the storm surge height differently. As water moves inland, the storm surge height will drop as it travels inland. KCC employs the 2016 NLCD LULC database to determine roughness impacts.

In addition to the land cover, the **forward speed** of the storm also impacts the storm surge attenuation. Storms with slower forward speed attenuate slower. A slow-moving storm can produce strong on-shore winds at the same location for a long period of time, increasing the potential for storm surge waters to penetrate further inland.

After the attenuated storm surge height is calculated over land, the **ground elevation** is accounted for to calculate the inundation height at a 30-meter resolution. USGS 1 arc-second Digital Elevation Models (DEMs) are used as the elevation source.

For a location to be considered inundated, two requirements must be met: the water surface elevation at any point must be higher than the ground elevation and the inundated location must have a path to the ocean consisting of adjacent flooded locations. Applying this criteria eliminates “ponding” from the inundation map, in which low elevation points near the coast flood even though they are naturally protected from the storm surge by surrounding higher elevation.

Vulnerability Module

The KCC US Flood Reference Model incorporates thousands of vulnerability functions reflecting differences in construction, occupancy, age of structure, region, first floor height (FFH), and other property-specific characteristics. For each combination, damages are estimated separately for building, appurtenant structure, contents, and time element coverages. Vulnerability functions are developed separately for inland and coastal flooding due to their unique damage modes.

Several sources of information are utilized for the construction of the vulnerability functions. First and foremost is the knowledge and expertise of KCC wind and structural engineers who have extensive experience in wind engineering and catastrophe modeling. KCC scientists and engineers have published and are well versed in the normative literature on flood damageability.

KCC experts have conducted post-disaster field surveys for 16 significant landfalling hurricanes since Hurricane Hugo in 1989, which included evaluating storm surge impacts and differentiating between storm surge and wind damage. KCC engineers have reviewed the building codes in all coastal states and have surveyed the local building inventories. Literature on the Florida building inventory (Michalski, 2016) is also used to inform the regional variation of vulnerability.

KCC uses a component-based methodology to develop the vulnerability functions. In this method, relevant building components are first identified and related to different states of damage. A vulnerability function is then developed for each component, and the component vulnerabilities are combined to produce the vulnerability function of the building structure. This approach is well documented in the literature (e.g., Unanwa, et al., 2000; Cope, 2004; Li & Ellingwood, 2006).

The vulnerability functions provide estimates of the mean damage in response to inundation depth experienced at the location. For each structure type (construction, occupancy, year built, etc.), there are four vulnerability functions representing the Mean Damage Ratios (MDRs) for building, appurtenant structure, contents, and time element coverages.

The KCC vulnerability functions have been validated using client-specific and NFIP claims data.

Financial Module

The MDRs from the vulnerability functions are expressed as percentages of the coverage replacement values. For each MDR, the RiskInsight® Financial Module considers the full range of damage levels around the mean (the secondary uncertainty) with empirical distributions. Empirical distributions are chosen because actual losses do not exhibit a simple central behavior, and these distributions better correlate with reality and actual claims experience.

RiskInsight® represents the secondary uncertainty distributions as discrete bins, where each bin corresponds to the probability of experiencing a specific damage level, and every distribution includes a non-zero probability mass at 0 and at 100 percent loss. Secondary uncertainty is always considered in the loss calculations.

There are 100,000 secondary uncertainty distributions for MDRs ranging from .00001 to 1. KCC scientists developed a complex iterative process to create these distributions so that the following mathematical constraints are met:

- The probabilities add up to 1
- The MDRs are maintained
- The probability mass at 0 falls as the MDR increases
- The probability mass at 1 rises as the MDR increases

The diagram below illustrates the implementation of secondary uncertainty in the KCC US Flood Reference Model.

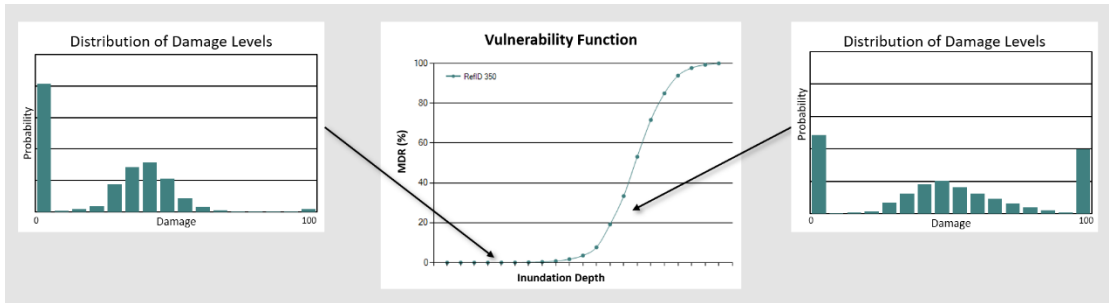


Figure 2 - Illustration of secondary uncertainty for different MDRs

The KCC US Flood Reference Model calculates losses at the location level and for individual coverages separately. The location level losses can be aggregated to different levels of resolution, such as five-digit ZIP Codes or counties, and they serve as the basis for the loss cost and probable maximum loss estimates. The financial module ensures that the combined loss from all perils at a location never exceeds the total exposure value at that location.

3. Provide a flowchart that illustrates interactions among major flood model components.

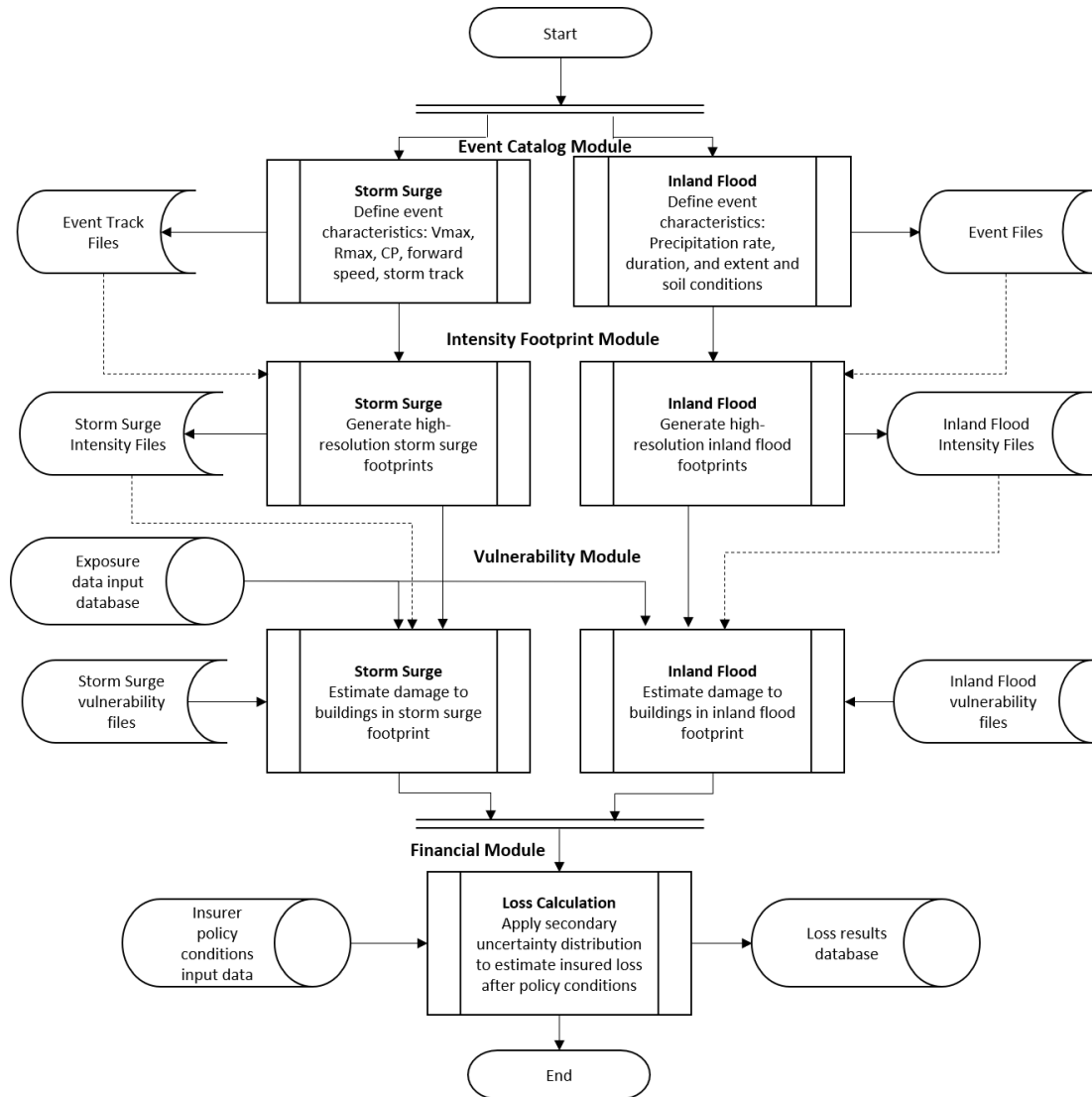


Figure 3 - Interactions of major model components in the KCC US Flood Reference Model

4. Provide a comprehensive list of complete references pertinent to the submission by flood standard grouping using professional citation standards.

General

Federal Emergency Management Agency (FEMA). (2019.) National Flood Hazard Layer. FEMA. Retrieved from: <https://www.floodmaps.fema.gov/NFHL/status.shtml>

Florida Geographic Data Library (FGDL). (2018). Florida Parcel Data Statewide – 2018. University of Florida GeoPlan Center. Retrieved from: <http://www.fgdl.org/metadataexplorer/explorer.jsp>

National Oceanic and Atmospheric Administration (NOAA). (n.d.) Orthometric height conversion. Retrieved from: https://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.pr137,

Meteorology

Akbar, M.K., Kanjanda, S., & Misinguzi, A. (2017). Effect of bottom friction, wind drag coefficient, and meteorological forcing in hindcast of Hurricane Rita storm surge using SWAN + ADCIRC model. *Journal of Marine Science and Engineering*, 5(38). doi: 10.3390/jmse5030038

- Barrientos, C. S., & Jelesnianski, C. P. (1973). *Storm surge shoaling corrections along the Gulf coast*. Silver Spring, Maryland: NOAA/NWS-TDL. Retrieved from: https://www.weather.gov/media/mdl/Barrientos_1974_StormSurgeShoaling.pdf
- Barrientos, C.S., & Chen, J. (1974). *Storm surge shoaling corrections along the east coast*. Silver Spring, Maryland: National Weather Service. Retrieved from: https://www.weather.gov/media/mdl/Barrientos_1974_StormSurgeShoaling.pdf
- Barrientos, C.S., & Jelesnianski, C.P. (1977). SPLASH – A model for forecasting tropical storm surges. *Proceedings of the Fifteenth Conference on Coastal Engineering*. Honolulu, Hawaii. doi: 10.1061/9780872620834.056
- Bergemann, M., Jakob, C., & Lane, T.P. (2015). Global detection and analysis of coastline-associated rainfall using an objective pattern recognition technique. *Journal of Climate*, 28, 7225-7236. doi: 10.1175/JCLI-D-15-0098.1
- Brabson, B.B., & Palutikof, J.P. (2000). Tests of the Generalized Pareto Distribution for predicting extreme weather events. *Journal of Applied Meteorology*, 39, 1627-1640. doi: 10.1175/1520-0450(2000)039<1627:totgpd>2.0.co;2
- Chiu, S., & Small, C. (2016). Observations of cyclone-induced storm surge in coastal Bangladesh. *Journal of Coastal Research*, 32(5), 1149-1161. doi: 10.2112/JCOASTRES-D-15-00030.1
- Conner, W.C., Kraft, R.H. & Harris, D.L. (1957). Empirical methods for forecasting the maximum storm tide due to hurricanes and other tropical storms. *Monthly Weather Review*, 85, 113–116. doi: 10.1175/1520-0493(1957)085<0113:EMFFTM>2.0.CO;2
- Courtney, J., & Knaff, J.A. (2009). Adapting the Knaff and Zehr wind-pressure relationship for operational use in tropical cyclone warning centres. *Australian Meteorological and Oceanographic Journal*, 58, 167-179. doi: 10.22499/2.5803.002
- Dean, R.G., & Bender, C.J. (2006). Static wave setup with emphasis on damping effects by vegetation and bottom friction. *Coastal Engineering*, 53, 149-156. doi: 10.1016/j.coastaleng.2005.10.005
- de Leeuw, J., Methven, J., & Blackburn, M. (2016). Variability and trends in England and Wales precipitation. *International Journal of Climatology*, 36(8), 2823-2836. doi: 10.1002/joc.4521
- Dartmouth Flood Observatory (2019). Space-based measurement, mapping, and modeling of surface water: For research, humanitarian, and water management applications. Boulder, CO: University of Colorado. Retrieved from: <http://floodobservatory.colorado.edu/>
- Demuth, J.L., DeMaria, M., & Knaff, J.A. (2006). Improvement of advanced microwave sounding unit tropical cyclone intensity and size estimation algorithms. *Journal of Applied Meteorology and Climatology*, 45, 1573-1581. doi:10.1175/JAM2429.1
- Du, H., Alexander, L.V., Donat, M.G., Lippmann, T., Srivastava, A., Salinger, J., ... & Wu, Z. (2019). Precipitation from persistent extremes is increasing in most regions and globally. *Geophysical Research letters*, 46. doi: 10.1029/2019GL081898
- Edmiston, H.L., Fahrny, S.A., Lamb, M.S., Levi, L.K., Wanat, J.M., Avant, J.S., ... & Selly, N.C. (2008). Tropical storm and hurricane impacts on a Gulf Coast estuary: Apalachicola Bay, Florida. *Journal of Coastal Research*, 38-49. doi:10.2112/si55-009.1
- Eichler, T., & Higgins, W. (2006). Climatology and ENSO-related variability of North American extratropical cyclone activity. *Journal of Climate*, 19(10), 2076-2093,
- Emanuel, K., & Jagger, T. (2010). On estimating hurricane return periods. *Journal of Applied Meteorology and Climatology*, 49, 837-844. doi:10.1175/2009JAMC2236.1

- Federal Emergency Management Agency (FEMA). (2011). Coastal construction manual (FEMA P-55). FEMA.
- Fischer, T., Su, B., Luo, Y., & Scholten, T. (2012) Probability distribution of precipitation extremes for weather index-based insurance in the Zhujiang River Basin, South China. *Journal of Hydrometeorology*, 13, 1023-1037. doi: 10.1175/jhm-d-11-041.1
- Fritz, H.M., Blount, C., Sokoloski, R., Singleton, J., Fuggle, A., McAdoo, B.G., ... & Tate, B. (2007). Hurricane Katrina storm surge distribution and field observations on the Mississippi Barrier Islands. *Estuarine, Coastal and Shelf Science*, 74(1-2), 12-20. doi: 10.1016/j.ecss.2007.03.015
- Furl, C., Ghebreyesus, D., & Sharif, H.O. (2018). Assessment of the performance of satellite-based precipitation products for flood events across diverse spatial scales using GSSHA modeling system. *Geosciences*, 8(191). doi: 10.3390/geosciences8060191
- Gesch, D.B., Oimoen, M.J., & Evans, G.A. (2014). *Accuracy assessment of the U.S. Geological Survey National Elevation Dataset, and comparison with other large-area elevation datasets—SRTM and ASTER* (U.S. Geological Survey Open-File Report 2014–1008). USGS. doi: 10.3133/ofr20141008
- Hamblin, P. F. (1978). Storm surge forecasting methods in enclosed seas (pp. 998-1015). In *Coastal Engineering*. doi:10.1061/9780872621909.060
- Ho, F.P., Su, J.C., Hanevich, K.L., Smith, R.J., & Richards, F.P. (1987). *Hurricane climatology for the Atlantic and Gulf Coasts of the United States*. FEMA. Retrieved from https://coast.noaa.gov/hes/images/pdf/ATL_GULF_HURR_CLIMATOLOGY.pdf
- Horsburgh, K., & De Vries, H. (2011). *Guide to storm surge forecasting*. World Meteorological Organization. Retrieved from: https://library.wmo.int/index.php?lvl=notice_display&id=6648#.XZY3w0ZKjcs
- Hsu, S.A., Braud, D., & Blanchard, B. (2006). Rapid estimation of maximum storm surges induced by Hurricanes Katrina and Rita in 2005. *NWA Electronic Journal of Operational Meteorology*. Retrieved from: <http://nwafiles.nwas.org/ej/pdf/2006-EJ9.pdf>
- Irish, J.L., Resio, D.T., & Ratcliff, J.J. (2008). The influence of storm size on hurricane surge. *Journal of Physical Oceanography*, 38(9), 2003-2013. doi: 10.1175/2008jpo3727.1
- Jagger, T. H., & Elsner, J. B. (2006). Climatology models for extreme hurricane winds near the United States. *Journal of Climate*, 19, 3220-3236. doi:10.1175/JCLI3913.1
- Jelesnianski, C.P. (1967). Numerical computations of storm surges with bottom stress. *Monthly Weather Review*, 95(11), 740-756. doi: 10.1175/1520-0493(1967)095<0740:NCOSSW>2.3.CO;2
- Jelesnianski, C.P. (1972). *SPLASH I. Landfall storms* (NWS TDL-46). National Weather Service. Silver Spring, Maryland. Retrieved from: <https://repository.library.noaa.gov/view/noaa/13509>
- Knaff, J.A., & Zehr, R.M. (2007). Reexamination of tropical cyclone wind-pressure relationships. *Weather and Forecasting*, 22, 71-88. doi:10.1175/WAF965.1
- Kossin, J.P., Knapp, K.R., Olander, T.L., & Velden, C.S. (2020). Global increase in major tropical cyclone exceedance probability over the past four decades. *PNAS* 117(22), 11975-11980. doi: 10.1073/pnas.1920849117
- Landsea, C.W., & Franklin, J.L. (2013). Atlantic hurricane database uncertainty and presentation of a new database format. *Monthly Weather Review*, 141, 3576-3592. doi:10.1175/MWR-D-12-00254.1
- Li, M., Zhong, L., Boicourt, W.C., Zhang, S., & Zhang, D.L. (2006). Hurricane-induced storm surges, currents and destratification in a semi-enclosed bay. *Geophysical Research Letters*, 33. doi: 10.1029/2005GL024992

- Lin, N. (2015). An integrated approach to assess and manage hurricane risk in a changing climate. *The Bridge*, 45(4), 45-51. Retrieved from: https://ninglin.princeton.edu/wp-content/uploads/sites/248/2014/10/Lin_Bridge_2015.pdf
- Lin, N., & Chavas, D. (2012). On hurricane parametric wind and applications in storm surge modeling. *Journal of Geophysical Research*, 117. doi: 10.1029/2011JD017126
- Lin, N., & Emanuel, K. (2015). Grey swan tropical cyclones. *Nature Climate Change*, 6(1), 106-111. doi: 10.1038/nclimate2777
- Loder, N.M., Irish, J.L., Cialone, M.A., & Wamsley, T.V. (2009). Sensitivity of hurricane surge to morphological parameters of coastal wetlands. *Estuarine, Coastal and Shelf Science*, 84, 625-636. doi: 10.1016/j.ecss.2009.07.036
- Lu, E., Zhao, W., Zou, X., Ye, D., Zhao, C., & Zhang, Q. (2017). Temporal-spatial monitoring of an extreme precipitation event: Determining simultaneously the time period it lasts and the geographic region it affects. *Journal of Climate*, 30, 6123-6132. doi: 10.1175/JCLI-D-17-0105.1
- Murakami, H., Delworth, T.L., Cooke, W.F., Zhao, M., Xiang, Baoqiang, & Hus, P.-C. (2020). Detected climatic change in global distribution of tropical cyclones. *PNAS*, 117 (20), 10706-10714. doi: 10.1073/pnas.1922500117
- National Center for Environmental Protection (NCEP)/Climate Prediction Center (CPC) (2019). CPC unified gauge-based analysis of daily precipitation over CONUS. NCEP/Climate Prediction Center. Retrieved from: <https://www.esrl.noaa.gov/psd/>
- National Centers for Environmental information (NCEI). (2019). *Storm events database*. NOAA/NCEI. Retrieved from: <https://www.ncdc.noaa.gov/stormevents/>
- National Hurricane Center. (2019). *Introduction to storm surge*. Retrieved from: https://www.nhc.noaa.gov/surge/surge_intro.pdf
- National Weather Service (NWS). (1994). *Superstorm of March 1993: March 12-14 1993*. Silver Spring, Maryland: NWS/US Department of Commerce. Retrieved from: https://www.weather.gov/media/publications/assessments/Superstorm_March-93.pdf
- Needham, H. F., Keim, B. D., & Sathiaraj, D. (2015). A review of tropical cyclone-generated storm surges: Global data sources, observations, and impacts. *Reviews of Geophysics*, 53(2), 545-591. doi: 10.1002/2014rg000477
- Needham, H.F., & Keim, B.D. (2012). A storm surge database for the US Gulf Coast. *International Journal of Climatology*, 32(14), 2108-2123. doi: 10.1002/joc.2425
- Palutikof, J.P., Brabson, B.B., Lister, D.H., & Adcock, S.T. (1999). A review of methods to calculate extreme wind speeds. *Meteorological Applications*, 6, 119-132. doi:10.1017/S1350482799001103
- Papalexiou, S.M., Koutsoyiannis, D., & Makropoulos, C. (2013). How extreme is extreme? An assessment of daily rainfall distribution tails. *Hydrological Earth System Sciences*, 17, 851-862. doi:10.5194/hess-17-851-2013
- Peng, M., Xie, L., & Pietrafesa, L.J. (2006). A numerical study on hurricane-induced storm surge and inundation in Charleston Harbor, South Carolina. *Journal of Geophysical Research: Oceans*, 111(C8). doi: 10.1029/2004JC002755
- Ponce, V.M. (2014). *Engineering hydrology, principles and practices*. Victor M. Ponce. Retrieved from: <http://ponce.sdsu.edu/enghydro/>
- Rego, J.L., & Li, C. (2010). Storm surge propagation in Galveston Bay during Hurricane Ike. *Journal of Marine Systems*, 82, 265-279. doi: 10.1016/j.jmarsys.2010.06.001

- Roos, P.C., Pitzalis, C., Lipari, G., Reef, K.R.G., & Hulscher, S.J.M.H. (2017). Time-dependent linearisation of bottom friction for storm surge modelling in the Wadden Sea. *4th International Symposium of Shallow Flows*. Eindhoven, Netherlands. Retrieved from: https://research.utwente.nl/files/13501911/Roos_Time_dependent_linearisation_of_bottom_friction_for_storm_surge_modelling_in_the_Wadden_Sea.pdf
- Rutledge, K., McDaniel, M., Boudreau, D., Ramroop, T., Teng, S., Sprout, E., Costa, H., Hall, H., & Hunt, J. (2011) Storm surge. Retrieved from: <https://www.nationalgeographic.org/encyclopedia/storm-surge/>
- Schwerdt, R.W., Ho, F.P., Watkins, R.R. (1979). *Meteorological criteria for standard project hurricane and probable maximum hurricane windfields, Gulf and East Coasts of the United States*. Washington, D.C.: US Department of Commerce. Retrieved from http://www.nws.noaa.gov/oh/hdsc/Technical_reports/TR23.pdf
- Sheng, Y.P., Alymov, V., & Paramygin, V.A. (2010). Simulation of storm surge, wave, currents, and inundation in the Outer Banks and Chesapeake Bay during Hurricane Isabel in 2003: The importance of waves. *Journal of Geophysical Research*, 115. doi: 10.1029/2009JC005402
- Simoes, N.E., Ochoa-Rodriguez, S., Wang, L.-P., Pina, R.D., Marques, A.S., Onof, C., & Leitao, J.P. (2015). Stochastic urban pluvial flood hazard maps based upon a spatial-temporal rainfall generator. *Water*, 7, 3396-3406. doi:10.3390/w7073396
- Touma, D., Michalak, A.M., Swain, D.L., & Diffenbaugh, N.S. (2018). Characterizing the spatial scales of extreme daily precipitation in the United States. *Journal of Climate*, 31, 8023-8037. doi: 10.1175/JCLI-D-18-0019.1
- Venkatesh, S. (1974). *The development of manual techniques for the real-time prediction of storm surges on the Great Lakes*. Canadian Centre for Inland Waters. Unpublished.
- Wang, T., Hamann, A., Spittlehouse, D. L., & Aitken, S. N. (2006). Development of scale-free climate data for western Canada for use in resource management. *International Journal of Climatology: A Journal of the Royal Meteorological Society*, 26(3), 383-397.
- Wang, T., Hamann, A., Spittlehouse, D. L., & Murdock, T. Q. (2012). ClimateWNA—high-resolution spatial climate data for western North America. *Journal of Applied Meteorology and Climatology*, 51(1), 16-29.
- Weisberg, R.H., & Zheng, L. (2006). Hurricane storm surge simulations for Tampa Bay. *Estuaries and Coasts*, 29(6A), 899-913. doi: 10.1007/bf02798649
- Welander, P. (1961). Numerical prediction of storm surges. In H.E. Landsberg & J. van Miegham (eds.) *Advances in Geophysics Volume 8*. New York City, New York: Academic Press.
- Wilks, D. S. (1995). *Statistical Methods in the Atmospheric Sciences*. Boston, MA: Academic Press.
- Willoughby, H.E., Darling, R., & Rahn, M.E. (2006). Parametric representation of the primary hurricane vortex. Part II: A new family of sectionally continuous profiles. *Monthly Weather Review*, 134, 1102-1120. doi:10.1175/MWR3106.1
- World Meteorological Organization (2011). *Guide to storm surge forecasting* (WMO-No. 1076). Retrieved from: https://library.wmo.int/index.php?lvl=notice_display&id=6648#.XZYv9kZKiUk
- Wu, H., Adler, R.F., Hong, Y., Tian, Y., & Policelli, F. (2012). Evaluation of global flood detection using satellite-based rainfall and a hydrologic model. *Journal of Hydrology*, 13, 1268-1284. doi: 10.1175/JHM-D-11-087.1
- Wu, H., Adler, R.F., Tian, Y., Huffman, G.J., Li, H., Wang, J.J. (2014). Real-time global flood estimation using satellite-based precipitation and a coupled land surface and routing model. *Water Resources Research*, 50, 2693-2717. doi: 10.1002/2013WR014710

- Wu, X., Guo, S., Yin, J., Yang, G., Zhong, Y., & Liu, D. (2018). On the event-based extreme precipitation across China: Time distribution patterns, trends, and return levels. *Journal of Hydrology*, *562*, 306-317. doi: 10.1016/j.jhydrol.2018.05.028
- Yang, T., Shao, Q., Hao, Z.-C., Chen, X., Zhang, Z., Xu, C.-Y., & Sun, L. (2010) Regional frequency analysis and spatial-temporal pattern characterization of rainfall extremes in the Pearl River Basin, China. *Journal of Hydrology*, *380*, 386-405. doi:10.1016/j.jhydrol.2009.11.013
- Yeo, D., Lin, N., Simiu, E. (2012). *Estimation of hurricane wind speed probabilities: Application to New York City and other coastal locations* (NIST Technical Note 1773). Gaithersburg, Maryland: National Institute of Standards and Technology. Retrieved from: https://www.itl.nist.gov/div898/winds/pdf_files/N1_NIST_TN_1773.pdf
- Zervas, C. (2013). Extreme Water Levels of the United States 1893-2010 (NOAA Technical Report NOS CO-OPS 067). Silver Spring, Maryland: National Oceanic and Atmospheric Administration. Retrieved from: <https://repository.library.noaa.gov/view/noaa/14420>
- Zhang, K., Douglas, B. C., & Leatherman, S. P. (2000). Twentieth-century storm activity along the US east coast. *Journal of Climate*, *13*(10), 1748-1761.
- Zhang, J.A., & Uhlhorn, E.W. (2012). Hurricane sea surface inflow angle and an observation-based parametric model. *Monthly Weather Review*, *140*, 3587-3605. doi:10.1175/MWR-D-11-00339.1
- Zijlema, M., van Vledder, G.Ph., & Holthuijsen, L.H. (2012). Bottom friction and wind drag for wave models. *Coastal Engineering*, *65*, 19-26. doi: 10.1016/j.coastaleng.2012.03.002

Hydrological/Hydraulic

- Agel, L., Barlow, M., Qian, J.-H., Colby, F., Douglas, E., & Eichler, T. (2015). Climatology of daily precipitation and extreme precipitation events in the northeast United States. *Journal of Hydrometeorology*, *16*, 2537-2557. doi: 10.1175/JHM-D-14-0147.1
- Akbar, M.K., Kanjanda, S., & Misinguzi, A. (2017). Effect of bottom friction, wind drag coefficient, and meteorological forcing in hindcast of Hurricane Rita storm surge using SWAN + ADCIRC model. *Journal of Marine Science and Engineering*, *5*(38). doi: 10.3390/jmse5030038
- Archuleta, C.M., Constance, E.W., Arundel, S.T., Lowe, A.J., Matney, K.S., & Phillips, L.A. (2017). *The National Map seamless digital elevation model specifications* (Techniques and Methods 11-b9). US Geological Survey. doi: 10.3133/tm11B9
- Barbier, E.B., Georgiou, I.Y., Enchelmeyer, B., & Reed, D.J. The value of wetlands in protecting southeast Louisiana from hurricane storm surges. *PlosOne*, *8*(3). doi: 10.1371/journal.pone.0058715
- Barrientos, C. S., & Jelesnianski, C. P. (1973). *Storm surge shoaling corrections along the Gulf coast*. Silver Spring, Maryland: NOAA/NWS-TDL. Retrieved from: https://www.weather.gov/media/mdl/Barrientos_1974_StormSurgeShoaling.pdf
- Barrientos, C.S., & Chen, J. (1974). *Storm surge shoaling connections along the east coast*. Spring, Maryland: National Weather Service. Retrieved from: https://www.weather.gov/media/mdl/Barrientos_1974_StormSurgeShoaling.pdf
- Barrientos, C.S., & Jelesnianski, C.P. (1977). SPLASH – A model for forecasting tropical storm surges. *Proceedings of the Fifteenth Conference on Coastal Engineering*. Honolulu, Hawaii. doi: 10.1061/9780872620834.056
- Blain, C.A., Westerink, J.J., & Luettich Jr., R.A. (1994). The influence of domain size on the response characteristics of a hurricane storm surge model. *Journal of Geophysical Research*, *99*(C9), 18,467-18,479. doi: 10.1029/94JC01348
- Botzen, W.J.W., Kunreuther, H., Czajkowski, J., & de Moel, H. (2019). *Adoption of individual flood damage mitigation measures in New York City: An extension of protection motivation theory*. Philadelphia,

- Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2019/02/WP201902_Botzen-et-al_Flood-damage-mitigation-NYC.pdf
- Campbell, K.A., Laurien, F., Czajkowski, J., Keating, A., Hochrainer-Stigler, S., & Montgomery, M. (2019). First insights from the flood resilience measurement tool: A large-scale community flood resilience analysis. *International Journal of Disaster Risk Reduction*, 40. doi: 10.1016/j.ijdrr.2019.101257
- Chen, C., Beardsley, R.C., Luettich Jr., R.A., Westerink, J.J., Wang, H., Perrie, W., ... & Toulany, B. (2013). Extratropical storm inundation testbed: Intermodel comparisons in Scituate, Massachusetts. *Journal of Geophysical Research: Oceans*, 118, 5054-5073. doi: 10.1002/jgrc.20397
- Chiu, S., & Small, C. (2016). Observations of cyclone-induced storm surge in coastal Bangladesh. *Journal of Coastal Research*, 32(5), 1149-1161. doi: 10.2112/JCOASTRES-D-15-00030.1
- Chow, V.T., & Ben-Zvi, A. (1973). Hydrodynamic modeling of two-dimensional watershed flow. *Journal of the Hydraulics Division*, 99(11), 2023-2040.
- Clapp, R.B., & Hornberger, G.M. (1978). Empirical equations for some soil hydraulic properties. *Water Resources Research*, 14(4), 601-604.
- Cutrell, A.K., Rozelle, J., Bausch, D., Hines, S.H., Longenecker, H.E., Zuzak, C., Montague, N. (2018). *Hazus flood model: FEMA standard operating procedure for Hazus level 2 flood analysis*. FEMA. Retrieved from: https://www.fema.gov/media-library-data/1561466386519-b15dc59f1acf1738944b43f42a8b01d7/Hazus_Flood_Model_SOP_level2analysis.pdf
- Czajkowski, J., Villarni, G., Montgomery, M., Michel-Kerjan, E., & Goska, R. (2017). Assessing current and future freshwater flood risk from North Atlantic tropical cyclones via insurance claims. *Scientific Reports*, 7. doi: 10.1038/srep41609
- Dai, Y., Xin, Q., Wei, N., Zhang, Y., Shangguan, W., Yuan, H., ... & Lu, X. (2019). A global high-resolution data set of soil hydraulic and thermal properties for land surface modeling. *Journal of Advances in Modeling Earth Systems*, 11. doi: 10.1029/2019MS001784
- Darcy, H. P. G. (1856). *Les Fontaines publiques de la ville de Dijon. Exposition et application des principes à suivre et des formules à employer dans les questions de distribution d'eau, etc.* V. Dalamont.
- Dean, R.G., & Bender, C.J. (2006). Static wave setup with emphasis on damping effects by vegetation and bottom friction. *Coastal Engineering*, 53, 149-156. doi: 10.1016/j.coastaleng.2005.10.005
- DeWitt, J.D., Warner, T.A., & Conley, J.F. (2015). Comparison of DEMs derived from USGS DLG, SRTM, a statewide photogrammetry program, ASTER GDEM and LiDAR: implications for change detection. *GIScience & Remote Sensing*, 52 (2), 179-197. doi: 10.1080/15481603.2015.1019708
- Edmiston, H.L., Fahrny, S.A., Lamb, M.S., Levi, L.K., Wanat, J.M., Avant, J.S., Wren, K., & Selly, N.C. (2008). Tropical storm and hurricane impacts on a Gulf coast estuary: Apalachicola Bay, Florida. *Journal of Coastal Research*, 55, 38-49. doi: 10.2112/SI55-009.1
- FEMA. (2003). *SLOSH display training*. Retrieved from: https://www.fema.gov/pdf/plan/prevent/nhp/slosh_display_training.pdf
- Feng, D., & Beighley, E. (2020). Identifying uncertainties in hydrologic fluxes and seasonality from hydrologic model components for climate change impact assessments. *Hydrology and Earth System Sciences*, 24, 2253-2267. doi: 10.5194/hess-24-2253-2020
- Ferreira, C.M., Irish, J.L., & Olivera, F. (2014). Uncertainty in hurricane surge simulation due to land cover specification. *Journal of Geophysical Research: Oceans*, 119, 1812-1827. doi: 10.1002/2013JC009604

- Ferreira, C.M., Olivera, F., & Irish, J.L. (2014). ARC StormSurge: Integrating hurricane storm surge modeling and GIS. *Journal of the American Water Resources Association*, 50(1), 219-233. doi: 10.1111/jawr.12127
- Filipova, V., Lawrence, D., & Skaugen, T. (2018). A stochastic event-based approach for flood estimation in catchments with mixed rainfall/snowmelt flood regimes. *Natural Hazards and Earth System Sciences*, 19, 1-18. doi: 10.5194/nhess-2018-174
- Frey, A.E., Morang, A., & King, D.B. (2016). *Galveston Island, Texas, sand Management Strategies* (16-3). Galveston, Texas: U.S. Army Corps of Engineers. Retrieved from: <https://usace.contentdm.oclc.org/digital/collection/p266001coll1/id/3714/>
- Fritz, H.M., Blount, C., Sokoloski, R., Singleton, J., Fuggle, A., McAdoo, B.G., Moore, A., Grass, C., & Tate, B. (2007). Hurricane Katrina storm surge distribution and field observations on the Mississippi Barrier Islands. *Estuarine Coastal and Shelf Science*, 74, 12-20. doi: 10.1016/j.ecss.2007.03.015
- Ghimire, B., Chen, S.A., Guidolin, M., Keedwell, E.C., Djordjevic, S., & Savic, D.A. (2013). Formulation of a fast 2D urban pluvial model using a cellular automata approach. *Journal of Hydroinformatics*, 15(3), 676-686. doi: 10.2166/hydro.2012.245
- Guidolin, M., Chen, S.A., Ghimire, B., Keedwell, E.C., Djordjevic, S., & Savic, D.A. (2016). A weighted cellular automata 2D inundation model for rapid flood analysis. *Environmental Modelling & Software*, 84, 378-394. doi: 10.1016/j.envsoft.2016.07.008
- Haer, T., Wouter Botzen, W.J., & Aerts, J.C.J.H. (2018). *Integrating Dynamic Adaptive Behavior in Flood Risk Assessments*. Philadelphia, Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/12/WP2018-12_Adaptive-Behavioural-Flood-Risk_Haer_etal.pdf
- Harris, D.L. (1963). *Characteristics of the hurricane storm surge* (Technical Paper No. 48). Washington, D.C.: U.S. Weather Bureau. Retrieved from: https://coast.noaa.gov/hes/images/pdf/CHARACTERISTICS_STORM_SURGE.pdf
- Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., & Megown, K. (2015). Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, 81(5), 345-354.
- Horton, R.E. (1933). The role of infiltration in the hydrologic cycle. *Eos, Transactions American Geophysical Union*, 14(1), 446-460.
- Hsu, S.A., Braud, D., & Blanchard, B. (2006). *Rapid estimation of maximum storm surges induced by Hurricanes Katrina and Rita in 2005*. Baton Rouge, Louisiana: Earth Scan Lab, Louisiana State University. Retrieved from: <http://nwafiles.nwas.org/ej/pdf/2006-EJ9.pdf>
- Jamali, B., Bach, P.M., Cunningham, L., & Deletic, A. (2019). A cellular automata fast flood evaluation (CAffe) model. *Water Resources Research*, 55(6). Doi: 10.1029/2018WR023679
- Jelesnianski, C.P. (1967). Numerical computations of storm surges with bottom stress. *Monthly Weather Review*, 95(11), 740-756. doi: 10.1175/1520-0493(1967)095<0740:NCOSSW>2.3.CO;2
- Jelesnianski, C.P. (1972). *SPLASH (Special program to List Amplitudes of Surges from Hurricanes)* (NWS TDL-46). Silver Spring, Maryland: National Weather Service. Retrieved from: <https://repository.library.noaa.gov/view/noaa/13509>
- Jelesnianski, C.P., Chen, J., & Shaffer, W.A. (1992). *Sea, lake, and overland surges from hurricanes* (NWS 48). Silver Spring, Maryland: National Weather Service. Retrieved from: https://coast.noaa.gov/hes/images/pdf/SLOSH_TR48.pdf

- Knighton, J., Steinschneider, S., & Walter, M.T. (2017). A vulnerability-based, bottom-up assessment of future riverine flood risk using a modified peaks-over-threshold approach and a physically based hydrologic model. *Water Resources Research*, 53, 10,043–10,064. doi: 10.1002/2017WR021036
- Krauss, K.W., Doyle, T.W., Doyle, T.J., Swarzenski, C.M., From, A.S., Day, R.H., & Conner, W.H. (2009). Water level observations in mangrove swamps during two hurricanes in Florida. *Wetlands*, 29(1), 142-149. doi: 10.1672/07-232.1
- Kunreuther, H., Wachter, S., Kousky, C., Lacour-Little, M. (2018). *Flood risk and the U.S. housing market*. Philadelphia, Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/11/Flood_Risk_and_the_U.S._Housing_Market_10-30_.pdf
- Lam, D., Thompson, C., Croke, J., Sharma, A., & Macklin, M. (2017). Reducing uncertainty with flood frequency analysis: The contribution of paleoflood and historical flood information. *Water Resources Research*, 53, 2312-2327. doi: 10.1002/2016WR019959
- Li, M., Zhong, L., Boicourt, W.C., Zhang, S., & Zhang, D.L. (2006). Hurricane-induced storm surges, currents and destratification in a semi-enclosed bay. *Geophysical Research Letters*, 33. doi: 10.1029/2005GL024992
- Liu, S., Wei, Y., W.M. Post, W.M, Cook, R.B., Schaefer, K., & Thornton, M.M. (2014). NACP MsTMIP: Unified North American Soil Map. Data set. Oak Ridge, TN: Oak Ridge National Laboratory Distributed Active Archive Center. doi: 10.3334/ORNLDAAC/1242
- Liu, Z., Merwade, V., & Jafarzadegan, K. (2018). Investigating the role of model structure and surface roughness in generating flood inundation extents using 1D and 2D hydraulic models. *Journal of Flood Risk Management: e12347*.
- Loder, N.M., Irish, J.L., Cialone, M.A., & Wamsley, T.V. (2009). Sensitivity of hurricane surge to morphological parameters of coastal wetlands. *Estuarine, Coastal and Shelf Science*, 84, 625-636. doi: 10.1016/j.ecss.2009.07.036
- Marsooli, R., & Lin, N. (2018). Numerical modeling of historical storm tides and waves and their interactions along the U.S. east and Gulf coasts. *Journal of Geophysical Research: Oceans*, 123, 3844-3874. doi: 10.1029/2017JC013434
- McInerney, M.A., Shaffer, W., Taylor, A., Sandell, K.A., Jarvinen, B., Baig, S., ... & Hauser, H. (2006). *SLOSH Sea, lake, and overland surges from hurricanes: User & technical software documentation*. Silver Spring, Maryland: Meteorological Development Laboratory.
- Nasiri, H., Yusof, M.J.M., & Ali, T.A.M. (2016). An overview to flood vulnerability assessment methods. *Sustainable Water Resources Management*, 2(3), 331-336. doi: 10.1007/s40899-016-0051-x
- National Centers for Environmental information (NCEI) (2019). *Storm events database*. NOAA/NCEI. Retrieved from: <https://www.ncdc.noaa.gov/stormevents/>
- National Hurricane Center. (2019). *Introduction to storm surge*. Retrieved from: https://www.nhc.noaa.gov/surge/surge_intro.pdf
- Needham, H., & Keim, B.D. (2011). Storm surge: Physical processes and an impact scale. In A. Lupo (ed.) *Recent Hurricane Research: Climate, Dynamics, and Societal Impacts* (pp. 385-406). London, United Kingdom: Intech Open Limited. doi: 10.5772/592
- Needham, H.F., & Keim, B.D. (2013). Correlating storm surge heights with tropical cyclone winds at and before landfall. *Earth Interactions*, 18(7), 1-26. doi: 10.1175/2013EI000527.1
- Needham, H.F., Keim, B.D., & Sathiaraj, D. (2015). A review of tropical cyclone-generated storm surges: Global data sources, observations, and impacts. *Reviews of Geophysics*, 53, 545-591. doi: 10.1002/2014RG000477

- Needham, H.F., Keim, B.D., Sathiaraj, D., & Shafer, M. (2013). A global database of tropical storm surges. *Eos*, 94(24), 213-220. doi: 10.1002/2013EO240001
- Njoku, E., Entekhabi, D., Kellogg, K., & O'Neill, P. (2009). The Soil Moisture Active and Passive (SMAP) Mission. In *Earth Observation and Water Cycle Science* (Vol. 674).
- Parkes, B., & Demeritt, D. (2016). Defining the hundred year flood: A Bayesian approach for using historic data to reduce uncertainty in flood frequency estimates. *Journal of Hydrology*, 540, 1189-2108. doi: 10.1016/j.jhydrol.2016.07.025
- Peng, M., Xie, L., & Pietrafesa, L.J. (2006). A numerical study on hurricane-induced storm surge and inundation in Charleston Harbor, South Carolina. *Journal of Geophysical Research*, 111. doi: 10.1029/2004JC002755
- Ponce, V.M. (1989). *Engineering hydrology: Principles and practices* (Vol. 640). Englewood Cliffs, NJ: Prentice Hall.
- Ponce, V.M. (2014). *Engineering hydrology, principles and practices*. Victor M. Ponce. Retrieved from: <http://ponce.sdsu.edu/enghydro/>
- Ponce, V.M., & Lugo, A. (2001). Modeling looped ratings in Muskingum-Cunge routing. *Journal of Hydrologic Engineering* 6(2),119-124.
- Rao, N.S.B., & Mazumdar, S. (1966). A technique for forecasting storm waves. *Indian Journal of Meteorology and Geophysics*, 17, 333–346.
- Rego, J.L., & Li, C. (2010). Storm surge propagation in Galveston Bay during Hurricane Ike. *Journal of Marine Systems*, 82. 265-279. doi: 10.1016/j.jmarsys.2010.06.001
- Roos, P.C., Pitzalis, C., Lipari, G., Reef, K.R.G., & Hulscher, S.J.M.H. (2017). Time-dependent linearisation of bottom friction for storm surge modelling in the Wadden Sea. *4th International Symposium of Shallow Flows*. Eindhoven, Netherlands. Retrieved from: https://research.utwente.nl/files/13501911/Roos_Time_dependent_linearisation_of_bottom_friction_for_storm_surge_modelling_in_the_Wadden_Sea.pdf
- Sadiq, A., Tyler, J., Noonan, D., Norton, R.K., Cunniff, S.E., & Czajkowski, J. (2018). *A review of the Federal Emergency Management Agency's community rating system program*. Wharton of the University of Pennsylvania. Philadelphia, Pennsylvania. Retrieved from: <https://pdfs.semanticscholar.org/81ec/d76368df125045a456e44ba201eb0b8ce686.pdf>
- Salinas, J.L., Kiss, A., Viglione, A., Viertl, R., & Blöschl, G. (2016). A fuzzy Bayesian approach to flood frequency estimation with imprecise historical information. *Water Resources Research*, 52, 6730-6750. doi: 10.1002/2016WR019177
- Sampson, C.C., Smith, A.M., Bates, P.D., Neal, J.C., Alfieri, L., & Freer, J.E. (2015). A high-resolution global flood hazard model. *Water Resources Research*, 51, 7358-7381. doi:10.1002/2015WR016954
- Sheng, Y.P., Alymov, V., & Paramygin, V.A. (2010). Simulation of storm surge, wave, currents, and inundation in the Outer Banks and Chesapeake Bay during Hurricane Isabel in 2003: The importance of waves. *Journal of Geophysical Research*, 115. doi: 10.1029/2009JC005402
- Sheng, Y.P., Lapetina, A., & Ma, G. (2012). The reduction of storm surge by vegetation canopies: Three-dimensional simulations. *Geophysical Research Letters*, 39. doi: 10.1029/2012GL053577
- Southwest Florida Water Management District (2005). A plan for the use and management of the lower Hillsborough flood detention area. Brooksville, Florida: Southwest Florida Water Management District. Retrieved from: https://www.swfwmd.state.fl.us/sites/default/files/medias/documents/2005_Lower_Hillsborough_FDA_LU-Mgmt_Plan.pdf

- Te Chow, V. (Ed.). (1964). *Handbook of applied hydrology: a compendium of water-resources technology* (Vol. 1). McGraw-Hill.
- US Army Corps of Engineers (USACE) (1981). *Galveston's bulwark against the sea; History of the Galveston Seawall*. Retrieved from: <https://www.swg.usace.army.mil/Portals/26/docs/PAO/GalvestonBulwarkAgainsttheSea.pdf>
- US Army Corps of Engineers (USACE) (2000). *Hydrologic modeling system HEC-HMS technical reference manual*. Washington: USACE. Retrieved from: [https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference%20Manual_\(CPD-74B\).pdf](https://www.hec.usace.army.mil/software/hec-hms/documentation/HEC-HMS_Technical%20Reference%20Manual_(CPD-74B).pdf)
- US Army Corps of Engineers (USACE) (2019). *National Levee Database*. Retrieved from: <https://levees.sec.usace.army.mil/#/>.
- US Geological Survey (USGS) (2014). National Land Cover (2011 Edition, amended 2014) – National Geospatial Data Asset (NGDA) Land Use Land Cover. USGS. Retrieved from <http://www.mrlc.gov>
- US Geological Survey (USGS) (2018). *Elevation products (3DEP)*. USGS. Retrieved from: <https://viewer.nationalmap.gov/basic/>
- US Geological Survey (USGS) (2019). *USGS surface-water historical instantaneous data for the nation*. US Department of Interior/USGS. Retrieved from: <https://waterdata.usgs.gov/nwis/uv?>
- Wamsley, T.V., Cialone, M.A., Smith, J.M., Atkinson, J.H., & Rosait, J.D. (2010). The potential of wetlands in reducing storm surge. *Ocean Engineering*, 37, 59-68. doi: 10.1016/j.oceaneng.2009.07.018
- Weisberg, R.H., & Zheng, L. (2006). Hurricane storm surge simulations for Tampa Bay. *Estuaries and Coasts*, 29(6A), 899-913. doi: 10.1007/bf02798649
- Westerink, J.J., Luettich, R.A., Feyen, J.C., Atkinson, J.H., Dawson, C., Roberts, H.J., Powell, M.D., Dunion, J.P., Kubatko, E.J., & Pourtaheri, H. (2008). A basin-to channel-scale unstructured grid hurricane storm surge model applied to southern Louisiana. *Monthly Weather Review*, 136, 833-864. doi: 10.1175/2007MWR1946.1
- Whiteaker, T.L., Robayo, O., Maidment, D.R., Obenour, D. (2006). From a NEXRAD rainfall map to a flood inundation map. *Journal of Hydrologic Engineering*, 37-45. doi: 10.1061/(ASCE)1084-0699(2006)11:1(37)
- Williams, G.P. (1978). Bank-full discharge of rivers. *Water Resources Research*, 14(6), 1141-1154.
- Wooding, R.A. (1965). A hydraulic model for the catchment-stream problem: I. Kinematic-wave theory. *Journal of Hydrology*, 3(3-4), 254-267.
- Wooding, R.A. (1965). A hydraulic model for the catchment-stream problem: II. Numerical solutions. *Journal of Hydrology*, 3(3-4), 268-282.
- Wooding, R.A. (1966). A hydraulic model for the catchment-stream problem: III. Comparison with runoff observations. *Journal of Hydrology*, 4, 21-37.
- Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., ... & Xian, G. (2018). A new generation of the United States National Land Cover Database: Requirements, research priorities, design, and implementation strategies, *ISPRS Journal of Photogrammetry and Remote Sensing*, 146, 108-123. doi: 10.1016/j.isprsjprs.2018.09.006
- Yin, J., Lin, N., & Yu, D. (2016). Coupled modeling of storm surge and coastal inundation: A case study in New York City during Hurricane sandy. *Water Resources Research*, 52, 8685-8699. doi: 10.1002/2016WR019102
- Zhang, K., Gann, D., Ross, M., Robertson, Q., Sarmiento, J., Santana, S., Rhome, J., & Fritz, J. (2019). Accuracy assessment of ASTER, SRTM, ALOS, and TDX DEMs for Hispaniola and implications for

mapping vulnerability to coastal flooding. *Remote Sensing of Environment*, 225, 290-306. doi: 10.1016/j.rse.2019.02.028

Zhang, K., Li, Y., Liu, H., Rhome, J., & Forbes, C. (2013). Transition of the coastal and estuarine storm tide model to an operational storm surge forecast model: A case study of the Florida coast. *Weather Forecasting*, 28, 1019-1037. doi: 10.1175/WAF-D-12-00076.1

Zhao, Y., & Beighley, E. (2016). Upscaling surface runoff routing processes in large-scale hydrologic models: Application to the Ohio River Basin. *Journal of Hydrological Engineering*. doi: 10.1061/(ASCE)HE.1943-5584.0001478

Zijlema, M., van Vledder, G.Ph., & Holthuijsen, L.H. (2012). Bottom friction and wind drag for wave models. *Coastal Engineering*, 65, 19-26. doi: 10.1016/j.coastaleng.2012.03.002

Statistical References

Andrews, J.D., & Dunnett, S.J. (2000). Event-tree analysis using binary decision diagrams. *IEEE Transactions on Reliability*, 49(2), 230-238. doi:10.1109/24.877343

Angus, J.E. (1994). The probability integral transform and related results. *SIAM Review*, 36(4), 652-654. doi:10.1137/1036146

Bacher, A., Bodini, O., & Jacquot, A. (2017). Efficient random sampling of binary and unary-binary trees via holonomic equations. *Theoretical Computer Science*, 695, 42-53. doi:10.1016/j.tcs.2017.07.009

Bahnemann, D. (2015). *Distributions for actuaries*. Arlington, VA: Casualty Actuarial Society.

Best, D., & Roberts, D. (1975). Algorithm AS 89: The Upper Tail Probabilities of Spearman's Rho. *Journal of the Royal Statistical Society. Series C (Applied Statistics)*, 24(3), 377-379. doi:10.2307/2347111

Beck, A. (2014). *Introduction to nonlinear optimization: Theory, algorithms, and applications with MATLAB*. Philadelphia, Pennsylvania: SIAM.

Bommer, J.J. (2005). On the use of logic trees for ground-motion prediction equations in seismic hazard analysis, *Bulletin of the Seismological Society of America*, 95(2), 377-389. doi: 10.1785/0120040073

Brockwell, P.J., & Davis, R.A. (2016). *Introduction to time series and forecasting* (3rd ed.). New York: Springer.

Choun, Y.-S., & Kim, M.-K. (2019). Logic tree approach for probabilistic typhoon wind hazard assessment. *Nuclear Engineering and Technology*, 51, 607-617. doi:10.1016/j.net.2018.11.006

Clark, K.M. (1986). A formal approach to catastrophe risk assessment and management. *Proceedings of the Casualty Actuarial Society*, 73(140), 69-92.

Finger, R. (2013). Investigating the performance of different estimation techniques for crop yield data analysis in crop insurance applications. *Agricultural Economics*, 44(2). doi: 10.1111/agec.12005

GeoPentech, Inc. (2015). *Southwestern United States ground motion characterization SSHAC level 3: Technical report*. (2nd revision).

Gibbons, J.D., & Chakraborti, S. (2003). *Nonparametric Statistical Inference* (4th ed.). New York: Marcel Dekker, Inc.

Hall, T.M., & Jewson, S. (2007). Statistical modelling of North Atlantic tropical cyclone tracks. *Tellus*, 59A, 486-498. doi:10.3402/tellusa.v59i4.15017

Hogg, R.V., McKean, J.W., & Craig, A.T. (2018). *Introduction to mathematical statistics* (8th ed.). New York: Pearson.

Iman, R.L., & Johnson, M.E. (2002). Assessing hurricane effects. Part 2. Uncertainty analysis. *Reliability Engineering & System Safety*, 78, 147-155. doi:10.1016/S0951-8320(02)00134-5

- Iman, R.L., Johnson, M.E., & Schroeder, T.A. (2001). *Professional team demonstration uncertainty/sensitivity analysis*. Southwest Technology Consultants.
- Iman, R.L., Johnson, M.E., & Schroeder, T.A. (2002). Assessing hurricane effects. Part 1. Sensitivity analysis. *Reliability Engineering and System Safety*, 78, 131-145. doi:10.1016/S0951-8320(02)00133-3
- Innal, F., Rauzy, A., & Dutuit, Y. (2017, December). Handling epistemic uncertainty in fault trees: New proposal based on evidence theory and Kleene Ternary decision diagrams. In *2017 2nd International Conference on System Reliability and Safety (ICSRS)* (pp. 354-359). IEEE.
- Jin-Peng, Q., Jie, Q., Fang, P., & Tao, G. (2015). Multi-channel detection for abrupt change based on the ternary search tree and Kolmogorov statistic method. *34th Chinese Control Conference*. Hangzhou, China: IEEE. doi:10.1109/ChiCC.2015.7260412
- Klugman, S.A., Panjer, H.H., & Willmot, G. . (2012). *Loss models: From data to decisions* (4th ed.). Hoboken: Wiley.
- Kvam, P., & Vidakovic, B. (2007) *Nonparametric Statistics with Applications in Science and Engineering*. John Wiley & Sons.
- Larsen, R.J., & Marx, M L. (2017). *An introduction to mathematical statistics and its application* (6th ed.). New York: Pearson.
- Lilliefors, H.W. (1967). On the Komogorov-Smirnov test for normality with mean and variance unknown. *Journal of the American Statistical Association*, 62(318), 399-402. doi:10.2307/2283970
- Lilliefors, H.W. (1969). On the Kolmogorov-Smirnov test for the exponential distribution with mean unknown. *Journal of the American Statistical Association*, 64(325), 387-389. doi:10.2307/2283748
- Martin, J., Daffos Ruiz de Adana, D., & Asuero, A. G. (2017), Fitting Models to Data: Residual Analysis, a Primer. InTech. doi: 10.5772/68049
- McKay, M.D., Morrison, J.D., & Upton, S.C. (1999). Evaluating prediction uncertainty in simulation models. *Computer Physics Communication*, 117(1-2), 44-51. doi:10.1016/S0010-4655(98)00155-6
- Moriasi, D. N. et al. (2007). Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. *Transactions of the ASABE*. 50(3), 885–900
- Muhlbauer, A., Spichtinger, P., & Lohmann, U. (2009). Application and comparison of robust linear regression methods for trend estimation. *Journal of Applied Meteorology and Climatology*, 48, 1961-1970. doi: 10.1175/2009JAMC1851.1
- Nash, J. E., and Sutcliffe, J. V. (1970). River flow forecasting through conceptual models. I—A discussion of principles. *J. Hydrol.*, 10(3), 282–290.
- Pearson, E.S. (1938). The probability integral transformation for testing goodness of fit and combining independent tests of significance. *Biometrika* 30(1), 134-148. doi: 10.2307/2332229
- Pielke R., Landsea, C.W., Gratz, J., Collins, D., Saunders, M.A., Musulin, R. (2008). Normalized hurricane damage in the United States: 1900-2005. *Natural Hazards Review* 9(1), 29-42. doi: 10.1061/(ASCE)1527-6988(2008)9:1(29)
- Rabinowitz, N., Steinberg, D.M., & Leonard, G. (1998). Logic trees, sensitivity analyses, and data reduction in probabilistic seismic hazard assessment. *Earthquake Spectra*, 14(1), 189-201. doi: 10.1193/1.1585995
- Ran, Q. et al. (2018). Evaluation of Quantitative Precipitation Predictions by ECMWF, CMA, and UKMA for Flood Forecasting: Application to Two Basins in China. *Natural Hazards Review*, 19(2).

- Scherbaum, F., Bommer, J.J., Bungum, H., Cotton, F., & Abrahamson, N.A. (2005). Composite ground-motion models and logic trees: Methodology, sensitivities, and uncertainties. *Bulletin of the Seismological Society of America*, 95(5), 1575-1593. doi: 10.1785/0120040229
- Siciliano, R., & Mola, F. (1998). Ternary classification trees: A factorial approach. In J. Blasius, & M. Greenacre (Eds.), *Visualization of Categorical Data* (pp. 311-323). San Diego, California: Academic Press.
- Toro, G.R., Resio, D.T., Divoky, D., Niedorada, A.W., & Reed, C. (2010). Efficient joint-probability methods for hurricane surge frequency analysis. *Ocean Engineering*, 37, 125-134. doi:10.1016/j.oceaneng.2009.09.004
- Vickery, P., Wadhera, D., Cox, A., Cardone, V., Hanson, J., & Blanton, B. (2013). *Costal Storm Surge Analysis: Storm Forcing*. FEMA.
- Wasserman, L. (2006). *All of Nonparametric Statistics*. New York: Springer. doi: 10.1007/0-387-30623-4
- Weiss, N.A. (2005). *A Course in Probability* (1st ed.). New York: Pearson.
- Wilks, D. S. (1995). *Statistical Methods in the Atmospheric Sciences*. Boston, MA: Academic Press.
- Yang, K., Paramygin, V., & Sheng, Y.P. (2019). An objective and efficient method for estimating probabilistic coastal inundation hazards. *Natural Hazards*, 99, 1105-1130. doi: 10.1007/s11069-019-03807-w
- Yellowlees, A., Bursa, F., Fleetwood, K.J., Charlton, S., Hirst, K.J., Sun, R., & Fusco, P.C. (2016). The appropriateness of robust regression in addressing outliers in an Anthrax vaccine potency test. *BioScience*, 66, 63-72. doi:10.1093/biosci/biv159

Vulnerability

- American Institute for Research. (2005). *A chronology of major events affecting the National Flood Insurance Program*. FEMA. Retrieved from: https://www.fema.gov/media-library-data/20130726-1602-20490-7283/nfip_eval_chronology.pdf
- American Society of Civil Engineers (ASCE). (2006). *Flood Resistant Design and Construction* (ASCE/SEI 24-05). ASCE. doi: 10.1061/9780784408186
- American Society of Civil Engineers (ASCE). (2015). *Flood Resistant Design and Construction* (ASCE/SEI 24-14). ASCE. doi: 10.1061/9780784413791
- ASCE. (2000). *Flood resistant design and construction*. Reston, VA: American Society of Engineers.
- ASCE. (2010). *Minimum design loads for buildings and other structures* (ASCE/SEI 7-10). Reston, VA: American Society of Engineers.
- Bailey, J.R., Amoroso, S.D., Coulbourne, W., Kennedy, A., Smith, D.A. (2016). *A proposed methodology for estimating wind damage to residential slab-only claims resulting from a hurricane impacting the Texas coastline*. Texas Department of Insurance, Austin, Texas.
- Baradaranshoraka, M. (2017). *Vulnerability model of residential structures subject to hurricane induced wind, surge and inundation*. Melbourne, FL: Florida Institute of Technology.
- Baradaranshoraka, M., Pinelli, J.P., Gurley, K., Peng, X., & Zhao, M. (2017). Hurricane wind versus storm surge damage in the context of a risk prediction model. *Journal of Structural Engineering*, 143(9). doi: 10.1061/(ASCE)ST.1943-541X.0001824
- Baradaranshoraka, M., Pinelli, Gurley, K., & Zhao, M. (2019). Characterization of coastal flood damage states for residential buildings. *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering*, 5(1). doi: 10.1061/AJRU6.0001006

- Becker, A.B., Johnstone, W.M., & Lence, B.J. (2011). Wood frame building response to rapid-onset flooding. *Natural Hazards Review*, 12(2). doi: 10.1061/(ASCE)NH.1527-6996.0000029
- Büchle, B., Kreibich, H., Kron, A., Thieken, A., Iringer, J., Oberle, P., Merz, B., & Nestmann, F. (2006). Flood-risk mapping: Contributions towards an enhanced assessment of extreme events and associated risks. *Natural Hazards and Earth System Sciences*, 6, 485-503. doi: 10.5194/nhess-6-485-2006
- Caraballo-Nadal, N.C., Zapata-Lopez, R.E., & Pagan-Trinidad, I. (2006). Building damage estimate due to riverine floods, storm surges and tsunamis: A proposed methodology. *Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology*. Mayaguez: Puerto Rico.
- Central Valley Flood Management Planning Program. (2012). *Attachment 8F: Flood Damage Analysis*. Sacramento, California: California Natural Resources Agency. Retrieved from: https://water.ca.gov/LegacyFiles/cvfm/docs/CVFPPAttVol4_20120307.pdf
- Chidambarathanu, N., & Retnan, R. (2013). Vulnerability of reinforced concrete structures subjected to flood. In O. Petrucci (ed.) *Natural Disasters: Multifaceted Aspects in Management and Impact Assessment*. London: IntechOpen. doi: 10.5772/53879
- Cope, A.D. (2004). *Predicting the vulnerability of typical residential buildings to hurricane damage*. Gainesville, FL: University of Florida. Retrieved from http://etd.fcla.edu/UF/UFE0005820/cope_a.pdf
- Cuomo, G., Shams., G., Jonkman, S., & van Gelder, P. (2008). Hydrodynamic loading of buildings in floods. In J. McKee Smith (ed.) *Coastal Engineering 2008 - Proceedings of the 31st International Conference* (pp. 3744-3756). Hamburg, Germany. doi: 10.1142/9789814277426_0310
- Custer, R., & Nishijima, K. (2015). Flood vulnerability assessment of residential buildings by explicitly damage process modelling. *Natural Hazards*, 78, 461-496. doi: 10.1007/s11069-015-1725-7
- Czajkowski, J. (2017). *Freshwater vs. storm surge: Development of a deeper understanding of tropical cyclone flood insurance claims*. Philadelphia, Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: <https://www.willis.com/documents/WillisResearchNetwork/Development%20of%20a%20deeper%20understanding%20of%20tropical%20cyclone%20flood%20insurance%20claims%20-%20Jeffrey%20Czajkowski.pdf>
- Czajkowski, J., Kunreuther, H., & Michel-Kerjan, E. (2013). Quantifying riverine and storm-surge flood risk by single-family residence: Application to Texas. *Risk Analysis*, (33)12, 2092-2110. doi: 10.1111/risa.12068
- de Beurs, K.M., McThompson, N.S., Owsley, B.C., & Henebry, G.M. (2019). Hurricane damage detection on four major Caribbean islands. *Remote Sensing of Environment*, 229, 1-13. doi: 10.1016/j.rse.2019.04.028
- de Brugin, K., Wagenaar, D., Slager, K., de Bel, M., Burzel, A. (2015). *Updated and improved method for flood damage assessment: SSM2015 (version 2)*. Netherland: Deltares. Retrieved from: https://www.helpdeskwater.nl/publish/pages/132789/1220043-003-hye-0012-r-updated_and_improved_method_for_flood_damage_assessment_ssm2015_version_2.pdf
- de Moel, H., Asselman, N.E.M., & Aerts, J.C.J.H. (2012). Uncertainty and sensitivity analysis of coastal flood damage estimates in the west of the Netherlands. *Natural Hazards and Earth System Sciences*, 12, 1045-1058. doi: 10.5194/nhess-12-1045-2012
- Department of Housing and Urban Development (HUD). (2010). On-site completion of construction of manufactured homes (24 CFR Parts 3282 and 3285). *Federal Register*, 75(120).

- Do, T.Q., van de Lindt, J.W., & Cox, D.T. (2020). *Journal of Structural Engineering*, 146(1). doi: 10.1061/(ASCE)ST.1943-541X.0002472
- Federal Emergency Management Agency (FEMA). (2005). *Hurricane Ivan in Alabama and Florida: Observations recommendations, and technical guidance* (FEMA 489). Retrieved from: <https://www.fema.gov/media-library/assets/documents/2338>
- Federal Emergency Management Agency (FEMA). (2006). *Hurricane Katrina in the Gulf Coast: Mitigation Assessment Team report, building performance observations, recommendations, and technical guidance*. FEMA. Retrieved from: <https://www.fema.gov/media-library/assets/documents/4069>
- Federal Emergency Management Agency (FEMA). (2008). *Design and construction guidance for breakaway walls: Below elevated buildings located in coastal high hazard areas in accordance with the National Flood Insurance Program* (Technical Bulletin 9). Retrieved from: <https://www.fema.gov/media-library/assets/documents/3514>
- Federal Emergency Management Agency (FEMA). (2008). *Engineering principles and practices: For retrofitting flood-prone residential structures, third edition* (FEMA P-259). Retrieved from: <https://www.fema.gov/media-library/assets/documents/3001>
- Federal Emergency Management Agency (FEMA). (2009) *Protecting manufactured homes from floods and other hazards* (FEMA P-85). FEMA. Retrieved from: <https://www.fema.gov/media-library/assets/documents/2574>
- Federal Emergency Management Agency (FEMA). (2010). *Home builder's guide to coastal construction: Technical fact sheet series* (FEMA P-499). Retrieved from: <https://www.fema.gov/media-library/assets/documents/6131>
- Federal Emergency Management Agency (FEMA). (2010). *Multi-hazard loss estimation methodology: Flood model* (Hazard-MH MR5: Technical Manual). Department of Homeland Security/FEMA. Retrieved from: <https://www.hsdl.org/?view&did=12771>
- Federal Emergency Management Agency (FEMA). (2018) *Lowest floor guide*. Retrieved from: https://www.fema.gov/media-library-data/1523307311381-4cf9726b2eb04c3471a3e9d37a58fa6a/07_lowest_floor_guide_508_apr2018.pdf
- Federal Emergency Management Agency (FEMA). (2019). *User's guide to technical bulletins: Developed in accordance with the National Flood Insurance Program* (NFIP Technical Bulletin 0). FEMA. Retrieved from: <https://www.fema.gov/nfip-technical-bulletins>
- Federal Emergency Management Agency (FEMA). (2011). *Coastal construction manual* (FEMA P-55). FEMA.
- Federal Emergency Management Agency (FEMA). (2019). *FIMA NFIP redacted claims data set*. FEMA. Retrieved from: <https://www.fema.gov/media-library/assets/documents/180374>
- Florida Building Commission. (2000). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Building Commission. (2004). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Building Commission. (2007). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Building Commission. (2010). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Building Commission. (2014). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Building Commission. (2017). Florida building code. Tallahassee, FL: Florida Building Commission.
- Florida Division of Emergency Management. (2017). *Floodplain management in Florida: Quick Guide*. Tallahassee, Florida: Bureau of Mitigation. Retrieved from:

<https://www.floridadisaster.org/contentassets/5a671dfdfadf45ab9a2c61635e2a4fed/quick-guide-for-floodplain-management.pdf>

- Florida Division of Emergency Management. (2018). *Florida's CRS-CAV pilot program*. Tallahassee, FL: Florida Division of Emergency Management. Retrieved from: <https://www.floridadisaster.org/dem/mitigation/floodplain/communityresources/>
- Friedland, C.J., & Levitan, M.L. (2009). Loss-consistent categorization of hurricane wind and storm surge damage for residential structures. *Proceedings of the 11th Americas Conference on Wind Engineering*. San Juan, Puerto Rico. Retrieved from <http://www.iawe.org/Proceedings/11ACWE/11ACWE-Friedland.pdf>
- Frimpong, E., Petrolino, D.R., Harri, A., & Cartwright, J.H. (2019). *Flood insurance and claims: The impact of the Community Rating System* (Working Paper Number 19-1). Mississippi State University.
- Fritz, H.M., Blount, C., Sokoloski, R., Singleton, J., Fuggle, A., McAdoo, B.G., Moore, A., Grass, C., & Tate, B. (2007). Hurricane Katrina storm surge distribution and field observations on the Mississippi Barrier Islands. *Estuarine, Coastal, and Shelf Science* 74. 12-20. Doi: 10.1016/j.ecss.2007.03.015
- Genovese, E., Hallegatte, S., & Dumas, P. (2011) Damage assessment from storm surge to coastal cities: Lessons from the Miami area. In S. Geertman et al. (Eds.), *Advancing Geoinformation Science of a Changing World* (pp 21-43). Utrecht, Netherlands: Springer-Verlag Berlin Heidelberg. Doi: 10.1007/978-3-642-19789-5
- Gordon, A.M., & McFarlane, B.J. (2019). *Developing first floor elevation data for coastal resilience planning in Hampton roads*. Chesapeake, Virginia: Hampton Roads Planning District Commission. Retrieved from: https://www.hrpdcva.gov/uploads/docs/07A_Attachment_Developing_First_Floor_Elevation_Data_for_Coastal_Resilience_Planning_in_Hampton_Roads_HRPDC.pdf
- Hatzikyriakou, A., & Lin, N. (2017). Simulation storm surge waves for structural vulnerability estimation and flood hazard mapping. *Natural Hazards* 89, 939-962. doi: 10.1007/s11069-017-3001-5
- Hallegatte, S., Ranger, N., Mestre, O., Dumas, P., Corfee-Morlat, J., Herweijer, C. & Wood, R.M. (2011). Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen. *Climatic Change*, 104 (1), 113-137. doi: 10.1007/s10584-010-9978-3
- Herbert, D.M., Gardner, D.R., Harbottle, M., & Hughes, T.G. (2012). The strength of masonry walls when subject to flood loading. *15th International Brick and Block Masonry Conference*. Florianopolis, Brazil: UFSC.
- Ho, F.P., Su, J.C., Hanevich, K.L., Smith, R.J., & Richards, F.P. (1987). *Hurricane climatology for the Atlantic and Gulf Coasts of the United States*. FEMA. Retrieved from https://coast.noaa.gov/hes/images/pdf/ATL_GULF_HURR_CLIMATOLOGY.pdf
- Hom-ma, M., & Horikawa, K. (1965). Wave forces against sea wall. In *Coastal Engineering 1964* (pp. 490-503).
- Huang, G., He, H., Mehta, K.C., & Liu, X. (2015). Data-based probabilistic damage estimation for asphalt shingle roofing. *Journal of Structural Engineering*, 141(12). doi:10.1061/(ASCE)ST.1943-541X.0001300
- Hudson, P., Botzen, W.J.W., & Aerts, J.C.J.H. (2019). *Flood insurance arrangements in the European Union for future flood risk under climate and socioeconomic change*. Philadelphia, Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2019/05/WP201901_Flood-Insurance-Arrangements-in-the-EU.pdf

- Huizinga, J., de Moel, H., & Szewczyk, W. (2017). *Global flood depth-damage functions: Methodology and the database with guidelines* (Joint Research Centre Technical Report). European Commission, Luxembourg. Doi: 10.2760/16510
- Jones, C.P., & Krecic, M.R. (2011). Coastal flood and erosion damage functions for mid- and high-rise buildings. In *Solutions to Coastal Disasters 2011* (pp. 678-689). ASCE.
- Kelman, I. (2002). *Physical flood vulnerability of residential properties in coastal, eastern England*. Cambridge, UK: University of Cambridge.
- Kelman, I., & Spence, R. (2003). A limit analysis of unreinforced masonry failing under flood water pressures. *Masonry International*, 16(2), 51-61.
- Kousky, C., & Michel-Kerjan, E. (2015). Examining flood insurance claims in the United States: Six key findings. *The Journal of Risk and Insurance*, 84(3). doi: 10.1111/jori.12106
- Li, Y., & Ellingwood, B.R. (2006). Hurricane damage to residential construction in the US: Importance of uncertainty modeling in risk assessment. *Engineering Structures*, 28, 1009-1018. doi:10.1016/j.engstruct.2005.11.005
- Li, Y., van de Lindt, J.W., Dao, T., Bjarnadottir, S., & Ahuja, A. (2012). Loss analysis for combined wind and surge in hurricanes. *Natural Hazards Review*, 13(1). doi: 10.1061/(ASCE)NH.1527-6996.0000058
- Lopeman, M. (2015). *Extreme storm surge hazard estimation and windstorm vulnerability assessment for quantitative risk analysis*. New York City, New York: Columbia University. Retrieved from: <https://academiccommons.columbia.edu/doi/10.7916/D8BC3XNR>
- Marshall, T., & Haag, P.E. (2014). Storm surge damage to buildings. *30th Conference on Hurricanes and Tropical Meteorology*. Pont Vedra, Florida.
- Masoomi, H., van de Lindt, J.W., Ameri, M.R., Do, T.Q., & Webb, B.M. (2019). Combined wind-wave-surge hurricane-induced damage prediction for buildings. *Journal of Structural Engineering*, 145(1). doi: 10.1061/(ASCE)ST.1943-541X.0002241
- McGee, B.D., Tollett, R.W., & Goree, B.B. (2007). Monitoring Hurricane Rita inland storm surge. In Farris, G.S., Smith, G.J., Crane, M.P., Demas, C.R., Robbins, L.L., & Lavoie, D.L. (eds.) *Science and the Storms – The USGS Response to the Hurricanes of 2005* (pp. 257-263). US Geological Survey. Retrieved from: <https://pubs.usgs.gov/circ/1306/index.html>
- Merz, B., Thieken, A.H. (2009). Flood risk curves and uncertainty bounds. *Natural Hazards*, 51(3), 437-458. doi: 10.1007/s11069-009-9452-6
- Michalski, J. (2016). *Building exposure study in the state of Florida and application to the Florida Public Hurricane Loss Model*. Melbourne, Florida: Florida Institute of Technology.
- Middelmann-Fernandes, M.H. (2010). Flood damage estimation beyond stage-demand functions; an Australian example. *Journal of Flood Risk Management*, 3, 88-96. doi: 10.1111/j.1753-318X.2009.01058.x
- Missouri Department of Public Safety Emergency Management. (2019). *2019 state of Missouri flood damage assessment packet*. Missouri Emergency Management. Retrieved from: <https://www.floods.org/ace-images/2019FloodDamageAssessmentPacket.pdf>
- Nadal, N.C., Zapata, R.E., P Pagán, I., López, R., & Agudelo, J. (2010). Building damage due to riverine and coastal floods. *Journal of Water Resources Planning and Management*, 136(3). doi: 10.1061/(ASCE)WR.1943-5452.0000036
- Nasiri, H., Yusof, M.J.M., Ali, T.A.M. (2016). An overview to flood vulnerability assessment methods. *Sustainable Water Resource Management*, 2, 331-336. doi: 10.1007/s40899-016-0051-x

- Park, S., van de Lindt, J.W., & Li, Y. (2012). ABV procedure combined with mechanistic response modeling for roof- and surge-loss estimation in hurricanes. *Journal of Performance of Constructed Facilities*, 28(2). doi: 10.1061/(ASCE)CF.1943-5509.0000397
- Porter, K.A., Kiremidjian, A.S., & LeGrue, J. (2001). Assembly-based vulnerability of buildings and its use in performance evaluation. *Earthquake Spectra*, 17(2). doi: 10.1193/1.1586176
- Prevatt, D.O., Gurley, K.R., Roueche, D.B., & Wong-Parodi, G. (2018). *Survey and investigation of buildings damaged by Category II, III, IV, and V hurricanes in FY 2017-2018 – Hurricane Irma 2017* (Report No.06-18). Tallahassee, Florida: Florida Department of Business and Professional Regulation. Retrieved from: http://www.floridabuilding.org/fbc/publications/PrevattUF_FBC_2017_2018_FinalReport-Irma.pdf
- Roos, I.W. (2003). *Damage to Buildings (DCI-233-9)*. Delft, Netherlands: Delft Cluster.
- Smith, C.S., & Scyphers, S. (2019). Past hurricane damage and flood zone outweigh shoreline hardening for predicting residential-scale impacts of Hurricane Matthew. *Environmental Science and Policy*, 101. 46-53. doi: 10.1016/j.envsci.2019.07.009
- Smith, D.I. (1994). Flood damage estimation – A review of urban stage-damage curves and loss functions. *Water SA*, 20(3), 231-238. Retrieved from: https://hdl.handle.net/10520/AJA03784738_1124
- Suppasri, A., Pakoksung, K., Charvet, I., Chua, C.T., Takahashi, N., Ornthammarath, T., Latcharote, P., Leelewat, N., & Imamura, F. (2019). Load-resistance analysis: An alternative approach to tsunami damage assessment applied to the 2011 Great East Japan tsunami. *Natural Hazards and Earth System Sciences*, 19, 1807-1822. doi: 10.5194/nhess-19-1807-2019
- The Heinz Center (2000) Evaluation of erosion hazards. FEMA/The Heinz Center. Retrieved from: <https://www.fema.gov/pdf/library/erosion.pdf>
- Tomiczek, T., Kennedy, A., & Rogers, S. (2014). Collapse limit state fragilities of wood-framed residences from storm surge and waves during Hurricane Ike. *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 140(1). doi: 10.1061/(ASCE)WW.1943-5460.0000212
- Tonn, G., & Czajkowski, J. (2018). *An analysis of U.S. tropical cyclone flood insurance claim losses: Storm surge vs. freshwater*. Philadelphia, Pennsylvania: Wharton of the University of Pennsylvania. Retrieved from: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2018/12/WP2018-12_Cyclone-Flood-Claims_TonnCzajkowski.pdf
- Turnipseed, D.P., Van Wilson, K., Stoker, J., & Tyler, D. (2007). Mapping Hurricane Katrina peak surge in Alabama, Mississippi, and Louisiana. *Proceedings of the 37th Annual Mississippi Water Resources Conference*. Jackson, Mississippi: Water Resources Research Institute, Mississippi State University.
- Unanwa, C.O., McDonald, J.R., Mehta, K.C., & Smith, D.A. (2000). The development of wind damage bands for buildings. *Journal of Wind Engineering and Industrial Aerodynamics*, 84, 119-149. doi:10.1016/S0167-6105(99)00047-1
- US Army Corps of Engineers (USACE). (2005). *Local flood proofing programs*. USACE.
- US Army Corps of Engineers (USACE). (2006). *Depth-damage relationships for structures, contents, and vehicles and content-to-structure value ratios (CSVr) in support of the Donaldsonville to the Gulf, Louisiana, feasibility study*. New Orleans: USACE. Retrieved from: <https://www.mvn.usace.army.mil/Portals/56/docs/PD/Donaldsv-Gulf.pdf>
- US Army Corps of Engineers (USACE) (2015). *North Atlantic coast comprehensive study: Resilient adaptation to increasing risk (Physical depth damage function summary report)*. USACE.

- Wagenaar, D.J., de Bruijn, K.M., Bouwer, L.M., & de Moel, H. (2016). Uncertainty in flood damage estimates and its potential effect on investment decisions. *Natural Hazards and Earth System Sciences*, 16, 1-14. doi: 10.5194/nhess-16-1-2016
- Walton, T.L., Ahrens, J.P., Truitt, C.L., & Dean, R.G. (1989). *Criteria for evaluating coastal flood-protection structures* (CERC-89-15). USACE.
- Wang, H.V., Loftis, J.D., Liu, Z., Forrest, D., & Zhang, J. (2014). The storm surge and sub-grid inundation modeling in New York City during Hurricane Sandy. *Journal of Marine Science and Engineering*, 2, 226-246. doi: 10.3390/jmse2010226
- Westrik, L. (n.d.) Building strength and flood fatalities (Technical Report CIE4040-09). Delft, Netherlands: Delft University of Technology.
- Wing, O.E.J., Pinter, N., Bates, P.D., & Kousky, C. (2020). New insights into US flood vulnerability revealed from flood insurance big data. *Nature Communications*, 11 (1444). doi: 10.1038/s41467-020-15264-2
- Yokel, F.Y., Yancey, C.W.C., & Mullen, C.L. (1981). *A study of reaction forces on mobile home foundations caused by wind and flood loads* (NBS Building Science Series 132). FEMA.

Actuarial

- Ahmadi, N., & Shahandashti, S. (2018). Role of predisaster construction market conditions in influencing postdisaster demand surge. *Natural Hazards Review*, 19(3). doi:10.1061/(ASCE)NH.1527-6996.0000296
- Altmaier, D., Case, A., Chaney, M., Dolese, N., Donelon, J.J., Farmer, R.G., ... & Travis, T. (2017). *CIPR Study: Flood risk and Insurance*. National Association of Insurance Commissioners. Kansas City, Missouri. Retrieved from: http://www.naic.org/cipr_special_reports.htm
- Bahnemann, D. (2015). *Distributions for actuaries*. Arlington, VA: Casualty Actuarial Society.
- Döhrmann, D., Gürtler, M., & Hibbeln, M. (2013). *Insured loss inflation: How natural catastrophes affect reconstruction costs*. doi:10.2139/ssrn.2222041
- Hallegatte, S., Schlumberger, M.-E., Boissonnade, A., & Muir-Wood, R. (2018). *Demand surge and worker migrations in disaster aftermaths: application to Florida in 2004 and 2005*.
- Hogg, R.V., & Klugman, S.A. (1984). *Loss Distributions*. New York: John Wiley & Sons.
- Mitchell, K., Jones, M., Hiller, J., & Foote, M. (2017). *Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide*. Hoboken: John Wiley & Sons.
- Munich Re. (2006). *The 1906 earthquake and Hurricane Katrina: Similarities and differences - Implications for the insurance industry*. Munich Re.
- Olsen, A., & Porter, K. (2011). What we know about demand surge: Brief summary. *Natural Hazards Review*, 12(2). doi:10.1061/(ASCE)NH.1527-6996.0000028
- Pielke R., Landsea, C.W., Gratz, J., Collins, D., Saunders, M.A., Musulin, R. (2008). Normalized hurricane damage in the United States: 1900-2005. *Natural Hazards Review* 9(1), 29-42. doi: 10.1061/(ASCE)1527-6988(2008)9:1(29)

Computer Information Standards

- Clements, P., Bachmann, F., Bass, L., Garlan, D., Ivers, J., Little, R., . . . Stafford, J. (2011). *Documenting software architecture* (2nd ed.). New York: Pearson.

International Organization for Standardization (1985). Information processing – Documentation symbols and conventions for data, program and system flowcharts, program network charts and system resources charts (1st ed.). *ISO 5807*.

5. ***Provide a list and description of any potential interim updates to underlying data relied upon by the flood model. State whether the time interval for the update has a possibility of occurring during the period of time the flood model could be found acceptable by the Commission under the review cycle in this Flood Standards Report of Activities.***

No interim updates are anticipated to the KCC US Flood Reference Model.

6. ***Identify and describe the modeling-organization-specified, predetermined, and comprehensive exposure dataset used for projecting personal residential flood loss costs and flood probable maximum loss levels.***

To project personal residential flood loss costs and flood probable maximum loss (PML) levels, the developed Flood Insured Database was used. This database of properties has been developed using a variety of sources including data from third party vendors, tax appraiser data, HAZUS publications, construction cost manuals, FIMA NFIP Redacted Policies Dataset, and US census data for location-level personal residential flood loss costs and flood probable maximum losses.

GF-2 Qualifications of Modeling Organization Personnel and Consultants Engaged in Development of the Flood Model

- A. *Flood model construction, testing, and evaluation shall be performed by modeling organization personnel or consultants who possess the necessary skills, formal education, and experience to develop the relevant components for flood loss projection methodologies.***

The KCC US Flood Reference Model was developed and verified by professionals who possess the requisite experience and formal education. Further information about the qualifications of individuals involved in the development, testing, and evaluation of the KCC US Flood Reference Model can be found in Standard G-2, Disclosure 2.

KCC professionals possess a wide range of skills and expertise in fields including meteorology, hydrology, hydraulics, engineering, computer science, and statistics honed through experience and education. All model developers possess advanced degrees, and the majority hold PhDs in their fields. At each stage of model development, these experts evaluated and tested the model for accuracy and reliability using accepted methodologies and rigorous standards appropriate to their respective disciplines.

- B. *The flood model and flood model submission documentation shall be reviewed by modeling organization personnel or consultants in the following professional disciplines with requisite experience: hydrology and hydraulics (advanced degree or licensed Professional Engineer(s) with experience in coastal and inland flooding), meteorology (advanced degree), statistics (advanced degree), structural engineering (licensed Professional Engineer(s) with experience in coastal and inland flooding), actuarial science (Associate or Fellow of Casualty Actuarial Society or Society of Actuaries), and computer/information science (advanced degree or equivalent experience and certifications). These individuals shall certify Expert Certification Forms GF-1 through GF-7 as applicable.***

The KCC US Flood Reference Model and associated documentation have been thoroughly reviewed by individuals holding the above-mentioned qualifications and are detailed further in Standard G-2, Disclosure 2.

Disclosures

1. Organization Background

- A. *Describe the ownership structure of the modeling organization engaged in the development of the flood model. Describe affiliations with other companies and the nature of the relationship, if any. Indicate if the organization has changed its name and explain the circumstances.***

KCC is a privately held firm with no external affiliations and has not changed its name.

- B. *If the flood model is developed by an entity other than the modeling organization, describe its organizational structure and indicate how proprietary rights and control over the flood model and its components are exercised. If more than one entity is involved in the development of the flood model, describe all involved.***

KCC developed the KCC US Flood Reference Model without an external entity and holds all proprietary rights and control over the model.

- C. *If the flood model is developed by an entity other than the modeling organization, describe the funding source for the development of the flood model.***

KCC funded the development and implementation of the model.

D. Describe any services other than flood modeling provided by the modeling organization.

KCC professionals are globally recognized experts in catastrophe risk assessment and management with extensive experience in all types of natural perils, including earthquakes, windstorms, and floods. KCC provides consulting services and licenses software to the insurance industry.

KCC consultants conduct comprehensive reviews of the models and modeling processes for the world's largest (re)insurers and US primary insurers. Other consulting services include M&A due diligence, peer company analyses, and executive briefings.

The KCC suite of models currently includes **US hurricane, storm surge, severe convective storm (SCS), earthquake, Caribbean hurricane and earthquake, Japan tropical cyclone and earthquake, European windstorm, Australia tropical cyclone, and New Zealand earthquake.** KCC clients can access these models on a service basis or by licensing the models as part of the RiskInsight® loss modeling platform. KCC models are licensed on an ongoing basis by top 10 US P&C insurers, Florida domestic insurers, and global insurers, reinsurers, and ILS funds.

E. Indicate if the modeling organization has ever been involved directly in litigation or challenged by a governmental authority where the credibility of one of its U.S. flood model versions for projection of flood loss costs or flood probable maximum loss levels was disputed. Describe the nature of each case and its conclusion.

KCC has not been involved in litigation or challenged by a government authority regarding loss cost or probable maximum loss projections for a US flood model.

2. Professional Credentials

A. Provide in a tabular format (a) the highest degree obtained (discipline and university), (b) employment or consultant status and tenure in years, and (c) relevant experience and responsibilities of individuals currently involved in the acceptability process or in any of the following aspects of the flood model:

1. Meteorology

2. Hydrology and Hydraulics

3. Statistics

4. Vulnerability

5. Actuarial Science

6. Computer/Information Science

Credentials of KCC professionals involved in the KCC US Flood Reference Model development are shown in the following table. All are employees of KCC with the exception of Dr. James Michael Grayson who completed an external peer review on the vulnerability components of the model.

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
Statistics	Kioumars Afshari	Ph.D. Geotechnical Engineering University of California, Los Angeles	Senior Engineer / 2	<p>Dr. Afshari earned a Ph.D. in Geotechnical Earthquake Engineering with additional coursework in Statistics and Structural Engineering. Dr. Afshari has published research papers on subjects that utilize nonlinear mixed-effects regression, data cleaning, and probabilistic hazard analyses pertaining to ground motion. In addition to his research on ground motion, he has completed the coursework requirement for M.Sc. degree in statistics as a part of his Ph.D.</p> <p>Dr. Afshari’s contributions to the KCC US Flood Reference Model include peer reviewing the probabilistic components of model.</p>
Computer/ Information	Vivek Basrur	M.S. Management Sciences University of Waterloo	KCC Co-Founder/ 12	<p>Mr. Basrur has over 40 years of experience in software design and development. He architected and designed KCC’s RiskInsight® loss modeling platform, which provides advanced exposure management and analytical tools to US and global insurers, reinsurers, and ILS investors. RiskInsight® functionality includes high-resolution global mapping, interactive exposure and loss dashboards, Characteristic Events (CEs), and real-time hurricane tracking along with the traditional Exceedance Probability (EP) curve risk metrics. Prior to co-founding KCC in 2007, Mr. Basrur was the Executive Vice President and Director of Software Development at AIR Worldwide from 1993-2007, where he led the development of AIR’s catastrophe modeling software applications. Before Mr. Basrur’s long career in catastrophe modeling, he was co-founder and Vice President for Software Development of FormWorx Corporation and the principal of an investment consulting practice at Resource Planning Associates. Mr. Basrur received graduate education at the University of Waterloo, Massachusetts Institute of Technology, and Harvard University, and he earned his Civil Engineering undergraduate degree from the Indian Institute of Technology.</p> <p>Mr. Basrur’s contributions to the KCC US Flood Reference Model include overall management of RiskInsight® development and the implementation of the flood model components.</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
Hydrology and Hydraulics, Computer/ Information	Christopher Burke	Ph.D. Physics Tufts University	Senior Research Scientist / 1	<p>Dr. Burke has extensive experience in computational analytics and working with large datasets. As a postdoctoral researcher, he developed and implemented techniques to computationally reconstruct and analyze the geometry of nanoscopic polymer networks and a physics algorithm to simulate block copolymers with orientational interactions. Dr. Burke has developed and co-taught computational physics and is well-versed in numerical simulation techniques.</p> <p>Dr. Burke has worked on the development of several KCC models, including the Severe Convective Storm and European Windstorm models.</p> <p>His contributions to the KCC US Flood Reference Model include developing and optimizing the event footprint generation methodology and computer code.</p>
General	Karen Clark	M.B.A. M.A. Economics Boston University	CEO and President / 12	<p>Karen Clark is a leading global authority on catastrophe risk assessment and management. Ms. Clark developed the first hurricane model and founded the first catastrophe modeling company, AIR, which she grew to cover all the major natural perils in over 50 countries as well as terrorism in the US.</p> <p>The probabilistic catastrophe modeling techniques and innovative technologies that Ms. Clark pioneered revolutionized the way insurers, reinsurers, and other financial institutions assess and manage their catastrophe risk.</p> <p>Ms. Clark is now leading the KCC team in the development of new scientific models that are transparent to the user and provide additional risk metrics for decision makers. She is also leading the development of RiskInsight, an advanced and open loss modeling platform.</p> <p>Ms. Clark reviewed and visually inspected the major components of the KCC US Flood Reference Model.</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
Computer/ Information	Adrian Corman	Ph.D. Physics University of Missouri	Senior Software Developer / 1	<p>Dr. Corman has eight years of professional programming experience and a strong analytical background. Prior to joining KCC, Dr. Corman was a programmer analyst where he streamlined company processes, maintained SQL databases, created backend and frontend software, and developed stored procedures to increase efficiency. During his graduate research, he used advanced statistical techniques to identify correlations in data and developed software to convert raw data into an appropriate input for computer simulations. His contributions to the KCC US Flood Reference Model include work on the footprint generation module, such as coding the algorithm used for riverine flooding.</p>
Vulnerability, Computer/ Information	Glen Daraskevich	M.S. Engineering and Information Systems Boston University	Senior Vice President / 11	<p>Mr. Daraskevich has extensive experience in catastrophe modeling, pricing, and risk management. As the head of KCC's consulting practice, Mr. Daraskevich has conducted comprehensive reviews of catastrophe models and catastrophe modeling processes for regional, national, and global insurers. These reviews have entailed detailed model evaluations, peer review studies, and M&A due diligence. Prior to joining KCC, he was the Vice President of the Research and Modeling team at AIR for six years, where he led the development of several of the company's key catastrophe models. He has also directed several post-event damage surveys following hurricanes in 2004, 2005, and 2008.</p> <p>Mr. Daraskevich's contributions to the KCC Flood Reference Model include design of the exposure import and loss results software components, quality assurance, and testing.</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
Computer/ Information	Adam Dimanshteyn	B.A. Economics and Mathematics Boston University	Risk Analyst / 2	<p>Mr. Dimanshteyn has had an ongoing role in constructing and maintaining databases of client exposure data, testing the functionality of new software and model features, and using RiskInsight® to generate loss and exposure metrics and exhibits for various clients. Prior to joining KCC, he worked on predictive modeling which sought to identify patterns in equity data with a hedge fund and created research summaries and business plans with a local product development firm.</p> <p>Mr. Dimanshteyn’s contributions to the KCC US Flood Reference Model include assisting with the construction of databases used to produce the Actuarial and Statistical exhibits and conducting various tests to validate the model output.</p>
Computer/ Information	Grant Elgin	Computer Science	Senior Software Engineer / 7	<p>Mr. Elgin is a self-taught software engineer and an integral member of the KCC software development team. He has taken academic and professional courses in discrete mathematics, Java, data structures, computer architecture, data structures and algorithms, computer networks, operating systems, dynamic web applications, C#, and software design and defensive programming techniques.</p> <p>Mr. Elgin has worked extensively on the RiskInsight® loss modeling platform including developing HazardMapper® for generating the intensity footprints, the interactive map engine for displaying the event footprints, and the Analysis Server Cluster.</p> <p>His contributions to the KCC US Flood Reference Model include extending the RiskInsight® platform to support the unique attributes of the high-resolution event footprints as well as the specialized damage functions to properly capture the community-based vulnerability requirements.</p>
Computer/ Information	Arnold Fernandes	M.A. Earth Sciences Boston University M.S. Geology University of Mumbai	Assistant Research Scientist / 2	<p>Mr. Fernandes has worked on projects and published research focusing on the impact of hurricanes and storm surge on coastal forests. His experience also encompasses earthquakes and earth science systems. Additionally, he has completed risk assessments for hurricane landfall scenarios and sea level rise along the east coast. His coursework included geology, natural hazards, GIS, and statistical modelling.</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
				<p>Mr. Fernandes is responsible for researching and analyzing location specific data and developing the KCC industry property databases by country.</p> <p>Mr. Fernandes’s contributions to the KCC US Flood Reference Model include geospatial analyses, developing the insured property database, and preparing the loss validation data.</p>
Vulnerability	James Michael Grayson	Ph.D., P.E. Civil Engineering Clemson University	Consultant / N.A.	<p>Dr. Grayson is the founder of Innovative Engineering and Education Services, LLC, and has 19 years of experience in hurricane wind and wind-borne debris impact risk modeling and in the light and heavy construction industries. In addition to being a licensed Professional Engineer (P.E.), he has published engineering papers in peer reviewed journals and presented engineering research at conferences.</p> <p>His contributions to the KCC US Flood Reference Model include providing an external peer review of the Vulnerability Module.</p>
Statistics	Natalia Gust-Bardon	M.S. Statistics and Data Science University of Texas at San Antonio Ph.D., Economics, University of Szczecin	Research Statistician / <1	<p>Dr. Gust-Bardon has a background in statistical analysis and research methods. She has experience in supervised machine learning, generalized additive models, discrete choice models, time series modeling, and distribution fitting.</p> <p>Her contributions to the KCC US Flood Reference Model include refining the statistical components of the model and conducting sensitivity and uncertainty analyses.</p>
Meteorology, Vulnerability	Filmon Habte	Ph.D. Structural/Wind Engineering Florida International University	Senior Wind Engineer / 4	<p>Dr. Habte is an expert in the area of hurricane impacts on structures. During his education, he conducted several experiments using the Wall of Wind to test building components against known wind speeds to identify failure modes. He has published a number of papers and given conference presentations on his research. Dr. Habte has experience conducting statistical and structural analyses to evaluate building vulnerability to different perils, including inland and coastal flooding.</p> <p>Dr. Habte has led the development of several KCC models, including Caribbean Hurricane and Japan Typhoon. He led the development of the vulnerability functions for the KCC US Hurricane</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
				<p>Model, and he has conducted post-disaster surveys for Hurricanes Maria (2017), Irma (2017), Matthew (2016), and Michael (2018).</p> <p>Dr. Habte's contributions to the KCC US Flood Reference Model include developing the vulnerability functions and internally peer reviewing the storm surge Intensity Module.</p>
General, Statistics, Vulnerability	Nozar Kishi	Ph.D. M.S. Structural Engineering University of Kyoto	Vice President of Model Development / 4	<p>Dr. Kishi has 25 years of catastrophe modeling experience and has been an engineer on staff at EQECAT (now CoreLogic), RMS, and AIR, and was the Chief Research Scientist at Flagstone Re from 2006 to 2010. In addition to developing vulnerability functions for hurricanes, earthquakes, floods, and wild fires, he has conducted extensive post-event reconnaissance surveys including for Hurricanes Bonnie (1998), Isabel (2003), Ivan (2004), Matthew (2016), Harvey (2017), Irma (2017), and Typhoons Paka (1997), and Chaba (2004).</p> <p>Dr. Kishi's contributions to the KCC US Flood Reference Model include developing the vulnerability functions and peer reviewing the probabilistic components of the model.</p>
General	Katelynn Larson	B.A. English/ Communications Massachusetts College of Liberal Arts	Senior Technical Writer / 3	<p>Ms. Larson has previously worked in academic and community settings as a tutor for written and spoken English and developed employee manuals for a nonprofit as part of her responsibilities. Since joining KCC, she has worked on multiple technical documents, including documentation for the KCC US Earthquake and Severe Convective Storm Reference Models, white papers, and software user guides.</p> <p>Her contributions to this submission include reviewing the submission document for grammatical and spelling errors, monitoring the development and compilation of the document, and ensuring that the document is formatted according to FCHLPM specifications.</p>
Computer/ Information	Linshou Li	M.S. Information Technology Worcester Polytechnic Institute	Software Engineer / 2	<p>Mr. Li has developed numerous web-based tools, built relational and NoSQL databases, and used analytics to improve system effectiveness.</p> <p>Mr. Li's contributions to the KCC US Flood Reference Model include the development of the OEF Importer UI, the Model Manager UI, and contributions to the Map Tile Server for generating</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
				high performance, high resolution maps of flood events.
Computer/ Information	Marshall Pagano	B.A. Mathematics and Quantitative Economics Tufts University	Senior Risk Analyst / 4	<p>Mr. Pagano has extensive experience in working with insurer exposure data and catastrophe loss analytics. Mr. Pagano is an expert on the RiskInsight® loss modeling platform and has used the software to perform loss analyses for major insurers, to conduct detailed claims analyses, and to provide insurers with estimates of claims and losses as catastrophe events are unfolding. Prior to joining KCC, he conducted data analyses and developed predictive models for political polls.</p> <p>Mr. Pagano's contributions to the KCC US Flood Reference Model include designing and documenting the KCC database schema, designing and documenting quality assurance tests, managing the testing process, and working with client exposure and claims data.</p>
Meteorology, Statistics,	Daniel Ward	Ph.D. Atmospheric Science Colorado State University	Senior Meteorologist / 3	<p>Dr. Ward's doctoral research encompassed developing numerical weather and climate models as well as field-based research. Dr. Ward participated in the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report as a Contributing Author and collaborated with scientists at the National Center for Atmospheric Research on global earth systems modeling. His published research includes aerosol dispersal and the effects of land use change on carbon cycle feedbacks and global climate forcing.</p> <p>Dr. Ward has worked on the development of the KCC US Hurricane and Severe Convective Storm models and is responsible for KCC's daily and weekly severe weather outlooks.</p> <p>Dr. Ward's contributions to the KCC US Flood Reference Model include generating the historical and stochastic catalogs and the event intensity footprints.</p>
Statistical, Actuarial	Joanne Yammine	B.S. Mathematics Université de Montréal	Director of Actuarial Services / 2	<p>Ms. Yammine has ten years of actuarial experience and is a Fellow of the Casualty Actuarial Society. She is responsible for leading client consulting engagements. Prior to joining KCC, Ms. Yammine was Actuarial Manager of Canada pricing and reserving for Esurance. She has also worked for TD Insurance as an Actuarial and Senior Actuarial Analyst for rating and classification and as an</p>

Standard(s)	Individual	A. Degree, University, Discipline	B. KCC Status / Tenure (years)	C. Experience and Responsibilities
				<p>Actuarial Analyst for The Economical Insurance Group.</p> <p>Ms. Yammine’s contributions to the KCC US Flood Reference Model include reviewing the statistical components of the Event Catalog Module and the actuarial components of the Financial Module.</p>
Hydrology and Hydraulics	Yuanhao Zhao	<p>Ph.D. Hydrology Northeastern University</p> <p>M.S. Water Resources Engineering Marquette University</p>	Senior Hydrologist / 1	<p>Dr. Zhao has conducted extensive research in the areas of surface runoff, the effects of climate change on coastal watersheds, and hydrologic and hydraulic models. In conjunction with his Ph.D. in Hydrology and M.S. in Water Resources Engineering, Dr. Zhao has completed courses in Urban Hydraulic Design, Advanced River Engineering, and Hydraulic Modeling. Prior to joining KCC, he increased the computation efficiency of hydrologic model simulations and investigated the effects of different model scales. He also developed a hydrological simulation of surface and subsurface processes for the Ohio River Basin.</p> <p>Dr. Zhao’s contributions to the KCC US Flood Reference Model include developing and implementing the methodology for inland flood footprint generation.</p>

Table 1 - Credentials and tenure of individuals contributing to the KCC US Flood Reference Model

B. Provide visual business workflow documentation connecting all personnel related to flood model design, testing, execution, maintenance, and decision-making.

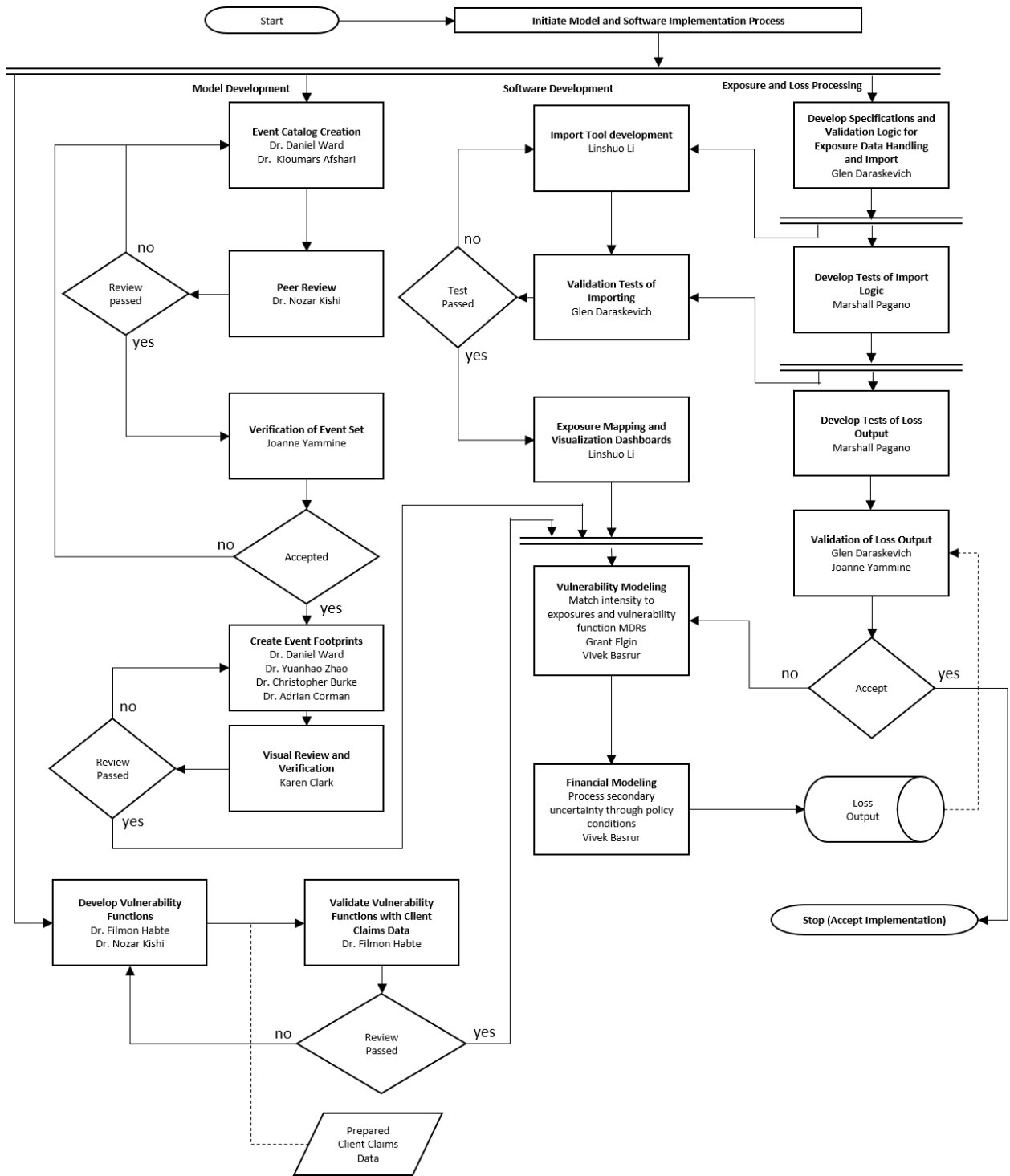


Figure 4 - KCC personnel involved in the development of the KCC US Flood Reference Model

3. Independent Peer Review

A. Provide reviewer names and dates of external independent peer reviews that have been performed on the following components as currently functioning in the flood model:

- 1. Meteorology**
- 2. Hydrology and Hydraulics**
- 3. Statistics**
- 4. Vulnerability**
- 5. Actuarial Science**
- 6. Computer/Information Science**

The KCC US Flood Reference Model Vulnerability Module was peer reviewed by Dr. James Michael Grayson on February 26, 2020.

B. Provide documentation of independent peer reviews directly relevant to the modeling organization responses to the flood standards, disclosures, or forms. Identify any unresolved or outstanding issues as a result of these reviews.

Documentation of independent peer reviews can be found in Appendix F. No unresolved or outstanding issues remain as a result of these reviews.

C. Describe the nature of any on-going or functional relationship the organization has with any of the persons performing the independent peer reviews.

KCC has no ongoing or functional relationship with independent peer reviewers.

4. Provide a list of rating agencies and insurance regulators that have reviewed the flood model. Include the dates and purpose of the reviews.

No rating agencies or insurance regulators have reviewed the flood model.

5. Provide a completed Form GF-1, General Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].

[Form GF-1: General Flood Standards Expert Certification](#)

6. Provide a completed Form GF-2, Meteorological Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].

[Form GF-2: Meteorological Flood Standards Expert Certification](#)

7. Provide a completed Form GF-3, Hydrological and Hydraulic Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].

[Form GF-3: Hydrological and Hydraulic Flood Standards Expert Certification](#)

8. Provide a completed Form GF-4, Statistical Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].

[Form GF-4: Statistical Flood Standards Expert Certification](#)

9. Provide a completed Form GF-5, Vulnerability Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].

[Form GF-5: Vulnerability Flood Standards Expert Certification](#)

10. ***Provide a completed Form GF-6, Actuarial Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].***

Form GF-6: Actuarial Flood Standards Expert Certification

11. ***Provide a completed Form GF-7, Computer/Information Flood Standards Expert Certification. Provide a link to the location of the form [insert hyperlink here].***

Form GF-7: Computer/Information Flood Standards Expert Certification

GF-3 Insured Exposure Location

- A. ZIP Codes used in the flood model shall not differ from the United States Postal Service publication date by more than 48 months at the date of submission of the flood model. ZIP Code information shall originate from the United States Postal Service.**

KCC uses United States Postal Service ZIP Code data that is post-processed by third-party vendors, including Zip-Codes.com and GreatData. The current KCC ZIP Code database is from September 2018.

- B. Horizontal location information used by the modeling organization shall be verified by the modeling organization for accuracy and timeliness and linked to the personal residential structure where available. The publication date of the horizontal location data shall be no more than 48 months prior to the date of submission of the flood model. The horizontal location information data source shall be documented and updated.**

Florida Department of Revenue's Tax data Parcel database (2018) is used for the horizontal location information. KCC's ZIP Code centroid data is obtained from GreatData's "US ZIP Codes Geo" dataset. The centroids are population-weighted and examined to ensure accuracy and that centroids are also constrained to be within the boundary of the respective ZIP Code. KCC confirms that these conditions are met through visual verification.

- C. If any hazard or any flood model vulnerability components are dependent on databases pertaining to location, the modeling organization shall maintain a logical process for ensuring these components are consistent with the horizontal location database updates.**

Spatial information on the local municipality boundaries and other information about FIRM dates and Flood Zones are used in the model vulnerability component and derived from the National Flood Hazard Layer (NFHL) database. KCC maintains a logical process for ensuring consistency and for updating these databases.

- D. Geocoding methodology shall be justified.**

The KCC geocoding methodology uses justified, industry-proven geocoding methods that are routinely quality-checked to ensure accuracy.

- E. Use and conversion of horizontal and vertical projections and datum references shall be consistent and justified.**

The vertical datum of National Geodetic Vertical Datum of 1929 (NGVD29) related to the water surface elevation from USGS gauge data is converted to North American Vertical Datum of 1988 (NAVD88), which is consistent with the vertical datum of the Digital Elevation Model data from USGS.

Disclosures

- 1. List the current location databases used by the flood model and the flood model components to which they relate. Provide the effective dates corresponding to the location databases.**

KCC uses two postal code databases: ZIP Code boundaries generated by Zip-Codes.com (September 2018) and ZIP Code population-weighted centroids acquired from GreatData (September 2018).

KCC also uses the Florida Department of Revenue's Tax database (2018) Parcel Data and the Federal Insurance & Mitigation Administration National Flood Insurance Program (FIMA NFIP) Redacted Policies Dataset (2020) to develop insured databases and TIGER/Line Shapefiles Database for horizontal location data.

The KCC US Flood Reference Model utilizes the NFIP's Community Rating System (CRS) to group communities into different vulnerability regions. These vulnerability regions capture the differences in

vulnerability that result from community flood management and mitigation measures. This information was used in conjunction with the information about political boundaries within the Flood Risk Project area as a part of the 2019 National Flood Hazard Layer (NFHL). Further details on the vulnerability region development is provided in Section VF-1 Disclosure 9.

2. Describe in detail how invalid ZIP Codes, parcels, addresses, and other location information are handled.

If, during the process of adding an address to KCC's exposure database, a ZIP Code or geocode is found to be invalid, the address is rejected. Users have the option to correct the data and then re-enter it into the KCC exposure database, such as by directly setting the latitude and longitude or entering a valid ZIP Code (an invalid ZIP Code will not be modeled).

3. Describe any methods used for subdividing or disaggregating the location input data and the treatment of any variations for populated versus unpopulated areas.

No disaggregation or subdivision of location input data is used because KCC utilizes parcel data.

4. Describe the data, methods, and process used in the flood model to convert between street addresses and geocode locations (latitude-longitude).

When a new address is imported into the exposure database, it is first checked to see if the address, and geocode, is already in the database. If not, the address goes through the USPS standardization process where it is sub-divided into its individual components which are then standardized one at a time (e.g., "Florida" standardizes to "FL," as would an error like "Florid," leading zeroes missing from a ZIP Code are added). If the address passes the standardization process, a geocode is requested from KCC's geocoder. The geocoder then converts the input address into a latitude-longitude pairing at the highest possible resolution (ideally street address, but, for example, if an exact match to the street number cannot be found, a centroid interpolated along the street segment containing that address may be returned). In the event that the standardization process cannot discern a valid street address, or the geocoder does not provide a geocode that is based on the full physical address, the address is assigned a population-weighted ZIP Code centroid geocode (from a database furnished by GreatData) based on the standardized ZIP Code.

5. Describe the use of geographic information systems (GIS) in the process of converting among street address and geocode locations, and the generation of insured exposure locations.

KCC scientists use an ensemble of GIS and Open Source tools to develop the insured exposure underlying the actuarial forms. KCC starts with the Florida Department of Revenue's Tax database (2018) Parcel Data and groups individual houses into clusters using US Census block boundary data and k-means algorithms. The Federal Insurance & Mitigation Administration National Flood Insurance Program (FIMA NFIP) Redacted Policies Dataset is used to estimate the insured properties by cluster and flood zone. The generation of insured exposure locations is performed using industry proven methods and is well documented.

6. List and provide a brief description of each database used in the flood model for determining geocode location.

Florida Department of Revenue's Tax database Parcel Data

The Florida Department of Revenue's Tax database Parcel Data contains the 2018 vintage parcel boundaries with each parcel's associated tax information from the Florida Department of Revenue's tax database. Attributes include occupancy, site street addresses, GIS boundaries, land use codes, valuation, building details, legal description, and more.

TIGER/Line Shapefiles

KCC uses the 2018 vintage of the TIGER/Line Shapefiles database, a core geographic product from the U.S. Census Bureau which include polygon boundaries of census related geographic areas and features, as well as linear features.

ZIP Code Boundaries

KCC obtains ZIP Code boundary data from Zip-Codes.com, which uses the United States Postal Service's ZIP Code database to construct polygons for postal ZIP Codes based on carrier route boundaries. These boundaries are used for the creation of thematic maps for aggregation of data such as insured values and losses. This feature affords users the ability to perform visual inspection at a variety of scales, including the ZIP Code-level.

ZIP Code Centroids

ZIP Code centroids are acquired from GreatData. The centroids are population-based (weighted), rather than geometric, and undergo a manual verification process at Great Data to ensure points do not fall in a lake, airport, forest, or similar. A visual inspection is performed by KCC to confirm the centroids are satisfactory prior to inclusion in the model. The geocoded centroids are used to estimate losses when address-level geocoding is not available.

7. Describe the process for updating flood model geocode locations as location databases are updated.

KCC routinely acquires updates to the ZIP Code databases from two third-party vendors: GreatData (for population-weighted centroid data) and Zip-Codes.com (for boundary data). KCC also regularly monitors updates to Florida Department of Revenue's Tax database Parcel Data. The standard operating procedure for updating ZIP Code databases is as follows:

1. Data acquired from provider(s)
2. ZIP Code data are subjected to quality assurance testing
 - a. ZIP Code boundaries are checked against previous vintages and the most recent US Census Bureau ZIP Code Tabulation Area (ZCTA) boundaries.
 - b. ZIP Code centroids are checked to ensure population-weighting was used by comparing against United States Census Block Group population data.
 - c. The Florida Department of Revenue's Tax database Parcel Data aggregate totals for Residential and Commercial Risks are validated against Census information.
3. If the data pass the aforementioned inspections, KCC will deploy a new vintage of the flood model with updated ZIP Codes.

8. Describe in detail the methods by which ground elevation data at the insured exposure location (e.g., building) is associated with the location databases and how this associated data is used in the flood model.

Elevation data is incorporated into the Intensity Footprint Module. The Intensity Footprint Module takes into account multiple factors including elevation, total precipitation, and drainage rate to determine the depth of water an insured location experiences. As a result, elevation data is not included in the exposure data set but is accounted for in the flood footprint.

9. For each parameter used in the flood model, provide the horizontal and vertical projections and datum references, if applicable. If any horizontal or vertical datum conversions are required, provide conversion factors and describe the conversion methodology used.

All parameters used in the KCC US Flood Reference Model use the same horizontal and vertical datum references. The horizontal datum is the World Geodetic System 1984 (WGS 1984) and the vertical datum is the North American Vertical Datum of 1988 (NAVD 88). If the vertical datum from USGS gauges is National Geodetic Vertical Datum 1929 (NGVD29), it is converted to NAVD88 using the NOAA Orthometric Height Conversion. For instances where a different horizontal datum was used in the original data, the

data sources were converted to WGS 84 using third-party software before being implemented in the KCC US Flood Reference Model.

GF-4 Independence of Flood Model Components

The meteorology, hydrology and hydraulics, vulnerability, and actuarial components of the flood model shall each be theoretically sound without compensation for potential bias from other components.

All model components were developed and validated independently to mitigate and avoid any potential bias from other components and are theoretically sound.

GF-5 Editorial Compliance

The flood model submission and any revisions provided to the Commission throughout the review process shall be reviewed and edited by a person or persons with experience in reviewing technical documents who shall certify on Form GF-8, Editorial Review Expert Certification, that the flood model submission has been personally reviewed and is editorially correct.

The flood model submission and revisions have been reviewed and edited by a person with the requisite experience. In signing Form GF-8, Editorial Review Expert Certification, the signatory certifies that the submission document has been personally reviewed and is editorially correct.

Disclosures

- 1. Describe the process used for document control of the flood model submission. Describe the process used to ensure that the paper and electronic versions of specific files are identical in content.***

In order to develop the submission document, each standard was first generated in separate Microsoft Word documents and later aggregated into a master document. The generation of each standard's documentation was initiated by the standards expert, reviewed by the editorial personnel, and finalized by the standards expert. If extensive content edits occurred by either editorial personnel or standards expert, this process repeated.

During the process of submission development, Track Changes was used extensively to monitor changes to content. Periodically, a new document version was saved, and changes were accepted, declined, or made. This allowed changes at each stage of submission development to be monitored. The documents were saved into a centralized document repository, which allowed multiple individuals to contribute to the documents.

After being finalized, each standard was compiled into the central document. The forms were additionally imported into the central document and final edits were made, which included formatting and hyperlinking sections. At this time, no content changes were made unless expressly directed by the standards expert.

Once the editorial personnel completed formatting, the document was peer reviewed by KCC professionals to ensure consistency between electronic files and the submission document. Any inconsistencies noted by the peer reviewer were discussed with the SME and a solution to ensure consistency implemented with SME approval. After the peer review and any necessary edits, the SME reviewed the document to ensure completeness and accuracy.

The Word document was then exported to a PDF and printed. No further edits were permitted to be made to the electronic version of the submission.

For revisions to the original document, initial changes were made by the editorial personnel and/or SME using Track Changes. A peer reviewer verified that all changes were consistent and accurate prior to the SME giving final approval. The document was then exported as a PDF and printed.

- 2. Describe the process used by the signatories on the Expert Certification Forms GF-1 through GF-7 to ensure that the information contained under each set of flood standards is accurate and complete.***

Throughout the process of generating the submission document, standard experts monitored content for completeness and accuracy. Standard experts also reviewed their respective sections prior to the document being compiled and exported as a PDF. Once the document was ready for submission, experts again reviewed their respective standards to ensure the completeness and accuracy of the finalized document.

- 3. Provide a completed Form GF-8, Editorial Review Expert Certification. Provide a link to the location of the form [insert hyperlink here].**

Form GF-8: Editorial Review Expert Certification

Meteorological Flood Standards

MF-1 Flood Event Data Sources

- A. *The modeling of floods in Florida shall involve meteorological, hydrological, hydraulic, and other relevant data sources required to model coastal and inland flooding.***

The KCC US Flood Reference Model is based on technical literature and data sources encompassing meteorological, hydrological, hydraulic, and other relevant data sources required to model coastal and inland flooding. A list of all technical literature and data sources can be found in Standard GF-1, Disclosure 4.

- B. *The flood model shall incorporate relevant data sources in order to account for meteorological, hydrological, and hydraulic events and circumstances occurring either inside or outside of Florida that result in, or contribute to, flooding in Florida.***

The KCC US Flood Reference Model incorporates data sources accounting for meteorological, hydrological, and hydraulic events and circumstances occurring inside or outside Florida that result in or contribute to flooding in Florida. A full list of technical literature and data sources can be found in Standard GF-1, Disclosure 4.

- C. *Coastal and inland flood model calibration and validation shall be justified based upon historical data consistent with peer reviewed or publicly developed data sources.***

Coastal and inland flood model calibration and validation are justified and based on historical data consistent with peer reviewed or publicly developed data sources. A full list of references and data sources can be found in Standard GF-1, Disclosure 4.

- D. *Any trends, weighting, or partitioning shall be justified and consistent with current scientific and technical literature.***

The KCC US Flood Reference Model was developed with no weighting or partitioning of historical data. Historical loss data are trended to account for inflation and changes in exposure and vulnerability as part of the loss validation process using a method similar to that described in Pielke et al. (2008).

Disclosures

- 1. *Specify relevant data sources, their release dates, and the time periods used to develop and implement flood frequencies for coastal and inland flooding into the flood model.***

KCC used the following data sources to develop and implement flood frequencies for coastal and inland flooding.

Data Source	Release Date	Time Period
Climate Prediction Center Unified Gauge-Based Analysis of Precipitation	7/31/2019	01/01/1948-12/31/2018
Global Peak Storm Surge Database (SURGEDAT); Needham and Keim (2013)	2/1/2015	1/1/1880-2/1/2015
HURDAT2 (Landsea and Franklin, 2013)	5/10/2019	1/1/1900-12/31/2018

Table 2 - Sources, release dates, and included time periods of data used to develop the KCC US Flood Reference Model

2. ***Where the flood model incorporates modification, partitioning, or adjustment of the historical data leading to differences between modeled climatological and historical data, justify each modification and describe how it is incorporated.***

The historical data are not modified, partitioned, or adjusted during the development of the model flood climatology.

3. ***Describe any assumptions or calculations used in the flood model relating to future conditions (e.g., sea level rise, changes in precipitation patterns, changes in storm frequency or severity).***

No assumptions or calculations were used in the KCC US Flood Reference Model that anticipate changes in future conditions.

4. ***If precipitation is explicitly modeled for either inland or coastal flooding, then describe the underlying data and how they are used as inputs to the flood model.***

Precipitation is explicitly modeled as a component of the Event Generation Module in the KCC US Inland Flood Reference Model. Distributions of precipitation event rain rate, spatial extent, and duration are determined using rain gauge-based data from the Climate Prediction Center (CPC). This dataset contains daily precipitation amounts on a 0.25° by 0.25° grid from 1948 to the present. The data from the CPC are downscaled to 0.08° by 0.08° with bilinear interpolation, an often-used methodology for precipitation data (e.g. Wang et al., 2006; Wang et al., 2012). Representation of local precipitation extremes remains limited by the spatial resolution of the original CPC dataset. The downscaled data are input into the KCC US Inland Flood Reference Model for historical flood events.

5. ***Provide citations to all data sources used to develop and support bottom friction for storm surge modeling, including publicly developed or peer reviewed information.***

Bottom friction is implicitly considered in the near shore adjustments along with bathymetry and shoaling impacts. NOAA's Technical Memorandum NWS TDL-46 (Jelesnianski, 1972), Jelesnianski (1967), Barrientos and Jelesnianski (1973), Barrientos and Chen (1974), Dean and Bender (2006), Loder et al. (2009), Zijlema et al. (2012), Roos et al. (2017), and Akbar et al. (2017) were used to produce the initial near shore adjustments, which were calibrated using SURGEDAT and USGS high water mark (HWM) data.

6. ***State whether the model includes flooding other than coastal and inland flooding. State whether the other flooding types are independent of the minimum required sub-perils of coastal and inland flooding.***

The KCC US Flood Reference Model does not include flooding other than coastal and inland flooding.

MF-2 Flood Parameters (Inputs)

- A. *The flood model shall be developed with consideration given to flood parameters that are scientifically appropriate for modeling coastal and inland flooding. The modeling organization shall justify the use of all flood parameters based on information documented in current scientific and technical literature.***

Scientifically appropriate flood parameters were used when developing the KCC US Flood Reference Model, and the selection of parameters was based on current scientific and technical literature. Additional information on the justification of parameters is found in Standard MF-2, Disclosure 1.

- B. *Differences in the treatment of flood parameters between historical and stochastic events shall be justified.***

There are no differences in the treatment of flood parameters between historical and stochastic events in the KCC US Flood Reference Model.

- C. *Grid cell size(s) used in the flood model shall be justified.***

The KCC US Flood Reference Model employs a grid size of 1 arc-second. This grid size was selected based on comparisons of different grid sizes to the average building size and the scale of elevation changes. From these analyses results, KCC scientists concluded that the grid size of 1 arc-second produced the most accurate results for calculating location-level inundation. Larger grid sizes are not a good representation of the topography because small-scale features such as roadways and small channels are not represented. Smaller grid sizes can result in greater uncertainty about the elevation of a building at a geocoded location in that a single building can be identified as being at several different elevations given the scale of the geocode to the grid size.

Disclosures

- 1. *For coastal and inland flood model components, identify and justify the various flood parameters used in the flood model.***

Coastal Flooding

The KCC US Coastal Flood Reference Model is based on the following parameters.

- **Central Pressure:** The peak storm surge is calculated as a function of the storm central pressure, which is the most important variable for determining storm surge height because it captures the effects of both wind speed and low pressure on storm surge. There is a direct relationship between maximum wind speed, which causes water piling, and central pressure (Courtney & Knaff, 2009). Additionally, a decrease in the central pressure is a decrease in the force exerted by the weight of air on the ocean, which causes an increase in water height (NHC, 2019; Rutledge et al., 2011).
- **Radius of Maximum Winds (R_{max}):** The radius of maximum winds is the distance that high wind speeds extend outward from the storm center and is used to calculate the areal extent of the resulting storm surge. Storms with a larger R_{max} produce a larger storm surge extent (Irish et al., 2008). The R_{max} is also used to compute the position of the peak storm surge in a given event, which typically occurs at the location of highest winds within a storm.
- **Translation Speed:** The peak storm surge is dependent on the storm forward speed. A fast-moving storm will generate a higher peak surge than a slow-moving storm with the same central pressure (Jelesnianski, 1972). This modification is accounted for in the KCC US Coastal Flood Reference Model peak storm surge calculation.

- **Translation Direction:** As a storm approaches land, the angle between the hurricane track and the shore affects how much water is piled towards the shore and how much is pushed out to sea. In general, a storm moving close to perpendicular to the shore generates a higher storm surge than a storm moving parallel or at an angle to the shore. As with the modification of the peak storm surge due to translation speed, the translation direction results in a modification to the peak storm surge in the KCC US Coastal Flood Reference Model.
- **Near Shore Adjustment:** Near shore adjustments are determined by local bathymetry and coastal geometry and capture the way in which a wall of water increases in height when entering shallow waters. In general, the adjustments will be higher in areas with wider and shallower continental shelves as more water can accumulate as the storm moves onshore in these areas. The initial parameter values were adapted from Jelesnianski (1972) and Barrientos and Chen (1974) and were calibrated and validated against observed storm surge data from SURGEDAT and bathymetry maps along the US Atlantic and Gulf coasts.
- **Bay Adjustment:** Amplification of storm surge in bays and river mouths is accounted for using a local bay adjustment parameter. Extensive studies have been performed on the amplification of the storm surge height caused by bays, including Weisberg and Zheng (2006), Li et al. (2006), Peng et al. (2006), Fritz (2007), Edmiston (2008), Rego and Li (2010), Sheng et al. (2010), Needham et al. (2015), and Chiu and Small (2016). The published literature and observations from SURGEDAT were used to calculate the KCC amplification impacts.

Inland Flooding

The hazard component of the KCC US Inland Flood Reference Model consists of two components: the water balance module and the runoff routing module.

The water balance module is based on the following parameters.

- **Precipitation amount and duration (P):** Precipitation amount and duration define the total amount of water entering each model unit at an hourly time step. Daily precipitation is simulated with a spatial resolution of 0.08° by 0.08°.
- **Precipitation Spatial Extent (S):** Extreme precipitation events occur across a range of sizes and shapes. The spatial extent of the precipitation fields is represented in the model as an ellipse that is characterized by total area, eccentricity, and orientation relative to a line of latitude.
- **Initial Water Balance (WB):** The partitioning of water between the groundwater, surface runoff, and channel discharge pools at the beginning of an event dictates the amount of precipitation that is needed to cause flooding. The initial WB is calculated using a 60-day spinup of the water balance module with a climatologically average, high, or low precipitation rate.

The runoff routing module is based on the roughness parameter.

- **Roughness:** Based on Manning's equation, roughness is used to calculate the discharge rate for surface runoff (catchment and channel). NLCD (2016) land cover and soil data are used to determine the roughness in accordance with Ponce (2014). A higher roughness corresponds to slower discharge rate and a longer flow time.

2. *For coastal and inland flood model components, describe the dependencies among flood model parameters and specify any assumed mathematical dependencies among these parameters.*

Central pressure and the R_{max} are both calculated from maximum wind speed. The R_{max} is calculated from the maximum wind speed and the latitude (ϕ) of the cyclone center following the equation given by Willoughby et al. (2006) with coefficients C_1 , C_2 , and C_3 estimated using historical data, hereafter referred to as the modified Willoughby equation:

$$R_{max} = C_1 e^{(C_2 V_{max} + C_3 \phi)}$$

Central pressure is calculated based on the maximum wind speed following the formula from Courtney and Knaff (2009) where V_{srm1} is the storm-relative maximum wind speed:

$$P_C = 23.286 - 0.483V_{srm1} - \left(\frac{V_{srm1}}{24.254}\right)^2 - 12.587S - 0.483\theta + P_e$$

Where

P_C = the storm central pressure (hPa)

θ = the latitude in degrees,

S = a unitless size factor

P_e = an environmental pressure

For inland flood model components, the event duration and spatial extent are both calculated as a function of the total precipitation amount. Analysis of the historical catalog of extreme precipitation events derived from the CPC dataset showed statistically significant correlations between event duration and total precipitation amount, as well as between the event spatial extent and the total precipitation amount. In general, as the total precipitation amount increases, both the duration and spatial extent of the event also increase. The historical data are divided into North Florida events and South Florida events for this analysis since the data exhibit distinct differences between these regions. Events with a similar total precipitation amount tend to have a smaller spatial extent and longer duration in South Florida compared to North Florida.

The changes in event duration with total precipitation are represented by a linear relationship with parameters determined using regression analysis. Different parameter values were calculated for North Florida and South Florida. A minimum duration of one day is applied in the model to be consistent with the time resolution of the CPC data. A linear relationship also effectively captures the changes in the spatial extent of historical events with total precipitation. Regression analysis was used to determine the linear relationship between spatial extent and total precipitation for North Florida and South Florida separately.

3. *For coastal and inland flood model components, describe the dependencies that exist among the flood model components.*

The coastal and inland flood model components are treated independently, and there are no dependencies.

4. *Identify whether physical flood parameters are modeled as random variables, functions, or fixed values for the stochastic flood event generation. Provide rationale for the choice of parameter representations.*

KCC US Coastal Flood Reference Model

Central Pressure: The minimum central pressure of a model event is calculated from the maximum 1-minute sustained wind speed at landfall (V_{max}), which is modeled as a random variable following a Generalized Pareto Distribution fit to historical data. The conversion from wind speed to central pressure follows the empirical formula provided by Courtney and Knaff (2009).

Radius of Maximum Wind: The R_{max} is calculated as a function of the V_{max} and latitude of the storm center following the modified Willoughby equation. Uncertainty in the R_{max} is modeled as a random variable that is computed using the difference between the observed R_{max} and the R_{max} calculated with the modified Willoughby equation for landfalling hurricanes.

Translation Speed: Forward speed at landfall is modeled as a random variable determined by the climatological movement of hurricanes that cross the state of Florida. The observed forward speeds are drawn from the historical data, and the distribution of the observations is modeled as a Weibull distribution. This distribution was selected based on meteorological expertise and the results of goodness-of-fit tests.

Translation Direction: Track direction at landfall is dependent on the climatological direction of storm movement at each coastal location and on the shape of the coastline. Model track directions are modeled as a random variable computed from the means and standard deviations of observed hurricane track directions at landfall within approximately 100-mile coastal segments. Additional smoothing and minor adjustments are applied to ensure nearly parallel tracks for adjacent coastal points. Changes in direction after landfall are computed as a function of latitude that describes the eastward turn of Atlantic hurricanes as they move northward into the path of extratropical waves.

KCC US Inland Flood Reference Model

Precipitation Amount: The precipitation amount refers to the total rainfall at the event center location, representing the peak rainfall for the event. The precipitation amount is modeled as a random variable following a Pareto Type II distribution as recommended by Papalexiou et al. (2013). The distribution parameters are fit using gridded historical daily precipitation data from 1948-2018.

Precipitation Event Duration: The event duration is calculated based on the event precipitation amount. The variability in observed event duration relative to the expected duration based on the relationship with the precipitation amount is modeled as a random variable following a lognormal distribution. This distribution was selected based on goodness-of-fit testing.

Precipitation Event Spatial Extent: The spatial extent of precipitation events is calculated based on the event precipitation amount, where a smaller extent is associated with a smaller precipitation amount. The variability in the size of the observed precipitation events relative to the size expected from the precipitation amount is modeled as a random variable following a lognormal distribution. This distribution was selected based on goodness-of-fit testing.

Precipitation Event Eccentricity: The eccentricity of the elliptical precipitation field is modeled as a fixed value that is dependent on the center location of the precipitation field.

Precipitation Event Orientation: The orientation of the elliptical precipitation field is defined as the tilt of the long axis of the ellipse relative to a line of constant latitude. The orientation is modeled as a fixed value that is dependent on the center location of the precipitation field. The orientation varies by location and represents the climatological mean determined from historical data.

Initial Water Balance: The initial water balance refers to the groundwater, surface runoff, and channel discharge conditions that are present at the beginning of a model inland flood event. The water balance is determined using a water balance model spinup of 60 days with constant non-zero precipitation. The precipitation rate relative to the climatological rate determines whether the water balance conditions are wet, dry, or average at the event start. The precipitation rate used during the spinup is modeled as a random variable following a gamma distribution. This distribution is commonly used to represent precipitation data (Wilks, 1995).

Roughness: The surface roughness is modeled as a fixed variable that is dependent on the underlying LULC data from the 2016 NLCD dataset.

5. ***Describe if and how any physical flood parameters are treated differently in the historical and stochastic flood event sets, and provide rationale.***

Flood parameters are treated the same in the historical and stochastic flood event sets.

6. ***If there is explicit modeling of precipitation-driven flooding, then describe how rainfall extent, duration, and rate are modeled. If the effects of precipitation are implicitly incorporated into the flood model, describe the method and implementation.***

The KCC US Inland Flood Reference Model generates precipitation-driven flooding by explicitly modeling precipitation, which becomes the input in the flood calculation. The rainfall extent, duration, and rate are modeled based on the statistics of these quantities derived from historical precipitation data.

As a first step, extreme precipitation events are identified from the historical precipitation dataset from the CPC gridded gauge-based data from 1948 to 2018. Extreme rainfall events can have different durations, some lasting for only a single day and others for multiple days. The average precipitation at each location is used as a threshold to determine whether consecutive rainy days constitute the same event (Du et al., 2019). This threshold gives a reasonable distribution of extreme event durations that matches expectations derived from the duration of flooding events in the historical catalog. The most extreme precipitation events, those with precipitation amounts over 100 mm, are selected from the historical data. Then, a Pareto Type II distribution is fit to the extreme event set using a modified mean square error method, which is described by Papalexiou et al. (2013). This analysis also provides the frequency of these extreme events by location.

Rainfall extent is determined using an ellipse pattern-detection technique similar to the approach of Bergemann et al. (2015). In the ellipse-fitting process, the points on the CPC grid are set to true or false depending on whether the rainfall at that location exceeds a threshold amount during the event, and both the orientation and eccentricity of the historical event are recorded. The model rainfall event areas are calculated based on the statistics of the historical events and are centered on a set of over 300 locations that cover all basins affecting Florida. The highest precipitation rate occurs at the center of the rainfall area and decreases away from the center.

7. ***For coastal flood analyses, describe how the coastline is segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.***

Coastal flood frequency in the KCC US Coastal Flood Reference Model follows the historical frequency of hurricane landfall events in Florida. These frequencies are calculated for locations on the coast that are 10 miles apart. The event frequency at each coastal location is calculated by smoothing the historical landfall data.

8. ***For coastal flooding, describe how astronomical tides are incorporated and combined with storm surge to obtain storm tide.***

The average astronomical tide height for each coastal location is applied at every model time step to calculate storm tide for all model events.

9. ***Describe if and how any flood parameters change or evolve during an individual flood life cycle (e.g., astronomical tide, representation of Manning's roughness varying with flood depth).***

Throughout the evolution of a coastal flood event, several of the parameters driving the storm surge change. Firstly, the storm central pressure increases as a function of time since landfall with the increase in CP dependent on the exponential decay of the V_{max} . Secondly, the R_{max} changes along the storm track as a function of storm center latitude and the V_{max} . Finally, track direction changes after landfall to represent the climatological curvature of tropical cyclone tracks in the Atlantic Basin. These changes occur mainly after landfall and therefore have a minimal impact on the resulting storm surge.

During inland flood events, the impact of the roughness parameter on the velocity of surface water movement changes with the depth of the water.

10. For coastal modeling, describe any wave assumptions, calculations or proxies and their impact on flood elevations.

The KCC US Flood Reference Model addresses wave impact in the vulnerability functions used in the Vulnerability Module. For this purpose, the wave height is assumed to be a function of the inundation depth at all inundated locations.

11. Provide the source, resolution, datum, and accuracy of the topography and bathymetry throughout the flood model domain.

Digital Elevation Models (DEMs) for topography and elevation data employed in the KCC US Flood Reference model are extracted from the USGS 3D Elevation Program (3DEP). The USGS 3DEP is at a 1 arc-second (approximately 30 m) horizontal resolution and represents the topographic bare-earth surface. Because this data is compiled from different sources, the data is processed to a common coordinate system (North American Vertical Datum of 1988, or NAVD88) and vertical units (inches). The mean relative vertical accuracy of the DEM is 0.81 m (Gesch et al., 2014).

The bathymetry maps are compiled by the National Ocean Survey (NOS). Bathymetry survey data complies with International Hydrographic Organization (IHO) Special Publication 44 accuracy standards and/or standards used as of the date of the surveys. The vertical datum is the mean low water, and 1:100,000, 1:250,000, 1:50,000, and 1:1,000,000 scale maps were used.

12. Describe the grid geometry used in the coastal flood model.

KCC scientists selected a uniform grid size of 1 arc-second in the model. This grid size was considered based on an analysis of the average building size and changes in the elevation with different grid sizes.

MF-3 Wind and Pressure Fields for Storm Surge**A. Modeling of wind and pressure fields shall be employed to drive storm surge models due to tropical cyclones.**

The KCC US Flood Reference Model uses the radius of maximum winds (R_{max}) and central pressure (CP), which are both calculated based on the maximum wind speed, to drive storm surge from tropical cyclones.

B. The wind and pressure fields shall be based on current scientific and technical literature or developed using scientifically defensible methods.

The development of the wind fields is based on the Willoughby et al. (2006) radial wind model, and central pressure is calculated using the work of Courtney and Knaff (2009).

C. The modeling of wind and pressure fields that drive coastal flood models shall be conducted over a sufficiently large domain that storm surge height is converged.

The storm surge is calculated for the entire US coast at each 5-minute time step of the modeled events.

D. The features of modeled wind and pressure fields shall be consistent with those of historical storms affecting Florida.

The features of modeled wind and pressure fields are consistent with those of storms historically affecting Florida. The KCC US Hurricane Reference Model wind footprints have been validated against observed wind speeds tabulated by the National Hurricane Center (NHC), and those events form the basis of the KCC US Coastal Flood Reference Model.

Disclosures**1. Describe the modeling of the wind and pressure fields for tropical cyclones. State and justify the choice of the parametric forms and the parameter values.**

The KCC US Coastal Flood Reference Model utilizes the model first defined in Willoughby et al. (2006) for the radial wind profile. The wind speed (V) at any location within the hurricane windfield is a function of distance from the center of the storm (r), R_{max} , and the maximum wind speed. In a stationary hurricane, the structure is roughly symmetric about the center with a maximum wind speed located at a distance equal to the R_{max} . Asymmetry of the windfield is calculated by adding or deducting an asymmetry value that depends on the wind direction relative to the motion of the storm as described by Schwerdt et al. (1979).

Willoughby et al. (2006) provides formulations for two types of wind profiles, namely the single- and dual-exponential profile. In the KCC US Coastal Flood Reference Model, the choice of profile formulation depends on the intensity of the storm. Other windfield parameters, such as $X1$ (the exponential decay length in the outer vortex), n (the exponent for the power law inside the eye), and A (sets the proportion of the two exponentials in the profile) are calculated from the V_{max} and latitude of the storm. The formulations for $X1$, n , and A are specified in Willoughby et al. (2006), and $X2$ is a fixed parameter of 25 km as specified in Willoughby et al. (2006).

The R_{max} is a function of the peak wind speed and the latitude of the cyclone center following the equation given by Willoughby et al. (2006) with coefficients estimated using historical data, hereafter referred to as the modified Willoughby equation. Uncertainty in the R_{max} is computed using the difference between the observed R_{max} and the R_{max} calculated with the modified Willoughby equation for landfalling hurricanes. These residuals are represented by a normal distribution that describes the natural variation around the calculated value. This distribution was selected based on meteorological expertise and the

results of goodness-of-fit tests. Deviations from the calculated R_{max} defined by the fitted distributions are used to select R_{max} values for events in the stochastic storm set.

The minimum central pressure of a model event is calculated from the maximum 1-minute sustained wind speed at landfall (V_{max}) following the empirical formula provided by Courtney and Knaff (2009), which is modeled as a random variable following a Generalized Pareto Distribution fit to historical data. The conversion from wind speed to central pressure follows the empirical formula provided by Courtney and Knaff (2009).

2. Provide the historical data used to estimate parameters and to develop stochastic storm sets.

The stochastic event set of hurricanes has been developed using the following datasets:

- HURDAT2 (Landsea and Franklin, 2013)
- Extended Best Tracks (Demuth et al, 2006)

The stochastic event set of inland flood events has been developed using the following datasets:

- Climate Prediction Center Unified Gauge-Based Analysis of Precipitation (precipitation data)
- River daily discharge data from United States Geological Survey (USGS)
- Soil moisture data from Soil Moisture Active Passive (SMAP)

3. Provide a rotational (y-axis) versus radial (x-axis) plot of the average or default wind and pressure fields for tropical cyclones. Provide such plots for non-tropical cyclones, if non-tropical cyclones are modeled explicitly.

The wind speed radial profile is developed based on the radial variation of winds as described in Willoughby et al. (2006). This wind profile was developed using hundreds of flight level observations. Reasonable validation against observational data justifies the use of this wind profile.

The following figure shows the default wind speed profile versus distance from the eye (expressed as a ratio of the radius of maximum wind speeds), for a maximum wind speed of 110 mph and latitude of 28°. For those input parameters, the model produces the exponential decay length in the outer vortex (X1) of 126 miles, and exponent for the power law inside the eye (n) of 0.94.

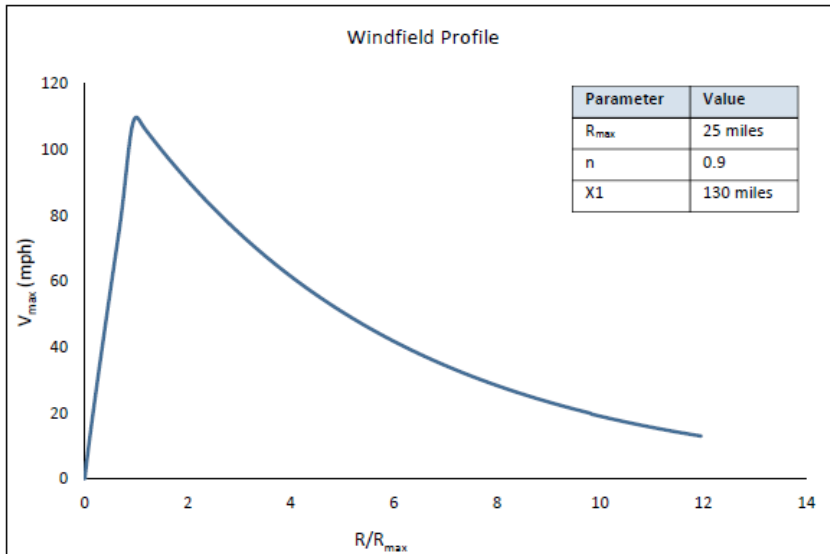


Figure 5 - Rotational wind speed plot of a symmetric wind profile for a Florida hurricane

- 4. If windfields are modeled above the surface and translated to the surface to drive storm surge, then describe this translation; e.g., via planetary boundary layer models or empirical surface wind reduction factors and inflow angles. Discuss the associated uncertainties.**

The V_{\max} input into the wind speed radial profile and the windfield output are both the 1-minute sustained wind speed at a height of 10 m above the surface. This eliminates the need for translation or reduction of higher level winds.

- 5. Describe how storm translation is accounted for when computing surface windfields.**

Stationary tropical cyclones can typically be approximated to have symmetrical wind speed profiles along all their radials, but a moving hurricane has an asymmetric wind field. The translational, or forward speed, and direction of tropical cyclones are governed by several factors including global wind patterns and the location and strength of large-scale high and low-pressure systems. Generally, in the Northern hemisphere, the movement of a tropical cyclone increases the winds on the right side of the track and decreases the winds on the left.

In the KCC US Coastal Flood Reference Model, the asymmetry in tropical cyclones is evaluated by an asymmetry value, A , which is either added or deducted from the symmetrical windfield depending on the wind direction relative to the motion of the hurricane. This formulation is consistent with the description of hurricane asymmetry from Schwerdt et al. (1979). The asymmetry factor is directly proportional to the forward speed and the cosine of the angle between the track direction and the local wind direction. The local wind direction is computed from the inflow angle, which is estimated using the formulation provided in Zhang and Uhlhorn (2012).

- 6. Describe how storm surge due to non-tropical cyclones is accounted for in the flood model. If it is not accounted for, explain why.**

Storm surge from non-tropical cyclones is not accounted for in the coastal flood model. Coastal impacts from tropical storms are far more common in Florida than impacts from extratropical storms (Zhang et al., 2000), which occur less frequently at Florida latitudes (Eichler and Higgins, 2006). The frequency of non-tropical cyclone storm surge in Florida is low enough that this type of event does not warrant inclusion in the model event set.

- 7. Describe and justify the averaging time of the windspeeds used to drive the storm surge model.**

The hourly track point V_{\max} values are interpolated to 5-minute time steps which are then used to calculate the maximum 10-meter, 1-minute sustained wind speed at all locations on a 1-kilometer grid. The modeled storm surge is also calculated on the 5-minute time step, which is sufficient to model changes in peak surge over the life cycle of the storm.

- 8. Describe the process for verifying storm surge height convergence as a function of domain size.**

The storm surge is calculated for the entire US coast at a high time resolution of 5-minutes. Therefore, storm surge height convergence is not limited by the model domain size.

MF-4 Flood Characteristics (Outputs)

- A. Flood extent and elevation or depth generated by the flood model shall be consistent with observed historical floods affecting Florida.**

The flood extent and depth generated by the flood model have been validated using observations from historical coastal and inland flood events.

- B. Methods for deriving flood extent and elevation or depth shall be scientifically defensible and technically sound.**

The flood extent and inundation depth are simulated using technically sound methods that make use of published scientific literature.

- C. Methods for modeling or approximating wave conditions in coastal flooding shall be scientifically defensible and technically sound.**

The KCC US Flood Reference Model implicitly addresses the wave impact on the flood elevations in the vulnerability functions. For this purpose, the wave height is assumed to be a function of the inundation depth (FEMA, 2011).

- D. Modeled flood characteristics shall be sufficient for the calculation of flood damage.**

The flood model simulates all flood characteristics required for calculating flood damage including maximum inundation depth and flood spatial extent.

Disclosures

- 1. Demonstrate that the coastal flood model component incorporates flood parameters necessary for simulating storm-surge-related flood damage in Florida. Provide justification for validation using any historical events not specified in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps.**

The KCC US Flood Reference Model produces reliable storm-surge-related flood damage in Florida, as demonstrated by validation of historical storm surge events with SURGEDAT and USGS datasets and observations, examples of which are shown below.

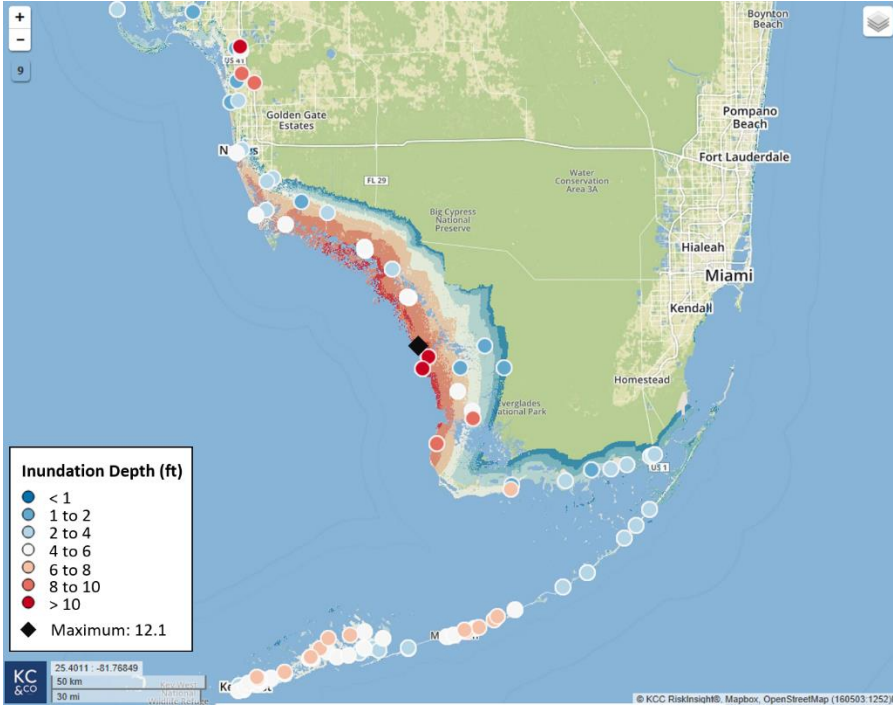


Figure 6 - KCC storm surge intensity footprint for Hurricane Wilma (2005) compared to SURGEDAT storm tide observations (dots)

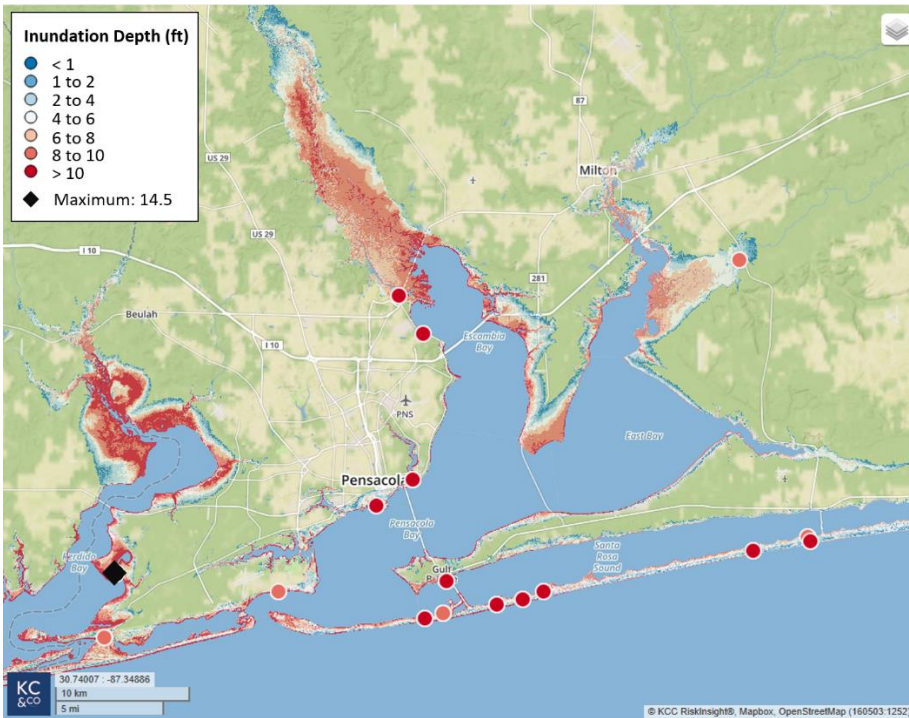


Figure 7 - KCC storm surge intensity footprint for Hurricane Ivan (2004) near Pensacola compared to SURGEDAT storm tide observations (dots)

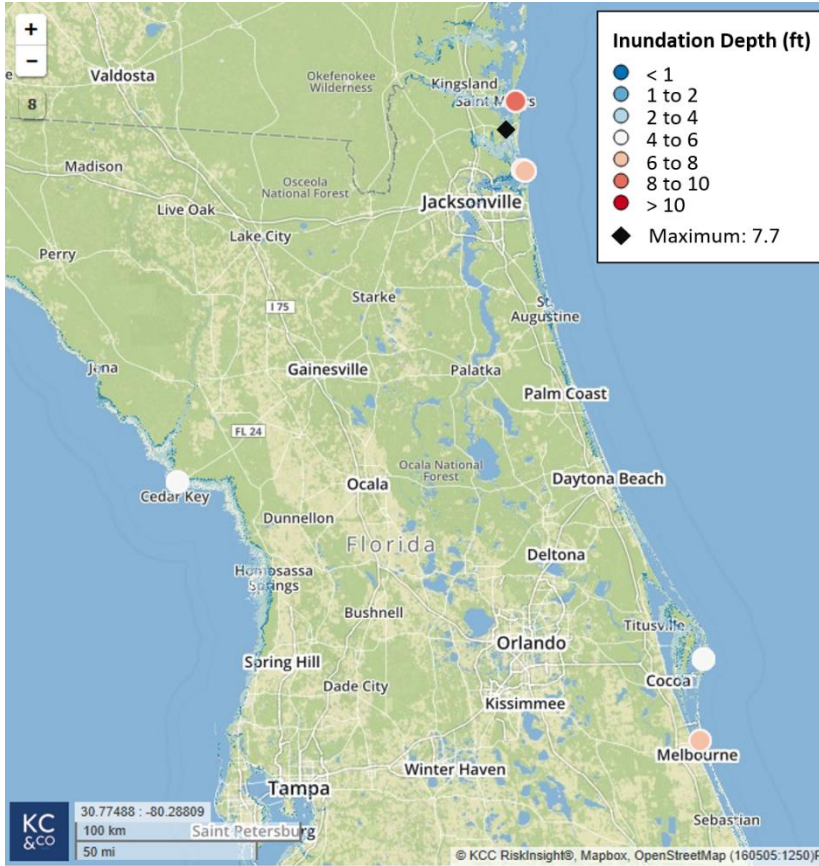


Figure 8 - KCC storm surge intensity footprint for Hurricane Jeanne (2004) in Central Florida compared to SURGEDAT storm tide observations (dots)

2. For coastal flooding, describe how the presence, size, and transformation of waves are modeled or approximated.

The presence, size, or transformation of waves in the KCC US Flood Reference Model are accounted for in the vulnerability functions.

3. For coastal modeling, describe if and how the flood model accounts for flood velocity, flood duration, flood-induced erosion, floodborne debris, salinity, and contaminated floodwaters.

The KCC US Flood Reference Model does not account for flood duration, flood-induced erosion, floodborne debris, and contaminated floodwaters. Flood velocity is included in the derivation of the coastal and inland flood vulnerability functions. Moreover, the differences between saltwater and freshwater are implicitly included in the vulnerability functions.

4. Describe if and how the coincidence and interaction of inland and coastal flooding is modeled.

The interaction between coastal and inland flooding is accounted for in the financial component of the model.

5. Provide a flowchart illustrating how the characteristics of each flood model component are utilized in other components of the flood model.

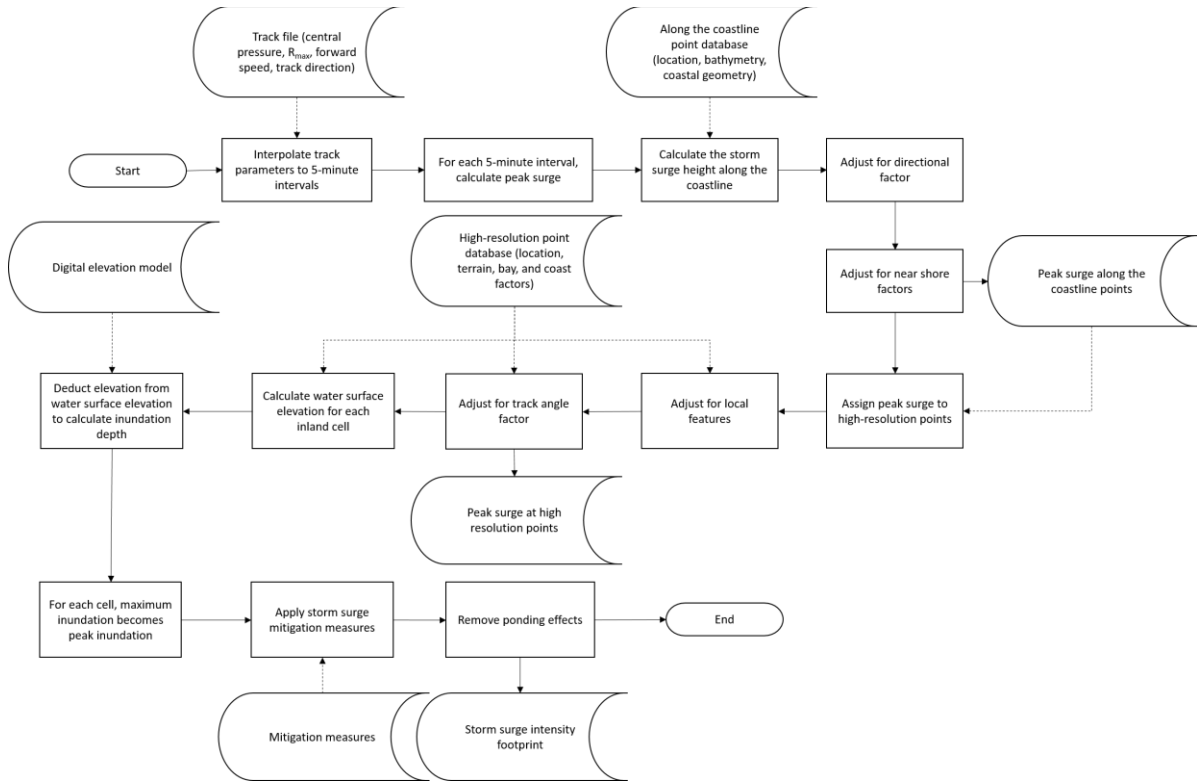


Figure 9 - Flow chart describing the processes of the KCC US Coastal Flood Reference Model

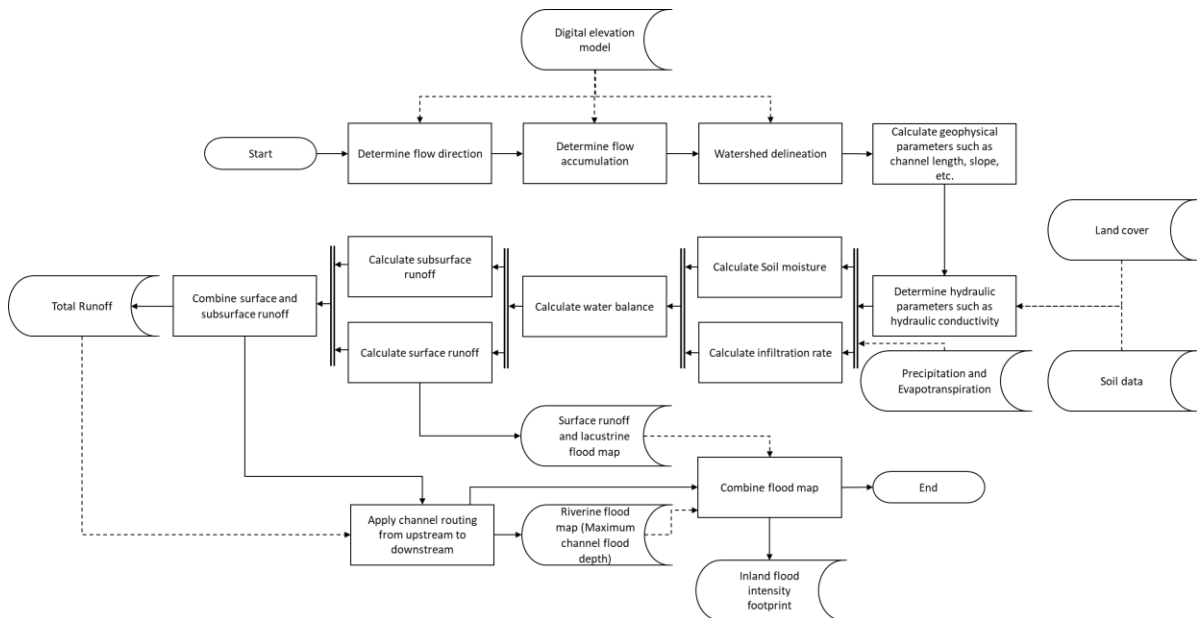


Figure 10 - Flow chart describing the processes of the KCC US Inland Flood Reference Model

6. Describe and justify the appropriateness of the databases and methods used for the calibration and validation of flood extent and elevation or depth.

The KCC US Flood Reference Model intensity footprints have been extensively validated against results from post-event damage surveys, NOAA aerial photos and storm data, USGS high water marks (HWM), stream gauge datasets, SLOSH, and published literature.

The NOAA Storm Event Database contains records of inland and coastal floods that include observations of inundated locations and inundation depths. This dataset is used to validate the extent of inland flooding for events that occurred between 1996 and 2018.

Following major events, USGS dispatches trained specialists to document HWM in affected areas. The HWM can be used to validate inundation depth and locations.

SLOSH is a computerized numerical model developed by the National Weather Service, and KCC storm surge intensity footprints show good agreement with SLOSH.

For older events, there are fewer resources available. KCC scientists employ US Army Corps of Engineers (USACE), Federal Emergency Management Association (FEMA), and other published sources to validate model output.

7. Describe any variations in the treatment of the flood model flood extent and elevation or depth for stochastic versus historical floods, and justify this variation.

The KCC US Flood Reference Model does not apply any variations in the treatment of flood characteristics between the historical and stochastic floods.

8. Provide a completed Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability. Provide a link to the location of the form [insert hyperlink here].

[Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability](#)

9. Describe the effects of storm size, bathymetry, and windspeed on storm surge height for the coastal flood model.

Storm size, defined as the R_{max} , determines the extent of the storm surge along the coast. The peak surge usually coincides with the R_{max} , where wind speeds are the highest and can push the most water towards land. An empirically-derived coastal surge profile represents the decrease in surge height with distance from the location of peak surge in the KCC US Coastal Flood Reference Model. The rate of the decrease is normalized to the storm R_{max} , meaning if a storm's R_{max} increases by 10%, the storm surge extent will also increase by 10%, though the peak storm surge height located at the R_{max} remains the same.

Local bathymetry affects the way in which a wall of water increases in height when entering shallow waters. In general, coastal flood inundation will be higher in areas with wider and shallower continental shelves as more water can accumulate as the storm moves onshore. This impact of bathymetry is represented in the KCC US Flood Reference Model by applying near shore adjustments to the storm surge that are characteristic of the near-coast bathymetry at each coastal location.

A fraction of storm surge is driven by central pressure, which is calculated from wind speed. A decrease in central pressure is a decrease in the force exerted by the weight of air in the Earth's atmosphere on the ocean and results in an increase in water height. Surge height from central pressure is about five percent of the total storm surge in severe hurricane events (NHC, 2019; Rutledge et al., 2011) and is an increase of about 0.4 inches for every millibar decrease in air pressure (Horsburgh & De Vries, 2011).

10. Describe the effects of windspeed, depth, fetch, and wind duration on locally generated wave heights or wave proxies for the coastal flood model.

The KCC US Flood Reference Model implicitly addresses the wave impact on the flood elevations in the vulnerability functions. For this purpose, the wave height is assumed to be a function of the inundation depth, and the added forces due to waves are accounted for when assessing building vulnerability. The relationship between wave height and inundation in the KCC US Flood Reference Model is based on recent publications as described in the Vulnerability Standard disclosures.

The model inundation depth depends on wind speed, fetch and wind duration; therefore, the wave height can also be impacted by those variables through changes in the inundation depth.

MF-5 Flood Probability Distributions

- A. Flood probability, its geographic variation, and the associated flood extent and elevation or depth shall be scientifically defensible and shall be consistent with flooding observed for Florida.**

Flood probability, flood extent, and inundation depth are validated with observations of historical floods in the state of Florida.

- B. Flood probability distributions for storm tide affected areas shall include tropical, and if modeled, non-tropical events.**

Flood probability distributions for coastal areas include storm surge driven by tropical cyclones affecting Florida.

- C. Probability distributions for coastal wave conditions, if modeled, shall arise from the same events as the storm tide modeling.**

The KCC US Flood Reference Model implicitly addresses the wave impact on the flood elevations in the vulnerability functions. For this purpose, the wave height is assumed to be a function of the inundation depth, and the added forces due to waves are accounted for when assessing building vulnerability. The relationship between wave height and inundation in the KCC US Flood Reference Model is based on recent publications as described in the Vulnerability Standard disclosures.

- D. Any additional probability distributions of flood parameters and modeled characteristics shall be consistent with historical floods for Florida resulting from coastal and inland flooding.**

The probability distributions of all flood parameters and modeled characteristics are derived from historical coastal flooding events in Florida and historical extreme precipitation events that are consistent with historical datasets.

Disclosures

- 1. Describe how non-tropical and tropical event coastal storm tide flood probability distributions are combined, if applicable. Provide an example demonstrating the process.**

Non-tropical event coastal flooding is not applicable to the KCC US Coastal Flood Reference Model.

- 2. Provide the rationale for each of the probability distributions used for relevant flood parameters and characteristics.**

Central Pressure: Central pressure, which is used to compute the model peak storm surge, is calculated from the storm V_{max} . The distribution of V_{max} values is represented with the Generalized Pareto Distribution with parameters estimated from historical data for different regions within Florida and for neighboring states. The Generalized Pareto Distribution has been shown to accurately represent the distribution of extreme winds (e.g., Palutikof et al., 1999) and especially for US hurricanes (Jagger and Elsner, 2006; Emanuel and Jagger, 2010). Goodness-of-fit tests support the use of this functional form.

R_{max} : The model R_{max} is calculated using the relationship between R_{max} , V_{max} , and latitude developed by Willoughby et al. (2006) with coefficients estimated using the historical data. The expected R_{max} decreases with increasing V_{max} and increases with increasing latitude.

Translation speed: Graphical representations of Florida forward speed data indicate similar probabilities for a wide range around the average forward speed value. The data and the results of goodness-of-fit tests support the choice of the Weibull distribution for representing forward speed.

Translation direction: Track direction at landfall is dependent on the orientation of the coastline and climatology. Track direction is modeled for appropriate coastline lengths for which there are ranges of equally likely track directions. Goodness-of-fit tests support the choice of the uniform distribution.

Precipitation Amount: The severity distribution for the precipitation amount is modeled using a Pareto Type II distribution, which has been shown to effectively capture the tail of the exceedance probabilities for precipitation events (Papalexiou et al., 2013). Several studies have shown that heavy-tailed distributions perform better for representing the severity of extreme precipitation events when compared to the light-tailed gamma distribution (e.g. Yang et al., 2010; Fischer et al., 2012; Simoes et al., 2015). Goodness-of-fit tests support this distribution for the precipitation amount parameter. The occurrence frequency of extreme precipitation events of any severity varies spatially based on the historical frequency of events centered at each model location. The frequency of events of a given severity at a model location is determined by applying the severity distribution to the total event frequency.

Precipitation Event Duration: The event duration is calculated as a function of the event precipitation amount. The residuals of the observed event duration when compared to the calculated duration are modeled as a random variable following a lognormal distribution. This distribution was selected based on goodness-of-fit testing.

Precipitation Event Spatial Extent: The spatial extent of precipitation events is calculated as a function of the event precipitation amount. The residuals of the observed spatial extent when compared to the calculated value and normalized to the calculated value are modeled as a random variable following a lognormal distribution. This distribution was selected based on goodness-of-fit testing.

Initial Water Balance: The initial water balance refers to the groundwater, surface runoff, and channel discharge conditions that are present at the beginning of a model inland flood event. The water balance is determined using a water balance model spinup of 60 days with constant precipitation. The precipitation rate relative to the climatological rate determines whether the water balance conditions are wet, dry, or average at the event start. The precipitation rate used during the spinup is modeled as a random variable following a gamma distribution. This distribution is commonly used to represent precipitation data (Wilks, 1995).

Annual Number of Events: The number of extreme precipitation events that occur in a year is determined by fitting a Poisson distribution to the historical event frequency for the entire region affecting Florida. The Poisson distribution is suitable for count data for which the mean and variance are similar, as in the case of the historical precipitation event occurrence data. The Chi-Square goodness-of-fit test supports this distribution for representing the annual number of events.

3. *Demonstrate that simulated flood elevation or depth frequencies are consistent with historical frequencies.*

KCC US Flood Reference Model flood elevation frequencies are consistent with historical frequencies. The example below shows the water elevation exceedance probabilities for the 20 and 50 year return periods extrapolated by NOAA from the tide gauge data compared to the model results at Fort Myers and Cedar Key. The extrapolation is performed by fitting the parameters of the Generalized Extreme Value (GEV) probability distribution function to the extremes tide levels in the gauge dataset using an iterative maximum likelihood estimation (Zervas, 2013). The tide gauges at Fort Myers and Naples were chosen for this comparison because of their long period of record relative to other Florida stations. However, the uncertainty in the GEV fit to the tide gauge data increases substantially for return periods longer than 50 years and, therefore, longer return periods are not shown.

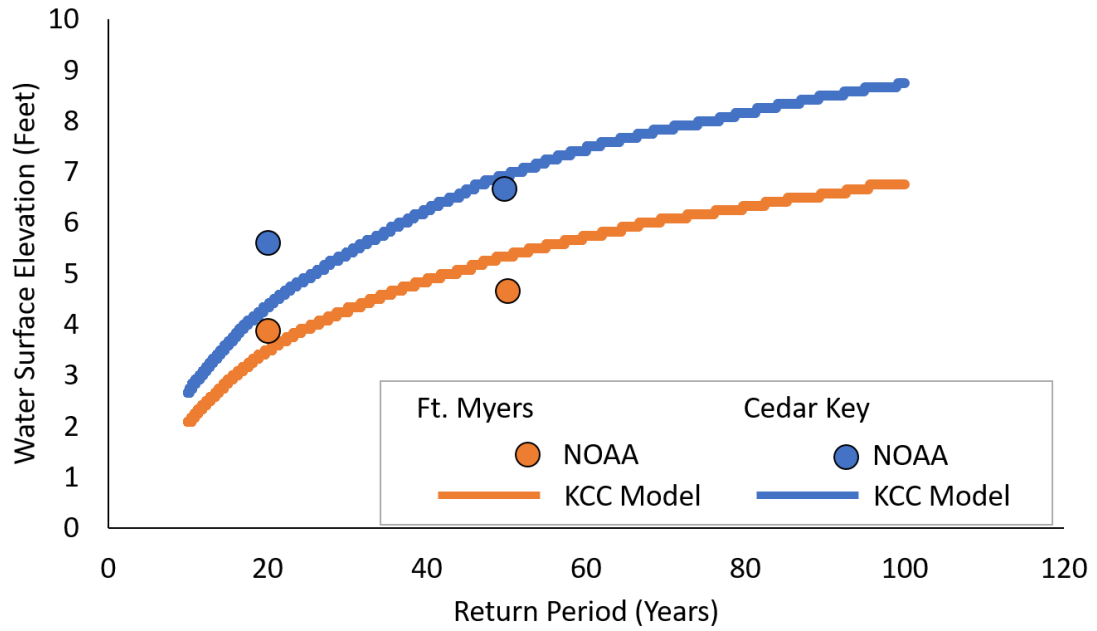


Figure 11 - Sample water elevation validation with NOAA tide gauge data for two points along the Florida coast

Hydrological and Hydraulic Flood Standards

HHF-1 Flood Parameters (Inputs)

- A. *Treatment of land use and land cover (LULC) effects shall be consistent with current scientific and technical literature. Any LULC database used shall be consistent with the National Land Cover Database (NLCD) 2006 or later. Use of alternate datasets shall be justified.***

KCC employs the 2016 NLCD LULC database for land use/land cover information. The treatment of LULC is consistent with current scientific and technical literature. A full list of scientific and technical literature used to develop the model can be found in Standard GF-1, Disclosure 4.

- B. *Treatment of soil effects on inland flooding shall be consistent with current scientific and technical literature.***

The treatment of soil effects on inland flooding in the KCC US Flood Reference Model are consistent with current scientific and technical literature. A full list of scientific and technical literature used in development of the model can be found in Standard GF-1, Disclosure 4.

Disclosures

- 1. *For inland flood analyses associated with riverine and lacustrine flooding, describe how the rivers, lakes, and associated floodplains are segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.***

Using Digital Elevation Model (DEM) data, the flow direction grid is generated by applying an eight-direction (D8) flow model method wherein water flows from one cell towards the lowest elevation cell within the eight surrounding cells. Once the flow direction grid is determined, the flow accumulation grid is calculated by summing the total amount of water that has flowed into lower elevation cells from higher elevation cells.

The channel units (rivers, lakes, and floodplains) are delineated by headwater drainage areas determined from flow direction and flow accumulation grids. The pour points for the channel are the junctions of the stream network derived from the flow accumulation grid.

- 2. *For inland flood analyses associated with surface water flooding, describe how the affected area is segmented (or partitioned) in determining the parameters for flood frequency used in the flood model.***

Using the channel network generated in Standard HHF-1, Disclosure 1, the catchment associated with surface water flooding is determined using the flow direction grid and flow accumulation grid. Each catchment is composed by the catchment grids that flow to the same channel and pour point of the channel. The surface water flooding inside the catchment is simulated using a 2-D approach.

- 3. *Describe any assumptions or calculations used in the inland flood model relating to initial and boundary conditions (e.g., groundwater levels, lake levels, river discharges, tides, soil moisture).***

KCC analyzed the average yearly riverine flow from 2000-2018, which was calculated based on USGS river gauge data. The initial river discharge of the model is assumed to be the mean yearly river discharge and is consistent with the historical data.

For historical event simulations, the initial and boundary conditions are the mean yearly river discharge observed in the historical data. The parameters related to river discharges and soil moisture are then calibrated using 7-year moving historical discharge time series data. Depending on the calibration, the calibrated model parameters can limit the effects of the initial condition.

For stochastic event simulation, the initial condition of river discharge and soil moisture is determined based on precipitation (i.e. extension, duration, and intensity). A constant precipitation rate based on the

climatological precipitation is applied to the model domain for a 60-day spinup period prior to the modeled extreme precipitation event. The precipitation rate for the spinup period is determined from the distribution of climatological precipitation and governs whether the conditions at the initial event time are wet, dry, or average.

The initial and boundary conditions for lake levels and tides are based on the USGS 3DEP DEM data for both historical and stochastic event simulations.

4. Provide the grid resolution or other area partitioning used to model the inland flood extent and depth and how the hydrological and hydraulic characteristics are determined on these scales.

The grid resolution is 1 arc-second (approximately 30 m). The state of Florida and part of the surrounding states affecting Florida (Georgia and Alabama) are divided into six basins: Apalachicola-Choctawhatchee-Escambia, Peace-Tampa, St. Johns, St. Mary, Suwannee-Ochlocknee, and South Florida. Each basin is identified based on the headwater drainage area (which forms the geographic threshold of the modeled basin) and delineated into 1 arc-second model units. The hydrological and hydraulic characteristics are determined for each model unit as average spatial values using zonal statistics.

5. Describe any assumptions or calculations used in the inland flood model relating to flood-induced erosion or topographic changes.

The KCC US Flood Reference Model does not account for flood-induced erosion. KCC routinely checks the USGS 3D Elevation Program (3DEP) for updates in the Digital Elevation Model (DEM). When an update has been released, KCC scientists verify the data for logical consistency and update the model elevation files. KCC assumes that the most current DEM accurately reflects the flood-induced effects of erosion and topography changes.

6. Provide citations to all data sources used to develop and support the land-use evaluation methodology, including publicly-developed or peer-reviewed information.

The use of LULC data and the methodology for evaluation used by KCC is consistent with peer-reviewed literature. The following sources specifically address these areas. A full list of references used to develop the model can be found in Standard GF-1, Disclosure 4.

References for the National Land Cover Database (NLCD) Land Cover 2016 include:

Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., ... & Xian, G. (2018). A new generation of the United States National Land Cover Database: Requirements, research priorities, design, and implementation strategies, *ISPRS Journal of Photogrammetry and Remote Sensing*, 146, 108-123. doi: 10.1016/j.isprsjprs.2018.09.006

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., & Megown, K. (2015). Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing*, 81(5), 345-354.

References for the LULC evaluation methodology include:

Liu, Z., Merwade, V., & Jafarzadegan, K. (2018). Investigating the role of model structure and surface roughness in generating flood inundation extents using 1D and 2D hydraulic models. *Journal of Flood Risk Management*: e12347.

Ponce, V. M. (1989). *Engineering hydrology: Principles and practices* (Vol. 640). Englewood Cliffs, NJ: Prentice Hall.

7. Provide the collection and publication dates of the LULC and soil data used in the flood model and justify the applicability and timeliness of the data for Florida.

KCC uses the 2016 NLCD LULC data for land cover, which is the most current LULC database. This provides the most up-to-date reflection of land use/land cover in the US, including Florida.

For soil data, the unified North American Soil Map (2014) and the global high-resolution dataset of soil hydraulic and thermal parameters for land surface modeling (Dai et al., 2019) are utilized. These provide the most current soil dataset required for flood modeling.

8. Describe the methodology used to convert LULC information into a spatial distribution of hydrological parameters, including roughness coefficients, throughout the flood model domain.

The hydrological parameters are derived from LULC information based on numerous technical and scientific sources, including Ponce (1989) and HEC-HMS Technical Reference Manual (CPD-74B). Each LULC classification type is assigned a value consistent with published literature, and each pixel in the LULC database is assigned a value accordingly. To determine the LULC parameter for each model unit (i.e. catchment), the average pixel value within the model unit is calculated. The roughness coefficients for each model unit are calibrated according to discharge data from USGS gauges.

9. Describe the methods used to account for soil infiltration and percolation rates and soil moisture conditions in the inland flood model, if applicable. Provide citations to all data sources used to develop and support the soil infiltration and percolation rates and soil moisture conditions methodology, including publicly-developed or peer-reviewed information.

KCC applies a current scientific method (Clapp and Hornberger method) to calculate soil infiltration rate. KCC employs the widely accepted Darcy's Law equation and calculates the subsurface flow rate using kinematic wave routing. Key parameters for this calculation are hydraulic conductivity and the porosity derived from Dai et al. (2019). The parameters are calculated as the spatial average value for each model unit (i.e. catchment).

Soil data used in the model are extracted from Liu et al. (2014) and Dai et al. (2019), the full references of which are below.

Liu, S., Wei, Y., W.M. Post, W.M, Cook, R.B., Schaefer, K., & Thornton, M.M. (2014). NACP MsTMIP: Unified North American Soil Map. Data set. Oak Ridge, TN: Oak Ridge National Laboratory Distributed Active Archive Center. doi: 10.3334/ORNLDAAAC/1242

Dai, Y., Xin, Q., Wei, N., Zhang, Y., Shangguan, W., Yuan, H., ... & Lu, X. (2019). A global high-resolution data set of soil hydraulic and thermal properties for land surface modeling. *Journal of Advances in Modeling Earth Systems*, 11. doi: 10.1029/2019MS001784

The soil moisture data is extracted from the Soil Moisture Active and Passive (SMAP) mission (Njoku et al., 2009), and the initial soil moisture condition is determined as the yearly average value. The reference for SMAP data follows.

Njoku, E., Entekhabi, D., Kellogg, K., & O'Neill, P. (2009). The Soil Moisture Active and Passive (SMAP) Mission. In *Earth Observation and Water Cycle Science* (Vol. 674).

Additional references used to develop the KCC model can be found in Standard GF-1, Disclosure 4.

HHF-2 Flood Characteristics (Outputs)**A. Flood extent and elevation or depth generated by the flood model shall be consistent with observed historical floods affecting Florida.**

Flood extent and depth generated by the KCC US Flood Reference Model are consistent with observed historical floods affecting Florida. Additional validation can be found in Standard HHF-2, Disclosure 1.

B. Methods for deriving flood extent and depth shall be scientifically defensible and technically sound.

The methods employed to derive flood extent and depth are scientifically defensible and technically sound. Additional information about methods employed is detailed in Standard HHF-2, Disclosures 4-8, and a list of references used to develop the model can be found in Standard GF-1, Disclosure 4.

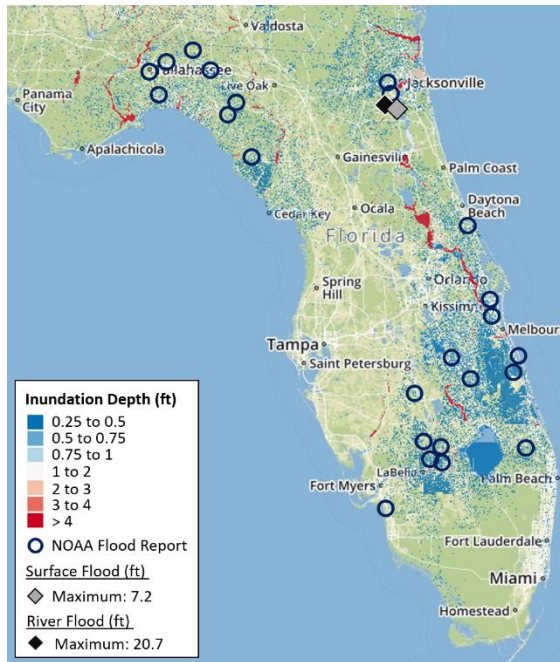
C. Modeled flood characteristics shall be sufficient for the calculation of flood damage.

The KCC US Flood Reference Model exports the maximum flood depth for a certain location during the event. Analysis of inundation versus flood velocity for surface runoff and channel flows showed that the maximum depth per second is a reasonable estimate for inland flood velocity. This is consistent with FEMA (2011) lower bounds of flood velocity for storm surge. The calculation of flood damage is generated using these modeled flood characteristics.

Disclosures**1. Provide comparisons of the modeled and historical flood extents and elevations or depths for the storm events listed in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps. For any storms where sufficient data are not available, the modeling organization may substitute an alternate historical storm of their choosing. Describe how each substituted storm provides similar coastal and inland flooding characteristics to the storm being replaced.**

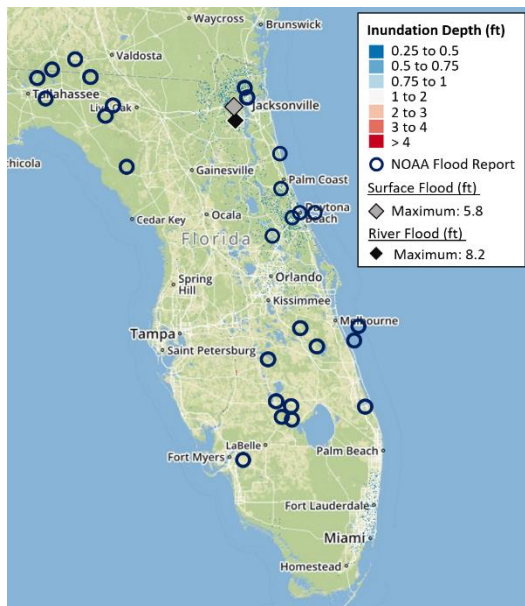
KCC routinely validates the modeled flood footprints with data from the NOAA Storm Events Database. The figures below show the comparisons of KCC modeled and historical flood for Tropical Storm Fay (August 2008), Unnamed Storm in East Florida (May 2009), and Unnamed Storm in Panhandle (July 2013). Blue squares are the reported flood locations from NOAA Storm Events Database demonstrating consistency between the modeled and actual flood extents.

The flood depths from NOAA storm reports are estimated using the provided description in the storm report database. The modeled flood depths are determined from the minimum and maximum flood depths in the square area. The comparison between modeled and observed flood depths are included in the tables below. Note that in the following tables 'NA' represents no specific description of flood depth from the NOAA Storm Events Database.



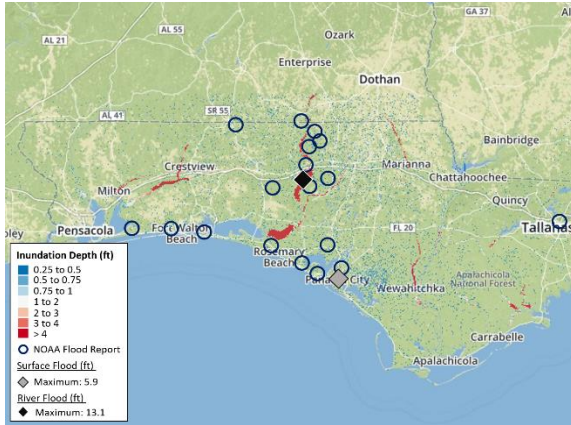
Latitude	Longitude	NOAA Flood depth, in	Modeled flood depth, in
30.6	-83.9	~ 12	12- 48
30.5	-84.4	~ 12	12-48
30.4	-83.6	~ 12	12- 48
30.4	-81.7	> 36	24- 60
30.3	-81.7	> 36	12- 60
30.2	-84.2	~ 12	12- 36
30.1	-83.3	12- 24	12- 24
30.0	-83.4	12- 24	6- 24
29.0	-80.9	12- 24	12-24
28.3	-80.7	~ 36	12- 48
28.1	-80.7	NA	12- 48
27.8	-81.2	12- 36	12- 24
27.8	-80.4	NA	< 24
27.6	-80.5	NA	< 12
27.6	-80.9	NA	< 12
27.4	-81.5	~ 12	12- 36
27.0	-80.3	NA	< 12
27.0	-81.4	NA	12-36
26.8	-81.3	NA	12- 24
26.7	-81.2	NA	12- 24
26.4	-81.8	~ 12	< 12

Figure 12 - Comparison of NOAA flood extent and depth to KCC modeled footprint for Tropical Storm Fay (August 2008)



Latitude	Longitude	NOAA flood depth, in	Modeled flood depth, in
30.4	-81.7	< 12	12- 36
30.3	-81.7	12- 24	12- 36
29.6	-81.3	12- 36	12-36
29.9	-81.3	12- 24	12- 24
29.3	-81.1	12- 36	12- 48
29.1	-81.3	12- 24	12- 36
30.9	-86.9	< 12	< 12

Figure 13 - Comparison of NOAA estimated flood depth and KCC modeled flood depth for Unnamed Storm in East Florida (May 2009)



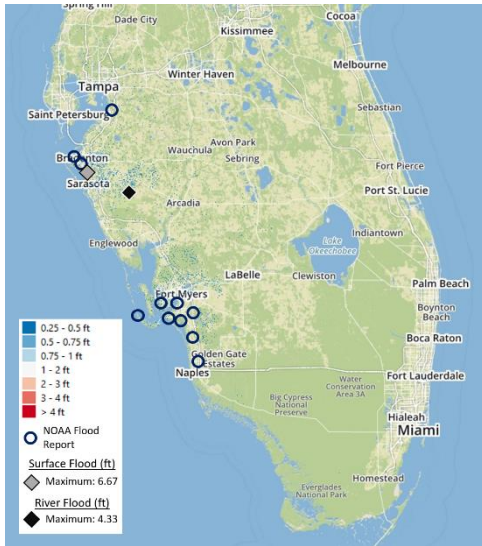
Latitude	Longitude	NOAA flood depth, in	Modeled flood depth, in
31.0	-85.8	12- 24	12- 36
31.0	-86.2	12- 24	12- 36
30.9	-85.7	12- 24	12- 36
30.6	-86.0	12- 24	12- 36
30.7	-85.7	12- 24	12- 48
30.5	-84.3	12- 24	12- 48
30.6	-85.8	12- 24	12- 48
30.4	-86.9	> 6	12- 24
30.4	-86.5	6- 24	12- 24
30.3	-86.1	6- 9	12- 24
30.2	-85.8	6- 24	12- 48
30.2	-85.6	12- 24	24- 48
30.1	-85.7	12- 36	12- 48

Figure 14 - Comparison of NOAA estimated flood depth and KCC modeled flood depth for Unnamed Storm in Panhandle (July 2013)

2. ***Demonstrate that the inland flood model component incorporates flood parameters necessary for simulating inland flood damage and accommodates the varied geographic, geologic, hydrologic, hydraulic, and LULC conditions in Florida. Provide justification for validation using any historical events not specified in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps.***

Extensive validation test results demonstrate that the model flood parameters are sufficient for modeling flood conditions in regions of different geographic, geologic, hydrologic, hydraulic, and LULC conditions.

In addition to the validation results from Standard HHF-2, Disclosure 1, KCC scientists selected Unnamed Storm Event in Peace Tampa Region (August 2017) to ensure consistency of model validation results across the entire state because the Southwest Florida region was underrepresented by the requested validations. In addition to the events listed in Form HHF-1, this demonstrates that all flood parameters necessary for accurately capturing the flood risk are included in the KCC US Flood Reference Model.



Latitude	Longitude	NOAA flood depth, in	Modeled flood depth, in
27.8	-82.4	~ 24	12-24
27.5	-82.6	~ 36	12- 48
27.4	-82.5	12- 36	12- 48
26.6	-81.9	~ 36	12- 48
26.6	-82.1	12- 36	12-36
26.4	-81.8	~ 24	12- 24
26.3	-81.8	12 -24	12- 24
26.2	-81.7	~ 12	12

Figure 15 - Comparison of NOAA estimated flood depth and KCC modeled flood depth for Unnamed Storm in Peace Tampa Region (August 2017)

3. For each of the storm events in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, resulting in inland flooding, provide a comparison of the modeled flood flow to recorded flow data from selected United States Geological Survey (USGS) or Florida Water Management District (FWMD) gauging stations. Provide the rationale for gauging station selections.

The KCC scientists selected United States Geological Survey (USGS) gauges for analyses based on the criteria listed below:

- The selected gauges include flow data and gauge height data for the storm events listed in Form HHF-1.
- Since the KCC US Flood Reference Model is calibrated based on data encompassing seven years (2003-2009), the gauge should have the flow and gauge height data continuously from 2003 to 2009.
- Gauge datum information for the USGS gauges must be available in order to calibrate the water surface elevation, either NAVD88 or NGVD29. The water surface elevation in NGVD29 is converted to NAVD88.
- For each watershed, not only an outlet USGS gauge should be selected, but any available USGS gauges on tributaries should be included.

All USGS gauges used to conduct the following model comparisons met these requirements.

Comparisons of modeled versus observed flood flow and water surface elevation for Tropical Storm Fay (2008) were conducted using USGS gauge 02330100.

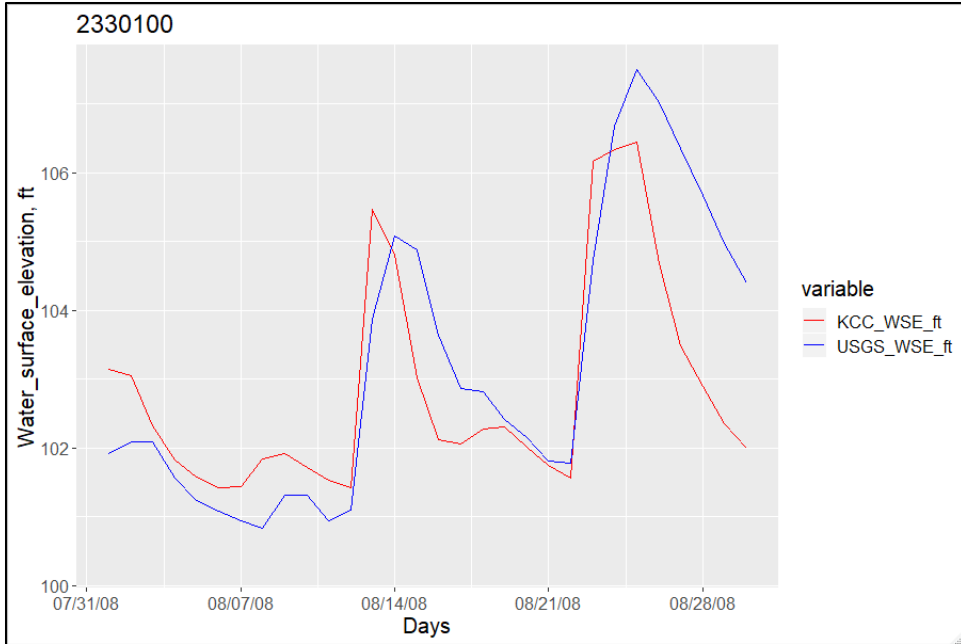


Figure 16 - Comparison of KCC modeled (red) to recorded (blue) water surface elevation for Tropical Storm Fay (August 2008)

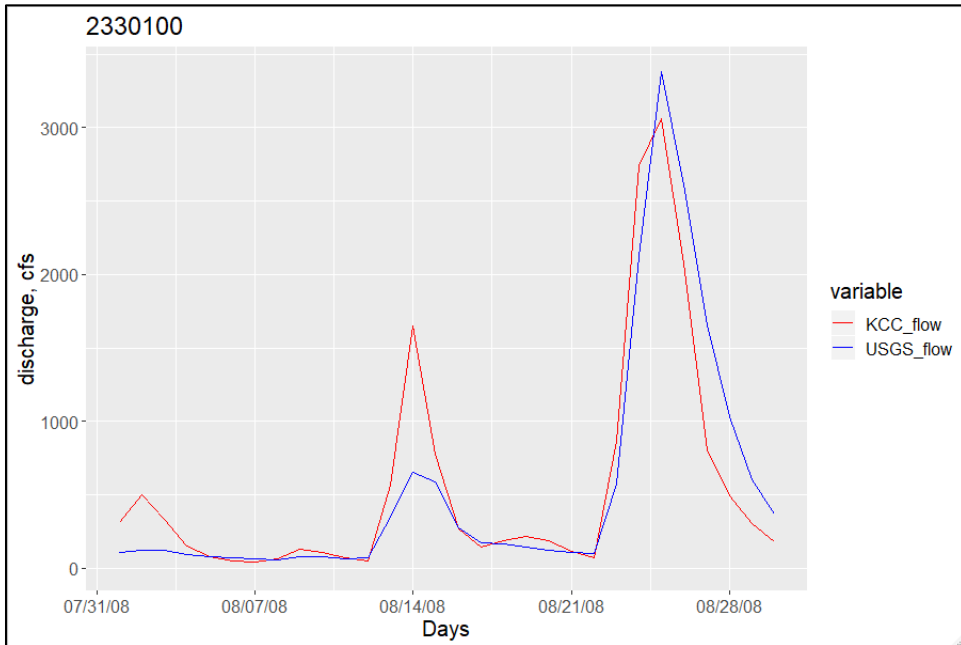


Figure 17 - Comparison of modeled (red) to recorded (blue) river discharge for Tropical Storm Fay (August 2008)

Comparisons of modeled versus observed flood flow and water surface elevation for Unnamed Storm in East Florida (May 2009) were conducted using USGS gauge 02245500.

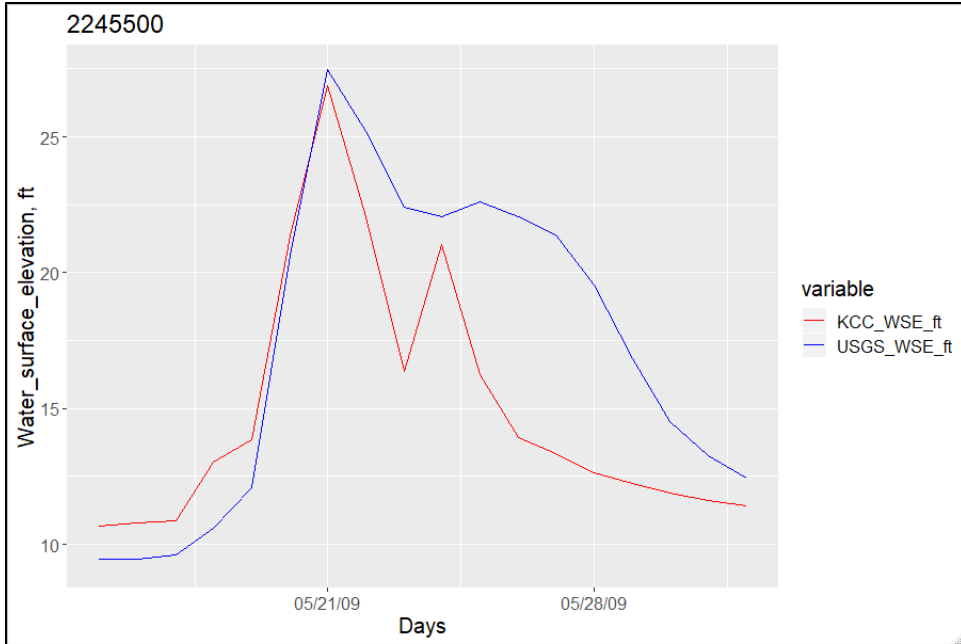


Figure 18 - Comparison of KCC modeled (red) to recorded (blue) water surface elevation for Unnamed Storm in East Florida (May 2009)

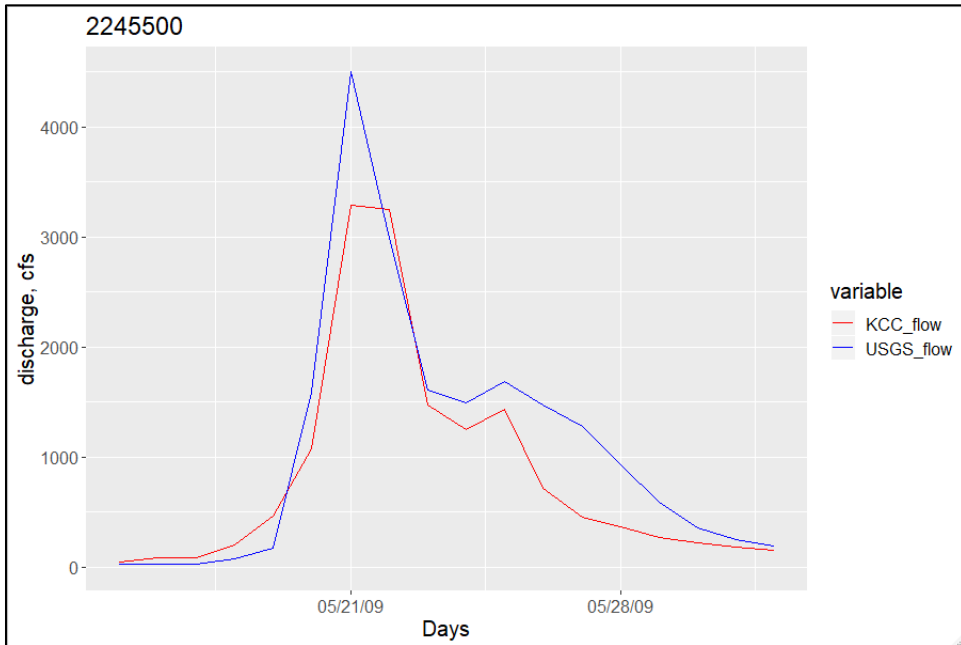


Figure 19 - Comparison of modeled to recorded river discharge for Unnamed Storm in East Florida (May 2009)

Comparisons of modeled versus observed flood flow and water surface elevation for Unnamed Storm in Panhandle (July 2013) were conducted using USGS gauge 02368000.

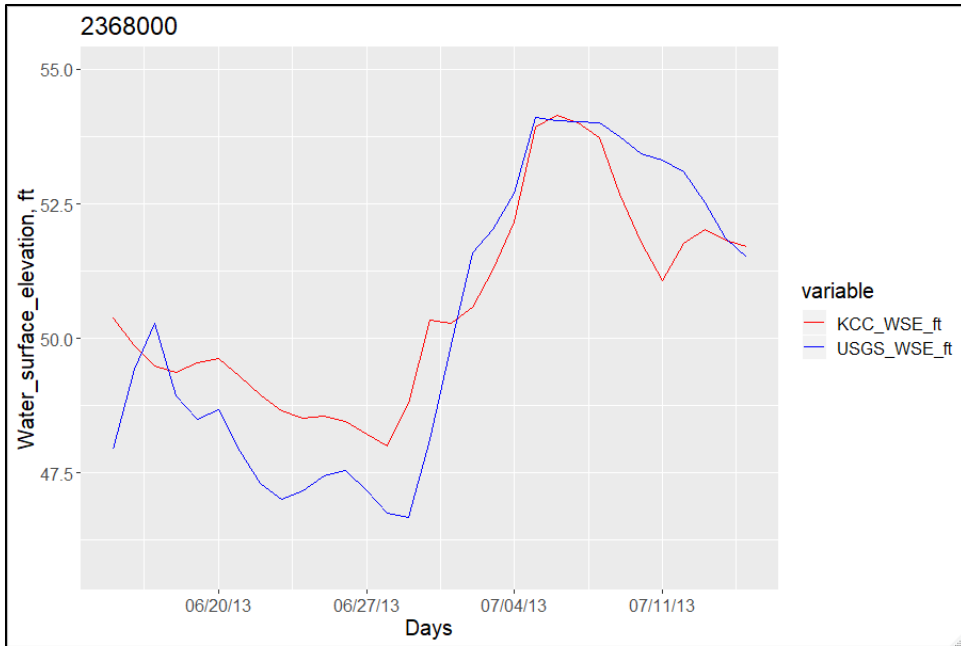


Figure 20 - Comparison of KCC modeled (red) to recorded (blue) water surface elevation for Unnamed Storm in Panhandle (July 2013)

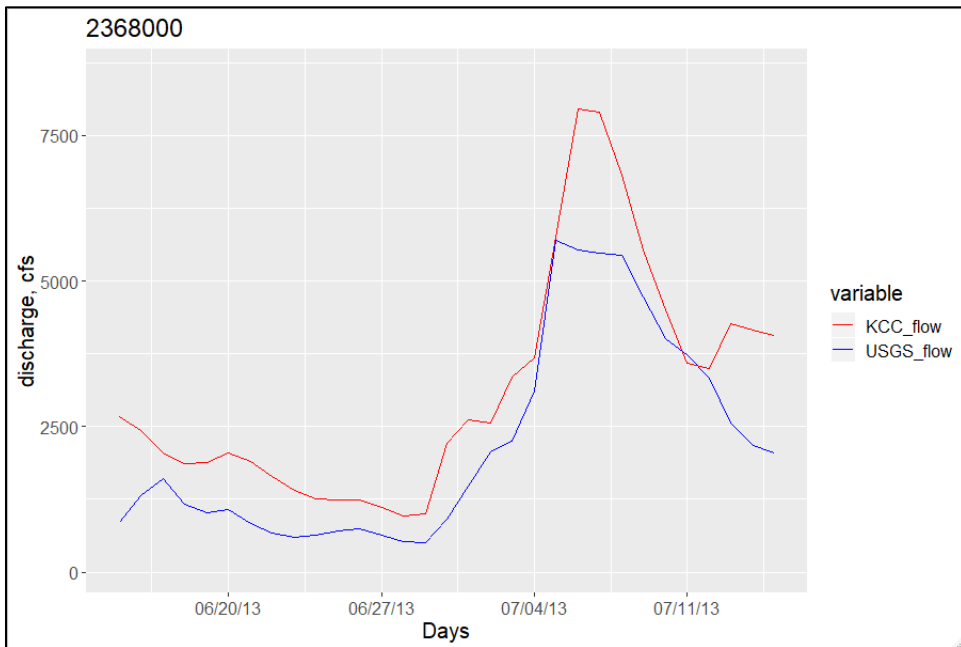


Figure 21 - Comparison of KCC modeled (red) to recorded (blue) river discharge for Unnamed Storm in Panhandle (July 2013)

4. Identify all hydrological and hydraulic variables that affect the flood extent, elevation, depth, and other flood characteristics.

For surface water flooding, the hydrological and hydraulic variables used in the KCC US Flood Reference Model are:

- Catchment length
- Catchment surface roughness
- Catchment slope
- Soil moisture in percentile
- Soil hydraulic conductivity

For riverine flood, the hydrological and hydraulic variables used in the KCC US Flood Reference Model are:

- Channel length
- Channel slope
- Channel roughness
- Bankfull discharge channel depth
- Bankfull discharge channel width
- Channel surface roughness
- Cross section area

5. For inland flood modeling, describe if and how the flood model accounts for flood velocity, flood duration, flood-induced erosion, floodborne debris, and contaminated floodwaters.

The KCC US Flood Reference Model models flood depth but does not explicitly model flood duration, flood-induced erosion, flood borne debris, or contaminated floodwaters. Analysis of inundation versus flood velocity for surface runoff and channel flows showed that the maximum depth per second is a reasonable estimate for inland flood velocity. This is consistent with the FEMA (2011) lower bounds of flood velocity for storm surge. As described in Standard VF-1, Disclosure 6, the impact of these other flood characteristics is accounted for in the development of vulnerability functions.

6. Describe the effect of any assumptions or calculations relating to initial and boundary conditions on the flood characteristics.

The initial and boundary conditions for riverine floods are defined as the average yearly river discharge derived from 60 USGS gauges from 2000-2018. This determines the discharge in the river at the beginning of the simulation. The initial flood stages are calculated using the initial and boundary conditions of discharge with the assumption of a wide rectangular shape for the channel and floodplain. For surface water and lacustrine flood, the initial soil moisture percentile is set to the yearly average soil moisture derived from Soil Moisture Active and Passive (SMAP) mission. The parameters of riverine and surface flooding are calibrated using the 7-year historical data from USGS (2003-2009). The KCC US Flood Reference Model applies the initial and boundary conditions with the calibrated parameters to simulate the historical events with a spinup time of 90 days.

For stochastic event simulations, the initial river discharge and soil moisture are simulated using a constant daily precipitation rate for a 60-day spinup period prior to the modeled extreme precipitation event. The precipitation rate is determined from the distribution of climatological precipitation and governs whether the conditions at the initial event time are wet, dry, or average.

The precipitation rate during the spinup period impacts the initial river discharge and soil moisture before the stochastic event simulation starts. High initial river discharge requires relatively less precipitation to generate a higher riverine flood depth. Also, a high soil moisture means more water will remain in the soil, and relatively less precipitation is required to generate surface water flooding. For low river discharge and soil moisture conditions, the precipitation will need to be relatively high to induce flooding as most of the water can be absorbed by the soil and can result in minimal to no surface water flooding. Therefore, the flood depth of stochastic events is affected by the initial and boundary conditions both for surface and riverine flooding.

7. Describe and justify the appropriateness of the databases and methods used for the calibration and validation of flood extent and elevation or depth.

The flood depth for the KCC US Flood Reference Model is calibrated and validated against United States Geological Survey (USGS) river gauge data. The USGS maintains historical stream gauge observations for thousands of sites across the US and is the standard for surface water recordings. Data is available between 15-60 minute intervals, and historical observations are verified by USGS scientists.

Precipitation (rain rate, extent, and duration) is validated using data from the Dartmouth Flood Observatory and National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS). The Dartmouth Flood Observatory, a project of the University of Colorado, conducts reanalysis of historical floods to ascertain their extent and relative severity using a variety of sources, including journalism, governmental reports, and instrumental and remote sensing methods. NOAA NWS maintains databases about historical and current precipitation across the US. Data can be extracted from NOAA NWS databases, and historical data has been verified for accuracy by NOAA NWS.

8. Describe any variations in the treatment of the flood model flood extent and elevation or depth for stochastic versus historical floods, and justify this variation.

The KCC US Flood Reference Model does not apply any variations in the treatment of flood characteristics between the historical and stochastic floods.

9. Provide a completed Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps. Provide a link to the location of the form [insert hyperlink here].

[Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps](#)

10. Provide a completed Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability. Provide a link to the location of the form [insert hyperlink here].

[Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability](#)

HHF-3 Modeling of Major Flood Control Measures

- A. *The flood model's treatment of major flood control measures and their performance shall be consistent with available information and current state-of-the-science.***

Major flood control measures are consistent with state-of-the-science and available information. The KCC Flood Reference Model includes information for major dams and levees in Florida, which is derived from National Inventory of Dams (NID) database and National Levee Database (NLD) maintained by US Army Corps of Engineers (USACE). Additional resources from local water management agencies are also used to supplement the USACE data. Flood control measures are modeled as height barriers along the floodplain. The USGS DEM elevation files are verified against the levee and dam data to ensure major flood control measures are included.

- B. *The modeling organization shall have a documented procedure for reviewing and updating information about major flood control measures and if justified, shall update the flood model flood control databases.***

KCC maintains a documented procedure for evaluating and updating information about major flood control measures. If justified, the model is updated in accordance with Standard CIF-6, Part A.

- C. *Treatment of the potential failure of major flood control measures shall be based upon current scientific and technical literature, empirical studies, or engineering analyses.***

The KCC US Inland Flood Reference Model applies the 2D water movement method to simulate the failure of major flood control measures.

Disclosures

- 1. *List the major flood control measures incorporated in the flood model and the sources of all data employed.***

The National Inventory of Dams (NID) database and National Levee Database (NLD) is used to design the flood protection structures in the KCC US Flood Reference Model (USACE, 2019). All major dams and levees identified in the USACE databases are incorporated into the model. Below are the major dams with high hazard risk and the NID storage greater than 50,000 acre-feet.

- (i) Herbert Hoover Dike in Okeechobee County
- (ii) Jim Woodruff Dam for Lake Seminole In Gadsden County
- (iii) Jackson Bluff Dam for Lake Talquin In Leon County
- (iv) Martin Plant Cooling Water Reservoir Dam in Martin County

In addition, the L-31 East Levee flood control structure in Miami-Dade County, designed for protection against coastal flooding, is explicitly included in the model.

KCC maintains a documented procedure for evaluating and updating information about major flood control measures. If justified, the model is updated in accordance with Standard CIF-6, Part A.

- 2. *Describe the methodology to account for major flood control measures in the flood model and indicate if these measures can be set (either to on or off) in the flood model.***

Flood control measures are modeled as height barriers along the floodplain and cannot be set by the model user. The heights of flood barriers are extracted from DEMs generated by the USGS and are consistent with data maintained by the USACE. The KCC US Flood Reference Model considers the dams and levees included in the model unit (i.e. catchment and channel). The KCC US Inland Flood Reference Model includes the simulation of dam or levee failure for specific locations and durations. The height of dams and levees are extracted from DEMs generated by the USGS.

3. Describe if and how major flood control measures that require human intervention are incorporated into the flood model.

The KCC US Flood Reference Model considers the dams and levees included as model units. The discharge and water surface elevation for dams and levees are calibrated based on USGS flow discharge and water gauge height information. In addition, the model is capable of simulating dam and levee break scenarios. However, the model does not model human intervention on major flood control measures, such as dam shutdown or flow control.

4. Describe and justify the methodology used to account for the potential failure or alteration of major flood control measures in the flood model and if the level of failure can be adjusted in the flood model.

The KCC US Inland Flood Reference Model can simulate the levee failure based on the failure location and failure duration. A 2D surface water movement simulation is used to simulate the levee failure. The parameters used in this method are the flood control measure failure location (latitude and longitude), the failure time in seconds, and flow discharge rate in m³/s.

5. Provide an example of the flood extent and elevation or depth showing the potential impact of a major flood control measure failure.

The L-31 East levee system in Miami-Dade County is selected to illustrate the levee break scenario. It was completed in 1968 in an effort by the USACE to prevent saltwater flooding of parts of Homestead and Florida City. The levee is 7 feet tall and stretches for 19 miles along the Biscayne Bay coastline. The figures below show the simulation of levee break during a major hurricane.

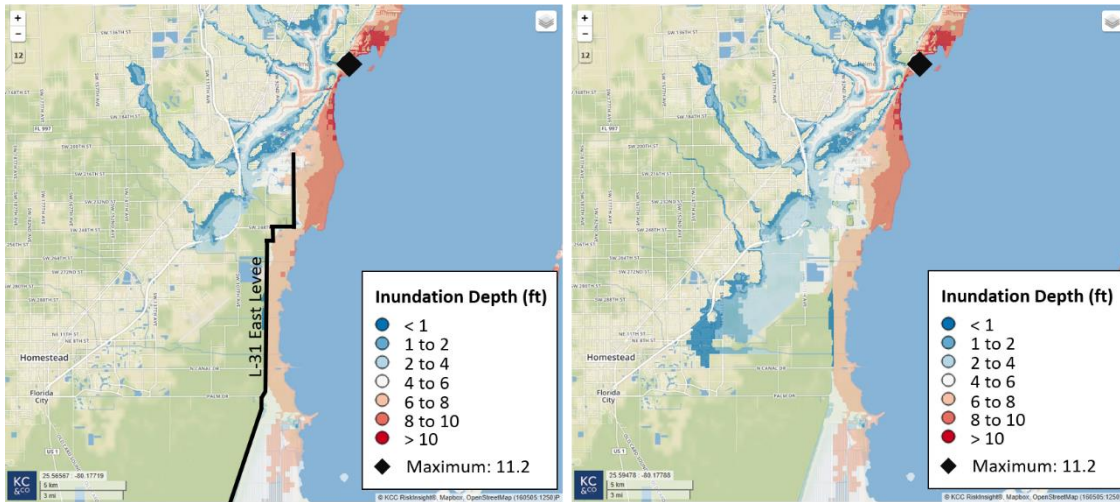


Figure 22 - The KCC US Coastal Flood Reference Model footprints for a major hurricane showing inundation in and around Homestead, FL (left) and with a levee break near the Black Creek Canal (right)

HHF-4 Logical Relationships Among Flood Parameters and Characteristics

- A. At a specific location, water surface elevation shall increase with increasing terrain roughness at that location, all other factors held constant.**

Because Manning's equation is employed in the KCC US Flood Reference Model, as the terrain roughness increases with all other factors (terrain steepness and discharge rate) remaining constant, the cross section area will increase, which leads increased water surface elevation. Please see Figure 22 in HHF-4 Disclosure 1 for examples from different regions in Florida.

- B. Rate of discharge shall increase with increase in steepness in the topography, all other factors held constant.**

Because Manning's equation is employed in the KCC US Flood Reference Model, as the steepness in the topography increases with all other factors (terrain roughness and cross section geometry) remaining constant, the discharge rate will increase. Please see Figure 23 in HHF-4 Disclosure 1 for examples from different regions in Florida.

- C. Inland flood extent and depth associated with riverine and lacustrine flooding shall increase with increasing discharge, all other factors held constant.**

Because Manning's equation is employed in the KCC US Flood Reference Model, as the discharge rate increases with all other factors (terrain roughness and steepness in the topography) remaining constant, the cross section area will increase, which leads to increased inland flood extent and depth. Please see Figure 24 in HHF-4 Disclosure 1 for examples from different regions in Florida.

- D. The coincidence of storm tide and inland flooding shall not decrease the flood extent and depth, all other factors held constant.**

The coincidence of storm tide and inland flooding does not decrease the flood extent and depth for either peril. The interaction between coastal and inland flooding is accounted for in the financial component of the model.

Disclosures

- 1. Provide a sample graph of water surface elevation and discharge versus time associated with inland flooding for modeling-organization-defined locations within each region in Florida identified in Figure 4. Discuss how the flood characteristics exhibit logical relationships.**

All figures shown below demonstrate logical relationships among flood parameters and characteristics, including terrain roughness, steepness in the topography, and discharge rate. Water surface elevation consistently increases with increasing terrain roughness and flow discharge rate, all other factors held constant. Flow discharge consistently increases with increases in the steepness of the topography (slope), all other factors held constant.

The following charts demonstrate the relationships for the Panhandle, North Florida, East Florida, Southeast Florida, and Southwest Florida. Each model parameter was systematically adjusted to demonstrate the logical relationship between the model parameter and modeled discharge. This was repeated for modeled surface water elevation.

The table below shows the general information for selected model units in each region.

Region	County	Stream	Close to USGS gauge	USGS gauge No.
Panhandle	Okaloosa	Yellow River	Y	02368000
North Florida	Gilchrist	Santa Fe River	Y	02322500
Southwest Florida	Sarasota	Myakka River	Y	02298830
East Florida	Highlands	Arbuckle Creek	Y	02270500
Southeast Florida	Miami-Dade	Black Creek	Y	02290709

Table 3 - Information for selected model units in each region.

Part A: Increased Terrain Roughness Comparisons

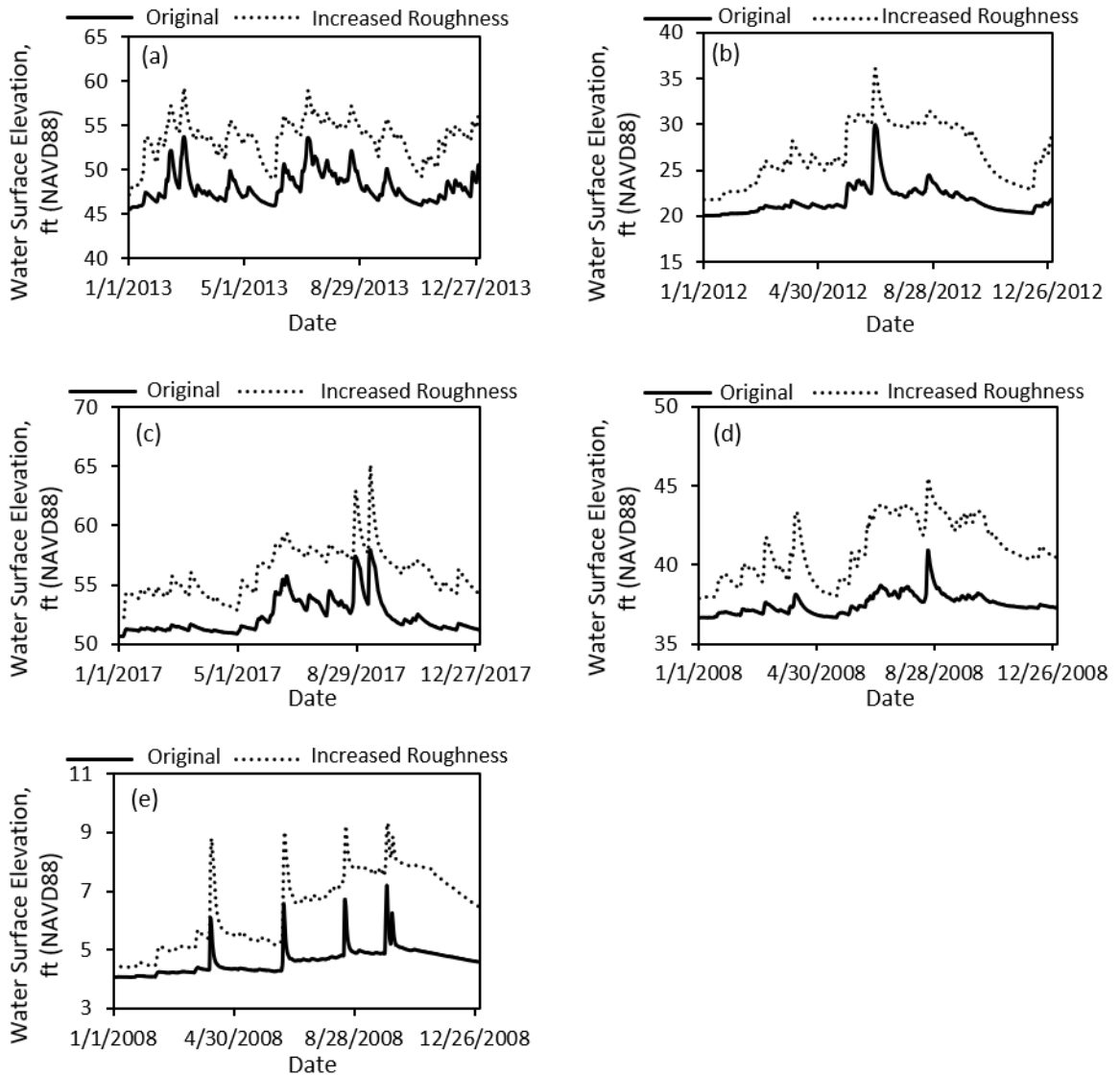


Figure 23 – Demonstration of the logical relationship of model parameters to water surface elevation by increasing terrain roughness in different regions: (a) Panhandle, (b) North Florida, (c) Southwest Florida, (d) East Florida, and (e) Southeast Florida

Part B: Increased Steepness in the Topography Comparisons

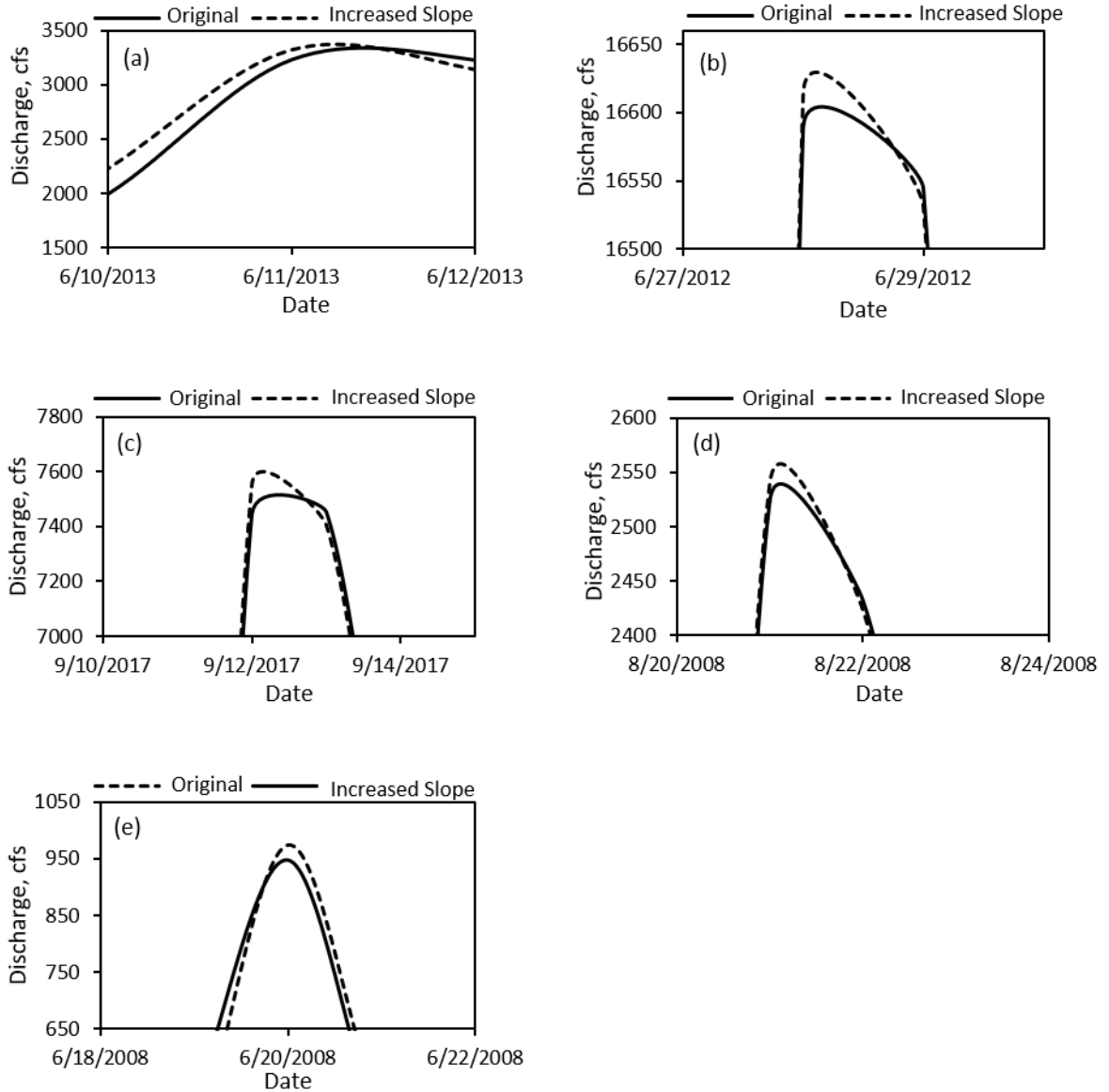


Figure 24 - Demonstration of the logical relationship of model parameters to water surface elevation by increasing steepness in the topography in different regions: (a) Panhandle, (b) North Florida, (c) Southwest Florida, (d) East Florida, and (e) Southeast Florida

Part C: Increased Discharge Comparisons

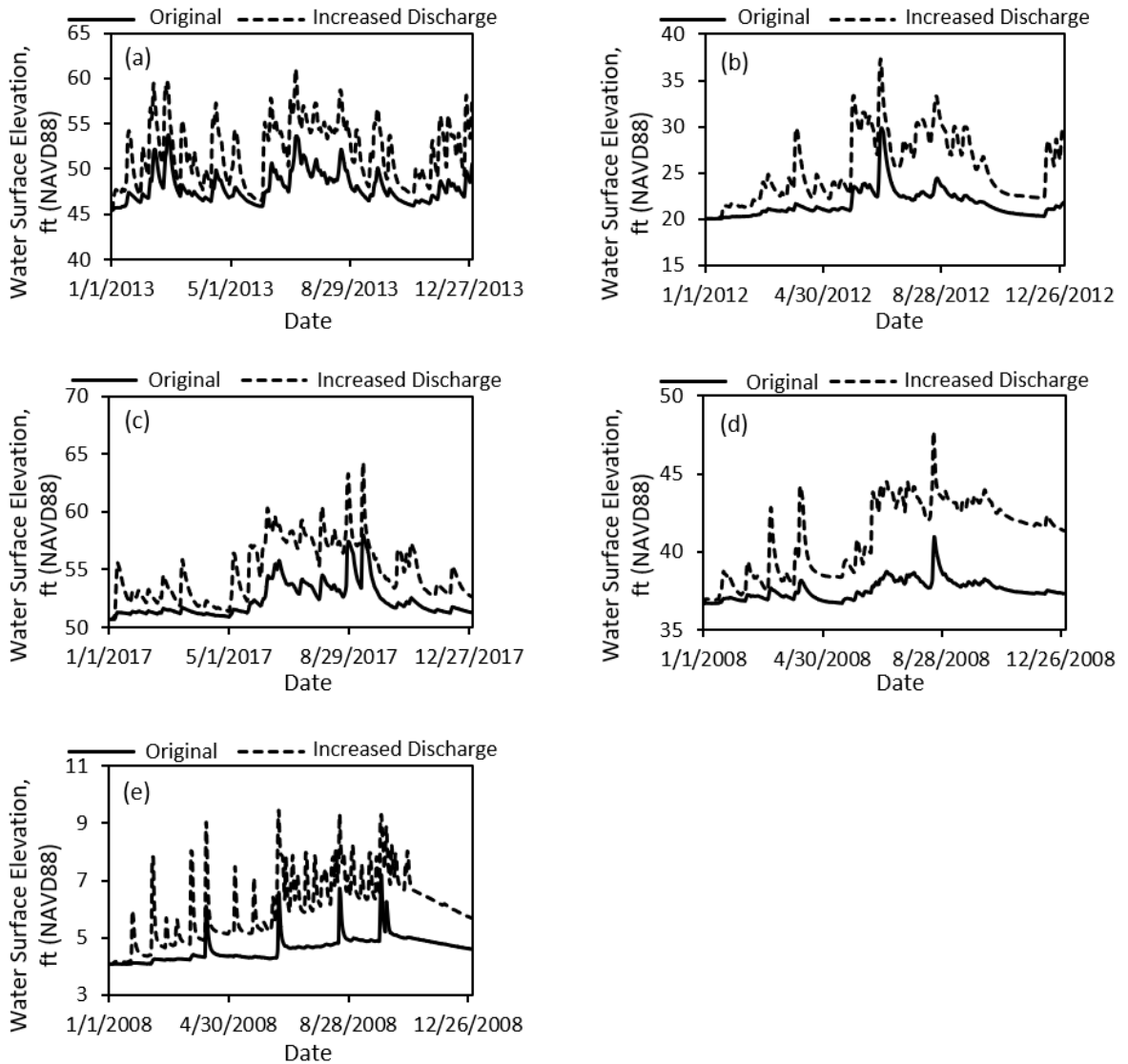


Figure 25 - Demonstration of the logical relationship of model parameters to water surface elevation by increasing discharge in different regions: (a) Panhandle, (b) North Florida, (c) Southwest Florida, (d) East Florida, and (e) Southeast Florida

2. Describe the analysis performed in order to demonstrate the logical relationships in this standard.

All logical relationships are derived from Manning's equation, shown below.

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

Where

Q = flow discharge rate in ft³/s

n = roughness coefficient

A = cross section area, in ft²

R = hydraulic radius, in ft

S = slope

KCC simulates an increased discharge by increasing the precipitation rate. From Manning's equation, if all other factors held constant including geometry, a high flow discharge rate results in a larger cross section area. Thus, the water surface elevation and flood depth will increase, which is shown in Standard SF-1, Disclosure 1.

For riverine flood simulations, the increase in the elevation at one location can increase the slope, resulting in an increased rate of discharge according to Manning's equation.

With the flow discharge and steepness in the topography constant, increasing the terrain roughness leads to a larger cross section area, which results in an increased water surface elevation.

To complete the analyses, KCC scientists systematically re-simulated the same event with one parameter adjusted to evaluate the impact of that parameter on the modeled results. As demonstrated in Standard HHF-4, Disclosure 1, the modeled results were consistent with the expectations derived from Manning's equation.

Statistical Flood Standards

SF-1 Modeled Results and Goodness-of-Fit

- A. The use of historical data in developing the flood model shall be supported by rigorous methods published in current scientific and technical literature.**

The historical data used for the development of the coastal flood and inland flood models is from the normative data sources and is supported with rigorous data analysis techniques based on current scientific and technical literature.

- B. Modeled results and historical observations shall reflect statistical agreement using current scientific and statistical methods for the academic disciplines appropriate for the various flood model components or characteristics.**

The statistical analysis of the historical data and modeled results follow statistical methods that are supported by academic literature within the appropriate disciplines.

Disclosures

- 1. Provide a completed Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland). Identify the form of the probability distributions used for each function or variable, if applicable. Identify statistical techniques used for estimation and the specific goodness-of-fit evaluations applied along with appropriate metrics. Describe whether the fitted distributions provide a reasonable agreement with available historical data. Provide a link to the location of the form [insert hyperlink here].**

Form SF-1: Distributions of Stochastic Flood Parameters (Coastal, Inland)

Additional information on goodness-of-fit test results can be found in Standard SF-1, Disclosure 5.

- 2. Provide the date of loss of the insurance claims data used for validation and verification of the flood model.**

The following chart summarizes the dates of events for which insurance claims data were used for validation and verification of the flood model.

Event	Start	End
1	3/30/2009	3/31/2009
2	5/15/2009	5/21/2009
3	12/12/2009	12/15/2009
4	6/9/2012	6/12/2012
5	6/22/2012	7/2/2012
6	7/3/2013	7/6/2013
7	4/30/2014	5/1/2014
8	10/21/2014	10/22/2014
9	9/2/2016	9/10/2016
10	10/6/2016	10/9/2016
11	6/22/2017	6/23/2017
12	8/27/2017	8/31/2017
13	9/8/2017	9/19/2017
14	10/9/2018	10/12/2018

Table 4 - Dates of events for which insurance claims data were used to validate the KCC US Flood Reference Model

3. Provide an assessment of uncertainty in flood probable maximum loss levels and in flood loss costs for flood output ranges using confidence intervals or other scientific characterizations of uncertainty.

KCC scientists have studied the contribution of different model parameters. For coastal flood, central pressure, radius of maximum winds, forward speed, and the track direction were examined. For inland flood, the precipitation amount, duration, spatial extent, eccentricity, theta value, and the initial precipitation parameters were analyzed. The results described in Standard SF-3, Disclosures 1-3, show that the track direction is the largest contributor to the uncertainty in the loss costs for coastal flood. For inland flood, the largest contributor to the uncertainty in flood model loss costs varies significantly by both precipitation category and region. In southern Florida, the duration of the event was the greatest contributor to the uncertainty in loss costs for events with lower and average precipitation, whereas the precipitation amount was the greatest contributor to the uncertainty in loss costs for events with higher precipitation. In northern Florida, the initial precipitation was the greatest contributor to loss costs for events with lower precipitation, whereas the extent of the event was the greatest contributor to loss costs for events with average and higher precipitation.

4. Justify any differences between the historical and modeled results using current scientific and statistical methods in the appropriate disciplines.

Modeled results, using scientific and statistical methods in the appropriate disciplines, are consistent with historical results.

5. Provide graphical comparisons of modeled and historical data and goodness-of-fit evaluations. Examples to include are flood frequencies, flow, elevations or depths, and available damage.

Annual Frequency (Inland Flood)

The following graph displays the inland flood frequency implemented in the KCC US Inland Flood Reference Model. The historical data was fit to a Poisson distribution. The Chi-Square test was used to test the goodness-of-fit and resulted in a p-value of 0.56, which suggests a good fit.

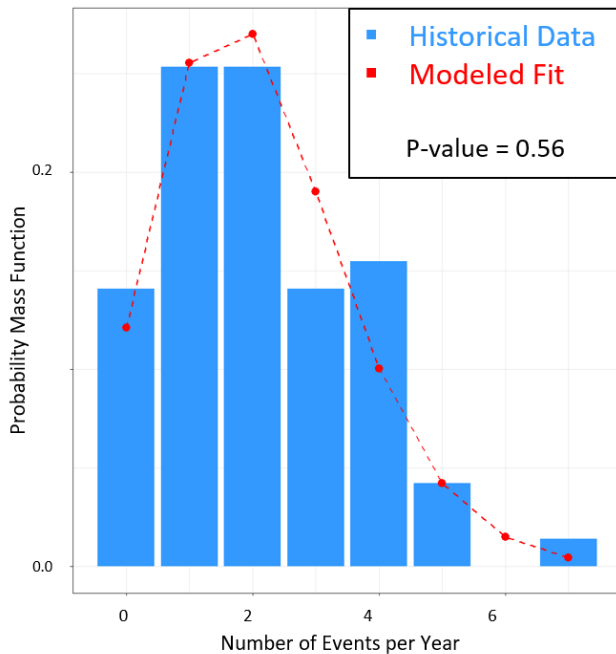


Figure 26 - PDF of historical inland flood events per year compared to the fitted distribution used to model the number of inland flood events per year

Precipitation Amount

The following figures show the PDFs of the historical precipitation per event and the distribution used in the model for event precipitation in four regions. Precipitation events were identified using the CPC gridded precipitation dataset that includes data for the years 1948 through 2018. Events are assigned to a region based on the location of maximum precipitation amount in the event. For the purposes of modeling event precipitation, the Pareto Type II distribution was used, as recommended in Papalexiou et al. (2013). The p-values, provided below, indicate a reasonable fit with this distribution, and the goodness-of-fit was determined with the Shapiro-Wilk test.

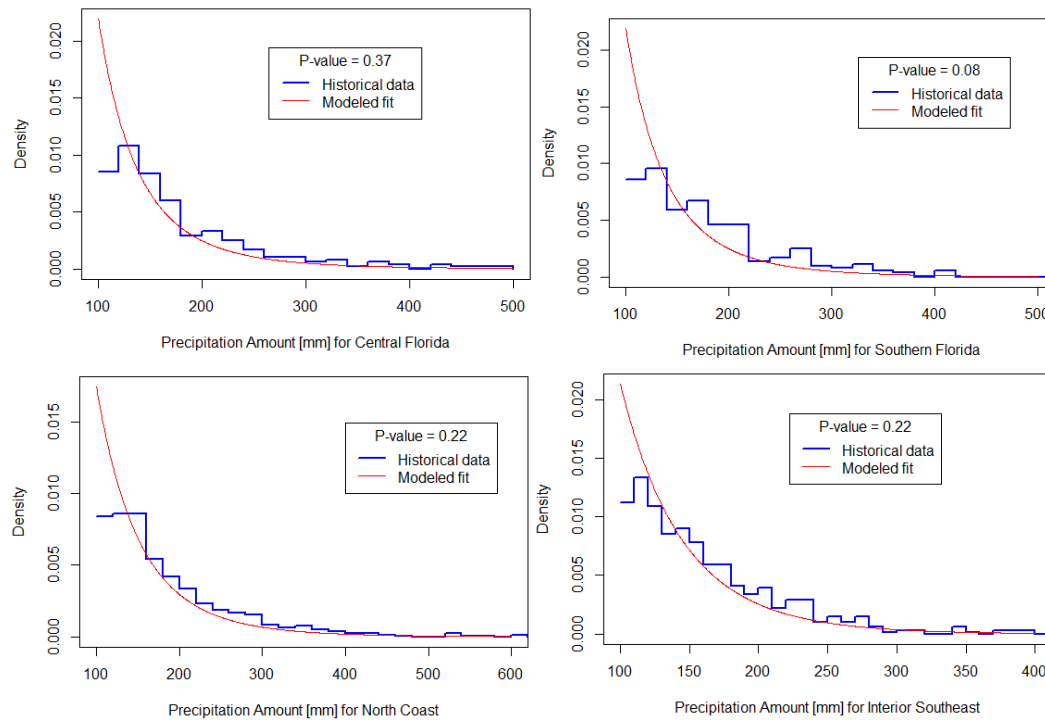


Figure 27 - PDFs of historical total precipitation per event compared to the fitted distribution used to model the precipitation per event for four modeled regions

Water Elevation, Discharge, and Peak Surge

To evaluate water elevation, discharge, and peak surge, the model results were compared with historical observations. The evaluation techniques include the coefficient of correlation (r) and the Nash-Sutcliffe efficiency (E) (Ran et al. 2018):

$$r = \frac{\sum_{i=1}^n (O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^n (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^n (P_i - \bar{P})^2}}$$

$$E = 1 - \frac{\sum_{i=1}^n (O_i - P_i)^2}{\sum_{i=1}^n (O_i - \bar{O})^2}$$

where

O_i = observed values

P_i = predicted values

The coefficient of correlation r estimates the combined dispersion against the single dispersion of the observed and predicted series, reflecting the linear association between them. The range of r lies between -1 and 1 , which indicates to what degree the observed dispersion can be explained by the predicted series. A value of zero means no correlation at all, whereas a value of 1 means that the dispersion of the prediction is equal to that of the observation. Typically, values greater than 0.5 are considered acceptable (Moriassi 2007). With respect to the Nash coefficient E , the range is between 1 (perfect fit) and $-\infty$. Values between 0.0 and 1.0 are generally viewed as acceptable levels of performance, whereas values <0.0 indicates that the mean observed value is a better predictor than the simulated value, which indicates unacceptable performance (Nash and Sutcliffe 1970).

	Water Elevation	Discharge	Peak Surge
r	0.95	0.75	0.94
E	0.90	0.51	0.88

Table 5 - Evaluation Methods: the coefficient of correlation and the Nash-Sutcliffe efficiency

The evaluation results presented in Table 5 prove that the modeled results of water elevation, discharge, and peak surge show good agreement with historical observations.

6. ***Provide a completed Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined). Provide a link to the location of the form [insert hyperlink here].***

Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined)

SF-2 Sensitivity Analysis for Flood Model Output

The modeling organization shall have assessed the sensitivity of temporal and spatial outputs with respect to the simultaneous variation of input variables using current scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action.

The sensitivity of temporal and spatial outputs with respect to the simultaneous variation of input values for the KCC US Flood Reference Model has been analyzed using accepted scientific and statistical methods. The results of this analysis are discussed further in Standard SF-2, Disclosures 1-4. Any appropriate action indicated by the results of these analyses has been taken.

Disclosures

1. Identify the most sensitive aspects of the flood model and the basis for making this determination.

Coastal Flood

The most sensitive aspect of the model is the track direction. This result is based on studies conducted by KCC scientists and the results demonstrated in the sensitivity analysis.

The sensitivity analysis follows the methodology detailed by Iman and Johnson (2002) and Iman et al. (2001) for assessing the sensitivity of model losses to changes in parameter values. The sensitivity tests of the flood model included varying four model parameters: central pressure, radius of maximum winds, forward speed, and track direction. The guidelines from the Commission were followed for the sensitivity analysis for the loss cost. The standardized regression coefficient was computed for all four input parameters at three different hurricane intensities (Category 1, Category 3, Category 5). The results show that in general the track direction was the greatest contributor to the change in loss cost.

The sensitivity of the modeled surge heights was evaluated spatially using the storms of the sensitivity analysis.

Inland Flood

The most sensitive aspect of the model varies significantly by both precipitation category and region. The event duration, spatial extent and precipitation amount made large contributions to the sensitivity around the loss cost. This result is based on studies conducted by KCC scientists and the results demonstrated in the sensitivity analysis.

The sensitivity analysis was designed following Iman et al. (2002) and Iman et al. (2001) and included six model parameters: amount of precipitation, duration of the event, extent of the event, eccentricity of the event footprint, theta value of the event footprint, and the initial precipitation. The guidelines from the Commission were followed for the sensitivity analysis for the loss cost. The standardized regression coefficient was computed for all six input parameters at three different precipitation intensities. The result showed that in southern Florida the duration of the event was the greatest contributor to the sensitivity of loss cost for events with both lower and middle levels of precipitation. The precipitation amount is the most sensitive parameter for events with higher levels of precipitation. In northern Florida, the initial precipitation was the most sensitive parameter for events with lower levels of precipitation, the extent of the event was the most sensitive parameter for events with middle levels of precipitation, and the precipitation amount was the most sensitive parameter for events with higher levels of precipitation.

The sensitivity of the modeled flood depths was evaluated spatially using the storms of the sensitivity analysis.

Spatial Analysis

Since insured losses are dependent on the final impact from a flood event and not the temporal variation, the KCC US Coastal Flood Reference Model and the KCC US Inland Flood Reference Model do not output losses on an hourly basis. Consequently, an analysis of the sensitivities of the modeled flood depths were evaluated spatially using the storms of the sensitivity analysis.

The following figure displays the standardized regression coefficient for Category 1, 3, and 5 hurricanes at landfall for one point in southern Florida for coastal flood. The result showed that the track direction had the greatest impact for Categories 1 and 3 events, whereas R_{max} had the greatest impact for Category 5 events.

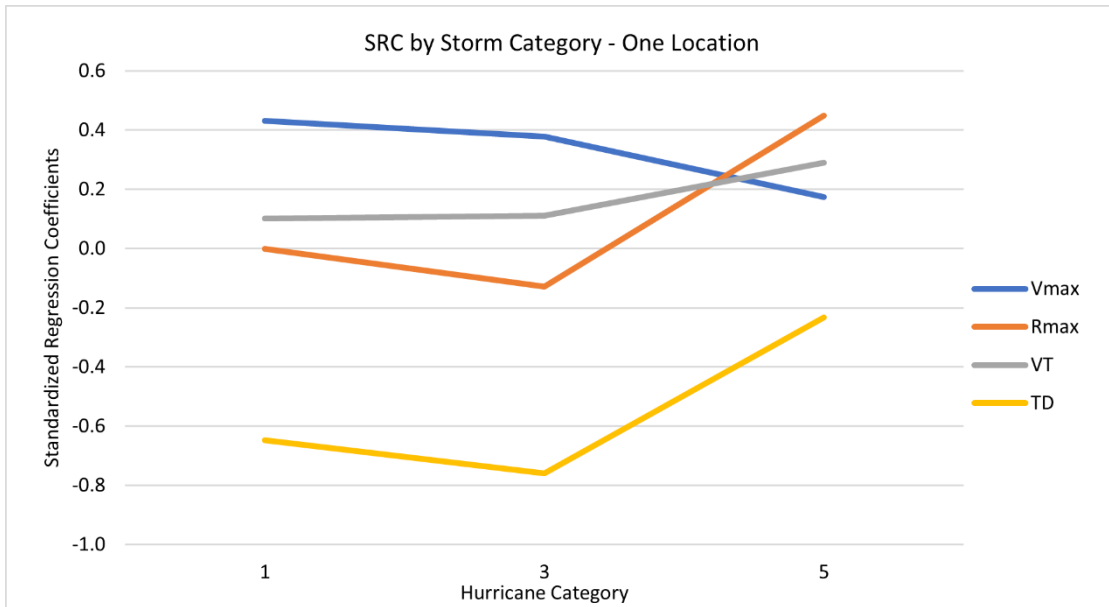


Figure 28 - SRC by storm category for coastal flooding sensitivity analysis

The following figures display the standardized regression coefficient for 3 different precipitation intensities for two points (one in southern Florida and one in northern Florida) for inland flood. The result showed that the duration of the event had the greatest impact in southern Florida at all levels of precipitation. For northern Florida, the initial precipitation had the greatest impact for events with lower and middle levels of precipitation, with the precipitation amount having the greatest impact for events with higher levels of precipitation.

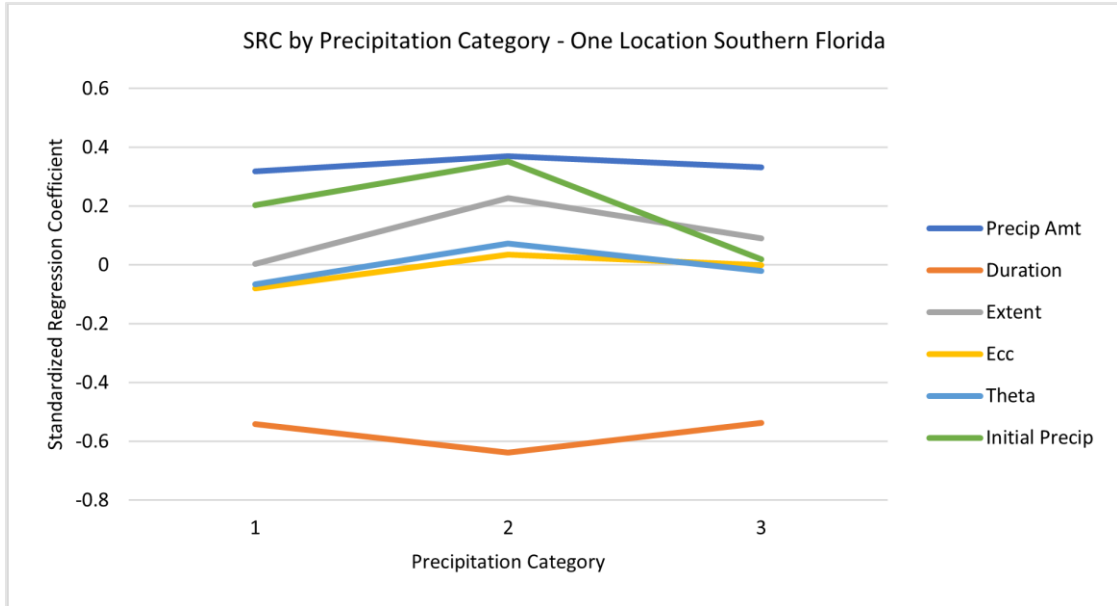


Figure 29 - SRC by precipitation category for inland flooding sensitivity analysis in southern Florida

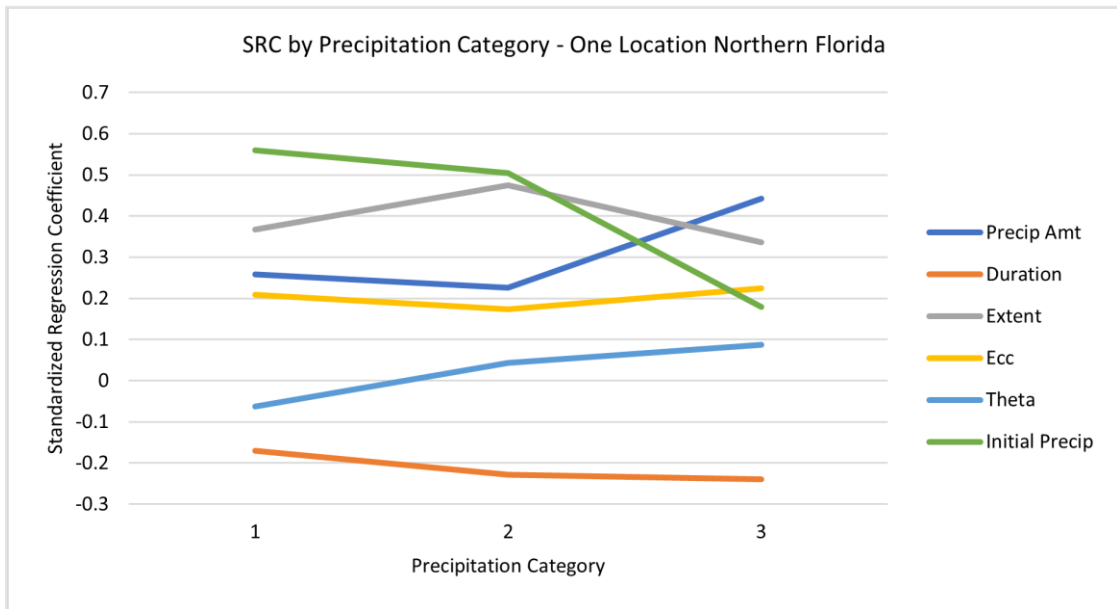


Figure 30 - SRC by precipitation category for inland flooding sensitivity analysis in northern Florida

The result of this analysis is for singular points and could vary significantly depending on which points are selected.

- 2. Identify other input variables that impact the magnitude of the output when the input variables are varied simultaneously. Describe the degree to which these sensitivities affect output results and illustrate with an example.**

No other input variables impact the magnitude of the output when the input variables of central pressure, R_{max} , forward speed, and track direction are varied simultaneously for coastal flood or the input variables of amount of precipitation, duration of the event, extent of the event, eccentricity of the event footprint, theta value of the event footprint, and the initial precipitation are varied simultaneously for inland flood.

- 3. Describe how other aspects of the flood model may have a significant impact on the sensitivities in output results and the basis for making this determination.**

One additional aspect of the coastal flood model that may have an impact on the sensitivity to the modeled loss costs is the landfall location. This determination was made by studies performed by KCC scientists on both uniform and actual exposure. The location of maximum precipitation rate may have an impact on the sensitivities of the inland flood model loss costs. To make this determination, this sensitivity study was conducted for a location in southern Florida and a location in northern Florida.

- 4. Describe and justify action or inaction as a result of the sensitivity analyses performed.**

The sensitivity analyses have been thoroughly reviewed, and the results are reasonable. No action was taken as a result of the analyses performed.

SF-3 **Uncertainty Analysis for Flood Model Output**

The modeling organization shall have performed an uncertainty analysis on the temporal and spatial outputs of the flood model using current scientific and statistical methods in the appropriate disciplines and shall have taken appropriate action. The analysis shall identify and quantify the extent that input variables impact the uncertainty in flood model output as the input variables are simultaneously varied.

KCC scientists and statisticians have conducted uncertainty analyses on the temporal and spatial output of the KCC US Flood Reference Model using appropriate statistical and scientific methods. The results, described further in Standard SF-3, Disclosures 1-3, identify and quantify the extent that input variables impact the uncertainty in flood model output. Any appropriate action indicated by the results of the uncertainty analyses were taken.

zzDisclosures

- 1. Identify the major contributors to the uncertainty in flood model outputs and the basis for making this determination. Provide a full discussion of the degree to which these uncertainties affect output results and illustrate with an example.***

Coastal Flood

The track direction is the major contributor to the uncertainty in flood model loss costs. This result is based on studies conducted by KCC scientists and the results demonstrated in the uncertainty analysis.

The uncertainty analysis follows the methodology detailed by Iman et al. (2002) and Iman et al. (2001) for assessing the uncertainty in model losses when parameter values are varied. The uncertainty tests of the flood model included changes in four model parameters: central pressure, radius of maximum winds, forward speed, and track direction. The guidelines from the Commission were followed for the uncertainty analysis for the loss costs. The expected percentage reduction was computed for all four input parameters at three different hurricane intensities (Category 1, Category 3, Category 5). The result showed that the track direction was the greatest contributor to the uncertainty in loss costs across all intensities.

The uncertainty of the modeled surge heights was evaluated spatially using the storms of the uncertainty analysis.

Inland Flood

The biggest contributor to the uncertainty in flood model loss costs varies significantly by both precipitation category and region. However, all six parameters are very similar in their contribution to the uncertainty around the loss costs. This result is based on studies conducted by KCC scientists and the results demonstrated in the uncertainty analysis.

The uncertainty analysis was designed following Iman et al. (2002) and Iman et al. (2001) and included six model parameters: amount of precipitation, duration of the event, extent of the event, eccentricity of the event footprint, theta value of the event footprint, and the initial precipitation. The guidelines from the Commission were followed for the uncertainty analysis for the loss cost. The expected percentage reduction was computed for all six input parameters at three different precipitation intensity categories. In southern Florida, the result showed that the duration of the event was the greatest contributor to the uncertainty in loss costs for events with middle levels of precipitation, and the precipitation amount was the greatest contributor to the uncertainty in loss costs for events with higher precipitation. In northern Florida, the results show that the initial precipitation was the greatest contributor to the uncertainty in loss costs for events with lower precipitation, whereas the duration of the event was the greatest contributor to the uncertainty in loss cost for events with middle levels of precipitation, and the precipitation amount was the greatest contributor to the uncertainty in loss cost for events with higher levels of precipitation.

The uncertainty of the modeled flood depths was evaluated spatially using the storms of the uncertainty analysis.

Spatial Analysis

Since insured losses are dependent on the final impact from a flood event and not the temporal variation, the KCC US Coastal Flood Reference Model and the KCC US Inland Flood Reference Model do not output losses on an hourly basis. Consequently, an analysis of the uncertainties of the modeled flood depths were evaluated spatially using the storms of the uncertainty analysis.

The following figure displays the expected percentage reduction for Category 1, 3, and 5 hurricanes at landfall for one point in southern Florida for coastal flood. The result showed that the track direction had the greatest impact.

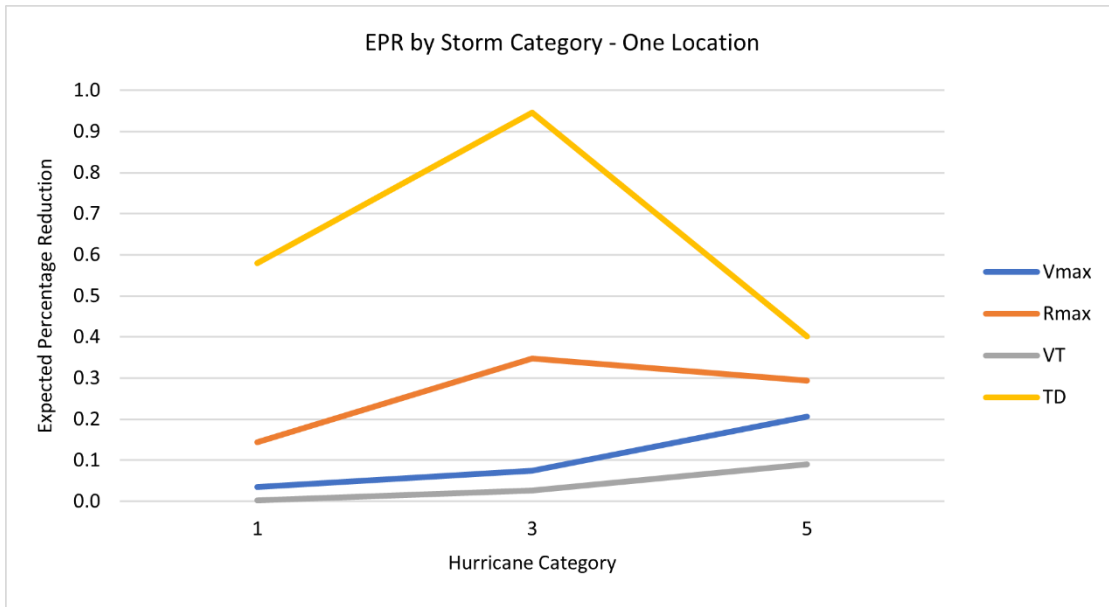


Figure 31 - EPR by hurricane category for coastal flooding uncertainty analysis

The following figures display the expected percentage reduction for 3 different precipitation intensities for two points (one in southern Florida and one in northern Florida) for inland flood. The result showed that the duration had the greatest impact for southern Florida for events with lower and higher levels of precipitation, and the theta value of the event has the greatest impact for events with middle levels of precipitation. For northern Florida, the initial precipitation had the greatest impact for events with lower precipitation, whereas the extent of the event had the greatest impact for events with middle and higher levels of precipitation.

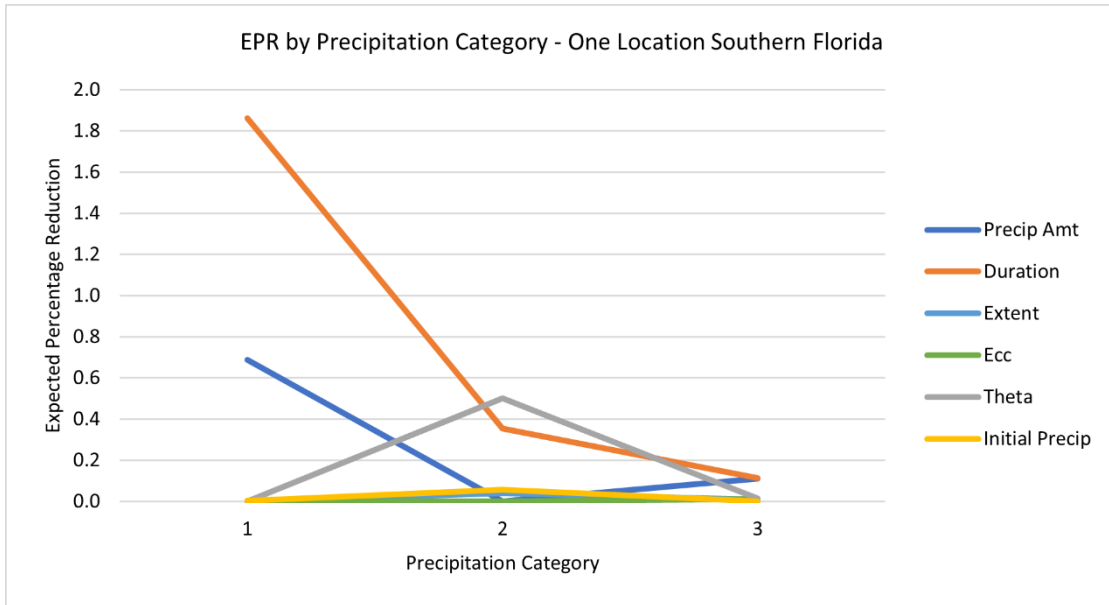


Figure 32 - EPR by precipitation category for inland flood uncertainty analysis in Southern Florida

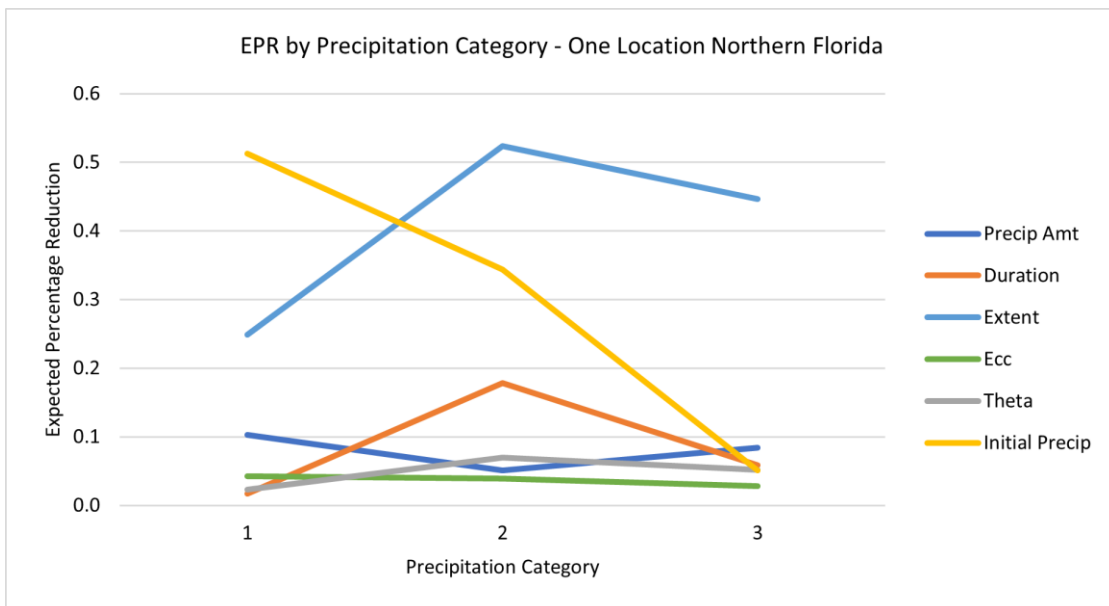


Figure 33 - EPR by precipitation category for inland flood uncertainty analysis in Northern Florida

The result of this analysis is for the specified coordinate points and could vary significantly depending on which points are selected on the grid.

2. Describe how other aspects of the flood model may have a significant impact on the uncertainties in output results and the basis for making this determination.

An aspect of the coastal flood model that may have an impact on the uncertainties in the modeled loss costs is the landfall location. This determination was made by studies performed by KCC scientists on both uniform and actual exposure. The location of maximum precipitation rate may have an impact on the uncertainties in the inland flood model loss costs. To make this determination, this uncertainty study was conducted for a location in southern Florida and a location in north Florida.

3. Describe and justify action or inaction as a result of the uncertainty analyses performed.

The uncertainty analyses have been thoroughly reviewed, and the results are reasonable. No action was taken as a result of the analyses performed.

SF-4 Flood Model Loss Cost Convergence by Geographic Zone

At a modeling-organization-determined level of aggregation utilizing a minimum of 30 geographic zones encompassing the entire state, the contribution to the error in flood loss cost estimates attributable to the sampling process shall be negligible for the modeled coastal and inland flooding combined.

The KCC US Flood Reference Model attains convergence at the county level. Using 30 geographic zones encompassing the entire state, the contribution of error in the flood loss costs due to the sampling methodology is negligible for the modeled coastal and inland flooding combined.

Disclosures

- 1. Describe the sampling plan used to obtain the average annual flood loss costs and flood output ranges. For a direct Monte Carlo simulation, indicate steps taken to determine sample size. For an importance sampling design or other sampling scheme, describe the underpinnings of the design and how it achieves the required performance.***

The sampling methodology for the KCC US Coastal Flood Reference Model and the KCC US Inland Flood Reference Model uses the Joint Probability Method (JPM) and a ternary tree structure to maintain symmetry. This method has several advantages over other simulation techniques, the most important of which is that it provides a stochastic catalog representing the entire range of potential future storm characteristics along with complete and consistent spatial coverage. This method does not introduce noise into the sample.

KCC US Coastal Flood Reference Model

The first step of the sampling process is to utilize the landfall frequency distribution and Generalized Pareto Distribution parameters to generate the number of events for each landfall point and the intensity of each event, represented by the peak storm surge, as a function of central pressure. KCC scientists conducted sensitivity tests to determine that a five mph increment is sufficient for representing the velocity of maximum wind at landfall (V_{max}) distributions for each landfall point.

After the central pressure values are assigned, values for the other important coastal flood parameters are selected following the Joint Probability Method (JPM) and using a ternary tree structure to maintain symmetry. This method has several advantages over other simulation techniques, the most important of which is that it provides a stochastic catalog representing the entire range of potential future storm characteristics along with complete and consistent spatial coverage. This method does not introduce noise into the sample.

The method starts with defining the hierarchy of importance for the parent nodes.

For the coastal flood model, the hierarchy is:

1. Track over land (TD)
2. Radius of maximum winds (R_{max})
3. Forward speed (F)

This hierarchy determines the design of the ternary tree as shown in the tree structure below.

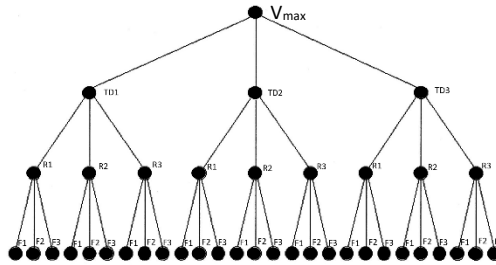


Figure 34 - Hierarchical structure for parameter value selection

At the root of the tree is the central pressure, the parent node. The first set of child nodes represent the three track directions (TD1, TD2, TD3). Each TD node will have its own three child nodes for R_{max} (R1, R2, R3). Finally, each R_{max} has three nodes for forward speed (F1, F2, F3). This tree structure and a set of branching rules, including the requirement to maintain tree symmetry, produces the set of hurricane characteristics assigned to each event. A few examples are shown below.

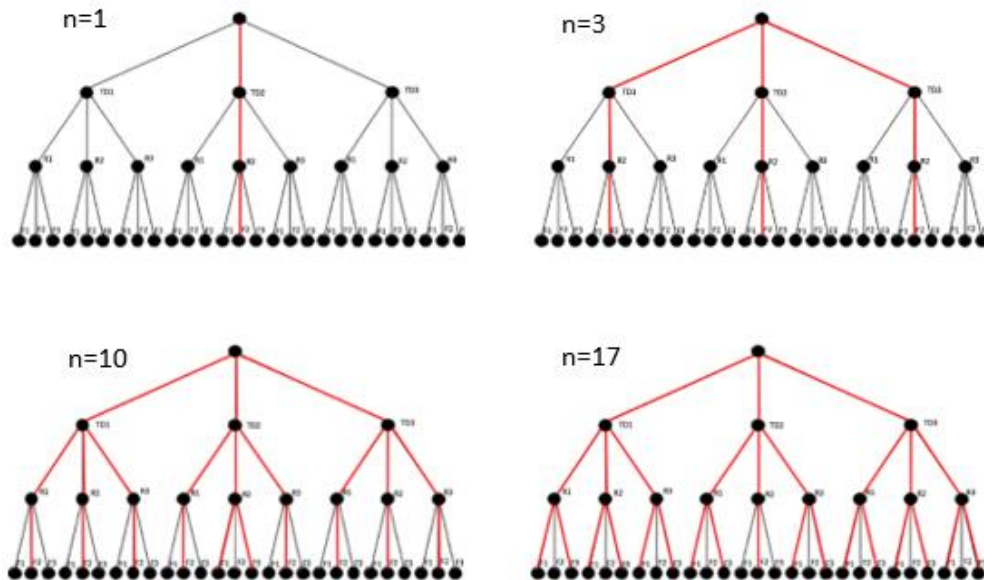


Figure 35 - Scenario selection for one (top left), three (top right), 10 (bottom left), and 17 (bottom right) events.

KCC US Inland Flood Reference Model

A similar methodology is used to produce the KCC US Inland Flood Reference Model event set.

The first step of the sampling process is to assess the frequency and intensity of extreme precipitation events at locations affecting Florida basins. This analysis is carried out for locations on a grid with a spacing of 0.5 degrees. The grid spacing was found through sensitivity testing to be sufficient to achieve even spatial coverage in precipitation. The historical event frequency and distribution of extreme precipitation amounts represented by a Pareto Type II distribution are combined to generate the number and intensity of model events at each grid location.

After the precipitation amount values are assigned for a location, values for the other important inland flood parameters are selected following the Joint Probability Method (JPM) and using a ternary tree structure to maintain symmetry.

For the KCC US Inland Flood Reference Model, the hierarchy is:

1. Spatial Extent of Precipitation
2. Event Duration
3. Initial Precipitation

KCC scientists used this methodology to produce a spatially unbiased and reproducible sample of extreme precipitation events that impact basins in Florida. Additional justification for this methodology includes:

- Every event in the KCC catalog has meaning and is named by its event characteristics. In the RiskInsight® application, insurers can readily identify which events and event characteristics are contributing to their largest losses.
- For every grid location and intensity level, represented as the precipitation amount, there is an event representing the expected values of all other characteristics. This enables insurers to obtain the Characteristic Event (CE) losses for selected hazard levels (i.e. return period rain events).
- No event in the catalog would be considered “suspect” by meteorological standards. There are no events in the stochastic catalog not likely to occur in nature.

KCC has conducted tests to ensure the event catalog resulting from this methodology has met performance requirements. KCC scientists have evaluated high-resolution wind speed maps generated from the catalog to verify that logical relationships to risk are achieved and that no localized anomalies are present. Statistical tests were also performed on the KCC US Coastal Flood Reference Model and the KCC US Inland Flood Reference Model loss costs to verify that the errors in the loss cost estimates due to sampling are negligible.

2. ***Describe the nature and results of the convergence tests performed to validate the expected flood loss projections generated. If a set of simulated flood events or simulation trials was used to determine these flood loss projections, specify the convergence tests that were used and the results. Specify the number of flood events or trials that were used.***

KCC has conducted tests to ensure that the expected flood loss projections resulting from the sampling methodology meet the performance requirements. Statistical tests were also performed on the KCC US Coastal Flood Reference Model and the KCC US Inland Flood Reference Model to verify that the errors in the loss cost estimates due to sampling are negligible. A bootstrap methodology was used to sample multiple alternative catalogs from the existing 100,000-year stochastic catalog, which includes 286,614 events. Results confirmed that the sampling errors in the loss costs are negligible.

SF-5 Replication of Known Flood Losses

The flood model shall estimate incurred flood losses in an unbiased manner on a sufficient body of past flood events, including the most current data available to the modeling organization. This standard applies to personal residential exposures. The replications shall be produced on an objective body of flood loss data by county or an appropriate level of geographic detail.

The KCC US Flood Reference Model estimates flood losses in an unbiased manner as has been demonstrated by historical comparisons, including recent events from 2017, for personal residential exposures. The model loss comparisons have been completed at a ZIP Code resolution, which is appropriate for ascertaining any bias in the model.

Disclosure

1. **Describe the nature and results of the analyses performed to validate the flood loss projections generated for personal residential losses. Include analyses for the events listed in Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps.**

KCC scientists and engineers have conducted rigorous analyses of insurer high-resolution claims data. KCC engineers mapped each individual claim amount to the policy generating that claim. The contemporaneous exposure data was provided for all policies in force on the date of the flood (not just those with claims), which is required for estimating the MDRs (mean damage ratios) by inundation depth.

For each flood, each claim was matched to the flood depth experienced at that location according to the modeled and validated high-resolution flood footprints. The table below shows the modeled versus actual losses for Florida coastal and inland flooding events.

In general, inland flooding events are expected to show a greater disparity between actual and modeled loss relative to coastal flooding because the event losses are smaller for inland flooding and the losses are more spatially variable. For small events, the percent difference between the actual and modeled losses is larger while the magnitude of the model error is similar for coastal flooding and inland flooding. Uncertainties in initial conditions and physical aspects of the inland flood model can be compounded for events that are spread over a large area that includes several basins.

Event	Classification	Actual	Modeled
Hurricane Hermine (2016)	Coastal	80,811,511	78,116,546
Hurricane Matthew (2016)	Coastal	287,817,364	360,396,270
Hurricane Michael (2018)	Coastal	332,939,119	330,678,982
Total	Coastal	701,567,995	769,191,798
March 30, 2009	Inland	202,284	129,557
May 15, 2009	Inland	20,803,723	36,139,662
December 12, 2009	Inland	209,079	1,648,596
June 9, 2012	Inland	17,622,456	22,878,924
June 22, 2012	Inland	65,022,177	67,373,327

Event	Classification	Actual	Modeled
July 3, 2013	Inland	19,130,820	35,846,845
April 30, 2014	Inland	99,198,183	98,705,181
October 21, 2014	Inland	256,418	323,001
June 22, 2017	Inland	3,830	2,165,187
August 27, 2017	Inland	29,790,306	29,382,587
Total Inland Flood	Inland	252,239,276	294,592,867
Hurricane Irma (2017)	Combined	1,437,992,758	1,561,336,862
Total of Events	Coastal, Inland, Combined	2,391,800,028	2,625,121,527

Table 6 - Comparisons of modeled losses to disguised insurer flood losses for coastal, inland, and combined events

Vulnerability Flood Standards

VF-1 Derivation of Personal Residential Structure Flood Vulnerability Functions

- A. Development of the personal residential structure flood vulnerability functions shall be based on two or more of the following: (1) rational structural analysis, (2) post-event site investigations, (3) technical literature, (4) expert opinion, (5) laboratory or field testing, and (6) insurance claims data. Personal residential structure flood vulnerability functions shall be supported by historical and other relevant data.**

The KCC personal residential structure flood vulnerability functions were developed based on rational structural analysis, post-event site surveys, technical literature, and expert opinion. Insurance claims data for historical events were used to validate the vulnerability functions. Throughout the vulnerability function development process, KCC engineers referred to current scientific research and accepted flood engineering principles. Flood vulnerability functions are consistent with historical and other relevant data.

- B. The derivation of personal residential structure flood vulnerability functions and their associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles.**

KCC engineers ensured that the vulnerability functions and related uncertainties comply with fundamental engineering principles and are theoretically sound. The vulnerability functions were developed and validated by experts in structural engineering and are based on published research, post-event site surveys, expert opinion, and rational structural analysis. The uncertainties associated with each damage level were developed based on sound statistical and engineering principles.

- C. Residential building stock classification shall be representative of Florida construction for personal residential structures.**

The KCC building stock classification is representative of the personal residential properties found in Florida. The building inventory and stock information was compiled from published studies on the Florida residential building stock, census and tax appraiser's data, public information from FEMA's HAZUS program, damage survey observations, and the Florida Hurricane Catastrophe Fund (FHCF) 2017 dataset. These data were then used to identify and classify the relevant building construction types.

- D. The following flood characteristics shall be used in the derivation of personal residential structure flood vulnerability functions: depth above ground, and in coastal areas, damaging wave action.**

The KCC vulnerability functions use the inundation depth above ground as the input to calculate the level of damage. The derivation of the vulnerability functions accounted for the hydrostatic and hydrodynamic loading from inundation depth and damaging wave action in coastal areas. The vulnerability functions are derived using a building component-based analysis, in which the vertical and lateral hydrostatic, hydrodynamic, and wave-action forces at different inundation depths are calculated for affected building components. All of these forces are separately calculated and then combined and compared with the building component resistances to develop the vulnerability functions.

- E. The following primary building characteristics shall be used or accounted for in the derivation of personal residential structure vulnerability functions: lowest floor elevation relative to ground, foundation type, construction materials, and year of construction.**

Lowest floor elevation relative to the ground, foundation type, construction materials, and year of construction have been accounted for in the derivation of personal residential building vulnerability functions. In the KCC US Flood Reference Model, lowest floor elevation relative to the ground is called first floor height (FFH). This is the same as the lowest floor elevation definition for NFIP Zone A. The same definition is used in both inland and coastal flood vulnerability functions. Different vulnerability functions have been derived for buildings with different FFHs.

F. Flood vulnerability functions shall be separately derived for personal residential building structures and manufactured homes.

Manufactured home and personal residential building structure vulnerability functions were derived separately.

Disclosures

1. Provide a flowchart documenting the process by which the personal residential structure flood vulnerability functions are derived and implemented.

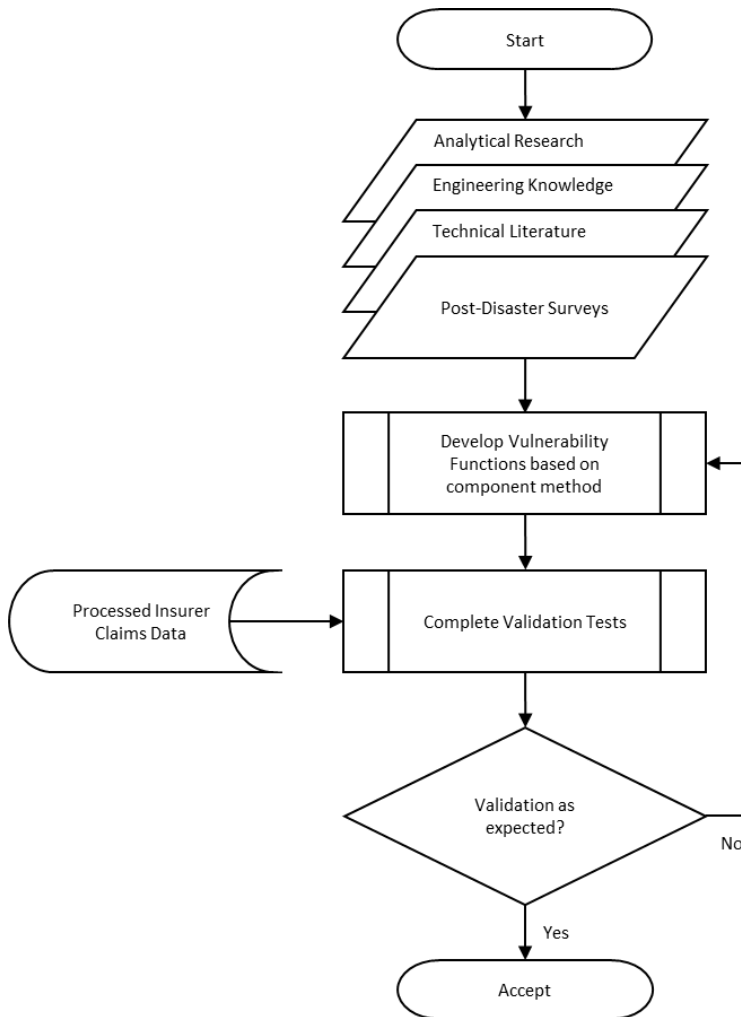


Figure 36 - Development and implementation of flood vulnerability functions

2. Describe the assumptions, data, methods, and processes used for the development of the personal residential structure flood vulnerability functions.

KCC engineers used a component-based engineering analysis to develop the building vulnerability functions. Each function is representative of a specific set of primary building characteristics.

During the engineering analysis, a building was assumed to be composed of several components (for example, the walls, openings, foundation, and others) that have distinct damage modes. A vulnerability function was developed for each component by considering direct damage (i.e. damage experienced due to the interaction between the flood water and the building component) and progressive damages (i.e.

damage experienced as a result of other building components being damaged) while addressing the complex interaction between the building components. The building interior (building non-structural elements) is treated as a separate building component, and it can experience damage due to water infiltration through cracks and openings or due to failure of other building components. Functional damage was also considered, which includes needed repairs unrelated to building damage, such as sanitization. The component vulnerabilities are combined using the weight of their relative component costs to produce the vulnerability function for the building structure.

Once the base vulnerability functions were developed, relativities between other building characteristics, such as the number of stories, year built, and first floor height (FFH), were established for the various construction types using scientific literature, post-event damage survey observations and reports, engineering judgment, and engineering analysis. The base building vulnerability functions were then modified according to these additional building characteristics. KCC engineers thoroughly inspected each vulnerability function during the development process to ensure consistency and logical relativities. In the KCC US Flood Reference Model, the first-floor height (FFH) is defined as the lowest floor elevation relative to the ground. This is similar to the lowest floor definition in NFIP Zone A and is used for both inland and coastal flood vulnerability functions.

The component methodology provides a robust understanding of building performance along with the contribution of individual building components to the overall building vulnerability. This enables different combinations of components to be used to create vulnerability functions for rare or unique building configurations that will be consistent with engineering principles.

When developing the flood vulnerability functions, the expected hydrostatic loads (due to depth of flooding), hydrodynamic loads (due to the depth of flooding and water velocity), and wave action at each inundation depth were considered. In the case of coastal flooding, in addition to the hydrostatic loading, the front (surge-ward) side of a building is susceptible to loads from water velocity and wave action. Coastal flooding from saltwater also generally causes more damage and is more expensive to repair than inland freshwater flooding. In the case of inland flooding, the flow-ward side of the building only experiences hydrodynamic loading from water velocity. As a result, KCC developed separate sets of vulnerability functions for coastal and inland flooding.

Scientific literature, post-event damage survey observations, and engineering judgment are the backbone of this methodology. The theory behind this approach is used to develop vulnerability functions for different perils such as wind, earthquake ground motion, and flood. The component methodology is well documented in published engineering studies including Unanwa et al. (2000), Porter et al. (2001), Cope (2004), Caraballo-Nadal et al. (2006), Li and Ellingwood (2006), Friedland (2009), Li et al. (2012), Park et al. (2012), Tomiczek et al. (2014), Custer and Nishijima (2015), Huang et al. (2015), Baradaranshoraka et al. (2017), Baradaranshoraka et al. (2019), and Masoomi et al. (2019). The process of vulnerability function development and the vulnerability functions themselves have been peer reviewed by experts in structural engineering.

3. *As applicable, describe the nature and extent of actual insurance claims data used to develop the personal residential structure flood vulnerability functions. Describe in detail what is included, such as, number of policies, number of insurers, dates of loss, and number of units of dollar exposure, separated into personal residential building structures and manufactured homes.*

KCC used claims data for 14 storms causing flood damage between 2009 to 2018. The number of policies and exposure amount by policy type are summarized in the following table.

Policy Type	Number of Policies	Exposure (\$)
Personal Residential	25,498,634	4,913,604,901,300
Manufactured Homes	48,731	2,668,990,900

Table 7 - Number of policies and exposure value of insurer claims data used to develop the KCC building vulnerability functions

KCC engineers mapped the claim amount to its associated policy so the claims data could be aggregated and analyzed separately by census tract, flood zones, occupancy, and other property characteristics. Most of the claims were also identified by coverage. The contemporaneous exposure data was representative for all policies in force on the date of the storm (not just those with claims), which was used to estimate the MDRs by inundation depth.

For each flood event, the claims were matched to the flood depth experienced at that location according to the modeled and validated high-resolution flood footprints. The claims MDRs were then compared to the modeled MDRs by flood depth to check the accuracy of the building vulnerability functions. In general, the engineering-based vulnerability functions performed well, and the claims data informed a few refinements to the vulnerability functions. An example of a refinement made due to the results of such analyses includes the adjustment of inland flood vulnerability functions for low inundation levels.

4. Summarize post-event site investigations, including the sources, and provide a brief description of the resulting use of these data in the development or validation of personal residential structure flood vulnerability functions.

Post-event surveys and site inspections provide important information for vulnerability function development. KCC professionals have decades of collective experience in hurricane related storm surge post-event data collection, starting with Hurricane Hugo in 1989. The most recent hurricane post-event damage surveys conducted by KCC engineers include Matthew, Harvey, Irma, Florence, and Michael. Four types of information are collected and analyzed post-event.

Neighborhood damage surveys. KCC engineers have implemented a standardized process and forms for collecting information on claim frequency and severity by flood depth. Areas are selected to cover the range of inundation experienced. Neighborhoods with similar properties and construction practices are surveyed to determine how many properties experienced damage and the distribution of damage levels. The information collected using this method can be analyzed statistically.

Detailed site investigations. KCC engineers select a sample of properties covering different construction and occupancy types to conduct more detailed damage observations—typically covering the interior as well as the exterior of the properties. These observations provide additional insight into the nature of the damage and cause of loss.

Review of desktop claims systems and files. Reviewing a larger number of claims provides more insight into the costs of more frequent repairs required after an event and enables the verification of material and labor costs across a large volume of claims. Damage observed in the field can then be validated against the ultimate paid claim.

5. Describe how the personal residential structure flood vulnerability functions incorporate depth of flooding (above ground and above lowest floor) and damaging wave action (in coastal areas). For coastal areas, define the thresholds indicating the presence of damaging wave action for personal residential building structures and manufactured homes. Describe the area over which vulnerability functions for damaging wave action or wave proxies are applied.

The KCC vulnerability functions use flood inundation depth above ground as the intensity measure, and the MDR increases as the inundation depth increases. The lowest floor height from ground (first floor height, or FFH) is included in the vulnerability functions as a primary building characteristic, and

vulnerability functions have been derived for buildings with different FFHs. Direct damage to the building interior only occurs when above ground inundation is greater than the FFH, i.e. above the lowest floor.

When developing the flood vulnerability functions, the expected hydrostatic (due to differences in depth of flooding between the inside and outside of the structure), hydrodynamic (due to the water speed), and wave action (in coastal flooding) loading at each inundation depth were considered. The hydrostatic, hydrodynamic, and wave forces are calculated using published engineering studies including Homma and Horikawa (1965), Walton et al. (1989), Cuomo et al. (2008), ASCE (2010), and FEMA (2011). The modeled inundation depths represent the mean height of inundation, which provide the hydrostatic forces.

During a coastal flooding event, a building can experience wave forces due to non-breaking, breaking, and broken waves. The vulnerability functions assume that coastal flooding inundation will be accompanied by waves, and hence wave forces, proportional to the still-water inundation depth. The KCC coastal flood vulnerability functions estimate mean wave impact by calculating breaking, non-breaking, and broken wave impacts at every inundation depth. According to FEMA (2011) and USACE (2015), the breaking wave height is equal to 0.78 of the still-water inundation depth, of which 70% rises above the inundation depth (the wave crest), and 30% is below the inundation depth (the wave trough). Therefore, the breaking wave height is assumed to be 0.55 of the still-water inundation depth ($0.78 * 70\%$). For example, at a location with a three-foot storm surge inundation depth, the breaking waves would be 1.65 ft higher than the still-water level, causing added hydrostatic and hydrodynamic pressures. For broken waves, the wave height is assumed to be 40% of the still-water depth, and the wave load is approximated as hydrodynamic pressure. For the non-breaking waves, a wave height of 18% of the still-water depth is used, and the wave load is approximated as hydrostatic pressure. As surge inundation attenuates further from the coast, the wave actions are assumed to decrease. For all exposures inundated by coastal flooding, wave action is considered, and there are no specific distance-from-coast thresholds at which wave action begins or ends. The wave heights specified herein are controlling wave heights.

Coastal flooding induces hydrostatic, hydrodynamic, and wave forces on a building, while inland flooding only induces hydrostatic and hydrodynamic forces. The assumed wave action provides loading on buildings unique to storm surge. Moreover, the hydrostatic pressure resulting from coastal flooding is greater than that from inland flooding because the depth of the wave also creates pressure on the structure.

6. State if the following flood characteristics are considered in the development of the personal residential structure flood vulnerability functions, and if so, how; if not, explain why:

a. Flood velocity,

Flood velocity is included in the derivation of the coastal and inland flood vulnerability functions. In the component-based engineering analysis, the hydrodynamic loading that the building components experience depends on the flood velocity, which is estimated from the inundation depth. The relationships between inundation depth and flood velocity specified in FEMA (2011) are used. FEMA (2011) provides upper bound and lower bound estimates of flood velocity as functions of the inundation depths. The KCC US Flood Reference Model uses the average of the upper and lower bounds to estimate flood velocity for coastal flooding and the lower bound to estimate flood velocity for inland flooding.

b. Flood duration,

Duration of flooding is implicitly included in the vulnerability functions due to validation with claims data, which reflect damage from flood events regardless of duration.

c. Flood-induced erosion,

Flood-induced erosion is not explicitly modeled. Because the vulnerability functions have been validated with claims data, impacts from flood-induced erosion have been implicitly included in the vulnerability functions.

d. Flood-borne debris,

Flood-borne debris is not explicitly modeled. Because the vulnerability functions have been validated with claims data, impacts from flood-borne debris have been implicitly included in the vulnerability functions.

e. Salinity (saltwater versus freshwater flooding), and

The KCC vulnerability functions are derived separately for fresh (inland) and saltwater (coastal) flooding. As a result, the differences between saltwater and freshwater are explicitly included in the vulnerability functions. Moreover, saltwater has a higher density than freshwater, and this difference in density is included when estimating the flood-induced forces incorporated into the vulnerability functions.

f. Contaminated floodwaters.

Contaminated floodwaters are not explicitly included in the vulnerability functions. Because the vulnerability functions have been validated with claims data, impacts from contaminated floodwaters have been implicitly included in the vulnerability functions.

7. Describe how the personal residential structure flood vulnerability functions incorporate the following primary building characteristics:

a. Lowest floor elevation relative to ground,

The lowest floor elevation relative to the ground, or the first floor height (FFH), was considered when developing building vulnerability functions. Different vulnerability functions have been developed for FFH's of 1-10 ft in 1 ft increments. FFH has a significant impact on flood vulnerability (both coastal and inland), particularly at shallower inundation depths. For exposure data where information on FFH is not available or unknown, the FFH is inferred from information on the building foundation type, year built, and building flood zone.

b. Foundation type,

Foundation type was considered in the development of flood building vulnerability functions. The foundation is an individual building component for which different vulnerability functions are developed based on the unique vulnerability of the foundation and its connections with the super-structure. Foundation type and FFH are used interchangeably to identify one another in the process of deriving and applying the flood vulnerability functions because different foundation types imply different FFH. For example, a crawl space foundation type typically corresponds with an FFH of three to four feet, and an FFH of eight feet could be translated to mean the building has an elevated structure foundation type.

In cases where FFH information is not provided in the exposure data, it is inferred using other building characteristics, such as foundation type, Pre- or Post-FIRM, and FEMA flood zone, as specified in Table 8. The sources for Table 8 are HAZUS-MH and expert opinion. The FFH for each foundation type is based on the FEMA flood zone and whether the building was constructed before or after its community's Flood Insurance Rate Map (FIRM) date. This allows two buildings of similar construction but with different foundation types to sustain different losses.

The following table shows that the assignment of the FFH for a specified foundation type varies by flood zone. These flood zones are consistent with the FBC and FEMA flood zones, which are typically collected by insurers and exist in the NFIP exposure data. Riverine represents all Flood Zones subjected to inland flooding, and A Zone Coastal refers to buildings in Flood Zone A subjected to coastal flooding. It should be noted that in the post-FIRM regulations, slab on grade, crawlspace, basement, and dry stack concrete foundations are not allowed in the special hazard zone areas, and this table is only used if the foundation type is specifically provided in the

exposure data. If foundation type is unknown, but flood zone is specified, then FFH will be inferred based on the flood zone requirements. For a location, if FFH is not specified, and the foundation type and flood zone is unknown, then a weight-averaged vulnerability function based on the building inventory data for the building’s construction era is used.

Foundation Type	Pre-FIRM	Post-FIRM		
		Riverine	A Zone Coastal	V Zone Coastal
Slab on grade	1	1	1	1
Crawlspace	3	4	4	4
Basement	4	4	4	4
Pile	7	8	8	8
Pier	5	6	6	8
Solid Wall	7	8	8	8
Dry Stack Concrete (Manufactured Home)	3	3	3	3

Table 8 - First floor height of different foundation types (feet)

c. Primary construction materials, and

Vulnerability functions were developed for primary construction materials (such as wood and masonry) that reflect the vulnerabilities unique to each construction material. In general, light metal, manufactured homes, and wood structures are shown to exhibit a relatively greater vulnerability to flood impacts, while reinforced concrete and steel structures have demonstrated a relatively lower vulnerability. The following ten construction types (the first seven for site built and the last three for manufactured homes) form the base construction types.

Construction Type	Description
Residential Buildings, Apartments, and Condominiums	
Wood Frame	Buildings where the exterior walls and roof frame are constructed using wood studs. The wall sidings are constructed using wood or other combustible materials, including wood iron-clad, stucco on wood, or plaster on combustible supports. Also includes aluminum or plastic siding over a frame.
Unreinforced Masonry	Buildings where the exterior (and some interior) walls are load-bearing and constructed of masonry, non-combustible, or fire resistive materials such as adobe, brick, concrete, gypsum block, hollow concrete block, stone, tile or other non-combustible materials. No steel reinforcement. The roofs are typically made of wood frame construction.
Reinforced Masonry	Buildings where the exterior walls are constructed load-bearing of masonry, non-combustible, or fire resistive materials such as adobe, brick, concrete, gypsum block, hollow concrete block, stone, tile or other non-combustible materials. The wall material is reinforced in-plane and out-of-plane with steel bars. The roofs are typically made of wood frame construction.
Reinforced Concrete	Buildings where the beams and columns are constructed of reinforced concrete. Infill walls are typically constructed of masonry. Floors are constructed of concrete slabs, steel or wooden joists.
Steel	Buildings where the beams and columns are constructed using steel.
Light Metal	Buildings constructed of light gauge steel frames. The walls can be constructed of brick veneer, EIFS, plywood, corrugated metal sheets, etc. Roof covering can be corrugated steel or similar to wood frame buildings. Here, columns and beams are not rigidly connected and do not act as a frame.
Masonry	Used when information on wall reinforcement in Masonry Buildings is not provided and represented by an inventory-weighted average of Reinforced Masonry and Unreinforced Masonry.
Unknown	Represented by an exposure-weighted average of the above.
Manufactured homes	
Mobile Home -Fully Tie-Downs	Mobile/Manufactured Housing, which has anchors and tie-downs as required by Section 320.8325, Florida Statutes, and Florida Administrative Code rules promulgated thereunder.
Mobile home - Partial Tie-Downs	Mobile/Manufactured Housing, which has anchors and tie-downs but not to the level required by Section 320.8325, Florida Statutes, and Florida Administrative Code rules promulgated thereunder.
Mobile home - No Tie- Downs	Mobile home is not tied down.
Unknown	Represented by an exposure-weighted average of the above.

Table 9 - Construction types in the KCC US Flood Reference Model applicable to personal residential classifications

d. Year of construction.

The year of construction was considered when developing building vulnerability functions. In general, older buildings exhibit a greater vulnerability than newer buildings of identical construction. Year-built bands were developed to capture the evolution in flood design provisions and requirements determined by the adoption of FIRM and revisions to the Florida Building Code (FBC), as described in the following table. In instances where information on if the specific building meets the requirements of FIRM is not provided in the exposure data, this is inferred based on when the FIRM was first implemented in the community where the building is located. In the KCC US Flood Reference Model, changes in the design requirements, and hence the differences in building vulnerabilities within the year-built bands, are captured by using building characteristics representative of those different year-built bands. Unique vulnerability functions were derived for each year-built bin.

Year Built Bin		Description
Pre-FIRM		These are built before development of FIRM maps for their community and have not had any major renovation after development of the FIRM maps.
Post-FIRM	Post-FIRM or Before 1981	These are built after the development of FIRM maps for their community but before FEMA’s 1981 change to the V Zone requirements, which included wave impacts.
	Post-FIRM or 1981 and Newer	These are built after the development of FIRM maps for their community and after FEMA’s 1981 change to the V Zone requirements, which included wave impacts.
2012 - 2017		These are built after the FBC 2010 became effective. The FBC 2010 adopted the I-codes for flood design provisions, which are consistent with NFIP’s minimum requirements. The FBC 2010 adopted the ASCE24-05 requirements, which met and exceeded some of the NFIP requirements of flood design elevations and mitigation measures. For example, in the FBC 2010, the use of design flood elevation (DFE) instead of base flood elevation (BFE) was required, and building utilities were also required to be placed at higher elevations.
2018 and Newer		These are built after the FBC 2017 became effective. The FBC 2017 included significant changes to the flood provision. Some of the additional requirements include changes to flood design depths, changes to flood opening requirements, and revision of the coastal construction control line requirements.

Table 10 - Year-built bands implemented in the KCC US Flood Reference Model

Different year-built bands are used for manufactured homes since they are designed as per the requirements of the U.S. Department of Housing and Urban Development (HUD). Four year-built bands (before 1976, 1976-1994, 1995-2008, and 2009 and newer) are used, and different vulnerability functions are derived for those year-built bins. These year-built bands capture the evolution of the HUD design requirements, particularly the requirements on tie-down anchors, which are also stated in Table 9.

8. State if the following building characteristics are considered in the development of the personal residential structure flood vulnerability functions, and if so, how; if not, explain why:

a. Number of stories,

The number of stories was included when developing the vulnerability functions. Separate vulnerability functions have been developed for different numbers of stories (1-10 stories at 1 story increments, and for buildings taller than 10 stories).

b. Use of each story (e.g., habitable space, parking, storage, other),

The use of each story was not incorporated into the vulnerability functions because this is not typically available in insurer exposure or claims data.

c. Presence of basement,

The presence of a basement is included in the KCC vulnerability functions. The presence of a basement increases the vulnerability of a building when the inundation floods the basement, causing damage to the building interior and contents. Whether a basement is finished or unfinished and any floodproofing done to the basement impacts the overall building vulnerability.

Vulnerability functions were developed for no basement, finished basement with floodproofing, finished basement without floodproofing, unfinished basement with floodproofing, and unfinished basement without floodproofing.

d. Replacement value of building,

The replacement value of a building was not considered when developing the KCC vulnerability functions but is used in the Financial Module to calculate the insured loss to a property.

e. Structure value by story,

The structure value by story was not incorporated into the vulnerability functions because this is not typically available in insurer exposure or claims data.

f. Square footage of living area, and

Square footage of living area was not considered in the KCC vulnerability functions as it has not been shown to impact damage flood vulnerability.

g. Other construction characteristics, as applicable.

No other construction characteristics were considered when developing the vulnerability functions.

9. Describe the process by which local construction practices, statewide and county building code, and floodplain management regulation adoption and enforcement are considered in the development of personal residential structure flood vulnerability functions.

The development of the Flood Insurance Rating Maps (FIRM) by FEMA, which is required for participation in the NFIP program, is performed at community (municipality or local government) level. Hence, the initial FIRM date varies by community. As a result, two identical structures built in the same year but belonging to different communities utilize different KCC vulnerability functions due to the difference in FIRM classifications and construction practices.

Moreover, the KCC US Flood Reference Model utilizes the NFIP's Community Rating System (CRS) to group communities into different vulnerability regions. These vulnerability regions capture the differences in vulnerability that result from community flood management and mitigation measures. The CRS program

assigns communities a CRS class from 1 (highest) to 10 (lowest), depending on the CRS credits earned. The CRS credits cover 19 categories with the end goals of reducing flood damage to insurable property, strengthening and supporting the insurance aspects of NFIP, and encouraging a comprehensive approach to floodplain management. The CRS program also evaluates community programs for elevation certificates and building code adoption and enforcement. Examination of past flood claims by several researchers have shown that, all other things being equal, communities with better CRS scores have fewer claims (Kousky & Michel-Kerjan, 2015). The CRS effective May 2018 is used.

All other building characteristics held constant, buildings in communities with the highest CRS scores are assumed to be generally less vulnerable compared to buildings in communities with low CRS scores. This is captured by assuming that buildings in low CRS score communities have weaker building components and a lower probability of adopting mitigation measures. This variation in building vulnerability by region is not applicable to Pre-FIRM buildings (as defined in Table 10).

The KCC US Flood Reference Model also captures the changes in the statewide building code requirements by deriving vulnerability functions for different year-built bins, as shown in Table 10. Flood provisions were first included in the 4th edition of Florida Building Code (FBC 2010), which was consistent with the minimum NFIP requirements. The FBC underwent a major revision to the flood provision, especially with regard to the design requirement in the V and coastal A flood zones in 2017. A few of the most impactful changes are provided in Table 10.

10. Provide the total number of personal residential structure flood vulnerability functions available for use in the flood model. Describe which structure flood vulnerability functions are used for personal residential building structures, manufactured homes, condo unit owners, and apartment renters.

The KCC US Flood Reference Model incorporates over 32,000 coastal flood building vulnerability functions and the same amount for inland flood vulnerability functions. Twenty-six primary construction types are included in the model and are summarized by personal residential building type below.

Residential Building Type	Construction Type(s)
Owners	Wood frame, unreinforced masonry, reinforced masonry, reinforced concrete, masonry, unknown
Manufactured Homes	Full tie-downs, partial tie-downs, no tie-downs, unknown
Condo unit owners	Wood frame, unreinforced masonry, reinforced masonry, reinforced concrete, steel, light metal, masonry, unknown
Renters	Wood frame, unreinforced masonry, reinforced masonry, reinforced concrete, steel, light metal, masonry, unknown

Table 11 - Primary construction types included in the KCC US Flood Reference Model

11. Describe the assumptions, data, methods, and processes used to develop personal residential structure flood vulnerability functions when:

- a. personal residential construction types are unknown, or**
- b. one or more primary building characteristics are unknown, or**
- c. building input characteristics are conflicting.**

Separate building vulnerability functions have been developed for each construction type, year built, number of stories, and FFH. Beside the distinct applicable combinations of those characteristics, vulnerability functions were developed by exposure weighted averaging the known vulnerability functions to create composite vulnerability functions to handle cases where one or more attributes are unknown.

Prior to running a loss analysis, exposure information must be imported into RiskInsight. During import, RiskInsight performs validation on all input exposure attributes, and the valid data types and input options are detailed in the *RiskInsight OEF2 Database Schema* user documentation. An initial level of validation ensures that on an individual risk characteristic resolution, only valid and non-conflicting information is entered. An additional validation is performed to ensure that combinations of risk characteristics do not conflict. All exposure locations contained in the input file that do not pass the validation rules due to conflicting input characteristics are reported in the Exposure Import Log, are not imported into RiskInsight, and are not available for loss analysis.

12. *Describe similarities and differences in how the personal residential structure flood vulnerability functions are developed and applied for coastal and inland flooding.*

The coastal flood and inland flood vulnerability functions share similar primary building characteristics, year-built bands, and vulnerability regions. However, inland and coastal flooding vulnerability functions are developed separately because the forces acting on a building during a coastal flood and inland flood are different. Additionally, the salinity of coastal flood waters has impacts on building damage and repair cost that are reflected in the vulnerability functions.

Both sets of vulnerability functions are created using the component method described in Standard VF-1, Disclosure 2.

13. *Provide a completed Form VF-1, Coastal Flood with Damaging Wave Action. Provide a link to the location of the form [insert hyperlink here].*

[Form VF-1: Coastal Flood with Damaging Wave Action](#)

14. *Provide a completed Form VF-2, Inland Flood by Flood Depth. Provide a link to the location of the form [insert hyperlink here].*

[Form VF-2: Inland Flood by Flood Depth](#)

VF-2 Derivation of Personal Residential Contents Flood Vulnerability Functions

A. Development of the personal residential contents flood vulnerability functions shall be based on some combination of the following: (1) post-event site investigations, (2) technical literature, (3) expert opinion, (4) laboratory or field testing, and (5) insurance claims data. Contents flood vulnerability functions shall be supported by historical and other relevant data.

The personal residential contents flood vulnerability functions were developed based on technical literature review, engineering judgement informed by rational structural analysis, and post-event damage surveys. Vulnerability functions were then validated using insurance claims data.

B. The relationship between personal residential structure and contents flood vulnerability functions shall be reasonable.

The relationship between modeled building vulnerability functions and modeled contents vulnerability functions is reasonable and has been validated with insurance claims data.

Disclosures

1. Provide a flowchart documenting the process by which the personal residential contents flood vulnerability functions are derived and implemented.

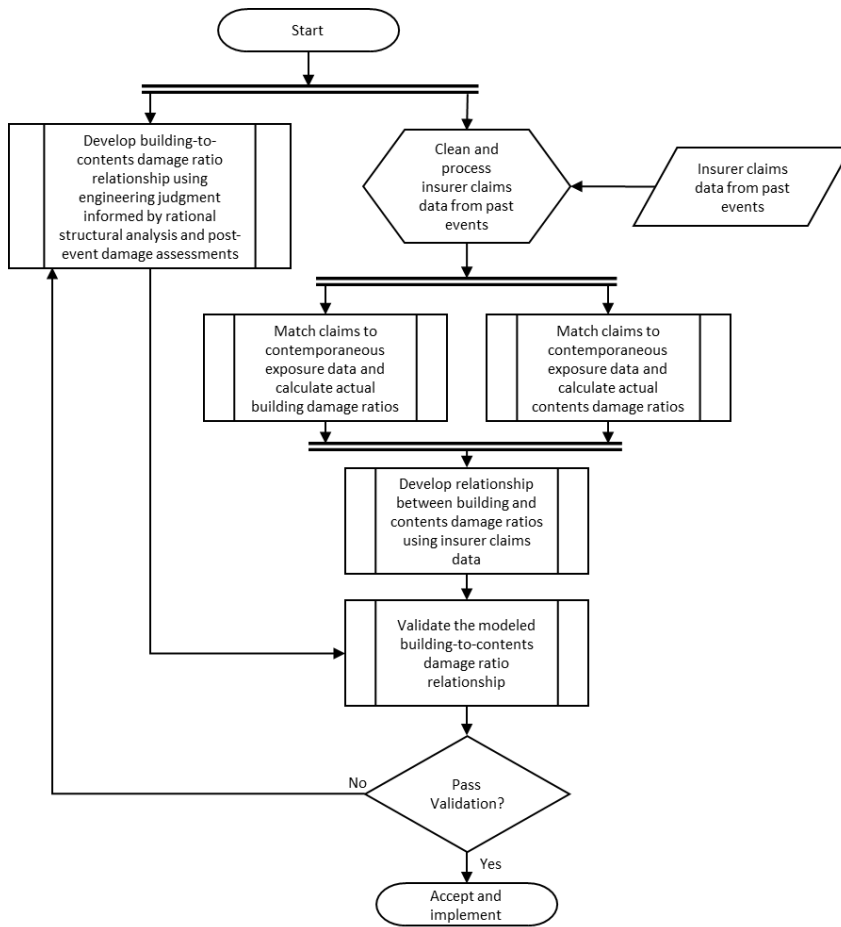


Figure 37 - Derivation and implementation of contents vulnerability functions

2. Describe the relationship between personal residential contents and personal residential structure flood vulnerability functions.

During a coastal or inland flooding event, water infiltration into a building through cracks and openings (including those caused by building damage) causes damage to the building interior and contents. Hence, the contents flood vulnerability functions correspond to building vulnerability functions so that as the building damage increases so does the contents damage. However, the relationship between building damage and contents damage is not linear. A slightly larger proportion of the contents are damaged at lower levels of building damage because when any water gets inside the building envelope, the contents, which are mostly on the floor, are damaged. As the building damage increases, the contents are already damaged from low levels of inundation, and the proportion of contents damage to building damage decreases. Because some contents are salvageable or non-destructible, when a building sustains complete damage, the contents damage ratio is less than 100%.

3. Describe any assumptions, data, methods, and processes used to develop and validate the personal residential contents flood vulnerability functions.

The process of developing the contents vulnerability functions is shown in Standard VF-2, Disclosure 1. The KCC US Flood Reference Model uses a building-to-contents damage relationship to estimate the contents losses. The initial building-to-contents relationship was developed based on engineering judgement informed by rational structural analysis and post-event damage surveys. Insurance claims data were then used to validate the relationship between building and contents damage.

4. As applicable, describe the nature and extent of actual insurance claims data used to develop the personal residential contents flood vulnerability functions. Describe in detail what is included, such as, number of policies, number of insurers, dates of loss, and number of units of dollar exposure, separated into personal residential building structures and manufactured homes.

KCC used claims data for 14 events causing flood damage between 2009 to 2018. The number of policies and exposure amount by policy type are summarized in the following table.

Policy Type	Number of Policies	Exposure (\$)
Personal Residential	18,101,360	1,014,956,219,900
Manufactured Homes	1,173	47,221,900

Table 12 - Number of policies and exposure value of insurer claims data used to develop the KCC contents vulnerability functions

KCC engineers mapped the claim amount to its associated policy so the claims data could be aggregated and analyzed separately by census tract, flood zones, occupancy, and other property characteristics. Most of the claims were also identified by coverage. The contemporaneous exposure data was representative for all policies in force on the date of the storm (not just those with claims), which was used to estimate the MDRs (mean damage ratios). Different sets of contents-to-building damage relationships were developed for different flood zones; however, it was observed that there were not significant differences in the relationships by flood zone.

Contents versus building damage relationships were developed using the claims data and then compared to the relationship developed using the engineering analysis. In general, the engineering-based vulnerability functions performed well, and the claims data informed a few refinements to the vulnerability functions. One example of the refinements performed was to reduce the building-to-contents damage relationship at low levels of building damage.

5. ***Provide the total number of personal residential contents flood vulnerability functions available for use in the flood model. Describe whether different contents flood vulnerability functions are used for personal residential building structures, manufactured homes, unit location for condo owners and apartment renters, and various building classes.***

The KCC US Flood Reference Model incorporates over 32,000 coastal flood contents vulnerability functions and the same amount for inland flood contents vulnerability functions. Different contents flood vulnerability functions are used for personal residential building structures, manufactured homes, unit location for condo owners and apartment renters, and various building classes.

6. ***Describe any relationships between flood characteristics and personal residential contents flood vulnerability functions.***

Separate contents flood vulnerability functions are developed for coastal and inland flood.

7. ***State the minimum threshold, if any, at which personal residential contents flood damage is calculated (e.g., personal residential contents flood damage is estimated for personal residential structure damage greater than x percent or flood depth greater than y inches). Provide documentation of assumptions and available validation data to verify the approach used.***

Contents damage is proportional to building damage (including both structural and non-structural damage), and there are cases where contents damage can be incurred without any building structural damage. In the KCC US Flood Reference Model, there is no minimum threshold of structural damage required for contents damage to be calculated.

8. ***Describe similarities and differences in how personal residential contents flood vulnerability functions are developed and applied for coastal and inland flooding.***

Separate building flood vulnerability functions were developed for coastal and inland flooding. Therefore, using the building-to-contents relationship, separate contents flood vulnerability functions are developed for coastal and inland flooding.

9. ***Describe the assumptions, data, methods, and processes used to develop personal residential contents flood vulnerability functions when:***

- a. ***personal residential construction types are unknown, or***
- b. ***one or more primary building characteristics are unknown, or***
- c. ***building input characteristics are conflicting.***

Separate contents vulnerability functions have been developed for each construction type, year built, number of stories, and FFH. Beside the distinct applicable combinations of those characteristics, vulnerability functions for cases where one or more of these building attributes are unknown/missing were developed by exposure weighted averaging the known vulnerability functions to create composite vulnerability functions to handle cases where one or more attribute is unknown.

Prior to running a loss analysis, exposure information must be imported into RiskInsight. During import, RiskInsight performs validation on all input exposure attributes, and the valid data types and input options are detailed in the *RiskInsight OEF2 Database Schema* user documentation. An initial level of validation ensures that on an individual risk characteristic resolution, only valid and non-conflicting information is entered. An additional validation is performed to ensure that combinations of risk characteristics do not conflict. All exposure locations contained in the input file that do not pass the validation rules due to conflicting input characteristics are reported in the Exposure Import Log, are not imported into RiskInsight, and are not available for loss analysis.

VF-3 Derivation of Personal Residential Time Element Flood Vulnerability Functions

- A. Development of the personal residential time element flood vulnerability functions shall be based on one or more of the following: (1) post-event site investigations, (2) technical literature, (3) expert opinion, (4) laboratory or field testing, and (5) insurance claims data.**

The time element flood vulnerability functions were developed based on engineering judgement informed by rational structural analysis and post-event damage surveys.

- B. The relationship among personal residential structure, contents, and time element flood vulnerability functions shall be reasonable.**

The relationship between modeled building, time element, and contents vulnerability functions is reasonable.

Disclosures

- 1. Provide a flowchart documenting the process by which the personal residential time element flood vulnerability functions are derived and implemented.**

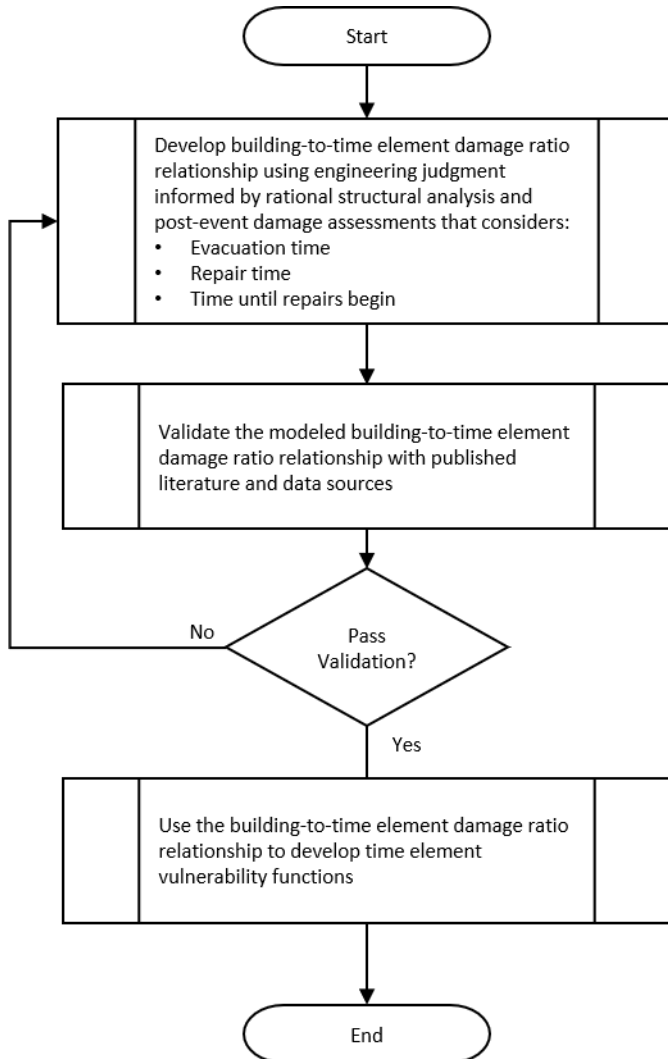


Figure 38 - Derivation and implementation of the time element vulnerability functions

2. Describe the assumptions, data, methods, and processes used to develop and validate personal residential time element flood vulnerability functions.

The process for developing the flood vulnerability functions for time element losses is shown in Standard VF-3, Disclosure 1. During the development of time element vulnerability functions, losses causing time element claims are assumed to be divided into direct losses (time to repair a damaged building) and indirect losses (e.g., infrastructure disruption, mandatory evacuation, claims processes, loss of access to house). Direct loss represents time element losses related to building-repair, which is the time needed to repair a structure to the point where the occupants can return and depends on the level of damage to the building. The indirect time element losses include evacuation during the event, loss of access to the building due to infrastructure disruption, and the length of time before repairs can begin.

Both losses are included in the KCC vulnerability functions, which use a building-to-time element relationship to derive time element vulnerability functions. The building-to-time element relationship was developed based on engineering judgement informed by rational structural analysis, cost and repair analysis, and post-event damage surveys.

3. Describe the relationships among personal residential structure, contents, and time element vulnerability functions.

Time element vulnerability functions reflect the time required for a building to be repaired, which is largely dependent on the building's damage state. Therefore, the time element vulnerability functions generally follow the building vulnerability functions so that as the building damage level increases so does the time element. Additional factors, such as infrastructure disruption and damage to contents, also impact the time element losses.

In contrast to the relationship between building damage and contents damage, for low level building damage states, the time element increases at a relatively slow rate, and as the building damage state becomes more severe, the time element increases at a faster rate. At lower building damage states, the repairs are not significant enough to force the occupants to leave, and most time element losses are due to indirect losses. However, as the building damage increases, the repair times become progressively longer and more extensive, which is more likely to make the dwelling uninhabitable and increase time element losses.

4. As applicable, describe the nature and extent of actual insurance claims data used to develop the personal residential time element flood vulnerability functions. Describe in detail what is included, such as number of policies, number of insurers, dates of loss, and number of units of dollar exposure, separated into personal residential building structures and manufactured homes.

This is not applicable since there is very limited claims information regarding time element losses induced by flooding damage.

5. Provide the total number of personal residential time element flood vulnerability functions available for use in the flood model. Describe whether different time element flood vulnerability functions are used for personal residential building structures, manufactured homes, unit location for condo owners and apartment renters, and various building classes.

The KCC US Flood Reference Model incorporates over 32,000 coastal flood time element vulnerability functions and the same amount for inland flood time element vulnerability functions. Different time element flood vulnerability functions are used for personal residential building structures, manufactured homes, condo owners and apartment renters, and various building classes.

6. Describe similarities and differences in how personal residential time element flood vulnerability functions are developed and applied for coastal and inland flooding.

Similar building-to-time element mean damage ratio relationships are used for personal residential coastal and inland flooding. However, separate building flood vulnerability functions are developed for

coastal and inland flooding. Therefore, using the building-to-time element relationship, separate time element flood vulnerability functions are developed for coastal and inland flooding.

Both the coastal and inland flood time element vulnerability functions are developed with the same methodology.

7. Describe whether and how personal residential structure classification and characteristics, and flood characteristics, are incorporated into the personal residential time element flood vulnerability functions.

Using the building-to-time element relationship, time element vulnerability functions are developed for the different flood types (inland and coastal) and residential structure classifications and characteristics. As a result, the time element vulnerability functions account for personal residential structure classification and characteristics as well as flood characteristics insofar as the building vulnerability functions incorporate them.

8. Describe whether and how personal residential time element flood vulnerability functions take into consideration the damage to local and regional infrastructure, or personal residential time element vulnerability resulting from a governmental mandate associated with flood events (e.g., evacuation and re-entry mandates).

One of the components reliant on engineering judgement is the effect that local and regional infrastructure disruption has on the amount of time between a building being uninhabitable and occupants returning. This effect could be independent of the repair time (for example, a building with no damage but located in an area with infrastructure disruption) or coincide with the repair time (such as if infrastructure disruption delayed repairs to a damaged building). When calculating loss costs, the time element vulnerability functions do not explicitly distinguish between the direct loss (repair time) and indirect loss (infrastructure disruption); however, the effects of local and regional infrastructure disruption are included when developing the building-to-time element relationships, which are used to derive the time element vulnerability functions.

9. Describe the assumptions, data, methods, and processes used to develop personal residential time element flood vulnerability functions when:

- a. personal residential construction types are unknown, or**
- b. one or more primary building characteristics are unknown, or**
- c. building input characteristics are conflicting.**

Separate time element vulnerability functions have been developed for each construction type, year built, number of stories, and FFH. Beside the distinct applicable combinations of those characteristics, vulnerability functions for cases where one or more of these building attributes are unknown/missing were developed by exposure weighted averaging the known vulnerability functions to create composite vulnerability functions to handle cases where one or more attribute is unknown.

Prior to running a loss analysis, exposure information must be imported into RiskInsight. During import, RiskInsight performs validation on all input exposure attributes, and the valid data types and input options are detailed in the *RiskInsight OEF2 Database Schema* user documentation. An initial level of validation ensures that on an individual risk characteristic resolution, only valid and non-conflicting information is entered. An additional validation is performed to ensure that combinations of risk characteristics do not conflict. All exposure locations contained in the input file that do not pass the validation rules due to conflicting input characteristics are reported in the Exposure Import Log, are not imported into RiskInsight, and are not available for loss analysis.

VF-4 Flood Mitigation Measures

- A. Modeling of flood mitigation measures to improve flood resistance of personal residential structures, the corresponding effects on flood vulnerability, and their associated uncertainties shall be theoretically sound and consistent with fundamental engineering principles. These measures shall include design, construction, and retrofit techniques that affect the flood resistance or flood protection of personal residential structures. The modeling organization shall justify all flood mitigation measures considered by the flood model.**

The impact of mitigation measures and secondary characteristics on a building's flood load resistance is captured through the use of modification factors that increase or decrease the building vulnerability functions. The default vulnerability functions are those developed for the distinct combinations of primary building characteristics described in Standard VF-1. The secondary characteristics relevant to building flood vulnerability include type of basement, opening protection, wall-to-foundation connection, and type of mitigation measure. For each secondary characteristic, detailed engineering analysis, supported by post-event damage survey data, and engineering judgement are used to determine its effects on overall building performance.

The mitigation measures and secondary building characteristics included in the KCC US Flood Reference Model have been well documented with respect to their impacts on building performance during flooding.

- B. Application of flood mitigation measures that affect the performance of personal residential structures and the damage to contents shall be justified as to the impact on reducing flood damage whether done individually or in combination.**

The application of flood mitigation measures is justified by sound structural engineering analysis. Each mitigation measure impacts the vulnerability function of a related building component(s) and consequently modifies the building vulnerability function. The effect of each flood mitigation measure is estimated separately. If more than one mitigation measure is present, the effects of multiple mitigation measures are combined systematically, as described in Standard VF-4, Disclosure 5. The application of individual or a combination of flood mitigation measures and the resulting vulnerability functions are reasonable and in agreement with engineering principles.

Disclosures

- 1. Provide a completed Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage. Provide a link to the location of the form [insert hyperlink here].**

[Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage](#)

- 2. Provide a description of all flood mitigation measures used by the flood model, whether or not they are listed in Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage.**

The following tables summarize the secondary characteristics and flood mitigation measures included in the KCC US Flood Reference Model.

Secondary Characteristic	Options	In Form VF-3	Description
Basement	Unknown		The presence of basement can increase the vulnerability of a building when the inundation reaches a certain amount and could flood the basement, causing damage to the building interior and contents.
	No basement		
	Unfinished basement		
	Finished basement		

Secondary Characteristic	Options	In Form VF-3	Description
Foundation Connection	Anchorage Bolts		It is important that a building have an integrated load-path from the wall to the foundation. Structurally connected connections are the strongest, while nails are the weakest.
	Nails		
	Straps		
	Clips		
	Structurally connected		
	Unknown		
Floor of Interest	Unknown		The floor of interest is very important particularly for the case of condo-unit policies since this dictates the potential level of flooding a condo-unit experiences.
	Ground Floor		
	One Floor Above Ground		
	Two Floors Above Ground		
	Three or More Floors Above Ground		

Table 13 - Secondary characteristics included in the KCC US Flood Reference Model

Mitigation Measures	Options	In Form VF-3	Description
Elevate structure	1 foot	✓	Elevating a structure is one of the most important and effective mitigation measures. If the water doesn't reach the building, no damage can result.
	2 feet	✓	
	3 feet	✓	
	4 feet		
	Not elevated		
	Unknown		
Elevate or protect utility equipment	Up to 1 foot	✓	Utilities are among one of the most expensive components averaging between 15-25% of the building cost. Protecting them could reduce the damages to the building. Once the inundation level exceeds the protection level, the mitigation measure loses its effectiveness. In the vulnerability function development process, utilities represent a sub-component (portion of the building interior building component), with separate damage functions.
	Up to 2 feet	✓	
	Up to 3 feet	✓	
	Up to 4 feet		
	Not elevated or protected		
	Unknown		
Wet floodproofing	Up to 1 foot	✓	Wet floodproofing allows the water to enter for the purpose of quickly
	Up to 2 feet	✓	

Mitigation Measures	Options	In Form VF-3	Description
	Up to 3 feet	✓	reducing the differences in static pressure between the inside or outside of the structure. However, there are costs with the cleanup after the event. Once the inundation level exceeds the protection level, the mitigation measure loses its effectiveness.
	Up to 4 feet		
	Not floodproofed		
	Unknown		
Dry floodproofing	Up to 1 foot	✓	Dry floodproofing protects the structure from water entering the building up to the protected level. Once the inundation level exceeds the protection level, the mitigation measure loses its effectiveness.
	Up to 2 feet	✓	
	Up to 3 feet	✓	
	Up to 4 feet		
	Not floodproofed		
	Unknown		
Building Enclosure	Enclosed walls, with flood openings	✓	Enclosures below the base flood elevation (BFE) are required to be breakaway walls to prevent propagation of damage to elevated structures. Flood openings are an effective way equalizing the water pressure on both sides of a wall by allowing water to enter the space behind the wall. This reduces the pressure on the walls and decreasing the damages. However, there are costs with the cleanup after the event.
	Enclosed walls, without flood openings		
	Breakaway walls, with flood openings		
	Breakaway walls, without flood openings		
	Open Foundation		
	Unknown		

Table 14 - Mitigation measures included in the KCC US Flood Reference Model

3. Describe how personal residential time element losses are affected by performance of flood mitigation measures. Identify any assumptions.

Building damage decreases with the implementation of flood mitigation measures as the relative vulnerability decreases, and secondary characteristics can increase or decrease the building vulnerability. Because time element vulnerability functions are derived from building vulnerability functions, time element losses change in proportion with the building damage.

4. Describe how personal residential structure and contents damage and their associated uncertainties are affected by flood mitigation measures. Identify any assumptions.

Building damage decreases with the implementation of flood mitigation measures as the relative vulnerability decreases, and secondary characteristics can increase or decrease the building vulnerability. Because contents vulnerability functions are derived from building vulnerability functions, contents damage changes in proportion with the building damage.

5. Describe how the effects of multiple flood mitigation measures are combined in the flood model and the process used to ensure that multiple flood mitigation measures are correctly combined.

The process of combining the effects of multiple flood mitigation measures is done systematically to avoid double-counting. Some of the mitigation measures are sub-measures of others. For example, wet floodproofing includes using flood-resistant material in the area expected to be flooded, elevating or protecting utilities, and adding flood openings. In such cases, the maximum mitigation modifier for every intensity level is used.

In cases where multiple mitigation measures impact different building components, for example dry floodproofing and elevating utility equipment, the combined effect is computed by adding the percent of impact that each measure has on the vulnerability function. For example, if mitigation measure “a” decreases the vulnerability by 2% and mitigation “b” decreases the vulnerability by 3%, the combined effect would be a decrease of 5% in the vulnerability.

The mitigation measures are broadly grouped into those intended to prevent water from coming into the building (i.e. dry floodproofing), those that mitigate damage assuming water will come into a building (elevated utilities, wet floodproofing, and elevating the structure), and those that impact building enclosure and below floor structures. In cases where three or more mitigation measures are present, modifiers within the same group are first combined before their combined percent of impact is incorporated into the vulnerability function. This approach was observed to be consistent with the engineering analysis used to develop the secondary modifiers and produces reasonable combinations of any number of secondary building characteristics and mitigation measures.

6. Describe how flood mitigation measures affect the uncertainty of the vulnerability. Identify any assumptions.

In the KCC US Flood Reference Model, the uncertainty around the vulnerability is a function of MDR. During loss calculation, the mitigation measures and secondary characteristics modify the MDRs, thereby changing the secondary uncertainty of the modeled vulnerability. No other assumptions are made with respect to the mitigation measures and secondary characteristics.

Actuarial Flood Standards

AF-1 Flood Modeling Input Data and Output Reports

- A. Adjustments, edits, inclusions, or deletions to insurance company or other input data used by the modeling organization shall be based upon generally accepted actuarial, underwriting, and statistical procedures.**

All adjustments, edits, inclusions, or deletions to insurance company input or other input data are based upon accepted actuarial, underwriting, and statistical procedures.

- B. All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the flood model shall be actuarially sound and shall be included with the flood model output report. Treatment of missing values for user inputs required to run the flood model shall be actuarially sound and described with the flood model output report.**

Model input data is provided by the user for each catastrophe loss analysis. RiskInsight® performs validation tests during exposure data import and includes exposure data validation tools within the user interface that assist users in verifying data integrity. All modifications, adjustments, assumptions, inputs and input file identification, and defaults necessary to use the flood model are actuarially sound and are included with the flood model output report and in the RiskInsight® documentation. Treatment of missing values required to run the flood model are actuarially sound and described in the RiskInsight® documentation.

Disclosures

- 1. Identify insurance-to-value assumptions and describe the methods and assumptions used to determine the property value and associated flood losses. Provide a sample calculation for determining the property value.**

The model makes no insurance-to-value assumptions. The KCC US Flood Reference Model assumes that the Replacement Value input is the true property value. The model has separate inputs for replacement values and policy limits.

Users can account for underinsured policies by adjusting the exposure data outside of the model.

As an example, a policy with an insured value of \$200,000 that is 20% underinsured would be entered as:

Replacement value field: $\$200,000 / (1 - 20\%) = \$250,000$

Limit field: \$200,000

- 2. Identify depreciation assumptions and describe the methods and assumptions used to reduce insured flood losses on account of depreciation. Provide a sample calculation for determining the amount of depreciation and the actual cash value (ACV) flood losses.**

The KCC US Flood Reference Model makes no depreciation assumptions and does not reduce flood losses on account of depreciation. As such, no sample calculation has been provided.

- 3. Describe the different flood policies, contracts, and endorsements as specified in s. 627.715, F.S., that are modeled.**

The KCC US Flood Reference Model does not consider non-flood water-intrusion losses. The KCC US Flood Reference Model can accommodate all policy terms, conditions, and endorsements as specified in s.627.715, F.S., including the incorporation of building, time element, and contents coverages, and other flexible terms.

4. **Provide a copy of the input form(s) used by the flood model with the flood model options available for selection by the user for the Florida flood model under review. Describe the process followed by the user to generate the flood model output produced from the input form. Include the flood model name and version identification on the input form. All items included in the input form submitted to the Commission should be clearly labeled and defined.**

Tab Separated Values (TSV) are used to import exposure information into the KCC exposure database. The RiskInsight® OEF Import Guide documents the input file names, field names, and data types that are supported during import, including the required fields for generating loss estimates.

KCC utilizes an analysis input form to record and set import loss analysis specifications including: model and model version, loss analysis resolution, and demand surge, among other options. The contents of this analysis input form are recorded in the flood model output report, a sample of which is provided in Standard A-1, Disclosure 5.

The table below shows the analysis option settings that are required for ratemaking purposes.

Analysis Option	Required Setting for Florida Ratemaking	Description
Exposure Set		
Ceding Company	n/a	The combination of the Ceding Company, Analysis Name, and Notes fields are used to build a meaningful text description that uniquely identifies each analysis. The Ceding Company field is used to identify the insurance company name.
Analysis Name	n/a	The analysis name allows the user to record a concise text summary of the analysis purpose and analysis settings.
Notes	n/a	Additional notes fields that can be used to provide further descriptive comments regarding the analysis.
Database Type	KCC_OEF2	KCC database format in which the exposure data is saved.
Database	n/a	The name of the SQL exposure database on which losses will be run.
Portfolio	n/a	The portfolio within the exposure database on which losses will be run.
Excl/Incl. Treaties	n/a	This enables the ability to import/include reinsurance treaty data.
Exposure Perils	4: Flood	Specific peril associated with the exposure that RiskInsight® will use.
Loss Analysis Options		
Currency	USD: Dollars	Currency for loss estimates.
Want Catalog Events	Check	When selected, the model includes loss estimates from the stochastic event set.
Want Historical Events	n/a	When selected, loss estimates are calculated for historical events.
Want Custom Events	n/a	When selected, loss estimates are calculated for custom events.

Analysis Option	Required Setting for Florida Ratemaking	Description
Want Live Events	n/a	When selected, loss estimates are calculated for live (active tropical cyclone) events.
Event Loss Resolution Drop Down	Event Totals Only	The level at which event losses will be saved in the results database. A variety of resolutions are supported including location, policy, LOB, State, and State and LOB.
Loss Perspective Drop Down	YLT using Gross Losses	Loss perspective for the Year Loss Table stored in the results database.
Include Demand Surge	Check	When selected, loss estimates are increased to reflect increases in material and labor costs associated with repairing properties after significant catastrophe events.
Want AAL by	Location	When selected, average annual loss estimates are stored in the results database by location.
Model Options		
Model for Losses	KCC US_Flood_v1.0	Model RiskInsight® will use for running losses.
Include Location Details	Check	Indicates flood mitigation measures applied in the analysis.
Event Set	STOC	Set of model-associated events on which RiskInsight® will run losses.
Job Options		
Cluster	n/a	Identifies the group of servers that will be used to generate loss estimates during the analysis.
Priority	n/a	RiskInsight® can run multiple analyses in parallel on independent clusters of hardware resources. Users can select between High, Normal, and Low analysis queues to prioritize analyses.
Notify	n/a	Entering an email address will trigger an automated email once an analysis is completed.

Table 15 - Analysis options available in RiskInsight® through the user interface

A representative sample input file supported by the model is shown below. The RiskInsight® import functionality detects field names in the input file and automatically maps them into the required KCC exposure database field.

LocationID	AccountID	PostalCode	BuildingValue	OtherValue	ContentsValue	TimeElementValue	RiskCount	ConstructionCodeType	ConstructionCode	OccupancyCodeType
17387	2	32712	1043100	0	0	0	2	KCC	MS10	ATC
17388	2	32751	4076383	0	0	0	2	KCC	MS10	ATC
17389	2	32751	0	96563	0	0	5	KCC	MS10	ATC
17390	2	32751	13587077	126126	0	0	18	KCC	MS10	ATC
17391	2	32751	40000	0	0	0	1	KCC	MS10	ATC
17392	2	32751	4193018	159540	0	0	8	KCC	MS10	ATC
17393	2	32751	814100	76575	0	0	2	KCC	MS10	ATC
17394	2	32751	940899	0	0	0	1	KCC	MS10	ATC
17395	2	32751	11823132	0	0	0	15	KCC	MS10	ATC
17396	2	32751	0	78600	0	0	1	KCC	MS10	ATC

Figure 39 - Sample input file imported into RiskInsight® for exposure mapping

As an initial step in the import process, the user selects import options, including the destination exposure database and the location of the import files, which are illustrated in the image below.

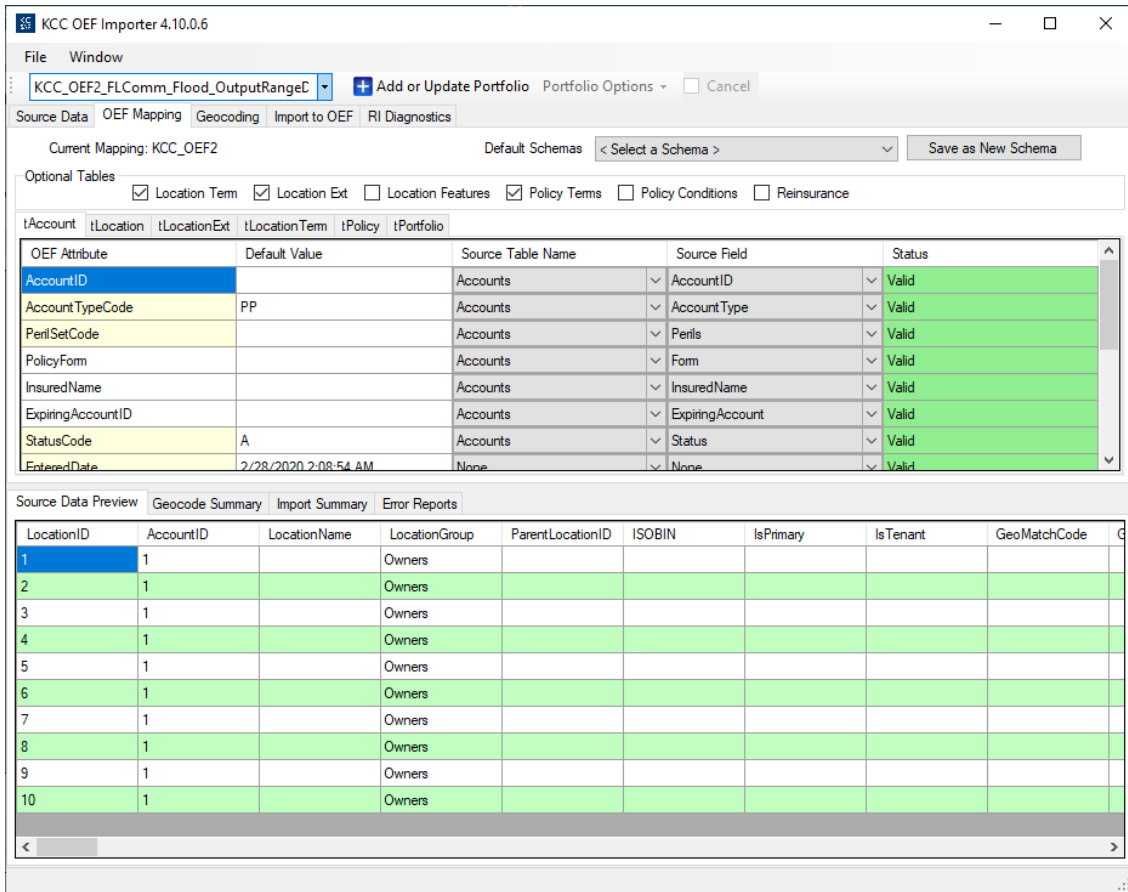


Figure 40 - Options available on exposure data import

After the exposure data is imported and prior to generating results, the user selects a number of analysis options that specify the type and resolution for the model output. The process followed by the user to generate the model output produced from the exposure input is provided below.

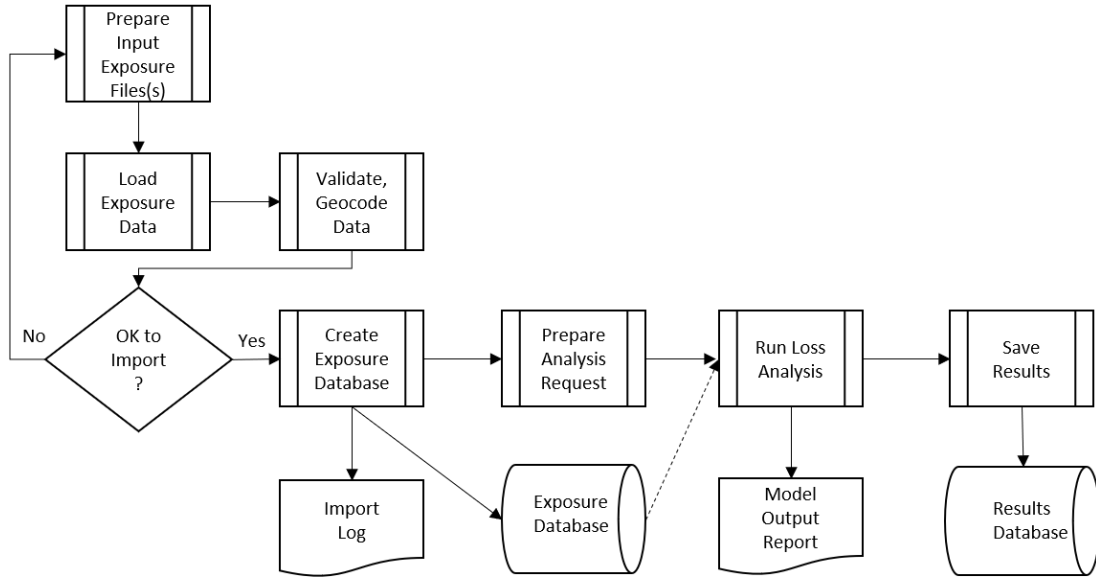


Figure 41 - Process to generate model output from initial exposure input

5. **Disclose, in a flood model output report, the specific inputs required to use the flood model and the options of the flood model selected for use in a personal residential property flood insurance rate filing. Include the flood model name and version identification on the flood model output report. All items included in the flood model output report submitted to the Commission should be clearly labeled and defined.**

The inputs required to use the flood model and the options required for residential property insurance rate filing are detailed in Standard A-1, Disclosure 4.

A sample flood model output report is shown below, which includes the flood model name and version. Definitions for the flood model output report labels are included in Standard A-1, Disclosure 4.

Attribute	Value
RiskInsight Version	4.10.2.140
RI Results Database Version	4.9
Analysis Type	Loss
Analysis Ceding Company	FLCOM AF-5 201020_STOC
Analysis Name	Sample Report
Analysis Notes	
Analysis ID	16
Analysis Parent Analysis ID	0
Analysis Queue ID	1
Analysis Job ID	1304
Analysis Job Priority	High
Analysis User	kccaws\adimanshteyn
Analysis Time Submitted	10/21/2020 9:35:23 AM
Analysis Time Started	10/21/2020 9:35 AM
Analysis Time Ended	10/21/2020 11:38 AM

Analysis Duration 2:03:02
Analysis Status Completed in 122.8 minutes at 2020-10-21 11:38
Analysis Error Summary False
Exposure SQL Server Version Microsoft SQL Server 2019 (RTM-CU1)
(KB4527376) - 15.0.4003.23 (X64)
Exposure SQL Server Name FLCOM1-SQL
Exposure Type KCC_OEF2
Exposure Version KCC_OEF2.1
Exposure Filter
Exposure Database KCC_OEF2_FormAF_5_200925
Exposure PortfolioID 0
Exposure Portfolio Name ALL
Exposure Accounts 0
Exposure Policies 0
Exposure Locations 0
Exposure Sublimits 0
Exposure Reinsurance 0
Exposure Total Replacement Value 0
Model Event Set Type STOC
Model Secondary Peril 0
Model Secondary Qualifier
Analysis Demand Surge True
Analysis Used Cached Exposures False
Analysis Custom Demand Surge False
Analysis Plugins used in Analysis
Model Peril Set Codes Multi_Peril
Model Peril IDs Multi_Peril
Model ID 9002050980
Model Name KCC US_Flood_FL_V1
Model Version 201019:2058
Model Catalog
\\FLCOMSQL\RI_Hazard\KCC_US_FLOOD_FL_V1\KCC_STOC_US_FLOOD_MPMEven
tList_201020.txt
Model Events 108,310
Model Catalog Version 1.0
Model DF Version 1.0
Model Rates Version 1.0
Analysis Intra-policy correlation setting 0.6

Analysis Simulation Count 1000
 Analysis Apply Residential Location Terms False
 Analysis Reinsurance Program name
 Exposure FAC reinsurance count
 Exposure Treaty reinsurance count
 Analysis Loss Perspectives RL
 Analysis Event Losses by AAL_by_Location
 Analysis AAL Resolution Location
 ASC Job Server FLCOM1-SQL
 ASC Number of workers 6
 ASC Workers FLCOM1-LA01, FLCOM1-LA02, FLCOM1-LA03, FLCOM1-LA04, FLCOM1-LA05, FLCOM1-LA06
 ASC Worker cores 48, 48, 48, 48, 48, 48
 ASC Worker RAM (GB) 384, 384, 384, 384, 384, 384
 Results SQL Server FLCOM1-SQL
 Results Database KCC_OEF2_FormAF_5_200925_ResultsRI4
 Analysis Results Currency USD
 Model is MultiPeril True
 Model Secondary Uncertainty File
 \\FLCOMSQL\RI_Hazard\KCC_US_FLOOD_FL_V1\SecUnc_v2\KCCLoss_MDR_Beta_Probs_00001.bin
 Model Minimum Intensity Threshold 0

6. Explain the differences in data input and flood model output required for coastal and inland flood modeling.

There are no differences in the data input and flood model output for coastal and inland flood modeling.

7. Describe actions performed to ensure the validity of insurer or other input data used for flood model inputs or for validation/verification.

RiskInsight® performs validation tests during exposure data import and also provides exposure data validation tools within the user interface that assist users in verifying data integrity. When a validation error occurs during exposure data import, the offending input record is flagged and reported to the user in the Exposure Import Log and is not imported into the KCC exposure database. The user has the opportunity to correct the error, and if the augmented record passes all import exposure validation tests, it can then be imported into the exposure database.

8. *Disclose if changing the order of the flood model input exposure data produces different flood model output or results.*

Changing the order of the KCC US Flood Reference Model input exposure data does not produce different flood model output or results.

9. *Disclose if removing or adding policies from the flood model input file affects the flood model output for the remaining policies.*

Removing or adding policies from the KCC US Flood Reference Model input file will not affect the flood model output for the remaining policies.

AF-2 Flood Events Resulting in Modeled Flood Losses

- A. *Modeled flood loss costs and flood probable maximum loss levels shall reflect insured flood related damages from both coastal and inland flood events impacting Florida.***

Modeled flood loss costs and flood probable maximum loss levels reflect insured flood related damages from coastal and inland flood events impacting Florida.

- B. *The modeling organization shall have a documented procedure for distinguishing flood-related losses from other peril losses.***

KCC has a documented procedure for distinguishing flood losses from other peril losses and will be available for review by the Professional Team during the on-site visit.

Disclosures

- 1. *Describe how damage from flood model generated floods (originating either inside or outside of Florida) is excluded or included in the calculation of flood loss costs and flood probable maximum loss levels for Florida.***

The calculation of flood loss costs and flood probable maximum loss levels for Florida include damage from model-generated floods originating inside and outside of Florida.

- 2. *Describe how wind losses associated with coastal and inland flooding are treated in the calculation of flood loss costs and flood probable maximum loss levels for Florida.***

Wind losses associated with coastal and inland flooding are excluded from flood loss costs and flood probable maximum loss levels in this submission.

- 3. *Describe how the flood model considers the correlation and potential overlap of flood losses associated with coastal and inland flooding.***

The KCC US Flood Reference Model has been implemented as a multi-peril model (MPM) within RiskInsight. This means that each peril (coastal flood and inland flood) has its own intensity footprint for each event, and for locations for which these footprints overlap, the financial module will calculate the loss from each peril and then save and report the maximum loss for each location.

- 4. *Other than coastal and inland flooding, state whether any other types of flooding events are modeled. If so, describe how damage resulting from these flood type events is treated in the calculation of flood loss costs and flood probable maximum loss levels for Florida.***

No other type of flooding event is modeled.

- 5. *Describe which non-flood water losses are considered flood losses from water intrusion. Describe how water intrusion losses are considered in the calculation of flood loss costs and flood probable maximum loss levels for Florida.***

Non-flood water losses are not considered flood losses from water intrusion in the KCC US Flood Reference Model. These losses are not included in the calculation of flood loss costs and flood probable maximum loss levels for Florida.

AF-3 Flood Coverages

- A. *The methods used in the calculation of personal residential structure flood loss costs shall be actuarially sound.***

The KCC US Flood Reference Model calculates building loss costs separately from appurtenant structures, contents, and time element flood loss costs. The methods used in the calculation of building flood loss costs are actuarially sound.

- B. *The methods used in the calculation of personal residential appurtenant structure flood loss costs shall be actuarially sound.***

The KCC US Flood Reference Model calculates appurtenant structure flood loss costs separately from building, contents, and time element loss costs. The methods used in the calculation of appurtenant structure flood loss costs are similar to the methods used for the calculation of building flood loss costs and are actuarially sound.

- C. *The methods used in the calculation of personal residential contents flood loss costs shall be actuarially sound.***

The KCC US Flood Reference Model calculates contents loss costs separately from building, appurtenant structures, and time element flood loss costs. The methods used in the calculation of contents flood loss costs are similar to the methods used for the calculation of building flood loss costs and are actuarially sound.

- D. *The methods used in the calculation of personal residential time element flood loss costs shall be actuarially sound.***

The KCC US Flood Reference Model calculates time element flood loss costs separately from building, appurtenant structures, and contents flood loss costs. The methods used in the calculation of time element flood loss costs are similar to the methods used for the calculation of building flood loss costs and are actuarially sound.

Disclosures

- 1. *Describe the methods used in the flood model to calculate flood loss costs for residential structure coverage associated with personal residential properties.***

When the exposure data is read into the model, each location is assigned a reference vulnerability function code appropriate for the attributes of that property. Personal residential properties are identified by occupancy codes that are different from the commercial residential occupancy codes. The reference vulnerability function code is used to assign the appropriate vulnerability function to the individual location property. The appropriate building vulnerability function is used to estimate the building ground-up loss from each event in the simulated catalog using the inundation depth from that event at the property location. The gross losses are calculated by applying secondary uncertainty and the policy terms. The losses are multiplied by their respective event rates, and then summed across all events to estimate average annual losses. Loss costs are estimated by dividing the average annual losses by the exposure and then multiplying by 1,000.

- 2. *Describe the methods used in the flood model to calculate flood loss costs for appurtenant structure coverage associated with personal residential properties.***

The KCC US Flood Reference Model uses the methodology described in Standard A-3, Disclosure 1 to calculate flood loss costs for appurtenant structure coverage associated with personal and commercial residential properties.

3. Describe the methods used in the flood model to calculate flood loss costs for contents coverage associated with personal residential properties.

The KCC US Flood Reference Model uses the methodology described in Standard A-3, Disclosure 1 to calculate flood loss costs for contents coverage associated with personal and commercial residential properties.

4. Describe the methods used in the flood model to calculate flood loss costs for time element coverage associated with personal residential properties.

The KCC US Flood Reference Model uses the methodology described in Standard A-3, Disclosure 1 to calculate flood loss costs for time element coverage associated with personal and commercial residential properties.

AF-4 Modeled Flood Loss Cost and Flood Probable Maximum Loss Level Considerations

- A. Flood loss cost projections and flood probable maximum loss levels shall not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin.**

The KCC US Flood Reference Model generates loss estimates which do not include expenses, risk load, investment income, premium reserves, taxes, assessments, or profit margin. As a result, the flood loss cost projections and probable maximum loss levels included in this submission do not include any of those elements.

- B. Flood loss cost projections and flood probable maximum loss levels shall not make a prospective provision for economic inflation.**

The KCC US Flood Reference Model uses the replacement values and policy terms that the user inputs without any adjustments and consequently does not make a prospective provision for economic inflation in the flood loss cost projections and probable maximum loss levels.

- C. Flood loss cost projections and flood probable maximum loss levels shall not include any explicit provision for wind losses.**

Flood loss cost projections and flood probable maximum loss levels solely include inland and coastal flood losses and do not include any explicit provision for wind losses.

- D. Damage caused from inland and coastal flooding shall be included in the calculation of flood loss costs and flood probable maximum loss levels.**

The KCC US Flood Reference Model considers damage caused by both inland and coastal flood, which are included in the calculation of flood loss costs and flood probable maximum loss levels.

- E. Flood loss cost projections and flood probable maximum loss levels shall be capable of being calculated from exposures at a geocode (latitude-longitude) level of resolution including the consideration of flood extent and depth.**

In the KCC US Flood Reference Model, the flood loss cost projections and flood probable maximum loss levels can be calculated at a specific location level. Flood loss cost projections and flood probable maximum loss levels can then be calculated at any geographic level desired, including the geocode (latitude-longitude) level of resolution.

- F. Demand surge shall be included in the flood model's calculation of flood loss costs and flood probable maximum loss levels using relevant data and actuarially sound methods and assumptions.**

Demand surge, the increase in the repair or replacement cost of a damaged property, which may occur following a large-scale disaster due to a limited supply of labor, equipment, reconstruction materials, and financing is included in the KCC US Flood Reference Model's calculation of flood loss costs and flood probable maximum loss levels. The demand surge function has been developed using relevant data and actuarially sound methods and assumptions.

Disclosures

- 1. Describe the method(s) used to estimate annual flood loss costs and flood probable maximum loss levels. Identify any source documents used and any relevant research results.**

The KCC flood event catalog represents a 100,000-year sample. Annual flood losses are calculated by multiplying losses by their respective event rates and summing them across all events. Annual flood loss costs are calculated by dividing the average annual flood losses by the appropriate exposure and multiplying by 1,000. The one percent probable maximum losses are calculated as the 1,000th largest annual loss from the sample.

- 2. Identify the highest level of resolution for which flood loss costs and flood probable maximum loss levels can be provided. Identify all possible resolutions available for the reported flood output ranges.**

In the KCC US Flood Reference Model, flood loss costs and flood probable maximum loss can be provided at a specific location level. Flood loss costs and flood probable maximum loss level can then be calculated at any geographic level desired.

- 3. Describe how the flood model incorporates demand surge in the calculation of flood loss costs and flood probable maximum loss levels. Indicate if there are any differences in the manner that demand surge is incorporated for coastal and inland flooding.**

In the KCC US Flood Reference Model, demand surge is applied to ground-up losses based on the industry-wide loss amount for each event. Larger industry losses are expected and assumed to generate more demand surge. There are no differences in the manner that demand surge is incorporated for inland and coastal flooding.

- 4. Provide citations to published papers, if any, or modeling-organization studies that were used to develop how the flood model estimates demand surge.**

No published papers on demand surge were used to develop how the KCC US Flood Reference Model quantifies demand surge.

- 5. Describe how economic inflation has been applied to past insurance experience to develop and validate flood loss costs and flood probable maximum loss levels.**

When validating the KCC US Flood Reference Model using claims data, no adjustments were made to the exposure or loss data because claims could be matched to their contemporaneous exposure data.

AF-5 Flood Policy Conditions

- A. The methods used in the development of mathematical distributions to reflect the effects of deductibles, policy limits, and flood policy exclusions shall be actuarially sound.**

The methods used in the development of mathematical distributions that reflect the effects of deductibles, policy limits, and flood policy exclusions are actuarially sound.

- B. The relationship among the modeled deductible flood loss costs shall be reasonable.**

The relationship among the modeled deductible flood loss costs is reasonable.

- C. Deductible flood loss costs shall be calculated in accordance with s.627.715, F.S.**

Deductible flood loss costs are calculated in accordance with s.627.715, F.S.

Disclosures

- 1. Describe the methods used in the flood model to treat deductibles, policy limits, policy exclusions, loss settlement provisions, and insurance-to-value criteria when projecting flood loss costs and flood probable maximum loss levels. In particular, specify the loss settlement options available for manufactured homes.**

Percentage deductibles are converted into flat deductibles by multiplying them by the appropriate coverage amount. Flat deductibles are used directly. The model estimates a mean damage ratio, to which a secondary uncertainty function is applied. The model caps the losses at the policy limits. If desired by the user, insurance-to-value assumptions can be made to the input data prior to the user importing the data into the KCC database.

- 2. Provide an example of how insurer flood loss (flood loss net of deductibles) is calculated. Discuss data or documentation used to validate the method used by the flood model.**

Example:

(A)		(B)	(C)	(D)=(A)*(C)	(E)=(D)-(B)
Structure Value	Policy Limit	Deductible	Damage Ratio	Zero Deductible Flood Loss	Flood Loss Net of Deductible
\$100,000	\$90,000	\$1,500	2%	\$2,000	\$500

The methods used in the development of mathematical distributions to reflect the effects of deductibles and policy limits are actuarially sound.

The model generates mean damage ratios (MDRs), which represent the cost to repair the damage divided by the replacement value of the property. For each MDR, the model considers the secondary uncertainty, which is the full probability distribution of damage levels around the mean, using non-parametric distributions. The secondary uncertainty distribution is used to apply the effects of deductibles and limits.

$$\text{Expected Insured Loss} = \int_{x=0}^1 f_{\bar{D}}(x) \{ \text{Coins}\% * \max [0, \min(PL, x * RV - DED)] \} dx$$

where

$f_{\bar{D}}(x)$ = Secondary Uncertainty Distribution

Coins% = Coinsurance Percentage

x = Damage Ratio

RV = Replacement Value

PL = Policy Limit

DED = Deductible

In application, $f_{\overline{D}}(x)$ is discretized and numerical integration is used to estimate the expected insured loss.

The following chart demonstrates sample calculations used to generate the insurer flood loss.

Structure Value	Policy Limit	Participation	Deductible	Damage Ratio	Ground-up Flood Loss	Gross Flood Loss
\$1,000,000	\$600,000	80%	\$0	2%	\$20,000	\$15,889
\$1,000,000	\$500,000	50%	\$0	2%	\$20,000	\$9,913

Table 16 - Sample calculations of flood loss costs

3. Describe how the flood model treats annual deductibles.

For the first event loss within a simulated year, the applied deductible amount is the full value of the annual flood deductible. If the ground-up loss amount is less than the flood deductible, a “residual flood deductible” is estimated for each secondary uncertainty scenario. The expected residual flood deductible is estimated based on the probability of the secondary uncertainty scenarios. For the second event loss within a simulated year, the applied deductible amount is the maximum of either the expected residual flood deductible or all other perils deductible. For each subsequent event within a simulated year, the applied deductible amount will never be less than the all other perils deductible. For the next simulated year, the residual flood deductible amount resets, as the flood deductible would be at its full value.

AF-6 Flood Loss Outputs and Logical Relationships to Risk

- A. *The methods, data, and assumptions used in the estimation of flood probable maximum loss levels shall be actuarially sound.***

The methods, data, and assumptions used in the estimation of the flood probable maximum loss levels in the KCC US Flood Reference Model are actuarially sound.

- B. *Flood loss costs shall not exhibit an illogical relation to risk, nor shall flood loss costs exhibit a significant change when the underlying risk does not change significantly.***

The KCC US Flood Reference Model produces flood loss costs that exhibit a logical relation to risk and that do not exhibit a significant change when the underlying risk does not change significantly.

- C. *Flood loss costs cannot increase as the structure flood damage resistance increases, all other factors held constant.***

All else held constant, flood losses in the KCC US Flood Reference Model do not increase as flood damage resistance increases.

- D. *Flood loss costs cannot increase as flood hazard mitigation measures incorporated in the structure increase, all other factors held constant.***

All else held constant, flood loss costs do not increase as flood hazard mitigation measures increase.

- E. *Flood loss costs shall be consistent with the effects of major flood control measures, all other factors held constant.***

All else held constant, flood loss costs are consistent with the effects of major flood control measures.

- F. *Flood loss costs cannot increase as the flood resistant design provisions increase, all other factors held constant.***

All else held constant, flood loss costs do not increase as the flood resistant design provisions increase.

- G. *Flood loss costs cannot increase as building code enforcement increases, all other factors held constant.***

All else held constant, flood loss costs do not increase as building code enforcement increases.

- H. *Flood loss costs shall decrease as deductibles increase, all other factors held constant.***

Flood loss costs decrease as deductibles increase, all else held constant.

- I. *The relationship of flood loss costs for individual coverages (e.g., personal residential structure, appurtenant structure, contents, and time element) shall be consistent with the coverages provided.***

The relationship of flood loss costs in the KCC US Flood Reference Model for individual coverages is consistent with the coverages provided.

- J. *Flood output ranges shall be logical for the type of risk being modeled and apparent deviations shall be justified.***

Flood output ranges are logical for the type of risk being modeled. There are no apparent deviations in the flood output ranges.

- K. All other factors held constant, flood output ranges produced by the flood model shall in general reflect lower flood loss costs for personal residential structures that have a higher elevation versus those that have a lower elevation.**

All else held constant, flood output ranges reflect a higher flood loss cost for personal residential structures at a lower elevation and a lower loss cost for those at higher elevations.

- L. For flood loss costs and flood probable maximum loss level estimates derived from and validated with historical insured flood losses or other input data and information, the assumptions in the derivations concerning (1) construction characteristics, (2) policy provisions, and (3) contractual provisions shall be appropriate based on the type of risk being modeled.**

For the flood loss costs and flood PML level estimates derived from and validated with historical insured flood losses or other input data and information, the assumptions in the derivations concern construction characteristics, policy provisions, and contractual provisions are appropriate for the type of risk being modeled.

Disclosures

- 1. Provide a completed Form AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs. Provide a link to the location of the form [insert hyperlink here].**

[Form AF-1, Zero Deductible Personal Residential Standard Flood Loss Costs](#)

- 2. Provide a completed Form AF-2, Total Flood Statewide Loss Costs. Provide a link to the location of the form [insert hyperlink here].**

[Form AF-2, Total Flood Statewide Loss Costs](#)

- 3. Provide a completed Form AF-3, Personal Residential Standard Flood Loss Costs by ZIP Code. Provide a link to the location of the form [insert hyperlink here].**

[Form AF-3, Personal Residential Standard Flood Loss Costs by ZIP Code](#)

- 4. Provide a completed Form AF-4, Flood Output Ranges, using the modeling-organization- specified, predetermined, and comprehensive exposure dataset. Provide a link to the location of the form [insert hyperlink here].**

[Form AF-4, Flood Output Ranges](#)

- 5. Provide a completed Form AF-6, Flood Probable Maximum Loss for Florida. Provide a link to the location of the form [insert hyperlink here].**

[Form AF-6, Flood Probable Maximum Loss for Florida](#)

- 6. Describe how the flood model produces flood probable maximum loss levels.**

The method used to produce flood probable maximum loss levels is described in Standard AF-4, Disclosure 1.

- 7. Provide citations to published papers, if any, or modeling-organization studies that were used to estimate flood probable maximum loss levels.**

No published papers were used to estimate flood probable maximum loss levels.

- 8. Explain any differences between the values provided on Form AF-6, Flood Probable Maximum Loss for Florida, and those provided on Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined).**

There are no differences between the values provided on Form AF-6 and those provide on Form SF-2.

9. Provide an explanation for all flood loss costs that are not consistent with the requirements of this standard.

All loss costs generated by the KCC US Flood Reference Model are consistent with this standard.

Computer/Information Flood Standards

CIF-1 Flood Model Documentation

- A. *Flood model functionality and technical descriptions shall be documented formally in an archival format separate from the use of letters, slides, and unformatted text files.***

KCC maintains two sets of documents on model functionality and technical descriptions: one for external client use and the other set for internal use. All KCC documentation is managed through a version control system.

- B. *The modeling organization shall maintain a primary document repository, containing or referencing a complete set of documentation specifying the flood model structure, detailed software description, and functionality. Documentation shall be indicative of current model development and software engineering practices.***

KCC maintains a primary document repository containing a complete set of documentation aligned with software engineering practices. KCC uses generally accepted procedures to ensure the documents are readable, self-contained, and easy to understand. All system components are documented with requirement statements, class, data flow, and sequence diagrams as appropriate and provide relevant detail on the structure and flow of data between the components and subcomponents.

- C. *All computer software (i.e., user interface, scientific, engineering, actuarial, data preparation, and validation) relevant to the flood model shall be consistently documented and dated.***

KCC maintains pertinent computer software documents based on documentation templates that are consistently dated and that will be available for review by the Professional Team during the onsite visit.

- D. *The modeling organization shall maintain a table of all substantive changes in the flood model since this year's initial submission.***

KCC will maintain a table of all changes since the initial submission.

- E. *Documentation shall be created separately from the source code.***

The model, software, and database schema are documented separately from the source code using Word document templates and are maintained through a version control system.

- F. *The modeling organization shall maintain a list of all externally acquired currently used flood model-specific software and data assets. The list shall include (1) asset name, (2) asset version number, (3) asset acquisition date, (4) asset acquisition source, (5) asset acquisition mode (e.g., lease, purchase, open source), and (6) length of time asset has been in use by the modeling organization.***

KCC maintains a list of all externally acquired software and data assets, and this document will be available for review by the Professional Team during the onsite visit

CIF-2 Flood Model Requirements

The modeling organization shall maintain a complete set of requirements for each software component as well as for each database or data file accessed by a component. Requirements shall be updated whenever changes are made to the flood model.

KCC maintains documentation for each software component as well as each database and file accessed by the component. These documents, as appropriate, are updated when pertinent changes are made to the flood model.

Disclosure

1. Provide a description of the documentation for interface, human factors, functionality, documentation, data, human and material resources, security, and quality assurance.

KCC maintains documents provided to all clients that describe the specifications, product requirements, installation requirements, user interfaces, database schema, security considerations, and test databases for ensuring that all major components of the installation are functioning properly. These documents will be available for review by the Professional Team.

KCC developers also maintain comprehensive documentation on RiskInsight® and all KCC Reference Models. A documentation set for major components within RiskInsight® includes requirement specifications, software design documentation, code documentation, data schemas, test plans and test cases, and end-user documentation. Documents maintained by the KCC software development team for RiskInsight® components include:

- Software Requirement Specification
- Software Design Documentation
- Source Code Documentation
- Data Format Schema (OEF 2.1)
- Test Plans and Test Cases
- Installation and Configuration Guide
- End-User Guide
- Database Reference Manual
- Component Reference Manual (e.g., WindfieldBuilder)
- End-User workflow specific guides
- Coding Standards
- Technical Writing Guide
- Software Documentation Templates
- Security Documentation

CIF-3 Flood Model Architecture and Component Design

- A. The modeling organization shall maintain and document (1) detailed control and data flowcharts and interface specifications for each software component, (2) schema definitions for each database and data file, (3) flowcharts illustrating flood model-related flow of information and its processing by modeling organization personnel or consultants, and (4) system model representations associated with (1)-(3). Documentation shall be to the level of components that make significant contributions to the flood model output.**

KCC maintains documents that describe the flow of data between all relevant components of the software as well as the schema of the databases that host the exposures and results and the supporting API. These documents will be available for review by the Professional Team during the onsite visit.

- B. All flowcharts (e.g., software, data, and system models) shall be based on (1) a referenced industry standard (e.g., Unified Modeling Language (UML), Business Process Model and Notation (BPMN), Systems Modeling Language (SysML)), or (2) a comparable internally-developed standard which is separately documented.**

All flowcharts developed and maintained by KCC conform to the ISO 5807 standard. A sample is provided below.

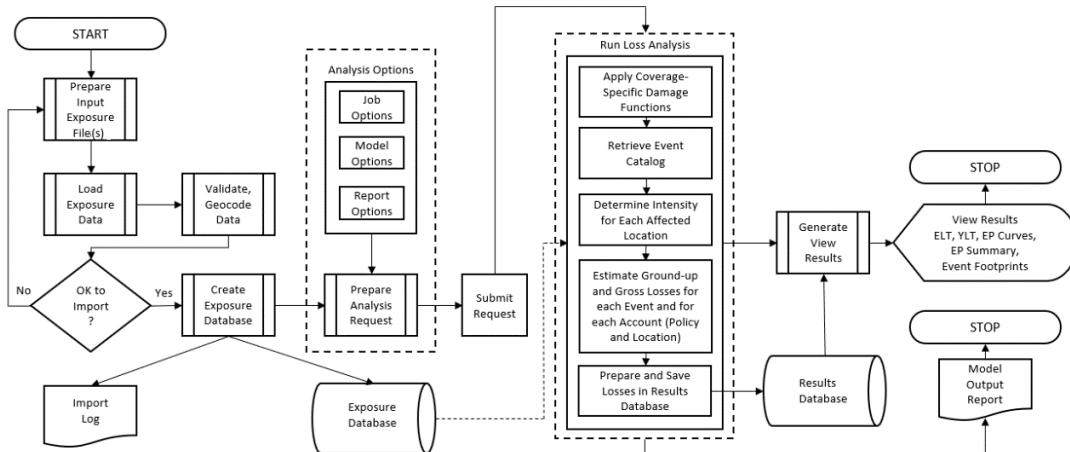


Figure 42 - Sample flowchart employed in KCC documentation standards

CIF-4 Flood Model Implementation

- A. *The modeling organization shall maintain a complete procedure of coding guidelines consistent with current software engineering practices.***

KCC maintains implementation procedures and coding guidelines to ensure all software components comply with our coding standards.

- B. *The modeling organization shall maintain a complete procedure used in creating, deriving, or procuring and verifying databases or data files accessed by components.***

KCC maintains procedures for creating and verifying databases and data files accessed by the software.

- C. *All components shall be traceable, through explicit component identification in the flood model representations (e.g., flowcharts) down to the code level.***

KCC guidelines require all components to be explicitly and clearly identified and traceable down to the code level.

- D. *The modeling organization shall maintain a table of all software components affecting flood loss costs and flood probable maximum loss levels with the following table columns: (1) component name, (2) number of lines of code, minus blank and comment lines, and (3) number of explanatory comment lines.***

KCC maintains a table meeting the requirement, which will be available for review by the Professional Team during its onsite visit.

- E. *Each component shall be sufficiently and consistently commented so that a software engineer unfamiliar with the code shall be able to comprehend the component logic at a reasonable level of abstraction.***

KCC coding guidelines require the code (e.g., projects, modules, classes, methods, variables, constants, enumerated constants) for all components to be clearly named and documented for efficient transfer of knowledge between any two software engineers broadly familiar with the subject matter. KCC standards also require all code changes to pass a formal code review process.

- F. *The modeling organization shall maintain the following documentation for all components or data modified by items identified in Standard GF-1, Scope of the Flood Model and Its Implementation, Audit 6:***

- 1. *A list of all equations and formulas used in documentation of the flood model with definitions of all terms and variables.***

This list is maintained and will be available for review by the Professional Team during the onsite visit.

- 2. *A cross-referenced list of implementation source code terms and variable names corresponding to items within F.1 above.***

This list is maintained and will be available for review by the Professional Team during the onsite visit.

Disclosure

1. **Specify the hardware, operating system, other software, and all computer languages required to use the flood model.**

The hardware and operating system requirements for the KCC US Flood Reference Model and RiskInsight® Loss Modeling Platform for each tier include:

- Application Tier
 - Windows 10
 - Windows Server 2012 – 2019
 - CPU: 3.0 GHz, 8 cores
 - RAM: 32 GB
 - Disk: 1 TB
- Loss Analysis Tier
 - Windows Server 2012 – 2019
 - CPU: 3.0 GHz, 12 cores
 - RAM: 128 GB
 - Disk: 1 TB
- Database Tier
 - Windows Server 2012 – 2019
 - CPU: 3.0 GHz, 8 cores
 - RAM: 64 GB
 - Disk: 1 TB
 - SQL Server: 2012 – 2019

Additional software requirements and programming languages include:

- Microsoft .NET 4.5.2 required on all systems
- Transact-SQL (SQL Server 2012 – 2019) required for queries
- XML 1.0 (eXtensible Markup Language) required for configuration files
- Internet Explorer 10.0 or later required for viewing maps
- LeafletJS v0.7 required to render maps
- WebGL 1.0 required to render location markers on maps
- Background map imagery provided by Mapbox
- JSON.NET C# library for serializing and deserializing RiskInsight data in JSON format
- PGRestAPI Node.js REST API for serving thematic map shapes
- FastColoredTextBox.dll for improved diagnostics reports
- SharpZipLib.dll for opening data stored in the zip archive file format
- DotNetZip.dll for opening data stored in the zip archive file format
- JacksonSoft.CustomTabControl.dll for customized tab styles (deprecated)
- Npgsql.dll access PostgreSQL from C# to retrieve thematic map objects from sds.kccriskinsight.co
- Mono.Security.dll used by Npgsql to access PostgreSQL
- PdfSharp.dll for creating PDF documents
- SharpKml.dll for reading and writing files in the KML file format
- BitMiracle.LibTiff.NET.dll for reading and writing files in Tiff format
- K4os.Compression.LZ4.dll for compression of Flood event files
- Natural Earth Source data for thematic map shapes

CIF-5 Flood Model Verification

A. General

For each component, the modeling organization shall maintain procedures for verification, such as code inspections, reviews, calculation crosschecks, and walkthroughs, sufficient to demonstrate code correctness. Verification procedures shall include tests performed by modeling organization personnel other than the original component developers.

KCC employs multiple procedures to verify code correctness. Members of the model development team independently develop prototypes and worked examples of the desired software implementation for key components. The prototypes and worked examples are shared with the KCC software team, including the component software developer, along with representative output prior to implementation. KCC does not outsource/offshore any development. All members of KCC's teams are US-based and organized for active, direct interaction and collaboration.

All code implementations as well as the principal outputs are subject to code reviews and tests by the primary developers and by experienced developers using appropriate combinations of hand calculations, unit tests, and visual inspection of graphical representations (using charts, maps, and tables) before being released from the DEV to the QA environment. The QA environment is then used by other KCC professionals (not software engineers) to independently verify the model's intermediate and final outputs and, where pertinent, to perform regression tests.

During implementation, the component software developer cross-references the provided input and output examples to verify that the code accurately reproduces intended results. Once the cross-reference verification is met, the software developer submits the code for peer review. The peer review is performed by other members of the software development team and includes checks of component inputs, outputs, code inspection, and adherence to KCC coding guidelines. Upon successful completion of the peer review, the component code is made available for the next build of the software.

KCC professionals other than the original component developer conduct rigorous quality assurance (QA) checks of the model output for each build of the software, including reviews of any component that has changed from the previous build. The QA checks include construction of purpose-built input files designed to isolate the behavior and output of an individual component, such as simulated inundation depth or a vulnerability function. The results of the QA checks are verified against expected outputs with relevant members of the software and research teams to ensure code correctness.

KCC uses the Microsoft Team Foundation Server for managing source code, documentation, test plans and project management. Automated tests are written using the NUnit testing framework and automated tests are run using JetBrains TeamCity Build Server and Test Runner.

Unit tests are written using NUnit and are executed by TeamCity. A history for each unit test is maintained on TeamCity. The software development team is notified immediately when a test fails. TeamCity provides access to the build history and test runs. Code check-ins that cause a test to fail and code check-ins that resolve a failed test are linked from the test history.

Regression and aggregation tests are run nightly. KCC team members perform manual testing following a Test Plan for each internal deployment to KCC environments.

B. Component Testing

1. *The modeling organization shall use testing software to assist in documenting and analyzing all components.*

KCC uses non-model-based software, including NUnit, TeamCity Builder, and TeamCity runner, to test and document all components. Every time code is changed/checked-in, it is immediately

subject to a suite of automated tests. Every evening, the entire code base is subject to another full suite of automated tests. In both cases, defects are immediately reported to the team.

2. Unit tests shall be performed and documented for each component.

Unit tests are performed in DEV and documented for each component using NUnit, TeamCity Builder, and TeamCity Runner.

3. Regression tests shall be performed and documented on incremental builds.

Regression tests are performed and documented for each build released to QA using TeamCity Builder and TeamCity Runner.

4. Aggregation tests shall be performed and documented to ensure the correctness of all flood model components. Sufficient testing shall be performed to ensure that all components have been executed at least once.

Aggregation tests using TeamCity Builder and TeamCity Runner are performed and documented for each build in DEV and in QA to ensure all components are functioning correctly and have been exercised.

C. Data Testing

1. The modeling organization shall use testing software to assist in documenting and analyzing all databases and data files accessed by components.

KCC has implemented testing software and protocols to test and analyze data accessed from databases and data files by each component. KCC uses Redgate products, SQL Test and SQL Data Compare, to test databases and their schema. Changes to non-SQL data sources are tracked through Team Foundation Server Source Control. A KCC Data Package file is stored in Team Foundation Server and is updated as needed. A check sum for collections of data files are maintained within the Data Package.

2. The modeling organization shall perform and document integrity, consistency, and correctness checks on all databases and data files accessed by the components.

KCC has implemented an extensive set of built-in “always-on” tests to ensure the integrity and consistency of data being exchanged between the components and the databases.

Disclosures

1. State whether any two executions of the flood model with no changes in input data, parameters, code, and seeds of random number generators produce the same flood loss costs and flood probable maximum loss levels.

Any two executions with the same inputs will produce the same results, same loss costs, and same probable maximum loss levels. The KCC US Flood Reference Model does not use random number generators.

2. Provide an overview of the component testing procedures.

The KCC component test process is as follows:

- Developer completes work on a task and submits the code for peer review.
- If the code passes review, the code is checked-in to Team Foundation Server.
- The TeamCity automated Build Server and Test Runner is notified of the change and pulls the latest code changes from Team Foundation Server.

- TeamCity performs a full build of all RiskInsight® components for every code change. If the build passes, a collection of automated unit tests is performed. If any tests fail, the KCC software development team is notified, and a team member is assigned to investigate the issue.
- On a daily basis, the TeamCity Build Server performs a full nightly rebuild and runs an extended set of automated aggregation tests. These tests confirm that exposure queries, loss analysis results, and other reports return the exact results as expected.
- If the nightly build succeeds, a “Build Artifact” is created. This is a collection of zip files that has passed all automated build steps and tests and is ready for deployment to KCC internal environments.
- The latest successful nightly build is deployed to internal KCC environments as needed for manual testing by KCC team members.
- Once all product specifications are satisfied and all tests pass for the current product backlog, a Semantic Version is assigned to a build and end-user documentation is prepared.

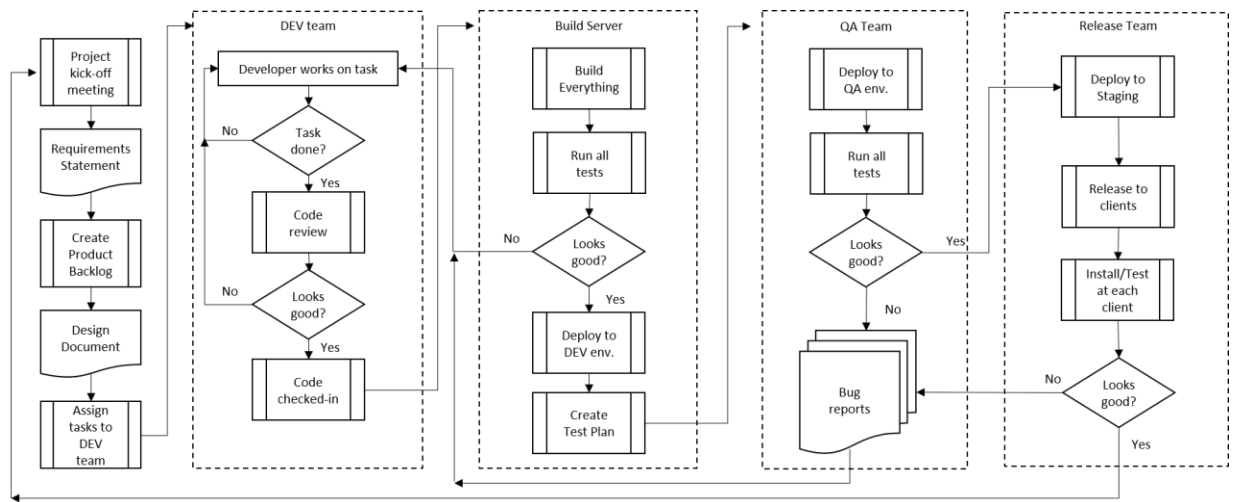


Figure 43 - Procedure for testing software components prior to release

3. Provide a description of verification approaches used for externally acquired data, software, and models.

KCC performs extensive verification on all externally acquired data, as is shown below. Additional detail pertaining to verification methods can be provided to the Professional Team during the onsite visit, if requested.

Source Title	Description	Verification Methods
United States Geological Survey (USGS) National Land Cover Database (NLCD)	Satellite-derived land cover classification for the entire United States at a 30-meter spatial resolution using Landsat’s Thematic Mapper sensor.	Spot checks in different land cover types performed and validated against actual satellite imagery.
Natural Earth Land Polygons	10-meter resolution land polygons for the world delineating coastline, land, ocean, inland waterbodies, and similar. Used by KCC in raster, rather than native vector, format.	Visual verification of test event; footprint should mirror land surface.

Source Title	Description	Verification Methods
Zip-Codes.com	Name and boundary information for postal ZIP Codes in the United States. Polygons are constructed using United States Postal Service (USPS) carrier route boundaries, using a combine/dissolve approach. To compensate for the fact that there are some areas without carrier routes, Zip-Codes.com generates “filler” ZIP Codes with logically derived names.	Zip-Codes.com boundaries compared against Census Bureau ZIP Code Tabulation Areas (ZCTAs), which are generalized areal representations of USPS carrier route boundaries, for general agreement.
US ZIP Codes Geo by GreatData	ZIP Code centroids for the United States weighted by population.	GreatData centroids are compared to United States Census Bureau block group population data by creating another set of population-weighted centroids with ZCTA boundaries. The two sets of population-weighted centroids should be similar, but not identical owing to the fact that ZCTAs are not as frequently updated as official USPS ZIP Codes.
USGS 3DEP DEM	1 arc-second resolution seamless dataset covers the conterminous U.S. and provides partial coverage of Alaska. The source data products for 3DEP DEM are lidar point cloud, IfSAR digital surface model, IfSAR orthorectified radar intensity image, and source resolution DEMs from USGS after January 2015. The elevation values are in meters and referenced to the North American Vertical Datum of 1988 (NAVD 88).	Spot checks performed and validated using other DEM products, such as Multi Error Removed Improved Terrain DEM (MERIT DEM) and Advanced Land Observing Satellite Global Digital Surface Model (ALOS DSM).
National Flood Hazard Layer (NFHL)	The NFHL is a geospatial database that contains current effective flood hazard data. FEMA provides the flood hazard data to support the National Flood Insurance Program.	Spot checks performed and validated using other sources of Flood Zone Data from the FIMA NFIP Redacted Policies Dataset.
Florida Department of Revenue’s Tax Database Parcel Data	Florida Department of Revenue’s Tax database Parcel Data contains the 2018 vintage parcel boundaries with each parcel's associated tax information from the Florida Department of Revenue's tax database. Attributes include occupancy, site street addresses, GIS boundaries, land use codes, valuation, building details, legal description, and more.	Spot checks performed and validated using aggregate totals. Risks are validated against US Census data.

Table 17 - External data sources and verification methods employed by KCC professionals

CIF-6 Flood Model Maintenance and Revision

- A. *The modeling organization shall maintain a clearly written policy for flood model review, maintenance, and revision, including verification and validation of revised components, databases, and data files.***

KCC maintains written policies that outline the protocol for changing the flood model in any way (be it for review, maintenance, or revision). This includes specific documentation for each model component, in which details such as purpose, objective, and impact are provided.

The scientist(s) and/or engineer(s) proposing a change first document the change itself and the methodology proposed to implement it. They also document specifically how that model change will improve the accuracy of the annual average loss costs and probable maximum losses generated by the model. They then present their proposed change, methodology, and expected impacts to the KCC model development team for peer review. If the model development team determines the proposed change will not address any model deficiency or enhance model accuracy, the proposed change is rejected.

When a proposed change is accepted, the model developers responsible for implementing the change will document the inherent assumptions and expected results. The methodology and assumptions are again discussed with the model development team. Alternative assumptions and methodologies are evaluated before the final specifications are developed.

When the change to the model is ready for testing, engineers and scientists on the model development team not directly involved in the model update perform tests to verify that the expected changes appear in the updated database(s) and/or files prior to implementation. These tests can vary in terms of scope, as changes can vary from minor updates to new model components. Once all tests are passed, the updated database and files are made available to the software development team for implementation into the model.

- B. *A revision to any portion of the flood model that results in a change in any Florida personal residential flood loss cost or flood probable maximum loss level shall result in a new flood model version identification.***

A revision to any portion of the KCC US Flood Reference Model that results in a change in any Florida residential flood loss cost or flood probable maximum loss will result in a new flood model version identification.

- C. *The modeling organization shall use tracking software to identify and describe all errors, as well as modifications to code, data, and documentation.***

KCC has implemented Microsoft Team Foundation Server to report errors and track software updates. Software modifications to address errors are seamlessly linked from the developer's peer-reviewed source control check-in via Visual Studio to the error reported in Team Foundation Server and the associated product feature backlog item or test.

Test plans, software design documentation, and user documentation are updated as appropriate when changes are made to the software.

- D. *The modeling organization shall maintain a list of all flood model versions since the initial submission for this year. Each flood model description shall have a unique version identification and a list of additions, deletions, and changes that define that version.***

KCC will maintain a list of all changes after this initial submission, each with a unique identification number and list of additions, deletions, and changes that define that version.

Disclosures

1. **Identify procedures used to review and maintain code, data, and documentation.**

The software development process starts with an initial project meeting, which establishes the purpose of a development project. Notes from the kick-off meeting are formally defined in traditional, text-based requirements statements. A product backlog item is created in Team Foundation Server, and the project is broken down to tasks that are assigned to members of the software development team.

The tasks created in Team Foundation Server are seamlessly integrated into the Visual Studio environment. As the developer makes progress on a work item, the developer is required to submit changes for code review to a peer member of the development team. Visual Studio provides a robust code review system. The reviewer has access to the software requirement, the work-item task, and a full-featured code comparison tool that permits commenting and highlighting any line item in the code presented for review. The entire software development team meets daily for a stand-up meeting to highlight the day's work items and alert team members of impending changes.

The KCC code check-in policy requires that all code pass a code review without any item noted as "Needs Work." All code reviews and comments provided by the reviewer and the developer are linked to the code check-in record, as well as the work item and the product backlog item.

After code has been reviewed and checked-in, the KCC TeamCity automated Build Server and Test Runner gets the latest code changes from all developers, then compiles and runs the code. A full suite of automated tests is executed to confirm that the latest changes have not broken any previously passing tests. In addition to the builds and tests for every code check-in, a nightly build is performed and an extended set of aggregation tests are performed. If all tests pass, the compiled applications are added to a ZIP archive that can then be deployed to internal KCC environments for further testing by KCC professionals.

KCC developers work with a written Test Plan to confirm all documented functionality is performing as expected. Test Plans, Software Design Documents, and Software Requirement Specifications are also managed through the Team Foundation Server system. All KCC developers have access to the latest documentation for all software components via the Team Foundation Server web portal. In addition to the web portal, developers have access to the documentation from within the Visual Studio Source Control Explorer.

2. **Describe the rules underlying the flood model and code revision identification systems.**

KCC models and software applications follow semantic versioning for released builds. For publicly released APIs within RiskInsight and for publicly released models, the version format is X.Y.Z {Major.Minor.Patch}. Bug fixes not affecting any public API or the model increment the "Patch." Backwards compatible additions or changes increment the "Minor" version. Any new features or changes that are not backwards compatible increment the "Major" version. This system simplifies dependency requirements in all client released software.

Internal builds include a build stamp appended to the end of the semantic version. {Major.Minor.Patch.Build}. The Build version is generated by a central build server after all code changes have been compiled and have passed a suite of automated unit tests. Each Build version can be used to trace all changesets included in the build.

CIF-7 Flood Model Security

The modeling organization shall have implemented and fully documented security procedures for (1) secure access to individual computers where the software components or data can be created or modified, (2) secure operation of the flood model by clients, if relevant, to ensure that the correct software operation cannot be compromised, (3) anti-virus software installation for all machines where all components and data are being accessed, and (4) secure access to documentation, software, and data in the event of a catastrophe.

KCC has fully documented security procedures for access to code, data, and documentation in accordance with standard industry practices. Additional information about the security procedures are detailed in Standard CIF-7, Disclosure 1.

Disclosure

1. Describe methods used to ensure the security and integrity of the code, data, and documentation.

Physical Security

- Building Security: the building employs 24-hour security personnel, and access to the building is restricted with an electronic badge system.
- Office Access: Only KCC employees with authorized electronic badges may enter the offices. All external-facing doors close and lock automatically.
- Data Room Access: Only Administrators have access to the locked data room located in the KCC offices, which is controlled by electronic badges.

Network Security

- Firewall: FortiGate firewalls are used to control all traffic in and out of the network. IDS and IPS software are used to detect and prevent network intrusions, and website blocking is used to filter user traffic to only approved external sites.
- User Accounts: Authorized KCC user accounts are required for network access. Former employees' user accounts are immediately closed following their last day of employment.
- Internal Access: Access to files and folders on all servers is regulated by Windows permissions. Permissions are set on a server-by-server, folder-by-folder, or file-by-file basis as appropriate. Access to SQL instances is set on a user-by-user basis.
- External Access: Access to the KCC network from outside the firewall is granted using a VPN gateway. VPN access is tied to a user's Windows account and is controlled by the IT department.

Server and Workstation Security

- Physical Access: All servers are located in the secured data room, which requires electronic badge access.
- Patches and Updates: Windows updates and patches are administered by the IT department and run regularly on a monthly basis. The distribution of updates is controlled by Group Policy at the domain level.
- Virus Protection: All servers and workstations are installed with Kaspersky antivirus software. Virus definitions are updated daily. Any updates to the antivirus software itself are deployed by the IT department via a web-based management console.
- Remote Access: By default, users are only allowed remote (RDP) access to their own workstation. Any access to other servers is granted on an as-needed basis and regulated by the IT department.
- Desktop Access: Every desktop, after 15 minutes of inactivity, is automatically locked and requires a valid password to unlock for use.

Data Security

- Data Transfer: All confidential data can be sent via SFTP with PGP encryption.
- File Storage: All confidential data must be stored in a physically secure location, the data room. Secure file and SQL servers are not used for external access, including the Internet and emails. Both remote access (RDP) and file access (Explorer, SMB) are restricted to only authorized users. Any server containing client and/or sensitive data must have antivirus software installed and is backed up nightly.
- Data Access: Just as with file storage, all types of data access must be regulated to authorized users. This includes access to Team Foundation Server for version control and SQL for database access.
- Code: Only developers have access to KCC code. Microsoft Team Foundation Server is used for version control, and only specified developers have access to the necessary Collections, Projects, and Solutions. Only Administrators have physical and remote (RDP) access to the TFS server.
- File Backups: All workstations and servers are backed up using Veeam, with full backups monthly and incremental backups nightly. Encrypted cloud backups are made monthly to an offsite disaster recovery service. Nightly backups to the cloud are made for the TFS installation.
- Data Deletion: All old hard drives are wiped clean by an Administrator when they are no longer needed. Non-SSD drives are wiped using DBAN, and SSD drives are wiped using SecureErase.

User Management

- NDA: All company personnel are required to sign a non-disclosure agreement as a condition of employment.
- Background Check: All company personnel are required to pass a background check upon employment.
- User Accounts: All KCC employees require an authorized user account to login to any workstation or server. Passwords must adhere to strict, industry-standard requirements. User account privileges are managed by the IT department.
- External Site Access: Access to potentially dangerous sites are restricted via the firewall. Developers may request access to certain sites for testing purposes only.
- Lockout Policy: Any user account with 5 unsuccessful logins will automatically be locked out.

Security of code, data, and documentation for each client organization is governed by strict licensing, mutually acceptable requirements under which they cannot reverse engineer or modify any of the binaries provided to them under the terms and conditions of the license, and secure installations involving both parties' IT departments.

Appendix A: General Forms

Form GF-1: General Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of **KCC US Flood Reference Model**
(Name of Flood Model)

Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the General Flood Standards (GF-1 – GF-5);
2. The disclosures and forms related to the General Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. My review involved ensuring the consistency of the content in all sections of the submission; and
5. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Nozar Kishi

Name

Signature (original submission)

Signature (response to deficiencies, if any)

Signature (revisions to submission, if any)

Signature (final submission)

**Ph.D. Earthquake Engineering
M.S. Structural Dynamics**

Professional Credentials (Area of Expertise)

February 28, 2020

Date

May 29, 2020

Date

October 23, 2020

Date

December 2, 2020

Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-1, General Flood Standards Expert Certification, in a submission appendix.



Form GF-2: Meteorological Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)


Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Meteorological Flood Standards (MF-1 – MF-5);
2. The disclosures and forms related to the Meteorological Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Daniel Ward

Name 

Signature (original submission) 

Signature (response to deficiencies, if any) 

Signature (revisions to submission, if any)

Signature (final submission) 

Ph.D. Atmospheric Science

Professional Credentials (Area of Expertise)

February 28, 2020
Date

May 29, 2020
Date

October 23, 2020
Date

December 2, 2020
Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission) Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-2, Meteorological Flood Standards Expert Certification, in a submission appendix.

Form GF-3: Hydrological and Hydraulic Flood Standards Expert Certification

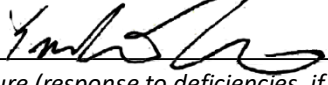
I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

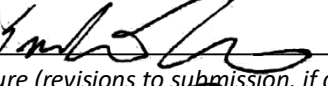
Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Hydrological and Hydraulic Flood Standards (HHF-1 – HHF-4);
2. The disclosures and forms related to the Hydrological and Hydraulic Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Yuanhao Zhao
Name


Signature (original submission)


Signature (response to deficiencies, if any)


Signature (revisions to submission, if any)


Signature (final submission)

Ph.D. Hydrology, M.S. Water Resources Engineering
Professional Credentials (Area of Expertise)

February 28, 2020
Date

May 29, 2020
Date

October 23, 2020
Date

December 2, 2020
Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-3, Hydrological and Hydraulic Flood Standards Expert Certification, in a submission appendix.

Form GF-4: Statistical Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Statistical Flood Standards (SF-1 – SF-5);
2. The disclosures and forms related to the Statistical Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Joanne Yammine

Name


Signature (original submission)

FCAS, B.S. Mathematics

Professional Credentials (Area of Expertise)

February 28, 2020

Date

Signature (response to deficiencies, if any)

Date

Signature (revisions to submission, if any)

Date

Signature (final submission)

Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-4, Statistical Flood Standards Expert Certification, in a submission appendix.

Form GF-4: Statistical Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Statistical Flood Standards (SF-1 – SF-5);
2. The disclosures and forms related to the Statistical Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Natalia Gust-Bardon
Name

M.S., Statistics
Professional Credentials (Area of Expertise)

Signature (original submission)

Date

Natalia Gust-Bardon
Signature (response to deficiencies, if any)

May 29, 2020
Date

Natalia Gust-Bardon
Signature (revisions to submission, if any)

October 23, 2020
Date

Natalia Gust-Bardon
Signature (final submission)

December 2, 2020
Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-4, Statistical Flood Standards Expert Certification, in a submission appendix.



Form GF-5: Vulnerability Flood Standards Expert Certification

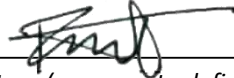
I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

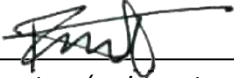
Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:


1. The flood model meets the Vulnerability Flood Standards (VF-1 – VF-4);
2. The disclosures and forms related to the Vulnerability Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Filmon Habte

Name 

Signature (original submission) 

Signature (response to deficiencies, if any) 

Signature (revisions to submission, if any) 

Signature (final submission)

Ph.D. Structural/Wind Engineering

Professional Credentials (Area of Expertise)

February 28, 2020
Date

May 29, 2020
Date

October 23, 2020
Date

December 2, 2020
Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-4, Statistical Flood Standards Expert Certification, in a submission appendix.



Form GF-5: Vulnerability Flood Standards Expert Certification

Purpose: This form identifies the signatory or signatories who have reviewed the current submission for compliance with the Vulnerability Flood Standards (VF-1 – VF-4) in accordance with the stated provisions.


I hereby certify that I have reviewed the current submission of KCC U.S. Flood Reference Model
(Name of Flood Model)

Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:


1. The flood model meets the Vulnerability Flood Standards (VF-1 – VF-4);
2. The disclosures and forms related to the Vulnerability Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession; and
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

James Michael Grayson
Name

Ph.D., P.E. Civil Engineering
Professional Credentials (Area of Expertise)


Signature (original submission)

2/26/2020
Date


Signature (response to deficiencies, if any)

5/28/2020
Date

Signature (revisions to submission, if any)

Date

Signature (final submission)

Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-5, Vulnerability Flood Standards Expert Certification, in a submission appendix.



Form GF-6: Actuarial Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Actuarial Flood Standards (AF-1 – AF-6);
2. The disclosures and forms related to the Actuarial Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Joanne Yammine

Name

Joanne Yammine

Signature (original submission)

Joanne Yammine

Signature (response to deficiencies, if any)

Joanne Yammine

Signature (revisions to submission, if any)

Joanne Yammine

Signature (final submission)

B.S. Mathematics, FCAS

Professional Credentials (Area of Expertise)

February 28, 2020

Date

May 29, 2020

Date

October 23, 2020

Date

December 2, 2020

Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-6, Actuarial Flood Standards Expert Certification, in a submission appendix.



Form GF-7: Computer/Information Flood Standards Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)

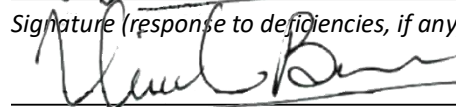
Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model meets the Computer/Information Flood Standards (CIF-1 – CIF-7);
2. The disclosures and forms related to the Computer/Information Flood Standards section are editorially and technically accurate, reliable, unbiased, and complete;
3. My review was completed in accordance with the professional standards and code of ethical conduct for my profession;
4. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Vivek Basur

Name 

Signature (original submission) 

Signature (response to deficiencies, if any) 

Signature (revisions to submission, if any) 

Signature (final submission)

M.S. Management Sciences

Professional Credentials (Area of Expertise)

February 28, 2020
Date

May 29, 2020
Date

October 23, 2020
Date

December 2, 2020
Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-7, Computer/Information Flood Standards Expert Certification, in a submission appendix.

Form GF-8: Editorial Review Expert Certification

I hereby certify that I have reviewed the current submission of KCC US Flood Reference Model
(Name of Flood Model)


Version 1.0 for compliance with the 2017 Flood Standards adopted by the Florida Commission on Hurricane Loss Projection Methodology and hereby certify that:

1. The flood model submission is in compliance with the Notification Requirements and General Flood Standard GF-5, Editorial Compliance;
2. The disclosures and forms related to each flood standards section are editorially accurate and contain complete information and any changes that have been made to the submission during the review process have been reviewed for completeness, grammatical correctness, and typographical errors;
3. There are no incomplete responses, charts or graphs, inaccurate citations, or extraneous text or references;
4. The current version of the flood model submission has been reviewed for grammatical correctness, typographical errors, completeness, the exclusion of extraneous data/ information and is otherwise acceptable for publication; and
5. In expressing my opinion I have not been influenced by any other party in order to bias or prejudice my opinion.

Katelynn Larson

Name


Signature (original submission)


Signature (response to deficiencies, if any)


Signature (revisions to submission, if any)


Signature (final submission)

B.A. English/Communications

Professional Credentials (Area of Expertise)
February 28, 2020

Date
May 29, 2020

Date
October 23, 2020

Date
December 2, 2020

Date

An updated signature and form are required following any modification of the flood model and any revision of the original submission. If a signatory differs from the original signatory, provide the printed name and professional credentials for any new signatories. Additional signature lines shall be added as necessary with the following format:

Signature (revisions to submission)

Date

Note: A facsimile or any properly reproduced signature will be acceptable to meet this requirement.

Include Form GF-8, Editorial Review Expert Certification, in a submission appendix.

Appendix B: Hydrological and Hydraulic Forms

Form HHF-1: Historical Event Flood Extent and Elevation or Depth Validation Maps

A. Provide color-coded contour or high-resolution maps with appropriate base map data illustrating modeled flood extents and elevations or depths for the following historical Florida flood events:

- Hurricane Andrew (1992)**
- Hurricane Ivan (2004)**
- Hurricane Jeanne (2004)**
- Hurricane Wilma (2005)**
- Tropical Storm Fay (2008)**
- Unnamed Storm in East Florida (May 2009)**
- Unnamed Storm in Panhandle (July 2013)**
- Storm chosen by modeling organization**

For any storms where sufficient data are not available, the modeling organization may substitute an alternate historical storm of their choosing.

B. Plot the locations and values associated with validation points (e.g., maximum flood elevations or depths from observations such as gauge data, high-water marks) on each contour or high-resolution map for the historical events.

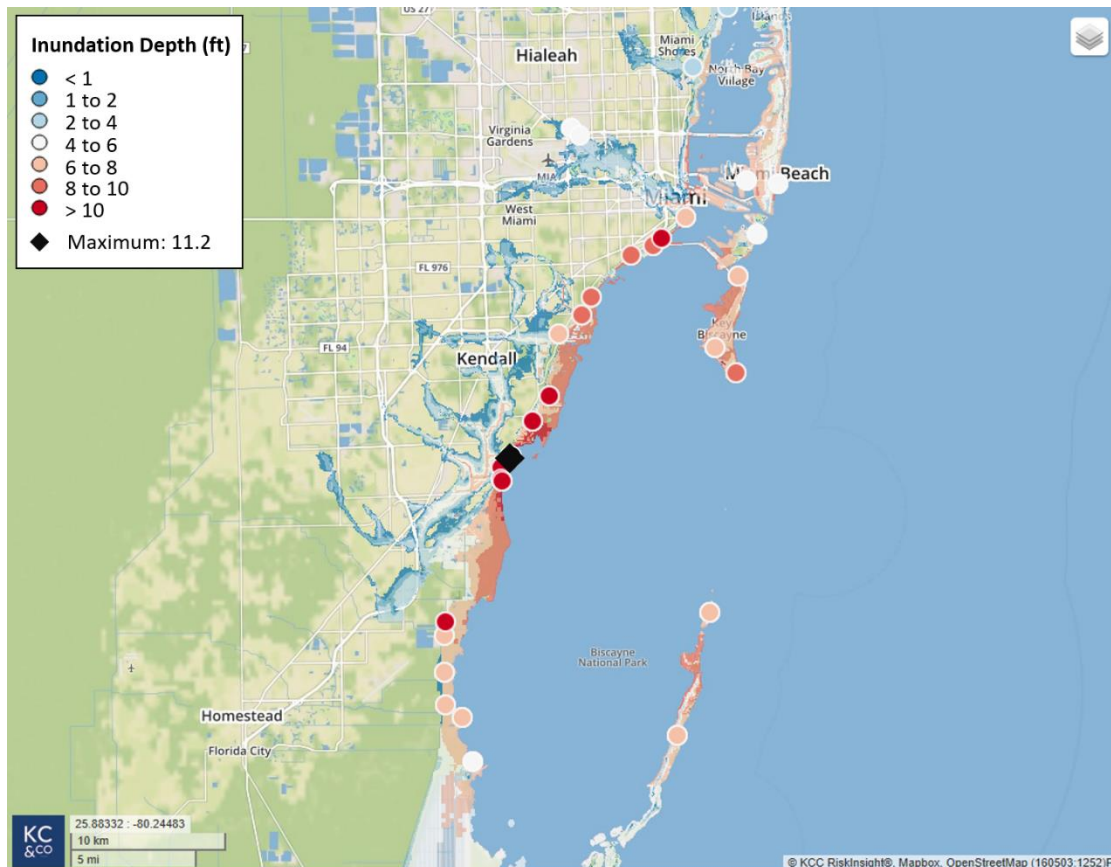


Figure 44 - Validation for Hurricane Andrew (1992) with peak identified

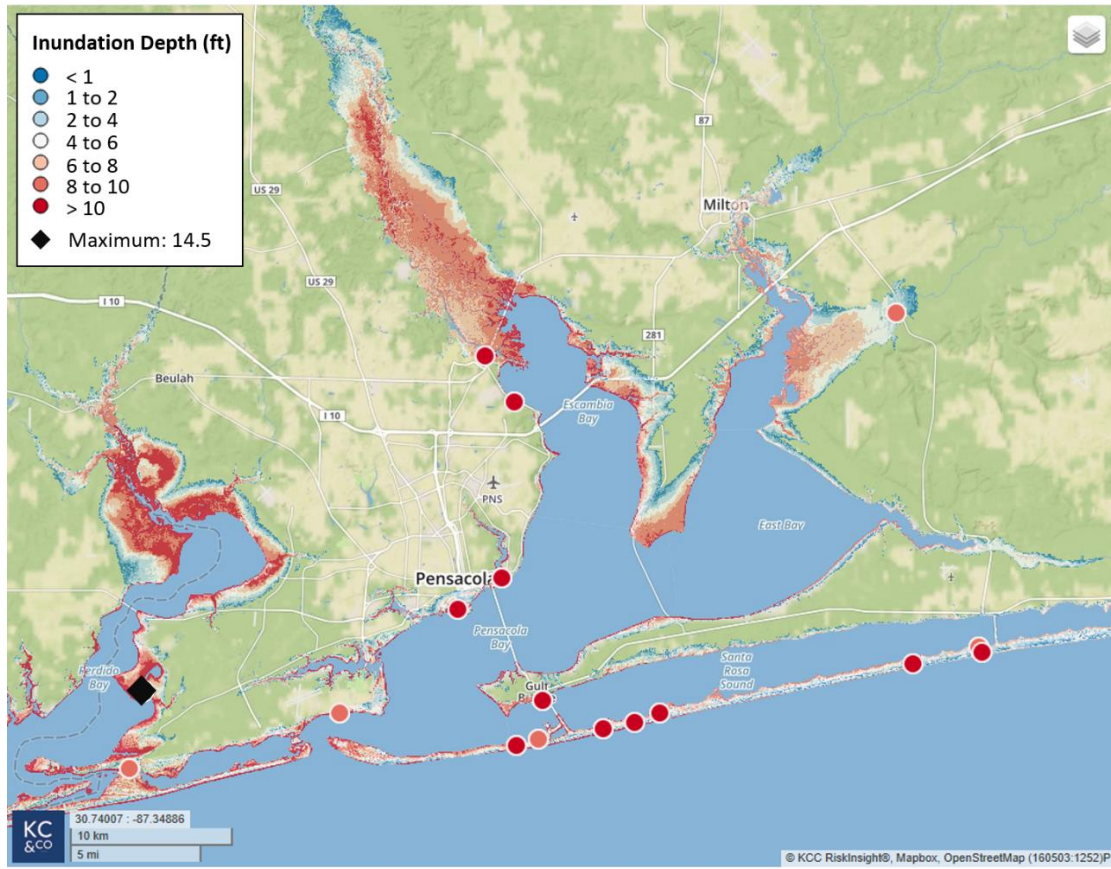


Figure 45 - Validation for Hurricane Ivan (2004) with peak identified

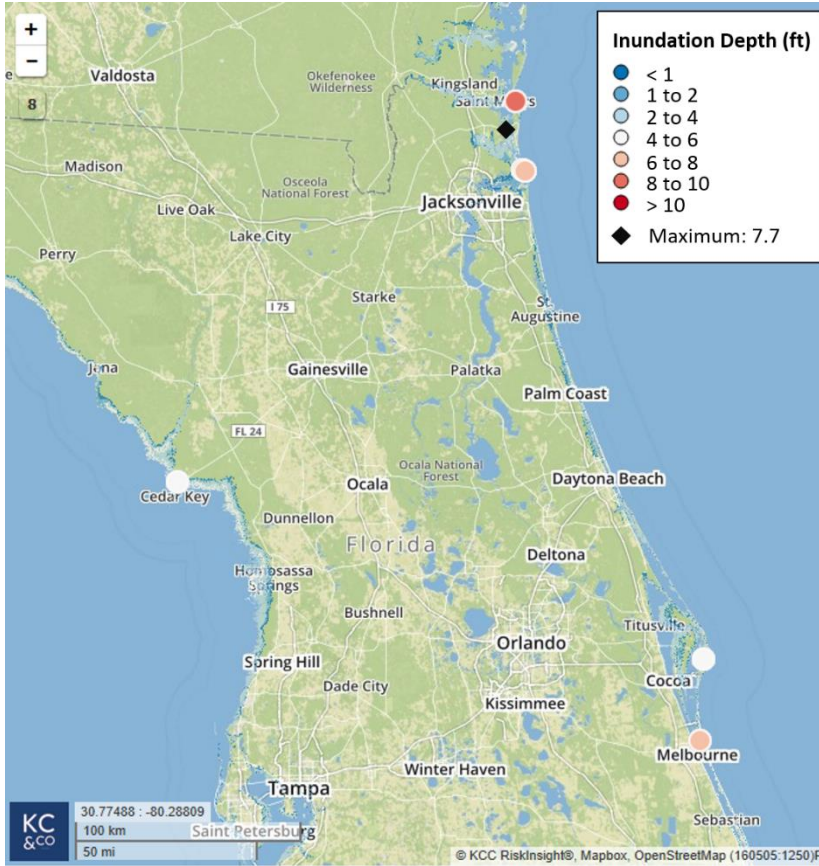


Figure 46 - Validation for Hurricane Jeanne (2004) with peak identified

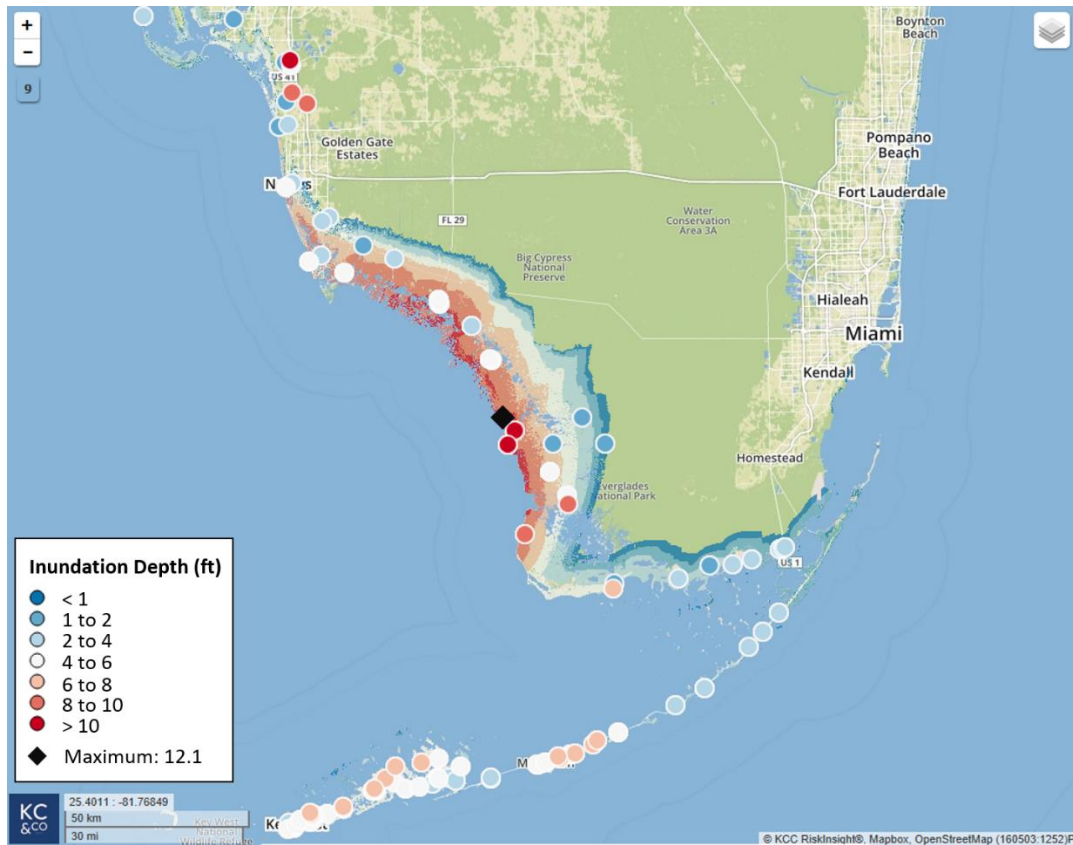


Figure 47 - Validation for Hurricane Wilma (2005) with peak identified

When comparing inland flood storm reports to modeled footprint, the majority of storm reports from NOAA were one foot deep. As a result, any unlabeled points are of one foot inundation depth.

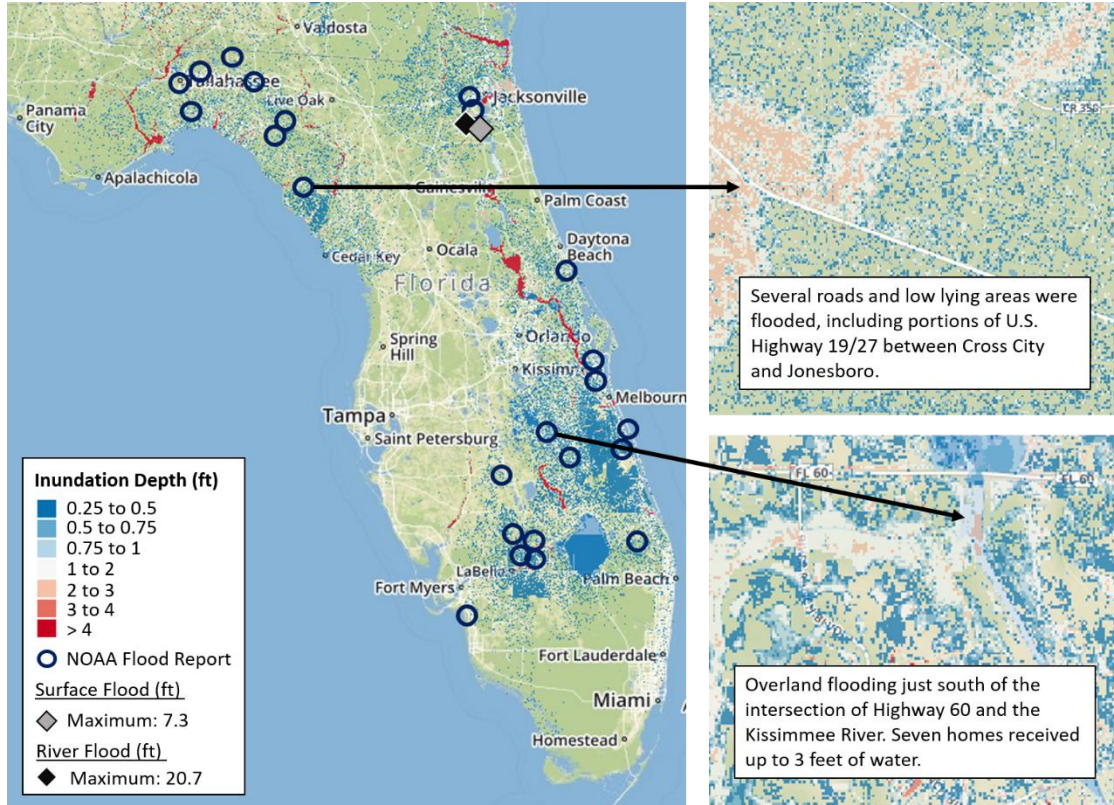


Figure 48 - Validation for Tropical Storm Fay (2008)

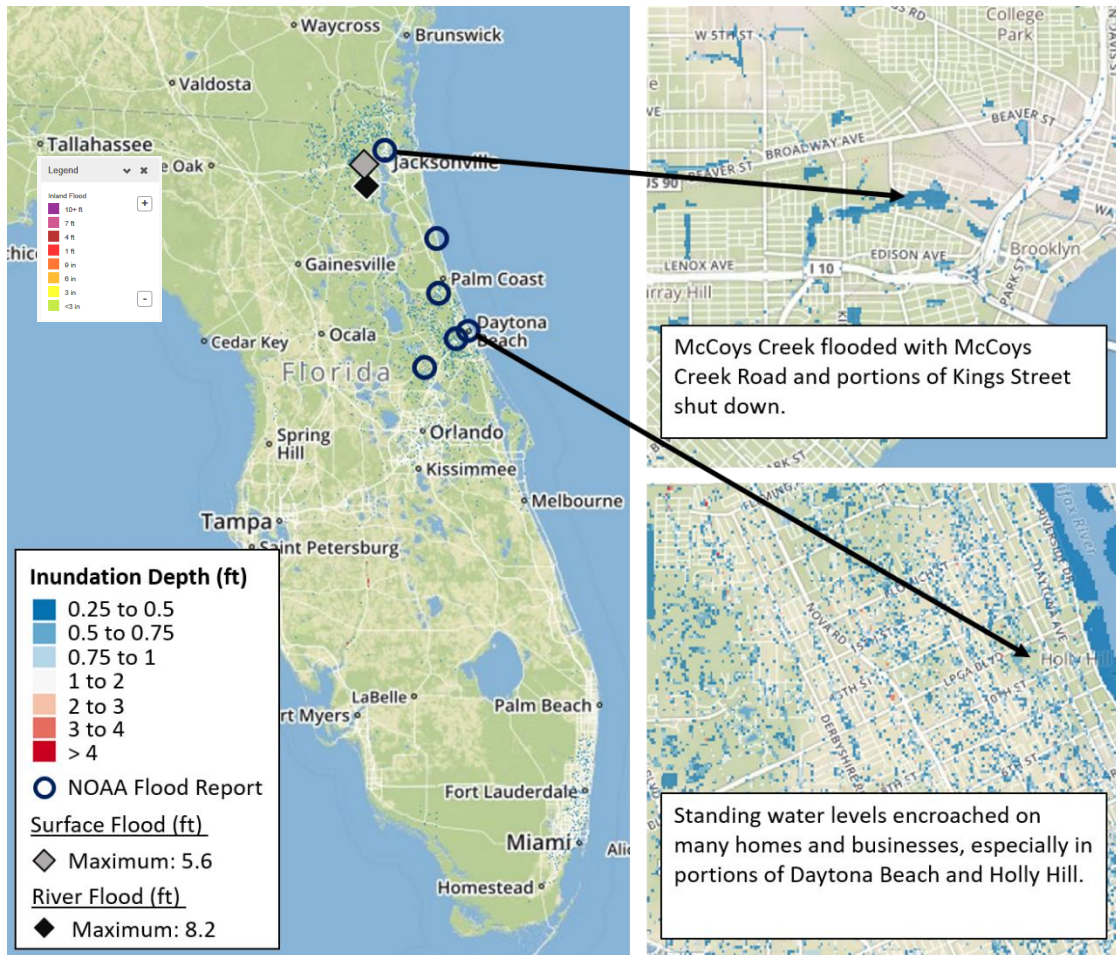


Figure 49 - Validation for Unnamed Storm in East Florida (May 2009)

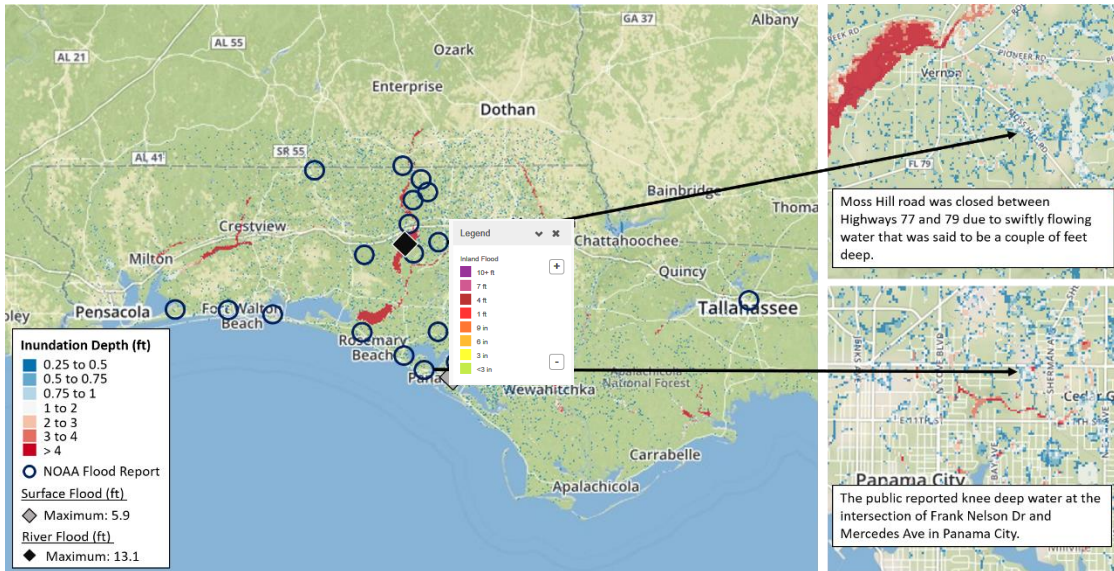


Figure 50 - Validation for Unnamed Storm in Panhandle (July 2013)

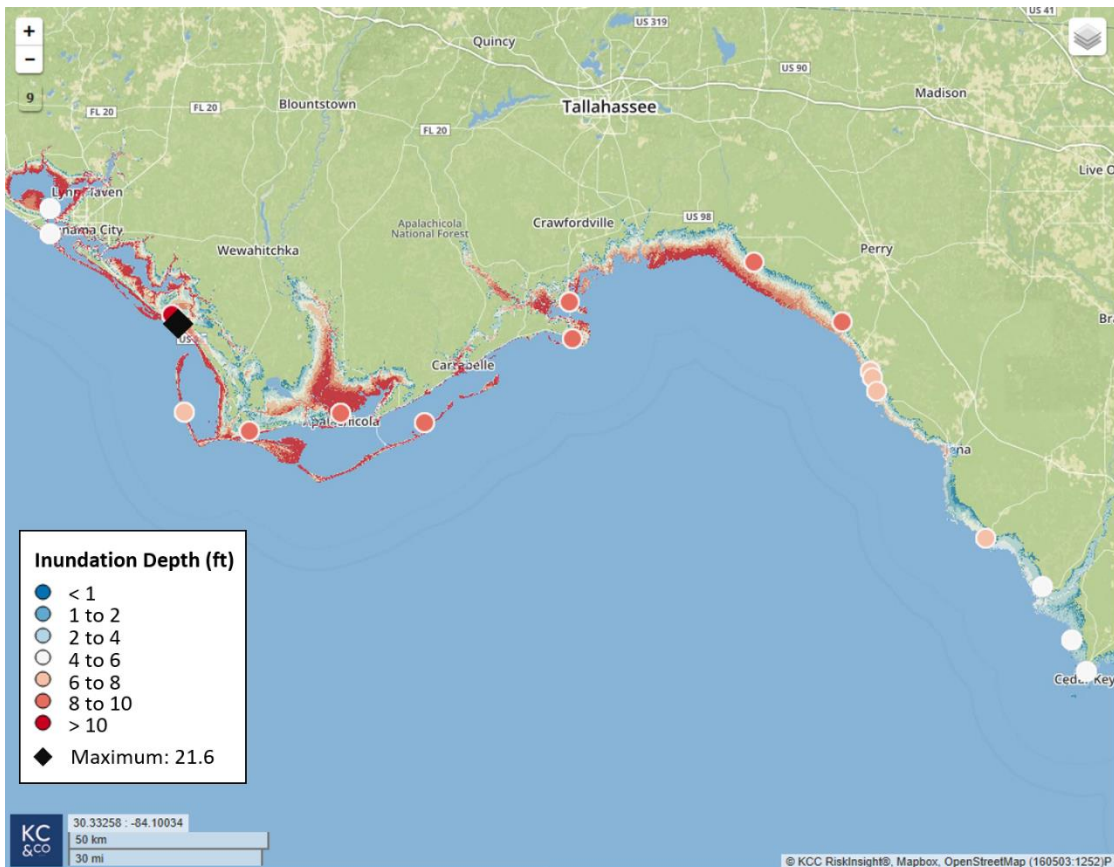


Figure 51 - Validation for Hurricane Michael (2018) with peak identified

C. Provide sources of the validation data.

For riverine and lacustrine flood simulation, the sources of validation are the river discharge and gauge elevation data from United States Geological Survey (USGS). For overland flood simulations, the validation data are flood reports extracted from the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database.

D. Indicate the resolution of the flood model elevation or depth grid used on each contour or high-resolution map.

The spatial resolution for the modeled flood elevation grid is 30 meters by 30 meters.

E. Demonstrate the consistency of the modeled flood extent and elevation or depth with observed flood extent and elevation or depth for each historical event.

As shown in the analyses included in Form HHF-1, Part B, and Standard HHF-2, Disclosure 1, the KCC US Flood Reference Model consistently produces event footprints for different flood events (coastal and inland) in different geographic regions that are in agreement with observed data.

F. Explain any differences between the modeled flood extent and elevation or depth and the historical floods observations. Include an explanation if the differences are impacted by major flood control measures.

From figures shown in HHF-2, the KCC flood footprints are a good match overall with the historical events reported from NOAA's storm events database. Some differences are to be expected due to model and instrumental uncertainty, including actual precipitation rate and distribution, small differences in soil properties, discharge rates, and gauge height data. Additionally, events included in the Storm Event Database occasionally only have descriptions of the depth, such as "knee height," which has to be approximated to a depth for the purposes of event footprint validation.

G. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a detailed description of how they are included.

No additional assumptions were used to complete this form.

H. Include Form HHF-1, Historical Event Flood Extent and Elevation or Depth Validation Maps, in a submission appendix.

Form HHF-2: Coastal Flood Characteristics by Annual Exceedance Probability

- A. Define one study area subject to coastal flooding within each of the five Florida geographic regions identified in Figure 4. The extent of each study area shall be determined by the modeling organization and shall be large enough to encompass at least one county. The modeling organization shall create the underlying grid for this form.
- B. Provide, for each study area, color-coded contour or high-resolution maps showing the modeled flood extent and elevation or depth corresponding to 0.01 annual exceedance probability. Flood extent and elevation or depth shall incorporate waves or wave proxies, if modeled. For locations subject to both coastal and inland flooding, this information should reflect only coastal flooding.

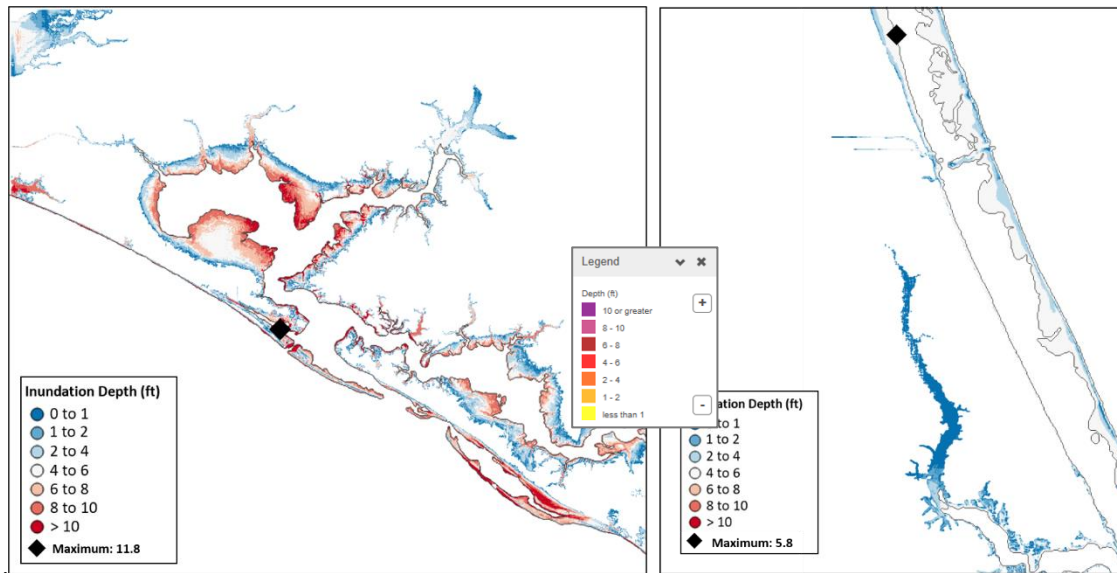


Figure 52 - Modeled flood extent and elevation for Bay County (left) and St. Lucie County (right) showing the 0.01 annual exceedance coastal flood probability extent and depth

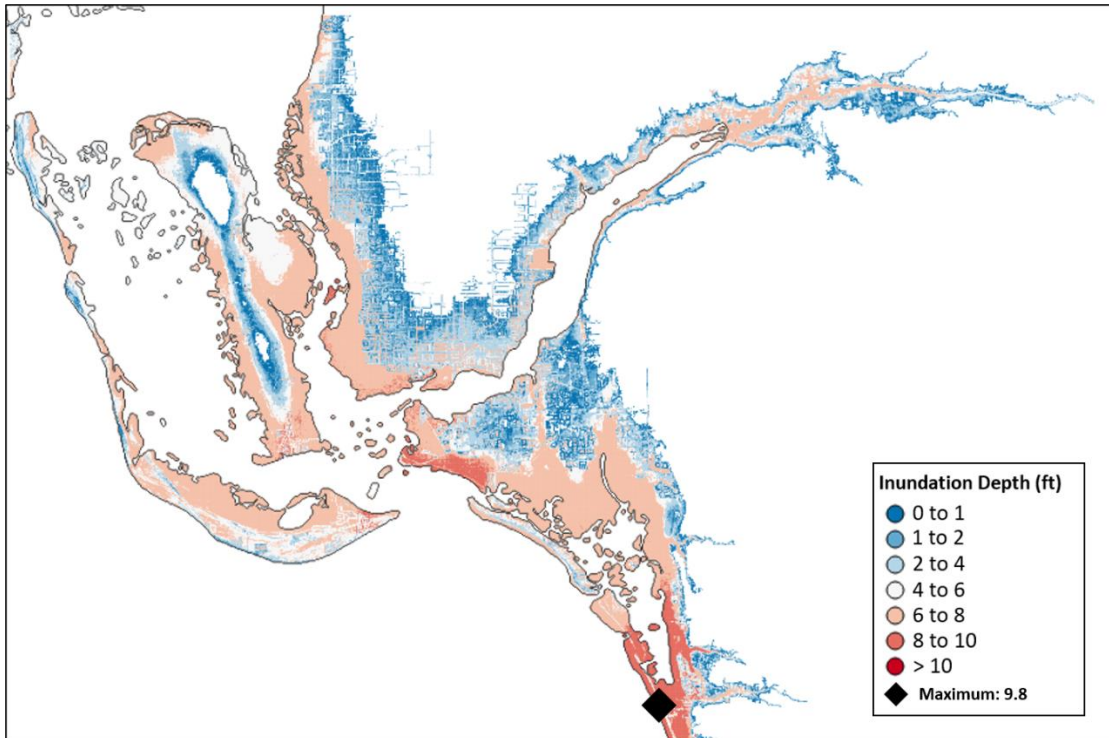


Figure 53 - Modeled flood extent and elevation for Lee County showing the 0.01 annual exceedance coastal flood probability extent and depth

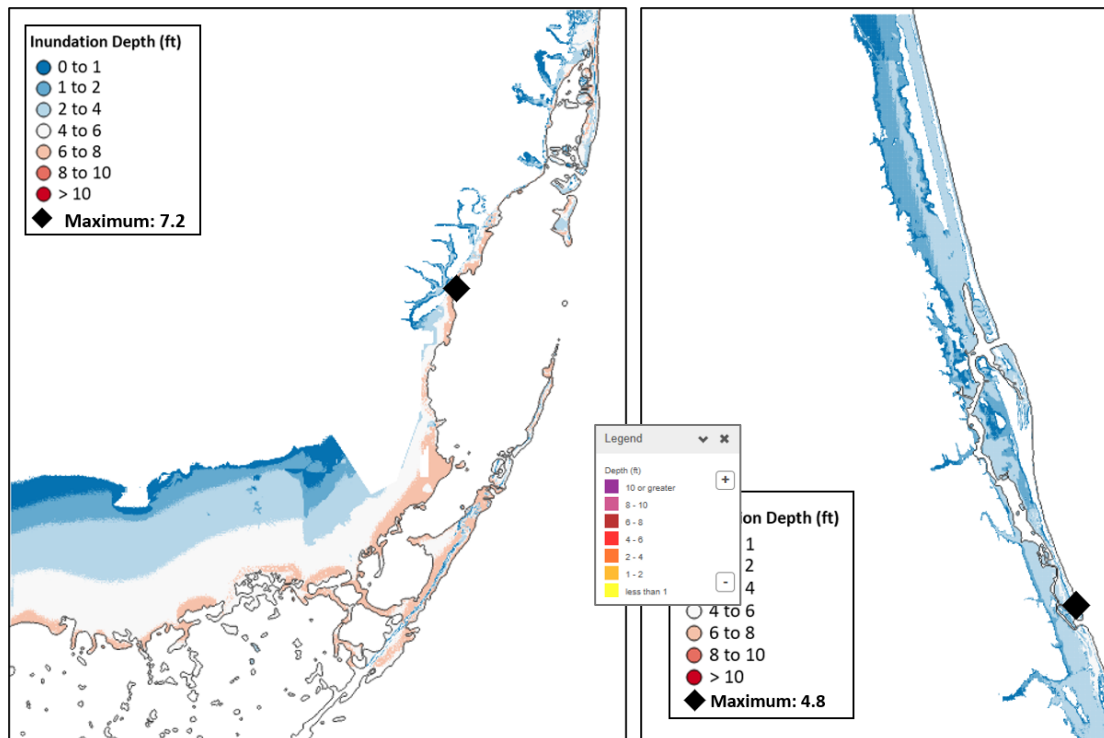


Figure 54 - Modeled flood extent and elevation for Miami-Dade County (left) and St. Johns County (right) showing the 0.01 annual exceedance coastal flood probability extent and depth

- C. ***Include Form HHF-2, Coastal Flood Characteristics by Annual Exceedance Probability, in a submission appendix.***

Form HHF-3: Coastal Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item)

Form HHF-3 is a trade secret item and as such will be provided to the Professional Team during their onsite visit and discussed during the closed portion of the Commission meeting.

Form HHF-4: Inland Flood Characteristics by Annual Exceedance Probability

- A. Define one study area subject to inland flooding within each of the five Florida geographic regions identified in Figure 4. The extent of each study area shall be determined by the modeling organization and shall be large enough to encompass at least one county. The modeling organization shall create the underlying grid for this form.

- B. Provide, for each study area, color-coded contour or high-resolution maps showing the modeled flood extent and elevation or depth corresponding to the 0.01 annual exceedance probability. Flood extent and elevation or depth shall incorporate the effects of flood-induced erosion, if modeled. For locations subject to both inland and coastal flooding, this information should reflect only inland flooding.

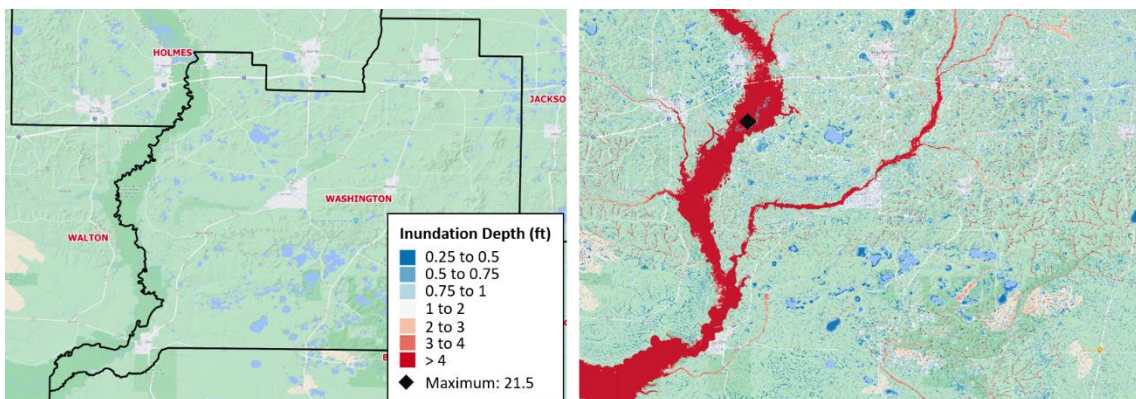


Figure 55 - Study area (left) and 0.01 annual exceedance probability of flood inundation depth (right) for the Panhandle

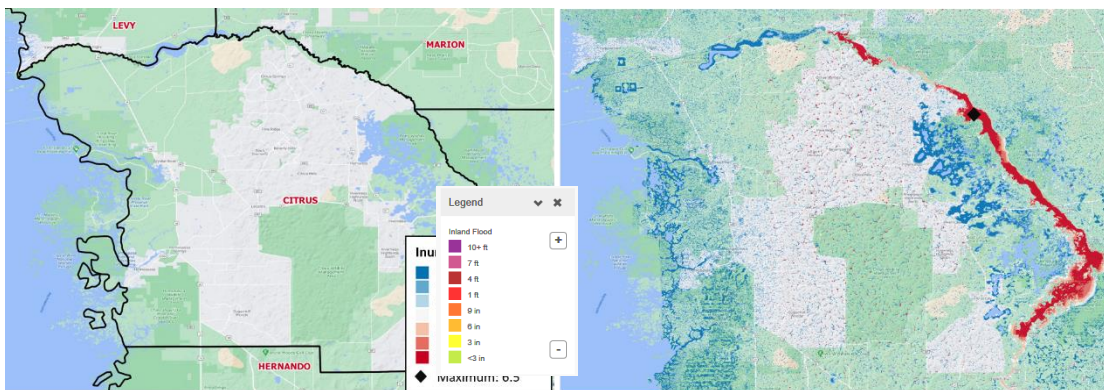


Figure 56 - Study area (left) and 0.01 annual exceedance probability of flood inundation depth (right) for North Florida

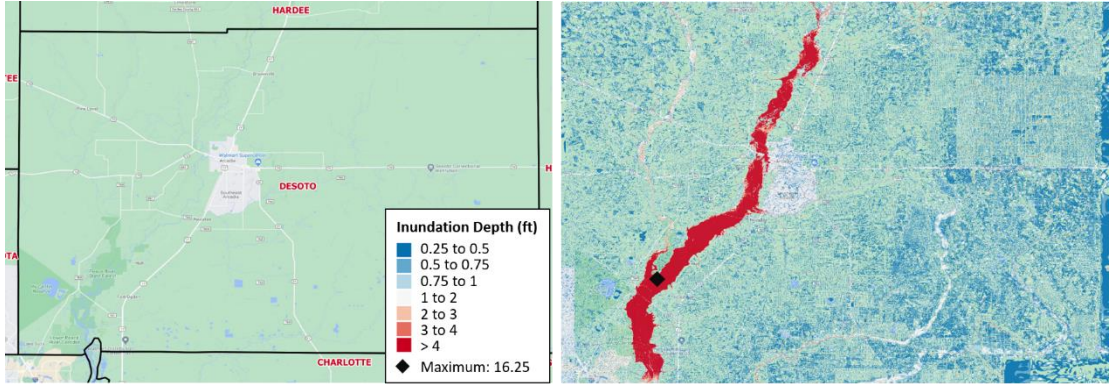


Figure 57 - Study area (left) and 0.01 annual exceedance probability of flood inundation depth (right) for Southwest Florida

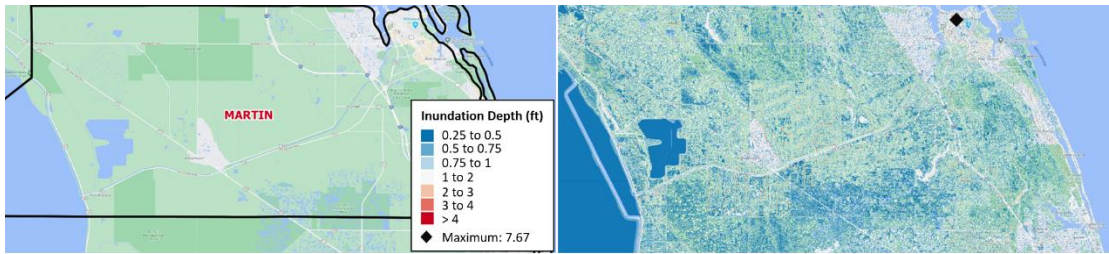


Figure 58 - Study area (top) and 0.01 annual exceedance probability of flood inundation depth (bottom) for East Florida

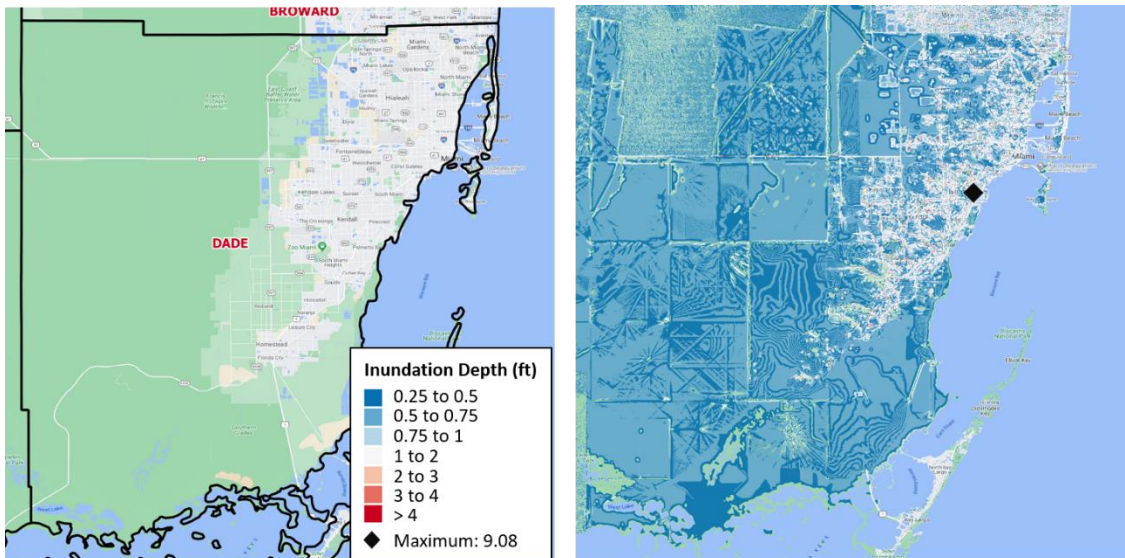


Figure 59 - Study area (left) and 0.01 annual exceedance probability of flood inundation depth (right) for Southeast Florida

C. Include Form HHF-4, Inland Flood Characteristics by Annual Exceedance Probability, in a submission appendix.

Form HHF-5: Inland Flood Characteristics by Annual Exceedance Probabilities (Trade Secret Item)

Form HHF-5 is a trade secret item and as such will be provided to the Professional Team during their onsite visit and discussed during the closed portion of the Commission meeting.

Appendix C: Statistical Forms

Form SF-1: Distributions of Stochastic Flood Parameters (Coastal, Inland)

- A. Provide the probability distribution functional form used for each stochastic flood parameter in the flood model (one each for coastal and inland flooding). Provide a summary of the justification for each functional form selected for each general classification. Specify the relevant classification (coastal or inland) for each distribution.**
- B. Include Form SF-1, Distributions of Stochastic Flood Parameters (Coastal, Inland), in a submission appendix.**

Stochastic Flood Parameter Function or Variable	Classification: Coastal or Inland	Functional Form of Distribution	Data Source	Year Range Used	Justification for Functional Form
Maximum sustained wind speed	Coastal	Generalized Pareto Distribution (μ, σ, ξ) where μ, σ , and ξ are the location, scale, and shape parameters, respectively $f(x) = \frac{1}{\sigma} \left(1 + \xi \left(\frac{x - \mu}{\sigma} \right) \right)^{-\left(\frac{1}{\xi} + 1\right)}$ $\mu \leq x \leq \mu - \sigma/\xi \quad (\xi < 0)$ $\mu, \xi, \in (-\infty, \infty)$ $\sigma \in (0, \infty)$	HURDAT2	1900-2018	The Generalized Pareto Distribution has been shown to accurately represent the distribution of extreme winds (e.g. Palutikof et al., 1999) and specifically for US hurricanes (Jagger and Elsner, 2006; Emanuel and Jagger, 2010). Goodness-of-fit tests support the use of this functional form.
Radius of maximum winds	Coastal	Normal distribution (μ, σ^2) where μ is the mean, and σ is the standard deviation $R_{max} = f(V_{max}, latitude) + \epsilon$ $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$ $\mu \in (-\infty, \infty)$ $\sigma^2 > 0$ $x \in (-\infty, \infty)$	Demuth et al. (2006); Ho et al. (1987)	1900-2018	The model uses the relationship between R_{max} , maximum sustained wind speed, and latitude developed by Willoughby et al. (2006) with coefficients estimated using the historical data. The expected R_{max} decreases with V_{max} and increases with latitude. The residual values, ϵ , normalized to the expected R_{max} , are modeled using a normal distribution supported by the results of goodness-of-fit tests.
Track direction at landfall	Coastal	Uniform distribution (a, b) where a is the lower bound and b is the upper bound $f(x) = \frac{1}{b - a}$ $a \leq x \leq b$ $a, b, \in (-\infty, \infty)$	HURDAT2	1900-2018	Track direction at landfall is dependent on the orientation of the coastline and climatology. Track direction is modeled for appropriate coastline lengths for which there are ranges of equally likely track directions. Goodness-of-fit tests support the choice of the uniform distribution.

Stochastic Flood Parameter Function or Variable	Classification: Coastal or Inland	Functional Form of Distribution	Data Source	Year Range Used	Justification for Functional Form
Forward speed	Coastal	Weibull distribution (α, β) where α and β are the scale and shape parameters, respectively $f(x) = \frac{\beta x^{\beta-1}}{\alpha^\beta} e^{-\left(\frac{x}{\alpha}\right)^\beta}$ $\alpha > 0$ $\beta > 0$ $x > 0$	HURDAT2	1900-2018	The Weibull distribution is suitable for representing the hurricane forward speed data that are both non-negative and positively skewed. The results of goodness-of-fit tests support the choice of the Weibull distribution for representing forward speed.
Annual Landfall Frequency	Coastal	Empirical Cumulative Distribution Function $F_n(x) = \frac{1}{n} \sum_{i=1}^n 1\{X_i \leq x\}$ $1\{X_i \leq x\} = \begin{cases} 1, & X_i < x \\ 0, & \text{otherwise} \end{cases}$ $x \in (-\infty, \infty)$	HURDAT2	1900-2018	The number of landfall events per year is best represented by an empirical distribution that can accurately reflect both the portion of historical years with no landfalls and the portion with multiple landfalls. Goodness-of-fit tests support the use of the empirical distribution for this model parameter.
Precipitation Amount	Inland	Pareto type II distribution (β, γ) where β is the scale parameter and γ is the shape parameter $f_{PII}(x) = \frac{1}{\beta} \left(1 + \gamma \frac{x}{\beta}\right)^{-\frac{1}{\gamma}-1}$ $x \in (0, \infty)$ $\beta > 0$ $\gamma \geq 0$	CPC	1948-2018	The Pareto type II distribution has been shown to accurately assign a return period to amount of rainfall - Pappalardo et al. (2013).
Spatial Extent	Inland	Expected values of the spatial extent are a function of the precipitation amount: $f(x) = \beta_0 + \beta_1(x) + \epsilon, x \leq P_c$ $f(x) = \text{constant}, x > P_c$ $P_c = 600\text{mm}$ $x > 0$ $\beta_0, \beta_1 \in (-\infty, \infty)$ The residuals follow a Lognormal Distribution, $g(y) = \frac{1}{(y+1)\sigma\sqrt{2\pi}} e^{-\frac{(\ln(y+1)-\mu)^2}{2\sigma^2}}$ $y \in (-1, \infty)$ $\mu \geq 0$ $\sigma > 0$	CPC	1948-2018	Events with higher magnitude precipitation amounts affect, on average, a larger area. This relationship applies below a threshold value of precipitation amount, above which the expected spatial extent is constant. The variability of spatial extent for events with the same precipitation amount can be represented by a lognormal distribution, supported with the use of goodness-of-fit tests.

Stochastic Flood Parameter Function or Variable	Classification: Coastal or Inland	Functional Form of Distribution	Data Source	Year Range Used	Justification for Functional Form
Duration	Inland	<p>Expected values of the duration are a function of the precipitation amount:</p> $f(x) = \beta_0 + \beta_1(x) + \epsilon, x \leq P_c$ $f(x) = \text{constant}, x > P_c$ <p>$P_c = 400\text{mm}$ $x > 0$ $\beta_0, \beta_1 \in (-\infty, \infty)$</p> <p>The residuals follow a Lognormal Distribution,</p> $g(y) = \frac{1}{(y+5)\sigma\sqrt{2\pi}} e^{-\frac{(\ln(y+5)-\mu)^2}{2\sigma^2}}$ <p>$y \in (-5, \infty)$ $\mu \geq 0$ $\sigma > 0$</p>	CPC	1948-2018	The event duration increases, on average, as the event precipitation amount increases. This relationship applies below a threshold value of precipitation amount, above which the expected duration is constant. The variability of the event duration can be represented by a lognormal distribution, which is supported with the use of goodness-of-fit tests.
Initial Precipitation	Inland	<p>The initial precipitation follows a Gamma Distribution,</p> $f(x) = \frac{\left(\frac{x}{\beta}\right)^{\alpha-1} e^{-(x/\beta)}}{\beta\Gamma(\alpha)}$ $\Gamma(x) = \int_0^\infty t^{\alpha-1} e^{-t} dt$ <p>$x \in (0, \infty)$ $\beta > 0$ $\alpha > 0$</p>	CPC	1948-2018	The gamma distribution is commonly used to represent precipitation data that are bounded on the left by zero and are positively skewed (Wilks, 1995). The choice of the gamma distribution is supported by goodness-of-fit testing.
Annual Extreme Precipitation Event Frequency	Inland	<p>The annual extreme precipitation event frequency follows a Poisson distribution (with rate λ)</p> $p(k) = \frac{\lambda^k e^{-\lambda}}{k!}$ <p>$k \in \{0, 1, 2, \dots\}$ $\lambda \in [0, \infty)$</p>	CPC	1948-2018	The Poisson distribution is suitable for count of discrete events like extreme precipitation events for which the probability of occurrence depends only on the size of the time interval over which they are counted. The use of the Poisson distribution is supported by the use of a goodness-of-fit test.

Table 18 - Distributions used for model parameters and justification

Form SF-2: Examples of Flood Loss Exceedance Estimates

- A. Provide estimates of the annual aggregate personal residential insured flood losses for various probability levels using a modeling-organization-specified, predetermined, and comprehensive exposure dataset justified by the modeling organization. Provide the total average annual flood loss for the loss exceedance distribution. If the modeling methodology does not allow the flood model to produce a viable answer for certain return periods, state so and why.
- B. Include Form SF-2, Examples of Flood Loss Exceedance Estimates (Coastal and Inland Combined), in a submission appendix.

Part A

Return Period (years)	Annual Probability of Exceedance	Estimated Flood Loss Modeling Organization Exposure Dataset
Top Event	N/A	48,952,195,016
10,000	0.0001	35,709,706,357
5,000	0.0002	32,811,733,120
2,000	0.0005	29,326,676,262
1,000	0.0010	26,825,652,801
500	0.0020	23,879,980,211
250	0.0040	20,464,607,794
100	0.0100	14,922,364,825
50	0.0200	10,607,773,677
20	0.0500	5,609,962,588
10	0.1000	2,875,355,675
5	0.2000	1,136,103,249

Table 19 - Modeled annual aggregate personal residential flood losses by return period

Part B

Mean (Total Average Annual Flood Loss): 1,117,841,547

Median: 196,627,951

Standard Deviation: 2,867,493,019

Interquartile Range: 755,777,485

Sample Size: 100,000

Appendix D: Vulnerability Forms

Form VF-1: Coastal Flood with Damaging Wave Action

- A. Sample personal residential exposure data for 8 reference structures as defined below and 26 flood depths (0-25 feet at 1-foot increments) are provided in the file named "VFEventFormsInput17.xlsx."**

Model the sample personal residential exposure data provided in the file versus the flood depths, and provide the damage ratios summarized by flood depth and construction type. Estimated Damage for each individual flood depth is the sum of ground up loss to all reference structures in the flood depth range, excluding demand surge.

Personal residential contents, appurtenant structures, or time element coverages are not included.

Reference Structures

Wood Frame	M	Manufactured Home
<p>#1 One story Crawlspace foundation Top of foundation wall 3 feet above grade</p>	<p>#4 One story Slab foundation Top of slab 1 foot above grade Unreinforced masonry exterior walls</p>	<p>#7 Manufactured post 1994 Dry stack concrete foundation Pier height 3 feet above grade Tie downs Single unit</p>
<p>#2 Two story Slab foundation Top of slab 1 foot above grade 5/8" diameter anchors at 48" centers for wall/slab connections</p>	<p>#5 Two story Slab foundation Top of slab 1 foot above grade Reinforced masonry exterior walls</p>	<p>#8 Manufactured post 1994 Reinforced masonry pier foundation Pier height 6 feet above grade Tie downs Single unit</p>
<p>#3 Two story Timber pile foundation Top of pile 8 feet above grade Wood floor system bolted to piles</p>	<p>#6 Two story Concrete pile foundation Concrete slab Top of pile 8 feet above grade Reinforced masonry exterior</p>	

- B. Confirm that the structures used in completing the form are identical to those in the above table for the reference structures.**

The structures used to complete this form are identical to those described in Form VF-1, Part A.

- C. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a description of how they are included.**

No additional assumptions were required to complete this form.

D. Provide a plot of the flood depth versus estimated damage/subject exposure data.

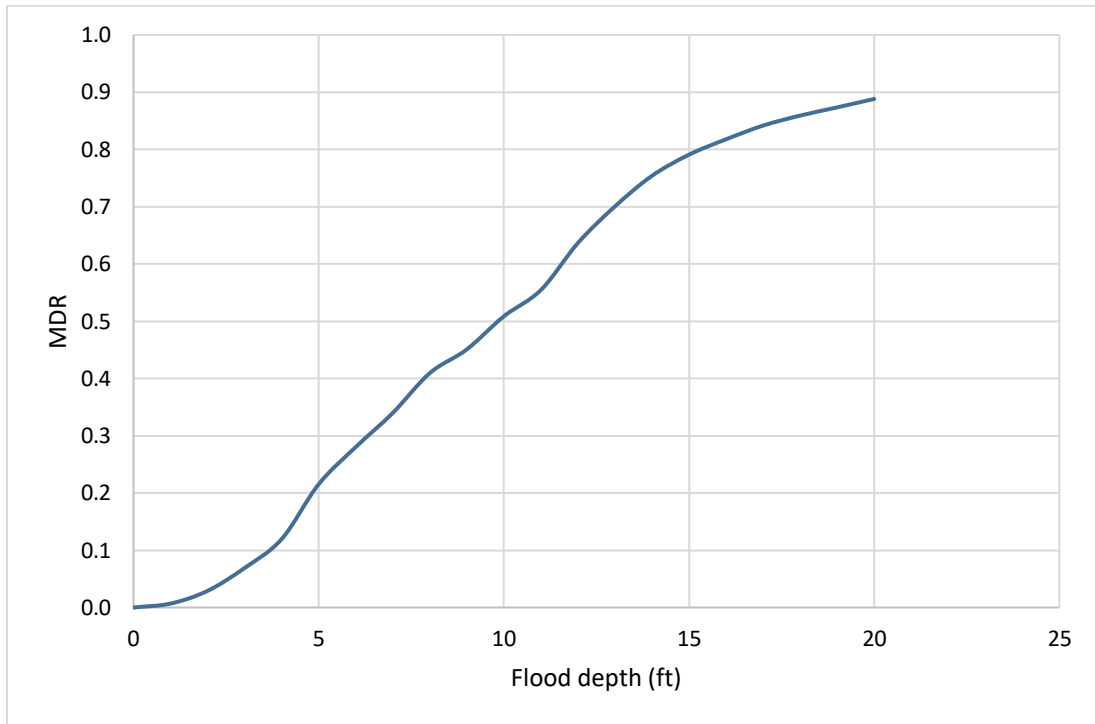


Figure 60 - Sample MDR by flood depth for coastal flooding

E. Include Form VF-1, Coastal Flood with Damaging Wave Action, in a submission appendix.

Flood Depth (ft) Above Ground Level	Estimated Damage/Subject Exposure
0	0
1	0.007
2	0.029
3	0.069
4	0.120
5	0.215
6	0.280
7	0.340
8	0.409
9	0.451
10	0.509
11	0.555
12	0.637

Flood Depth (ft) Above Ground Level	Estimated Damage/Subject Exposure
13	0.701
14	0.754
15	0.791
16	0.818
17	0.842
18	0.859
19	0.874
20	0.888

Table 20 - MDR by flood depth for coastal flooding

Form VF-2: Inland Flood by Flood Depth

- A. Sample personal residential exposure data for 8 reference structures as defined below and 26 flood depths (0-25 feet at 1-foot increments) are provided in the file named "VFEEventFormsInput17.xlsx."**

Model the sample personal residential exposure data provided in the file versus the flood depths, and provide the damage ratios summarized by flood depth and construction type. Estimated Damage for each individual flood depth is the sum of ground up loss to all reference structures in the flood depth range, excluding demand surge.

Personal residential contents, appurtenant structures, or time element coverages are not included.

Reference Structures

Wood Frame	Masonry	Manufactured Home
<p>#1 One story Crawlspace foundation Top of foundation wall 3 feet above grade</p>	<p>#4 One story Slab foundation Top of slab 1 foot above grade Unreinforced masonry exterior walls</p>	<p>#7 Manufactured post 1994 Dry stack concrete foundation Pier height 3 feet above grade Tie downs Single unit</p>
<p>#2 Two story Slab foundation Top of slab 1 foot above grade 5/8" diameter anchors at 48" centers for wall/slab connections</p>	<p>#5 Two story Slab foundation Top of slab 1 foot above grade Reinforced masonry exterior walls</p>	<p>#8 Manufactured post 1994 Reinforced masonry pier foundation Pier height 6 feet above grade Tie downs Single unit</p>
<p>#3 Two story Timber pile foundation Top of pile 8 feet above grade Wood floor system bolted to piles</p>	<p>#6 Two story Concrete pile foundation Concrete slab Top of pile 8 feet above grade Reinforced masonry exterior walls</p>	

- B. Confirm that the structures used in completing the form are identical to those in the above table for the reference structures.**

The structures used to complete this form are the same as those identified in Form VF-2, Part A.

C. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a description of how they are included.

No additional assumptions were required to complete this form.

D. Provide a plot of the flood depth versus estimated damage/subject exposure data.

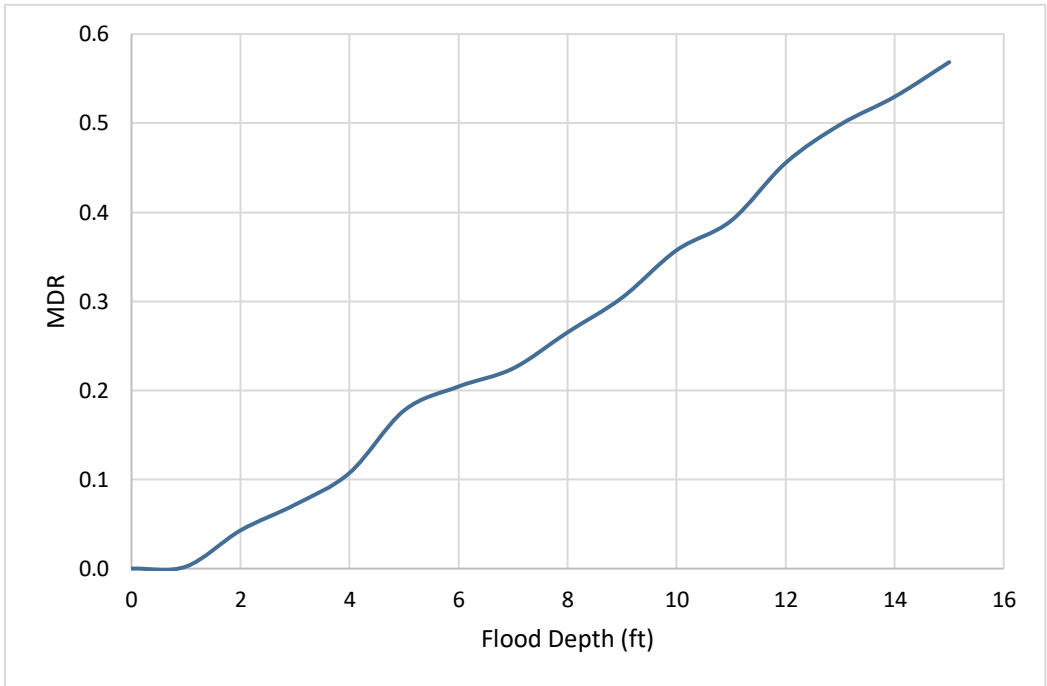


Figure 61 - Sample MDR by flood depth for Inland flooding

E. Include Form VF-2, Inland Flood by Flood Depth, in a submission appendix.

Flood Depth (ft) Above Ground Level	Estimated Damage/Subject Exposure
0	0
1	0.002
2	0.043
3	0.072
4	0.107
5	0.177
6	0.204
7	0.225
8	0.265
9	0.304
10	0.357
11	0.391

<i>Flood Depth (ft) Above Ground Level</i>	<i>Estimated Damage/Subject Exposure</i>
12	0.455
13	0.498
14	0.530
15+	0.568

Table 21 - MDR by flood depth for inland flooding

Form VF-3: Flood Mitigation Measures, Range of Changes in Flood Damage

- A. Provide the change in the personal residential reference building damage ratio (not loss cost) for each individual flood mitigation measure listed in Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage, as well as for the combination of the flood mitigation measures.**

The percent change in the personal residential reference building damage ratio for each flood mitigation measure in this form is included in the table on the following page.

- B. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a detailed description of how they are included.**

No additional assumptions were required to complete this form.

- C. Provide this form in Excel format without truncation. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name. Also include Form VF-3, Flood Mitigation Measures, Range of Changes in Flood Damage, in a submission appendix.**

Reference Structures

Wood Frame	Masonry
One story Crawlspace foundation Top of foundation wall 3 feet above grade	One story Slab foundation Top of slab 1 foot above grade Unreinforced masonry exterior walls
Two story Timber pile foundation Top of pile 8 feet above grade Wood floor system bolted to piles	

This form has been submitted in Excel format as KCC17_FormVF3.

- D. Place the reference structures at the following locations, with latitude and longitude referenced to the World Geodetic System of 1984 (WGS84) datum, and provide the aggregated results.**

Gulf of Mexico
Latitude: 27.9957517
Longitude: -82.8277373

St. Johns River
Latitude: 29.3768881
Longitude: -81.6190223

- E. Provide the ground elevation used from the flood model elevation database for both reference points.**

The elevation of the Gulf of Mexico (27.9957517, -82.8277373) is 1.3656 m.

The elevation of St. Johns River (29.3768881, -81.6190223) is 1.7106 m.

INDIVIDUAL FLOOD MITIGATION MEASURES		PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATIO - MITIGATED DAMAGE RATIO) / REFERENCE DAMAGE RATIO) * 100									
		TWO-STORY WOOD FRAME STRUCTURE					MASONRY STRUCTURE				
		FLOOD DEPTH (FT) ABOVE GROUND					FLOOD DEPTH (FT) ABOVE GROUND				
		7	9	11	13	15	1	3	5	7	9
	REFERENCE STRUCTURE	-	-	-	-	-	-	-	-	-	-
ELEVATE STRUCTURE	Elevate Floor 1 Foot	0.0	33.0	24.6	18.1	16.0					
	Elevate Floor 2 Feet	0.0	33.1	86.5	31.3	31.4					
	Elevate Floor 3 Feet	0.0	33.1	86.9	47.5	42.8					
UTILITY EQUIPMENT	Elevate or Protect 1 Foot	0.0	0.1	4.4	1.3	0.5	0.2	10.8	3.4	1.5	0.5
	Elevate or Protect 2 Feet	0.0	0.1	10.1	3.2	1.1	0.2	10.8	7.4	3.2	1.0
	Elevate or Protect 3 Feet	0.0	0.1	10.1	6.3	2.2	0.2	10.8	12.3	4.9	1.6
FLOODPROOFING	Wet 1 Foot	0.0	3.0	33.5	9.5	2.7	8.1	40.0	11.6	3.8	0.7
	Wet 2 Feet	0.0	3.0	79.5	25.2	6.5	8.1	84.3	29.4	8.6	1.5
	Wet 3 Feet	0.0	3.0	79.5	37.5	13.4	8.1	84.3	43.5	16.1	2.5
	Dry 1 Foot						7.9	29.2	8.2	2.2	0.2
	Dry 2 Feet						7.9	73.6	22.0	5.4	0.5
	Dry 3 Feet						7.9	73.6	31.2	11.2	0.9
FLOOD OPENINGS		ONE-STORY WOOD FRAME STRUCTURE									
		FLOOD DEPTH (FT) ABOVE GROUND									
		1	3	5	7	9					
		1.9	9.0	8.4	4.6	2.9					
	Flood Openings in Foundation Walls										
FLOOD MITIGATION MEASURES IN COMBINATION		PERCENTAGE CHANGES IN DAMAGE ((REFERENCE DAMAGE RATIO - MITIGATED DAMAGE RATIO) / REFERENCE DAMAGE RATIO) * 100									
		TWO-STORY WOOD FRAME STRUCTURE					MASONRY STRUCTURE				
		FLOOD DEPTH (FT) ABOVE GROUND					FLOOD DEPTH (FT) ABOVE GROUND				
		7	9	11	13	15	1	3	5	7	9
	Elevate Utility Equipment 2 Feet Above Floor and Wet Floodproof Structure to 2 Feet	0.0	3.0	79.5	25.2	6.5	8.1	84.3	29.4	8.6	1.5

Table 22 - Percent change in damages due to mitigation measures and secondary characteristics

Form VF-4: Coastal Flood Mitigation Measures, Mean Coastal Flood Damage Ratios and Coastal Flood Damage/\$1,000 (Trade Secret Item)

Form VF-4 is a trade secret item and as such will be provided to the Professional Team during their onsite visit and discussed during the closed portion of the Commission meeting.

Form VF-5: Inland Flood Mitigation Measures, Mean Inland Flood Damage Ratios and Inland Flood Damage/\$1,000 (Trade Secret Item)

Form VF-5 is a trade secret item and as such will be provided to the Professional Team during their onsite visit and discussed during the closed portion of the Commission meeting.

Appendix E: Actuarial Forms

Form AF-1: Zero Deductible Personal Residential Standard Flood Loss Costs

- A. Provide three maps, color-coded by rating areas or geographic zones (with a minimum of six value ranges), displaying zero deductible personal residential standard flood loss costs per \$1,000 of exposure for wood frame, masonry, and manufactured homes.

Note: Standard Flood in Florida is equivalent to the National Flood Insurance Program (NFIP). Rating areas or geographic zones shall be defined by the modeling organization.

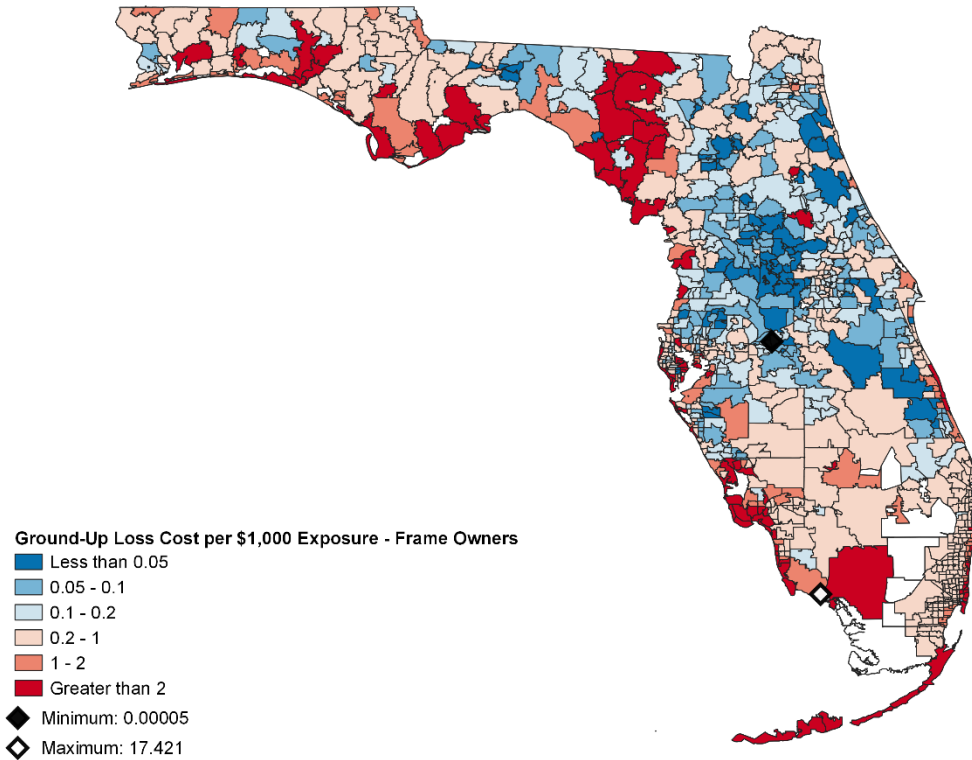


Figure 62 - Zero deductible personal residential flood loss costs per \$1,000 of exposure for wood frame owners

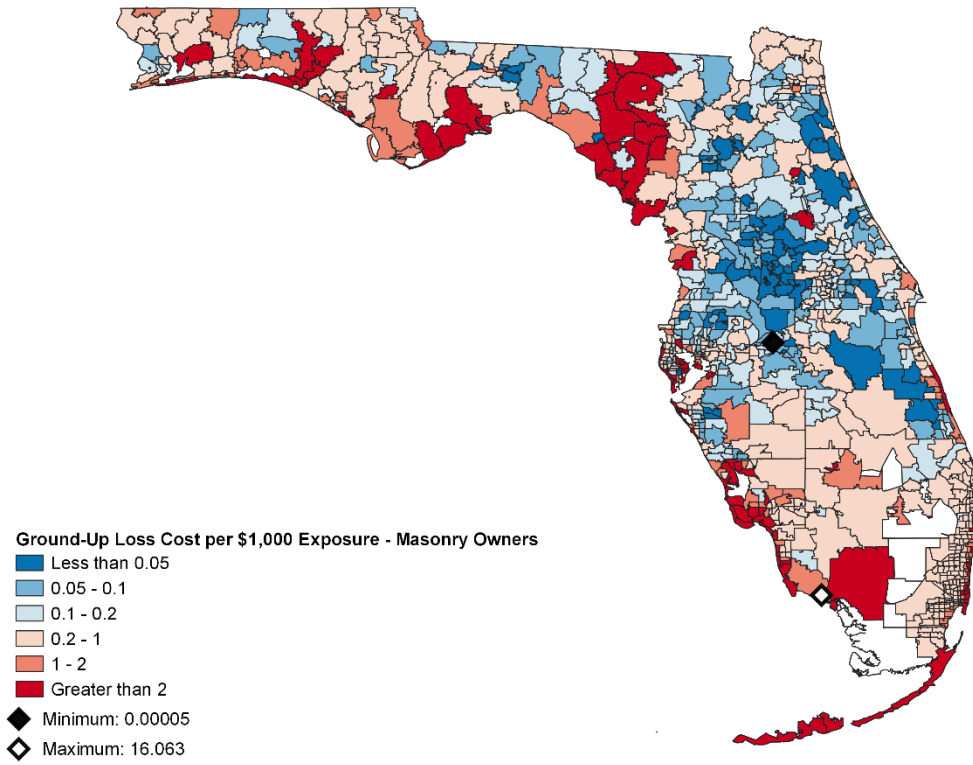


Figure 63 - Zero deductible personal residential flood loss costs per \$1,000 of exposure for masonry owners

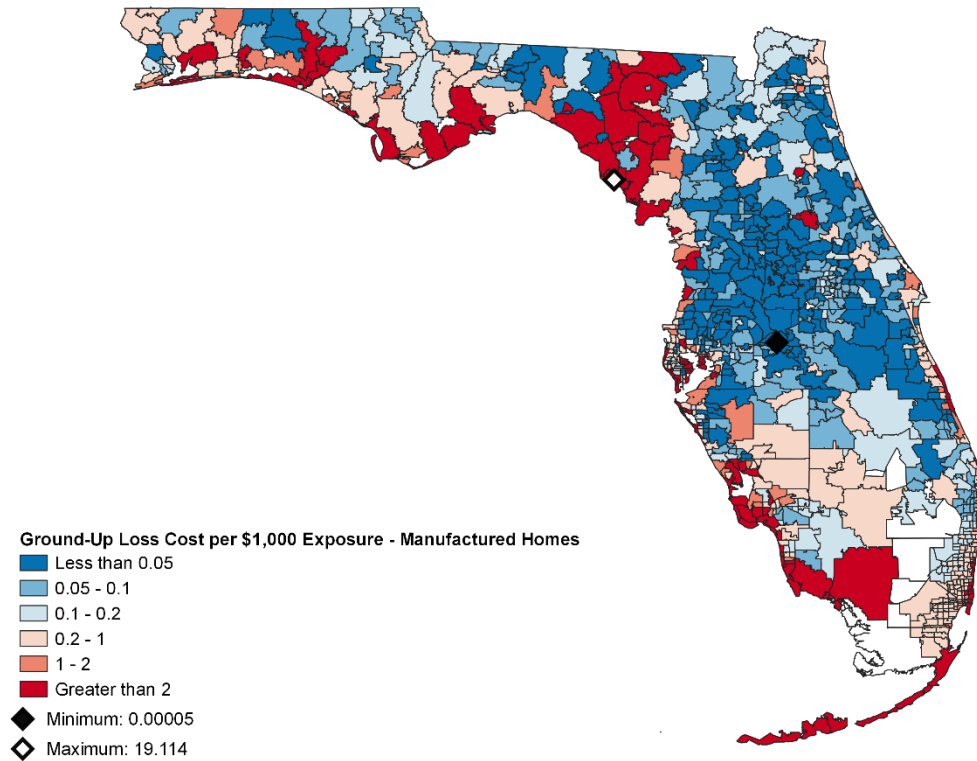


Figure 64 - Zero deductible personal residential flood loss costs per \$1,000 of exposure for manufactured homes

- B. Create exposure sets for these exhibits by modeling all of the buildings from Notional Set 3 described in the file “NotionalInput17_Flood.xlsx” geocoded to each rating area or geographic zone in the state, as provided in the flood model. Define the flood rating areas or geographic zones. Provide the predominant County name and the Federal Information Processing Standards (FIPS) Code associated with each rating area or geographic zone. Refer to the Notional Standard Flood Policy Specifications below for additional modeling information. Explain any assumptions, deviations, and differences from the prescribed exposure information.**

The exposure sets for these exhibits were created by modeling all of the buildings Notional Set 3 described in the file “NotionalInput17.xlsx.”

- C. Provide, in the format given in the file named “2017FormAF1.xlsx” in both Excel and PDF format, the underlying standard flood loss cost data, rounded to three decimal places, used for A. above. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name.**

A completed Form AF-1 has been provided in both Excel and PDF file formats.

Notional Standard Flood Policy Specifications

<u>Policy Type</u>	<u>Assumptions</u>
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Owners	Coverage A = Building Property <ul style="list-style-type: none">☐ Replacement cost equal to Coverage A limit☐ Excludes all appurtenant structures Coverage B = Personal Property <ul style="list-style-type: none">☐ Actual cash value equal to Coverage B limit Time Element Coverage <ul style="list-style-type: none">☐ To be defined by the modeling organization <p>☐ Flood loss costs per \$1,000 shall be related to the Coverage A limit for Coverage A, to the Coverage B limit for Coverage B, and to the Time Element limit for Time Element Coverage</p>
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Form AF-2: Total Flood Statewide Loss Costs

- A. Provide the total personal residential insured flood loss and the percentage contribution of the total personal residential insured flood loss assuming zero deductible policies for individual historical flooding events using a modeling-organization-specified, predetermined and comprehensive exposure dataset. The list of flooding events in this form shall include meteorological and hydrological events and circumstances occurring inside or outside of Florida that resulted in or contributed to flooding in Florida included in the modeling organization flood-event dataset (e.g., Florida and by-passing hurricanes, tropical cyclones below hurricane strength that caused flood losses in Florida, rainfall events that caused flood losses in Florida).**

The table below contains the minimum number of tropical cyclones from HURDAT2 and rainfall events to be included in the modeling organization flood-event dataset. As defined, a by-passing hurricane (ByP) is a hurricane which does not make landfall, but produces minimum damaging windspeeds or greater on land in Florida. For the by-passing hurricanes included in the table only, the hurricane intensity entered is the maximum windspeed at closest approach to Florida as a hurricane, not the windspeed over Florida. Each tropical cyclone and rainfall event has been assigned an ID number. Additional tropical cyclones and rainfall events included in the modeling organization flood-event dataset shall be added to the table below in order of year and assigned an intermediate ID number as the tropical cyclone and rainfall event falls within the bounding ID numbers.

- B. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a detailed description of how they are included.**

No additional assumptions were made to complete this form.

- C. Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name. Also include Form AF-2, Total Flood Statewide Loss Costs, in a submission appendix.**

This form has been provided in Excel format and within this submission appendix in the table below.

ID	Tropical Cyclone/ Hurricane Landfall/Closest Approach Date	Year	Name	Hurricane Landfall Region as defined in Figure 3- Category	Personal Residential Insured Flood Losses (\$)	Percentage Contribution
005	10/25/1921	1921	TampaBay06-1921	B-3	9,256,908,151	12.90
010	09/18/1926	1926	GreatMiami07-1926	C-4/A-3	12,027,723,751	16.76
015	09/17/1928	1928	LakeOkeechobee04-1928	C-4	2,464,951,661	3.43
020	09/03/1935	1935	LaborDay03-1935	C-5/A-2	3,061,470,884	4.27
025	08/31/1950	1950	Baker-1950	F-1/ByP-1	67,903,654	0.09
030	09/05/1950	1950	Easy-1950	A-3	966,895,562	1.35
035	10/18/1950	1950	King-1950	C-4	1,229,625,687	1.71
040	09/26/1953	1953	Florence-1953	A-1	51,781,984	0.07

ID	Tropical Cyclone/ Hurricane Landfall/Closest Approach Date	Year	Name	Hurricane Landfall Region as defined in Figure 3- Category	Personal Residential Insured Flood Losses (\$)	Percentage Contribution
045	10/09/1953	1953	Hazel-1953	B-1	1,104,807,038	1.54
050	09/25/1956	1956	Flossy-1956	A-1	24,123,252	0.03
055	09/10/1960	1960	Donna-1960	B-4	4,810,850,799	6.70
060	09/15/1960	1960	Ethel-1960	F-1	31,428	0.00
065	08/27/1964	1964	Cleo-1964	C-2	115,686,259	0.16
070	09/10/1964	1964	Dora-1964	D-2	733,501,226	1.02
075	10/14/1964	1964	Isbell-1964	B-3	156,165,380	0.22
080	09/08/1965	1965	Betsy-1965	C-3	1,882,836,959	2.62
085	06/09/1966	1966	Alma-1966	A-2	93,501,036	0.13
090	10/04/1966	1966	Inez-1966	B-1	189,105,799	0.26
095	10/19/1968	1968	Gladys-1968	A-2	857,844,836	1.20
100	08/18/1969	1969	Camille-1969	F-5	0	0.00
105	06/19/1972	1972	Agnes-1972	A-1	8,412,343	0.01
110	09/23/1975	1975	Eloise-1975	A-3	1,609,120,612	2.24
115	09/04/1979	1979	David-1979	C-2/E-2	377,215,825	0.53
120	09/13/1979	1979	Frederic-1979	F-3	1,492,377,438	2.08
125	09/02/1985	1985	Elena-1985	F-3/ByP-3	458,222,146	0.64
130	11/21/1985	1985	Kate-1985	A-2	46,745,133	0.07
135	10/12/1987	1987	Floyd-1987	B-1	33,344,633	0.05
140	08/24/1992	1992	Andrew-1992	C-5	6,944,054,409	9.68
145	08/03/1995	1995	Erin-1995	C-1/A-2	384,072,673	0.54
150	10/04/1995	1995	Opal-1995	A-3	1,904,542,516	2.65
155	07/19/1997	1997	Danny-1997	F-1	85,178	0.00
160	09/03/1998	1998	Earl-1998	A-1	100,181,659	0.14
165	09/25/1998	1998	Georges-1998	B-2/F-2	163,704,004	0.23
170	10/15/1999	1999	Irene-1999	B-1	570,146,154	0.79
175	08/13/2004	2004	Charley-2004	B-4	3,409,000,058	4.75
180	09/05/2004	2004	Frances-2004	C-2	751,791,662	1.05
185	09/16/2004	2004	Ivan-2004	F-3/ByP-3	639,415,673	0.89
190	09/26/2004	2004	Jeanne-2004	C-3	1,685,836,595	2.35
195	07/10/2005	2005	Dennis-2005	A-3	2,668,999,793	3.72
200	08/25/2005	2005	Katrina-2005	C-1	284,424,357	0.40

<i>ID</i>	<i>Tropical Cyclone/ Hurricane Landfall/Closest Approach Date</i>	<i>Year</i>	<i>Name</i>	<i>Hurricane Landfall Region as defined in Figure 3- Category</i>	<i>Personal Residential Insured Flood Losses (\$)</i>	<i>Percentage Contribution</i>
205	09/20/2005	2005	Rita-2005	ByP-2	834,046	0.00
210	10/24/2005	2005	Wilma-2005	B-3	3,833,192,329	5.34
215	08/18/2008	2008	Tropical Storm Fay-2008		451,091,676	0.63
220		May 2009	Unnamed Storm in East Florida-2009		43,099,029	0.06
225		July 2013	Unnamed Storm in Panhandle-2013		14,846,238	0.02
230	09/02/2016	2016	Hermine-2016	A-1	171,804,227	0.24
235	10/07/2016	2016	Matthew-2016	ByP-3	717,481,955	1.00
240	09/10/2017	2017	Irma - 2017	B-3	2,501,325,099	3.49
245	10/10/2018	2018	Michael - 2018	A-5	1,404,396,959	1.96
			<i>Total</i>		71,765,479,763	100.00

Table 23 - Total flood statewide costs

Form AF-3: Personal Residential Standard Flood Loss Costs by ZIP Code

A. Provide the percentage of personal residential zero deductible standard flood losses, rounded to four decimal places, and the monetary contribution from the events listed below using the modeling-organization-specified, predetermined, and comprehensive exposure dataset. Include all ZIP Codes where losses are material. Disclose the materiality threshold.

Hurricane Andrew (1992)

Hurricane Ivan (2004)

Hurricane Jeanne (2004)

Hurricane Wilma (2005)

Tropical Storm Fay (2008)

Unnamed Storm in East Florida (May 2009)

Unnamed Storm in Panhandle (July 2013)

Storm chosen by modeling organization

ZIP Code	County	Hurricane Andrew (1992)		Hurricane Ivan (2004)		Hurricane Jeanne (2004)		Hurricane Wilma (2005)		Tropical Storm Fay (2008)		Unnamed Storm in East Florida (May 2009)		Unnamed Storm in Panhandle (July 2013)		Hurricane Michael (October 2018)		Total All Events	
		Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)
33139	Miami-Dade	1,086,295,700	16.376	0	0.000	949,062	0.058	0	0.000	28,056	0.006	90,252	0.211	0	0.000	0	0.000	1,087,363,069	7.546
34145	Collier	13,129,945	0.198	0	0.000	54,595,179	3.310	1,013,554,044	27.538	96,953	0.022	0	0.000	101,665	0.695	0	0.000	1,081,477,786	7.505
33140	Miami-Dade	1,049,211,594	15.817	0	0.000	4,726,893	0.287	0	0.000	130,502	0.030	446,126	1.042	43,781	0.299	0	0.000	1,054,558,897	7.318
34102	Collier	0	0.000	0	0.000	87,803,082	5.323	739,908,263	20.103	0	0.000	0	0.000	0	0.000	0	0.000	827,711,346	5.744
33149	Miami-Dade	691,753,236	10.428	0	0.000	89,279	0.005	0	0.000	0	0.000	119,105	0.278	0	0.000	0	0.000	691,961,620	4.802
32963	Indian River	0	0.000	2,040,795	0.331	292,505,418	17.733	235,283,447	6.393	3,658,051	0.839	0	0.000	0	0.000	0	0.000	533,487,711	3.702
33156	Miami-Dade	429,313,932	6.472	0	0.000	667,684	0.040	7,434	0.000	89,244	0.020	1,132,800	2.645	203,018	1.387	0	0.000	431,414,113	2.994
33154	Miami-Dade	390,654,657	5.889	0	0.000	3,280,776	0.199	39,060	0.001	126,589	0.029	279,411	0.652	0	0.000	0	0.000	394,380,492	2.737
33160	Miami-Dade	372,301,589	5.612	0	0.000	1,750,158	0.106	0	0.000	45,254	0.010	61,941	0.145	542	0.004	0	0.000	374,159,484	2.597
33141	Miami-Dade	358,015,341	5.397	0	0.000	1,376,910	0.083	0	0.000	17,517	0.004	43,408	0.101	3,983	0.027	0	0.000	359,457,160	2.495
33157	Miami-Dade	329,990,865	4.975	0	0.000	43,402	0.003	0	0.000	26,376	0.006	418,270	0.977	160,636	1.098	0	0.000	330,639,549	2.295
32456	Gulf	0	0.000	80,947	0.013	57,785	0.004	0	0.000	31,326	0.007	0	0.000	61,206	0.418	292,672,337	21.891	292,903,600	2.033
33131	Miami-Dade	286,230,569	4.315	0	0.000	87,848	0.005	0	0.000	0	0.000	45	0.000	0	0.000	0	0.000	286,318,462	1.987



ZIP Code	County	Hurricane Andrew (1992)		Hurricane Ivan (2004)		Hurricane Jeanne (2004)		Hurricane Wilma (2005)		Tropical Storm Fay (2008)		Unnamed Storm in East Florida (May 2009)		Unnamed Storm in Panhandle (July 2013)		Hurricane Michael (October 2018)		Total All Events	
		Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)
32328	Franklin	0	0.000	237,683	0.039	551,064	0.033	0	0.000	33,088	0.008	0	0.000	16,136	0.110	231,481,981	17.314	232,319,953	1.612
33040	Monroe	1,217,006	0.018	0	0.000	0	0.000	220,261,282	5.985	0	0.000	0	0.000	0	0.000	0	0.000	221,478,288	1.537
32408	Bay	0	0.000	460,429	0.075	10,320	0.001	0	0.000	7,654	0.002	0	0.000	123,809	0.846	199,942,786	14.955	200,544,998	1.392
33189	Miami-Dade	192,525,098	2.902	0	0.000	0	0.000	0	0.000	5,208	0.001	164,260	0.384	60,268	0.412	0	0.000	192,754,833	1.338
33143	Miami-Dade	172,003,149	2.593	0	0.000	509,796	0.031	16,434	0.000	25,837	0.006	498,058	1.163	85,554	0.585	0	0.000	173,138,829	1.202
32507	Escambia	0	0.000	170,501,987	27.686	0	0.000	0	0.000	11,103	0.003	1,042	0.002	34,113	0.233	0	0.000	170,548,244	1.184
32561	Santa Rosa	0	0.000	157,095,480	25.509	0	0.000	0	0.000	15	0.000	0	0.000	154,881	1.058	371,518	0.028	157,621,893	1.094
32444	Bay	0	0.000	1,417,857	0.230	20,113	0.001	0	0.000	16,631	0.004	0	0.000	582,755	3.982	154,977,193	11.592	157,014,549	1.090
33133	Miami-Dade	155,128,216	2.339	0	0.000	299,996	0.018	2,851	0.000	13,127	0.003	85,394	0.199	15,272	0.104	0	0.000	155,544,855	1.079
34134	Lee	0	0.000	0	0.000	46,217,022	2.802	96,919,123	2.633	10,670	0.002	0	0.000	84,741	0.579	0	0.000	143,231,556	0.994
33181	Miami-Dade	137,108,474	2.067	0	0.000	1,482,840	0.090	0	0.000	42,248	0.010	207,111	0.484	221	0.002	0	0.000	138,840,893	0.964
33158	Miami-Dade	134,108,071	2.022	0	0.000	95,281	0.006	21,393	0.001	10,872	0.002	148,004	0.346	11,300	0.077	0	0.000	134,394,921	0.933
33109	Miami-Dade	126,994,759	1.914	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	126,994,759	0.881
34103	Collier	0	0.000	0	0.000	22,137,716	1.342	103,151,026	2.803	0	0.000	0	0.000	0	0.000	0	0.000	125,288,742	0.869
33042	Monroe	949,790	0.014	0	0.000	0	0.000	122,009,040	3.315	0	0.000	0	0.000	0	0.000	0	0.000	122,958,830	0.853
33050	Monroe	824,913	0.012	0	0.000	0	0.000	121,969,200	3.314	0	0.000	0	0.000	0	0.000	0	0.000	122,794,113	0.852
34113	Collier	339,396	0.005	0	0.000	3,540,564	0.215	118,660,031	3.224	0	0.000	0	0.000	8,895	0.061	0	0.000	122,548,887	0.850
33957	Lee	0	0.000	0	0.000	47,473,814	2.878	62,876,137	1.708	33,706	0.008	0	0.000	0	0.000	0	0.000	110,383,657	0.766
33132	Miami-Dade	110,254,365	1.662	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	110,254,365	0.765
33138	Miami-Dade	108,168,595	1.631	0	0.000	490,409	0.030	0	0.000	59,469	0.014	197,482	0.461	4,746	0.032	0	0.000	108,920,701	0.756
34114	Collier	0	0.000	0	0.000	186,008	0.011	98,242,921	2.669	17,285	0.004	0	0.000	194,317	1.328	0	0.000	98,640,532	0.685
34108	Collier	0	0.000	0	0.000	21,609,266	1.310	76,835,700	2.088	0	0.000	0	0.000	0	0.000	0	0.000	98,444,966	0.683
34949	Saint Lucie	0	0.000	15,701	0.003	49,956,178	3.029	47,510,021	1.291	150,507	0.035	0	0.000	0	0.000	0	0.000	97,632,406	0.678
33190	Miami-Dade	93,506,193	1.410	0	0.000	0	0.000	0	0.000	0	0.000	55,184	0.129	4,391	0.030	0	0.000	93,565,768	0.649
33137	Miami-Dade	89,684,022	1.352	0	0.000	144,571	0.009	0	0.000	743	0.000	6,821	0.016	0	0.000	0	0.000	89,836,156	0.623
32563	Santa Rosa	0	0.000	88,314,872	14.341	43,919	0.003	0	0.000	6,454	0.001	0	0.000	468,639	3.202	231,967	0.017	89,065,850	0.618
32405	Bay	0	0.000	621,141	0.101	39,071	0.002	0	0.000	28,319	0.006	0	0.000	433,566	2.962	83,608,104	6.254	84,730,201	0.588
32407	Bay	0	0.000	154,630	0.025	316	0.000	0	0.000	0	0.000	0	0.000	42,608	0.291	73,392,586	5.490	73,590,140	0.511



ZIP Code	County	Hurricane Andrew (1992)		Hurricane Ivan (2004)		Hurricane Jeanne (2004)		Hurricane Wilma (2005)		Tropical Storm Fay (2008)		Unnamed Storm in East Florida (May 2009)		Unnamed Storm in Panhandle (July 2013)		Hurricane Michael (October 2018)		Total All Events	
		Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)	Total Personal Residential Standard Flood Monetary Contribution (\$)	Percent of Losses (%)
32207	Duval	0	0.000	0	0.000	1,109,213	0.067	0	0.000	70,656,047	16.209	60,065	0.140	0	0.000	0	0.000	71,825,325	0.498
32404	Bay	0	0.000	204,267	0.033	17	0.000	0	0.000	5,282	0.001	0	0.000	943,918	6.449	63,777,703	4.770	64,931,188	0.451
33703	Pinellas	0	0.000	0	0.000	64,075,641	3.885	366,746	0.010	0	0.000	0	0.000	0	0.000	0	0.000	64,442,387	0.447
34957	Martin	0	0.000	0	0.000	28,771,114	1.744	32,538,103	0.884	1,346,002	0.309	740	0.002	0	0.000	0	0.000	62,655,958	0.435
33904	Lee	0	0.000	0	0.000	19,410,106	1.177	42,289,329	1.149	4,720	0.001	0	0.000	4,701	0.032	0	0.000	61,708,856	0.428
33715	Pinellas	0	0.000	0	0.000	60,484,925	3.667	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	60,484,925	0.420
33914	Lee	0	0.000	0	0.000	13,960,597	0.846	44,877,453	1.219	154,263	0.035	0	0.000	16,008	0.109	0	0.000	59,008,321	0.410
32550	Walton	0	0.000	21,421,810	3.478	259,714	0.016	0	0.000	41,405	0.009	12,581	0.029	1,331,912	9.100	33,402,455	2.498	56,469,878	0.392
34112	Collier	0	0.000	0	0.000	1,301,739	0.079	53,302,737	1.448	0	0.000	0	0.000	0	0.000	0	0.000	54,604,476	0.379
33043	Monroe	305,470	0.005	0	0.000	0	0.000	52,967,160	1.439	0	0.000	0	0.000	0	0.000	0	0.000	53,272,630	0.370
32459	Walton	0	0.000	33,875,190	5.501	228,747	0.014	0	0.000	82,021	0.019	8,367	0.020	418,809	2.861	16,148,401	1.208	50,761,535	0.352
33180	Miami-Dade	49,606,643	0.748	0	0.000	135,393	0.008	0	0.000	331,663	0.076	585,995	1.368	33,810	0.231	0	0.000	50,693,504	0.352
32960	Indian River	0	0.000	148,122	0.024	27,154,483	1.646	22,261,511	0.605	461,951	0.106	240	0.001	0	0.000	0	0.000	50,026,306	0.347
33908	Lee	0	0.000	0	0.000	11,913,413	0.722	35,851,694	0.974	10,800	0.002	0	0.000	32,495	0.222	0	0.000	47,808,402	0.332
33130	Miami-Dade	44,780,843	0.675	0	0.000	0	0.000	0	0.000	2,529	0.001	6,626	0.015	2,013	0.014	0	0.000	44,792,011	0.311
34996	Martin	0	0.000	0	0.000	17,863,489	1.083	21,671,604	0.589	2,133,212	0.489	0	0.000	0	0.000	0	0.000	41,668,305	0.289
33706	Pinellas	0	0.000	0	0.000	41,289,498	2.503	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	41,289,498	0.287
33032	Miami-Dade	40,862,698	0.616	0	0.000	0	0.000	0	0.000	309	0.000	85,828	0.200	33,397	0.228	0	0.000	40,982,232	0.284
32583	Santa Rosa	0	0.000	39,355,854	6.391	1,827	0.000	0	0.000	480,339	0.110	0	0.000	719,607	4.917	183,720	0.014	40,741,347	0.283
33931	Lee	0	0.000	0	0.000	14,592,691	0.885	25,952,795	0.705	0	0.000	0	0.000	0	0.000	0	0.000	40,545,485	0.281
34228	Sarasota	0	0.000	0	0.000	39,408,296	2.389	661,628	0.018	0	0.000	0	0.000	9,157	0.063	0	0.000	40,079,081	0.278
33956	Lee	0	0.000	0	0.000	16,790,813	1.018	22,463,624	0.610	8,439	0.002	0	0.000	0	0.000	0	0.000	39,262,877	0.272
34110	Collier	0	0.000	0	0.000	9,907,553	0.601	28,409,433	0.772	1,501	0.000	0	0.000	1,484	0.010	0	0.000	38,319,970	0.266
32967	Indian River	0	0.000	84,724	0.014	18,958,699	1.149	14,457,974	0.393	812,732	0.186	378	0.001	0	0.000	0	0.000	34,314,507	0.238
32346	Wakulla	0	0.000	234,966	0.038	1,805,678	0.109	0	0.000	59,198	0.014	0	0.000	3	0.000	30,544,117	2.285	32,643,961	0.227
33019	Broward	31,901,171	0.481	0	0.000	186,780	0.011	363	0.000	171,867	0.039	260,973	0.609	14,167	0.097	0	0.000	32,535,321	0.226
33037	Monroe	24,397,304	0.368	0	0.000	2,396	0.000	6,873,668	0.187	0	0.000	0	0.000	126,845	0.867	0	0.000	31,400,214	0.218
34217	Manatee	0	0.000	0	0.000	29,368,093	1.780	0	0.000	0	0.000	0	0.000	35,287	0.241	0	0.000	29,403,380	0.204



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32401	Bay	0	0.000	234,990	0.038	27,012	0.002	0	0.000	3,392	0.001	0	0.000	208,569	1.425	28,918,810	2.163	29,392,773	0.204
32204	Duval	0	0.000	0	0.000	182,678	0.011	0	0.000	27,800,848	6.378	4,300	0.010	0	0.000	0	0.000	27,987,826	0.194
33708	Pinellas	0	0.000	0	0.000	27,282,266	1.654	0	0.000	0	0.000	0	0.000	2,001	0.014	0	0.000	27,284,267	0.189
33036	Monroe	1,521,148	0.023	0	0.000	0	0.000	25,665,048	0.697	0	0.000	0	0.000	7,221	0.049	0	0.000	27,193,417	0.189
32409	Bay	0	0.000	165,448	0.027	6,684	0.000	0	0.000	4,065	0.001	0	0.000	58,910	0.402	26,349,570	1.971	26,584,678	0.184
32102	Lake	0	0.000	0	0.000	0	0.000	0	0.000	26,575,785	6.097	2,688	0.006	0	0.000	0	0.000	26,578,474	0.184
32322	Franklin	0	0.000	174,845	0.028	807,827	0.049	0	0.000	224,331	0.051	511	0.001	9,096	0.062	24,242,711	1.813	25,459,320	0.177
33921	Lee	0	0.000	0	0.000	17,805,110	1.079	5,435,624	0.148	0	0.000	0	0.000	0	0.000	0	0.000	23,240,735	0.161
34242	Sarasota	0	0.000	0	0.000	22,694,293	1.376	260,616	0.007	0	0.000	0	0.000	18,166	0.124	0	0.000	22,973,075	0.159
33767	Pinellas	0	0.000	0	0.000	22,629,676	1.372	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	22,629,676	0.157
32034	Nassau	0	0.000	0	0.000	9,207,695	0.558	0	0.000	9,104,439	2.089	3,661,805	8.551	0	0.000	0	0.000	21,973,939	0.152
33785	Pinellas	0	0.000	0	0.000	20,421,375	1.238	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	20,421,375	0.142
32962	Indian River	0	0.000	11,419	0.002	9,697,226	0.588	8,510,807	0.231	2,156,771	0.495	199	0.000	0	0.000	0	0.000	20,376,422	0.141
32951	Brevard	0	0.000	0	0.000	12,938,885	0.784	4,913,292	0.133	1,974,071	0.453	34,092	0.080	0	0.000	0	0.000	19,860,340	0.138
32566	Santa Rosa	0	0.000	19,513,546	3.169	0	0.000	0	0.000	12,847	0.003	0	0.000	143,092	0.978	17,103	0.001	19,686,587	0.137
33480	Palm Beach	0	0.000	0	0.000	5,173,563	0.314	4,741,523	0.129	9,524,443	2.185	0	0.000	0	0.000	0	0.000	19,439,529	0.135
32358	Wakulla	0	0.000	1,444	0.000	61,913	0.004	0	0.000	11,608,465	2.663	27,417	0.064	1,427,064	9.750	6,290,361	0.470	19,416,664	0.135
32320	Franklin	0	0.000	148,572	0.024	258,769	0.016	0	0.000	11,767	0.003	0	0.000	9,589	0.066	18,648,329	1.395	19,077,027	0.132
33981	Charlotte	0	0.000	0	0.000	12,579,655	0.763	5,649,434	0.153	2,699	0.001	3,381	0.008	0	0.000	0	0.000	18,235,169	0.127
33572	Hillsborough	0	0.000	0	0.000	17,475,317	1.059	357,212	0.010	0	0.000	0	0.000	0	0.000	0	0.000	17,832,529	0.124
33924	Lee	0	0.000	0	0.000	10,235,754	0.621	7,407,884	0.201	54,770	0.013	0	0.000	14,037	0.096	0	0.000	17,712,445	0.123
32937	Brevard	0	0.000	0	0.000	11,406,767	0.692	753,719	0.020	5,277,476	1.211	84,220	0.197	0	0.000	0	0.000	17,522,181	0.122
32413	Bay	0	0.000	32,208	0.005	0	0.000	0	0.000	37,583	0.009	2,591	0.006	207,967	1.421	16,926,186	1.266	17,206,535	0.119
33950	Charlotte	0	0.000	0	0.000	12,332,946	0.748	4,729,444	0.129	25,930	0.006	2,764	0.006	0	0.000	0	0.000	17,091,084	0.119
32327	Wakulla	0	0.000	36,427	0.006	647,299	0.039	0	0.000	1,845,723	0.423	2,503	0.006	28,638	0.196	13,962,187	1.044	16,522,777	0.115
32578	Okaloosa	0	0.000	11,923,588	1.936	200,280	0.012	0	0.000	1,381	0.000	77	0.000	84,929	0.580	3,955,132	0.296	16,165,387	0.112
34104	Collier	0	0.000	0	0.000	441,753	0.027	15,403,617	0.419	0	0.000	0	0.000	18,498	0.126	0	0.000	15,863,867	0.110
33707	Pinellas	0	0.000	0	0.000	15,578,016	0.944	0	0.000	0	0.000	0	0.000	7,199	0.049	0	0.000	15,585,216	0.108



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33946	Charlotte	0	0.000	0	0.000	12,301,947	0.746	3,163,890	0.086	0	0.000	5,154	0.012	0	0.000	0	0.000	15,470,991	0.107
33176	Miami-Dade	14,758,541	0.222	0	0.000	0	0.000	0	0.000	45,035	0.010	331,669	0.775	118,307	0.808	0	0.000	15,253,551	0.106
33919	Lee	0	0.000	0	0.000	5,226,285	0.317	9,944,443	0.270	0	0.000	0	0.000	33,705	0.230	0	0.000	15,204,432	0.106
33009	Broward	14,656,184	0.221	0	0.000	3,649	0.000	0	0.000	117,185	0.027	370,281	0.865	2,654	0.018	0	0.000	15,149,953	0.105
33704	Pinellas	0	0.000	0	0.000	15,066,032	0.913	60,170	0.002	0	0.000	0	0.000	1,749	0.012	0	0.000	15,127,952	0.105
33125	Miami-Dade	14,891,774	0.224	0	0.000	0	0.000	0	0.000	8,111	0.002	124,909	0.292	3,309	0.023	0	0.000	15,028,104	0.104
32952	Brevard	0	0.000	0	0.000	10,819,906	0.656	1,052,944	0.029	2,672,525	0.613	65,082	0.152	0	0.000	0	0.000	14,610,457	0.101
32541	Okaloosa	0	0.000	11,090,125	1.801	55,421	0.003	0	0.000	2,856	0.001	0	0.000	63,879	0.436	3,131,566	0.234	14,343,847	0.100
32506	Escambia	0	0.000	13,950,436	2.265	0	0.000	0	0.000	5,891	0.001	0	0.000	39,746	0.272	0	0.000	13,996,074	0.097
33903	Lee	0	0.000	0	0.000	4,479,035	0.272	9,186,440	0.250	131,647	0.030	0	0.000	107,845	0.737	0	0.000	13,904,967	0.096
34140	Collier	185,430	0.003	0	0.000	651,714	0.040	12,604,722	0.342	4,419	0.001	0	0.000	4,419	0.030	0	0.000	13,450,703	0.093
33786	Pinellas	0	0.000	0	0.000	13,442,701	0.815	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	13,442,701	0.093
32082	Saint Johns	0	0.000	0	0.000	7,082,630	0.429	0	0.000	5,339,702	1.225	385,789	0.901	0	0.000	0	0.000	12,808,120	0.089
34139	Collier	312,099	0.005	0	0.000	323,512	0.020	11,384,199	0.309	11,850	0.003	0	0.000	11,784	0.081	0	0.000	12,043,445	0.084
33917	Lee	0	0.000	0	0.000	3,439,748	0.209	7,912,064	0.215	599,849	0.138	0	0.000	58,205	0.398	0	0.000	12,009,867	0.083
32958	Indian River	0	0.000	11,656	0.002	6,299,002	0.382	4,451,562	0.121	535,418	0.123	842	0.002	0	0.000	0	0.000	11,298,480	0.078
32931	Brevard	0	0.000	0	0.000	9,098,618	0.552	574,243	0.016	1,418,463	0.325	42,488	0.099	0	0.000	0	0.000	11,133,811	0.077
33629	Hillsborough	0	0.000	0	0.000	10,729,855	0.650	222,199	0.006	0	0.000	8,106	0.019	8	0.000	0	0.000	10,960,168	0.076
32250	Duval	0	0.000	0	0.000	2,802,625	0.170	0	0.000	7,997,617	1.835	101,041	0.236	0	0.000	0	0.000	10,901,284	0.076
33952	Charlotte	0	0.000	0	0.000	7,322,324	0.444	3,381,639	0.092	7,167	0.002	6,403	0.015	0	0.000	0	0.000	10,717,533	0.074
33146	Miami-Dade	10,355,144	0.156	0	0.000	0	0.000	0	0.000	12,219	0.003	181,669	0.424	18,893	0.129	0	0.000	10,567,926	0.073
32903	Brevard	0	0.000	0	0.000	3,654,803	0.222	619,335	0.017	6,145,140	1.410	62,386	0.146	0	0.000	0	0.000	10,481,664	0.073
33702	Pinellas	0	0.000	0	0.000	10,462,109	0.634	0	0.000	110	0.000	1,558	0.004	2,220	0.015	0	0.000	10,465,997	0.073
33070	Monroe	2,322,880	0.035	0	0.000	0	0.000	7,398,361	0.201	0	0.000	0	0.000	20,166	0.138	0	0.000	9,741,408	0.068
32502	Escambia	0	0.000	9,451,202	1.535	3,137	0.000	0	0.000	4,125	0.001	0	0.000	9,973	0.068	16,336	0.001	9,484,774	0.066
33301	Broward	6,968,938	0.105	0	0.000	1,079,213	0.065	222,132	0.006	384,423	0.088	700,254	1.635	0	0.000	0	0.000	9,354,960	0.065
32905	Brevard	0	0.000	0	0.000	914,041	0.055	252,129	0.007	8,161,724	1.872	6,222	0.015	0	0.000	0	0.000	9,334,115	0.065
32569	Okaloosa	0	0.000	8,393,647	1.363	23,693	0.001	0	0.000	0	0.000	0	0.000	40,385	0.276	517,972	0.039	8,975,697	0.062



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34683	Pinellas	0	0.000	0	0.000	8,873,732	0.538	0	0.000	7,605	0.002	7,951	0.019	3,517	0.024	0	0.000	8,892,805	0.062
32189	Putnam	0	0.000	0	0.000	0	0.000	0	0.000	8,877,103	2.036	2,651	0.006	65	0.000	0	0.000	8,879,819	0.062
33161	Miami-Dade	8,410,781	0.127	0	0.000	17,483	0.001	0	0.000	77,681	0.018	258,027	0.603	3,097	0.021	0	0.000	8,767,069	0.061
34448	Citrus	0	0.000	0	0.000	8,176,139	0.496	0	0.000	24,849	0.006	9,513	0.022	3,186	0.022	23,280	0.002	8,236,968	0.057
33477	Palm Beach	0	0.000	0	0.000	2,581,069	0.156	2,966,912	0.081	2,525,911	0.579	0	0.000	0	0.000	0	0.000	8,073,893	0.056
33953	Charlotte	0	0.000	0	0.000	5,846,580	0.354	2,139,493	0.058	0	0.000	626	0.001	0	0.000	0	0.000	7,986,699	0.055
34990	Martin	0	0.000	0	0.000	2,736,940	0.166	1,762,976	0.048	3,401,115	0.780	0	0.000	0	0.000	0	0.000	7,901,030	0.055
33905	Lee	0	0.000	0	0.000	2,315,715	0.140	4,950,704	0.135	572,143	0.131	0	0.000	38,381	0.262	0	0.000	7,876,943	0.055
34667	Pasco	0	0.000	0	0.000	7,487,852	0.454	0	0.000	2,946	0.001	1,796	0.004	1,960	0.013	0	0.000	7,494,554	0.052
32940	Brevard	0	0.000	0	0.000	177,820	0.011	26,364	0.001	7,076,861	1.623	114,651	0.268	0	0.000	0	0.000	7,395,696	0.051
32720	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	7,315,217	1.678	39,037	0.091	27	0.000	0	0.000	7,354,281	0.051
34946	Saint Lucie	0	0.000	18,457	0.003	3,620,160	0.219	3,552,675	0.097	135,584	0.031	33	0.000	0	0.000	0	0.000	7,326,909	0.051
33177	Miami-Dade	6,822,406	0.103	0	0.000	0	0.000	0	0.000	1,321	0.000	165,153	0.386	53,140	0.363	0	0.000	7,042,019	0.049
34135	Lee	0	0.000	0	0.000	1,951,710	0.118	4,736,367	0.129	116,808	0.027	0	0.000	176,826	1.208	0	0.000	6,981,711	0.048
34216	Manatee	0	0.000	0	0.000	6,965,553	0.422	0	0.000	0	0.000	0	0.000	8,445	0.058	0	0.000	6,973,998	0.048
32224	Duval	0	0.000	0	0.000	0	0.000	0	0.000	6,695,382	1.536	106,451	0.249	0	0.000	0	0.000	6,801,833	0.047
33993	Lee	0	0.000	0	0.000	3,065,814	0.186	3,456,195	0.094	62,693	0.014	328	0.001	4,848	0.033	0	0.000	6,589,879	0.046
32080	Saint Johns	0	0.000	0	0.000	5,208,723	0.316	0	0.000	695,238	0.159	612,777	1.431	18,204	0.124	0	0.000	6,534,942	0.045
33922	Lee	0	0.000	0	0.000	4,208,416	0.255	2,270,028	0.062	5,958	0.001	0	0.000	0	0.000	0	0.000	6,484,401	0.045
32226	Duval	0	0.000	0	0.000	2,609,927	0.158	0	0.000	3,784,189	0.868	41,166	0.096	0	0.000	0	0.000	6,435,282	0.045
33487	Palm Beach	898,997	0.014	0	0.000	1,477,880	0.090	1,146,513	0.031	481,606	0.110	2,373,983	5.544	0	0.000	0	0.000	6,378,980	0.044
34223	Sarasota	0	0.000	0	0.000	5,459,555	0.331	839,748	0.023	464	0.000	5,714	0.013	82	0.001	0	0.000	6,305,564	0.044
33705	Pinellas	0	0.000	0	0.000	6,196,761	0.376	103	0.000	0	0.000	1,037	0.002	4,664	0.032	0	0.000	6,202,565	0.043
34698	Pinellas	0	0.000	0	0.000	6,074,788	0.368	0	0.000	4,271	0.001	4,321	0.010	4,760	0.033	0	0.000	6,088,140	0.042
33948	Charlotte	0	0.000	0	0.000	4,978,760	0.302	1,060,836	0.029	528	0.000	533	0.001	0	0.000	0	0.000	6,040,656	0.042
34677	Pinellas	0	0.000	0	0.000	5,988,386	0.363	15,047	0.000	2,077	0.000	2,077	0.005	2,077	0.014	0	0.000	6,009,664	0.042
33711	Pinellas	0	0.000	0	0.000	5,982,290	0.363	0	0.000	0	0.000	0	0.000	862	0.006	0	0.000	5,983,152	0.042
32136	Flagler	0	0.000	199,694	0.032	5,384,903	0.326	17,625	0.000	58,099	0.013	83,227	0.194	0	0.000	0	0.000	5,743,549	0.040



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32548	Okaloosa	0	0.000	5,128,253	0.833	12,293	0.001	0	0.000	591	0.000	0	0.000	29,031	0.198	524,337	0.039	5,694,504	0.040
33483	Palm Beach	1,066,241	0.016	0	0.000	2,154,195	0.131	1,934,515	0.053	0	0.000	455,200	1.063	0	0.000	0	0.000	5,610,151	0.039
34210	Manatee	0	0.000	0	0.000	5,569,973	0.338	38,478	0.001	0	0.000	0	0.000	11	0.000	0	0.000	5,608,462	0.039
32968	Indian River	0	0.000	0	0.000	0	0.000	0	0.000	5,574,058	1.279	0	0.000	0	0.000	0	0.000	5,574,058	0.039
34994	Martin	0	0.000	0	0.000	640,195	0.039	463,084	0.013	4,469,541	1.025	0	0.000	0	0.000	0	0.000	5,572,820	0.039
33621	Hillsborough	0	0.000	0	0.000	5,491,634	0.333	50,611	0.001	0	0.000	0	0.000	0	0.000	0	0.000	5,542,245	0.038
34236	Sarasota	0	0.000	0	0.000	5,469,974	0.332	43,862	0.001	699	0.000	699	0.002	25,130	0.172	0	0.000	5,540,363	0.038
32008	Suwannee	0	0.000	0	0.000	0	0.000	0	0.000	5,305,529	1.217	0	0.000	0	0.000	0	0.000	5,305,529	0.037
34138	Collier	94,327	0.001	0	0.000	82,148	0.005	4,987,312	0.136	16	0.000	0	0.000	16	0.000	0	0.000	5,163,818	0.036
32359	Taylor	0	0.000	37,834	0.006	693,886	0.042	0	0.000	3,212,967	0.737	0	0.000	246	0.002	1,207,761	0.090	5,152,695	0.036
32225	Duval	0	0.000	0	0.000	199,450	0.012	0	0.000	4,701,961	1.079	219,253	0.512	0	0.000	0	0.000	5,120,665	0.036
32579	Okaloosa	0	0.000	3,422,191	0.556	69,230	0.004	0	0.000	5,253	0.001	0	0.000	203,864	1.393	1,105,366	0.083	4,805,904	0.033
32169	Volusia	0	0.000	171,223	0.028	2,870,993	0.174	290,935	0.008	1,341,439	0.308	67,486	0.158	0	0.000	0	0.000	4,742,077	0.033
32907	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	4,706,821	1.080	13,149	0.031	0	0.000	0	0.000	4,719,970	0.033
32233	Duval	0	0.000	0	0.000	2,541,143	0.154	0	0.000	2,011,313	0.461	97,644	0.228	0	0.000	0	0.000	4,650,100	0.032
33455	Martin	0	0.000	0	0.000	1,545,727	0.094	2,018,218	0.055	1,036,180	0.238	0	0.000	0	0.000	0	0.000	4,600,125	0.032
33469	Palm Beach	0	0.000	0	0.000	372,477	0.023	399,046	0.011	3,803,631	0.873	0	0.000	0	0.000	0	0.000	4,575,153	0.032
32625	Levy	0	0.000	141,347	0.023	3,395,969	0.206	0	0.000	66,969	0.015	0	0.000	18	0.000	968,989	0.072	4,573,291	0.032
33990	Lee	0	0.000	0	0.000	1,352,107	0.082	2,774,569	0.075	190,648	0.044	0	0.000	129,326	0.884	0	0.000	4,446,650	0.031
32348	Taylor	0	0.000	43,831	0.007	1,067,796	0.065	0	0.000	321,971	0.074	50	0.000	1,314	0.009	3,006,088	0.225	4,441,050	0.031
34689	Pinellas	0	0.000	0	0.000	4,366,997	0.265	0	0.000	6,286	0.001	8,626	0.020	715	0.005	0	0.000	4,382,625	0.030
34224	Charlotte	0	0.000	0	0.000	3,575,273	0.217	782,466	0.021	0	0.000	5,639	0.013	0	0.000	0	0.000	4,363,378	0.030
33155	Miami-Dade	4,144,358	0.062	0	0.000	0	0.000	0	0.000	8,089	0.002	114,917	0.268	9,927	0.068	0	0.000	4,277,290	0.030
32771	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	4,204,434	0.965	33,198	0.078	0	0.000	0	0.000	4,237,632	0.029
32514	Escambia	0	0.000	3,503,202	0.569	3,004	0.000	0	0.000	394,736	0.091	282	0.001	69,502	0.475	7,515	0.001	3,978,240	0.028
32779	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	3,396,657	0.779	516,331	1.206	5,781	0.039	0	0.000	3,918,769	0.027
34429	Citrus	0	0.000	9,404	0.002	3,835,123	0.233	0	0.000	20,046	0.005	4,502	0.011	2,224	0.015	45,218	0.003	3,916,516	0.027
32526	Escambia	0	0.000	3,811,137	0.619	0	0.000	0	0.000	1,592	0.000	290	0.001	12,370	0.085	0	0.000	3,825,389	0.027



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33001	Monroe	91,527	0.001	0	0.000	0	0.000	3,711,252	0.101	0	0.000	0	0.000	0	0.000	0	0.000	3,802,779	0.026
33316	Broward	2,748,183	0.041	0	0.000	190,785	0.012	29,845	0.001	259,390	0.060	560,318	1.308	0	0.000	0	0.000	3,788,521	0.026
32680	Dixie	0	0.000	37,341	0.006	1,280,418	0.078	0	0.000	1,753,131	0.402	204	0.000	2,160	0.015	618,363	0.046	3,691,617	0.026
34607	Hernando	0	0.000	0	0.000	3,676,821	0.223	0	0.000	1,037	0.000	1,036	0.002	1,023	0.007	0	0.000	3,679,918	0.026
32955	Brevard	0	0.000	0	0.000	1,195,753	0.072	138,227	0.004	2,245,908	0.515	25,270	0.059	0	0.000	0	0.000	3,605,157	0.025
32953	Brevard	0	0.000	0	0.000	1,783,894	0.108	15,792	0.000	1,595,468	0.366	54,069	0.126	0	0.000	0	0.000	3,449,223	0.024
33136	Miami-Dade	3,424,654	0.052	0	0.000	0	0.000	0	0.000	1,045	0.000	21,195	0.049	0	0.000	0	0.000	3,446,894	0.024
34141	Collier	77,323	0.001	0	0.000	75,534	0.005	3,220,025	0.087	627	0.000	234	0.001	599	0.004	0	0.000	3,374,343	0.023
32205	Duval	0	0.000	0	0.000	60,209	0.004	0	0.000	3,172,585	0.728	121,970	0.285	476	0.003	0	0.000	3,355,240	0.023
33762	Pinellas	0	0.000	0	0.000	3,288,076	0.199	1,343	0.000	0	0.000	0	0.000	0	0.000	0	0.000	3,289,419	0.023
33770	Pinellas	0	0.000	0	0.000	3,277,158	0.199	0	0.000	685	0.000	537	0.001	1,339	0.009	0	0.000	3,279,717	0.023
32217	Duval	0	0.000	0	0.000	6,998	0.000	0	0.000	3,098,745	0.711	154,954	0.362	0	0.000	0	0.000	3,260,696	0.023
34652	Pasco	0	0.000	0	0.000	3,144,433	0.191	0	0.000	3,301	0.001	3,210	0.007	2,423	0.017	0	0.000	3,153,367	0.022
32732	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	3,115,053	0.715	16,502	0.039	196	0.001	0	0.000	3,131,751	0.022
34997	Martin	0	0.000	0	0.000	358,071	0.022	391,935	0.011	2,371,560	0.544	0	0.000	0	0.000	0	0.000	3,121,565	0.022
32648	Dixie	0	0.000	137,888	0.022	1,450,746	0.088	0	0.000	195	0.000	0	0.000	0	0.000	1,487,747	0.111	3,076,575	0.021
32068	Clay	0	0.000	0	0.000	0	0.000	0	0.000	2,925,249	0.671	66,434	0.155	160	0.001	0	0.000	2,991,842	0.021
33991	Lee	0	0.000	0	0.000	1,007,046	0.061	1,904,344	0.052	52,550	0.012	0	0.000	8,053	0.055	0	0.000	2,971,993	0.021
34221	Manatee	0	0.000	0	0.000	2,797,492	0.170	0	0.000	0	0.000	472	0.001	27,471	0.188	0	0.000	2,825,435	0.020
32934	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	2,712,031	0.622	42,859	0.100	0	0.000	0	0.000	2,754,890	0.019
33928	Lee	0	0.000	0	0.000	368,781	0.022	1,975,800	0.054	186,080	0.043	0	0.000	172,964	1.182	0	0.000	2,703,625	0.019
33308	Broward	1,485,686	0.022	0	0.000	449,775	0.027	71,452	0.002	279,310	0.064	398,467	0.931	0	0.000	0	0.000	2,684,690	0.019
34215	Manatee	0	0.000	0	0.000	2,667,856	0.162	0	0.000	0	0.000	0	0.000	48	0.000	0	0.000	2,667,904	0.019
32066	Lafayette	0	0.000	0	0.000	0	0.000	0	0.000	2,659,929	0.610	2	0.000	97	0.001	0	0.000	2,660,028	0.018
33611	Hillsborough	0	0.000	0	0.000	2,605,950	0.158	20,266	0.001	0	0.000	18,130	0.042	11,263	0.077	0	0.000	2,655,609	0.018
33616	Hillsborough	0	0.000	0	0.000	2,643,153	0.160	0	0.000	0	0.000	5,266	0.012	4,908	0.034	0	0.000	2,653,327	0.018
32901	Brevard	0	0.000	0	0.000	566,106	0.034	121,684	0.003	1,920,294	0.441	13,117	0.031	0	0.000	0	0.000	2,621,201	0.018
32935	Brevard	0	0.000	0	0.000	42,559	0.003	3,008	0.000	2,540,214	0.583	23,530	0.055	0	0.000	0	0.000	2,609,311	0.018



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33062	Broward	1,066,481	0.016	0	0.000	449,384	0.027	144,268	0.004	356,927	0.082	575,283	1.343	0	0.000	0	0.000	2,592,343	0.018
34209	Manatee	0	0.000	0	0.000	2,538,316	0.154	0	0.000	223	0.000	1,064	0.002	26,481	0.181	0	0.000	2,566,084	0.018
33458	Palm Beach	0	0.000	0	0.000	479,801	0.029	580,338	0.016	1,497,127	0.343	0	0.000	0	0.000	0	0.000	2,557,266	0.018
33570	Hillsborough	0	0.000	0	0.000	2,535,165	0.154	8,942	0.000	0	0.000	2,366	0.006	3,558	0.024	0	0.000	2,550,031	0.018
32174	Volusia	0	0.000	0	0.000	276,884	0.017	0	0.000	707,011	0.162	1,546,858	3.612	2,402	0.016	0	0.000	2,533,155	0.018
32764	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	2,513,500	0.577	4,959	0.012	0	0.000	0	0.000	2,518,459	0.017
32904	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	2,472,705	0.567	32,487	0.076	0	0.000	0	0.000	2,505,192	0.017
33615	Hillsborough	0	0.000	0	0.000	2,385,139	0.145	0	0.000	0	0.000	7,906	0.018	4,751	0.032	0	0.000	2,397,796	0.017
33955	Charlotte	0	0.000	0	0.000	1,849,007	0.112	523,509	0.014	992	0.000	436	0.001	0	0.000	0	0.000	2,373,944	0.016
32137	Flagler	0	0.000	102,994	0.017	2,022,663	0.123	0	0.000	112,809	0.026	124,660	0.291	0	0.000	0	0.000	2,363,126	0.016
32949	Brevard	0	0.000	2,614	0.000	1,192,034	0.072	437,725	0.012	678,576	0.156	5,771	0.013	0	0.000	0	0.000	2,316,721	0.016
33150	Miami-Dade	2,251,844	0.034	0	0.000	0	0.000	0	0.000	8,950	0.002	47,487	0.111	1,655	0.011	0	0.000	2,309,936	0.016
32084	Saint Johns	0	0.000	0	0.000	1,184,703	0.072	0	0.000	1,065,235	0.244	37,579	0.088	0	0.000	0	0.000	2,287,517	0.016
34105	Collier	0	0.000	0	0.000	224,266	0.014	2,058,713	0.056	0	0.000	0	0.000	3,676	0.025	0	0.000	2,286,655	0.016
32127	Volusia	0	0.000	48,470	0.008	1,362,433	0.083	65,136	0.002	130,696	0.030	675,440	1.577	0	0.000	0	0.000	2,282,175	0.016
32580	Okaloosa	0	0.000	1,476,575	0.240	42,497	0.003	0	0.000	0	0.000	0	0.000	72,061	0.492	640,610	0.048	2,231,743	0.015
33609	Hillsborough	0	0.000	0	0.000	2,120,081	0.129	58,572	0.002	0	0.000	684	0.002	0	0.000	0	0.000	2,179,337	0.015
32202	Duval	0	0.000	0	0.000	15,923	0.001	0	0.000	2,109,159	0.484	28	0.000	0	0.000	0	0.000	2,125,110	0.015
33410	Palm Beach	0	0.000	0	0.000	629,530	0.038	651,978	0.018	833,278	0.191	0	0.000	0	0.000	0	0.000	2,114,786	0.015
32950	Brevard	0	0.000	0	0.000	262,124	0.016	104,424	0.003	1,695,617	0.389	3,427	0.008	0	0.000	0	0.000	2,065,593	0.014
32439	Walton	0	0.000	1,603,472	0.260	2,693	0.000	0	0.000	12,057	0.003	7,569	0.018	76,367	0.522	344,354	0.026	2,046,512	0.014
33142	Miami-Dade	1,964,690	0.030	0	0.000	0	0.000	0	0.000	10,524	0.002	60,253	0.141	1,186	0.008	0	0.000	2,036,653	0.014
32210	Duval	0	0.000	0	0.000	60,277	0.004	0	0.000	1,364,899	0.313	587,972	1.373	0	0.000	0	0.000	2,013,148	0.014
32310	Leon	0	0.000	0	0.000	0	0.000	0	0.000	1,994,512	0.458	1,622	0.004	2,660	0.018	0	0.000	1,998,795	0.014
32725	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	1,856,341	0.426	58,739	0.137	0	0.000	0	0.000	1,915,080	0.013
33020	Broward	1,600,789	0.024	0	0.000	0	0.000	0	0.000	112,419	0.026	198,087	0.463	2,242	0.015	0	0.000	1,913,538	0.013
32303	Leon	0	0.000	0	0.000	0	0.000	0	0.000	1,846,594	0.424	12,586	0.029	46,727	0.319	0	0.000	1,905,907	0.013
33756	Pinellas	0	0.000	0	0.000	1,851,241	0.112	0	0.000	11,228	0.003	10,968	0.026	18,649	0.127	0	0.000	1,892,087	0.013



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32060	Suwannee	0	0.000	0	0.000	0	0.000	0	0.000	1,878,072	0.431	5	0.000	16	0.000	0	0.000	1,878,093	0.013
32218	Duval	0	0.000	0	0.000	0	0.000	0	0.000	1,783,126	0.409	63,255	0.148	0	0.000	0	0.000	1,846,380	0.013
33173	Miami-Dade	1,626,103	0.025	0	0.000	0	0.000	0	0.000	17,689	0.004	111,988	0.262	27,450	0.188	0	0.000	1,783,231	0.012
32571	Santa Rosa	0	0.000	1,016,093	0.165	8,484	0.001	0	0.000	652,722	0.150	0	0.000	10,583	0.072	33,839	0.003	1,721,721	0.012
33128	Miami-Dade	1,707,684	0.026	0	0.000	0	0.000	0	0.000	388	0.000	1,225	0.003	246	0.002	0	0.000	1,709,542	0.012
33432	Palm Beach	218,268	0.003	0	0.000	285,422	0.017	137,683	0.004	207,548	0.048	834,745	1.949	0	0.000	0	0.000	1,683,666	0.012
32336	Jefferson	0	0.000	5,936	0.001	48,875	0.003	0	0.000	606,466	0.139	0	0.000	0	0.000	1,020,790	0.076	1,682,067	0.012
33064	Broward	610,239	0.009	0	0.000	393,722	0.024	228,161	0.006	158,266	0.036	284,759	0.665	0	0.000	0	0.000	1,675,147	0.012
32713	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	1,651,335	0.379	19,296	0.045	0	0.000	0	0.000	1,670,630	0.012
32746	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	1,559,001	0.358	76,660	0.179	1,326	0.009	0	0.000	1,636,987	0.011
32266	Duval	0	0.000	0	0.000	1,218,448	0.074	0	0.000	373,892	0.086	8,699	0.020	0	0.000	0	0.000	1,601,039	0.011
32119	Volusia	0	0.000	0	0.000	55,874	0.003	0	0.000	412,208	0.095	1,047,066	2.445	588	0.004	0	0.000	1,515,737	0.011
32168	Volusia	0	0.000	0	0.000	35,025	0.002	0	0.000	977,855	0.224	482,995	1.128	0	0.000	0	0.000	1,495,875	0.010
33304	Broward	900,435	0.014	0	0.000	10,227	0.001	3,598	0.000	164,100	0.038	412,315	0.963	0	0.000	0	0.000	1,490,676	0.010
33471	Glades	0	0.000	0	0.000	0	0.000	0	0.000	1,474,768	0.338	0	0.000	11,949	0.082	0	0.000	1,486,717	0.010
32708	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	1,377,081	0.316	92,648	0.216	1,917	0.013	0	0.000	1,471,645	0.010
32976	Brevard	0	0.000	0	0.000	906,106	0.055	340,515	0.009	182,834	0.042	5,591	0.013	0	0.000	0	0.000	1,435,046	0.010
32547	Okaloosa	0	0.000	1,093,358	0.178	12,047	0.001	0	0.000	2,415	0.001	0	0.000	69,167	0.473	249,627	0.019	1,426,614	0.010
33126	Miami-Dade	1,370,402	0.021	0	0.000	0	0.000	0	0.000	4,913	0.001	49,366	0.115	1,179	0.008	0	0.000	1,425,861	0.010
33418	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	1,359,870	0.312	0	0.000	0	0.000	0	0.000	1,359,870	0.009
32780	Brevard	0	0.000	521	0.000	82,352	0.005	4,415	0.000	1,236,887	0.284	35,667	0.083	0	0.000	0	0.000	1,359,842	0.009
34952	Saint Lucie	0	0.000	0	0.000	98,375	0.006	71,037	0.002	1,159,017	0.266	0	0.000	0	0.000	0	0.000	1,328,429	0.009
33408	Palm Beach	0	0.000	0	0.000	298,625	0.018	309,704	0.008	717,454	0.165	0	0.000	0	0.000	0	0.000	1,325,784	0.009
33772	Pinellas	0	0.000	0	0.000	1,320,688	0.080	0	0.000	0	0.000	0	0.000	2,530	0.017	0	0.000	1,323,217	0.009
33764	Pinellas	0	0.000	0	0.000	1,290,806	0.078	0	0.000	6,394	0.001	6,394	0.015	15,762	0.108	0	0.000	1,319,356	0.009
34498	Levy	0	0.000	0	0.000	1,087,812	0.066	0	0.000	159,301	0.037	0	0.000	0	0.000	48,231	0.004	1,295,344	0.009
32806	Orange	0	0.000	0	0.000	0	0.000	0	0.000	1,281,583	0.294	9,850	0.023	518	0.004	0	0.000	1,291,951	0.009
32505	Escambia	0	0.000	1,277,140	0.207	0	0.000	0	0.000	875	0.000	0	0.000	4,143	0.028	0	0.000	1,282,159	0.009



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32701	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	1,246,976	0.286	30,983	0.072	0	0.000	0	0.000	1,277,959	0.009
32920	Brevard	0	0.000	0	0.000	415,026	0.025	2,424	0.000	845,533	0.194	2,596	0.006	0	0.000	0	0.000	1,265,580	0.009
32789	Orange	0	0.000	0	0.000	0	0.000	0	0.000	1,110,674	0.255	121,628	0.284	3,329	0.023	0	0.000	1,235,631	0.009
33606	Hillsborough	0	0.000	0	0.000	1,166,630	0.071	0	0.000	0	0.000	28	0.000	19	0.000	0	0.000	1,166,677	0.008
32128	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	582,858	0.134	576,874	1.347	0	0.000	0	0.000	1,159,732	0.008
34229	Sarasota	0	0.000	0	0.000	1,091,016	0.066	59,230	0.002	0	0.000	2,743	0.006	4,125	0.028	0	0.000	1,157,114	0.008
33305	Broward	527,594	0.008	0	0.000	140,493	0.009	30,050	0.001	182,169	0.042	275,843	0.644	0	0.000	0	0.000	1,156,149	0.008
34974	Okeechobee	0	0.000	0	0.000	0	0.000	0	0.000	1,149,284	0.264	0	0.000	0	0.000	0	0.000	1,149,284	0.008
32909	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	1,091,246	0.250	11,998	0.028	0	0.000	0	0.000	1,103,244	0.008
33634	Hillsborough	0	0.000	0	0.000	1,084,729	0.066	0	0.000	297	0.000	2,736	0.006	297	0.002	0	0.000	1,088,060	0.008
32750	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	1,029,910	0.236	39,565	0.092	1,089	0.007	0	0.000	1,070,564	0.007
33602	Hillsborough	0	0.000	0	0.000	1,034,293	0.063	0	0.000	0	0.000	837	0.002	0	0.000	0	0.000	1,035,130	0.007
32131	Putnam	0	0.000	0	0.000	0	0.000	0	0.000	1,019,066	0.234	4,550	0.011	0	0.000	0	0.000	1,023,616	0.007
32011	Nassau	0	0.000	0	0.000	0	0.000	0	0.000	550,273	0.126	472,057	1.102	0	0.000	0	0.000	1,022,330	0.007
32466	Bay	0	0.000	0	0.000	0	0.000	0	0.000	577	0.000	0	0.000	23,283	0.159	997,296	0.075	1,021,156	0.007
34275	Sarasota	0	0.000	0	0.000	993,069	0.060	7,984	0.000	2,238	0.001	3,467	0.008	3,366	0.023	0	0.000	1,010,123	0.007
34986	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	1,002,017	0.230	0	0.000	0	0.000	0	0.000	1,002,017	0.007
34668	Pasco	0	0.000	0	0.000	988,101	0.060	0	0.000	1,744	0.000	1,129	0.003	932	0.006	0	0.000	991,907	0.007
32738	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	878,706	0.202	73,701	0.172	0	0.000	0	0.000	952,407	0.007
32751	Orange	0	0.000	0	0.000	0	0.000	0	0.000	796,459	0.183	145,169	0.339	3,216	0.022	0	0.000	944,845	0.007
34120	Collier	0	0.000	0	0.000	0	0.000	0	0.000	722,750	0.166	0	0.000	221,663	1.514	0	0.000	944,413	0.007
32312	Leon	0	0.000	0	0.000	0	0.000	0	0.000	916,357	0.210	1,900	0.004	25,100	0.171	0	0.000	943,357	0.007
34972	Okeechobee	0	0.000	0	0.000	0	0.000	0	0.000	942,755	0.216	0	0.000	93	0.001	0	0.000	942,848	0.007
32754	Brevard	0	0.000	0	0.000	44,001	0.003	806	0.000	882,475	0.202	9,741	0.023	0	0.000	0	0.000	937,023	0.007
34231	Sarasota	0	0.000	0	0.000	915,212	0.055	1,152	0.000	23	0.000	554	0.001	12,054	0.082	0	0.000	928,996	0.006
34982	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	928,221	0.213	0	0.000	0	0.000	0	0.000	928,221	0.006
32724	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	833,640	0.191	87,165	0.204	438	0.003	0	0.000	921,243	0.006
32927	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	885,776	0.203	28,884	0.067	0	0.000	0	0.000	914,660	0.006



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33147	Miami-Dade	778,338	0.012	0	0.000	0	0.000	0	0.000	14,321	0.003	112,235	0.262	1,272	0.009	0	0.000	906,167	0.006
33635	Hillsborough	0	0.000	0	0.000	890,753	0.054	6,203	0.000	0	0.000	0	0.000	0	0.000	0	0.000	896,956	0.006
32223	Duval	0	0.000	0	0.000	27,239	0.002	0	0.000	811,112	0.186	47,460	0.111	0	0.000	0	0.000	885,810	0.006
33024	Broward	0	0.000	0	0.000	0	0.000	0	0.000	213,215	0.049	667,806	1.560	0	0.000	0	0.000	881,022	0.006
32187	Putnam	0	0.000	0	0.000	0	0.000	0	0.000	878,864	0.202	2,068	0.005	0	0.000	0	0.000	880,932	0.006
32796	Brevard	0	0.000	185	0.000	30,885	0.002	642	0.000	820,975	0.188	24,764	0.058	375	0.003	0	0.000	877,825	0.006
32714	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	691,945	0.159	149,100	0.348	4,379	0.030	0	0.000	845,424	0.006
32619	Gilchrist	0	0.000	0	0.000	0	0.000	0	0.000	843,811	0.194	166	0.000	374	0.003	0	0.000	844,350	0.006
32059	Madison	0	0.000	0	0.000	0	0.000	0	0.000	827,357	0.190	0	0.000	0	0.000	0	0.000	827,357	0.006
33446	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	332,441	0.076	474,554	1.108	0	0.000	0	0.000	806,995	0.006
32503	Escambia	0	0.000	763,613	0.124	0	0.000	0	0.000	1,645	0.000	0	0.000	29,975	0.205	0	0.000	795,232	0.006
33774	Pinellas	0	0.000	0	0.000	765,541	0.046	0	0.000	822	0.000	813	0.002	5,047	0.034	0	0.000	772,223	0.005
34983	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	757,409	0.174	0	0.000	0	0.000	0	0.000	757,409	0.005
32763	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	731,297	0.168	18,511	0.043	0	0.000	0	0.000	749,808	0.005
32176	Volusia	0	0.000	0	0.000	10,510	0.001	0	0.000	47,359	0.011	678,836	1.585	0	0.000	0	0.000	736,704	0.005
33496	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	215,835	0.050	507,954	1.186	0	0.000	0	0.000	723,788	0.005
32259	Saint Johns	0	0.000	0	0.000	394	0.000	0	0.000	670,080	0.154	52,966	0.124	0	0.000	0	0.000	723,441	0.005
34772	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	711,917	0.163	0	0.000	0	0.000	0	0.000	711,917	0.005
32536	Okaloosa	0	0.000	0	0.000	0	0.000	0	0.000	231,901	0.053	13,254	0.031	458,865	3.135	0	0.000	704,019	0.005
33755	Pinellas	0	0.000	0	0.000	678,609	0.041	0	0.000	4,769	0.001	4,769	0.011	6,602	0.045	0	0.000	694,749	0.005
33435	Palm Beach	20,955	0.000	0	0.000	283,018	0.017	278,295	0.008	70,570	0.016	33,478	0.078	0	0.000	0	0.000	686,317	0.005
33433	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	242,277	0.056	434,814	1.015	0	0.000	0	0.000	677,090	0.005
33021	Broward	0	0.000	0	0.000	0	0.000	0	0.000	191,674	0.044	483,643	1.129	0	0.000	0	0.000	675,316	0.005
32256	Duval	0	0.000	0	0.000	0	0.000	0	0.000	628,186	0.144	46,465	0.109	0	0.000	0	0.000	674,650	0.005
32703	Orange	0	0.000	0	0.000	0	0.000	0	0.000	536,758	0.123	132,080	0.308	544	0.004	0	0.000	669,382	0.005
33462	Palm Beach	0	0.000	0	0.000	287,380	0.017	233,880	0.006	135,317	0.031	0	0.000	0	0.000	0	0.000	656,577	0.005
32707	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	593,433	0.136	61,394	0.143	328	0.002	0	0.000	655,154	0.005
32141	Volusia	0	0.000	0	0.000	2,176	0.000	0	0.000	548,205	0.126	98,827	0.231	0	0.000	0	0.000	649,209	0.005



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33436	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	634,647	0.146	5,083	0.012	0	0.000	0	0.000	639,729	0.004
34953	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	637,834	0.146	0	0.000	0	0.000	0	0.000	637,834	0.004
32926	Brevard	0	0.000	0	0.000	130,304	0.008	17,802	0.000	480,340	0.110	8,978	0.021	0	0.000	0	0.000	637,424	0.004
33935	Hendry	0	0.000	0	0.000	0	0.000	0	0.000	627,103	0.144	0	0.000	1,475	0.010	0	0.000	628,578	0.004
32097	Nassau	0	0.000	0	0.000	257,480	0.016	0	0.000	347,601	0.080	22,181	0.052	0	0.000	0	0.000	627,262	0.004
33426	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	608,128	0.140	17,108	0.040	0	0.000	0	0.000	625,236	0.004
32908	Brevard	0	0.000	0	0.000	0	0.000	0	0.000	614,653	0.141	9,204	0.021	0	0.000	0	0.000	623,857	0.004
33170	Miami-Dade	539,215	0.008	0	0.000	0	0.000	0	0.000	0	0.000	57,981	0.135	26,109	0.178	0	0.000	623,306	0.004
32003	Clay	0	0.000	0	0.000	0	0.000	0	0.000	512,251	0.118	103,167	0.241	0	0.000	0	0.000	615,418	0.004
32626	Levy	0	0.000	26,730	0.004	273,689	0.017	0	0.000	81,934	0.019	19	0.000	42	0.000	228,558	0.017	610,973	0.004
32712	Orange	0	0.000	0	0.000	0	0.000	0	0.000	541,395	0.124	65,336	0.153	1,280	0.009	0	0.000	608,012	0.004
34984	Saint Lucie	0	0.000	0	0.000	12,996	0.001	5,217	0.000	582,925	0.134	0	0.000	0	0.000	0	0.000	601,139	0.004
33716	Pinellas	0	0.000	0	0.000	592,665	0.036	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	592,665	0.004
33441	Broward	161,694	0.002	0	0.000	126,900	0.008	83,815	0.002	78,322	0.018	141,435	0.330	0	0.000	0	0.000	592,166	0.004
32073	Clay	0	0.000	0	0.000	0	0.000	0	0.000	509,510	0.117	78,504	0.183	0	0.000	0	0.000	588,014	0.004
32765	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	541,867	0.124	38,755	0.091	1,901	0.013	0	0.000	582,523	0.004
33428	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	146,791	0.034	432,865	1.011	0	0.000	0	0.000	579,657	0.004
32465	Gulf	0	0.000	0	0.000	0	0.000	0	0.000	2,831	0.001	0	0.000	88,818	0.607	468,001	0.035	559,651	0.004
34266	DeSoto	0	0.000	0	0.000	0	0.000	0	0.000	475,687	0.109	1,276	0.003	78,188	0.534	0	0.000	555,151	0.004
32693	Gilchrist	0	0.000	0	0.000	36,183	0.002	0	0.000	472,825	0.108	280	0.001	2,056	0.014	25,078	0.002	536,423	0.004
34987	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	534,273	0.123	0	0.000	0	0.000	0	0.000	534,273	0.004
32277	Duval	0	0.000	0	0.000	80,832	0.005	0	0.000	367,016	0.084	40,582	0.095	0	0.000	0	0.000	488,430	0.003
32208	Duval	0	0.000	0	0.000	0	0.000	0	0.000	469,632	0.108	14,487	0.034	0	0.000	0	0.000	484,119	0.003
32455	Holmes	0	0.000	54	0.000	0	0.000	0	0.000	169,956	0.039	730	0.002	310,689	2.123	0	0.000	481,429	0.003
32810	Orange	0	0.000	0	0.000	0	0.000	0	0.000	384,947	0.088	91,361	0.213	1,871	0.013	0	0.000	478,179	0.003
33967	Lee	0	0.000	0	0.000	0	0.000	0	0.000	237,251	0.054	0	0.000	234,264	1.601	0	0.000	471,515	0.003
33060	Broward	153,718	0.002	0	0.000	45,442	0.003	0	0.000	114,074	0.026	152,426	0.356	0	0.000	0	0.000	465,660	0.003
33317	Broward	0	0.000	0	0.000	0	0.000	0	0.000	140,920	0.032	313,914	0.733	0	0.000	0	0.000	454,834	0.003



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33312	Broward	17,712	0.000	0	0.000	0	0.000	0	0.000	145,975	0.033	285,866	0.668	0	0.000	0	0.000	449,552	0.003
33431	Palm Beach	50,505	0.001	0	0.000	69,602	0.004	54,355	0.001	87,417	0.020	186,611	0.436	0	0.000	0	0.000	448,490	0.003
32177	Putnam	0	0.000	0	0.000	0	0.000	0	0.000	434,757	0.100	13,403	0.031	72	0.000	0	0.000	448,232	0.003
33319	Broward	0	0.000	0	0.000	0	0.000	0	0.000	153,157	0.035	294,491	0.688	0	0.000	0	0.000	447,648	0.003
34695	Pinellas	0	0.000	0	0.000	416,808	0.025	1,789	0.000	5,665	0.001	6,771	0.016	5,810	0.040	0	0.000	436,843	0.003
33437	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	380,600	0.087	42,190	0.099	0	0.000	0	0.000	422,789	0.003
33306	Broward	264,109	0.004	0	0.000	46,109	0.003	16,089	0.000	36,705	0.008	55,506	0.130	0	0.000	0	0.000	418,518	0.003
32301	Leon	0	0.000	0	0.000	0	0.000	0	0.000	396,505	0.091	4,599	0.011	14,494	0.099	0	0.000	415,599	0.003
33983	Charlotte	0	0.000	0	0.000	316,638	0.019	92,997	0.003	4,636	0.001	1,158	0.003	0	0.000	0	0.000	415,430	0.003
32355	Wakulla	0	0.000	0	0.000	0	0.000	0	0.000	249,610	0.057	0	0.000	0	0.000	165,678	0.012	415,288	0.003
33712	Pinellas	0	0.000	0	0.000	408,912	0.025	0	0.000	0	0.000	1,335	0.003	2,309	0.016	0	0.000	412,556	0.003
32792	Orange	0	0.000	0	0.000	0	0.000	0	0.000	379,077	0.087	25,715	0.060	707	0.005	0	0.000	405,499	0.003
32211	Duval	0	0.000	0	0.000	7,229	0.000	0	0.000	368,590	0.085	25,125	0.059	16	0.000	0	0.000	400,960	0.003
34449	Levy	0	0.000	0	0.000	273,992	0.017	0	0.000	122,394	0.028	1,122	0.003	0	0.000	0	0.000	397,509	0.003
33076	Broward	0	0.000	0	0.000	0	0.000	0	0.000	389,859	0.089	4,987	0.012	0	0.000	0	0.000	394,846	0.003
32043	Clay	0	0.000	0	0.000	0	0.000	0	0.000	388,565	0.089	5,027	0.012	30	0.000	0	0.000	393,622	0.003
32966	Indian River	0	0.000	0	0.000	0	0.000	0	0.000	385,243	0.088	1,739	0.004	0	0.000	0	0.000	386,982	0.003
33186	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	22,520	0.005	301,599	0.704	62,373	0.426	0	0.000	386,491	0.003
33412	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	384,785	0.088	0	0.000	0	0.000	0	0.000	384,785	0.003
32812	Orange	0	0.000	0	0.000	0	0.000	0	0.000	327,528	0.075	54,420	0.127	1,063	0.007	0	0.000	383,012	0.003
33478	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	361,402	0.083	18,793	0.044	785	0.005	0	0.000	380,980	0.003
34758	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	374,031	0.086	0	0.000	0	0.000	0	0.000	374,031	0.003
33980	Charlotte	0	0.000	0	0.000	289,673	0.018	78,577	0.002	3,862	0.001	1,612	0.004	0	0.000	0	0.000	373,724	0.003
32570	Santa Rosa	0	0.000	273,427	0.044	0	0.000	0	0.000	41,705	0.010	0	0.000	53,036	0.362	317	0.000	368,485	0.003
33309	Broward	0	0.000	0	0.000	0	0.000	0	0.000	123,236	0.028	244,648	0.571	0	0.000	0	0.000	367,883	0.003
33920	Lee	0	0.000	0	0.000	44,807	0.003	163,359	0.004	157,413	0.036	0	0.000	1,785	0.012	0	0.000	367,365	0.003
33404	Palm Beach	0	0.000	0	0.000	46,900	0.003	46,902	0.001	271,447	0.062	831	0.002	0	0.000	0	0.000	366,081	0.003
32836	Orange	0	0.000	0	0.000	0	0.000	0	0.000	299,635	0.069	64,464	0.151	834	0.006	0	0.000	364,933	0.003



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32052	Hamilton	0	0.000	0	0.000	0	0.000	0	0.000	363,160	0.083	186	0.000	321	0.002	0	0.000	363,667	0.003
33328	Broward	0	0.000	0	0.000	0	0.000	0	0.000	151,648	0.035	210,186	0.491	0	0.000	0	0.000	361,834	0.003
33414	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	361,217	0.083	0	0.000	0	0.000	0	0.000	361,217	0.003
32347	Taylor	0	0.000	0	0.000	0	0.000	0	0.000	346,387	0.079	643	0.002	2,538	0.017	0	0.000	349,568	0.002
32258	Duval	0	0.000	0	0.000	0	0.000	0	0.000	328,627	0.075	16,914	0.039	0	0.000	0	0.000	345,541	0.002
33129	Miami-Dade	312,923	0.005	0	0.000	28	0.000	0	0.000	4,032	0.001	16,975	0.040	1,836	0.013	0	0.000	335,794	0.002
32833	Orange	0	0.000	0	0.000	0	0.000	0	0.000	286,824	0.066	45,649	0.107	232	0.002	0	0.000	332,705	0.002
32114	Volusia	0	0.000	0	0.000	15,180	0.001	0	0.000	47,418	0.011	268,123	0.626	0	0.000	0	0.000	330,721	0.002
34285	Sarasota	0	0.000	0	0.000	291,201	0.018	33,809	0.001	338	0.000	4,384	0.010	224	0.002	0	0.000	329,956	0.002
33534	Hillsborough	0	0.000	0	0.000	325,003	0.020	946	0.000	0	0.000	136	0.000	136	0.001	0	0.000	326,221	0.002
32803	Orange	0	0.000	0	0.000	0	0.000	0	0.000	317,541	0.073	8,148	0.019	47	0.000	0	0.000	325,735	0.002
32117	Volusia	0	0.000	0	0.000	2,029	0.000	0	0.000	82,355	0.019	240,842	0.562	0	0.000	0	0.000	325,227	0.002
33166	Miami-Dade	205,429	0.003	0	0.000	0	0.000	0	0.000	14,141	0.003	102,163	0.239	2,397	0.016	0	0.000	324,129	0.002
32257	Duval	0	0.000	0	0.000	0	0.000	0	0.000	303,711	0.070	19,844	0.046	0	0.000	0	0.000	323,554	0.002
33023	Broward	0	0.000	0	0.000	0	0.000	0	0.000	103,084	0.024	211,617	0.494	8,638	0.059	0	0.000	323,340	0.002
34293	Sarasota	0	0.000	0	0.000	233,525	0.014	74,749	0.002	0	0.000	9,440	0.022	133	0.001	0	0.000	317,848	0.002
34207	Manatee	0	0.000	0	0.000	312,333	0.019	0	0.000	0	0.000	0	0.000	4,598	0.031	0	0.000	316,931	0.002
32766	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	282,891	0.065	31,490	0.074	1,413	0.010	0	0.000	315,793	0.002
33334	Broward	1,353	0.000	0	0.000	0	0.000	0	0.000	135,160	0.031	176,519	0.412	0	0.000	0	0.000	313,032	0.002
32221	Duval	0	0.000	0	0.000	0	0.000	0	0.000	258,003	0.059	53,342	0.125	0	0.000	0	0.000	311,345	0.002
33175	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	45,142	0.010	213,564	0.499	50,723	0.347	0	0.000	309,429	0.002
32132	Volusia	0	0.000	0	0.000	7,412	0.000	1,001	0.000	201,883	0.046	93,561	0.218	0	0.000	0	0.000	303,856	0.002
33473	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	178,301	0.041	125,092	0.292	0	0.000	0	0.000	303,393	0.002
32129	Volusia	0	0.000	0	0.000	405	0.000	0	0.000	105,808	0.024	196,031	0.458	0	0.000	0	0.000	302,244	0.002
33311	Broward	0	0.000	0	0.000	0	0.000	0	0.000	110,144	0.025	181,521	0.424	0	0.000	0	0.000	291,665	0.002
34981	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	290,061	0.067	0	0.000	0	0.000	0	0.000	290,061	0.002
34691	Pasco	0	0.000	0	0.000	280,611	0.017	0	0.000	2,745	0.001	3,248	0.008	173	0.001	0	0.000	286,777	0.002
34428	Citrus	0	0.000	0	0.000	223,494	0.014	0	0.000	51,915	0.012	7,798	0.018	249	0.002	786	0.000	284,242	0.002



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32209	Duval	0	0.000	0	0.000	0	0.000	0	0.000	274,722	0.063	8,157	0.019	47	0.000	0	0.000	282,926	0.002
32246	Duval	0	0.000	0	0.000	0	0.000	0	0.000	256,126	0.059	23,325	0.054	0	0.000	0	0.000	279,451	0.002
32462	Washington	0	0.000	75,096	0.012	947	0.000	0	0.000	2,235	0.001	10	0.000	171,307	1.170	29,846	0.002	279,441	0.002
33315	Broward	21,752	0.000	0	0.000	0	0.000	0	0.000	107,967	0.025	148,928	0.348	0	0.000	0	0.000	278,647	0.002
33411	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	277,126	0.064	0	0.000	0	0.000	0	0.000	277,126	0.002
33916	Lee	0	0.000	0	0.000	63,500	0.004	168,496	0.005	31,388	0.007	0	0.000	13,501	0.092	0	0.000	276,885	0.002
32065	Clay	0	0.000	0	0.000	0	0.000	0	0.000	267,634	0.061	8,696	0.020	0	0.000	0	0.000	276,330	0.002
33196	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	3,070	0.001	242,840	0.567	24,595	0.168	0	0.000	270,505	0.002
32305	Leon	0	0.000	0	0.000	0	0.000	0	0.000	262,660	0.060	2,370	0.006	5,400	0.037	0	0.000	270,429	0.002
33913	Lee	0	0.000	0	0.000	0	0.000	0	0.000	160,388	0.037	0	0.000	108,714	0.743	0	0.000	269,102	0.002
32216	Duval	0	0.000	0	0.000	0	0.000	0	0.000	252,573	0.058	15,237	0.036	0	0.000	0	0.000	267,810	0.002
32817	Orange	0	0.000	0	0.000	0	0.000	0	0.000	225,726	0.052	38,407	0.090	832	0.006	0	0.000	264,965	0.002
33440	Hendry	0	0.000	0	0.000	0	0.000	0	0.000	250,373	0.057	0	0.000	11,974	0.082	0	0.000	262,347	0.002
33486	Palm Beach	0	0.000	0	0.000	2,239	0.000	0	0.000	75,060	0.017	184,927	0.432	0	0.000	0	0.000	262,225	0.002
33025	Broward	0	0.000	0	0.000	0	0.000	0	0.000	62,447	0.014	196,529	0.459	809	0.006	0	0.000	259,785	0.002
32640	Alachua	0	0.000	0	0.000	0	0.000	0	0.000	257,595	0.059	977	0.002	0	0.000	0	0.000	258,572	0.002
33467	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	257,031	0.059	0	0.000	0	0.000	0	0.000	257,031	0.002
32193	Putnam	0	0.000	0	0.000	0	0.000	0	0.000	255,304	0.059	1,402	0.003	0	0.000	0	0.000	256,705	0.002
32118	Volusia	0	0.000	0	0.000	132	0.000	0	0.000	23,359	0.005	226,401	0.529	0	0.000	0	0.000	249,893	0.002
32773	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	246,562	0.057	2,174	0.005	0	0.000	0	0.000	248,736	0.002
34769	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	239,741	0.055	0	0.000	0	0.000	0	0.000	239,741	0.002
33063	Broward	0	0.000	0	0.000	0	0.000	0	0.000	92,233	0.021	147,492	0.344	0	0.000	0	0.000	239,724	0.002
33760	Pinellas	0	0.000	0	0.000	232,240	0.014	0	0.000	0	0.000	2,848	0.007	4,286	0.029	0	0.000	239,374	0.002
32809	Orange	0	0.000	0	0.000	0	0.000	0	0.000	189,278	0.043	46,471	0.109	1,587	0.011	0	0.000	237,336	0.002
33179	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	78,182	0.018	150,516	0.351	6,216	0.042	0	0.000	234,914	0.002
33498	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	65,700	0.015	167,017	0.390	0	0.000	0	0.000	232,717	0.002
33901	Lee	0	0.000	0	0.000	47,644	0.003	166,416	0.005	348	0.000	0	0.000	18,149	0.124	0	0.000	232,557	0.002
33401	Palm Beach	0	0.000	0	0.000	61,092	0.004	57,464	0.002	111,160	0.026	0	0.000	0	0.000	0	0.000	229,715	0.002



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33056	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	62,743	0.014	152,249	0.356	9,914	0.068	0	0.000	224,907	0.002
34771	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	219,997	0.050	1,118	0.003	0	0.000	0	0.000	221,114	0.002
33183	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	25,676	0.006	164,050	0.383	29,424	0.201	0	0.000	219,150	0.002
32063	Baker	0	0.000	0	0.000	0	0.000	0	0.000	145,214	0.033	69,722	0.163	364	0.002	0	0.000	215,300	0.001
34269	DeSoto	0	0.000	0	0.000	38,999	0.002	22,978	0.001	146,305	0.034	23	0.000	6,210	0.042	0	0.000	214,515	0.001
33445	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	80,059	0.018	133,609	0.312	0	0.000	0	0.000	213,669	0.001
32344	Jefferson	0	0.000	0	0.000	0	0.000	0	0.000	212,713	0.049	0	0.000	29	0.000	0	0.000	212,742	0.001
33407	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	210,202	0.048	0	0.000	0	0.000	0	0.000	210,202	0.001
33068	Broward	0	0.000	0	0.000	0	0.000	0	0.000	66,700	0.015	139,362	0.325	0	0.000	0	0.000	206,063	0.001
32081	Saint Johns	0	0.000	0	0.000	0	0.000	0	0.000	172,830	0.040	28,990	0.068	0	0.000	0	0.000	201,820	0.001
33461	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	200,043	0.046	0	0.000	0	0.000	0	0.000	200,043	0.001
32164	Flagler	0	0.000	0	0.000	0	0.000	0	0.000	72,821	0.017	126,776	0.296	219	0.001	0	0.000	199,815	0.001
32801	Orange	0	0.000	0	0.000	0	0.000	0	0.000	199,511	0.046	1	0.000	0	0.000	0	0.000	199,511	0.001
33169	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	61,524	0.014	131,669	0.307	5,282	0.036	0	0.000	198,474	0.001
33004	Broward	61,593	0.001	0	0.000	0	0.000	0	0.000	55,161	0.013	73,471	0.172	565	0.004	0	0.000	190,790	0.001
32825	Orange	0	0.000	0	0.000	0	0.000	0	0.000	148,848	0.034	39,685	0.093	212	0.001	0	0.000	188,745	0.001
33073	Broward	0	0.000	0	0.000	0	0.000	0	0.000	68,436	0.016	115,826	0.270	0	0.000	0	0.000	184,262	0.001
33434	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	51,124	0.012	132,827	0.310	0	0.000	0	0.000	183,951	0.001
33710	Pinellas	0	0.000	0	0.000	172,609	0.010	0	0.000	97	0.000	157	0.000	6,891	0.047	0	0.000	179,755	0.001
33324	Broward	0	0.000	0	0.000	0	0.000	0	0.000	73,481	0.017	104,627	0.244	0	0.000	0	0.000	178,108	0.001
33912	Lee	0	0.000	0	0.000	0	0.000	0	0.000	125,081	0.029	0	0.000	50,389	0.344	0	0.000	175,470	0.001
32244	Duval	0	0.000	0	0.000	0	0.000	0	0.000	105,987	0.024	68,612	0.160	0	0.000	0	0.000	174,599	0.001
34287	Sarasota	0	0.000	0	0.000	172,736	0.010	0	0.000	83	0.000	1,253	0.003	0	0.000	0	0.000	174,072	0.001
33405	Palm Beach	0	0.000	0	0.000	2,411	0.000	2,342	0.000	167,624	0.038	0	0.000	0	0.000	0	0.000	172,377	0.001
32804	Orange	0	0.000	0	0.000	0	0.000	0	0.000	151,972	0.035	19,990	0.047	261	0.002	0	0.000	172,224	0.001
33067	Broward	0	0.000	0	0.000	0	0.000	0	0.000	60,649	0.014	108,773	0.254	0	0.000	0	0.000	169,422	0.001
32206	Duval	0	0.000	0	0.000	397	0.000	0	0.000	166,527	0.038	2,254	0.005	0	0.000	0	0.000	169,178	0.001
33442	Broward	0	0.000	0	0.000	0	0.000	0	0.000	66,984	0.015	97,781	0.228	0	0.000	0	0.000	164,765	0.001



ZIP Code	County	Hurricane Andrew (1992)		Hurricane Ivan (2004)		Hurricane Jeanne (2004)		Hurricane Wilma (2005)		Tropical Storm Fay (2008)		Unnamed Storm in East Florida (May 2009)		Unnamed Storm in Panhandle (July 2013)		Hurricane Michael (October 2018)		Total All Events	
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32618	Alachua	0	0.000	0	0.000	0	0.000	0	0.000	161,427	0.037	22	0.000	0	0.000	0	0.000	161,450	0.001
34951	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	160,530	0.037	0	0.000	0	0.000	0	0.000	160,530	0.001
33051	Monroe	0	0.000	0	0.000	0	0.000	160,062	0.004	0	0.000	0	0.000	0	0.000	0	0.000	160,062	0.001
33010	Miami-Dade	104,569	0.002	0	0.000	0	0.000	0	0.000	1,867	0.000	51,507	0.120	0	0.000	0	0.000	157,942	0.001
33898	Polk	0	0.000	0	0.000	0	0.000	0	0.000	152,330	0.035	125	0.000	1,146	0.008	0	0.000	153,602	0.001
32309	Leon	0	0.000	0	0.000	0	0.000	0	0.000	149,475	0.034	92	0.000	3,356	0.023	0	0.000	152,923	0.001
33472	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	152,260	0.035	0	0.000	0	0.000	0	0.000	152,260	0.001
32304	Leon	0	0.000	0	0.000	0	0.000	0	0.000	95,246	0.022	5,965	0.014	46,501	0.318	0	0.000	147,712	0.001
32730	Seminole	0	0.000	0	0.000	0	0.000	0	0.000	126,172	0.029	20,265	0.047	903	0.006	0	0.000	147,340	0.001
33033	Miami-Dade	0	0.000	0	0.000	0	0.000	0	0.000	336	0.000	104,858	0.245	41,757	0.285	0	0.000	146,951	0.001
33134	Miami-Dade	100,621	0.002	0	0.000	0	0.000	0	0.000	4,047	0.001	36,069	0.084	5,174	0.035	0	0.000	145,912	0.001
32828	Orange	0	0.000	0	0.000	0	0.000	0	0.000	117,939	0.027	26,079	0.061	0	0.000	0	0.000	144,018	0.001
33313	Broward	0	0.000	0	0.000	0	0.000	0	0.000	48,422	0.011	95,323	0.223	0	0.000	0	0.000	143,746	0.001
32071	Suwannee	0	0.000	0	0.000	0	0.000	0	0.000	142,063	0.033	7	0.000	37	0.000	0	0.000	142,106	0.001
33776	Pinellas	0	0.000	0	0.000	141,909	0.009	0	0.000	0	0.000	0	0.000	0	0.000	0	0.000	141,909	0.001
33982	Charlotte	0	0.000	0	0.000	59,144	0.004	15,855	0.000	63,846	0.015	779	0.002	0	0.000	0	0.000	139,623	0.001
33972	Lee	0	0.000	0	0.000	0	0.000	0	0.000	95,595	0.022	0	0.000	40,668	0.278	0	0.000	136,263	0.001
32531	Okaloosa	0	0.000	0	0.000	0	0.000	0	0.000	50,313	0.012	48	0.000	84,164	0.575	0	0.000	134,524	0.001
32180	Volusia	0	0.000	0	0.000	0	0.000	0	0.000	132,495	0.030	464	0.001	0	0.000	0	0.000	132,960	0.001
32163	Sumter	0	0.000	0	0.000	0	0.000	0	0.000	87,020	0.020	45,033	0.105	747	0.005	0	0.000	132,800	0.001
34243	Manatee	0	0.000	0	0.000	103,096	0.006	0	0.000	2,378	0.001	2,378	0.006	23,369	0.160	0	0.000	131,220	0.001
33314	Broward	0	0.000	0	0.000	0	0.000	0	0.000	45,643	0.010	83,828	0.196	0	0.000	0	0.000	129,471	0.001
33449	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	129,208	0.030	0	0.000	0	0.000	0	0.000	129,208	0.001
32759	Volusia	0	0.000	0	0.000	23,766	0.001	0	0.000	98,879	0.023	4,988	0.012	0	0.000	0	0.000	127,633	0.001
32162	Sumter	0	0.000	0	0.000	0	0.000	0	0.000	84,287	0.019	41,781	0.098	346	0.002	0	0.000	126,414	0.001
33709	Pinellas	0	0.000	0	0.000	119,161	0.007	0	0.000	1,279	0.000	1,279	0.003	3,975	0.027	0	0.000	125,694	0.001
32317	Leon	0	0.000	0	0.000	0	0.000	0	0.000	122,636	0.028	0	0.000	1,390	0.009	0	0.000	124,026	0.001
33484	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	52,463	0.012	70,782	0.165	0	0.000	0	0.000	123,244	0.001



ZIP Code	County	Hurricane Andrew (1992)		Hurricane Ivan (2004)		Hurricane Jeanne (2004)		Hurricane Wilma (2005)		Tropical Storm Fay (2008)		Unnamed Storm in East Florida (May 2009)		Unnamed Storm in Panhandle (July 2013)		Hurricane Michael (October 2018)		Total All Events	
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32091	Bradford	0	0.000	0	0.000	0	0.000	0	0.000	103,938	0.024	17,479	0.041	977	0.007	0	0.000	122,394	0.001
34950	Saint Lucie	0	0.000	0	0.000	43,905	0.003	36,388	0.001	41,532	0.010	0	0.000	0	0.000	0	0.000	121,825	0.001
34251	Manatee	0	0.000	0	0.000	0	0.000	0	0.000	2,124	0.000	2,099	0.005	115,998	0.793	0	0.000	120,220	0.001
34786	Orange	0	0.000	0	0.000	0	0.000	0	0.000	110,612	0.025	8,561	0.020	0	0.000	0	0.000	119,173	0.001
34205	Manatee	0	0.000	0	0.000	109,784	0.007	0	0.000	294	0.000	294	0.001	8,507	0.058	0	0.000	118,878	0.001
34947	Saint Lucie	0	0.000	0	0.000	0	0.000	0	0.000	118,620	0.027	0	0.000	0	0.000	0	0.000	118,620	0.001
33330	Broward	0	0.000	0	0.000	0	0.000	0	0.000	66,393	0.015	50,383	0.118	0	0.000	0	0.000	116,776	0.001
32807	Orange	0	0.000	0	0.000	0	0.000	0	0.000	92,710	0.021	22,165	0.052	91	0.001	0	0.000	114,967	0.001
32219	Duval	0	0.000	0	0.000	0	0.000	0	0.000	106,253	0.024	7,577	0.018	0	0.000	0	0.000	113,830	0.001
33470	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	113,523	0.026	0	0.000	0	0.000	0	0.000	113,523	0.001
33406	Palm Beach	0	0.000	0	0.000	0	0.000	0	0.000	112,663	0.026	0	0.000	0	0.000	0	0.000	112,663	0.001
33325	Broward	0	0.000	0	0.000	0	0.000	0	0.000	40,890	0.009	69,034	0.161	0	0.000	0	0.000	109,925	0.001
34119	Collier	0	0.000	0	0.000	0	0.000	0	0.000	12,516	0.003	0	0.000	96,588	0.660	0	0.000	109,104	0.001
33323	Broward	0	0.000	0	0.000	0	0.000	0	0.000	35,066	0.008	70,574	0.165	0	0.000	0	0.000	105,640	0.001
33322	Broward	0	0.000	0	0.000	0	0.000	0	0.000	39,082	0.009	65,450	0.153	0	0.000	0	0.000	104,532	0.001
33605	Hillsborough	0	0.000	0	0.000	103,589	0.006	0	0.000	63	0.000	156	0.000	64	0.000	0	0.000	103,871	0.001
32818	Orange	0	0.000	0	0.000	0	0.000	0	0.000	75,684	0.017	27,676	0.065	407	0.003	0	0.000	103,766	0.001
34773	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	102,207	0.023	1,377	0.003	0	0.000	0	0.000	103,583	0.001
32822	Orange	0	0.000	0	0.000	0	0.000	0	0.000	84,505	0.019	18,761	0.044	63	0.000	0	0.000	103,329	0.001
33071	Broward	0	0.000	0	0.000	0	0.000	0	0.000	35,283	0.008	68,011	0.159	0	0.000	0	0.000	103,294	0.001
33857	Highlands	0	0.000	0	0.000	0	0.000	0	0.000	103,213	0.024	0	0.000	0	0.000	0	0.000	103,213	0.001
34744	Osceola	0	0.000	0	0.000	0	0.000	0	0.000	100,630	0.023	850	0.002	0	0.000	0	0.000	101,480	0.001
32222	Duval	0	0.000	0	0.000	0	0.000	0	0.000	73,354	0.017	27,666	0.065	0	0.000	0	0.000	101,020	0.001
33966	Lee	0	0.000	0	0.000	0	0.000	0	0.000	15,544	0.004	0	0.000	84,902	0.580	0	0.000	100,445	0.001
Total	Statewide	6,633,439,241	100	615,834,090	100	1,648,885,382	100	3,680,452,370	100	431,386,560	99	41,432,289	97	13,672,205	93	1,336,958,809	100	14,402,060,945	100

Table 24 - Personal residential zero deductible standard flood losses



B. Provide maps color-coded by ZIP Code depicting the percentage total personal residential standard flood losses from each flood event and for the cumulative flood losses using the following interval coding:

Red	Over 5%
Light Red	2% to 5%
Pink	1% to 2%
Light Pink	0.5% to 1%
Light Blue	0.2% to 0.5%
Medium Blue	0.1% to 0.2%
Blue Below	0.1%

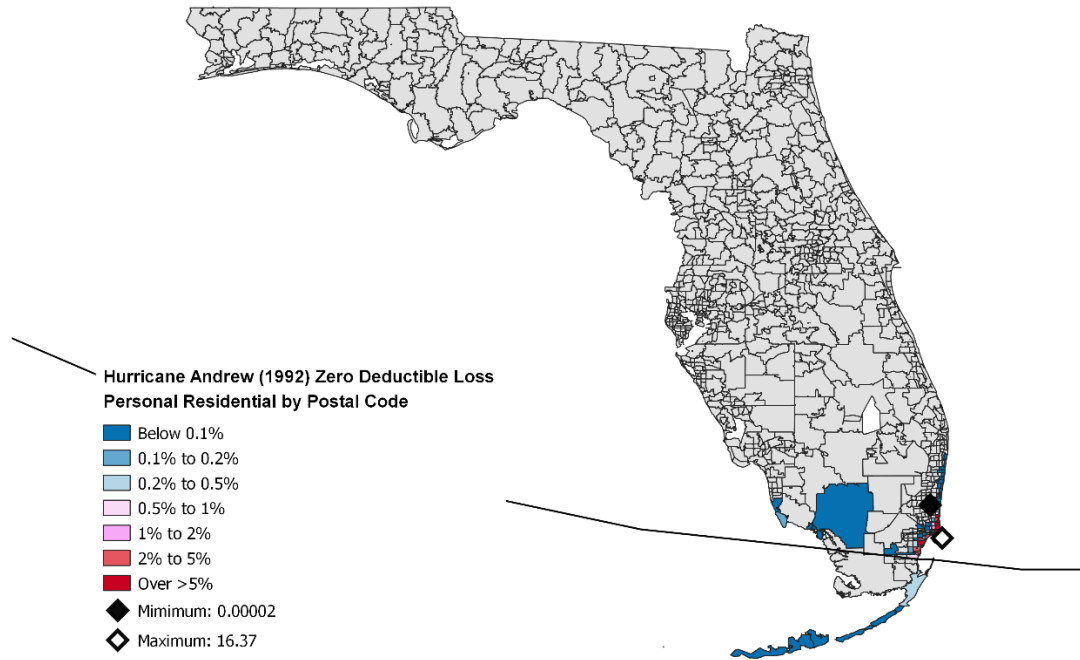


Figure 65 - Percentage of total personal residential standard flood losses from Hurricane Andrew (1992)

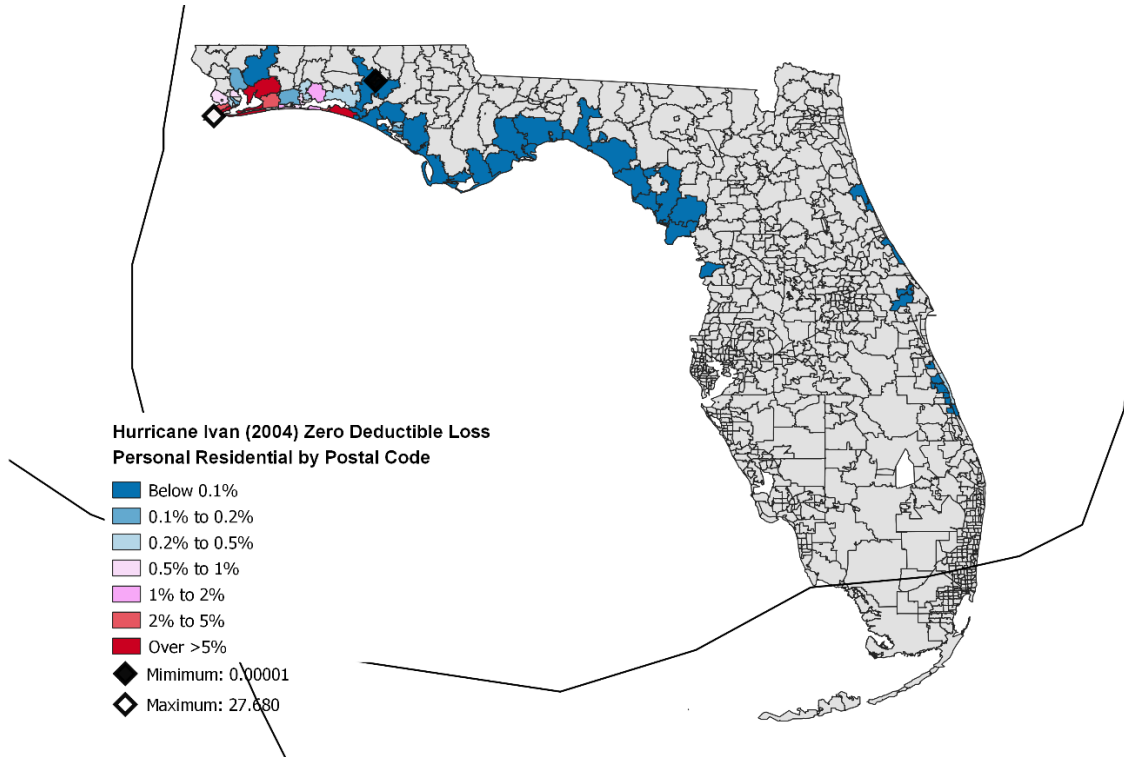


Figure 66 - Percentage of total personal residential standard flood losses from Hurricane Ivan (2004)

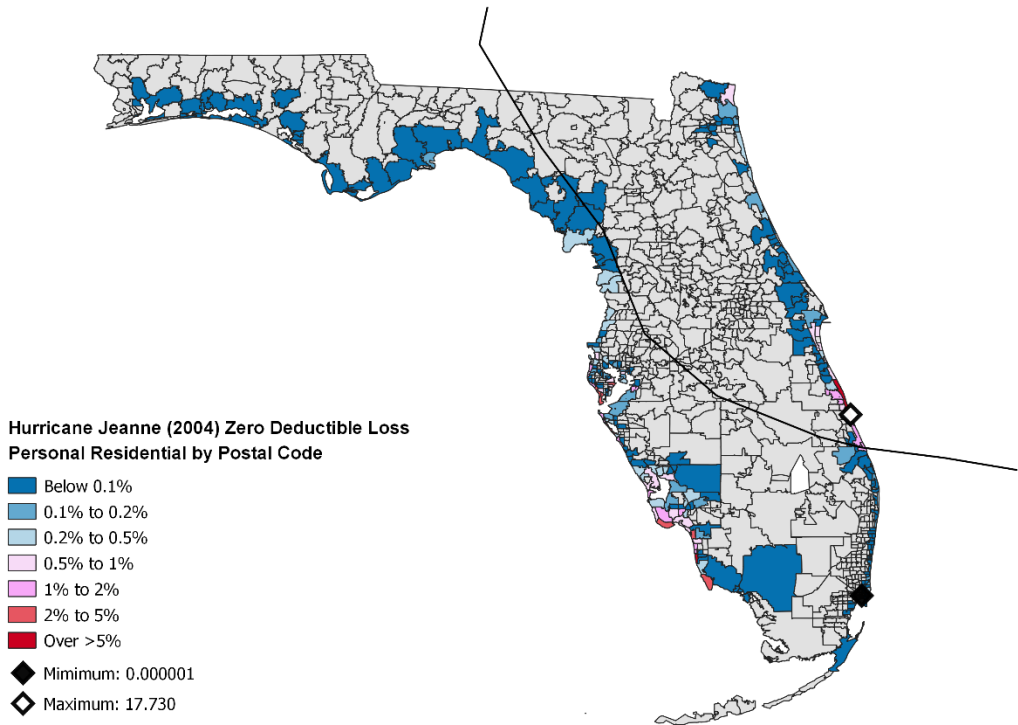


Figure 67 - Percentage of total personal residential standard flood losses from Hurricane Jeanne (2004)

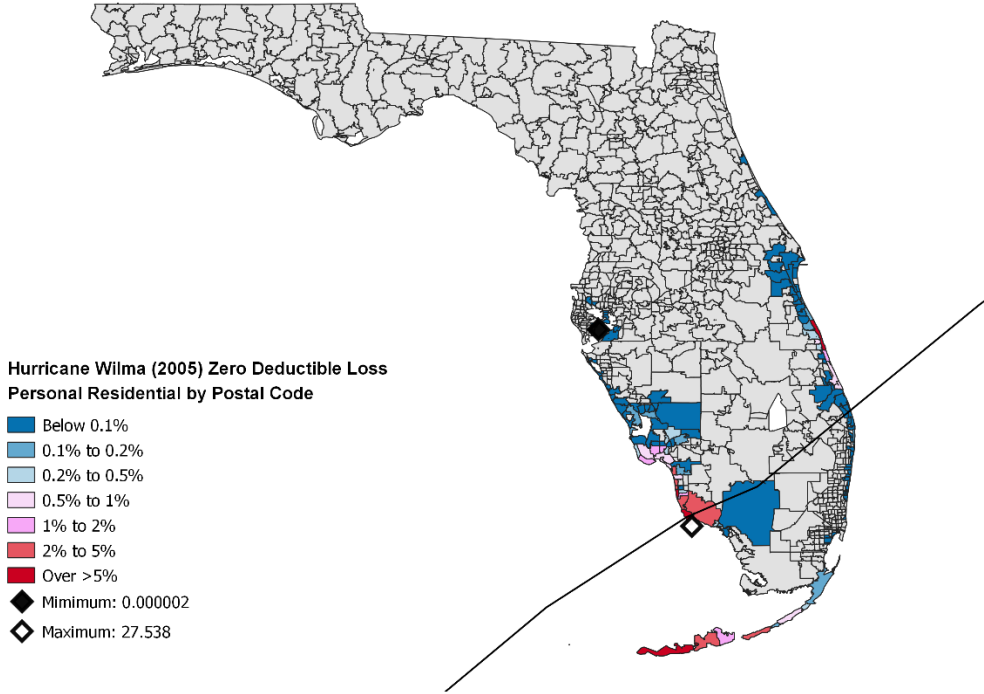


Figure 68 - Percentage of total personal residential standard flood losses from Hurricane Wilma (2005)

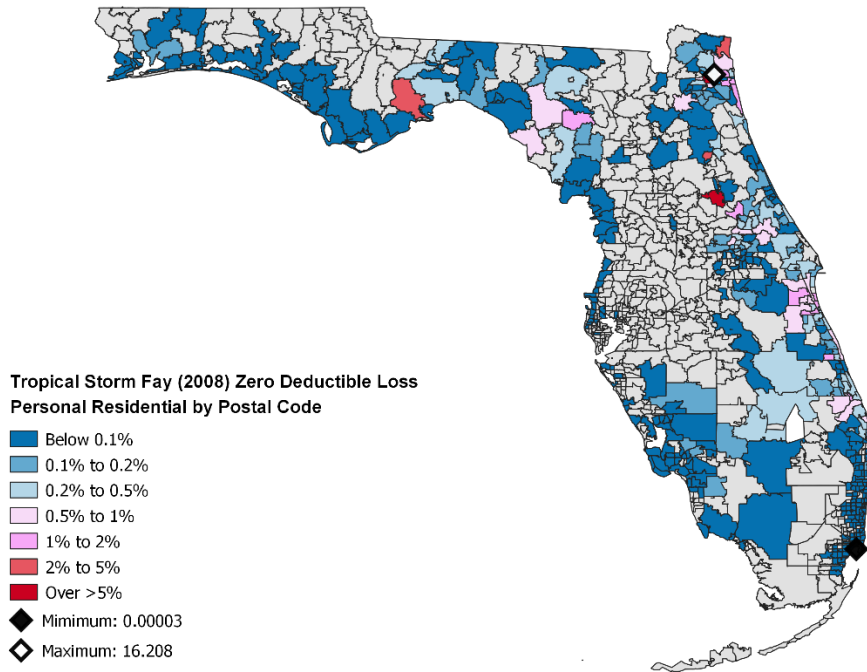


Figure 69 - Percentage of total personal residential standard flood losses from Tropical Storm Fay (2008)

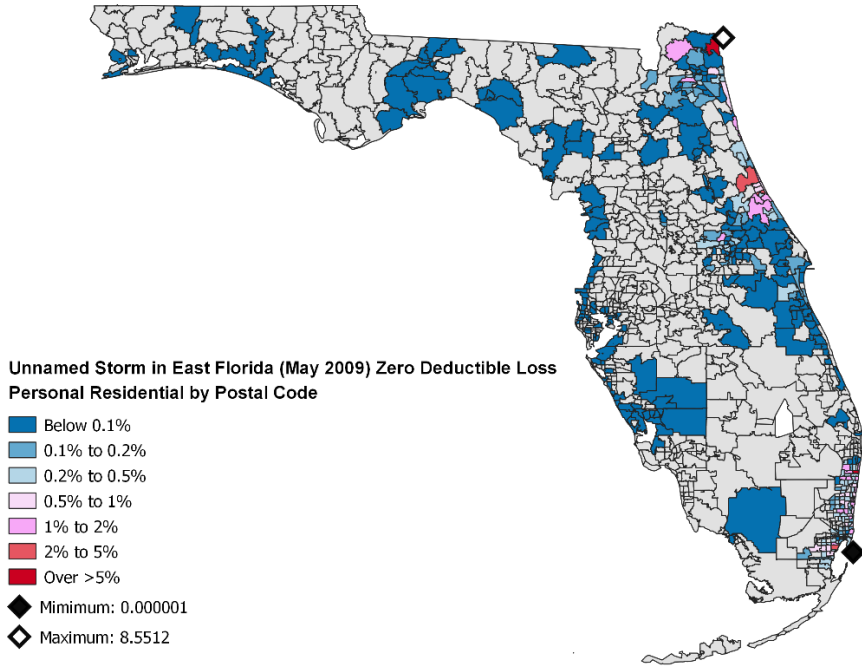


Figure 70 - Percentage of total personal residential standard flood losses from Unnamed Storm in East Florida (May 2009)

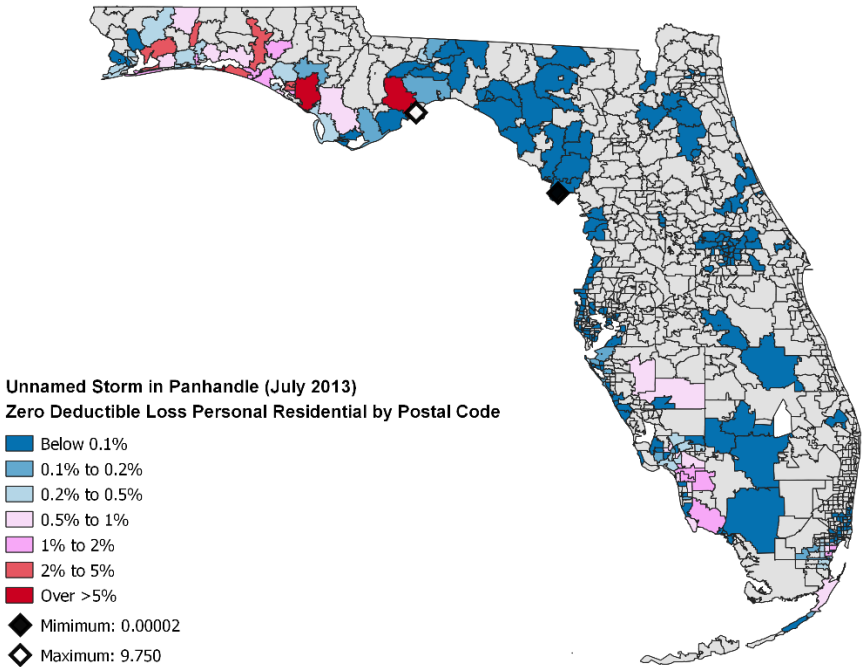


Figure 71 - Percentage of total personal residential standard flood losses from Unnamed Storm in Panhandle (July 2013)

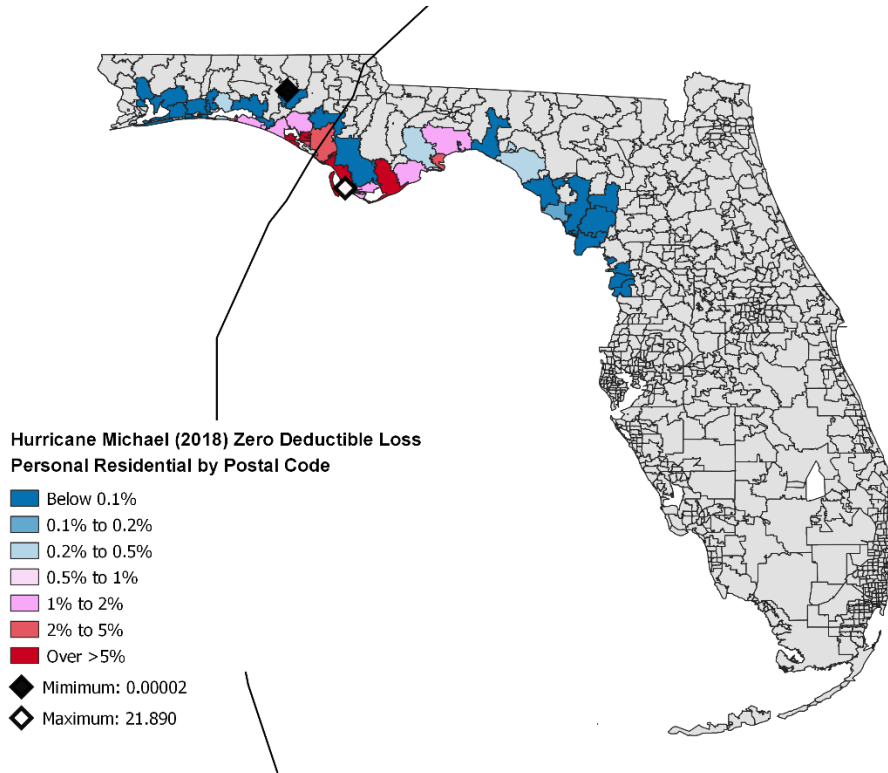


Figure 72 - Percentage of total personal residential standard flood losses from Hurricane Michael (2018)

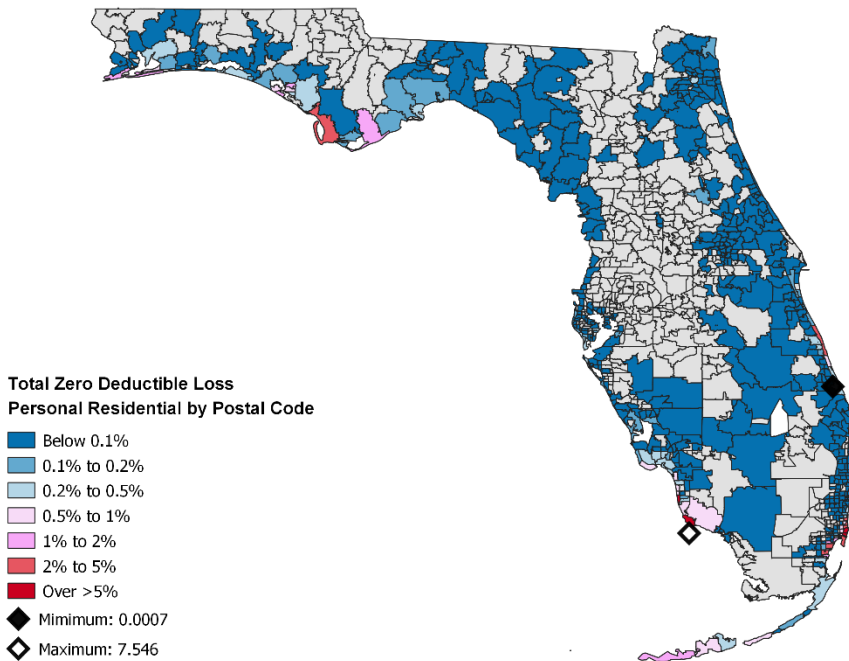


Figure 73 - Percentage of total personal residential standard flood losses from all events

- C. If additional assumptions are necessary to complete this form, provide the rationale for the assumptions as well as a detailed description of how they are included.**

No additional assumptions were used to generate this form.

- D. Provide, in the format given in the file named "2017FormAF3.xlsx," the total flood loss costs by ZIP Code. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name. Also include Form AF-3, Personal Residential Standard Flood Loss Costs by ZIP Code, in a submission appendix.**

This form has been provided in excel format and within the submission appendix.

Form AF-4: Flood Output Ranges

- A.** Provide personal residential flood output ranges in the format shown in the file named "2017FormAF4.xlsx" by using an automated program or script. Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name. Also include Form AF-4, Flood Output Ranges, in a submission appendix.

A completed Form AF-4 has been provided in Excel format and within this submission appendix.

- B.** Provide flood loss costs by county, rounded to three decimal places. Within each county, flood loss costs shall be shown separately per \$1,000 of exposure for frame owners, masonry owners, frame renters, masonry renters, frame condo unit owners, masonry condo unit owners, and manufactured homes. For each of these categories using rating areas or geographic zones, the flood output range shall show the highest flood loss cost, the lowest flood loss cost, and the weighted average flood loss cost. The aggregate personal residential exposure data for this form shall be developed from the modeling-organization-specified, predetermined, and comprehensive exposure dataset except for insured values and deductibles information. Insured values shall be based on the standard flood output range specifications given below. When calculating the weighted average flood loss costs, weight the flood loss costs by the total insured value calculated above. Include the statewide range of flood loss costs (i.e., low, high, and weighted average).

Standard Flood Loss Costs per \$1000 for 0% Deductible

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Alachua	LOW	0.001	0.001	0.001	0.019	0.000	0.000	0.000
	AVERAGE	0.105	0.108	0.164	0.041	0.041	0.037	0.033
	HIGH	0.617	0.611	0.492	0.341	0.333	0.092	0.091

Baker	LOW	0.098	0.098	0.093	0.069	0.066	NA	NA
	AVERAGE	0.373	0.381	0.148	0.174	0.212	NA	NA
	HIGH	0.437	0.437	0.214	0.253	0.251	NA	NA

Bay	LOW	0.064	0.064	0.057	0.040	0.039	0.164	0.163
	AVERAGE	0.947	0.826	1.060	0.643	0.508	0.440	0.468
	HIGH	1.600	1.476	16.608	5.909	4.604	0.763	0.753

Bradford	LOW	0.039	0.039	0.047	0.031	0.031	NA	NA
	AVERAGE	0.300	0.314	0.202	0.181	0.171	NA	NA
	HIGH	0.373	0.371	0.286	0.224	0.219	NA	NA

Brevard	LOW	0.066	0.000	0.050	0.000	0.000	0.030	0.030
	AVERAGE	0.246	0.248	0.243	0.157	0.161	0.140	0.246
	HIGH	1.443	1.335	0.759	0.885	0.707	0.667	0.661

Broward	LOW	0.310	0.310	0.161	0.216	0.216	0.114	0.114
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.771	0.658	0.506	0.534	0.500	0.341	0.414
	HIGH	3.989	3.680	1.223	2.406	1.896	1.925	1.909

Calhoun	LOW	0.180	0.180	0.122	0.110	0.150	NA	NA
	AVERAGE	0.418	0.372	0.399	0.188	0.160	NA	NA
	HIGH	2.599	2.566	2.498	0.298	0.284	NA	NA

Charlotte	LOW	0.074	0.073	0.335	0.055	0.056	0.139	0.008
	AVERAGE	2.340	1.778	2.877	1.064	0.833	1.454	1.020
	HIGH	6.799	6.263	10.109	4.029	3.107	3.291	3.251

Citrus	LOW	0.043	0.043	0.023	0.024	0.025	0.052	0.029
	AVERAGE	0.687	0.363	1.008	0.252	0.193	0.380	0.300
	HIGH	2.880	2.673	4.404	1.694	1.335	1.406	1.389

Clay	LOW	0.015	0.015	0.024	0.013	0.013	0.028	0.028
	AVERAGE	0.172	0.161	0.172	0.090	0.086	0.074	0.060
	HIGH	0.320	0.317	0.266	0.186	0.181	0.220	0.172

Collier	LOW	0.181	0.181	0.095	0.115	0.118	0.157	0.083
	AVERAGE	2.226	1.910	3.537	1.053	0.887	1.375	1.296
	HIGH	17.421	16.063	24.409	10.366	7.971	8.476	8.375

Columbia	LOW	0.009	0.009	0.015	0.007	0.051	0.048	0.049
	AVERAGE	0.225	0.212	0.215	0.110	0.114	0.111	0.142
	HIGH	0.618	0.610	0.493	0.347	0.344	0.173	0.182

DeSoto	LOW	0.000	0.000	0.000	0.419	0.408	0.409	0.437
	AVERAGE	0.729	0.737	0.710	0.430	0.419	0.538	0.554
	HIGH	0.858	0.829	1.000	0.509	0.472	0.557	0.555

Dixie	LOW	0.105	0.105	0.075	0.072	0.072	7.383	8.313
	AVERAGE	9.185	6.012	14.907	1.294	0.669	8.317	8.378
	HIGH	17.229	15.989	28.128	6.793	7.838	8.418	8.911

Duval	LOW	0.000	0.051	0.031	0.000	0.036	0.015	0.015
	AVERAGE	0.284	0.324	0.212	0.168	0.280	0.154	0.416
	HIGH	4.886	4.755	1.815	2.835	2.686	3.466	3.456

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Escambia	LOW	0.090	0.089	0.071	0.054	0.052	0.033	0.034
	AVERAGE	0.453	0.409	0.649	0.294	0.277	0.385	0.748
	HIGH	1.786	1.653	2.935	1.051	0.810	0.860	0.849
Flagler	LOW	0.044	0.044	0.040	0.032	0.033	0.006	0.007
	AVERAGE	0.334	0.183	0.741	0.137	0.110	0.177	0.183
	HIGH	1.320	1.215	1.516	0.797	0.626	0.621	0.614
Franklin	LOW	1.316	1.223	1.913	0.767	0.605	0.671	0.620
	AVERAGE	3.133	2.572	4.563	1.712	1.014	1.529	1.593
	HIGH	4.081	3.741	6.236	2.372	1.355	1.959	1.932
Gadsden	LOW	0.007	0.007	0.011	0.006	0.006	NA	NA
	AVERAGE	0.263	0.279	0.172	0.163	0.169	NA	NA
	HIGH	0.387	0.382	0.312	0.225	0.219	NA	NA
Gilchrist	LOW	1.330	1.289	1.691	0.787	0.738	NA	NA
	AVERAGE	3.270	3.136	5.139	1.478	1.577	NA	NA
	HIGH	8.293	8.026	12.018	4.929	4.652	NA	NA
Glades	LOW	1.958	1.936	0.716	1.137	1.110	NA	NA
	AVERAGE	1.960	1.939	1.288	1.137	1.110	NA	NA
	HIGH	2.060	2.060	1.316	1.137	1.110	NA	NA
Gulf	LOW	1.168	1.138	1.318	0.679	0.643	1.019	1.006
	AVERAGE	1.962	1.779	2.113	1.198	0.894	1.019	1.006
	HIGH	2.142	1.971	3.336	1.246	0.940	1.019	1.006
Hamilton	LOW	0.109	0.109	0.054	0.061	0.057	NA	NA
	AVERAGE	1.448	1.497	1.943	1.123	1.075	NA	NA
	HIGH	2.392	2.305	3.839	1.452	1.365	NA	NA
Hardee	LOW	0.121	0.121	0.101	0.091	0.090	0.182	NA
	AVERAGE	0.425	0.445	0.274	0.259	0.260	0.182	NA
	HIGH	0.565	0.559	0.433	0.330	0.323	0.182	NA
Hendry	LOW	0.144	0.144	0.239	0.118	0.358	0.351	0.343

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.608	0.622	0.431	0.375	0.380	0.418	0.403
	HIGH	0.677	0.675	0.454	0.410	0.407	0.424	0.423

Hernando	LOW	0.092	0.091	0.043	0.052	0.052	0.078	0.056
	AVERAGE	0.510	0.193	0.256	0.115	0.106	0.458	0.277
	HIGH	2.141	1.981	3.307	1.270	0.990	1.029	1.020

Highlands	LOW	0.106	0.106	0.066	0.071	0.072	0.048	0.026
	AVERAGE	0.169	0.168	0.098	0.097	0.100	0.084	0.084
	HIGH	0.791	0.791	0.333	0.265	0.517	0.152	0.151

Hillsborough	LOW	0.056	0.056	0.038	0.038	0.039	0.017	0.024
	AVERAGE	0.552	0.455	0.781	0.286	0.280	0.300	0.323
	HIGH	3.420	3.205	5.261	4.023	3.170	1.717	1.697

Holmes	LOW	0.276	0.276	0.110	0.161	0.159	NA	NA
	AVERAGE	1.454	1.097	1.740	1.226	1.100	NA	NA
	HIGH	5.942	5.762	8.340	3.505	3.314	NA	NA

Indian River	LOW	0.020	0.020	0.032	0.016	0.017	0.000	0.000
	AVERAGE	0.941	1.057	0.251	0.742	0.559	0.582	0.958
	HIGH	5.157	4.707	1.539	3.064	2.344	2.475	2.447

Jackson	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.509	0.528	0.197	0.296	0.307	NA	NA
	HIGH	1.236	1.236	0.571	0.706	0.694	NA	NA

Jefferson	LOW	0.075	0.075	0.033	0.044	0.043	NA	NA
	AVERAGE	0.241	0.180	0.365	0.111	0.172	NA	NA
	HIGH	1.963	1.878	2.387	1.140	0.985	NA	NA

Lafayette	LOW	6.340	6.094	10.385	3.845	3.615	NA	NA
	AVERAGE	6.340	6.094	10.385	3.845	3.615	NA	NA
	HIGH	6.340	6.094	10.385	3.845	3.615	NA	NA

Lake	LOW	0.010	0.010	0.005	0.007	0.007	0.004	0.006
	AVERAGE	0.157	0.076	0.285	0.042	0.028	0.442	0.230
	HIGH	11.097	10.843	12.703	6.425	0.109	7.982	7.959

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Lee	LOW	0.199	0.195	0.081	0.133	0.128	0.096	0.097
	AVERAGE	2.975	1.518	3.849	0.830	0.863	1.246	1.031
	HIGH	12.110	11.169	18.800	7.168	5.508	5.951	5.844

Leon	LOW	0.030	0.030	0.014	0.018	0.017	0.019	0.019
	AVERAGE	0.230	0.274	0.338	0.182	0.300	0.364	0.421
	HIGH	1.165	1.154	0.833	0.649	0.632	0.841	0.840

Levy	LOW	0.075	0.075	0.032	0.041	0.040	3.037	2.998
	AVERAGE	1.285	0.588	0.648	0.299	0.406	3.037	2.998
	HIGH	6.207	5.760	9.815	3.650	2.838	3.037	2.998

Liberty	LOW	0.010	0.010	0.016	0.130	0.127	NA	NA
	AVERAGE	0.284	0.265	0.237	0.157	0.127	NA	NA
	HIGH	0.480	0.475	0.396	0.276	0.127	NA	NA

Madison	LOW	0.114	0.114	0.064	0.072	0.071	NA	NA
	AVERAGE	1.182	1.025	2.752	0.415	0.230	NA	NA
	HIGH	8.649	8.385	12.123	5.162	4.882	NA	NA

Manatee	LOW	0.031	0.031	0.029	0.026	0.026	0.002	0.002
	AVERAGE	1.253	0.514	0.782	0.524	0.300	0.940	0.697
	HIGH	9.096	8.426	14.503	5.424	4.201	4.421	4.367

Marion	LOW	0.000	0.000	0.000	0.013	0.013	0.019	0.011
	AVERAGE	0.087	0.095	0.050	0.057	0.059	0.050	0.094
	HIGH	0.218	0.217	0.124	0.126	0.126	0.141	0.139

Martin	LOW	0.154	0.154	0.071	0.105	0.099	0.088	0.088
	AVERAGE	0.516	0.471	0.507	0.341	0.328	0.278	0.360
	HIGH	1.636	1.506	1.715	0.974	0.767	0.814	0.806

Miami-Dade	LOW	0.073	0.071	0.222	0.053	0.049	0.000	0.003
	AVERAGE	0.768	0.743	0.502	1.558	1.147	0.679	1.168
	HIGH	11.717	10.686	14.247	6.970	5.248	5.696	5.626

Monroe	LOW	2.695	2.457	5.814	1.606	1.213	2.174	1.293
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	7.540	5.891	8.282	4.256	2.848	3.047	2.716
	HIGH	10.703	9.764	14.248	5.800	4.742	3.718	5.172

Nassau	LOW	0.173	0.171	0.185	0.107	0.113	0.386	0.385
	AVERAGE	0.509	0.473	0.243	0.289	0.279	0.386	0.385
	HIGH	0.647	0.632	0.460	0.383	0.356	0.386	0.385

Okaloosa	LOW	0.057	0.057	0.043	0.039	0.038	0.110	0.187
	AVERAGE	1.158	1.049	0.884	0.679	0.531	0.856	0.879
	HIGH	2.225	2.050	3.575	1.297	0.985	1.069	1.055

Okeechobee	LOW	0.214	0.213	0.193	0.149	0.151	0.073	0.070
	AVERAGE	0.350	0.352	0.224	0.224	0.201	0.275	0.301
	HIGH	0.447	0.445	0.232	0.258	0.256	0.302	0.302

Orange	LOW	0.010	0.000	0.017	0.000	0.000	0.000	0.000
	AVERAGE	0.135	0.154	0.083	0.091	0.095	0.084	0.091
	HIGH	0.449	0.447	0.267	0.263	0.259	0.311	0.311

Osceola	LOW	0.000	0.000	0.000	0.000	0.000	0.042	0.000
	AVERAGE	0.199	0.214	0.087	0.141	0.150	0.126	0.111
	HIGH	0.376	0.376	0.178	0.231	0.230	0.246	0.246

Palm Beach	LOW	0.178	0.178	0.063	0.111	0.110	0.086	0.074
	AVERAGE	0.398	0.421	0.212	0.305	0.319	0.233	0.256
	HIGH	2.660	2.490	0.617	1.589	1.310	1.412	1.402

Pasco	LOW	0.025	0.025	0.023	0.017	0.018	0.010	0.008
	AVERAGE	0.174	0.231	0.219	0.097	0.121	0.093	0.186
	HIGH	2.876	2.656	4.409	1.710	0.498	0.532	0.527

Pinellas	LOW	0.035	0.035	0.025	0.026	0.026	0.012	0.013
	AVERAGE	1.648	1.235	1.098	0.995	0.776	1.365	1.197
	HIGH	10.959	10.176	11.555	6.559	5.127	5.323	5.258

Polk	LOW	0.000	0.000	0.000	0.000	0.000	0.003	0.000
	AVERAGE	0.142	0.131	0.068	0.080	0.089	0.108	0.089
	HIGH	0.395	0.394	0.323	1.713	1.709	0.277	0.276

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Putnam	LOW	0.045	0.045	0.038	0.026	0.034	0.086	0.085
	AVERAGE	0.444	0.416	0.953	0.265	0.187	0.581	0.480
	HIGH	3.506	3.423	4.069	2.040	1.947	2.640	2.633
St. Johns	LOW	0.027	0.026	0.028	0.020	0.019	0.007	0.007
	AVERAGE	0.212	0.248	0.167	0.206	0.165	0.210	0.204
	HIGH	0.691	0.632	0.842	0.414	0.320	0.324	0.320
St. Lucie	LOW	0.035	0.035	0.020	0.024	0.027	0.000	0.000
	AVERAGE	0.179	0.202	0.369	0.113	0.213	0.672	1.351
	HIGH	8.524	7.792	9.457	5.093	3.922	4.078	4.033
Santa Rosa	LOW	0.110	0.110	0.127	0.090	0.089	0.205	0.253
	AVERAGE	1.193	1.188	1.770	0.774	0.649	1.206	1.397
	HIGH	3.994	3.684	6.557	2.334	1.781	1.922	1.897
Sarasota	LOW	0.035	0.035	0.046	0.029	0.029	0.001	0.001
	AVERAGE	0.618	0.331	0.459	0.238	0.278	0.471	0.582
	HIGH	6.405	5.918	10.128	3.816	2.950	3.109	3.070
Seminole	LOW	0.055	0.055	0.033	0.036	0.036	0.029	0.029
	AVERAGE	0.196	0.191	0.114	0.128	0.116	0.129	0.133
	HIGH	0.954	0.953	0.613	0.538	0.536	0.672	0.672
Sumter	LOW	0.019	0.019	0.008	0.011	0.011	0.008	0.008
	AVERAGE	0.102	0.132	0.031	0.060	0.074	0.023	0.013
	HIGH	0.271	0.268	0.045	0.162	0.159	0.033	0.033
Suwannee	LOW	0.229	0.229	0.095	0.134	0.130	NA	NA
	AVERAGE	4.540	4.371	6.630	1.806	1.219	NA	NA
	HIGH	16.431	15.879	24.772	9.860	9.292	NA	NA
Taylor	LOW	0.006	0.006	0.009	0.094	0.093	0.000	3.471
	AVERAGE	1.885	1.331	3.093	0.694	0.585	3.403	3.471
	HIGH	5.858	5.620	7.594	3.368	2.892	3.497	3.471
Union	LOW	0.000	0.000	0.000	0.042	0.042	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.199	0.198	0.077	0.112	0.095	NA	NA
	HIGH	0.210	0.210	0.079	0.123	0.121	NA	NA
Volusia	LOW	0.022	0.022	0.023	0.016	0.017	0.005	0.005
	AVERAGE	0.161	0.148	0.118	0.093	0.091	0.119	0.107
	HIGH	0.833	0.828	0.616	0.468	0.458	0.271	0.270
Wakulla	LOW	0.625	0.588	0.725	0.371	0.305	0.331	2.960
	AVERAGE	2.182	2.478	2.291	1.395	1.646	1.750	2.960
	HIGH	14.279	13.804	19.090	8.402	7.830	2.990	2.960
Walton	LOW	0.008	0.008	0.007	0.006	0.005	0.004	0.004
	AVERAGE	1.922	1.425	1.258	1.165	0.924	1.358	1.425
	HIGH	3.339	3.085	5.330	1.955	1.506	1.615	1.595
Washington	LOW	0.000	0.000	0.000	0.113	0.201	2.905	NA
	AVERAGE	0.929	0.913	1.135	0.745	0.699	2.905	NA
	HIGH	4.769	4.650	5.125	2.758	2.582	2.905	NA
Statewide	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.633	0.567	0.873	0.318	0.404	0.430	0.677
	HIGH	17.421	16.063	28.128	10.366	9.292	8.476	8.911

Table 25 - Standard Flood Loss Costs per \$1000 for 0% Deductible

Standard Flood Loss Costs per \$1000 with Specified Deductibles

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Alachua	LOW	0.000	0.000	0.001	0.006	0.000	0.000	0.000
	AVERAGE	0.090	0.093	0.156	0.026	0.026	0.035	0.031
	HIGH	0.569	0.564	0.477	0.264	0.256	0.086	0.085

Baker	LOW	0.066	0.066	0.078	0.028	0.025	NA	NA
	AVERAGE	0.311	0.317	0.130	0.099	0.125	NA	NA
	HIGH	0.368	0.367	0.193	0.154	0.153	NA	NA

Bay	LOW	0.046	0.046	0.048	0.017	0.016	0.151	0.150
	AVERAGE	0.866	0.750	1.029	0.496	0.371	0.410	0.437
	HIGH	1.475	1.354	16.248	4.713	3.518	0.714	0.704

Bradford	LOW	0.022	0.022	0.040	0.010	0.009	NA	NA
	AVERAGE	0.260	0.273	0.189	0.123	0.115	NA	NA
	HIGH	0.326	0.325	0.271	0.156	0.151	NA	NA

Brevard	LOW	0.049	0.000	0.043	0.000	0.000	0.026	0.026
	AVERAGE	0.206	0.205	0.225	0.103	0.096	0.128	0.222
	HIGH	1.240	1.135	0.736	0.575	0.426	0.602	0.596

Broward	LOW	0.221	0.221	0.137	0.095	0.095	0.097	0.097
	AVERAGE	0.615	0.512	0.451	0.303	0.271	0.306	0.373
	HIGH	3.502	3.201	1.128	1.666	1.218	1.768	1.753

Calhoun	LOW	0.143	0.143	0.108	0.060	0.089	NA	NA
	AVERAGE	0.368	0.324	0.380	0.123	0.098	NA	NA
	HIGH	2.447	2.413	2.438	0.218	0.207	NA	NA

Charlotte	LOW	0.046	0.046	0.314	0.020	0.021	0.126	0.006
	AVERAGE	2.119	1.599	2.783	0.795	0.589	1.352	0.950
	HIGH	6.180	5.657	9.773	3.033	2.210	3.059	3.019

Citrus	LOW	0.037	0.037	0.020	0.015	0.015	0.048	0.027
	AVERAGE	0.621	0.322	0.976	0.183	0.133	0.354	0.279
	HIGH	2.631	2.429	4.272	1.292	0.970	1.311	1.295

Clay	LOW	0.008	0.008	0.020	0.004	0.004	0.025	0.025
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.147	0.137	0.164	0.055	0.052	0.067	0.054
	HIGH	0.287	0.283	0.255	0.135	0.130	0.208	0.162

Collier	LOW	0.136	0.136	0.080	0.054	0.056	0.142	0.074
	AVERAGE	2.028	1.734	3.446	0.802	0.645	1.287	1.214
	HIGH	15.865	14.536	23.628	7.853	5.695	7.898	7.799

Columbia	LOW	0.005	0.005	0.013	0.002	0.029	0.044	0.045
	AVERAGE	0.194	0.182	0.203	0.070	0.073	0.103	0.132
	HIGH	0.553	0.545	0.473	0.252	0.247	0.162	0.170

DeSoto	LOW	0.000	0.000	0.000	0.298	0.287	0.385	0.411
	AVERAGE	0.649	0.658	0.683	0.310	0.300	0.511	0.527
	HIGH	0.784	0.756	0.971	0.393	0.360	0.530	0.528

Dixie	LOW	0.074	0.074	0.063	0.031	0.031	7.105	7.844
	AVERAGE	8.672	5.672	14.647	1.071	0.497	7.865	7.923
	HIGH	16.083	14.867	27.505	5.749	6.097	7.947	8.579

Duval	LOW	0.000	0.034	0.026	0.000	0.014	0.014	0.014
	AVERAGE	0.250	0.287	0.200	0.120	0.211	0.145	0.396
	HIGH	4.602	4.473	1.760	2.352	2.209	3.327	3.316

Escambia	LOW	0.065	0.065	0.066	0.029	0.029	0.030	0.031
	AVERAGE	0.405	0.362	0.627	0.213	0.195	0.361	0.703
	HIGH	1.655	1.524	2.864	0.834	0.612	0.809	0.798

Flagler	LOW	0.029	0.029	0.031	0.010	0.012	0.006	0.006
	AVERAGE	0.283	0.150	0.693	0.084	0.062	0.160	0.165
	HIGH	1.148	1.047	1.424	0.531	0.386	0.562	0.556

Franklin	LOW	1.205	1.114	1.856	0.589	0.443	0.632	0.584
	AVERAGE	2.887	2.360	4.444	1.337	0.757	1.435	1.493
	HIGH	3.759	3.425	6.064	1.837	1.018	1.830	1.803

Gadsden	LOW	0.004	0.004	0.009	0.002	0.002	NA	NA
	AVERAGE	0.231	0.245	0.162	0.111	0.115	NA	NA
	HIGH	0.349	0.345	0.301	0.167	0.161	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Gilchrist	LOW	1.239	1.199	1.656	0.639	0.593	NA	NA
	AVERAGE	3.105	2.973	5.061	1.247	1.326	NA	NA
	HIGH	7.937	7.672	11.855	4.286	4.018	NA	NA

Glades	LOW	1.655	1.655	0.610	0.801	0.774	NA	NA
	AVERAGE	1.738	1.716	1.240	0.801	0.774	NA	NA
	HIGH	1.740	1.717	1.270	0.801	0.774	NA	NA

Gulf	LOW	1.097	1.067	1.290	0.560	0.526	0.953	0.940
	AVERAGE	1.809	1.633	2.060	0.930	0.661	0.953	0.940
	HIGH	1.970	1.803	3.245	0.964	0.685	0.953	0.940

Hamilton	LOW	0.091	0.091	0.049	0.036	0.034	NA	NA
	AVERAGE	1.378	1.424	1.914	0.979	0.932	NA	NA
	HIGH	2.291	2.205	3.790	1.273	1.189	NA	NA

Hardee	LOW	0.079	0.079	0.088	0.035	0.034	0.168	NA
	AVERAGE	0.370	0.388	0.259	0.175	0.176	0.168	NA
	HIGH	0.501	0.495	0.414	0.233	0.226	0.168	NA

Hendry	LOW	0.078	0.078	0.201	0.037	0.212	0.322	0.315
	AVERAGE	0.506	0.520	0.397	0.230	0.232	0.387	0.373
	HIGH	0.574	0.572	0.417	0.259	0.256	0.393	0.393

Hernando	LOW	0.077	0.077	0.040	0.034	0.033	0.072	0.052
	AVERAGE	0.457	0.166	0.245	0.078	0.068	0.426	0.257
	HIGH	1.951	1.794	3.205	0.963	0.711	0.958	0.949

Highlands	LOW	0.068	0.068	0.057	0.030	0.032	0.042	0.022
	AVERAGE	0.128	0.126	0.084	0.046	0.047	0.075	0.075
	HIGH	0.601	0.601	0.304	0.155	0.250	0.137	0.136

Hillsborough	LOW	0.040	0.040	0.031	0.016	0.017	0.015	0.021
	AVERAGE	0.498	0.406	0.758	0.213	0.201	0.282	0.303
	HIGH	3.202	2.992	5.153	3.269	2.483	1.632	1.612

Holmes	LOW	0.224	0.224	0.096	0.088	0.086	NA	NA
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	1.349	1.005	1.702	1.010	0.895	NA	NA
	HIGH	5.659	5.481	8.210	3.001	2.816	NA	NA

Indian River	LOW	0.011	0.011	0.027	0.002	0.002	0.000	0.000
	AVERAGE	0.820	0.915	0.233	0.501	0.351	0.530	0.871
	HIGH	4.559	4.123	1.450	2.119	1.499	2.255	2.228

Jackson	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.425	0.442	0.177	0.174	0.181	NA	NA
	HIGH	1.067	1.061	0.541	0.462	0.451	NA	NA

Jefferson	LOW	0.062	0.062	0.029	0.026	0.025	NA	NA
	AVERAGE	0.215	0.158	0.353	0.077	0.121	NA	NA
	HIGH	1.798	1.715	2.321	0.872	0.730	NA	NA

Lafayette	LOW	6.107	5.863	10.271	3.428	3.202	NA	NA
	AVERAGE	6.107	5.863	10.271	3.428	3.202	NA	NA
	HIGH	6.107	5.863	10.271	3.428	3.202	NA	NA

Lake	LOW	0.007	0.007	0.005	0.003	0.003	0.004	0.006
	AVERAGE	0.142	0.066	0.277	0.027	0.016	0.423	0.219
	HIGH	10.436	10.183	12.465	5.294	0.072	7.647	7.625

Lee	LOW	0.154	0.150	0.067	0.069	0.065	0.085	0.086
	AVERAGE	2.698	1.354	3.727	0.605	0.604	1.158	0.957
	HIGH	11.148	10.228	18.277	5.584	4.083	5.565	5.463

Leon	LOW	0.025	0.024	0.012	0.010	0.010	0.016	0.017
	AVERAGE	0.202	0.242	0.325	0.129	0.218	0.342	0.396
	HIGH	1.062	1.051	0.806	0.488	0.472	0.793	0.792

Levy	LOW	0.060	0.060	0.028	0.022	0.021	2.861	2.823
	AVERAGE	1.180	0.531	0.627	0.224	0.299	2.861	2.823
	HIGH	5.770	5.332	9.582	2.922	2.180	2.861	2.823

Liberty	LOW	0.005	0.005	0.014	0.080	0.077	NA	NA
	AVERAGE	0.248	0.230	0.225	0.106	0.077	NA	NA
	HIGH	0.443	0.439	0.383	0.216	0.077	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Madison	LOW	0.091	0.090	0.057	0.039	0.038	NA	NA
	AVERAGE	1.113	0.962	2.708	0.339	0.177	NA	NA
	HIGH	8.245	7.983	11.944	4.441	4.169	NA	NA
Manatee	LOW	0.017	0.017	0.024	0.009	0.009	0.002	0.002
	AVERAGE	1.145	0.461	0.757	0.398	0.213	0.881	0.652
	HIGH	8.374	7.718	14.105	4.242	3.134	4.145	4.091
Marion	LOW	0.000	0.000	0.000	0.006	0.006	0.018	0.010
	AVERAGE	0.072	0.080	0.045	0.035	0.036	0.045	0.086
	HIGH	0.184	0.183	0.114	0.078	0.077	0.130	0.129
Martin	LOW	0.113	0.113	0.060	0.047	0.048	0.078	0.078
	AVERAGE	0.440	0.398	0.474	0.210	0.196	0.251	0.325
	HIGH	1.439	1.313	1.618	0.664	0.486	0.742	0.734
Miami-Dade	LOW	0.051	0.049	0.180	0.025	0.022	0.000	0.002
	AVERAGE	0.594	0.569	0.426	1.054	0.713	0.620	1.071
	HIGH	10.546	9.542	13.629	5.102	3.576	5.262	5.194
Monroe	LOW	2.412	2.180	5.568	1.160	0.814	2.001	1.190
	AVERAGE	6.830	5.284	7.960	3.153	1.961	2.816	2.506
	HIGH	9.724	8.809	13.735	4.322	3.322	3.439	4.789
Nassau	LOW	0.132	0.130	0.165	0.056	0.059	0.354	0.352
	AVERAGE	0.425	0.391	0.218	0.174	0.163	0.354	0.352
	HIGH	0.549	0.534	0.429	0.239	0.215	0.354	0.352
Okaloosa	LOW	0.040	0.040	0.036	0.017	0.016	0.102	0.174
	AVERAGE	1.066	0.960	0.857	0.528	0.394	0.802	0.823
	HIGH	2.057	1.886	3.485	1.019	0.735	1.002	0.989
Okeechobee	LOW	0.153	0.152	0.168	0.067	0.069	0.064	0.062
	AVERAGE	0.287	0.289	0.207	0.134	0.113	0.253	0.278
	HIGH	0.383	0.381	0.216	0.164	0.162	0.279	0.279
Orange	LOW	0.005	0.000	0.014	0.000	0.000	0.000	0.000

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.106	0.121	0.072	0.047	0.051	0.076	0.083
	HIGH	0.394	0.392	0.253	0.180	0.176	0.290	0.289

Osceola	LOW	0.000	0.000	0.000	0.000	0.000	0.037	0.000
	AVERAGE	0.157	0.168	0.076	0.078	0.081	0.113	0.100
	HIGH	0.311	0.310	0.162	0.134	0.134	0.223	0.223

Palm Beach	LOW	0.132	0.132	0.053	0.058	0.057	0.072	0.063
	AVERAGE	0.320	0.332	0.188	0.168	0.171	0.207	0.228
	HIGH	2.314	2.148	0.571	1.063	0.820	1.286	1.276

Pasco	LOW	0.017	0.017	0.019	0.007	0.007	0.008	0.007
	AVERAGE	0.147	0.198	0.207	0.060	0.075	0.085	0.172
	HIGH	2.628	2.413	4.273	1.309	0.354	0.495	0.490

Pinellas	LOW	0.024	0.024	0.021	0.010	0.011	0.010	0.011
	AVERAGE	1.517	1.129	1.066	0.789	0.584	1.280	1.123
	HIGH	10.088	9.323	11.285	5.133	3.835	4.989	4.925

Polk	LOW	0.000	0.000	0.000	0.000	0.000	0.002	0.000
	AVERAGE	0.119	0.109	0.062	0.048	0.053	0.100	0.082
	HIGH	0.354	0.349	0.313	1.046	1.042	0.262	0.262

Putnam	LOW	0.033	0.033	0.033	0.012	0.020	0.081	0.081
	AVERAGE	0.403	0.375	0.931	0.198	0.132	0.553	0.457
	HIGH	3.283	3.200	3.990	1.668	1.578	2.529	2.521

St. Johns	LOW	0.018	0.017	0.024	0.008	0.007	0.006	0.006
	AVERAGE	0.180	0.210	0.154	0.136	0.100	0.191	0.185
	HIGH	0.606	0.548	0.797	0.283	0.201	0.295	0.291

St. Lucie	LOW	0.019	0.019	0.015	0.005	0.007	0.000	0.000
	AVERAGE	0.141	0.160	0.341	0.061	0.122	0.610	1.227
	HIGH	7.498	6.789	8.919	3.480	2.477	3.706	3.662

Santa Rosa	LOW	0.064	0.064	0.107	0.031	0.030	0.190	0.235
	AVERAGE	1.092	1.085	1.720	0.597	0.480	1.132	1.310
	HIGH	3.697	3.393	6.395	1.843	1.338	1.806	1.781

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Sarasota	LOW	0.019	0.019	0.039	0.009	0.009	0.000	0.001
	AVERAGE	0.552	0.286	0.437	0.167	0.190	0.439	0.542
	HIGH	5.872	5.397	9.831	2.948	2.168	2.906	2.868
Seminole	LOW	0.042	0.042	0.029	0.018	0.018	0.026	0.026
	AVERAGE	0.165	0.160	0.106	0.078	0.070	0.118	0.121
	HIGH	0.815	0.814	0.589	0.336	0.329	0.614	0.614
Sumter	LOW	0.014	0.014	0.007	0.005	0.005	0.007	0.007
	AVERAGE	0.087	0.114	0.027	0.038	0.048	0.021	0.012
	HIGH	0.238	0.235	0.041	0.113	0.110	0.030	0.031
Suwannee	LOW	0.192	0.192	0.084	0.082	0.078	NA	NA
	AVERAGE	4.343	4.177	6.543	1.555	1.022	NA	NA
	HIGH	15.786	15.239	24.456	8.683	8.132	NA	NA
Taylor	LOW	0.003	0.003	0.008	0.048	0.048	0.000	3.290
	AVERAGE	1.744	1.222	3.021	0.540	0.438	3.227	3.290
	HIGH	5.462	5.228	7.425	2.702	2.263	3.315	3.290
Union	LOW	0.000	0.000	0.000	0.015	0.015	NA	NA
	AVERAGE	0.162	0.162	0.067	0.061	0.050	NA	NA
	HIGH	0.172	0.172	0.069	0.068	0.067	NA	NA
Volusia	LOW	0.014	0.014	0.019	0.006	0.006	0.004	0.004
	AVERAGE	0.134	0.123	0.109	0.054	0.054	0.107	0.097
	HIGH	0.761	0.756	0.593	0.352	0.343	0.256	0.256
Wakulla	LOW	0.551	0.515	0.695	0.260	0.200	0.306	2.786
	AVERAGE	2.025	2.303	2.234	1.122	1.294	1.645	2.786
	HIGH	13.554	13.083	18.775	7.128	6.582	2.816	2.786
Walton	LOW	0.006	0.006	0.006	0.003	0.002	0.003	0.003
	AVERAGE	1.762	1.297	1.220	0.897	0.672	1.268	1.330
	HIGH	3.064	2.816	5.188	1.506	1.097	1.508	1.488
Washington	LOW	0.000	0.000	0.000	0.067	0.109	2.802	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.832	0.816	1.099	0.564	0.519	2.802	NA
	HIGH	4.449	4.331	5.000	2.214	2.050	2.802	NA
Statewide	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.569	0.484	0.844	0.228	0.262	0.400	0.626
	HIGH	16.083	15.239	27.505	8.683	8.132	7.947	8.579

Figure 74 - Standard Flood Loss Costs per \$1000 with Specified Deductibles

Standard Flood Loss Costs per \$1000 for 0% Deductible, Time Element

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Alachua	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.031	0.033	0.047	0.007	0.007	0.007	0.006
	HIGH	0.259	0.255	0.155	0.112	0.106	0.021	0.012

Baker	LOW	0.007	0.007	0.001	0.001	0.000	NA	NA
	AVERAGE	0.090	0.092	0.014	0.017	0.003	NA	NA
	HIGH	0.113	0.113	0.030	0.035	0.015	NA	NA

Bay	LOW	0.007	0.007	0.000	0.035	0.000	0.025	0.025
	AVERAGE	0.416	0.349	0.399	0.198	0.138	0.089	0.095
	HIGH	0.739	0.663	7.050	1.953	1.292	0.342	0.159

Bradford	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.097	0.102	0.059	0.072	0.124	NA	NA
	HIGH	0.125	0.124	0.072	0.073	0.124	NA	NA

Brevard	LOW	0.002	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.062	0.052	0.038	0.028	0.016	0.019	0.026
	HIGH	0.378	0.346	0.240	0.138	0.129	0.148	0.148

Broward	LOW	0.006	0.010	0.000	0.000	0.003	0.000	0.000
	AVERAGE	0.137	0.097	0.042	0.052	0.030	0.027	0.036
	HIGH	1.243	1.033	0.166	0.322	0.202	0.174	0.228

Calhoun	LOW	0.038	0.038	0.012	0.000	0.008	NA	NA
	AVERAGE	0.147	0.124	0.106	0.071	0.008	NA	NA
	HIGH	1.230	1.206	0.801	0.390	0.008	NA	NA

Charlotte	LOW	0.003	0.002	0.113	0.000	0.000	0.015	0.000
	AVERAGE	0.950	0.691	1.023	0.225	0.179	0.276	0.194
	HIGH	2.740	2.401	3.848	2.133	0.694	0.595	0.581

Citrus	LOW	0.004	0.004	0.000	0.000	0.000	0.006	0.000
	AVERAGE	0.277	0.128	0.372	0.058	0.034	0.075	0.055
	HIGH	1.229	1.097	1.636	0.781	0.318	0.296	0.279

Clay	LOW	0.000	0.000	0.000	0.000	0.000	0.002	0.000
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.049	0.043	0.054	0.011	0.007	0.006	0.005
	HIGH	0.125	0.121	0.089	0.039	0.014	0.028	0.009

Collier	LOW	0.017	0.017	0.012	0.000	0.001	0.000	0.016
	AVERAGE	0.947	0.789	1.413	0.296	0.209	0.287	0.272
	HIGH	7.214	6.342	8.580	2.990	1.719	1.591	1.553

Columbia	LOW	0.000	0.000	0.000	0.000	0.002	NA	0.003
	AVERAGE	0.068	0.062	0.055	0.016	0.012	NA	0.025
	HIGH	0.228	0.223	0.142	0.024	0.156	NA	0.026

DeSoto	LOW	0.000	0.000	0.000	0.003	0.076	0.179	0.000
	AVERAGE	0.284	0.289	0.237	0.045	0.091	0.179	0.159
	HIGH	0.379	0.358	0.345	0.049	0.155	0.179	0.159

Dixie	LOW	0.009	0.009	0.001	0.001	0.001	2.087	2.196
	AVERAGE	4.860	3.147	6.349	0.085	0.132	2.113	2.196
	HIGH	8.535	8.196	12.593	8.119	4.625	3.740	2.196

Duval	LOW	0.000	0.002	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.102	0.118	0.052	0.040	0.077	0.036	0.116
	HIGH	2.452	2.340	0.341	1.014	0.931	1.095	1.088

Escambia	LOW	0.012	0.012	0.000	0.000	0.000	0.007	0.000
	AVERAGE	0.181	0.156	0.238	0.074	0.063	0.084	0.175
	HIGH	0.848	0.762	1.194	0.347	0.225	0.198	0.194

Flagler	LOW	0.002	0.002	0.000	0.002	0.001	0.003	0.000
	AVERAGE	0.087	0.039	0.122	0.017	0.008	0.018	0.019
	HIGH	0.375	0.310	0.254	0.180	0.061	0.067	0.065

Franklin	LOW	0.581	0.520	0.645	0.321	0.035	0.197	0.336
	AVERAGE	1.388	1.110	1.724	0.622	0.035	0.326	0.374
	HIGH	1.786	1.584	2.317	0.988	0.035	0.400	0.445

Gadsden	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.088	0.093	0.045	0.033	0.040	NA	NA
	HIGH	0.152	0.149	0.092	0.057	0.063	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Gilchrist	LOW	0.657	0.622	0.686	0.228	0.262	NA	NA
	AVERAGE	1.793	1.681	2.207	0.517	0.521	NA	NA
	HIGH	4.734	4.487	5.241	4.988	2.988	NA	NA

Glades	LOW	0.330	0.330	0.021	0.265	0.207	NA	NA
	AVERAGE	0.605	0.587	0.413	0.265	0.207	NA	NA
	HIGH	0.611	0.593	0.432	0.265	0.207	NA	NA

Gulf	LOW	0.562	0.539	0.462	0.000	0.000	0.205	0.203
	AVERAGE	0.882	0.775	0.773	0.386	0.224	0.205	0.203
	HIGH	0.954	0.846	1.268	0.386	0.224	0.205	0.203

Hamilton	LOW	0.025	0.025	0.009	0.000	0.000	NA	NA
	AVERAGE	0.846	0.867	0.889	0.399	0.000	NA	NA
	HIGH	1.463	1.379	1.800	0.399	0.000	NA	NA

Hardee	LOW	0.003	0.003	0.000	0.000	0.000	NA	NA
	AVERAGE	0.138	0.145	0.079	0.015	0.039	NA	NA
	HIGH	0.203	0.197	0.135	0.021	0.049	NA	NA

Hendry	LOW	0.000	0.000	0.000	0.000	0.054	0.086	0.065
	AVERAGE	0.161	0.168	0.083	0.133	0.083	0.086	0.078
	HIGH	0.198	0.197	0.084	0.172	0.124	0.086	0.081

Hernando	LOW	0.020	0.019	0.004	0.000	0.001	0.020	0.000
	AVERAGE	0.194	0.055	0.081	0.010	0.012	0.073	0.052
	HIGH	0.894	0.792	1.200	0.265	0.200	0.148	0.193

Highlands	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.018	0.017	0.004	0.002	0.002	0.000	0.005
	HIGH	0.091	0.089	0.059	0.042	0.026	0.001	0.010

Hillsborough	LOW	0.002	0.002	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.238	0.183	0.320	0.083	0.070	0.068	0.073
	HIGH	1.780	1.637	2.342	1.471	1.017	0.466	0.460

Holmes	LOW	0.054	0.053	0.008	0.009	0.000	NA	NA
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.691	0.480	0.686	0.496	5.852	NA	NA
	HIGH	3.227	3.063	3.446	1.268	5.852	NA	NA

Indian River	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.273	0.282	0.095	0.164	0.055	0.065	0.105
	HIGH	1.601	1.319	0.273	0.599	0.252	0.287	0.279

Jackson	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.102	0.107	0.028	0.021	0.012	NA	NA
	HIGH	0.302	0.296	0.147	0.345	0.021	NA	NA

Jefferson	LOW	0.015	0.015	0.004	0.002	0.001	NA	NA
	AVERAGE	0.088	0.060	0.132	0.014	0.032	NA	NA
	HIGH	0.846	0.791	0.914	0.380	0.292	NA	NA

Lafayette	LOW	4.056	3.821	5.119	0.658	0.644	NA	NA
	AVERAGE	4.056	3.821	5.119	0.658	0.644	NA	NA
	HIGH	4.056	3.821	5.119	0.658	0.644	NA	NA

Lake	LOW	0.002	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.065	0.026	0.102	0.005	0.003	0.158	0.067
	HIGH	5.369	5.149	4.850	3.181	0.006	2.466	2.451

Lee	LOW	0.012	0.012	0.000	0.000	0.002	0.000	0.003
	AVERAGE	1.202	0.556	1.379	0.196	0.177	0.229	0.185
	HIGH	5.348	4.747	7.058	2.401	2.056	0.781	1.199

Leon	LOW	0.003	0.003	0.000	0.000	0.000	0.001	0.000
	AVERAGE	0.076	0.094	0.114	0.039	0.070	0.076	0.093
	HIGH	0.454	0.445	0.337	0.161	0.152	0.184	0.182

Levy	LOW	0.013	0.013	0.002	0.000	0.000	0.727	0.794
	AVERAGE	0.578	0.238	0.246	0.061	0.091	0.727	0.794
	HIGH	2.993	2.704	4.040	0.424	0.970	0.727	0.794

Liberty	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.103	0.093	0.073	0.001	0.000	NA	NA
	HIGH	0.210	0.207	0.124	0.001	0.000	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Madison	LOW	0.021	0.020	0.008	0.000	0.000	NA	NA
	AVERAGE	0.626	0.527	1.164	0.176	0.003	NA	NA
	HIGH	4.818	4.580	5.193	3.357	0.003	NA	NA

Manatee	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.550	0.205	0.284	0.149	0.067	0.205	0.146
	HIGH	4.099	3.668	5.789	1.786	1.102	0.963	0.942

Marion	LOW	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	AVERAGE	0.019	0.022	0.009	0.006	0.006	0.006	0.011
	HIGH	0.057	0.056	0.031	0.013	0.012	0.017	0.014

Martin	LOW	0.006	0.006	0.000	0.000	0.000	0.004	0.004
	AVERAGE	0.124	0.100	0.078	0.032	0.024	0.025	0.032
	HIGH	0.488	0.406	0.297	0.136	0.077	0.091	0.090

Miami-Dade	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.134	0.121	0.003	0.403	0.135	0.101	0.149
	HIGH	4.381	3.597	0.009	1.565	0.791	0.985	0.811

Monroe	LOW	0.910	0.758	1.518	0.311	0.151	0.327	0.165
	AVERAGE	2.840	2.039	2.314	1.067	0.454	0.466	0.396
	HIGH	4.155	3.560	4.277	1.399	0.820	0.592	0.824

Nassau	LOW	0.037	0.036	0.024	0.011	0.000	0.049	0.048
	AVERAGE	0.123	0.108	0.034	0.033	0.026	0.049	0.048
	HIGH	0.168	0.159	0.103	0.049	0.040	0.049	0.048

Okaloosa	LOW	0.004	0.004	0.000	0.000	0.003	0.000	0.034
	AVERAGE	0.520	0.455	0.295	0.210	0.133	0.186	0.187
	HIGH	1.023	0.912	1.866	0.412	0.279	0.231	0.328

Okeechobee	LOW	0.026	0.026	0.014	0.030	0.008	0.026	0.046
	AVERAGE	0.079	0.080	0.045	0.032	0.025	0.026	0.046
	HIGH	0.118	0.116	0.052	0.056	0.045	0.026	0.046

Orange	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.023	0.027	0.007	0.006	0.007	0.010	0.012
	HIGH	0.138	0.136	0.130	0.050	0.047	0.055	0.055

Osceola	LOW	0.000	0.000	0.000	0.000	0.000	0.001	0.000
	AVERAGE	0.023	0.023	0.007	0.010	0.009	0.009	0.008
	HIGH	0.073	0.072	0.030	0.029	0.023	0.027	0.026

Palm Beach	LOW	0.005	0.005	0.000	0.000	0.000	0.000	0.001
	AVERAGE	0.066	0.059	0.019	0.021	0.017	0.016	0.018
	HIGH	0.728	0.619	0.107	0.237	0.130	0.165	0.160

Pasco	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.050	0.070	0.064	0.012	0.017	0.014	0.031
	HIGH	1.223	1.083	1.673	0.514	0.108	0.134	0.097

Pinellas	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.753	0.541	0.418	0.331	0.212	0.309	0.266
	HIGH	4.964	4.463	8.226	2.066	1.370	1.193	1.168

Polk	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.033	0.028	0.014	0.008	0.007	0.016	0.012
	HIGH	0.160	0.156	0.106	0.124	0.122	0.036	0.037

Putnam	LOW	0.008	0.008	0.000	0.000	0.000	0.118	0.045
	AVERAGE	0.186	0.166	0.360	0.078	0.033	0.147	0.123
	HIGH	1.707	1.633	1.592	0.974	0.170	0.224	0.224

St. Johns	LOW	0.002	0.002	0.001	0.000	0.000	0.000	0.000
	AVERAGE	0.059	0.060	0.025	0.035	0.017	0.024	0.021
	HIGH	0.213	0.177	0.100	0.075	0.036	0.039	0.038

St. Lucie	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.036	0.040	0.070	0.007	0.017	0.099	0.150
	HIGH	2.549	2.089	1.628	1.806	0.390	0.451	0.436

Santa Rosa	LOW	0.001	0.000	0.000	0.000	0.000	0.049	0.048
	AVERAGE	0.530	0.515	0.634	0.224	0.155	0.266	0.305
	HIGH	1.860	1.664	1.373	0.753	0.507	0.426	0.416

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Sarasota	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.238	0.109	0.138	0.053	0.055	0.091	0.112
	HIGH	2.782	2.471	3.766	1.107	0.711	0.636	0.622

Seminole	LOW	0.008	0.008	0.000	0.001	0.001	0.003	0.003
	AVERAGE	0.046	0.043	0.024	0.015	0.012	0.015	0.016
	HIGH	0.317	0.311	0.179	0.133	0.096	0.077	0.076

Sumter	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.027	0.038	0.005	0.009	0.012	0.001	0.001
	HIGH	0.087	0.085	0.010	0.033	0.031	0.001	0.001

Suwannee	LOW	0.060	0.059	0.009	0.000	0.009	NA	NA
	AVERAGE	2.700	2.550	3.076	0.642	0.043	NA	NA
	HIGH	9.905	9.390	11.338	8.020	0.213	NA	NA

Taylor	LOW	0.000	0.000	0.000	0.000	0.000	0.000	1.240
	AVERAGE	0.882	0.602	1.285	0.269	0.609	0.887	1.240
	HIGH	2.767	2.610	3.077	0.588	0.609	0.887	1.240

Union	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.044	0.044	0.006	0.016	0.000	NA	NA
	HIGH	0.048	0.048	0.006	0.016	0.000	NA	NA

Volusia	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.038	0.034	0.020	0.010	0.010	0.012	0.009
	HIGH	0.325	0.322	0.172	0.203	0.229	0.063	0.073

Wakulla	LOW	0.204	0.177	0.165	0.090	0.005	0.590	0.693
	AVERAGE	1.031	1.173	0.864	0.342	0.728	0.590	0.693
	HIGH	7.644	7.246	8.058	2.146	0.918	0.590	0.693

Walton	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.838	0.592	0.468	0.365	0.273	0.276	0.287
	HIGH	1.467	1.307	2.095	0.588	0.345	0.329	0.321

Washington	LOW	0.000	0.000	0.000	0.000	0.001	1.805	NA
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.336	0.324	0.365	0.354	0.536	1.805	NA
	HIGH	2.158	2.075	1.756	1.777	2.537	1.805	NA
Statewide	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.251	0.171	0.317	0.076	0.064	0.083	0.113
	HIGH	9.905	9.390	12.593	8.119	5.852	3.740	2.451

Figure 75 - Standard Flood Loss Costs per \$1000 for 0% Deductible, Time Element

Standard Flood Loss Costs per \$1000 with Specified Deductibles, Time Element

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Alachua	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.027	0.028	0.042	0.006	0.005	0.006	0.005
	HIGH	0.228	0.224	0.138	0.093	0.088	0.017	0.010

Baker	LOW	0.005	0.005	0.000	0.000	0.000	NA	NA
	AVERAGE	0.074	0.076	0.012	0.013	0.001	NA	NA
	HIGH	0.095	0.094	0.025	0.027	0.009	NA	NA

Bay	LOW	0.006	0.006	0.000	0.029	0.000	0.020	0.020
	AVERAGE	0.377	0.316	0.378	0.171	0.117	0.073	0.078
	HIGH	0.673	0.603	6.723	1.696	1.109	0.275	0.130

Bradford	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.086	0.090	0.053	0.060	0.104	NA	NA
	HIGH	0.111	0.110	0.064	0.062	0.104	NA	NA

Brevard	LOW	0.001	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.053	0.044	0.033	0.023	0.012	0.015	0.020
	HIGH	0.321	0.308	0.218	0.117	0.108	0.124	0.123

Broward	LOW	0.003	0.005	0.000	0.000	0.001	0.000	0.000
	AVERAGE	0.114	0.079	0.037	0.041	0.022	0.019	0.026
	HIGH	1.081	0.892	0.150	0.261	0.157	0.134	0.174

Calhoun	LOW	0.032	0.032	0.011	0.000	0.006	NA	NA
	AVERAGE	0.131	0.110	0.095	0.060	0.006	NA	NA
	HIGH	1.114	1.090	0.719	0.334	0.006	NA	NA

Charlotte	LOW	0.002	0.002	0.105	0.000	0.000	0.012	0.000
	AVERAGE	0.856	0.623	0.969	0.193	0.151	0.225	0.159
	HIGH	2.462	2.153	3.629	1.816	0.581	0.485	0.472

Citrus	LOW	0.003	0.003	0.000	0.000	0.000	0.005	0.000
	AVERAGE	0.250	0.115	0.352	0.049	0.029	0.062	0.045
	HIGH	1.113	0.993	1.552	0.672	0.271	0.245	0.230

Clay	LOW	0.000	0.000	0.000	0.000	0.000	0.001	0.000
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.043	0.037	0.049	0.008	0.005	0.005	0.004
	HIGH	0.111	0.108	0.082	0.033	0.011	0.023	0.007

Collier	LOW	0.013	0.013	0.009	0.000	0.001	0.000	0.012
	AVERAGE	0.859	0.715	1.345	0.257	0.179	0.239	0.227
	HIGH	6.493	5.683	8.111	2.589	1.449	1.300	1.267

Columbia	LOW	0.000	0.000	0.000	0.000	0.002	NA	0.001
	AVERAGE	0.058	0.053	0.050	0.013	0.009	NA	0.018
	HIGH	0.202	0.197	0.129	0.020	0.131	NA	0.019

DeSoto	LOW	0.000	0.000	0.000	0.002	0.065	0.155	0.000
	AVERAGE	0.256	0.260	0.221	0.037	0.077	0.155	0.137
	HIGH	0.346	0.325	0.322	0.040	0.133	0.155	0.137

Dixie	LOW	0.007	0.007	0.001	0.000	0.001	1.768	1.857
	AVERAGE	4.509	2.918	6.040	0.074	0.115	1.792	1.857
	HIGH	7.840	7.510	12.024	7.182	4.027	3.274	1.857

Duval	LOW	0.000	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.092	0.106	0.048	0.035	0.066	0.031	0.101
	HIGH	2.254	2.144	0.315	0.889	0.810	0.958	0.951

Escambia	LOW	0.010	0.010	0.000	0.000	0.000	0.005	0.000
	AVERAGE	0.163	0.140	0.225	0.063	0.053	0.070	0.146
	HIGH	0.774	0.694	1.137	0.301	0.193	0.165	0.162

Flagler	LOW	0.002	0.002	0.000	0.002	0.001	0.003	0.000
	AVERAGE	0.074	0.033	0.109	0.014	0.006	0.014	0.014
	HIGH	0.320	0.262	0.225	0.143	0.045	0.050	0.048

Franklin	LOW	0.526	0.469	0.609	0.275	0.029	0.164	0.275
	AVERAGE	1.253	1.000	1.633	0.532	0.029	0.267	0.305
	HIGH	1.609	1.420	2.190	0.841	0.029	0.323	0.359

Gadsden	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.076	0.085	0.040	0.028	0.033	NA	NA
	HIGH	0.136	0.132	0.083	0.048	0.053	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Gilchrist	LOW	0.608	0.574	0.650	0.202	0.230	NA	NA
	AVERAGE	1.677	1.568	2.099	0.458	0.454	NA	NA
	HIGH	4.445	4.200	4.990	4.419	2.589	NA	NA

Glades	LOW	0.253	0.253	0.015	0.227	0.176	NA	NA
	AVERAGE	0.530	0.513	0.381	0.227	0.176	NA	NA
	HIGH	0.537	0.519	0.399	0.227	0.176	NA	NA

Gulf	LOW	0.514	0.492	0.428	0.000	0.000	0.167	0.164
	AVERAGE	0.798	0.699	0.726	0.329	0.186	0.167	0.164
	HIGH	0.862	0.761	1.202	0.329	0.186	0.167	0.164

Hamilton	LOW	0.020	0.020	0.008	0.000	0.000	NA	NA
	AVERAGE	0.799	0.818	0.853	0.365	0.000	NA	NA
	HIGH	1.390	1.306	1.730	0.365	0.000	NA	NA

Hardee	LOW	0.002	0.002	0.000	0.000	0.000	NA	NA
	AVERAGE	0.122	0.128	0.073	0.016	0.033	NA	NA
	HIGH	0.180	0.174	0.124	0.017	0.041	NA	NA

Hendry	LOW	0.000	0.000	0.000	0.000	0.045	0.069	0.054
	AVERAGE	0.140	0.145	0.072	0.108	0.067	0.069	0.063
	HIGH	0.171	0.170	0.076	0.139	0.100	0.069	0.065

Hernando	LOW	0.015	0.015	0.004	0.000	0.000	0.016	0.000
	AVERAGE	0.174	0.048	0.076	0.008	0.010	0.059	0.042
	HIGH	0.809	0.716	1.137	0.227	0.169	0.121	0.159

Highlands	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.014	0.013	0.003	0.002	0.001	0.000	0.003
	HIGH	0.079	0.077	0.054	0.035	0.022	0.000	0.006

Hillsborough	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.218	0.167	0.305	0.073	0.062	0.058	0.062
	HIGH	1.654	1.519	2.247	1.306	0.897	0.404	0.398

Holmes	LOW	0.043	0.043	0.006	0.007	0.000	NA	NA
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.633	0.435	0.647	0.430	4.890	NA	NA
	HIGH	3.001	2.840	3.256	1.108	4.890	NA	NA

Indian River	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.231	0.238	0.085	0.130	0.066	0.067	0.078
	HIGH	1.373	1.122	0.243	0.479	0.191	0.215	0.209

Jackson	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.082	0.086	0.024	0.015	0.009	NA	NA
	HIGH	0.254	0.248	0.133	0.289	0.016	NA	NA

Jefferson	LOW	0.012	0.012	0.004	0.001	0.001	NA	NA
	AVERAGE	0.078	0.053	0.124	0.012	0.026	NA	NA
	HIGH	0.761	0.709	0.859	0.321	0.242	NA	NA

Lafayette	LOW	3.867	3.634	4.939	0.590	0.572	NA	NA
	AVERAGE	3.867	3.634	4.939	0.590	0.572	NA	NA
	HIGH	3.867	3.634	4.939	0.590	0.572	NA	NA

Lake	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.059	0.023	0.095	0.005	0.002	0.137	0.058
	HIGH	4.911	4.694	4.523	2.763	0.004	2.137	2.122

Lee	LOW	0.008	0.008	0.000	0.000	0.001	0.000	0.002
	AVERAGE	1.083	0.498	1.304	0.168	0.149	0.187	0.152
	HIGH	4.854	4.304	6.692	2.076	1.757	0.643	0.995

Leon	LOW	0.002	0.002	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.067	0.083	0.107	0.032	0.058	0.062	0.075
	HIGH	0.400	0.392	0.320	0.134	0.126	0.165	0.148

Levy	LOW	0.010	0.010	0.001	0.000	0.000	0.615	0.670
	AVERAGE	0.527	0.215	0.233	0.056	0.080	0.615	0.670
	HIGH	2.743	2.472	3.853	0.371	0.844	0.615	0.670

Liberty	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.092	0.082	0.066	0.000	0.000	NA	NA
	HIGH	0.188	0.185	0.111	0.000	0.000	NA	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
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Madison	LOW	0.017	0.017	0.007	0.000	0.000	NA	NA
	AVERAGE	0.584	0.490	1.104	0.157	0.002	NA	NA
	HIGH	4.508	4.273	4.928	3.004	0.002	NA	NA

Manatee	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.501	0.186	0.270	0.129	0.057	0.171	0.122
	HIGH	3.734	3.336	5.507	1.552	0.948	0.806	0.787

Marion	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.016	0.018	0.008	0.005	0.005	0.005	0.008
	HIGH	0.049	0.048	0.029	0.010	0.010	0.013	0.011

Martin	LOW	0.004	0.004	0.000	0.000	0.000	0.002	0.003
	AVERAGE	0.104	0.083	0.068	0.024	0.018	0.019	0.023
	HIGH	0.417	0.344	0.264	0.108	0.058	0.068	0.068

Miami-Dade	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.114	0.102	0.002	0.334	0.108	0.081	0.116
	HIGH	3.865	3.152	0.007	1.300	0.634	0.776	0.636

Monroe	LOW	0.795	0.657	1.403	0.256	0.118	0.255	0.127
	AVERAGE	2.512	1.793	2.146	0.888	0.365	0.367	0.311
	HIGH	3.689	3.147	3.987	1.167	0.668	0.472	0.654

Nassau	LOW	0.033	0.032	0.018	0.008	0.000	0.037	0.036
	AVERAGE	0.104	0.090	0.030	0.026	0.022	0.037	0.036
	HIGH	0.142	0.134	0.094	0.039	0.029	0.037	0.036

Okaloosa	LOW	0.003	0.003	0.000	0.000	0.001	0.000	0.027
	AVERAGE	0.472	0.412	0.276	0.181	0.112	0.153	0.153
	HIGH	0.929	0.826	1.774	0.354	0.239	0.190	0.273

Okeechobee	LOW	0.022	0.022	0.012	0.023	0.006	0.019	0.036
	AVERAGE	0.067	0.067	0.040	0.025	0.020	0.019	0.036
	HIGH	0.100	0.098	0.046	0.046	0.036	0.019	0.036

Orange	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.019	0.022	0.006	0.005	0.006	0.008	0.010
	HIGH	0.120	0.118	0.115	0.041	0.039	0.044	0.044

Osceola	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.017	0.017	0.006	0.007	0.006	0.007	0.006
	HIGH	0.060	0.060	0.026	0.023	0.018	0.021	0.020

Palm Beach	LOW	0.002	0.002	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.054	0.048	0.017	0.016	0.012	0.011	0.013
	HIGH	0.621	0.523	0.096	0.190	0.099	0.124	0.121

Pasco	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.044	0.062	0.060	0.010	0.014	0.011	0.025
	HIGH	1.105	0.976	1.585	0.441	0.091	0.110	0.079

Pinellas	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.689	0.494	0.397	0.291	0.184	0.261	0.223
	HIGH	4.536	4.076	7.869	1.804	1.184	1.006	0.983

Polk	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.027	0.023	0.012	0.006	0.006	0.013	0.009
	HIGH	0.143	0.138	0.097	0.087	0.085	0.031	0.030

Putnam	LOW	0.007	0.007	0.000	0.000	0.000	0.098	0.039
	AVERAGE	0.169	0.149	0.338	0.067	0.028	0.125	0.106
	HIGH	1.567	1.494	1.494	0.852	0.147	0.174	0.174

St. Johns	LOW	0.002	0.001	0.001	0.000	0.000	0.000	0.000
	AVERAGE	0.051	0.051	0.022	0.028	0.013	0.018	0.016
	HIGH	0.184	0.152	0.087	0.060	0.027	0.029	0.028

St. Lucie	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.032	0.033	0.062	0.006	0.015	0.074	0.111
	HIGH	2.178	1.770	1.445	1.451	0.292	0.336	0.324

Santa Rosa	LOW	0.000	0.000	0.000	0.000	0.000	0.040	0.039
	AVERAGE	0.481	0.466	0.594	0.194	0.131	0.220	0.252
	HIGH	1.693	1.511	1.281	0.650	0.421	0.352	0.344

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
Sarasota	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.215	0.097	0.130	0.045	0.047	0.075	0.093
	HIGH	2.524	2.240	3.573	0.956	0.607	0.529	0.516
Seminole	LOW	0.007	0.007	0.000	0.000	0.001	0.002	0.002
	AVERAGE	0.039	0.036	0.021	0.012	0.009	0.011	0.012
	HIGH	0.279	0.273	0.160	0.111	0.079	0.056	0.056
Sumter	LOW	0.001	0.001	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.024	0.033	0.005	0.009	0.011	0.001	0.000
	HIGH	0.077	0.075	0.010	0.028	0.026	0.001	0.001
Suwannee	LOW	0.051	0.050	0.007	0.000	0.005	NA	NA
	AVERAGE	2.548	2.400	2.946	0.579	0.035	NA	NA
	HIGH	9.353	8.844	10.843	7.252	0.189	NA	NA
Taylor	LOW	0.000	0.000	0.000	0.000	0.000	0.000	1.038
	AVERAGE	0.803	0.548	1.219	0.238	0.534	0.742	1.038
	HIGH	2.515	2.367	2.899	0.519	0.534	0.742	1.038
Union	LOW	0.000	0.000	0.000	0.000	0.000	NA	NA
	AVERAGE	0.036	0.036	0.005	0.011	0.000	NA	NA
	HIGH	0.039	0.039	0.005	0.011	0.000	NA	NA
Volusia	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.032	0.029	0.017	0.008	0.008	0.009	0.007
	HIGH	0.284	0.281	0.149	0.168	0.188	0.053	0.063
Wakulla	LOW	0.176	0.152	0.152	0.076	0.005	0.489	0.577
	AVERAGE	0.945	1.074	0.816	0.298	0.624	0.489	0.577
	HIGH	7.096	6.707	7.617	1.913	0.787	0.489	0.577
Walton	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.758	0.533	0.443	0.312	0.229	0.225	0.234
	HIGH	1.329	1.181	1.989	0.503	0.289	0.268	0.262
Washington	LOW	0.000	0.000	0.000	0.000	0.000	1.559	NA

County	Loss Costs	Frame Owners	Masonry Owners	Manufactured Homes	Frame Renters	Masonry Renters	Frame Condo Unit	Masonry Condo Unit
	AVERAGE	0.298	0.286	0.334	0.301	0.454	1.559	NA
	HIGH	1.947	1.867	1.609	1.511	2.140	1.559	NA
Statewide	LOW	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AVERAGE	0.227	0.152	0.300	0.066	0.152	0.068	0.092
	HIGH	9.353	8.844	12.024	7.252	4.890	3.274	2.122

Figure 76 - Standard Flood Loss Costs per \$1000 with Specified Deductibles, Time Element

- C. If a modeling organization has flood loss costs for a rating area or geographic zone for which there is no exposure, give the flood loss costs zero weight (i.e., assume the exposure in that rating area or geographic zone is zero). Provide a list in the flood model submission document of those rating areas or geographic zones where this occurs.**

Loss costs were not produced for a rating area for which there is no exposure.

- D. If a modeling organization does not have flood loss costs for a rating area or geographic zone for which there is some exposure, do not assume such flood loss costs are zero, but use only the exposures for which there are flood loss costs in calculating the weighted average flood loss costs. Provide a list in the flood model submission document of the rating areas or geographic zones where this occurs.**

All rating areas for which there is some exposure have loss costs.

- E. NA shall be used in cells to signify no exposure.**

NA has been used in cells to signify no exposure.

- F. All flood loss costs that are not consistent with the requirements of Standard AF-6, Flood Loss Outputs and Logical Relationships to Risk, and have been explained in Disclosure AF- 6.9 shall be shaded.**

All flood loss costs provided in Form AF-4 are consistent with the requirements of standard AF-6.9.

Standard Flood Output Range Specifications

<u>Policy Type</u>	<u>Assumptions</u>
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Owners

Coverage A = Building Property

- Coverage A limit = \$100,000
- Replacement cost equal to Coverage A limit
- Deductible = \$1,500

Coverage B = Personal Property

- Coverage B limit = \$40,000
- Actual cash value equal to Coverage B limit
- Deductible = \$1,000

Time Element Coverage

- To be defined by the modeling organization

Flood loss costs per \$1,000 shall be specified for each coverage limit

Renters

Coverage B = Personal Property

- Coverage B limit = \$25,000
- No coverage for tenant improvements
- Deductible = \$1,000
- Actual cash value equal to Coverage B limit

Time Element Coverage

- To be defined by the modeling organization

Flood loss costs per \$1,000 shall be related to the Coverage B limit

Condo Unit Owners

Coverage A = Building Property

- Coverage A limit = 10% of Coverage B limit
- Replacement cost equal to Coverage A limit

Coverage B = Personal Property

- Coverage B limit = \$50,000
- Actual cash value equal to Coverage B limit
- Deductible = \$500

Time Element Coverage

- To be defined by the modeling organization

Flood loss costs per \$1,000 shall be related to the Coverage B limit

Policy Type **Assumptions**

Manufactured Homes

Coverage A = Building Property

- Coverage A limit = \$50,000
- Replacement cost equal to Coverage A limit
- Deductible = \$500

Coverage B = Personal Property

- Coverage B limit = \$25,000
- Actual cash value equal to Coverage B limit

Time Element Coverage

- To be defined by the modeling organization

Flood loss costs per \$1,000 shall be related to the coverage limit

Form AF-5: Logical Relationship to Flood Risk (Trade Secret Item)

Form AF-5 is a trade secret item and as such will be provided to the Professional Team during their onsite visit and discussed during the closed portion of the Commission meeting.

Form AF-6: Flood Probable Maximum Loss for Florida

- A. Provide the estimated flood loss and uncertainty interval for each of the Personal Residential Annual Exceedance Probabilities given in Part A, Annual Aggregate and Part B, Annual Occurrence. Describe how the uncertainty intervals are derived. Also, provide in Parts A and B, the Conditional Tail Expectation, the expected value of flood losses greater than the Estimated Flood Loss Level. If the modeling methodology does not allow the flood model to produce a viable answer for certain exceedance probabilities, state so and why.**

The uncertainty intervals for these return periods were computed using 10,000 permutations of KCC’s stochastic flood catalog. The events were randomly assigned to the 100,000 simulated years 10,000 times, based on the number of occurrences per year.

For each permutation, the PMLs were calculated at the annual aggregate level and at the annual occurrence level.

- B. Provide this form in Excel format. The file name shall include the abbreviated name of the modeling organization, the flood standards year, and the form name. Also include Form AF-6, Flood Probable Maximum Loss for Florida, in a submission appendix.**

A completed Form AF-6 has been provided in Excel format and within this submission appendix.

Part A – Personal Residential Flood Probable Maximum Loss for Florida
(Annual Aggregate)

Annual Exceedance Probability	Estimated Flood Loss Level (millions)	Uncertainty Interval (millions)	Conditional Tail Expectation (millions)
<i>Top Event</i>	48,952	39,392 – 70,994	---
<i>0.001</i>	26,826	26,632 – 27,984	30,602
<i>0.002</i>	23,880	23,608 – 24,577	27,862
<i>0.004</i>	20,465	19,891 – 20,619	24,898
<i>0.01</i>	14,922	14,523 – 14,954	20,333
<i>0.02</i>	10,608	10,453 – 10,723	16,441
<i>0.05</i>	5,610	5,553 – 5,684	11,155
<i>0.10</i>	2,875	2,853 – 2,920	7,574
<i>0.20</i>	1,136	1,122 – 1,148	4,694

Table 26 - Personal residential flood probable maximum loss for Florida (annual aggregate)

**Part B – Personal Residential Flood Probable Maximum Loss for Florida
(Annual Occurrence)**

<i>Annual Exceedance Probability</i>	<i>Estimated Flood Loss Level (millions)</i>	<i>Uncertainty Interval (millions)</i>	<i>Conditional Tail Expectation (millions)</i>
<i>Top Event</i>	35,341	---	---
<i>0.001</i>	24,783	24,766 – 24,783	27,909
<i>0.002</i>	21,845	21,823 – 21,851	25,573
<i>0.004</i>	18,168	18,090 – 18,177	22,697
<i>0.01</i>	13,040	12,974 – 13,051	18,243
<i>0.02</i>	9,151	9,081 – 9,170	14,580
<i>0.05</i>	4,660	4,637 – 4,692	9,726
<i>0.10</i>	2,286	2,280 – 2,317	6,494
<i>0.20</i>	840	835 - 852	3,945

Table 27 - Personal residential flood probable maximum loss for Florida (annual occurrence)

Appendix F: Model Evaluation

External Review of the KCC US Flood Reference Model Vulnerability Module

Innovative Engineering and Education Services, LLC

February 26, 2020

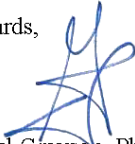
Karen Clark, CEO
Karen Clark & Company
116 Huntington Avenue
Boston, MA 02116

RE: Review of the Karen Clark & Company US Flood Reference Model Vulnerability Standards

Dear Ms. Clark:

This letter is provided in support of my opinion that the Karen Clark & Company (KCC) US Flood Reference Model Building Vulnerability Functions meets the vulnerability standards set forth by the 2017 Flood Standards Report of Activities (ROA) issued by the Florida Commission on Hurricane Loss Projection Methodology (FCHLPM). This conclusion is based on a thorough review of material provided by KCC and an in-depth presentation by KCC personnel of the KCC Coastal and Inland Flood Model on February 21, 2020. The remainder of this letter provides a detailed account of my review process as it pertains to the personal residential structure flood vulnerability functions development methodology. Please note that should new information, or changes to the previously reviewed information, directly related to the current FCHLPM submission building vulnerability functions become available, I would need to review this material to reaffirm the opinions and conclusions stated in this letter. Additionally, I have included a copy of my curriculum vitae for inclusion with your submission to the FCHLPM.

Best regards,



J. Michael Grayson, Ph.D., P.E. (SC #34824)

Innovative Engineering and Education Services, LLC

ATTACHED: Grayson Curriculum Vitae

Innovative Engineering and Education Services, LLC

KCC Letter of Review

The initial review process developed a basic evaluation plan that consisted of preliminary research into the vulnerability standard requirements within the FCHLPM 2017 Flood ROA, and a review of the foundational literature supporting previous flood loading and damage methodologies (e.g., US Army Corps of Engineers, Federal Emergency Management Agency, American Society of Civil Engineers). Additionally, KCC provided their FCHLPM Submission Standards, Disclosures and Forms pertaining to sections VF-1 to VF-3 to facilitate the review.

The in-depth presentation of the KCC Coastal and Inland Flood Model by KCC personnel consisted of a web meeting that provided an exhaustive review of the personal residential structure flood vulnerability functions development methodology. The development of the personal residential structure flood vulnerability functions follows the same component method of the wind vulnerability functions which further facilitated the review. The presentation, in-depth discussions with KCC personnel, and a thorough review of provided documentation confirmed that the KCC personal residential structure flood vulnerability functions development methodology is based on rational structural engineering analysis, laboratory and fieldtested data available in technical literature, expert opinion, and post-event surveys and site investigations conducted by KCC personnel. KCC personnel have extensive experience in all aspects utilized in the personal residential structure flood vulnerability functions development methodology, including but not limited to, catastrophe modeling, performing laboratory and field testing, and performing post-event damage assessments. Additionally, insurance claims data have been used for validation of various aspects of the personal residential structure flood vulnerability functions.

Determination of Florida Building Stock

A significant aspect of any building vulnerability function development methodology is an adequate representation of the local building stock. KCC personnel utilized a suite of highly credible resources, such as census and tax appraiser data, client exposure data, the Florida Hurricane Catastrophe Fund, in addition to building stock information ascertained from post-event damage surveys, site visits with claims adjusters, and a review of desktop claims systems and files. These sources have provided a substantial amount of information that I believe has provided a reasonably complete picture of the representative personal and commercial residential building stock throughout the state of Florida.

Building Vulnerability Functions Based on Primary Characteristics

The KCC Inland and Coastal Flood model utilizes flood characteristics that consider the hydrostatic and hydrodynamic forces developed from depth of inundation for coastal and inland areas, and wave action for coastal areas to determine the level of damage due to flooding. Vulnerability functions are developed for a set of primary building characteristics, including construction type (materials), building occupancy, number of stories, year built, foundation type and building location/region that are consistent with those required by the FCHLPM vulnerability standards. The KCC model considers both site-built buildings and manufactured homes as separately developed vulnerability functions.

KCC personnel have used reasonable methods to delineate each primary characteristic to capture the full spectrum of variability within each characteristic. Construction type includes the prevalent building stock in Florida for both site-built and manufactured homes. Building occupancy differentiates between owners, renters, and condo unit owners. Number of stories considers the number of floors of a building which is directly related to the percentage of the home damaged due to flooding. The year built incorporates Flood Insurance Rating Maps (FIRM) and building

code requirements to determine items such as freeboard and utility elevation requirements. Flood vulnerability regions are determined using National Flood Insurance Program (NFIP) community rating system scores. These regions are intended to incorporate differences in flood vulnerability as a result of community flood management and mitigation measures. First floor height significantly affects the vulnerability of a structure to coastal and inland flooding and is dictated by the foundation type of a structure. Defined flood zones are incorporated and determine the type and severity of flooding as well as additional building mitigation measures required of the structure. It should be noted that the developed building vulnerability functions also provide for structures that have unknown and/or conflicting primary characteristics using a reasonable exposure and inventory weighted-averaging scheme to assign the building vulnerability functions in these cases.

Building Vulnerability Functions Based on the Load and Resistance Component Method

The KCC model utilizes a load and resistance component-based methodology in the development of their building vulnerability functions. This method is fully supported in the research literature and forms the foundation, in some variation, for many current engineering-based damage models. Distinct building components (e.g., building walls, openings, wall-to-foundation connections, etc.) considered in the model are appropriate and specific to the construction type of the structure. Building component capacities were taken directly from technical literature when possible or determined from calculation using sound engineering judgement when technical information was limited.

Direct and indirect failures of building components are considered with direct failure of components occurring due to flood loading, and indirect failure of components occurring due to the initial failure of related components. This type of indirect failure of building components requires that the dependency of a component on the failure of another component be known. Because there is limited information on this relationship in the technical literature, KCC personnel experienced in structural engineering and post-event damage assessments utilized sound engineering judgement to develop an appropriate dependency matrix for the considered building components utilizing the most relevant technical literature available.

The KCC model considers various loads acting on a structure during a flood event. Coastal and inland flood loading considers lateral and vertical hydrostatic loads, and hydrodynamic loads. Lateral hydrostatic forces affect building walls, openings, wall-to-foundation connections and the foundation. Vertical hydrostatic forces affect the wall-to-foundation connections and the foundation. The KCC model also considers the impact that the rate of water infiltration has on the magnitude of lateral loads and how it influences the difference in hydrostatic pressure between the exterior and interior of a structure. Hydrodynamic forces occur due to the velocity of the water as it flows around the structure, and affect the building walls, openings, wall-to-foundation connections and foundations.

The KCC model differentiates between inland and coastal flood velocities using upper and lower bound velocities presented in relevant technical literature. Lower velocity inland flooding uses the lower bound and higher velocity coastal flooding uses an average of the upper and lower bound velocities. Coastal flood loading additionally considers wave action on a structure. Breaking waves can affect the building walls, openings, wall-to-foundation connections and the foundation. It should be noted that flood-borne debris loading, and localized scour and erosion are implicitly considered in the KCC model and are validated using claims data.

Vulnerability Functions Based for Contents, and Time Element Losses

Building vulnerability functions that address interior damage are based on a progressive failure concept. Building interior damage occurs either through failure of exterior building components or due to water infiltration. Additionally, the KCC model incorporates secondary damages from fresh and saltwater, such as mold and mildew. However, there is limited technical literature that directly relates the damage of the exterior building and water infiltration to damage of the building interior. Therefore, KCC personnel developed a dependency array based on expert opinion provided in published literature and sound engineering judgement that determines the probability of building interior failure as a function of damage to the wall-to-foundation connections, foundation, exterior walls and openings, and roof of a building.

Building contents and time element losses are also addressed within the vulnerability functions, and KCC personnel have relied primarily on post-damage assessments, engineering judgement developed through extensive damage assessment experiences, and rational structural analysis to develop reasonable relationships that are validated using insurance claims data. Building contents losses are related to the level of building damage, however, there have been instances identified in insurance claims data where content damages have occurred without any associated building damages. Building time element losses attributed to direct sources (e.g., building and equipment damage) due to flood and storm surge, and indirect sources (e.g., mandatory evacuation, additional living expenses) are included in the developed building vulnerability functions consistent with the vulnerability standards of the FCHLPM, but the portion of loss associated with each cause of loss is implicitly accounted for since the vulnerability function development methodology is based on post-event surveys, engineering judgement and subsequent validation using insurance claim data.

Impact of Detailed Building Characteristics, Including Flood Mitigation Measures, on the Developed Building Vulnerability Functions

Flood mitigation measure impacts (i.e., secondary modifications) to the developed primary (reference) building vulnerability functions are incorporated through a matrix of modification factors that depend on intensity. The modification factors are developed by investigating the influence of the secondary modifications on building performance to flooding and are calculated as a ratio of the mean damage ratio of the modified building to the reference building. Secondary modifications are classified as characteristics that affect the flood loading experienced by a structure (e.g., first floor elevation, etc.).

The KCC model secondary modifications consider the presence of basements, wall-to-foundation connections, the floor of interest, elevation of the structure, elevation or protection of utilities, type of building enclosure below the base flood elevation, and dry and wet floodproofing. Effects on the secondary modifications are informed by current technical literature, and engineering judgement informed by rational analysis. In instances where information from technical literature and/or testing data is limited, sound engineering judgement is employed to determine reasonable capacity values. There are two scenarios that the KCC model addresses when considering the combined effects of multiple secondary modification factors: the first scenario consists of multiple secondary modification factors that influence the same building component, or some mitigation measures being sub-measures of others. The second scenario consists of secondary modification factors that influence different building components. In the first scenario, the maximum secondary modifier is used. The second scenario, in which the secondary modifications affect different building components, assumes that the influence of one building component is additive with

additional building components. Both approaches can be scientifically supported for determining the influence of multiple secondary modifications.

Building Vulnerability Function Output

I have been provided with the output from Forms VF-1 to VF-5, but I have not explicitly reviewed the calculations that have gone into creating these documents. However, the results seem appropriate based on my professional construction, structural engineering research and design, and post-event damage assessment experiences.

Forms VF-1 and VF-2 provide reasonable Mean Damage Ratios (MDR) as a function of flood depth for coastal and inland flooding, respectively. It is expected that coastal flooding would provide a higher MDR when compared to inland flooding as coastal structures are subjected to wave action on the structure, higher water velocities, lower water infiltration rates, and exposure to saltwater. There is a notable increase in the MDR as the flood depth increases from four to five feet and again from eleven to twelve feet for coastal and inland flooding. This seems reasonable as it likely in this range of inundation depths that a significant number of fenestrations will become compromised for non-elevated and elevated reference structures, respectively.

The percentage changes in damage for individual mitigation measures provided in Form VF-3 are reasonable with respect to each other when considering the relative contribution of the item that is being mitigated to the overall vulnerability of the structure. It is well illustrated that first-floor height dictates when the structure begins to incur significant damage. This is particularly evident when considering the impact that elevating the structure has on mitigating the overall damage experienced by a structure.

Forms VF-4 and VF-5 provide the mean flood damage ratios and flood damage/\$1000 for coastal and inland flooding, respectively. An explicit comparison between construction types is not necessarily revealing due to the different first floor elevations and inundation depths of the reference structures. However, the results of a comparison of the performance of a reference structure to a flood mitigation measure with an increase in flood depth seem reasonable. This is evident as the decrease in damage ratio is compared across different mitigation measure intensities (e.g., elevate the first floor from one foot to two feet), particularly as the first floor becomes inundated with an increase in flood depth.

Conclusions

In my opinion, the KCC development methodology and developed building vulnerability curves meet the requirements of the FCHLPM vulnerability standards, and the information that I have assessed through the process of my review is technically accurate, reliable, unbiased and complete. I have not reviewed specific calculations, so I cannot attest to the accuracy of values presented in Forms VF-1 to VF-5, only that the values are appropriate and acceptable based on my professional construction, structural engineering research and design, and post-event damage assessment experiences. KCC personnel have extensive experience in catastrophe modeling, wind engineering, field and laboratory testing, and post-disaster damage assessments, and the building vulnerability function methodology employed by KCC personnel is theoretically sound and grounded in rational structural analysis, laboratory and field testing from technical literature, post-event site investigations and insurance claims data. KCC personnel have utilized relevant technical literature when available and filled in any deficiencies in the technical literature with field assessments and expert opinion while exhibiting sound engineering judgement.

Curriculum Vitae of Dr. J. Michael Grayson

J. Michael Grayson, PhD, PE (SC)

Summary of Qualifications and Skills

- ASCE ExCEED Teaching Fellow with significant teaching experience at The Citadel and Florida A&M–Florida State University (~5 years)
- Licensed professional engineer in the state of South Carolina
- Significant industry experience in structural engineering, engineering consulting, heavy highway construction, and the light-frame residential/commercial construction industries (~10 years)
- Proficient/familiar with the following software:
 - Autodesk software, including AutoCAD and Revit
 - Bentley Systems, including RAM Structural Systems and STAAD.Pro; MASTAN2; SAP 2000; RISA; Enercalc; RetainPro; Tedds; BeamChek; MathCAD; HydroCAD; EPANET; HEC-HMS
 - Programming languages: MATLAB; Python
 - Microsoft Office Products, including Word, Excel, and PowerPoint
- Experience in data collection and analysis for the ABET accreditation process

Professional Licensure/Certifications

- Professional Engineer South Carolina #34824
- State of California Safety Assessment Program Cal OES #84376

Education

- | | |
|--|--|
| <p>Doctor of Philosophy in Civil Engineering; Clemson University
 Emphasis: Structural Engineering; Reliability; Risk Assessment
 Clemson, SC USA
 Advisor: Weichiang Pang, PhD</p> | <p>August 2014</p> |
| <p>Master of Science in Civil Engineering; Clemson University
 Emphasis: Structural Engineering; Reliability; Risk Assessment
 Clemson, SC USA
 Advisor: Weichiang Pang, PhD</p> | <p>December 2011</p> |
| <p>Bachelor of Science in Civil Engineering; Clemson University
 Minor: Environmental Engineering
 Clemson, SC USA</p> | <p>December 2008
 Summa Cum Laude</p> |

Professional Experience

- | | |
|--|--|
| <p>Senior Structural Engineer/ Quality Control Manager
 Cates Engineering, Ltd.</p> | <p>January 2019 – Present
 Gainesville, VA, USA</p> |
|--|--|
- Project manager for unique/challenging projects that required in-depth analysis and design including, but not limited to, unreinforced masonry assessment of an existing office building, atypical attachment of roof top mechanical units, and the development of design calculations for a global recycled materials manufacturer
 - Internal peer review manager of over 60 active residential/commercial building projects
 - Led proposal development team for multi-phase project within the D.C. metro area.
 - Development of company standards, design and training procedures.

Curriculum Vitae

J. Michael Grayson, PhD, PE

Professional Experience (continued)

-
- Engineering Consultant** **January 2017 – Present**
 Innovative Engineering and Education Services, LLC Owner
- External peer reviewer of the building vulnerability model components for wind and flood for a global catastrophe risk management firm. The wind model was the first new model certified by the Florida Commission on Hurricane Loss Projection Methodology since 2006.
 - Engineering consultant during the product testing and certification process for a Southeastern lumber company.
 - External reviewer of design calculations for a proprietary composite floor system company.
- Assistant Professor** **June 2015 – December 2018**
 The Citadel: Department of Civil and Environmental Engineering Charleston, SC, USA
- Developed fragility curves for mitigation of residential homes to hurricane wind hazards.
 - Developed funding proposals (~\$3 million), technical reports and peer-reviewed publications.
 - Administered/managed courses/projects in: Statics, Mechanics of Materials, Mechanics of Materials Laboratory, Structural Analysis, Fluid Mechanics, Concrete Design, and Steel Design.
- Assistant Professor** **August 2014–May 2015**
 FAMU-FSU: Department of Civil and Environmental Engineering Tallahassee, FL, USA
- Developed a novel analytical damage quantification method for residential homes subjected to hurricane wind hazards.
 - Developed funding proposals, technical reports and peer-reviewed publications.
 - Administered/managed courses/projects in Structural Analysis, Fragility Analysis of Civil Infrastructure, and Multi-hazard Risk Assessment of Civil Infrastructure.
- National Science Foundation Graduate Research Fellow** **June 2011–August 2014**
 Clemson University: Glenn Department of Civil Engineering Clemson, SC, USA
- Developed a significant modular computational model that investigated building envelope failures of residential developments subjected to hurricane wind hazards.
 - Developed a computational model that provided a three-dimensional probabilistic wind-borne debris trajectory model.
 - Developed funding proposals, technical reports and peer-reviewed publications.
- Associate Engineer I** **May 2009–September 2009**
 Colleton Bridge Construction (SCDOT) Adams Run, SC, USA
- Field inspection of major highway and bridge construction.
 - Performed environmental compliance assessments.
 - Performed testing of soil, aggregates, concrete, and other materials as required.
- Residential and Commercial Construction** **September 2001–August 2007**
 Subcontractor Beaufort, SC USA
- Performed structural framing and exterior/interior trimming of low-rise commercial, residential, and coastal structures.
 - Provided project management and problem-solving for a variety of project-related issues.

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Curriculum Vitae

J. Michael Grayson, PhD, PE

Teaching (number of courses administered in parentheses)**The Citadel, The Military College of South Carolina June 2015 – December 2018**

1. CIVL 103 Introduction to Civil Engineering; (1)
2. CIVL 202 Statics; (4)
3. CIVL 304 Mechanics of Materials; (6)
4. CIVL 307 Materials Laboratory; (4)
5. CIVL 309 Structural Analysis; (1)
6. CIVL 320 Fluid Mechanics; (6)
7. CIVL 322 Introduction to Environmental Engineering; (4)
8. CIVL 404 Reinforced Concrete Design; (3)
9. CIVL 406 Steel Design; (2)

Florida A&M – Florida State University College of Engineering Aug 2014 – May 2015

1. CES 3100 Structural Analysis; (1)
2. CGN 5930 Risk Assessment of Civil Infrastructure; (1)
3. CGN 5905 Fragility Analysis of Civil Infrastructure; (1)

Notable Teaching Activities

- Mini-ExCEED presenter The Citadel; January 2017
- ASCE ExCEED Teaching Fellow United States Military Academy; July 2016
- Online Teaching Faculty Academy Graduate The Citadel; April 2016
- Assisted in preparation of new Construction Engineering curriculum Fall 2016–December 2018
- Assisted in the ABET accreditation process Fall 2015–December 2018

Book Chapters

1. Grayson, J.M., W. Pang. (2018) "Chapter 6: Wind-borne debris risk impact modeling" *Wind-borne Debris Hazards*. Ed. Nigel B. Kaye, PhD. Reston, VA: American Society of Civil Engineers. ISBN: 9780784414965.

Expert Letters of Review

1. Grayson, J.M. (2019) Expert Letter of Review of the Karen Clark & Company US Hurricane Reference Model – Version 2.0 Vulnerability Standards for Wind. p.331–339. https://www.sbafla.com/methodology/Portals/Methodology/ModelSubmissions/2017/KCC17_FCHLPM_Submission_20190524.pdf?ver=2019-05-24-132500-000

Curriculum Vitae

J. Michael Grayson, PhD, PE

Peer-Reviewed Journal Publications

1. **Grayson, J. M.**, Pang, W. (In preparation) "The performance of retrofitted homes within residential developments subjected to hurricane wind hazards."
2. **Grayson, J. M.**, Pang, W., Schiff, S. D. (2013) "Building envelope failure assessment framework for residential communities subjected to hurricanes." *Engineering Structures* 51, 245-258.
3. **Grayson, J. M.**, Khan, A. A., Karanfil, T. (2013) "Permeability of uniform and mixed size tire chips under different loading conditions." *Journal of Irrigation and Drainage Engineering* doi: 10.1061/(ASCE)IR.1943-4774.0000637.
4. **Grayson, J. M.**, Pang, W., Schiff, S. D. (2012) "Three-dimensional probabilistic wind-borne debris trajectory model for building envelope impact risk assessment." *Journal of Wind Engineering and Industrial Aerodynamics* 102, 22-35. [2012 AAWE Best Journal Paper Award Recipient]

Conference Proceedings

1. **Grayson, J.M.**, R.K. Giles, S.T. Ghanat. (abstract accepted). "General Civil or a Structural Engineering-focused Degree? Developing Successful Structural Engineers Regardless of Path." 2020 ASEE Annual Conference & Exposition, Montreal, Quebec. June 21-24, 2020.
2. Ghanat, S.M., **J.M. Grayson**. (2019) "Cookbook Approach vs. Discovery Approach in Materials Laboratory Course at The Citadel." 2019 ASEE Southeastern Section Conference, Raleigh, NC. March 10-12, 2019.
3. **Grayson, J.M.**, T.A. Wood, R.J.M. Robinson, J. Plumblee, S. Prince-Nelson (2018) "The Influence of mathematical preparedness on student performance in an engineering statics course." 2018 ASEE Southeastern Section Conference, Daytona Beach, FL. March 4-6, 2019.
4. Ghanat, S., **J.M. Grayson**, M. Bubacz, K. Skenes. (2018) "Lecture/laboratory instructor pairings- Does it make a difference?" 2018 ASEE Southeastern Section Conference, Daytona Beach, FL. March 4-6, 2019.
5. Ghanat, S., **J.M. Grayson**, M. Bubacz, K. Skenes (2018) "The influence of a summer lecture/laboratory course on students' transition from a two-year program to a four-year college." 2018 ASEE Southeastern Section Conference, Daytona Beach, FL. March 4-6, 2019.
6. **Grayson, J.M.** (2017). "Improving community resilience to hurricanes through adherence to building codes and implementation of code-plus practices." *In the proceedings of the 7th biennial professional conference of the ASCE Architectural Engineering Institute (AEI 2017)*; Oklahoma City, OK, April 11-13, 2017.
7. **Grayson, J.M.**, S. Ghanat, T.A. Wood. (2017). "Use of Active versus Passive Learning Pedagogies in a Statics course to Address Variations in Student Performance between Course Sections." *In the proceedings of the 2017 ASEE Zone 2 Spring Conference*. San Juan, Puerto Rico; March 2-5, 2017.
8. Wood, T.A., **J.M. Grayson**, K. Brown. (2017) "Faculty and Student Perceptions of Plickers." *In the proceedings of the 2017 ASEE Zone 2 Spring Conference*. San Juan, Puerto Rico; March 2-5, 2017.
9. Ghanat, S., M. Woo, M. Bubacz, **J.M. Grayson**. (2017). "From Analyzing Geotechnical Failures to Generating and Solving Crossword Puzzles: Adding Variety to a Geotechnical Engineering Course." *In the proceedings of the 2017 ASEE Zone 2 Spring Conference*. San Juan, Puerto Rico; March 2-5, 2017.

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Curriculum Vitae

J. Michael Grayson, PhD, PE

Conference Proceedings (continued)

10. Ghanat, S.T., D. Michalaka, **J.M. Grayson**. (2017). "Study of Pre- and Post-test Surveys in an Engineering Economy Course." *In the proceedings of the 2017 ASEE Zone 2 Spring Conference*. San Juan, Puerto Rico; March 2-5, 2017.
11. Ghanat, S.T., **J.M. Grayson**. (2016). "Using various active learning techniques to create excitement in a mechanics of materials laboratory course." *In the proceedings of the 2016 Mid-years Engineering Experience Conference (MYEE 2016)*; Texas A&M University, College Station, TX; March 30-April 1, 2016.
12. Welch, R.W., T.W. Mays, M. Bubacz, K. Skenes, K. Marley, **J.M Grayson**. (2016), "*Holistic Mentoring through Sharing an Entire Course Built on the ExCEED Model*" Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana.
13. **Grayson, J. M.**, W. Pang. (2015). "Analytical damage quantification method for residential developments subjected to hurricane wind hazards." *In the proceedings of the 12th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP12)*; Vancouver, British Columbia, Canada; July 12-15, 2015.
14. **Grayson, J. M.**, W. Pang. (2014) "The influence of community-wide hurricane wind hazard mitigation retrofits on community resilience." *In the proceedings of Structures Congress 2014*, Boston, Massachusetts, USA, April 3-5, 2014.
15. **Grayson, J. M.**, W. Pang, S. Schiff. (2013) "Accounting for exogenous wind-borne debris in building envelope failure assessment models." *In the proceedings of the 12th Americas Conference on Wind Engineering*. Seattle, Washington, USA, June 16-20, 2013.
16. **Grayson, J. M.**, W. Pang, S. Schiff (2013) "Statistical development of an exogenous wind-borne debris generator for building envelope failure assessment models." *In the proceedings of the 11th International Conference on Structural Safety and Reliability (ICOSSAR 2013)*. New York, New York, USA, June 16-20, 2013.
17. **Grayson, J. M.**, W. Pang, S. Schiff (2012) "Framework for the assessment of building envelope failures due to hurricane wind hazards." *In the proceedings of the Applied Technology Council (ATC)-Structural Engineering Institute (SEI): Advances in Hurricane Engineering*. Miami, Florida, USA, October 24-26, 2012.
18. **Grayson, J. M.**, W. Pang, S. Schiff (2011) "Probabilistic wind-borne debris trajectory model for building envelope impact risk assessment." *In the proceedings of the 11th International Conference on Applications of Statistics and Probability in Civil Engineering (ICASP 11)*. Zurich, Switzerland, August 1-4, 2011, ETH.

Other Publications

1. **Grayson, J.M.** (2014) "Building envelope failure assessment of residential developments subjected to hurricane wind hazards." Doctoral Dissertation. Clemson University.
2. **Grayson, J.M.**, W. Pang, S. Schiff (2012) "Predicting building envelope failures of residential structures due to Atlantic Basin hurricane wind hazard." South Carolina Sea Grant Consortium Report.
3. **Grayson, J.M.** (2011) "Development and application of a three-dimensional probabilistic wind-borne debris trajectory model." Master's Thesis. Clemson University.

Curriculum Vitae

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Presentations and Demonstrations

1. "Improving community resilience to hurricanes through adherence to building codes and implementation of code-plus practices." ASCE Architectural Engineering Institute (AEI 2017); Oklahoma City, OK, April 11-13, 2017.
2. "Using various active learning techniques to create excitement in a mechanics of materials laboratory course." 2016 Mid-years Engineering Experience Conference (MYEE 2016); Texas A&M University, College Station, TX; March 30-April 1, 2016.
3. "The role of building codes and code-plus practices in disaster resilience." 2016 Federal Alliance for Safe Homes (FLASH) Annual Conference, Orlando, Florida. January 2016.
4. "The influence of community-wide hurricane wind hazard mitigation retrofits on community resilience." 2014 Structures Congress, Boston, Massachusetts. April 2014.
5. "Building resilient: Taking steps towards a more sustainable future." The University of Oklahoma. School of Civil Engineering and Environmental Science. Norman, Oklahoma. March 2014.
6. "Building resilient: Taking steps towards a more sustainable future." FAMU-FSU College of Engineering Department of Civil and Environmental Engineering. Tallahassee, Florida. March 2014.
7. "Building resilient coastal communities subjected to hurricane wind hazards." 2013 Federal Alliance for Safe Homes (FLASH) Conference. Orlando, Florida. November 2013.
8. "Accounting for exogenous wind-borne debris in building envelope failure assessment models." 12th Americas Conference on Wind Engineering. Seattle, Washington. June 2013.
9. "Framework for the assessment of building envelope failures due to hurricane wind hazards." Applied Technology Council (ATC)-Structural Engineering Institute (SEI): Advances in Hurricane Engineering. Miami, Florida. October 2012.
10. Wind-borne debris impact damage demonstration/presentation. Congressional Black Caucus Political Education and Leadership Institute. 2011 Tunica Mississippi Policy Conference. Tunica, Mississippi. June 2011.

Grant Proposals

1. **Structural Assessment using UAVs (unfunded)** **\$93,600**
Property Drone Consortium
PI: Dr. Robert Rabb; Co-PIs: Dr. J. Michael Grayson; Dr. Timothy Mays; Dr. Patrick Bass Feb 2017
2. **FoC³us on STEM: Supporting STEM Education through Competencies, Collaboration, and Culture (unfunded)** **\$2,994,190**
National Science Foundation Improving Undergraduate STEM Education (IUSE)
PI: Dr. Jennifer Albert
Co-PI: Dr. Richard Robinson, Dr. J. Michael Grayson Submitted Jan 2016; Resubmitted Jan 2017
3. **Benefit/Cost Analysis of Implementing Building Codes and Code-plus Practices in Residential Developments in Hurricane-prone Regions (funded)** **\$3000**
The Citadel Foundation
PI: Dr. J. Michael Grayson Submitted Jan 2017

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J. Michael Grayson, PhD, PE

Grant Proposals (continued)

-
4. **Fragility Analysis of Residential Developments Subjected to Hurricane Wind Hazards Year 2 (funded)** **\$3000**
The Citadel Foundation
PI: Dr. J. Michael Grayson *Submitted Jan 2016*
 5. **Fragility Analysis of Residential Developments Subjected to Hurricane Wind Hazards Year 1 (funded)** **\$3000**
The Citadel Foundation
PI: Dr. J. Michael Grayson *Submitted Jan 2015*
 6. **Performance Assessment Considering Climate Change of a Typical Hillsborough County, Florida Residential Development Subjected to Hurricane Hazards (unfunded)** **\$240,000**
Florida Sea Grant Consortium
PI: Dr. J. Michael Grayson; Co-PI: Dr. Weichi Pang *Submitted Feb 2015*
 7. **Center for System-Level Modeling of Community Resilience-SECURE (unfunded)** **\$335,195**
National Institute of Standards and Technology Community Resilience Center of Excellence
Submitted as part of a consortium of universities PI: Univ. of Oklahoma *Submitted Sep 2014*
 8. **Building Resilient Residential Communities through Hurricane Mitigation Assessments (funded)** **~\$130,000**
National Science Foundation **Graduate Research Fellowship**
PI: Dr. J. Michael Grayson *Submitted Nov 2011*
 9. **Feasibility of Integrating Bridge Fragility Curves with Advanced Wireless Networks (unfunded)** **~\$130,000**
National Science Foundation **Graduate Research Fellowship**
PI: Dr. J. Michael Grayson *Submitted Nov 2009*

Professional Memberships

-
- American Association for Wind Engineering (AAWE) 2012–Present
 - American Concrete Institute (ACI) 2017–Present
 - American Institute of Steel Construction (AISC) 2017–Present
 - American Society of Civil Engineers (ASCE) 2007–Present
 - American Society for Engineering Education (ASEE) 2015–Present
 - Chi Epsilon, the Civil Engineering Honor Society 2007–Present
 - Society of American Military Engineers (SAME) 2015–Present
 - Structural Engineers Assoc. of South Carolina (SEA of SC) 2012–December 2018
 - Structural Engineers Assoc. of Metro. Washington (SEA-MW) January 2019–Present

Curriculum Vitae

J. Michael Grayson, PhD, PE

Notable Service Activities

- Assessment Officer; South Carolina State Guard; ENG CMD 2017–December 2018
 - Volunteer officer in the South Carolina State Guard conducting pre- and post-hazard structural assessment of civil infrastructure within the state of South Carolina.
 - Received relevant training from FEMA and ATC related to structural assessment to wind, flooding and earthquakes
 - Completed Basic Military Emergency Management Specialist (MEMS) requirements.
- NCSEA Structural Engineer Emergency Response (SEER) Member 2017–Present
- The Citadel Student Steel Bridge Team Advisor 2016–December 2018
- Water Mission Fall 2017
 - Assisted with testing of fiber-reinforced concrete for Healthy Latrine Design
- Journal Peer Reviewer
 - The Journal of Wind Engineering and Industrial Aerodynamics 2012–Present
 - Frontiers in Built Environment 2017–Present
 - Journal of Structural Engineering 2018–Present
 - Structure and Infrastructure Engineering 2018–Present
- 2017 ASEE Annual Conference Session Co-moderator June 2017
 - W506: Innovative Pedagogies for Facilitating Student-driven learning experiences
- Conference Proceedings Peer Reviewer
 - 2017 ASEE-Zone 2 Fall 2016
 - 2018 ASEE-Southeastern Conference Fall 2017
 - 2020 ASEE Annual Conference Reviewer Fall 2019
 - Civil Engineering Division
 - College-Industry Partnership Division
- ACI Faculty Network Committee Member 2017–December 2018
- The Citadel Engineering Leadership and Project Mgt. Search Committee Spring 2017
- The Citadel LeTellier Hall Chemical Hygiene Officer 2016–December 2018

Appendix G: Acronyms

2D: Two dimensional

3DEP: 3-Dimensional Elevation Program

AAL: Average annual loss

AIR: Applied Insurance Research

ALOS DSM: Advanced Land Observing Satellite Global Digital Surface Model

API: Application program interface

ASCE: American Society of Civil Engineers

B.M.: Bachelor's in mathematics

BFE: Base flood elevation

ByP: By-passing hurricane event

CDF: Cumulative distribution function

CE: Characteristic Event

CEO: Chief Executive Officer

cfs: Cubic feet per second

CP: Central Pressure

CPC: Climate Prediction Center

CPU: Central processing unit

CRS: Community Rating System

DBAN: Darik's Boot and Nuke (software for cleaning drives)

DEM: Digital Elevation Model

DEV: Software development environment

DLL: Dynamic link library

EIFS: External insulated finishing system

ELT: Event Loss Table

EP: Exceedance probability

ET: Evapotranspiration

ETF: Exchange-traded fund

Excl/Incl.: Exclude/Include

EPR: Expected Percentage Reduction

F: Forward speed

FBC: Florida Building Code

FCAS: Fellow of the Casualty Actuarial Society

FCHLPM: Florida Commission on Hurricane Loss Projection Methodology

FEMA: Federal Emergency Management Agency

FFH: First Floor Height
FGDL: Florida Geographic Data Library
FHCF: Florida Hurricane Catastrophe Fund
FIMA: Federal Insurance & Mitigation Administration
FIRM: Flood Insurance Rate Map
FPHLM: Florida Public Hurricane Loss Model
FWMD: Florida Water Management District
ft: Feet
GB: Gigabyte
GHz: Gigahertz
GIS: Geographic information system
HAZUS: Hazards in the United States
HUD: US Department of Housing and Urban Development
HURDAT/HURDAT2: Historical hurricane database
HWM: High Water Mark
IDS: Intrusion detection system
IHO: International Hydrographic Organization
IIS: International Insurance Society
ILS: Insurance-linked securities
IPCC: Intergovernmental Panel on Climate Change
IPS: Intrusion prevention system
ISO: International Organization for Standardization
IT: Information technology
JPM: Joint Probability Method
JSON: JavaScript Object Notation
KCC: Karen Clark and Company
km: Kilometer
KML: Keyhole markup language
KPD: KCC Property Database
LLC: Limited liability company
LOB: Line of Business
LULC: Land Use/Land Cover
M&A: Mergers and acquisitions
M&A: Modeling and analytics
MASE: Mean Absolute Scaled Errors

M.A.: Master of Arts
M.B.A.: Master of Business Administration
MPM: Multi-Peril Model
M.S.: Master of Science
m: meter
MDR: Mean damage ratio
MERIT DEM: Multi Error Removed Improved Terrain DEM
mm: millimeter
mph: miles per hour
N/A: Not applicable
n: The exponent for the power law inside the eye used in the Willoughby et al. (2006) radial wind profile
NAD: North American Datum
NAD83: North American Datum of 1983
NAVD: North American Vertical Datum
NAVD88: North America Vertical Datum of 1988
NCEI: National Centers for Environmental Information
NCEP: National Center for Environmental Protection
NDA: Non-disclosure agreement
NFHL: National Flood Hazard Layer
NFIP: National Flood Insurance Program
NGVD: National geodetic vertical datum
NGVD29: National geodetic vertical datum of 1929
NHC: National Hurricane Center
NID: National Inventory of Dams
NLCD: National Land Cover Database
NLD: National Levee Database
NOAA: National Oceanic and Atmospheric Administration
NOS: National Ocean Survey
NWS: National Weather Service
OEF: Open exposure format
P&C: Property and casualty
P&C: Property and casualty
P.E.: Professional engineer
P: The total amount of the water entering each sub-basin from precipitation
PDF: Portable document format, when referring to file types

PDF: Probably distribution function, when referring to statistics

PGP: Pretty Good Privacy

PhD: Doctorate degree

PML: Probable maximum loss

QA: Quality assurance

r: Distance of winds from the center of a storm as used in the Willoughby et al. (2006) radial wind profile

RAM: Random Access Memory

RDP: Remote Desktop Protocol

REST: Representational State Transfer

RI: RiskInsight

R_{max} : Radius of maximum winds

RMS: Risk Management Solutions

S: Size factor, used when converting V_{max} to CP

SCS: Severe Convective Storm

SFTP: Secure File Transfer Protocol

SLOSH: Sea, Lake, and Overland Surges from Hurricanes

SMAP: Soil Moisture Active Passive

SMB: Server Mail Message Block protocol

SME: Subject Matter Expert

SPLASH: Special Program to List the Amplitude of Surge from Hurricanes

SQL: Structured Query Language

SRC: Standardized Regression Coefficient

SSD: Solid State drive

STOC: Stochastic event set

SURGEDAT: Historical storm surge database

TB: Terabyte

TD: Track over land

TDL: Techniques Development Laboratory

TFS: Team Foundation Server

TSV: Tab separated values

UI: User interface

US: United States of America

USACE: United States Army Corps of Engineers

USD: United States Dollar

USGS: United States Geological Survey

USPS: United States Postal Service

V: Wind velocity used in the Willoughby et al. (2006) radial wind profile

V_{max} : Peak wind speed at landfall

VPN: Virtual Private Network

WB: Initial Water Balance

X1: The exponential decay length in the outer vortex used in the Willoughby et al. (2006) radial wind profile

X2: A fixed parameter used in the Willoughby et al. (2006) radial wind profile

XML: Extensible markup language

YLT: Year Loss Table

ZCTA: ZIP Code Tabulation Areas

ZIP: Zone Improvement Plan